
MARCH 1945
electronics
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electronics

MARCH • 1945

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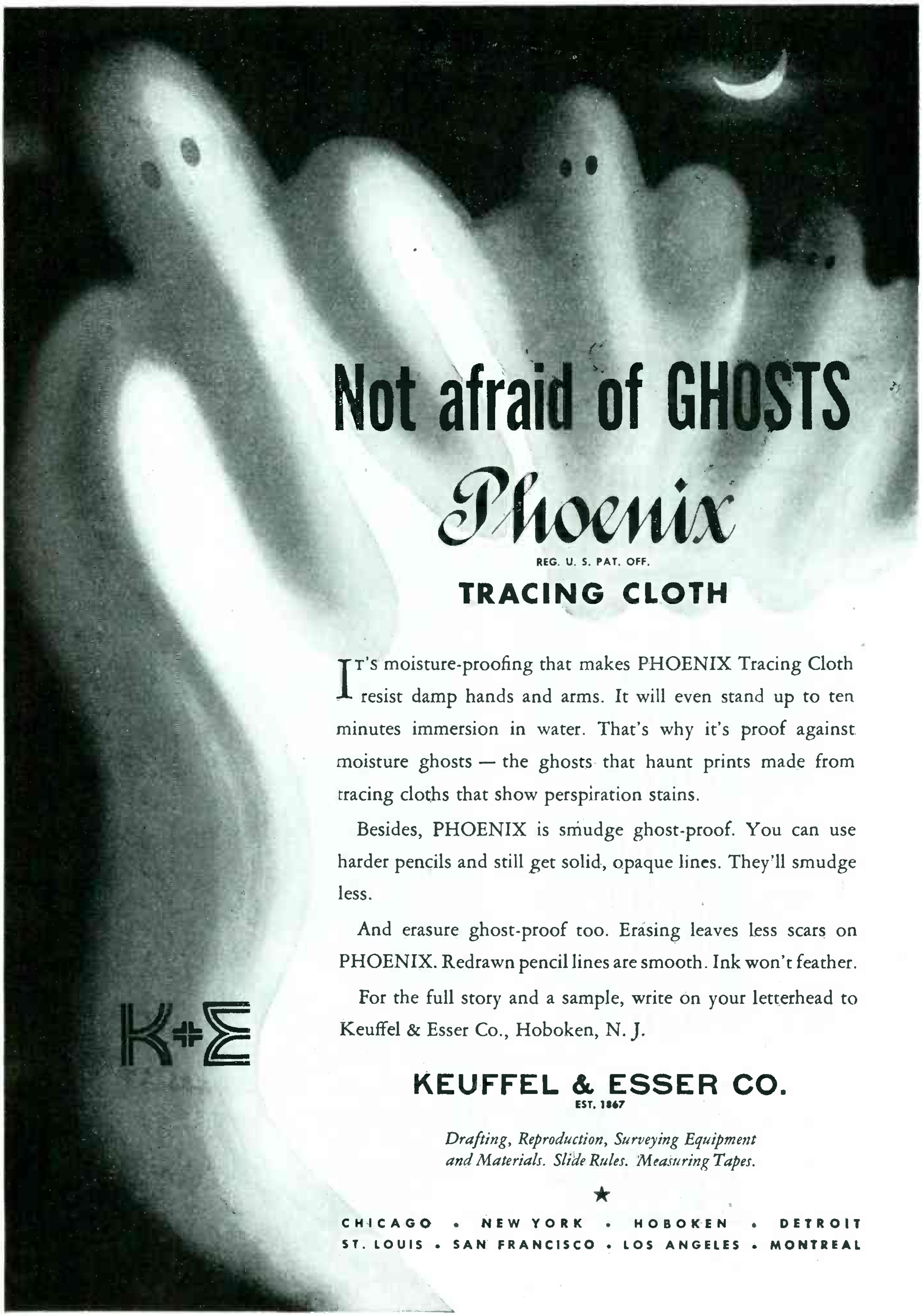
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TRACING CLOTH
IT'S moisture-proofing that makes PHOENIX Tracing Cloth resist damp hands and arms. It will even stand up to ten minutes immersion in water. That's why it's proof against moisture ghosts — the ghosts that haunt prints made from tracing cloths that show perspiration stains.
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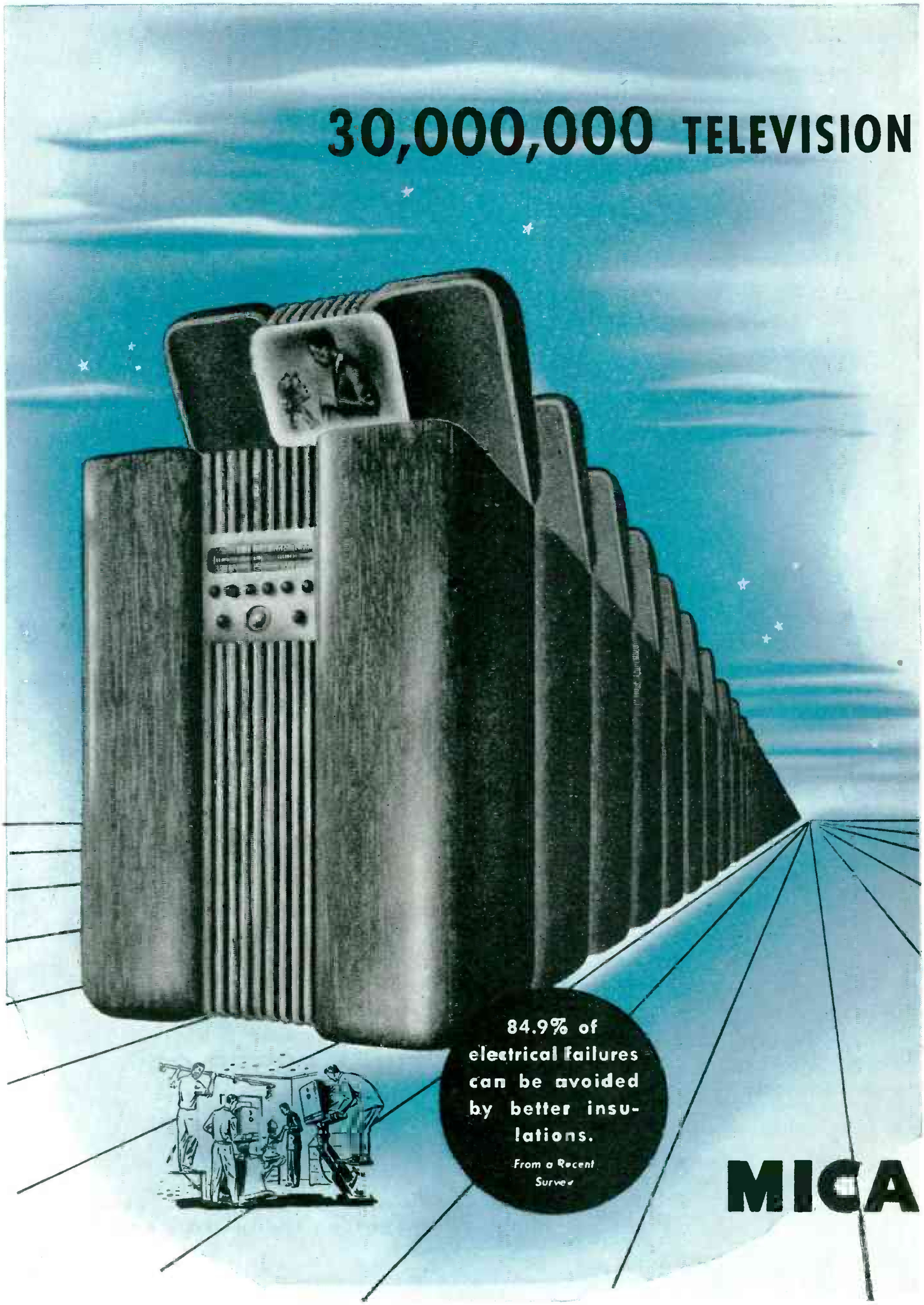

30,000,000 TELEVISION
84.9% of electrical failures can be avoided by better insulations.
From a Recent Survey
MICA

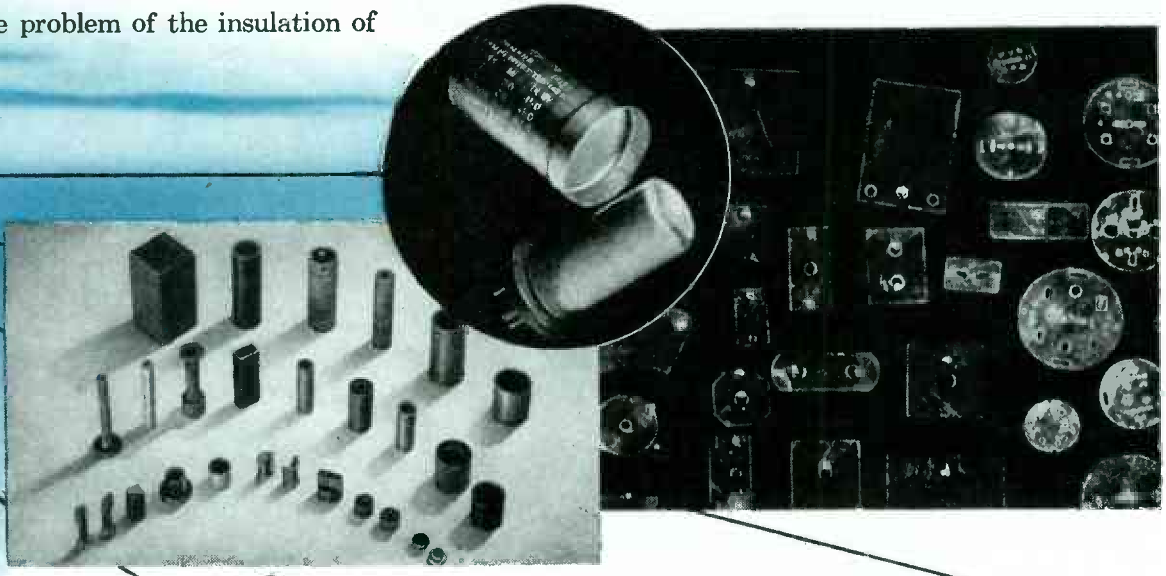
RECEIVERS WHOSE USEFUL LIFE WILL DEPEND ON *Insulation*

From the moment *tomorrow's* television receivers start rolling down assembly lines, twenty years of previous radio manufacturing experience will become history. And there'll be thirty million customers anxious to discard outmoded "sets" to buy the unit that will bring both sight and sound into America's living room.

In this highly competitive market, the manufacturer who builds extra long life as well as high fidelity reception into his receivers will have a keener edge on the sales tools he employs to fashion his market.

To the problem of the insulation of electrical and electronic equipment of all kinds, the Mica Insulator Company brings fifty years of experience in the manufacture and marketing of a wide range of insulating materials. And today offers to manufacturers a single supply source . . . an undivided responsibility in the fabrication of specialized insulating forms.

Engineers of the Mica Insulator Company will be glad to work with your staff to solve any specific design requirement.



MICA Insulator COMPANY

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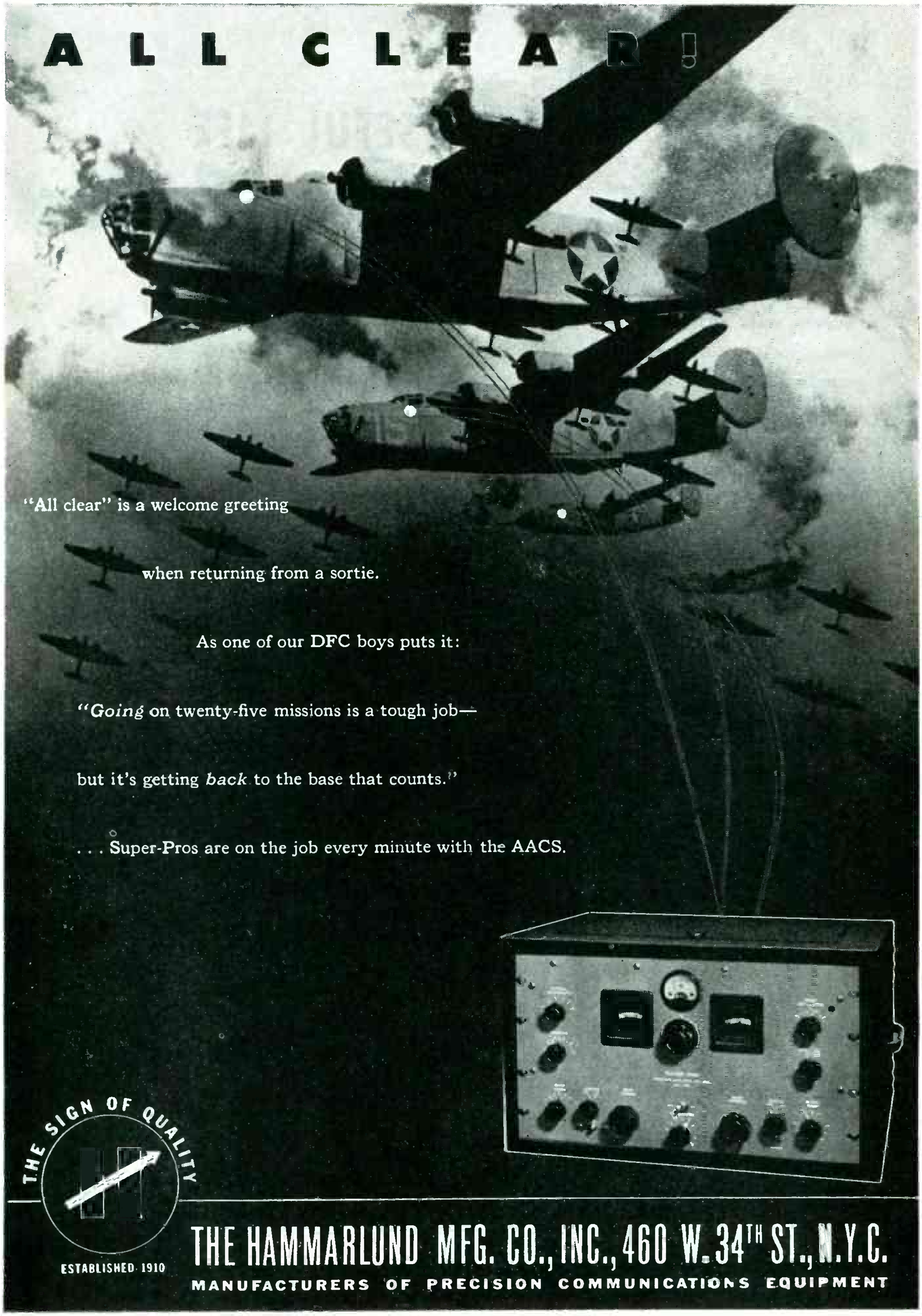
ALL CLEAR!
"All clear" is a welcome greeting
when returning from a sortie.
As one of our DFC boys puts it:
"*Going* on twenty-five missions is a tough job—
but it's getting *back* to the base that counts."
. . . Super-Pros are on the job every minute with the AACS.
THE SIGN OF QUALITY
ESTABLISHED 1910
THE HAMMARLUND MFG. CO., INC., 460 W. 34TH ST., N.Y.C.
MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT

Why

AMPEREX

WATER AND AIR COOLED TRANSMITTING AND RECTIFYING TUBES

In the production of *Amperex* tubes every construction step is carefully watched to insure greater operating efficiency and lower operating costs. Welding, for instance, is done in an inert or reducing atmosphere in specially designed apparatus. This "*Amperextra*" means that there is no oxidation of metal parts. As a consequence, there is much less liberation of gas later on in the life of the tube, and a more consistent *hard* vacuum is maintained.

More than 70% of all electro-medical apparatus in this country is equipped with Amperex tubes. More than 40% of the nation's broadcasting stations also specify our products as standard components. There's an *Amperex* type for *every application in every field* using transmitting and rectifying tubes. Your inquiries, for present or peacetime assignments, receive prompt attention.

NOTE: *Many of our standard tube types are now available through leading radio equipment distributors.*

AMPEREX ELECTRONIC CORPORATION

79 WASHINGTON STREET · · · · · · BROOKLYN 1, N. Y.
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NOW IS THE TIME WHEN YOUR DOLLARS COUNT · PLEASE SUPPORT THE RED CROSS WAR FUND

"Our Business, Like Yours, ...is *Different!*"

A few comments based on the first 50 years of the JAMES G. BIDDLE COMPANY

BUSINESSES, like people, usually have distinct, individual personalities. The smaller the business, the more clearly it will reflect the character of the man who built it.

In 1895, when the electrical industry was in its infancy, James G. Biddle went into business as a manufacturer's agent, selling electrical measuring instruments and scientific apparatus. One of his basic aims in the conduct of the business was to be more than a mere source of supply. He decided to provide a service that was outstanding by reason of its alert, interested, personal character. This aim has never been changed by Mr. Biddle or his associates during the last half century. It will continue to be an important factor in the policies of the James G. Biddle Company in the years to come. We are committed to this.

•

In celebration of our 50th anniversary, we have prepared a brief booklet entitled "Report at Mid-Century." It touches upon interesting points regarding the growth and advancements of the electrical field in general and our business in particular. We would be pleased to send you a copy upon request.

JAMES G. BIDDLE CO. • 1211-13 ARCH STREET • PHILADELPHIA 7, PENNA.

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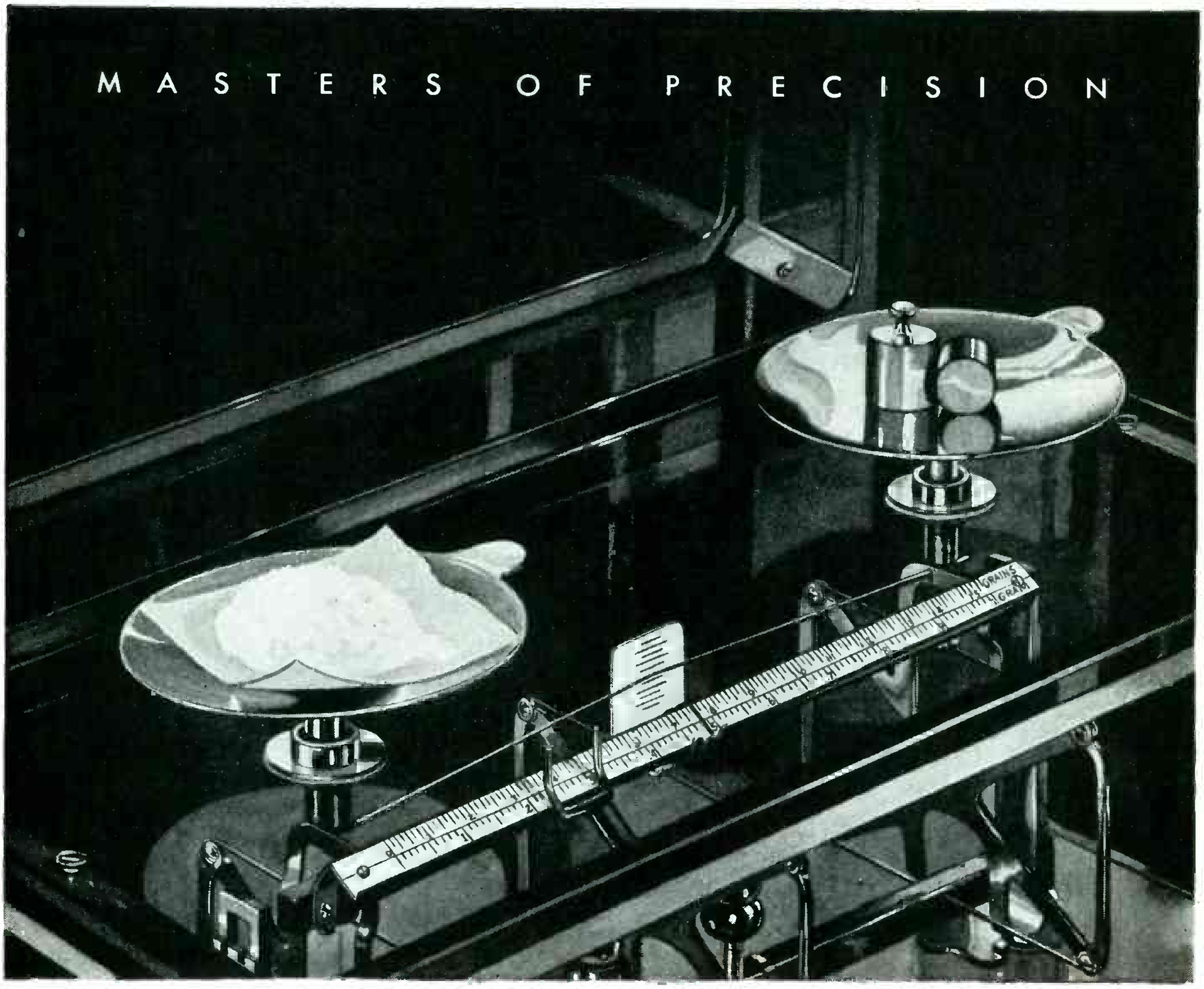
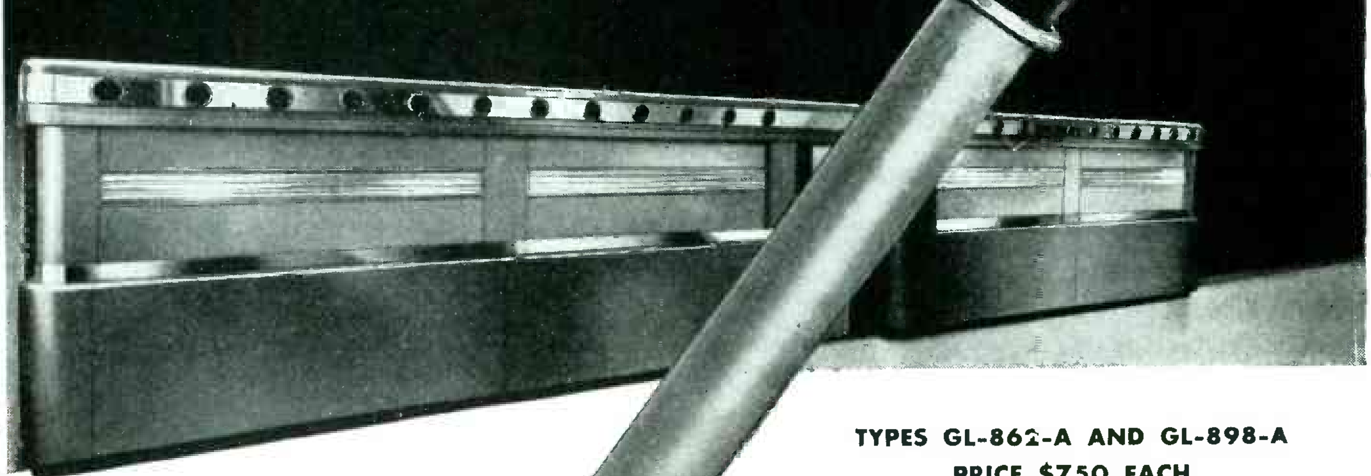

MASTERS OF PRECISION

To build BIG tubes takes BIG experience

G-E "know-how" is your safeguard when buying heavy-duty, high-power amplifiers



The modern 50-kw broadcast station requires powerful tubes like the water-cooled husky at the right. These large triodes represent a substantial investment—must be dependable, fully efficient.

TYPES GL-862-A AND GL-898-A
PRICE $750 EACH

These 3-electrode, water-cooled power tubes, for use as radio-frequency amplifiers, oscillators, or Class B modulators, also are widely employed industrially in high-frequency heating. They will dissipate 50 to 100 kw, depending on the type of service. Filament voltage for both tubes is 33 v; current is 207 amp for 862-A, and 70 amp for each of the three filament sections of 898-A. Maximum plate ratings for both tubes in Class C service are 20,000 v and 10 amp. Frequency at maximum ratings, 1.6 megacycles.

The water-cooled transmitting tube with tungsten filament and copper anode was pioneered by G-E in 1919—one of an impressive group of General Electric electronic "firsts." Since that time the record has been one of continuous development and progress. At one time 500 to 1,000 hours was the average life of a high-power transmitting tube. Today this term is but a fraction of what may be expected in period of service.

Numerous technical improvements have punctuated the years since these large tubes were developed. Some of the most significant apply to the current models GL-862-A and GL-898-A as against their predecessors. One such important advancement is the self-supporting filament and grid structure, which obviates the need of internal insulators, as well as helps do away with the problem of "transients" such as temporary overvoltage. GL-862-A and GL-898-A also are much easier to "break in." Despite improvements of this nature constantly being introduced, new G-E production methods and equipment made possible by large demand have brought about substantial cost savings, by reason of which the price of these tubes recently has been lowered from $1,650 to $750—a drop of more than one-half!

Telephone your nearest G-E office or distributor for information on high-power transmitting tubes or any other type included in the complete G-E line. Prices, ratings, performance charts, and other descriptive data will be furnished you promptly. Or write direct . . . to *Electronics Dept., General Electric, Schenectady 5, N. Y.*

• • •

Hear the G-E radio programs: "The World Today" news, Monday through Friday, 6:45 p. m., EWT, CBS. "The G-E All-Girl Orchestra," Sunday 10 p. m., EWT, NBC. "The G-E House Party," Monday through Friday 4 p. m., EWT, CBS.

GENERAL ELECTRIC

161-D3-8850

FROM SOFT TO LOUD

FM does it

More than double the Dynamic Range

A vast new program naturalness for your listeners

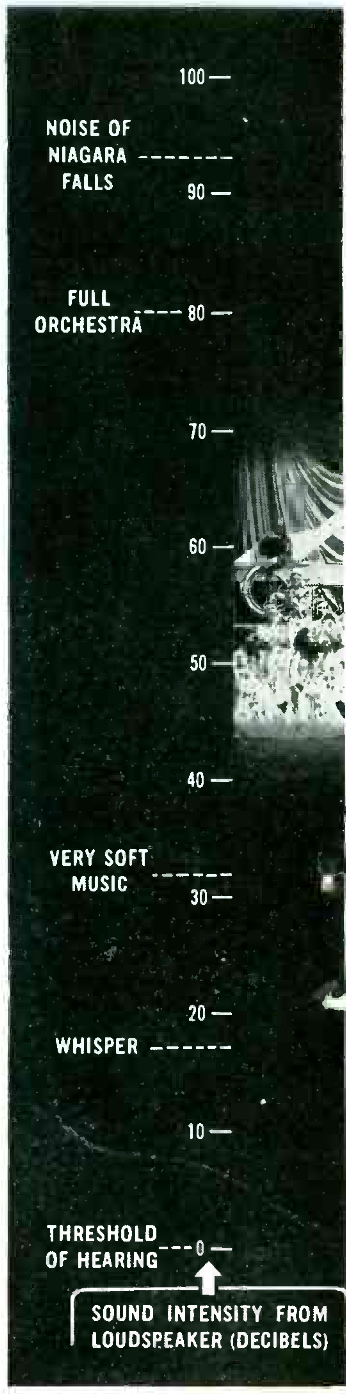
Dynamic Range — the infinite contrasts of sound intensities from soft to loud—give hearing its perspective. Match in true magnitude the sounds of a whisper, the full orchestra, the lion's roar and you have dynamic range that provides reception in all its glorious realism.

FM captures shades of sound that vastly widen dynamic range. It removes the unreality of artificially controlled sound levels that compress the fortissimo—for an FM broadcast transmitter requires no limiting of audio peaks in a program pick-up. It eliminates the unnaturalness of the expanded pianissimo that AM needs to over-ride high background noise levels—for an FM receiver does away with background noise that normally masks AM reception, particularly at low sound levels.

Consider the reasons why an FM broadcast program is able to provide over twice the dynamic range of an AM broadcast program. The intensities of ordinary sounds range from the threshold of hearing at 0 decibels to the crash of thunder at 110 decibels. In this range, AM is capable of reproducing sound intensities from the average minimum noise level of a typical AM receiver at 40 decibels to its maximum audio sound-handling ability at 70 decibels—a dynamic range of 30 decibels. Compare this limited range with that of FM which is capable of reproducing *faithfully* sound intensities from the minimum noise level of a typical FM receiver at about 20 decibels to its maximum audio sound-handling ability at approximately 80 decibels—a dynamic range of 60 decibels! FM's ability to handle a greater range of sound intensities will bring a new dimension to your program reception, increase listener interest, and provide a better service for your advertisers.

When you plan your FM station, look to General Electric. G.E. is the one radio manufacturer with experience in designing and building complete FM broadcast systems—from transmitters to receivers. G.E. has designed and built more FM broadcast transmitters than any other manufacturer. G.E. built the first FM home receivers and has furnished a large percentage of the half million now in use. Today, the six studio-transmitter FM relay links now operating in the 340-megacycle band are all G.E.—with thousands of hours of regular operation to their credit. And at Schenectady, G.E. operates its own FM proving-ground station, WGFM. For information on General Electric FM broadcast equipment, write Electronics Department, General Electric, Schenectady 5, N. Y.

Establish a priority on delivery of your FM equipment. Write for your copy of the "G-E Equipment Reservation Plan" which explains General Electric's plan to help you obtain early delivery of transmitters and associated equipment.

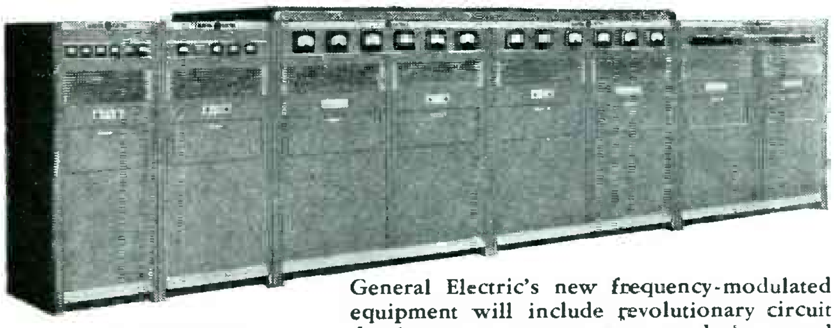


50 FM BROADCAST STATIONS ARE ON THE AIR; OVER 370 APPLICATIONS ARE PENDING.

STUDIO AND STATION EQUIPMENT • TRANSMITTERS

GENERAL ELECTRIC

160-D2-6914



The G-E pre-war 50-kw FM transmitter

General Electric's new frequency-modulated equipment will include revolutionary circuit developments, new component designs, and improved layout features.

FM DOES IT—

• FM gives your audience programs with virtually no man-made noise or static. • FM multiplies your effective coverage day and night. • FM minimizes station interference. • FM gives your programs vivid naturalness with greater dynamic sound range. • FM contributes to the economy of a broadcast system.

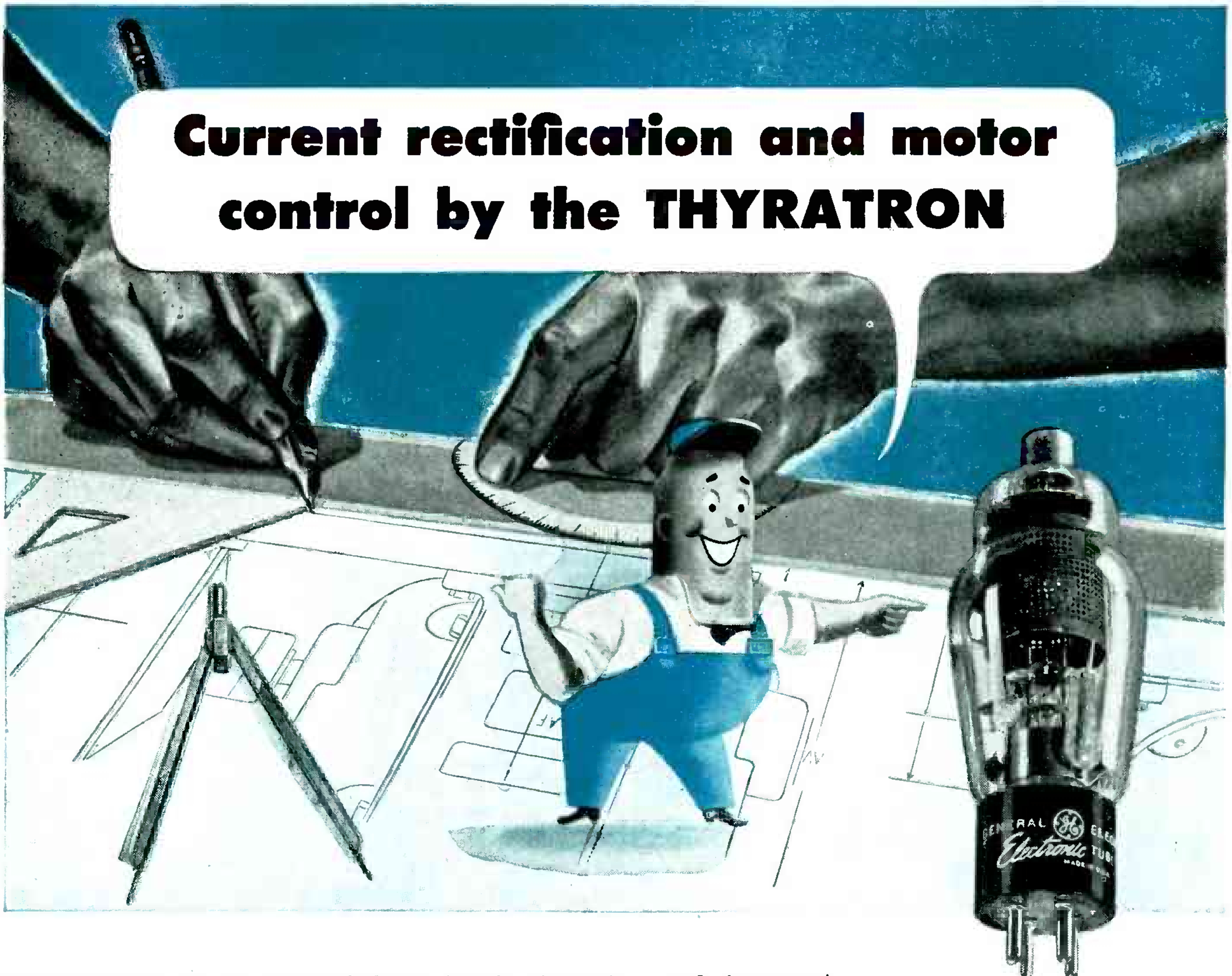
Hear the G-E radio programs: "The World Today" news, Monday through Friday, 6:45 p.m., EWT, CBS. "The G-E All-Girl Orchestra," Sunday 10 p.m., EWT, NBC. "The G-E House Party," Monday through Friday, 4 p. m., EWT, CBS.

ANTENNAS • ELECTRONIC TUBES • HOME RECEIVERS

FM • TELEVISION • AM

See G.E. for all three!

ONE OF A SERIES EXPLAINING HOW ELECTRONIC TUBES CAN BE USED TO IMPROVE EQUIPMENT DESIGN



Two of the chief applications of electronic tubes in equipment design may be named as (1) to rectify electrical current without the use of rotating equipment, (2) to provide automatic regulation of speeds, temperature, etc. In the thyratron —most versatile of tubes—these functions are efficiently combined.

Thyratron equipment is employed to operate small d-c motors from an a-c power source, and at the same time keep these motors running at the proper speed, regardless of varying loads. The thyratron is a gas-filled tube with one or more grids to control power with split-second precision. Pioneered by General Electric, it performs numerous valuable functions in industry with which design engineers may profitably acquaint themselves.

The many advantages of electronic-tube applications of various types justify a thoroughgoing study of such applications *in every case* where a design is on your boards for development. General Electric will be glad to cooperate in this study, by providing engineering advice on which you may safely base final construction plans. For general or specific information about G-E electronic tubes and their industrial applications, consult your nearest G-E office or distributor. Also ask for the illustrated book on "How Electronic Tubes Work." It is filled with facts about the way tubes operate, how they are classified by design and function, and the many difficult tasks you may turn over to them with confidence. *Electronics Department, General Electric, Schenectady 5, N. Y.*

TUNE IN General Electric's "The World Today" and hear the news from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS network. On Sunday evening listen to the G-E "All Girl Orchestra" at 10 E.W.T. over NBC.

THYRATRON GL-3C23
PRICE $9

This widely used thyratron is a rectifier-regulator, 3-electrode tube of medium output—1,250 v (peak inverse) and 1.5 amp (average). The coated-filament cathode is a quick-heating type; only 15 seconds are required. Exemplifying an important industrial use of the thyratron group, type GL-3C23 is especially applicable to motor control circuits. Singly it can be used for motors of ⅓ to ½ hp, and in pairs for larger motors up to 3 hp where 3 amp is required.

The gas mixture of argon and mercury vapor helps to provide constancy over an exceptionally wide temperature range —from −40 to +80 C—which is important where motors must be started in subzero weather or function at high temperature levels. Another feature is uniformity of electrical characteristics. This gives assurance of successful operation to the design engineer who includes the GL-3C23 in his circuits.

G. E. HAS MADE MORE BASIC ELECTRONIC-TUBE DEVELOPMENTS THAN ANY OTHER MANUFACTURER

GENERAL ELECTRIC

162-D2-8850

SNIP IT, SEAL IT, SHIP IT!

in Traco "All-Size" Bags

Tubular Form—1000 Foot Reels

Make quickly in your own plant TITE-SEAL Cellophane Bags of any size that seal out dust, air, water and moisture-vapor. They protect military supplies from damage in transport or storage.

Acceptable for Methods I and IA, type III packaging . . . available in 3, 4, 6 and 8 inch widths under proper priority . . . 1000 feet to the reel. Saves stocking large quantities of special-sized bags. (Stock Bags also available in above widths.)

"All-Size" Containers and custom made bags can be furnished plain or printed in any widths or lengths desired on special orders of sufficient quantity.

Heavy foil-lined laminated bags meet every requirement of Methods I, IA and II Military Packaging. LOXTITE Partitions give crash protection to fuses, rations, and delicate or fragile items.

Reasonably prompt shipment can be made on government orders bearing end use.

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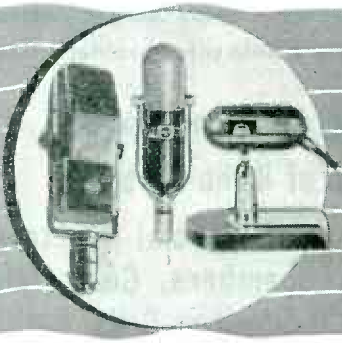
In Equipment for

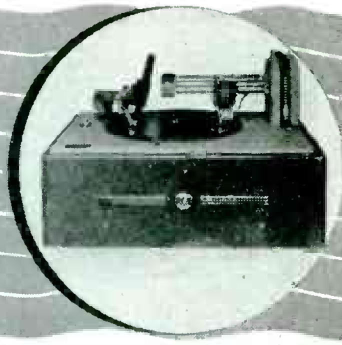
For years, RCA broadcast transmitters and RCA studio equipment have been known as the finest. This reputation for quality, plus the outstanding engineering and design features of these equipments, have made them the undisputed first choice of broadcast stations for the past decade.

During this ten-year period, most of the major advances in transmitter design have appeared first in RCA transmitters—including high-level Class B modulation, air-cooled, high-power tubes, front-of-panel access and many others. Postwar, RCA transmitters will



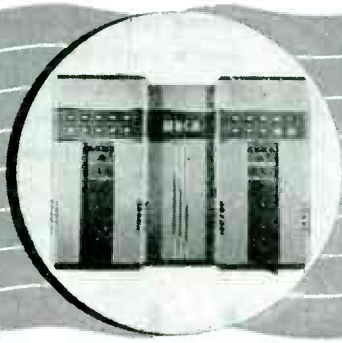
1. *MICROPHONES* — RCA microphones of these three types—the 44-B for high-quality, studio pickups, the 77-C for special, directional pickups and the 88-A for field use—are the symbols of the industry.

2. *TRANSCRIPTION TURNTABLES* — The RCA 70-C Turntable — with combination vertical and lateral pickup head—is the standard to which others are compared, over a thousand in use.

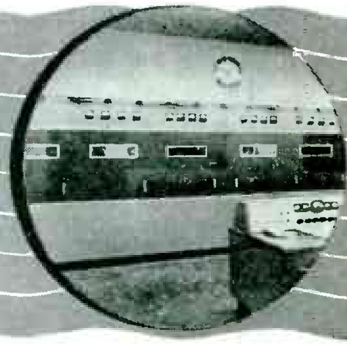


3. *RECORDERS* — The RCA 73-B high-quality recording equipment is the finest broadcast-type recorder produced today. The OR-1A portable recorder and the 72-D recording attachment are also popular.

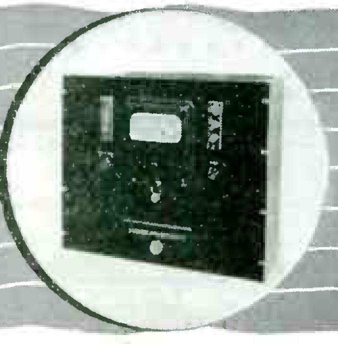
7. *AUDIO AMPLIFIERS* — The individual units of deluxe, RCA, audio equipments are also available separately. There are special units for use as pre-amplifiers, line amplifiers, monitoring amplifiers, etc. Also racks, shelves, etc.



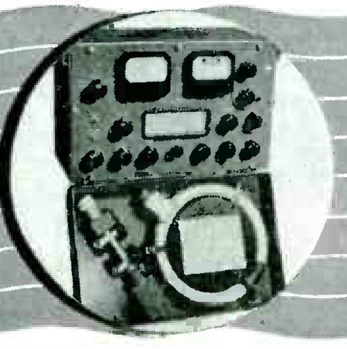
8. *LOW POWER TRANSMITTERS* — Modern-styled, RCA transmitters of proven performance and reliability are available in all powers. The unit above is the 1 KW (the left-hand section alone is a complete 250 watt transmitter).



9. *5/10 KW TRANSMITTER* — RCA engineers developed the first air-cooled 5 KW transmitter a number of years ago and have been constantly improving on it ever since. The 5E/10E, latest model in this series is shown here at WMCA.



13. *MONITORING EQUIPMENT* — RCA modulation monitors, frequency monitors and phase monitors are standard units, designed specifically for broadcast use and built to match other RCA broadcast units.



14. *FIELD INTENSITY METER* — The RCA, 308-A Broadcast Field Intensity Meter, designed for field or mobile use, is the standard measuring instrument used by most consultants and station engineers.

15. *MEASURING EQUIPMENT* — The RCA, 68-B Audio Oscillator and the RCA, 69-C Distortion Meter are universally used for determining the frequency response and distortion characteristics of broadcast installations.

AM Broadcast Stations

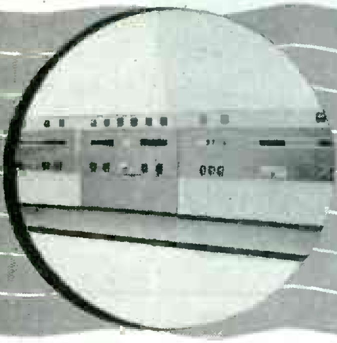
embody new features developed from the unequalled experience of RCA engineers in building *the most advanced types* of electronic equipment for the military services.

Moreover, it is worthy of note that only RCA actually builds all of the equipment items—microphones, turntables, amplifiers, transmitters, antennas, etc.—which are required in a modern broadcast station. These equipments are *designed to work together* and thus provide maximum convenience, efficiency and performance. Most important, they are *proven* units which RCA has built in the past and is building today.

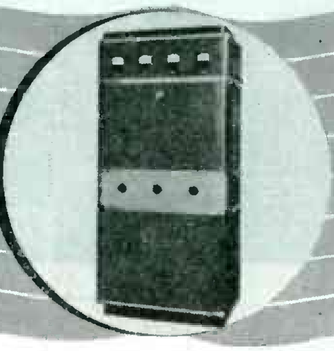
4. *PORTABLE EQUIPMENT* — This is the RCA OP-6 portable pickup equipment. A companion unit, the OP-7, provides a four-position, high-level mixing system also suitable for outside use.

5. *STUDIO CONSOLETTE* — The RCA 76-B2 Studio Consolette is a complete speech-input equipment for small and medium-sized stations. Provides the advantages of RCA quality in a "package" unit.

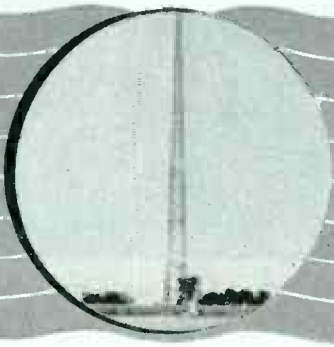
6. *DELUXE STUDIO CONSOLES*—Custom-built RCA consoles and rack assemblies — such as this one at WFBR—represent the very finest in broadcast studio equipments. In use in many network studios.



10. *50 KW TRANSMITTER* — The RCA, 50-E Transmitter, shown here, is also air-cooled. It uses the high-level, high-efficiency, Class B modulation circuit first introduced to broadcasting in RCA transmitters.



11. *ANTENNA PHASING EQUIPMENT* — RCA custom-built antenna coupling and phasing units (for both directional and nondirectional systems) are another industry standard. Built in several sizes and cabinet models.



12. *ANTENNAS* — After the war, RCA will offer AM antenna towers in several designs, thereby bringing to broadcast stations the full advantages of overall, RCA engineering and responsibility.

16. *MONITORING ASSEMBLIES* — RCA, custom-built assemblies of audio and monitoring units for the transmitter station represent the most advanced and finest type of equipment for the purpose.

RCA

RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION · CAMDEN, N. J.

In Canada, RCA VICTOR COMPANY LIMITED, Montreal

How many places can you use this *VERSATILE CERAMIC?*

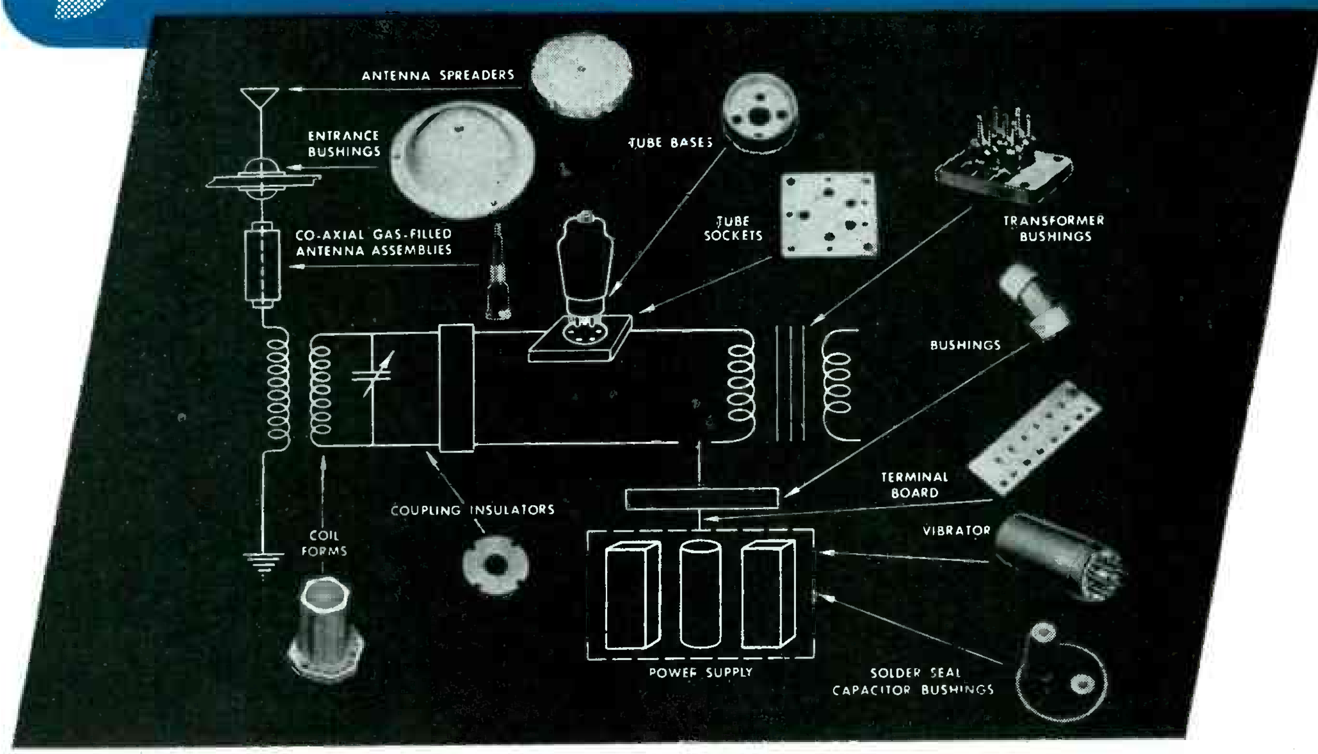


Illustration from Westinghouse book B-3244

NEW HIGH-STRENGTH ZIRCON PRESTITE IMPROVES INSULATION ON EVERY TYPE OF COMMUNICATIONS PRODUCT

This new, strong Zircon Prestite created by Westinghouse brings many advantages to designers and manufacturers of every type and size of communications equipment.

Zircon Prestite is a low-loss ceramic with exceptionally high resistance to thermal and mechanical shock (see table). Combined with the exclusive Westinghouse Solder-Seal process, it provides a gas-tight hermetic seal that excludes dirt, moisture and corrosive atmospheres permanently and maintains dielectric characteristics of enclosed gases regardless of temperature, humidity and pressure cycles.

Your nearest Westinghouse office can give you complete information on the many uses of this versatile Zircon Prestite for modern communications and electronics equipment. Or write Westinghouse Electric & Mfg. Co., P.O. Box 868, Pittsburgh 30, Pa. J-94660

How ZIRCON PRESTITE compares

Property	*Zircon Prestite	High-Tension Porcelain
Specific Gravity	3.68	2.4
Water Absorption in %	0.00	0.00
Dye Penetration	None	None
**Linear Coeff. of Thermal Expansion (20 to 700 deg C) per deg C	4.9 x 10-6	5.3 x 10-6
Tensile Strength, lbs per sq in	12,700	5,000
Compressive Strength, lbs per sq in	90,000	48,000
Transverse Strength, lbs per sq in	25,000	11,000
Impact Resistance (modified Charpy method) in gm per sq cm	17,800	6,000

*Approved as L-4 material by the Army-Navy Electronics Standards Agency.
**This is one of the characteristics that gives Zircon Prestite its remarkable thermal shock properties and warrants comparison with other low-loss, high-frequency ceramic materials.

Westinghouse

. . . one of many Westinghouse contributions to improve electronic and communication design

Zircon Prestite is just one of many Westinghouse developments to improve modern electronic and communications design.

Weight reduction, high altitude and humidity resistance, greater strength and sensitive measurement are typical of the problems solved by these new Westinghouse developments.

Here is a quick check list of these important products . . . what they are, where to use them, what they will do. Like Zircon Prestite, each possesses characteristics giving designers greater freedom in design.

Your nearest Westinghouse office can give complete data on any of these exceptional communications products. Ask for the book number shown in parentheses on each item.

A QUICK CHECK LIST OF WESTINGHOUSE COMMUNICATIONS PRODUCTS

Hipersil . . .

Hipersil cores—made of new electrical steel with 1/3 greater flux-carrying capacity—eliminate time-wasting stacking of tissue-thin core laminations by hand. Available in 3 types for low to very high frequencies, pre-assembled Hipersil cores are delivered in two ready-to-assemble pieces for each core. (B-3223-A)

Dynamotors . . .

Smooth, functional design gives Westinghouse dynamotors high flexibility for radio equipment where space is precious. Lightweight and compact, these long-lived dynamotors are supplied for input ratings from 12 to 28 volts. (B-3242)

Capacitors . . .

Light weight, small volume and high reliability are advantages of Westinghouse Inerteen Capacitors for d-c service at 400 to 250,000 volts. Aluminum foil electrodes, noninflammable Inerteen and Westinghouse Solder-Sealing give these capacitors outstanding performance values. (B-3300)

Insulating Materials . . .

Westinghouse "Tuffernell" Insulating Materials will supply the *right* grade needed for numberless communications jobs. Backed by more than 50 years of field tests, these materials are adequately tested and proved for every application. (B-3322)

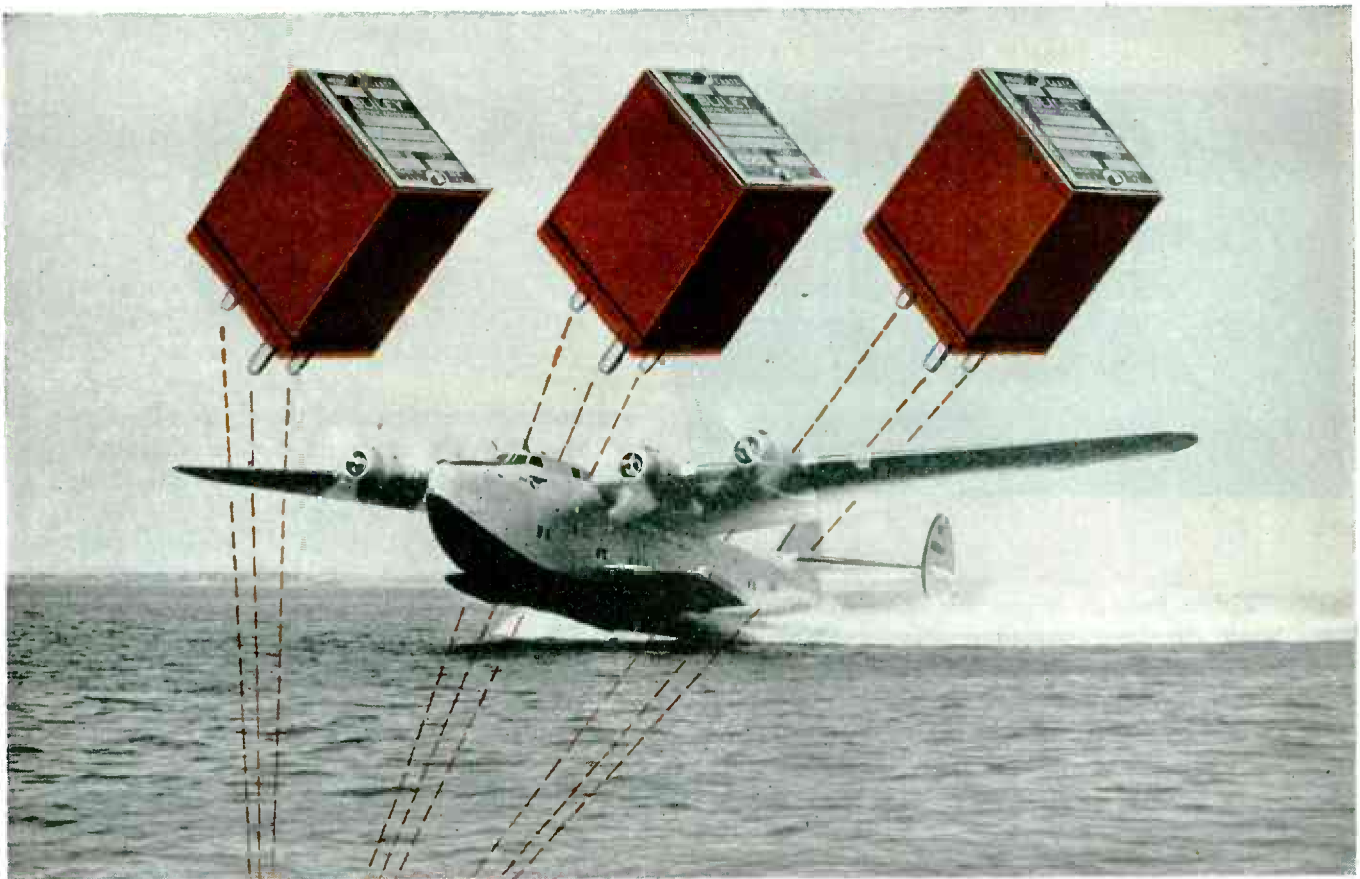
Electronic Tubes . . .

Uniform, trouble-free, long-life service of electronics equipment depends to a high degree on the tube itself. Westinghouse electronic tubes are made with complete quality control in every stage of production for the complete Westinghouse line . . . Pliotrons, Kenotrons, Phototubes, Thyratrons and Ignitrons.

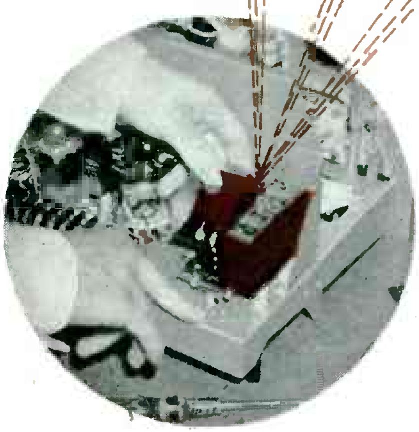
Instruments . . .

Westinghouse instruments range in sizes and types from miniature panel instruments to 4-foot boiler room indicators for all types of mountings—round, wide-flange; round, narrow-flange; rectangular; and American War Standard. (B-3283)

EQUIPMENT FOR THE COMMUNICATIONS INDUSTRY



BLILEY CRYSTALS, of course, fly with Pan American



Bliley *acid etched** crystals persistently show up wherever there is an important communications job to be done such as the combination two-way telephone and telegraph and range finder systems of Pan American World Airways. In peace and in war Bliley crystals have flown millions of world-wide miles with their famous Clippers.

Bliley crystals are pre-conditioned for just such rugged assignments. In the Bliley Electric Company plant there is a large section where Bliley *acid etched** crystals receive their pedigree. Here each crystal gets "the works". Its activity and frequency are *proved* under tough laboratory created service conditions of altitude, humidity, temperature, immersion, shock and vibration.

But licking tough assignments is a tradition with Bliley engineers and craftsmen. This background of research and skill has been responsible for the distinguished record of Bliley Crystals in every field of radio communication. Whatever your crystal problem may be—specify Bliley.

A new star has been added

ARMY NAVY

**Acid etching quartz crystals to frequency is a patented Bliley process. United States Patent No. 2,364,501*

Bliley CRYSTALS

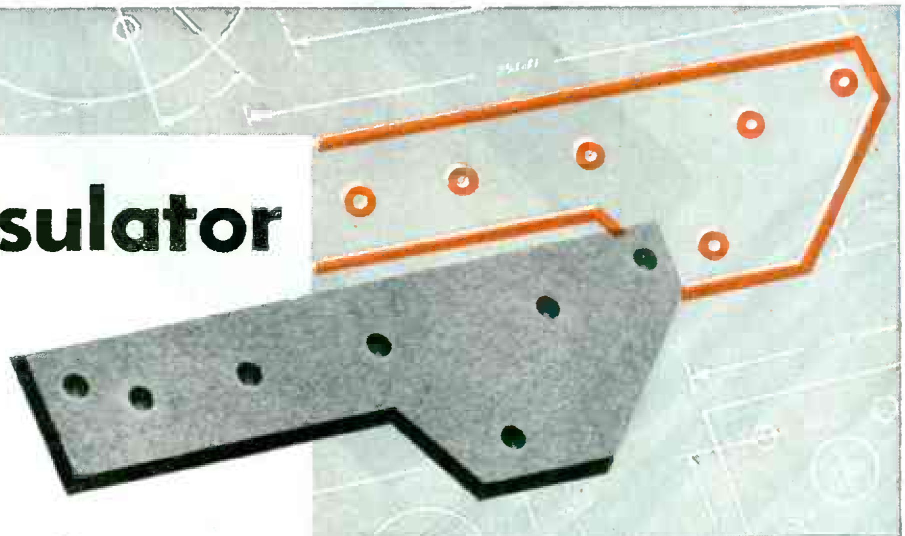
Do more than before . . .
buy extra War Bonds

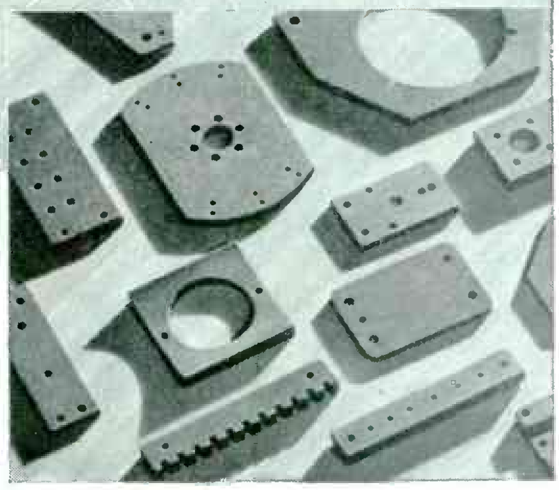
BLILEY ELECTRIC COMPANY · UNION STATION BUILDING · ERIE · PENNSYLVANIA

When insulator design calls for *Quick Action*

DEPEND ON MYKROY

PERFECTED MICA CERAMIC INSULATION





When time is of the utmost importance the ease and precision with which Mykroy can be fabricated into insulator parts makes it exceptionally useful to electronic and electrical engineers. Make those design changes on the spot . . . make them *quickly* and *economically* with Mykroy, for, here is a ceramic which can be worked in your own shop. Just transfer your design to the Mykroy sheet . . . then using conventional shop tools . . . produce the desired part by simple cutting, grinding, drilling, tapping and polishing techniques.

Because it has high structural strength and physical stability Mykroy can be machined to critical tolerances more readily than other types of ceramics. In addition, its electrical characteristics are of the highest order and do not shift under any conditions short of actual destruction of the insulation itself. This, plus excellent chemical and physical properties, makes it one of the best insulating materials ever developed for general and high frequency applications.

Get the full facts about this versatile dielectric now. Ask for a copy of the new MYKROY BULLETIN 102 which describes the new larger (19¼" x 29¾") sheet now available and call upon our engineers to help with your problems.

A representative group of parts fabricated in Mykroy to customer's specifications in our own plant. We have complete facilities to produce such parts in any quantities on rapid delivery schedules. Send us your specifications.

MECHANICAL PROPERTIES*

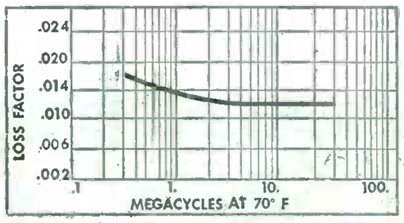
MODULUS OF RUPTURE.................18000-21000psi
HARDNESS
Mohs Scale 3-4 BHN. BHN 500 K9 Load. 63-74
IMPACT STRENGTH.........ASTM Charpy .34-.41 ft. lbs.
COMPRESSION STRENGTH.......................42000 psi
SPECIFIC GRAVITY......................................2.75-3.8
THERMAL EXPANSION..........000006 per Degree Fahr.
APPEARANCE.................Brownish Grey to Light Tan

ELECTRICAL PROPERTIES*

DIELECTRIC CONSTANT..6.5-7
DIELECTRIC STRENGTH (⅛").........630 Volts per Mil
POWER FACTOR.............001-.002 (Meets AWS L-4)

***THESE VALUES COVER THE VARIOUS GRADES OF MYKROY**

GRADE 8. Best for low loss requirements.
GRADE 38. Best for low loss combined with high mechanical strength.
GRADE 51. Best for molding applications.
Special formulas compounded for special requirements.



Based on Power Factor Measurements made by Boonton Radio Corp. on standard Mykroy stock.

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CHICAGO 47: 1917 N. Springfield Ave., Tel. Albany 4310
EXPORT OFFICE: 89 Broad Street, New York 4, New York

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- ALTERNATES FOR VARNISHED SILK
- VARNISHED PAPERS
- SLOT INSULATIONS
- INSULATING PUNCHINGS
- VARNISHED TUBINGS AND SATURATED SLEEVINGS
- EXTRUDED PLASTIC TUBINGS
- WIRE MARKERS
- FIBRON PLASTIC TAPES
- INSULATING VARNISHES

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TYPE
P4N
FEATURES
1. Bakelite Resinoid Ends. Lead wire cannot pull out, even under hot conditions.
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3. Excellent Temperature Coefficient.
4. Very high leakage Resistance.
5. Fine Power-Factor.
6. Range from 20 MMFD to .25 MFD. From 150 volts to 600 volts.
7. Types P4N, P5N for 100% humidity operation.
8. Types P4, P5 for 95% humidity operation.
Samples and price list on Request
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Accuracy plus Speed in Cathode-Ray Tube Production Tests

Cathode-Ray Tube Characteristic Test Set

Sherron Model C-2

. . . for Magnetic Or Electro-Static Deflection Type Tubes

- Designed to check 3", 5", 7" magnetic type focus and deflection Cathode-Ray Tubes.
- Can be modified to check 2", 3", 5", 7" electro-static type deflection Cathode-Ray Tubes.
- Designed to cover all phases of safety.
- Readings of voltages and currents on meters located on front panel accelerate production tests.
- This unit can be equipped with automatic ejector to remove tube at completion of test.

This Sherron Model C-2 has been conceived to inspect Cathode-Ray tubes for the following:

- ELECTRICAL SHORTS BETWEEN ELEMENTS
- PRE-HEATING FOR INSPECTION OF TUBE
- HEATER CURRENT
- ANODE CURRENT
- GAS
- VOLTAGE BREAKDOWNS
- GRID CUT-OFF
- LEAKAGE: GRID #1, GRID #2
- SCREEN QUALITY
- LIGHT OUTPUT OF SCREEN
- FOCUSING CURRENT (AMPERE TURNS)
- SPOT POSITION AND DISPLACEMENT
- BEAM CURRENT
- LINE WIDTHS

The performance of the Cathode-Ray Tube in the wartime scheme of things presages an extraordinary range of applications in the peacetime future. We foresee quality control as a factor of ever-increasing significance. With an eye to tube manufacturers' high quality standards, we are projecting our model C-2 to anticipate their requirements. This Sherron unit will be available on a custom-built basis. It will be manufactured to the individual manufacturer's specifications. It can be manufactured to check the persistency of the different type screens used in Cathode-Ray Tubes, classified or unclassified.

Sherron Electronics

SHERRON ELECTRONICS COMPANY

Division of Sherron Metallic Corporation

1201 FLUSHING AVENUE, BROOKLYN 6, N. Y.

"Where the Ideal is the Standard, Sherron Units are Standard Equipment"

What are the uses of Carbonyl Iron Powders?

The examples illustrated may suggest more specific applications of G.A.F. Carbonyl Iron Powders to many electrical design engineers. Other members of the profession, however, may desire a more detailed description of these powders. This is given below.

G.A.F. Carbonyl Iron Powders are obtained by thermal decomposition of iron penta-carbonyl. There are five different grades in production, which are designated as "L," "C," "E," "TH," and "SF" Powder. Each of these five types of iron powder is obtained by special process methods and has its special field of application.

The particles making up the powders "E," "TH," and "SF," are spherical with a characteristic structure of concentric shells. The particles of "L" and "C" are made up of homogenous spheres and agglomerates.

The chemical analysis, the weight-average particle size, the "tap density" (i.e. the density of the powder after a container is filled with loose powder has been tapped in a prescribed manner), and the apparent density or bulking factor as determined in a Scott Volumeter are given in the following table for the five different grades:

TABLE I

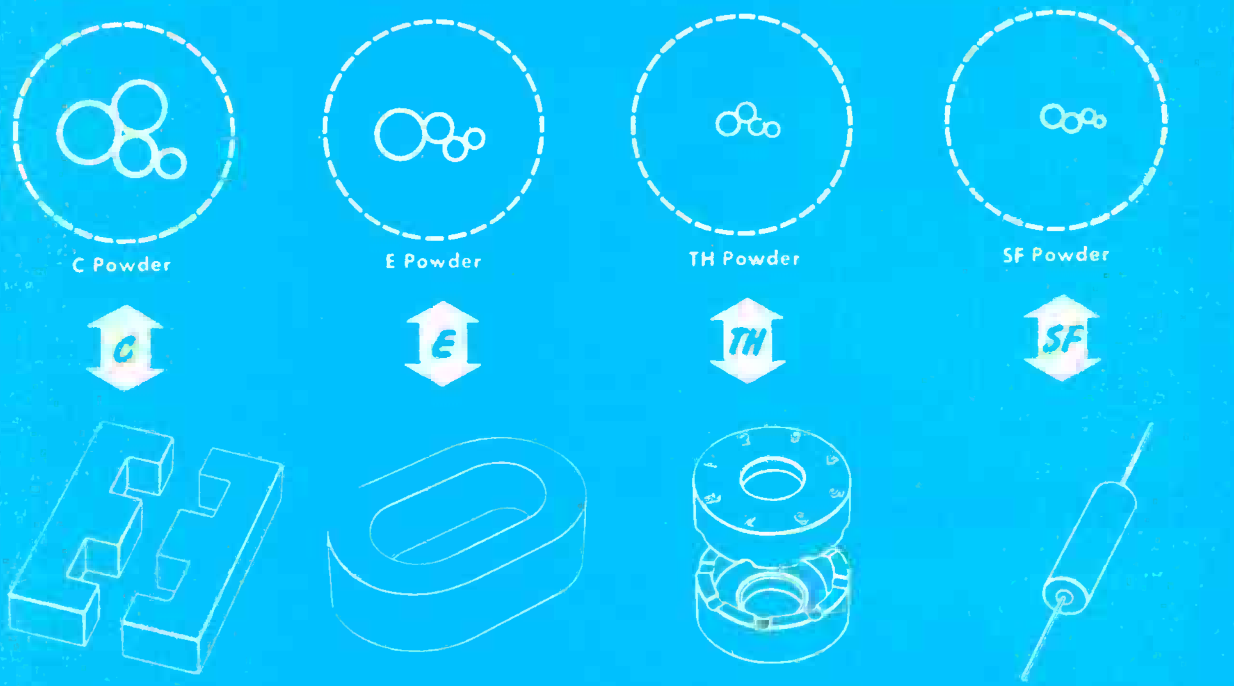
Grade	Chemical Analysis % Carbon	% Oxygen	% Nitrogen	Wt. Ave. diameter microns	Tap Density g/cm3	Apparent Density g/cm3
L	0.005—0.03	0.1 —0.2	0.005—0.05	20	3.5—4.0	1.8—3.0
C	0.03 —0.12	0.1 —0.3	0.01 —0.1	10	4.4—4.7	2.5—3.0
E	0.65 —0.80	0.45—0.60	0.6 —0.7	5	4.4—4.7	2.5—3.5
TH	0.5 —0.6	0.5 —0.7	0.5 —0.6	5	4.4—4.7	2.5—3.5
SF	0.5 —0.6	0.7 —0.8	0.5 —0.6	3	4.7—4.8	2.5—3.5

Spectroscopic analysis shows that other elements, if any, are present in traces only.

Carbonyl Iron Powders are primarily useful as electromagnetic material over the entire communication frequency spectrum.

CARBONYL IRON POWDERS AND SOME OF THEIR PRESENT USES

The different grades of CARBONYL IRON POWDERS as seen in the microscope



"C" Type Powder for E-cores in filter coils.

For antenna coils, "E" Type Powder used in cores

"TH" Type Powder is employed for cup shields in coils

One use of "SF" Type Powder is in high frequency choke cores (with sealed-in leads).

Table 2 below gives relative Q values (quality factors) and effective permeabilities for the different grades of carbonyl iron powder. The values given in the table are derived from measurements on straight cylindrical cores placed in simple solenoidal coils. Although the data were not obtained at optimum conditions, the Q values as expressed in percentage of the best core give an indication of the useful frequency ranges for the different powder grades.

"L" and "C" powders are also used as powder metallurgical material because of their low sintering temperatures, high tensile strengths, and other very desirable qualities. (Sintering begins below 500° C and tensile strengths reach 150,000 psi.)

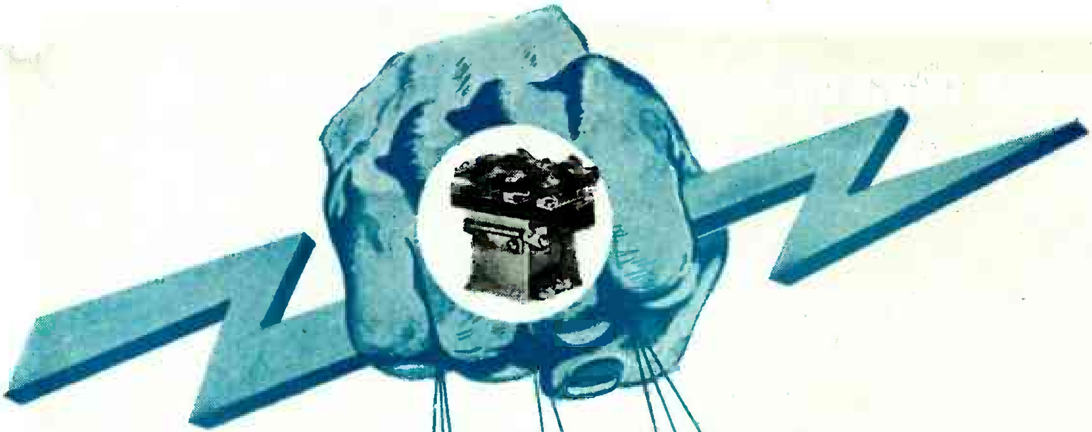
TABLE 2

Carbonyl Iron Grade	Effective Permeability at 1 kc	Relative Quality Factor at 10 kc	150 kc	200 kc	1 Mc	100 Mc
L	4.16	100	96	90	43	1
C	3.65	94	100	96	72	3
E	3.09	81	94	100	97	30
TH	2.97	81	93	98	100	54
SF	2.17	62	71	78	84	100

(Note: The actually measured Q values can be obtained by multiplying the rows respectively with: 0.78, 1.09, 1.25, 2.63, and 1.62.)

Further information can be obtained from the Special Products Sales Dept., General Aniline & Film Corporation 435 Hudson Street, New York 14, N. Y.

G.A.F. CARBONYL IRON POWDERS



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Allied relays are designed to assure troublefree service under the most adverse conditions resulting from terrific temperature changes, altitude and excessive vibration. Whether the requirements are for power application or extreme sensitivity where the relay must operate under almost negligible power, Allied design meets the severest tests.

Allied has been foremost in engineering and design of relays for special applications. If your product requires electrical control we recommend that you specify . . . Allied.

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A group of Hytron engineers decided in 1938 that to get those ideal tubes for "ham" radio — they must build them themselves. Combining years of experience in tube manufacture with exact knowledge of the tube characteristics desired, they went to work.

First they concentrated their efforts. Low and medium power types were most needed by the majority of hams. Hytron was equipped to make them. Gradually the engineers translated ideals into a comprehensive line—v-h-f triodes and pentodes, low and medium mu triodes, instant-heating r.f. beam tetrodes, and sub-miniatures.

Hams themselves, the engineers knew their brain children would be given the works. They built the tubes rugged; rated them conservatively. And did the amateur go for them! The v-h-f types — HY75, HY114B, HY615 — soon became accepted standards. Today's WERS operators use them almost exclusively.

Performance in the proving ground of amateur radio was the proof of the pudding. You will find Hytron transmitting and special purpose tubes in war and civilian jobs of all kinds. Like the BANTAM GT and BANTAM JR., they are popular because they are built right for the job.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

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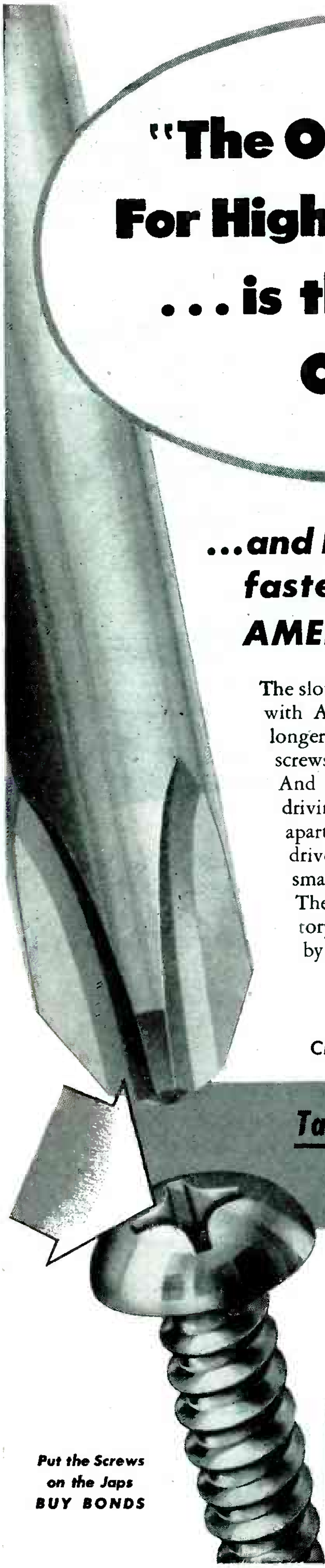
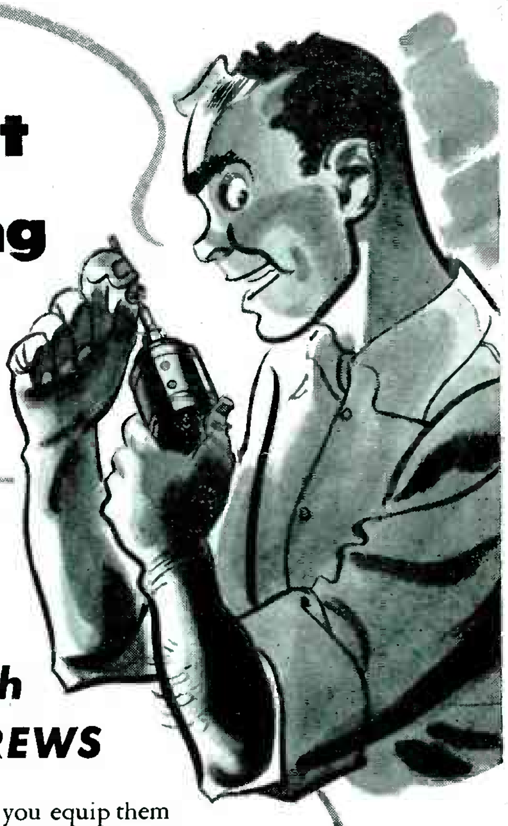


"The Only Ticket I Get For High-Speed Driving . . . is the Inspector's OK Tag!"



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The slowest workers become highly efficient when you equip them with American Phillips Screws and power drivers. They're no longer slowed down by frequent fumbling and dropping, by crooked driving, or by screws with broken heads that must be backed out and replaced.

And the driving process itself is far faster, with American Phillips Screws. For the driving bit and screw align themselves into one straight driving unit . . . can't twist apart . . . don't have to be held in line by main strength. This permits the use of power drivers, multiplies man power, and gives maximum return on screw-driving costs, to small users as well as large.

The American brand of Phillips Recessed Head Screws is made under rigid laboratory check, and a unique system of piece inspection. Delivery service is maintained by high-speed production. And engineering service is at *your* service on any problem.

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WILCO NOW EQUIPPED

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WILCO wire, tubing and other products are used in various electronic applications for the Army and Navy. In response to the wartime demand for these various products, the H. A. Wilson Company has enlarged its plant, increased its manufacturing facilities, added essential new equipment and developed new products and techniques. Both present and future customers will find these new WILCO developments of great advantage.

The H. A. Wilson Company manufactures and is interested in receiving inquiries regarding the following typical products—

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Silver Jacketed Invar
Silver Jacketed Brass
Silver Jacketed Steel
Gold Jacketed Silver (Fine, Sterling, Coin)
Gold Jacketed Brass or Bronze
Copper Jacketed Monel
Nickel Jacketed Copper

WILCO JACKETED TUBING

Silver Tubing (Fine, Sterling or Coin)
Gold Tubing (any Color or Karat)
Silver Jacketed Brass or Bronze (one or both sides)
Gold Jacketed Silver (one or both sides)
Gold Jacketed Brass or Bronze (one or both sides)

WILCO STRIP MATERIAL

Silver (Fine, Sterling or Coin) on Brass or Bronze (Inlay or Overlay)
Gold on Silver (any Karat on Fine, Sterling or Coin)
Gold on Brass or Bronze

Other WILCO products include Electrical *Contacts*—

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Let us analyze your problems.

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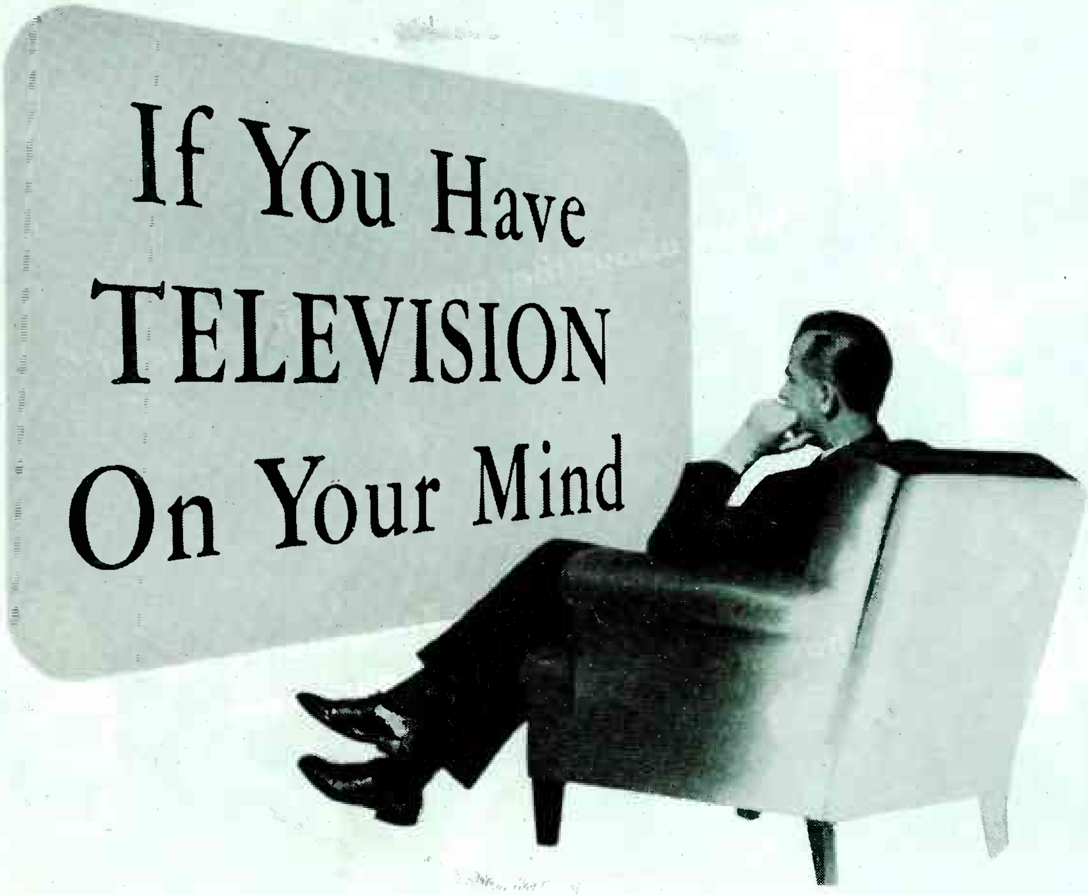

MANY enterprising individuals will make fortunes in the operation of television stations—and have a barrel of fun doing it. Right now, some of these people are asking if there's enough cost data available to discuss economics and television potentials in the same breath.

We think we have most of the answers—gained through DuMont's: 1—design and construction of 3 of the nation's 9 television stations (more than any other company); 2—experimental operation of our own pioneer television station, WABD New York, for more than 4 years, and 3—development of commercial programming techniques in collaboration with leading advertisers and advertising agencies. DuMont's television economics are strongly weighted by the low operating cost, extreme flexibility and rugged dependability of DuMont station equipment.

It is important that prospective station operators arrange *now* for early postwar delivery of station equipment... and anticipate needs in trained operating personnel. Both are assured through the DuMont Equipment Reservation Plan. Our aid, too, will be given gladly in preparing applications to the Federal Communications Commission. Call, write or telegraph today.

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30,000,000 LINES PER SQ. CM.

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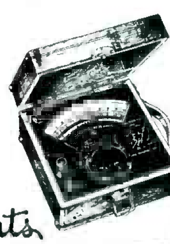

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Weight 2 Lbs. 4 Ozs.

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Surface Mounted 500 to V.A.

The transformer illustrated to the left is designed for an input of 115 volts and an output of 0 to 130 Volts—3.85 amperes maximum. Frequency range 350 to 2400 cycles.

It is furnished with an A.N. connector to fit automatic circuit disconnect plug. Overall size, 6" x 4⅞" x 2⅜". Total weight two pounds four ounces.

Full specifications will be sent on request.

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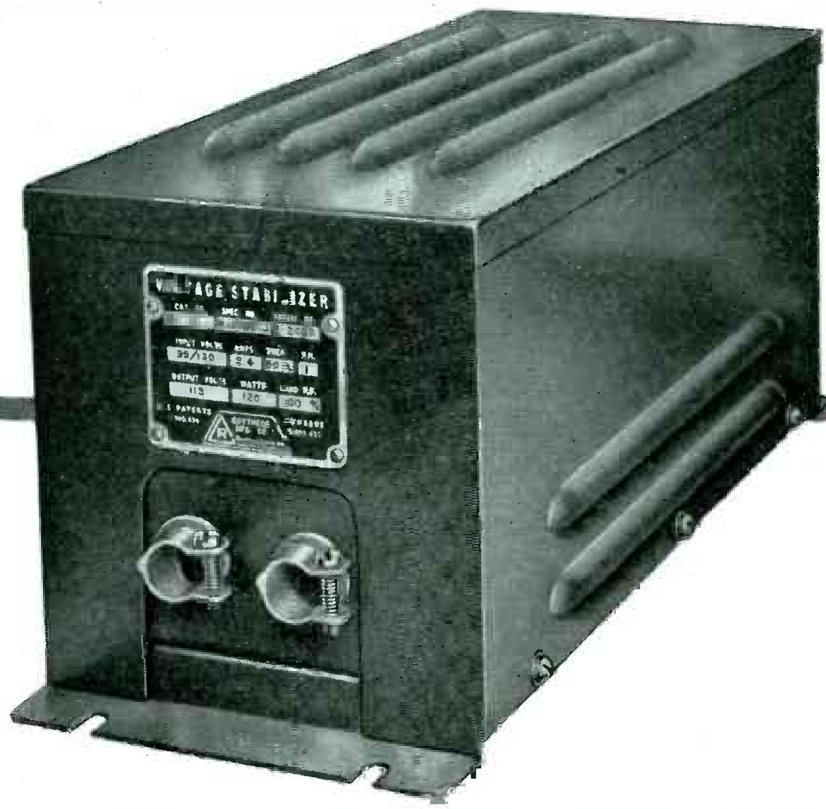
RAYTHEON VOLTAGE STABILIZERS



CONTROL VARYING LINE VOLTAGES

TO 115 VOLTS ± ½%

Ordinary A.C. line voltages as taken from supply mains often vary as much as from 95 to 130 volts. This impairs the precision operation of electrical equipment.

A Raytheon Voltage Stabilizer, built into new products or incorporated into equipment already in use, overcomes the disadvantage of fluctuating voltages by providing an accurately controlled source of power to ±½%.

Here's what a Raytheon Stabilizer does—stabilizes varying input voltage from 95 to 130 volts to 115 volts ±½% within 2 cycles.

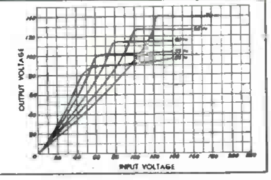
Raytheon Voltage Stabilizers are entirely automatic. They require no adjustments or repeated maintenance. No moving parts assure long life. Write for bulletin DL 48–537.

EFFECT OF VARIABLE FREQUENCY

Since partial resonance is a requisite design feature, these devices are sensitive to frequency changes. The output voltage will vary in the same direction and 1.4 times the percentage change in frequency, over a range of 5% of the normal frequency.

Stabilization, however, will be within ±½% at the output voltage which is established by the frequency.

TYPE VR 2
INPUT VS OUTPUT VOLTAGE
FOR VARIOUS FREQUENCIES

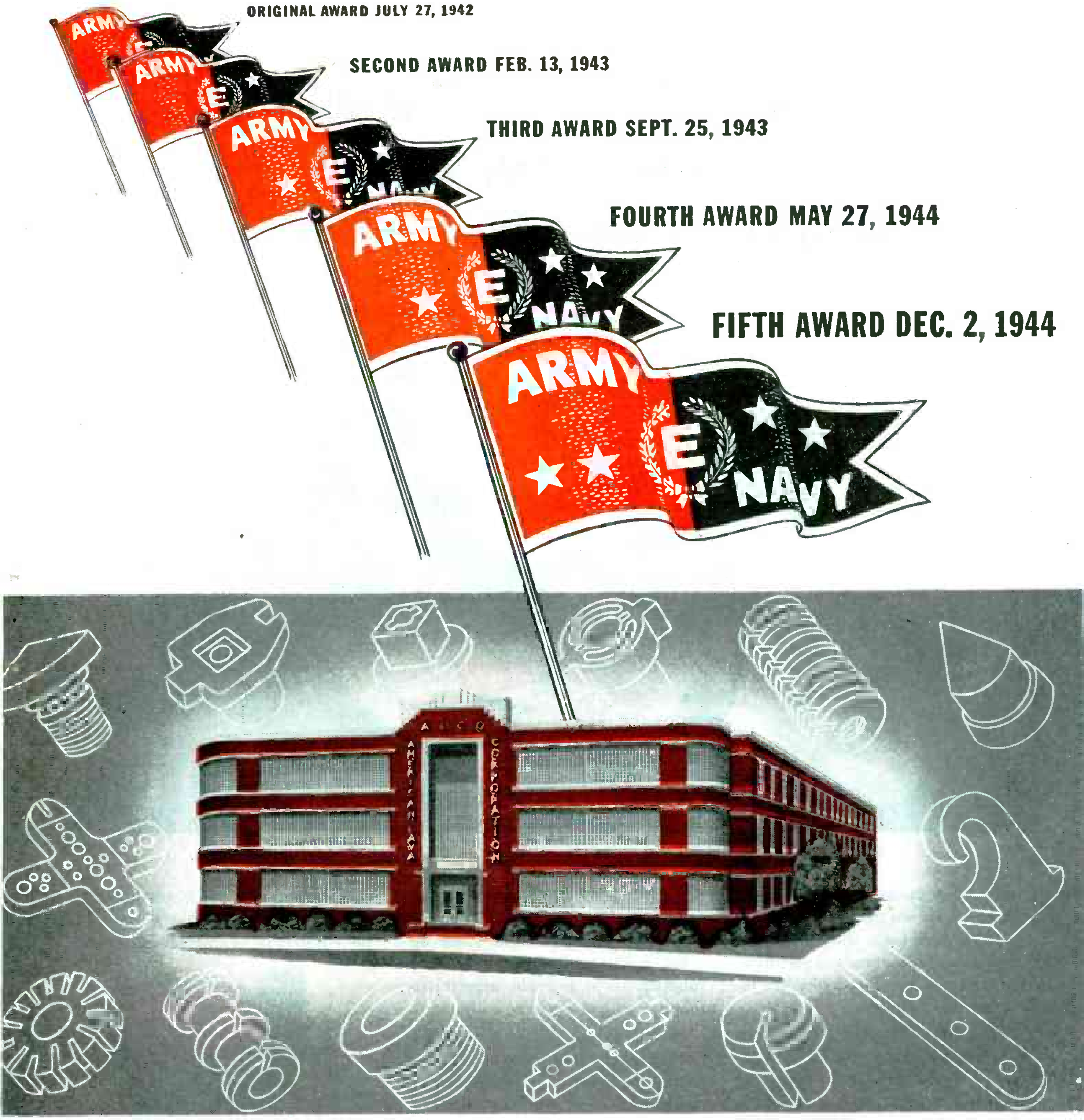


Tune in the Raytheon radio program: "MEET YOUR NAVY," every Saturday night on the Blue Network. Consult your local newspaper for time and station

RAYTHEON
MANUFACTURING COMPANY
Electrical Equipment Division
190 WILLOW STREET, WALTHAM, MASS.

The coveted Army-Navy "E," for Excellence in the manufacture of war equipment and tubes, flies over all four Raytheon Plants where over 16,000 men and women are producing for VICTORY.

Devoted to research and manufacture of complete electronic equipment; receiving, transmitting and hearing aid tubes; transformers; and voltage stabilizers.



For the fifth consecutive time, the men and women of American Lava have earned the Army-Navy "E" Award "for continued excellence in quantity and quality of essential war production." All of us are very thankful that the necessary knowledge, experience and skill were available at American Lava *to maintain the high standard of quality* of ALSIMAG products, while meeting production schedules that once seemed incredible.

AMERICAN LAVA CORPORATION • *Chattanooga 5, Tennessee*

43RD YEAR OF CERAMIC LEADERSHIP

ALSIMAG

TRADE MARK REG. U. S. PAT. OFFICE

CERAMIC INSULATORS

For Use in:

- Electronic Devices
- Electrical Circuits and Appliances
- Gas and Oil Heating
- Automotive Equipment
- Chemical Processes

That SOLA CONSTANT VOLTAGE TRANSFORMER, built into our equipment, will eliminate a majority of our most critical field problems

Every sales manager of electrical equipment knows the number of expensive service calls, the number of complaints of sub-standard performance that can be traced directly to unstable line voltages.

A majority of them can be avoided by simply specifying "SOLA Constant Voltage Transformers" while the equipment is still on the drafting board.

The inclusion of SOLA Constant Voltage Transformers in the basic design can generally be accomplished at an actual saving in cost. Their use frequently eliminates the need for other component parts whose only function is to provide superfluous manual control over the equipment.

SOLA Constant Voltage Transformers require no supervision. They have no moving parts or delicate networks to get out of order. They react instantly and automatically to line voltage disturbances, correct fluctuations as great as 30% to the safe operating limits called for on the label. They protect both themselves and the equipment against short circuit.

To Manufacturers:

Built-in voltage control guarantees the voltage called for on your label. Consult our engineers on details of design specifications.

Ask for Bulletin DCV-102

SOLA Constant Voltage Transformers

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • Door Bells and Chimes • etc. **SOLA ELECTRIC CO., 2525 Clybourn Ave., Chicago 14, Ill.**

These are the reasons Heintz and Kaufman endorses

TUBE STANDARDIZATION

STANDARDIZATION IS A WARTIME NECESSITY

Colonel C. C. Irwin, commanding officer of the Signal Corps Standards Agency, recently stated that a majority of Signal Corps contractors are heartily cooperating with the standardization program sponsored by his agency to the end that approved component parts and materials are used wherever possible in equipment supplied to the Signal Corps.

"However, there are some," Colonel Irwin said, "fortunately only a few, who view this program as an attempt to put an unsound theory into practice. Such is, of course, not the case. Standardization is vitally necessary, not only to relieve bottlenecks in production and distribution; to facilitate maintenance by providing interchangeability of parts; but more important, to reduce equipment failures in the field.

"There is no theory in a Gold Star.

"If the reasons behind the laconic phrases 'killed in action,' 'missing,' and 'plane failed to return' could be explained, it is quite probable that equipment failures would bulk large among the reasons.

"It is not expected that the use of approved standard component parts will eliminate equipment failures, but it most certainly will reduce them."

EQUALLY ADVANTAGEOUS IN THE POSTWAR PERIOD

Joint Army and Navy Specifications ("Jan-1A specs") have already established standards of electrical similarity and physical dimensions for vacuum tubes. Heintz and Kaufman will voluntarily continue to apply these engineering standards to postwar Gammatrons as the benefits are so obvious that we believe the designers of communications equipment will insist upon their continuation:

1. Standardization of specifications will facilitate equipment design and production, since it assures the designer that there will be no physical or electrical changes made in the tube type he has selected. Often such changes have necessitated extensive redesign of equipment.

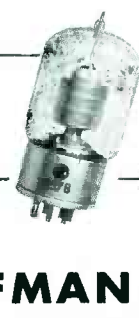
2. It will assure performance where performance is vital . . . in air transport and marine communications, in navigation and direction finding.

3. By establishing rigid electrical and physical requirements and tests, tube failures will be materially reduced. Such failures often reflect on the manufacturer of equipment, and must be guarded against just as carefully in peacetime as in war.

STANDARDIZATION DOES NOT LIMIT NEW DESIGN

Standardization of the specifications for current Gammatron tube types will not restrict the development of additional types to meet future needs. (Next month we will list here the Gammatron tubes which will be available indefinitely under our voluntary standardization program.)

Have you written for data on the HK-257B (JAN. 4E27)?

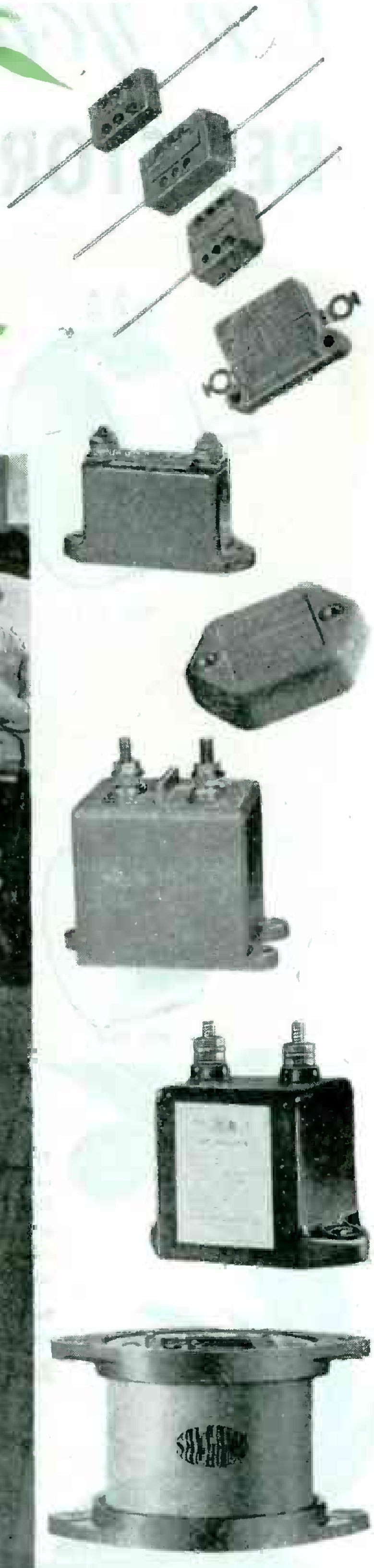


HEINTZ AND KAUFMAN LTD.

SOUTH SAN FRANCISCO • CALIFORNIA

KEEP BUYING WAR BONDS

Gammatron Tubes



On your VARIABLE RESISTOR *problems...*

Perhaps you didn't realize that you had any "variable resistor problems." It frequently happens that way. That is why, years ago, Chicago Telephone Supply established the practice of submitting a sample whenever a customer orders variable resistors made to new specifications.

Before starting production on such an order, CTS just wants to make certain that no unforeseen problems exist. And in the course of many years' experience, the soundness of this practice has been demonstrated time and time again. It has saved many a manufacturer untold grief and very considerable sums of money.

Chicago Telephone Supply Company is a specialist in the field of variable resistors. As such, they feel obligated to do more than merely fill orders. They do their utmost to make sure that their variable resistors will do the job they are meant for.

Manufacturers of Quality Electro-Mechanical Components Since 1896

VARIABLE RESISTORS
PLUGS AND JACKS
SWITCHES, RINGERS
TELEPHONE GENERATORS

CHICAGO TELEPHONE SUPPLY
Company

ELKHART • INDIANA

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R. W. Farris Co.
406 West Thirty-fourth Street
Kansas City 2, Missouri
Phone: Logan 7495

Frank A. Emmet Co.
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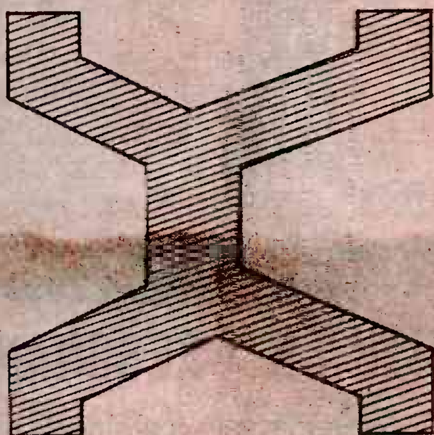
Los Angeles 6, California
Phone: Rochester 9111

BRANCH OFFICES

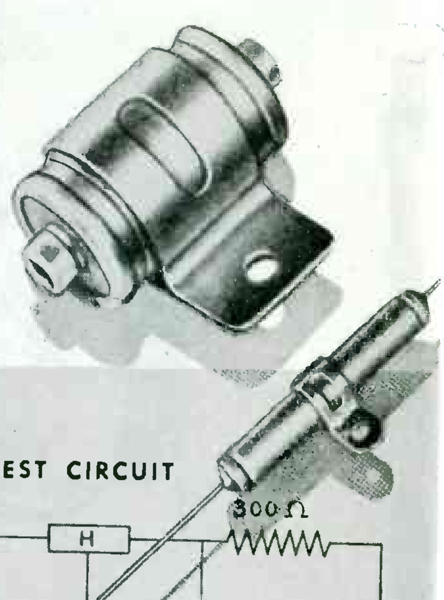
S. J. Hutchinson, Jr.
401 North Broad Street
Philadelphia 8, Pennsylvania
Phone: Walnut 5369

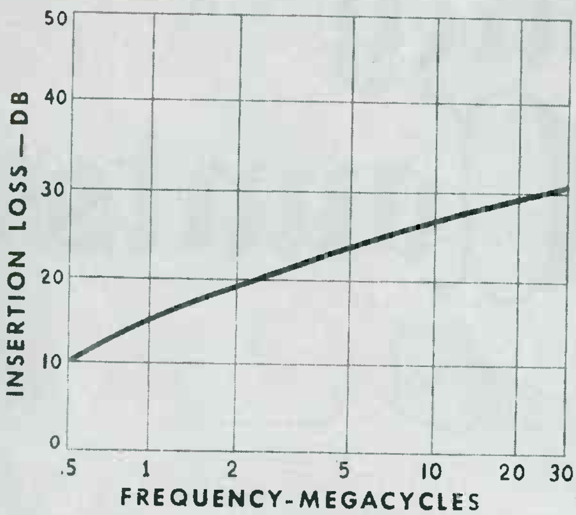
IN CANADA

C. C. Meredith & Co.
Streetsville, Ontario

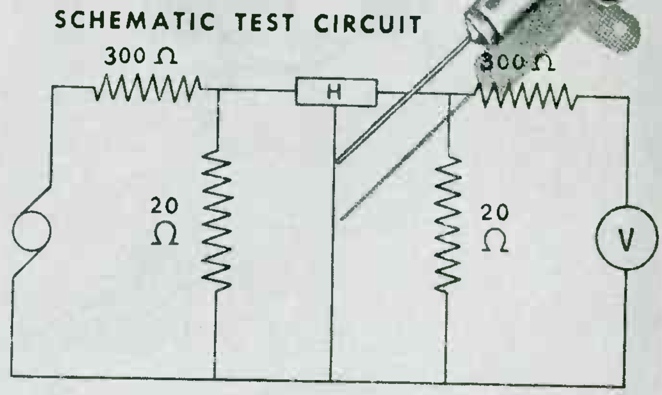


SPRAGUE HYPASS* CAPACITORS





Curve showing insertion loss of a Sprague HYPASS Capacitor.



The Solution to "WHAT TO DO WITH ANTI-RESONANT FREQUENCIES?"

Conventional methods of getting rid of vibrator "hash" usually call for the use of a by-pass capacitor, shunted by a mica capacitor. This system, however, has at least one anti-resonant frequency. Of course the engineer juggles his constants so that this anti-resonant frequency comes where it causes the least trouble—BUT, in today's all-wave devices, there just isn't any such place!

The New Sprague Method is simply to utilize the Sprague HYPASS Capacitor. Technically, this is a 3-terminal network which, at low frequencies, "looks" like a capacitor in respect to its capacity, voltage rating, and size. At high frequencies—well, the above diagram tells the story. Although accurate measurements of their performance at the very high end of the spectrum are difficult to obtain as yet, qualitative indications show that HYPASS units do the job at 100 megacycles and more—so much so that, if you have a "hash" problem, we'd welcome an opportunity to stack them against it.

SPRAGUE ELECTRIC COMPANY, *North Adams, Mass.*
(Formerly Sprague Specialties Co.)

*T. M. REG. U. S. PAT. OFFICE

ARMY E NAVY

SPRAGUE

CAPACITORS — *KOOLOHM RESISTORS

The values of Lexel insulation tape for low tension circuits have been proved in many military applications. If your products call for insulation with any or all of the following characteristics, consider Lexel tape in your planning:

Perfect centering of the conductor within the helically-wound, heat-sealed tape.

Saves about 25% weight and bulk in primary insulation.

High dielectric strength and insulation resistance.

Noncorrosive . . . low moisture absorption.

Ask for detailed information and samples. Dobeckmun engineers will help you test Lexel tape for future use, or for present products with necessary priorities.

* * * * * *

CUSTOM-MADE INSULATION

As a regular service, Dobeckmun engineers also develop laminated insulation products, custom-made to special purpose specifications, such as slot cell and phase insulation for motors, insulation for shipboard cables and other uses. If your requirements are unusual, call on us.

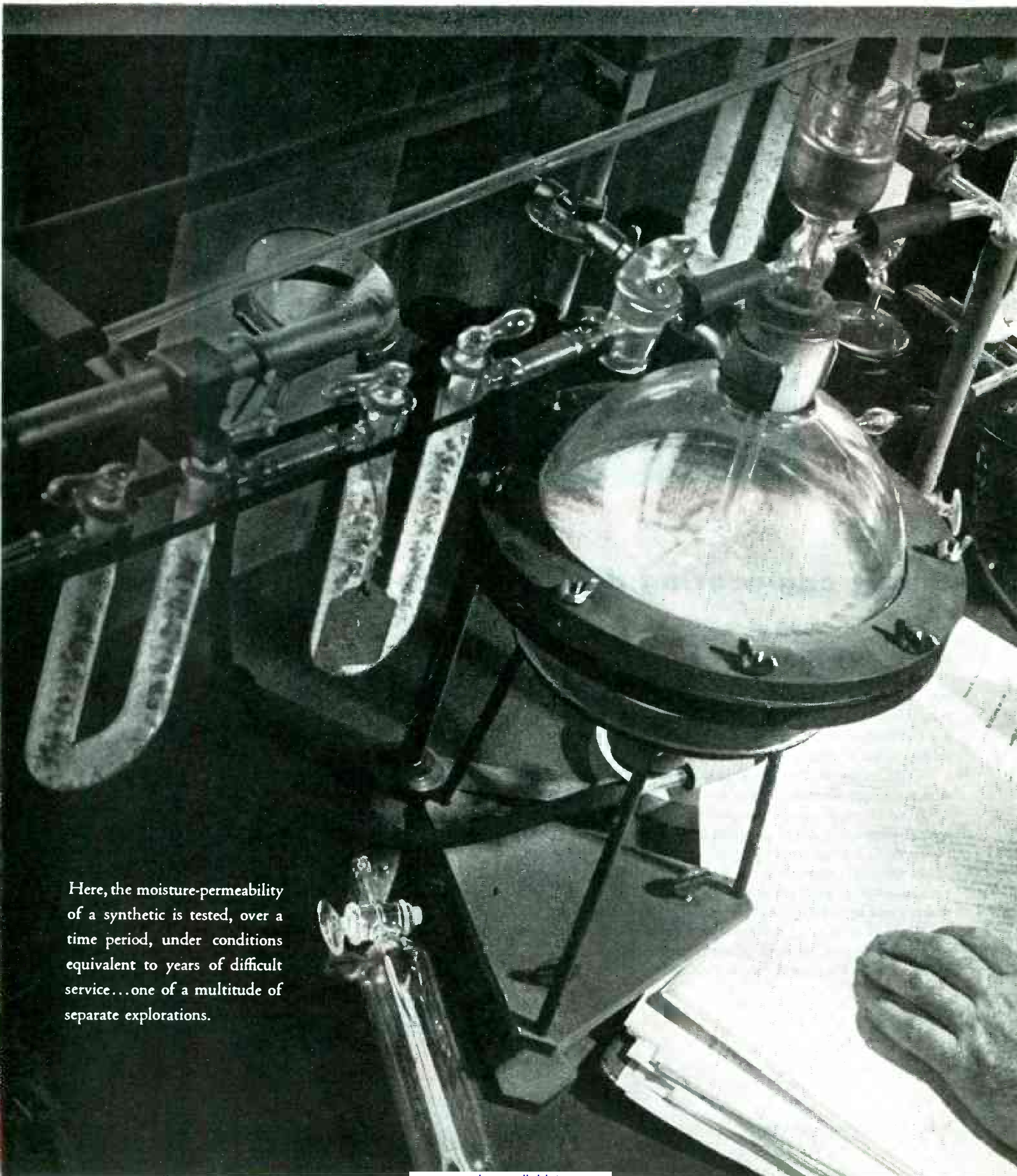
MADE BY THE MAKERS OF "DOBAR" LAMINATED PAPER INSULATION

"LEXEL" is a registered trade-mark of The Dobeckmun Company.

THE DOBECKMUN COMPANY

INDUSTRIAL PRODUCTS DIVISION • CLEVELAND 13, OHIO
WESTERN SALES HEADQUARTERS • SAN FRANCISCO 4, CALIF.

SEARCH IN

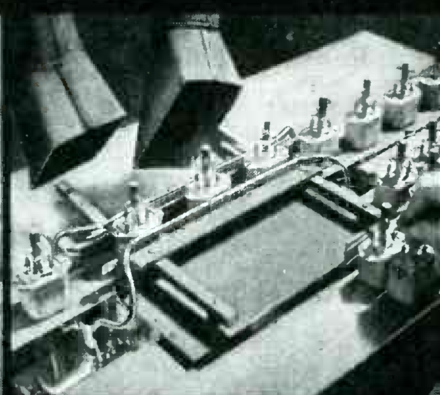


Here, the moisture-permeability of a synthetic is tested, over a time period, under conditions equivalent to years of difficult service...one of a multitude of separate explorations.

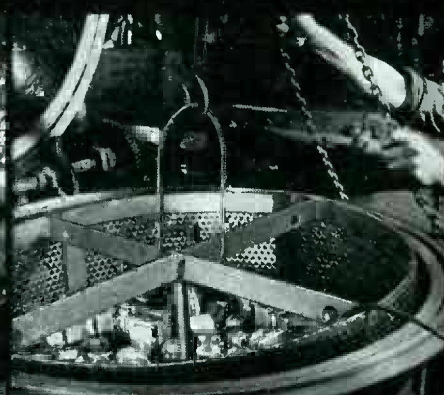
The Seal

THAT MEANS PERFECT HERMETIC SEALING

IMMERSION VACUUM TEST of each unit—not just random units—after final assembly, is standard procedure at AmerTran. Quality control of hermetic sealing is thus rigidly maintained.



INDUCTION SOLDERING insures quality sealing of all case seams enabling the unit to withstand vibration and severe air pressure changes.



VACUUM IMPREGNATION with varnish removes moisture from coil and provides excellent turn, layer and section insulation, resulting in long trouble-free life.

Other Safeguards like infra-red preheating of cores and coils before compound filling, torque-gauging and resilient gaskets to protect ceramic terminals provide full protection against moisture, temperature changes, and pressures encountered in airborne service. Yet AmerTran Hermetically Sealed Transformers are designed to minimum weight and dimensions. Write for complete details.

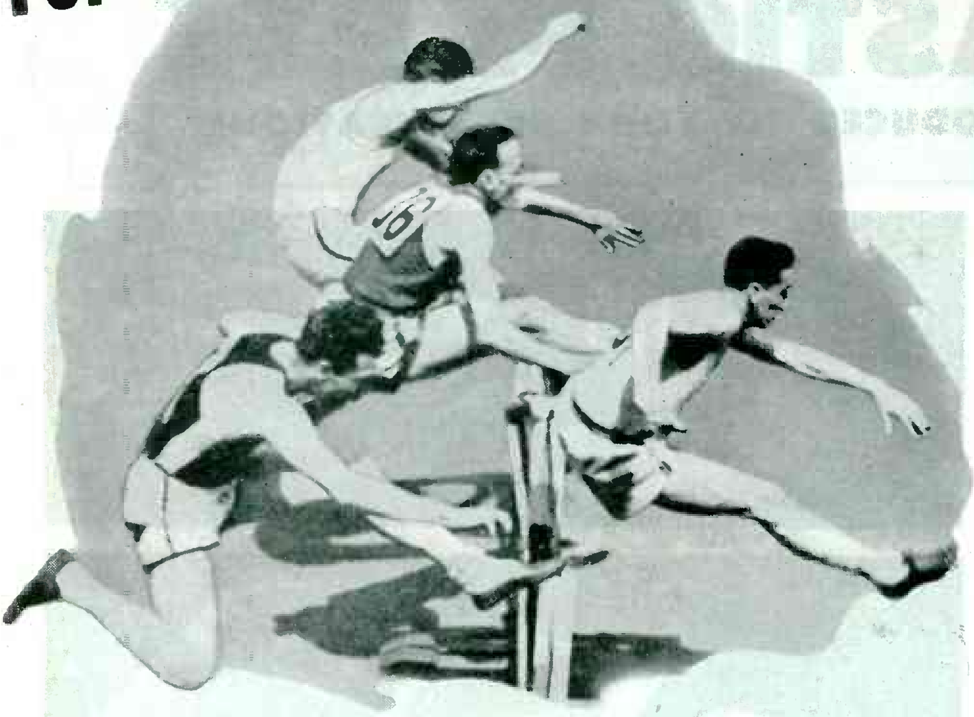
THE AMERICAN TRANSFORMER CO., 178 Emmet St., Newark 5, N.J.

AMERTRAN

MANUFACTURING SINCE 1901 AT NEWARK, N. J.

Pioneer Manufacturers of Transformers, Reactors and Rectifiers for Electronics and Power Transmission

For Television Transmission



... count on

Western Electric

equipment to lead the way!

Just as soon as final Victory opens the door to post-war progress in television, Western Electric plans an active program of development work as well as manufacture of television transmitters. In this field, as in sound broadcasting, you can be sure of advanced design and highest quality equipment engineered by Bell Telephone Laboratories and made by Western Electric.

Western Electric

Distributed by Graybar

Buy all the War Bonds you can . . . and keep all you buy!

BACKGROUND FOR LEADERSHIP IN TELEVISION

Back in 1927, Bell Labs and Western Electric transmitted black and white images over wire circuits and also by radio.

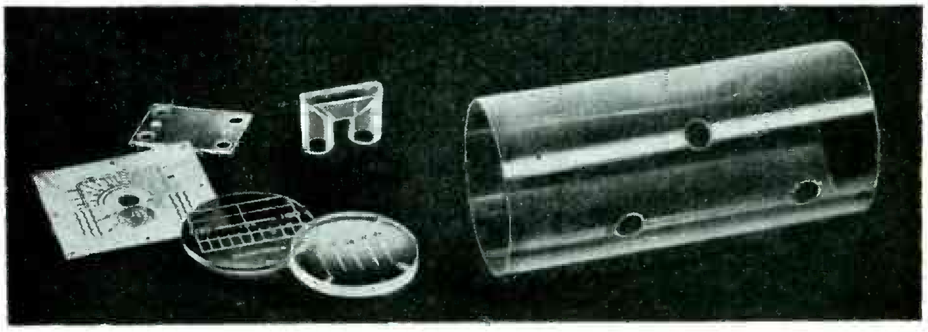
In 1929, the first public demonstration of full-color television marked another advance by Bell Labs and Western Electric.

Here is a fanned out section of the latest type of Western Electric coaxial cable—destined for an important place in television networks.

Development work by scientists of Bell Labs will lead to more pioneering advances in television for tomorrow.

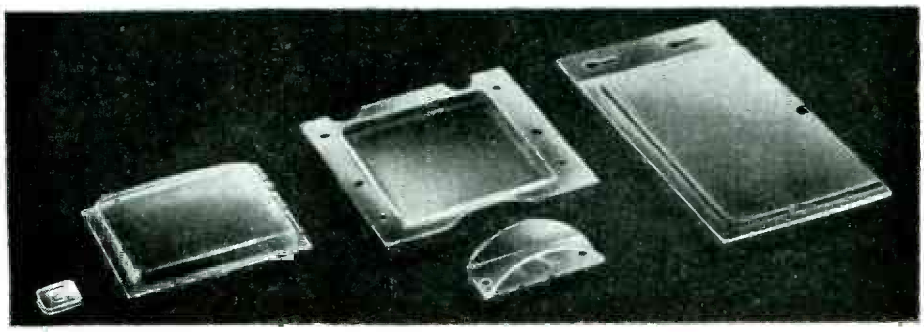
PLASTIC PARTS

. . . . PRODUCED TO YOUR SPECIFICATIONS



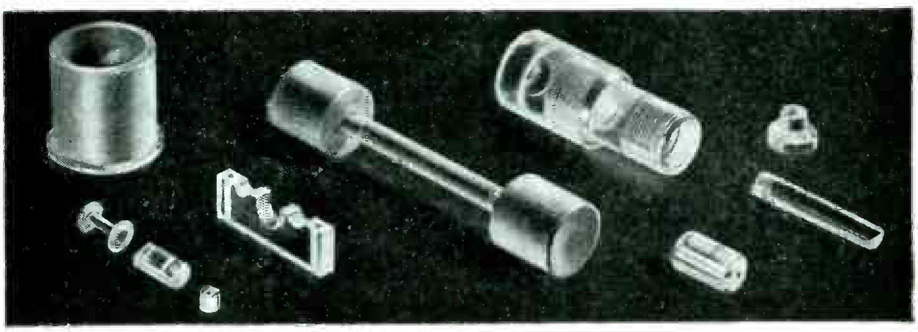
PRINTING
DIE CUTTING
CEMENTING

Wide experience by all known processes in the application of printing, engraving, silk screening, die cutting and cementing of all thermoplastics.



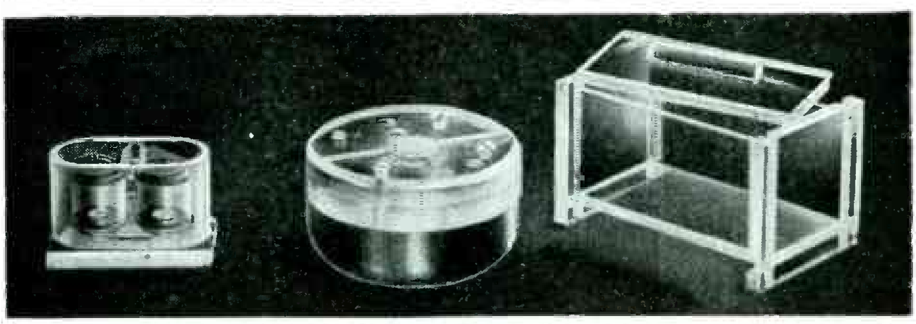
FORMING

Specialists in deep drawing radio dial windows, embossing, swaging and bending in Acetate, Vinylite and Acrylics.



MACHINING

Precision threading, screw machine, milling, drilling, turning of Polystyrene, Acrylics, Phenolics, nylon Tenite sheets, tubes and rods; through spindle capacity up to 2½" rod.

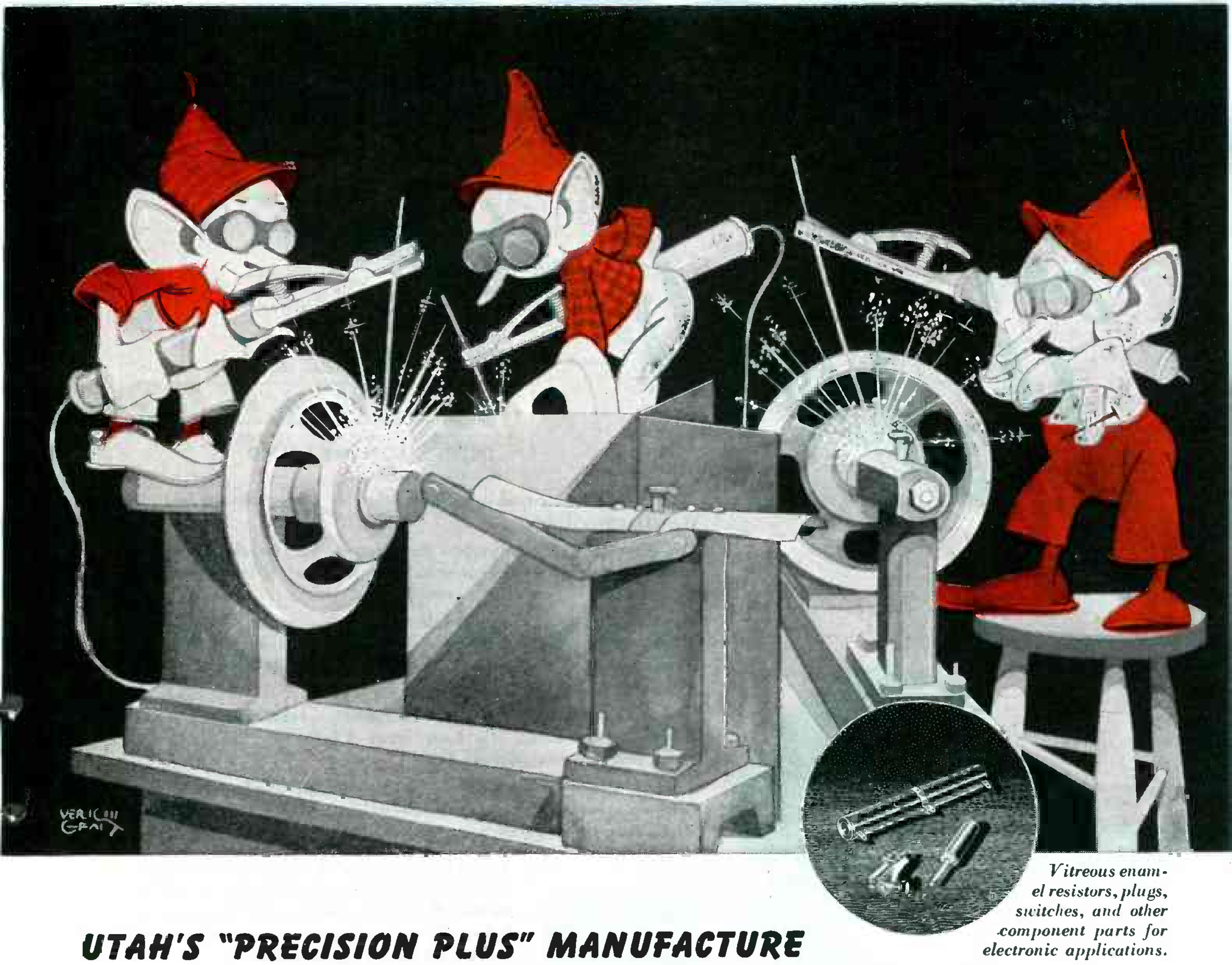


ASSEMBLY

Our engineers can assist you in problems of design and assembly of your plastic units.

PRINTLOID, *Inc.*

93 Mercer Street
New York 12, N. Y.



Vitreous enamel resistors, plugs, switches, and other component parts for electronic applications.

UTAH'S "PRECISION PLUS" MANUFACTURE ... SPEAKS FOR ITSELF!

Utalins* at work . . . welding . . . and proud as punch at the technique they've developed. They know welding is just one of several steps in the production of Utah's radio parts and electronic devices. But they give it that "precision plus" accuracy that Utah demands all the way.

Every phase of manufacture done in Utah's own factory is to perfection standards.

First comes the careful purchase of quality raw materials. Then Utalins make the tools that make the Utah products. The modern methods of production, the testing, the supervision, even the infinite care in shipping all add up to Utah's comprehensive process—an infallible system of manufacture that enables Utah—and you—to be proud of the finished products.

Utah products finally become hidden parts of your radio, and the world listens—with pleasure—as Utah performance speaks for itself!

**Utalins—Utah's helpers*

utah
RADIO PRODUCTS COMPANY
CHICAGO, ILLINOIS

ARMY E NAVY

Utah Radio Products Co., 820 Orleans St., Chicago 10, Ill.
Utah Products (Canada) Ltd., 300 Chambly Rd., Longueuil, Montreal (23) P. Q.

Surface Hardening at Machine Gun Speed!

with

-MEGATHERM-*

INDUCTION HEATING

Here is a history-making application of a Megatherm Induction Heating Unit.

On this typical production line setup, 75 bearing pins a minute are surface hardened. This hardening is done after finish grinding has been completed.

In one high-speed operation the pins are hardened to Rockwell C 60—above file hardness—and costly finish grinding of hardened steel is avoided because scale and distortion are eliminated.

The pins are 2⅓" long and ½" in diameter, made of chromium molybdenum steel. To heat treat 4,500 bearing pins an hour costs approximately 50¢.

Each pin is heated above critical temperature in less than one second. Quick heating and quenching prevents scaling or distortion and gives accurate control over the hardened case depth.

This is only one of the many new applications of Megatherm Heat in the metal industry. Pieces as small as ⅛" diameter or bearing surfaces up to 6" are handled as easily, all with Megatherm.

More information on how Federal's Megatherm High Frequency Heat can save you money on your production line is yours for the asking. Check Megatherm now.

This Microphoto

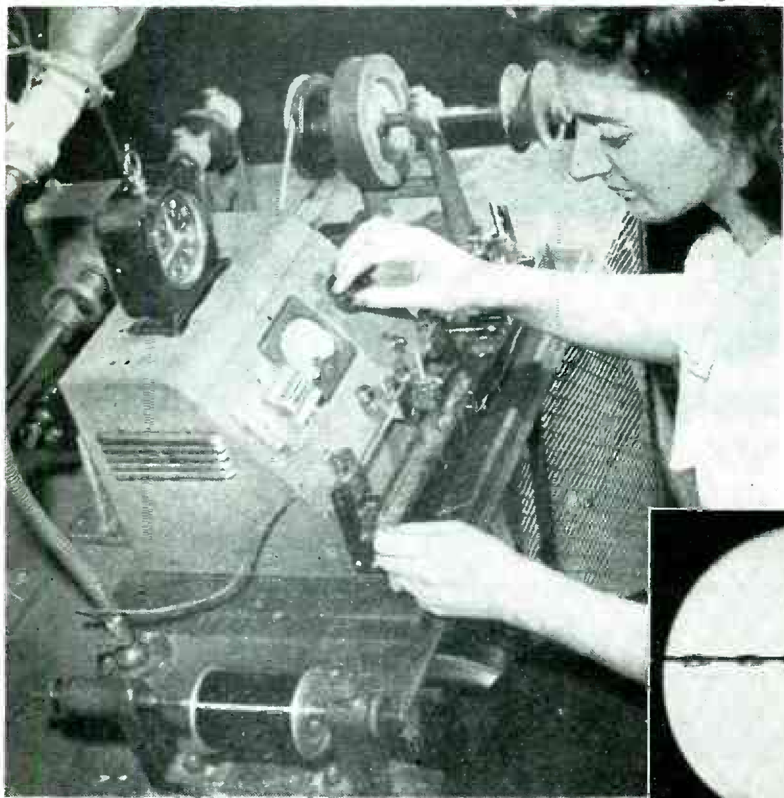
magnified 100 diameters shows the hardened surface developed on bearing pins. The white portion is that of the hardened outside layer which extends to a depth of 25 thousandths of an inch. At no point in the zone between the fully hardened case and the unhardened core was there any softening or tempering.

100 X

Federal Telephone and Radio Corporation

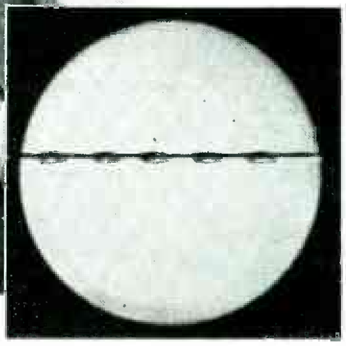
INDUSTRIAL ELECTRONICS DIVISION — AN IT&T ASSOCIATE — Newark 1, N. J.

* REG. U. S. PAT. OFFICE

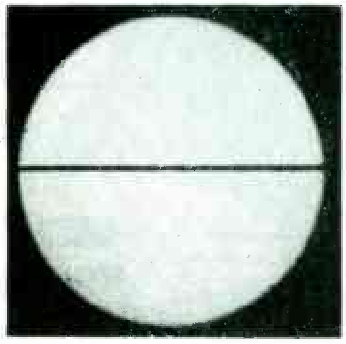


Enamel-Coated FINE WIRE to meet your specifications

This precision instrument checks finished enameled fine wire and instantly registers insulation defects should any be present. This is but one of many rigid tests to which NORELCO enameled fine wire is subjected.



This microphoto shows "beady" enamel due to poor wire-coating technique and process control. Magnification 40X.



Microphoto of the even enamel coating on NORELCO fine wire, the result of advanced coating techniques and rigid process control. Magnification 40X.

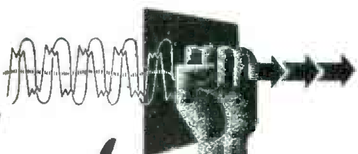
Where NORELCO Fine Wires Are Used in the Electronics Field — Precision wire-wound resistors; hearing aids; radio headphones; sensitive recording and indicating meters; sensitive relays; electronic tube grids and filaments; fractional horsepower motors; and hundreds of other uses wherever fine wire is required.

Enamel-coated fine wire is judged chiefly for its insulation qualities. Uneven coating, a high percentage of pin holes, a tendency of the enamel to crack or peel, non-uniform resistance makes wire useless for precision electronic applications.

The drawing and coating of high quality fine wire with rigid requirements of close tolerance, perfect roundness and faultless surface condition, are exacting processes in which the North American Philips Company have long been specialists. Aside from the advanced techniques developed by our engineers for producing high quality enamel coating, the finished product is subjected to rigid voltage, pin hole, resistance and bead tests that meet all customers specifications.

North American Philips manufacture fine wire below .003" diameter in silver, copper, nickel chrome, aluminum alloy and other metal alloys. We plate many types of wire, silver, tungsten, molybdenum and alloys up to .010" with gold, copper or other metals. Manufacturers have found our unusual skill of great value in helping them meet wartime production schedules. North American Philips have the knowledge of processes and techniques developed by an organization with a background of over half a century in the electrical field. Call on our specialized engineering service whenever you have a fine-wire problem.

OTHER PRODUCTS: In addition to fine wire and diamond dies for our own drawing, we make: Tungsten and Molybdenum products; Quartz Oscillator Plates; Amplifier, Transmitting, Rectifier and Cathode Ray Tubes; Searchray (Industrial X-ray) Equipment; X-ray Diffraction Apparatus; Medical X-ray Equipment, Tubes and Accessories. When in New York, be sure to visit our Industrial Electronics Showroom.



Send for NORELCO Fine Wire Booklet on your letterhead. It contains valuable conversion tables for ready reference of buyers and design engineers.

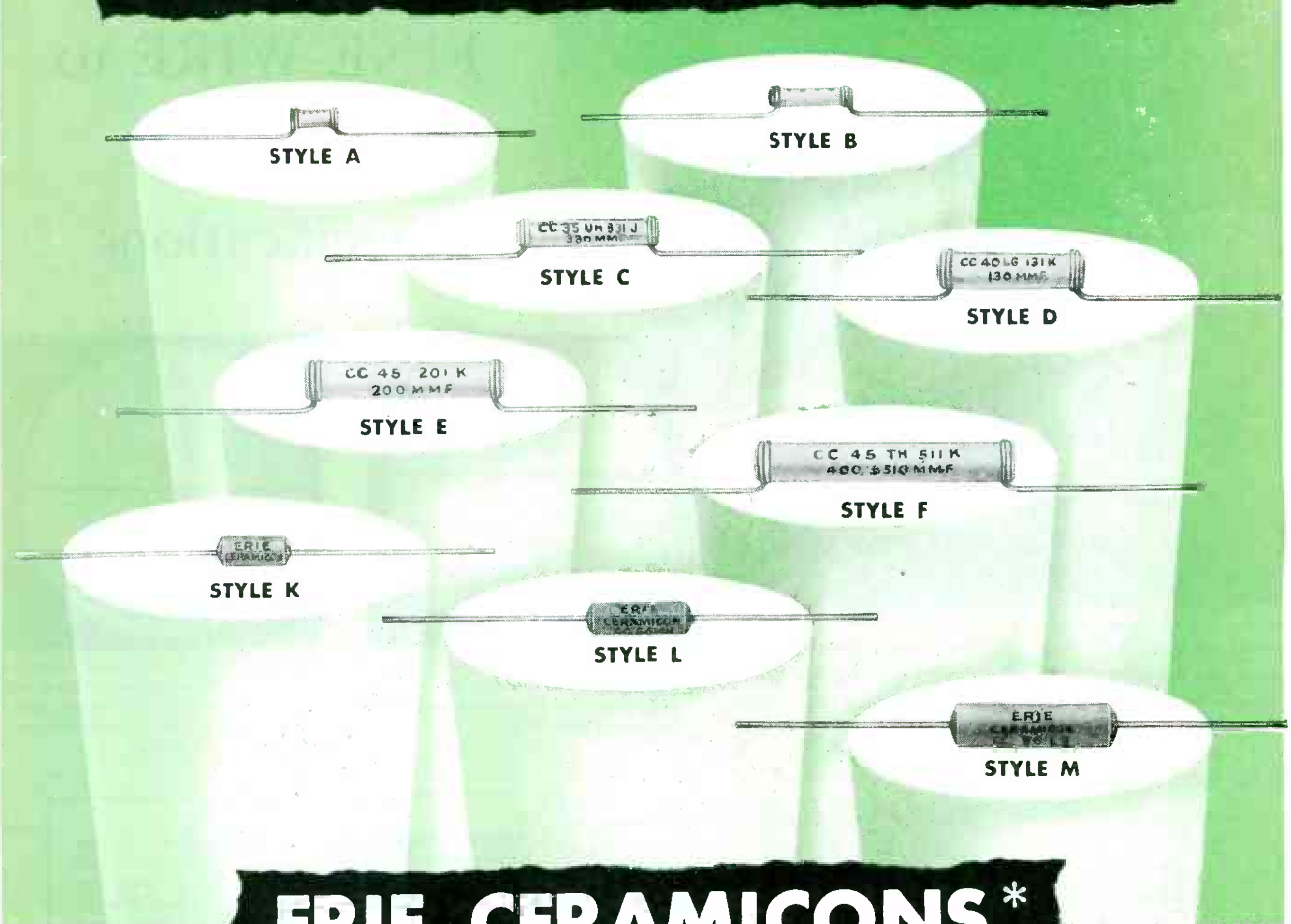
Norelco
Reg. U. S. Pat. Off.
ELECTRONIC PRODUCTS by

NORTH AMERICAN PHILIPS COMPANY, INC.

Executive Offices: 100 East 42nd Street, New York 17, N. Y.
Factories in Dobbs Ferry, N. Y.; Mount Vernon, N. Y. (Metalix Division); Lewiston, Maine (Elmet Division)

North American Philips Company, Inc.
100 East 42nd Street, New York 17, N. Y.
Gentlemen:
Please send me a copy of your booklet "Norelco Fine Wire".
Name__________
Title__________
Company__________
Address__________

Ideal General Purpose Condensers



ERIE CERAMICONS*

REG. U. S. PAT. OFF.

When Erie Resistor introduced the first silvered ceramic condensers in this country several years ago, engineers were provided with a simple method of compensating for frequency drift in other components.

Expanded war time demand for condensers has definitely proved that Ceramicons are also superior as general purpose condensers in circuits where some moderate degree of capacity change with temperature is permissible. For example, Ceramicons make excellent coupling condensers, particularly plate-to-grid, where high insulation resistance is of paramount importance.

When specifying Ceramicons under JAN-C-20 for general purpose use, temperature coefficient characteristic "SL" should be given. If Erie designations are used, specify "any temperature coefficient between P100 and N750." The temperature coefficient of these Ceramicons will be between +150 and —870 parts/million/°C, as determined by measurement at 25°C and 85°C. Particularly in the low capacity ranges, this temperature coefficient limit will, in many cases, permit us to ship quickly from stock, since the Ceramicons can be selected from any one of the 10 standard temperature coefficients between P120 and N750. The capacity range for equivalent physical size is given in the table below.

May we submit samples of Erie Ceramicons to you for your general purpose applications?

CHARACTERISTICS

CAPACITY RANGE IN MMF	JAN-C-20 STYLE	ERIE STYLE	MAXIMUM OVERALL DIMENSIONS
1 to 51	CC20 CC21	A K	.200 x .400 .250 x .562
52 to 110	CC25 CC26	B L	.200 x .656 .250 x .812
111 to 360	CC35 CC36	C M	.265 x 1.125 .340 x 1.328
361 to 510	CC40	D	.375 x 1.110
511 to 820	CC45	E	.375 x 1.560
821 to 1100	CC45	F	.375 x 2.00

** Ceramicon is the registered trade name of silvered ceramic condensers made by Erie Resistor Corporation.*

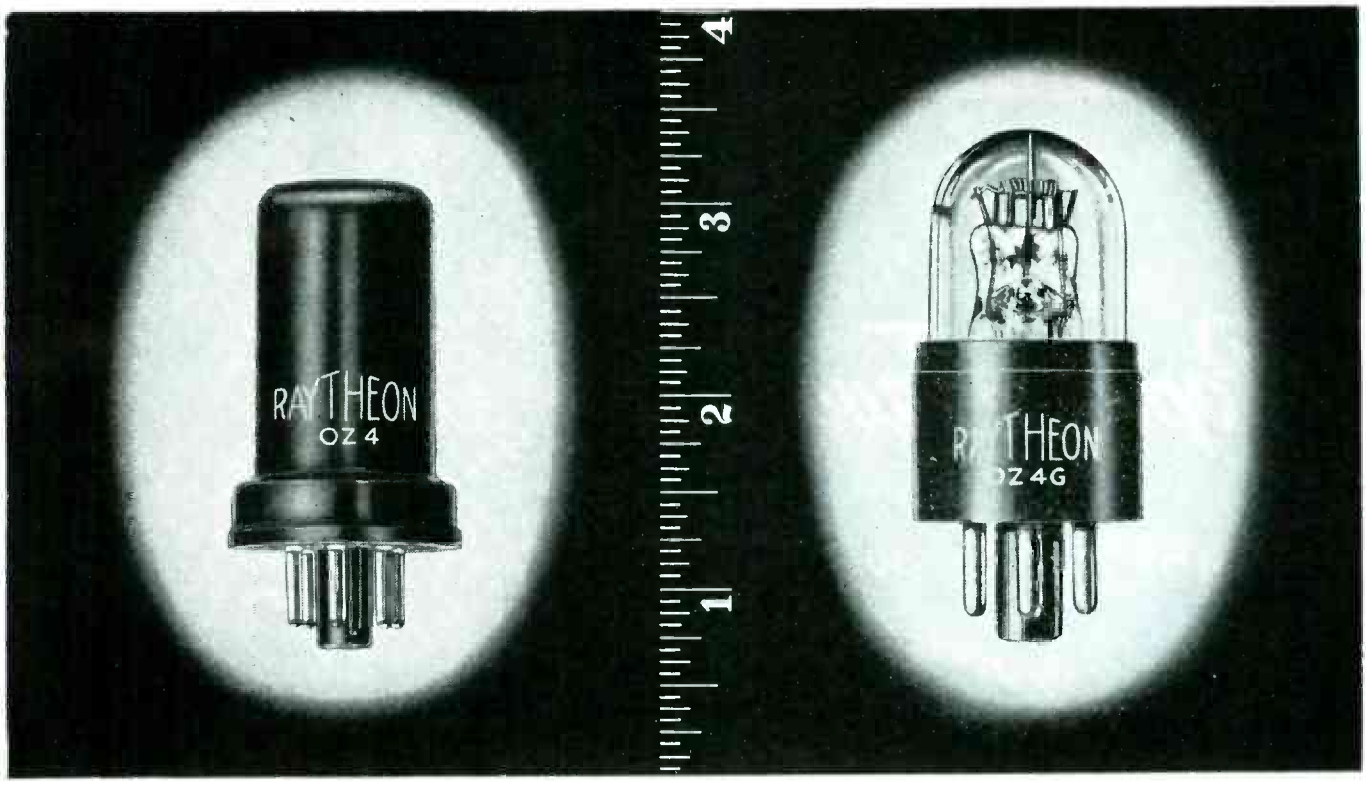
Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND · · TORONTO, CANADA

NAVY
FOR HIGH ACHIEVEMENT IN WAR PRODUCTION

★ ★ ★ Do More Than Before—Buy EXTRA War Bonds ★ ★ ★



Increased Output from RAYTHEON OZ4 and OZ4G Tubes

Many manufacturers realize the advantages of small ionically heated cathode gas rectifiers which require no heater power, can be used under any atmospheric condition, and yet operate with very low internal power losses. Convincing evidence is the widespread use of such tubes in automobile radios and other equipment where maximum performance must be obtained with minimum power input.

Millions of Raytheon OZ4 and OZ4G tubes have given reliable and efficient service in such equipment . . . service which will prompt engineers to incorporate them in numerous postwar products.

First developed by Raytheon as a refinement of the BH to obtain internal drops comparable to the larger directly heated cathode types, these tubes are now further improved to the point where the output rating has been increased from 75 ma to 90 ma when functioning as a full wave rectifier. Hence, it can be used to advantage in supplying the extra "B" drain imposed by larger receivers or low-power mobile transmitters.

The OZ4 and OZ4G are examples of Raytheon's ability to design and produce *better* tubes . . . tubes which will be in great demand in the postwar radio and electronics industry.

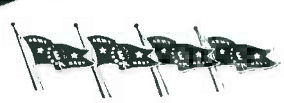
Specifications of OZ4 & OZ4G

	OZ4	OZ4G
Maximum Overall Length	2-5/8 in.	2-5/8 in.
Maximum Seated Height	2-1/16 in.	2-1/16 in.
Maximum Diameter	1-5/16 in.	1-3/64 in.

Typical Operation Ratings as a Full Wave Condenser Input Rectifier:

Heater Power	None
Minimum DC Output Current	30 ma
Maximum DC Output Current	90 ma
Maximum Peak Anode Current	270 ma
Minimum Starting Voltage— Peak (P to K)	320 volts
Average Dynamic Voltage Drop	24 volts
Maximum Peak Inverse Voltage	880 volts

RAYTHEON
RADIO RECEIVING TUBE DIVISION
Newton, Mass. • Los Angeles • New York • Chicago • Atlanta



All Four Divisions Have Been Awarded Army-Navy "E" with Stars

Listen to "MEET YOUR NAVY" Every Saturday Night ENTIRE BLUE NETWORK Coast-to-Coast 181 Stations

DEVOTED TO RESEARCH AND THE MANUFACTURE OF TUBES AND EQUIPMENT FOR THE NEW ERA OF ELECTRONICS

One of a series of Electro-Voice advertisements explaining in detail the applications and specifications of Electro-Voice microphones

... a general-purpose dynamic microphone with an exceptionally wide and flat frequency response—for both indoor and outdoor speech and music pick-up —is required ...

Electro-Voice MODEL 630

This versatile, moderately priced microphone is excellent for public address, all types of dispatching and call systems, paging systems, churches, auditoriums, hotels, recording studios and broadcast remote pick-ups. Though somewhat lighter in weight, it is a sturdy microphone, built with typical Electro-Voice care to serve satisfactorily over a long period of time. Attractively styled, it is finished in lustrous chromium. The Model 630 is unusually flat through lower and middle register, rising 5 db on upper frequencies for added crispness of speech. Operates efficiently in salt air and humidity.

OUTPUT LEVEL: Power ratings: 54 db below 6 milliwatts for 10 bar pressure. Voltage rating (high impedance) 7 db above .001 volt/bar, open circuit. Voltage developed by normal speech (10 bars): .0224 volt.

FREQUENCY RESPONSE: 40-8000 c.p.s., with slightly rising characteristics.

WEIGHT: 1½ pounds.

TILTABLE HEAD: 90° tiltable head for directional or non-directional operation.

CABLE CONNECTOR: Built-in cable connector permits movement of head without moving the cable.

CASE: Built of highest quality, high impact pressure cast metal.

TRANSFORMER CORE: Nickel alloy; hydrogen annealed, low capacity windings.

DIAPHRAGM: Fine quality, heat-treated duralumin; corrosion-inhibited for use in salt air and humidity.

CONDUCTOR CABLE: 20-ft. well shielded cable and connector, low impedance balanced to ground.

HI-Z (DIRECT TO GRID) or 50, 200, 250 and 500 ohms.

SCIENTIFICALLY DESIGNED GRILLE: Reduces wind noise.

ON-OFF SWITCH: Standard ⅝"—27 stand coupler.

MAGNETIC CIRCUIT: Employs Alnico V and Armco magnetic iron.

List Price, $30.00

Contact your nearest radio parts distributor today. His knowledge of Electro-Voice microphones may aid you in selecting the appropriate type for your individual need. He may also be an important factor in speeding your order.

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ASKS YOUR HELP
... GIVE GENEROUSLY

Electro-Voice MICROPHONES

ELECTRO-VOICE CORPORATION • 1239 SOUTH BEND AVENUE • SOUTH BEND 24, INDIANA
Export Division: 13 East 40th Street, New York 16, N. Y., U. S. A. Cables: Arlab

ARMY E NAVY

CONSIDER PEDIGREE where QUALITY COUNTS

Nichrome

. . . the Quality resistance alloy made *ONLY* by Driver-Harris

45 years of continuous research devoted entirely to the perfection of the *World's finest resistance alloy* . . . that is the pedigree of NICHROME*.

For just as champions are created through selective scientific breeding, so do Driver-Harris Engineers, by means of perfected melting, hot rolling and cold finishing processes and exclusive quality controls, succeed in producing the champion of all heat and oxidation resisting alloys—NICHROME.

Although there are several excellent Nickel Chromium combinations, there is *only one* NICHROME and it is made *only* by Driver-Harris.

So put the "stamp of quality" on your post-war products by assuring dependable performance and longer life with NICHROME and other D-H resistance alloys.

*Trade Mark Reg. U. S. Pat. Off.

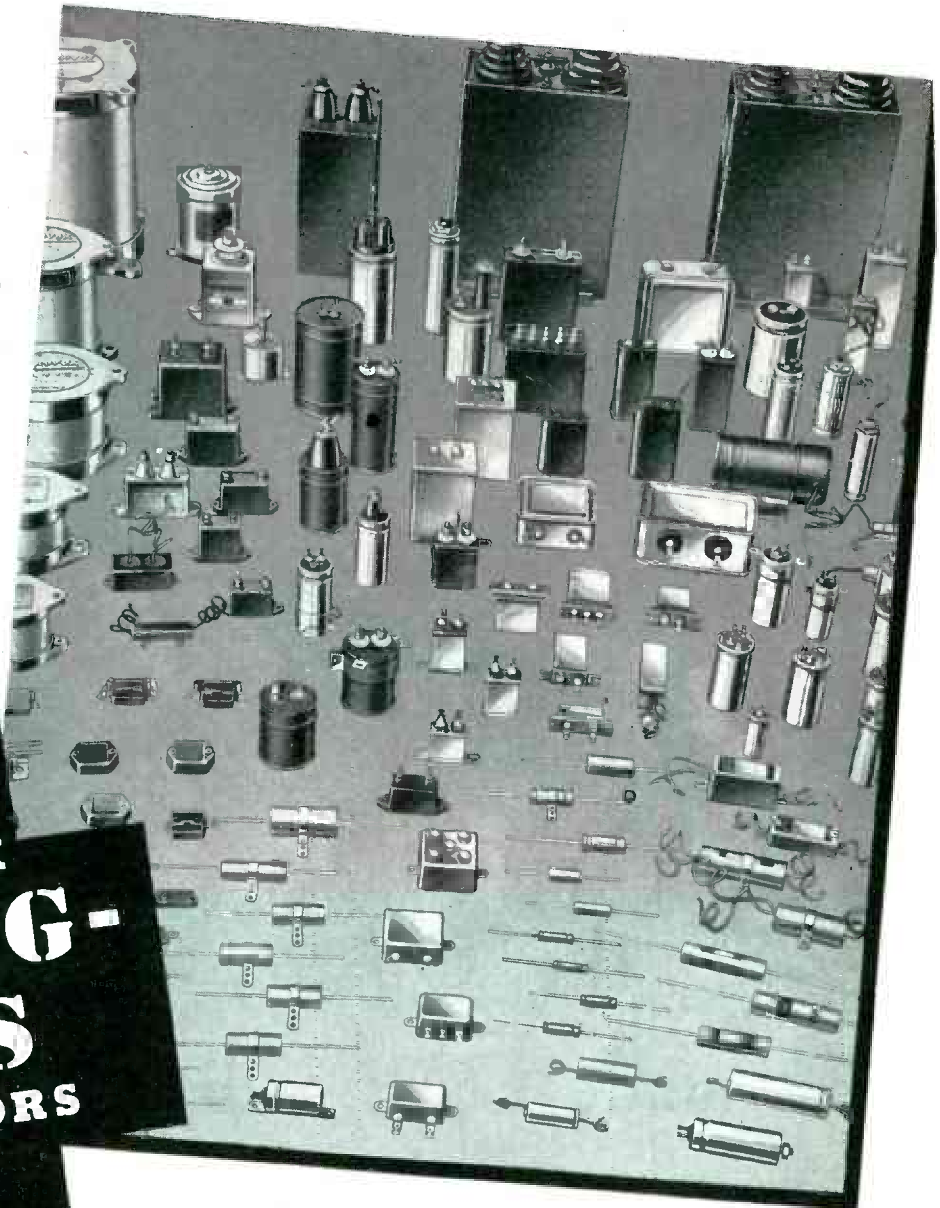
D-H SPECIAL PURPOSE ALLOYS SINCE 1899

Driver-Harris
COMPANY
HARRISON, NEW JERSEY

ARMY E NAVY

BRANCHES: CHICAGO • DETROIT • CLEVELAND • LOS ANGELES • SAN FRANCISCO • SEATTLE

For the widest range of transmitting and severe-service electronic assemblies . . .



AEROVOX

RATING-PLUS

CAPACITORS

● Critical equipment designers, builders and users are insuring their assemblies with Aerovox *rating-plus* capacitors. That Aerovox extra safety factor is widely recognized today. Service records speak for themselves.

All Aerovox paper-capacitor voltage ratings are for standard temperature, pressure and humidity conditions, namely, 20° C., 30 inches of mercury (760 millimeters), and 50% relative humidity.

Where Aerovox capacitors are in hermetically-sealed cases, the only effect caused by changes in standard conditions will be in the external flash-over voltage occurring at lower voltages for conditions involving reduced pressure and increased humidity. The capacitor proper remains unaffected.

The maximum operating temperature for continuous operation at rated voltage is 65° C. ambient. If temperature is greater, operating voltage must be reduced. Derating data will be supplied, on request.

Yes indeed, it will pay you to look into this matter of Aerovox *rating-plus* insurance. Remember, it costs no more but it can save you much expense and trouble.

● ***Submit your capacitance problems. Literature on request.***

AEROVOX Capacitors

INDIVIDUALLY TESTED

AEROVOX CORPORATION, NEW BEDFORD, MASS., U. S. A. • SALES OFFICES IN ALL PRINCIPAL CITIES

Export: 13 E. 40 ST., NEW YORK 16, N. Y. • Cable: 'ARLAB' • In Canada: AEROVOX CANADA LTD., HAMILTON, ONT.

ANNOUNCING AN ENTIRELY NEW
CERAMIC CAPACITOR DIELECTRIC
MYCALEX K

The MYCALEX CORPORATION OF AMERICA has developed and now has in production a new capacitor dielectric which embodies important new advancements in properties.

Designated MYCALEX "K," this new ceramic material is unique in that it offers a *selective* range of dielectric constants, from 8 to 15 at one megacycle.

Engineers whose requirements call for a material with a dielectric constant of 10, need only specify MYCALEX K-10. If a dielectric constant of 8 is indicated, MYCALEX K-8 will meet that exact requirement. Other applications might call for use of MYCALEX K-11 or K-12, etc.

MYCALEX K-10 already has been approved by the Army and Navy as Grade H1C5H4 Class H material (JAN-I-12). While other Class H materials are available, to the best of our knowledge these are all steatite or bonded titania or titanate types, obtainable only in relatively small dimensions and subject to wide variations in tolerances. MYCALEX K is available in sheets 14″ x 18″ in thicknesses of ⅛″ to 1″; in thicknesses down to 1/32″ in smaller sheets, and in rods ¼″ to 1″ in diameter.

Of importance also is the fact that MYCALEX K series can be molded to specifications, with electrodes or metal inserts molded in. It can be fabricated to close tolerances.

So far as we are aware, the MYCALEX CORPORATION OF AMERICA is the exclusive developer and only supplier of this kind of capacitor dielectric.

Write today for further information to Department 12.

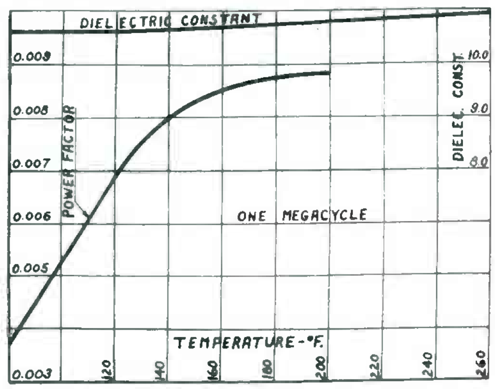
MYCALEX K-10

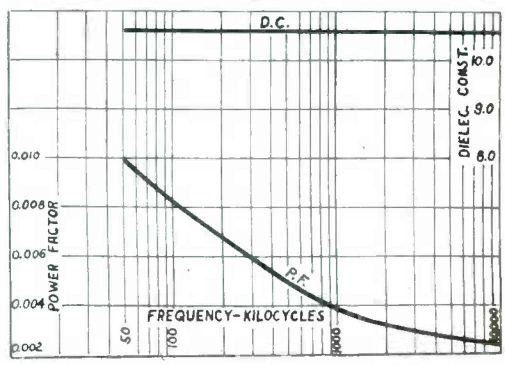
Grade H1C5H4, in accordance with JAN-I-12

Dielectric constant	10.6 } 1 megacycle
Q-Factor	310 } 1 megacycle
Loss Factor	0.034 } 1 megacycle
Volume resistivity	6.0 x 10^{12} ohms—cms.
Dielectric strength	270 volts/mil (0.10″ thickness)
Modulus of rupture	9000 lbs./sq.in.
Fractional decrease of capacitance with temperature change	0.0056
Fractional increase of capacitance with temperature change	0.0076
Porosity—no dye penetration after six hours at 10,000 lbs./sq.in.	

The above properties were measured in accordance with the procedures of JAN-I-12.

Density	0.116 lbs. per cu.in.
Specific gravity	3.22
Softening temperature	400° C.





Other Products of Mycalex Are:

MYCALEX 400—the most highly perfected form of MYCALEX insulation, approved by Army and Navy as Grade L-4 insulation. In sheets, rods and fabricated form.

MOLDED MYCALEX, available to specifications in regular shapes and into which metal inserts may be incorporated.

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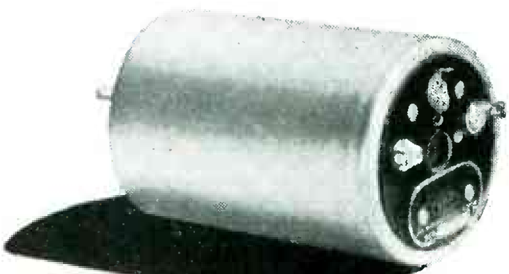
EAD

Now Available

CENTRIFUGAL BLOWER UNITS AND MOTORS

MODEL J 50 A BLOWER UNIT
60 CYCLES
115 VOLTS

Delivers 10 cu. ft. per minute of free air. Weight 21.5 oz. Overall diameter 3 11/16". Overall length 4 1/16".



POWERED BY MODEL J 49 C
60 CYCLES 115 VOLTS 1/300 H.P.

Weight 16 oz. Diameter 1 3/4". Length 2 11/16"

OTHER E. A. D. MOTORS

MODEL J31A—400 Cycles. 115 Volts. 1/100 H.P. Weight 15 oz. Diameter 1 15/16". Length 2 29/32".

MODEL J33D—400 Cycles. 115 Volts. 1/50 H.P. Reversible motor for intermittent duty or continuous fan duty.

MODEL J71—60 Cycles. 115 Volts. 1/50 H.P. Continuous duty. 3 lbs. diameter 3 5/16". Length 3 1/8".

MODEL J72—400 Cycles. 115 Volts. 1/15 H.P. Weight 3 lbs. Diameter 3 5/16". Length 3 1/8" for intermittent duty or for continuous fan duty.

OTHER CENTRIFUGAL BLOWER UNITS

MODEL J53—28 Volts, D.C.—Delivers 22 CFM.

MODEL J57—60 Cycles. 115 Volts. Centrifugal Blower. Delivers 110 CFM.

MODEL J80A—60 Cycles. 115 Volts. Axial flow. Delivers 65 CFM.

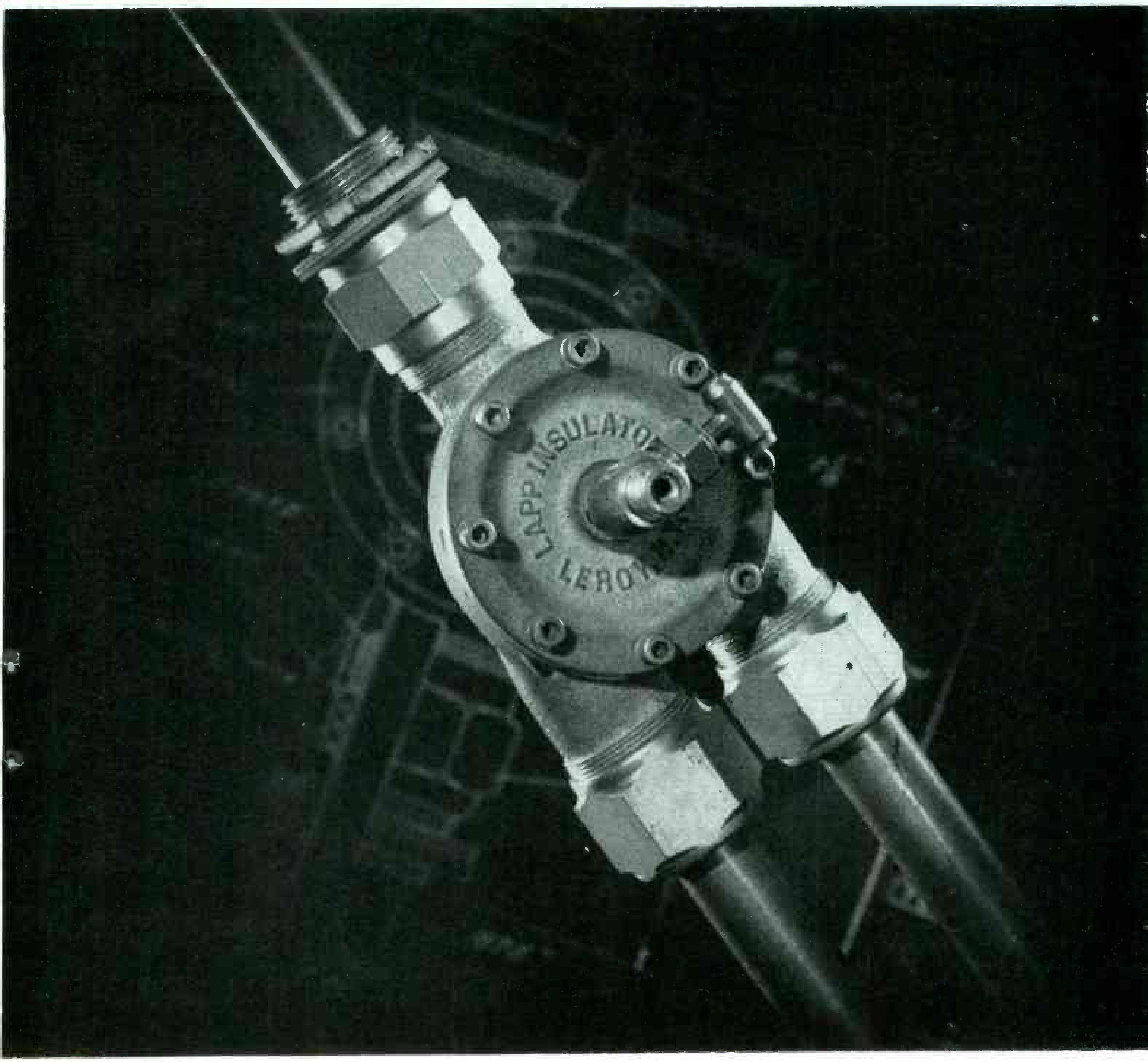
MODEL J51 BLOWER UNIT

400 CYCLES, 115 VOLTS

Delivers 22 cu. ft. per min. of free air. Weight: 21.5 oz., Diameter 3 11/16", Length 4 9/32".

EASTERN AIR DEVICES, INC.
An Affiliate of the Fred Goat Co., Inc., Est. 1893
585 DEAN STREET, BROOKLYN 17, N. Y.

JENSEN RADIO MANUFACTURING COMPANY • 6601 SOUTH LARAMIE AVENUE, CHICAGO 38, ILLINOIS



Electronic Parts: ENGINEERING AND PRODUCTION

The gadget above is a junction box for a co-axial gas-filled transmission line. It is one of a series of coupling units, end seals and other fittings for high-frequency transmission—designed and built by Lapp.

To this type of construction, Lapp brings several innovations and improvements. For example, such a line from Lapp parts is genuinely leak-proof. Every gasket is under spring loading, so there's no leakage created by vibration or thermal change.

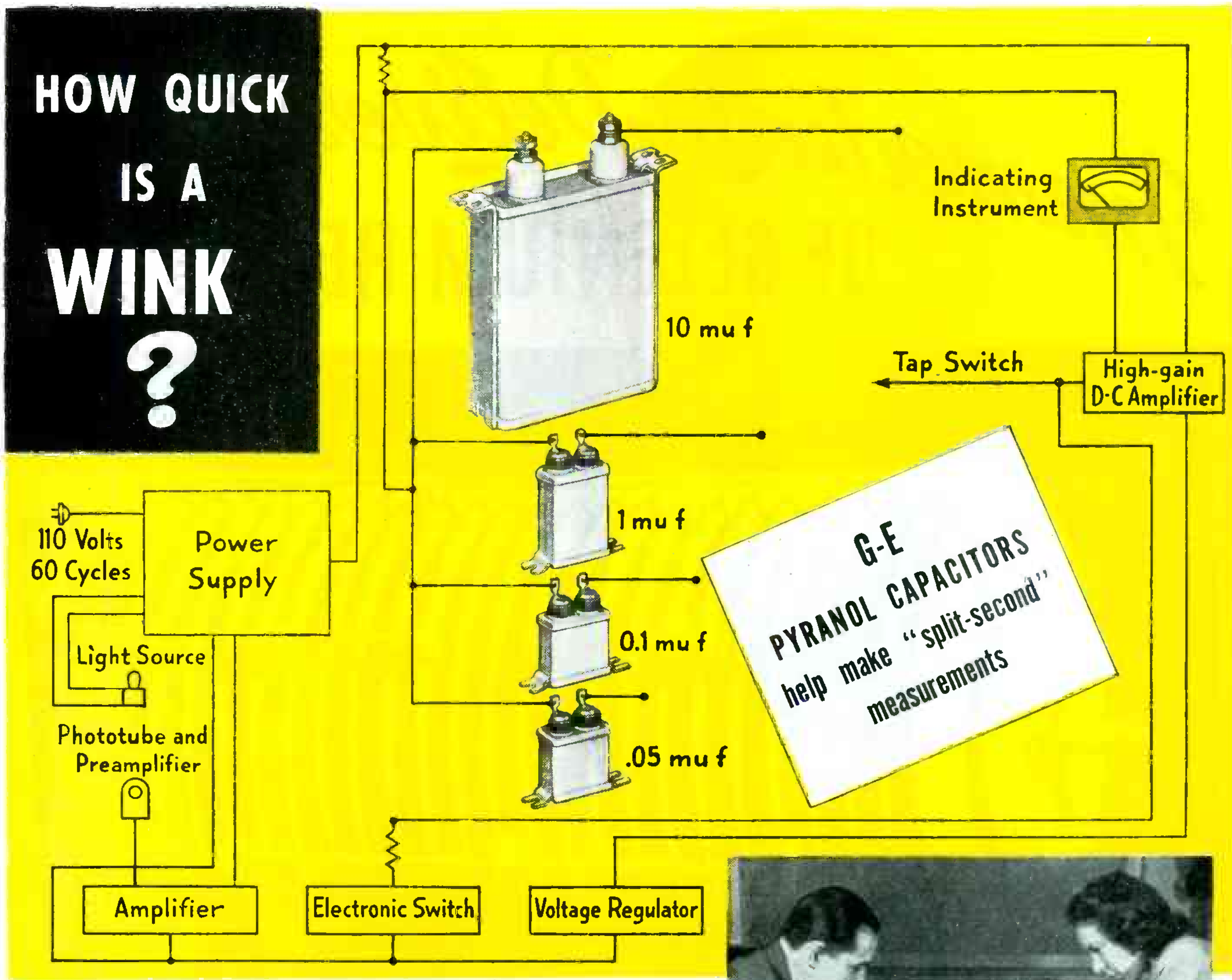
Whether or not you're interested in gas-filled transmission lines, you ought to know about Lapp. Here is an organization of engineers and manufacturers with broad basic knowledge of ceramics and their application. With experience in hundreds upon hundreds of special-purpose electronic parts, we have been able countless times to improve performance, or reduce costs, or cut production time through the application of our specialized skills to design and manufacture of parts involving porcelain or steatite and associated metal parts.

For quick and efficient assistance on a war production subcontract—or for the competitive advantage Lapp-designed and Lapp-built parts will give to you in the postwar battle—an inquiry to Lapp now may pay you dividends. *Lapp Insulator Co., Inc., LeRoy, N. Y.*

Lapp

ARMY E NAVY

HOW QUICK IS A WINK?



This sensitive electronic instrument accurately measures time intervals as short as 1/10,000 second. It is being used here to measure the time the man takes to react and turn off the lamp after it has been turned on by the girl. (Reaction time on this test: 175–200 milliseconds.)

Another new job for capacitors

WHILE we have not yet measured the quickness of a wink with the time-interval meter, we know that it will do more practical jobs like measuring the time required for a camera shutter to open, or the time that it remains open. This meter is also being used to synchronize flash-bulb contacts on camera shutters, test relay performance, and measure the velocity of moving bodies.

Here's how Pyranol* capacitors are used in its circuit: An external contact or a phototube, working through the amplifier, causes the electronic switch to close during the time period to be measured. While the electronic switch is closed, one of the Pyranol capacitors is charged at a constant rate through a precision resistor. Thus, the voltage developed across the Pyranol capacitor is a direct measure of the required time interval.

Four Pyranol capacitors and several charging resistors are used to obtain eight full-scale ranges (0.001, 0.003, 0.01, 0.03, 0.1, 0.3, 1, and 3 seconds). A tap switch on the instrument panel is used to select the correct Pyranol capacitor and resistor for the desired scale range.

An inverse feed-back arrangement holds the charging rate constant while the Pyranol capacitor is charging, and also corrects for leakage in several elements. The feed-back principle also enables the use of a direct indicating instrument to measure the capacitor charge, without discharging the capacitor.

The way Pyranol capacitors are used in this circuit may suggest a better way to do some job in one of your circuits. Remember that the high capacitance per cubic inch of Pyranol capacitors, their compact, space-saving shapes, and long life make them ideal for a wide variety of built-in applications.

Booklets on our various lines—h-f paper dielectric, h-f parallel plate, Lectrofilm, as well as Pyranol units—are yours for the asking. General Electric, Schenectady 5, N. Y.

*Trade-mark Reg. U.S. Pat. Off.

GENERAL ELECTRIC

BUY WAR BONDS

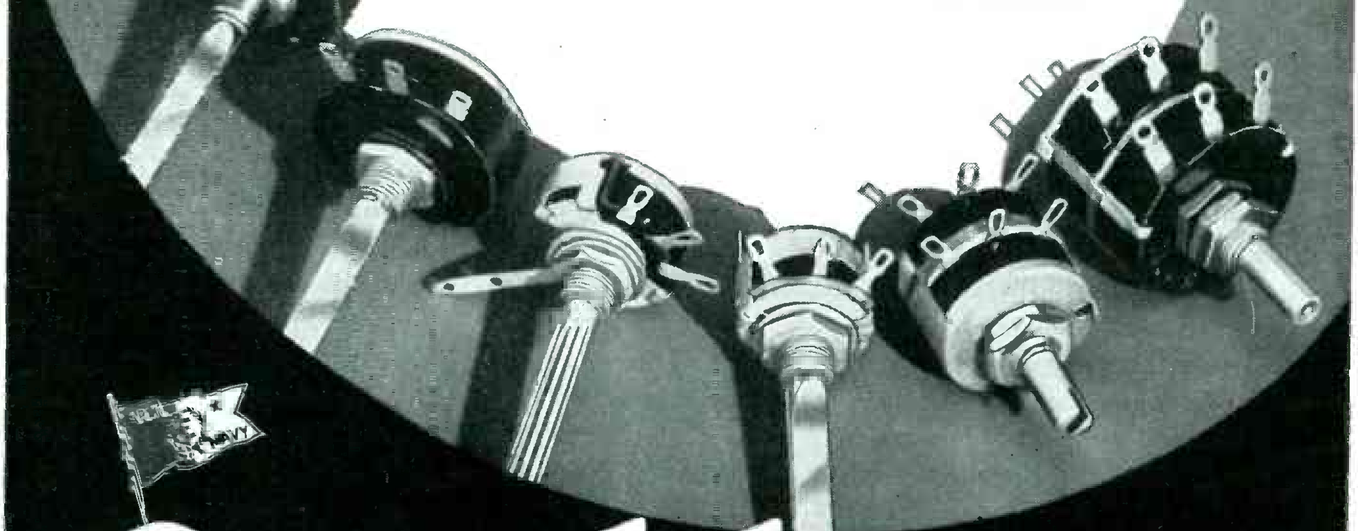
407-96-8700

Centralab STANDARD, MIDGET AND ELF Radiohms

● For more than two decades the name CENTRALAB on a volume control has been a synonym for QUALITY.

The long wall-type resistance sector, the smooth performance and the satisfactory operation of these controls are in no small measure responsible for the fame of Centralab. Whether for original equipment or replacement always specify

CENTRALAB Radiohms



Centralab

CRL

Division of GLOBE-UNION INC., Milwaukee

Producers of VARIABLE RESISTORS — SELECTOR SWITCHES — CERAMIC CAPACITORS, FIXED AND VARIABLE — STEATITE INSULATORS — SILVER MICA CAPACITORS

RUGGED-DEPENDABLE

...HOUR AFTER HOUR!

You can tell just by looking at it—this tube is built to l-a-s-t.

This new air-cooled Westinghouse Pliotron No. WL473 is small, compact and designed especially for dielectric and induction heating. It is extremely economical in operation, having the lowest cost per R.F. kilowatt hour of any tube in its class on the market today.

For technical data or any other information on the Pliotron No. WL473 or any Westinghouse Electronic Tube, consult your nearest Westinghouse Office or write to Westinghouse Electric & Manufacturing Company, Electronic Tube Division, Bloomfield, New Jersey.

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE

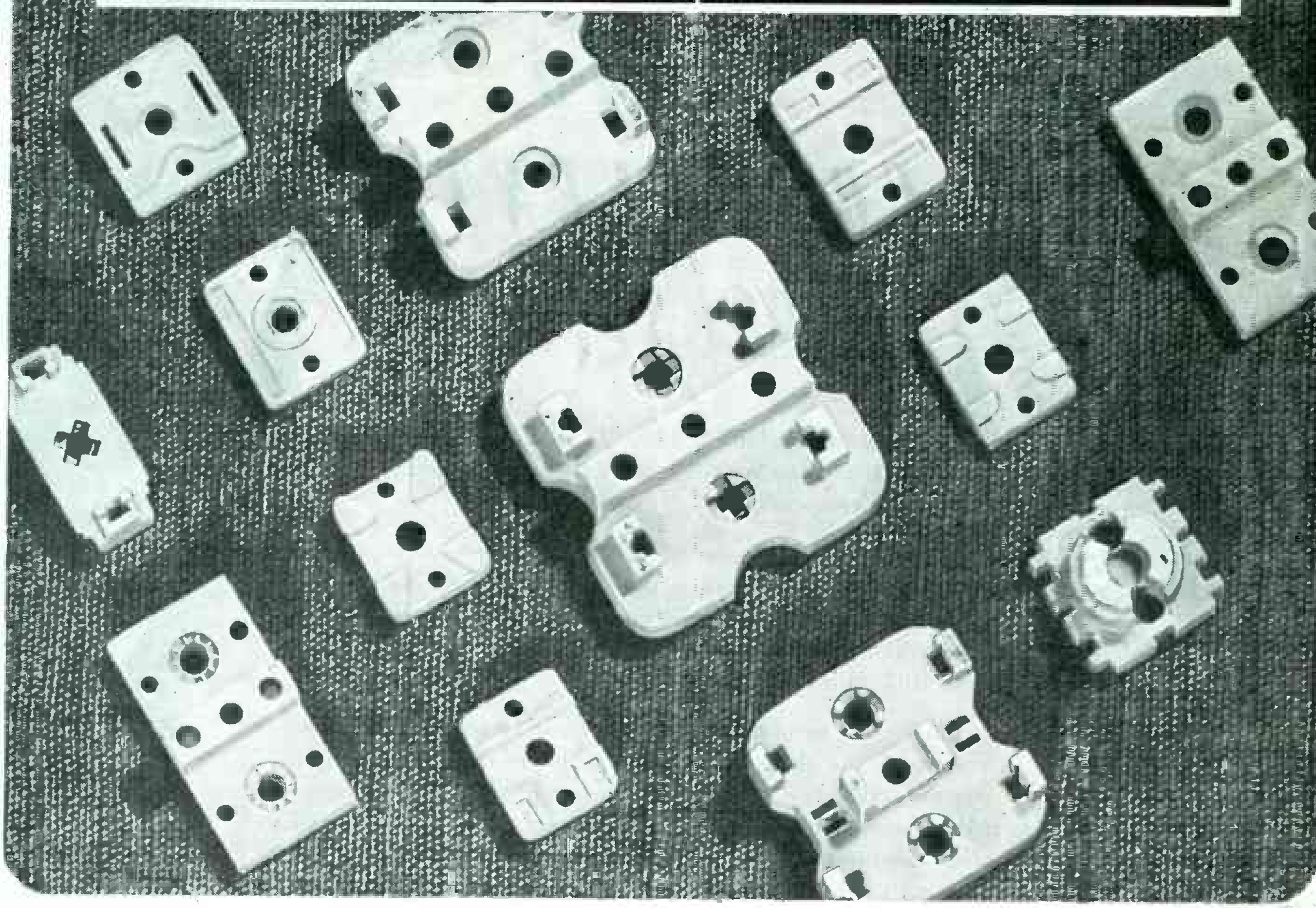
Quality Controlled Electronic Tubes


no curling irons
no electric shavers
no washing machines
no percolators
no air conditioners
RADIO COMPONENTS EXCLUSIVELY!
No, we don't claim to be a "Jack of all trades"! Our line is, and has been—for more than two decades—radio components.
When Uncle Sam sounded the sos for highest-standard, precision instruments in our specialized field we were ready to turn them out, and ship them out, in mass quantities to the far horizons of the war fronts of the world. This job still claims our all-out attention.
But we will be in a strategic position when reconversion time comes. For we shall return without undue effort or interruption to the production of our original line of variable condensers, tuning units, actuators and record changers. There'll be innovations and improvements, of course—and new items, too, such as our recently announced SPEAKER line—all obviously and logically in our specialized realm of radio components.
We still have capacity for urgent war assignments.
GENERAL INSTRUMENT
CORPORATION
829 NEWARK AVENUE
ELIZABETH 3, N. J.
The first in our industry to be so honored
ARMY E NAVY

Padder and Trimmer Bases

by

STUPAKOFF



- MECHANICALLY – ***STRONG***
- DIMENSIONALLY – ***ACCURATE***
- ELECTRICALLY – ***STABLE***

EXACTING characteristics are necessary for steatite bases used in the production of electronic equipment. The bases illustrated, produced by the Stupakoff method of precision manufacture, minimize production losses due to breakage and misfits in rapid assembly lines. Carefully selected, laboratory controlled materials reflect proper electrical characteristics into your completed assemblies. The highly vitreous state to which these bases are fired assures greater stability.

Stupakoff—manufacturers and developers of thousands of ceramic type insulators—offers specific solutions to *your* insulation problems. Modern production methods, trained personnel and competent engineering give assurance of sound ceramic service. Your inquiries will be given immediate consideration.

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STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Ceramics for the World of Electronics


ELECTRONIC ENGINEER'S
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PRICE $1.00
Compiled and Published by
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NATIONAL UNION RADIO CORPORATION
NEWARK 2, NEW JERSEY

ELECTRONICS DESIGNER'S

Now Available!

G-E CAPACITORS

that conform to

AMERICAN WAR STANDARD

Fixed paper-dielectric G-E capacitors that conform to American War Standard proposed JAN C-25 (superseding C-75.16—1944) are now available with characteristics E and F, and with capacitance tolerance of 10 per cent (K), in the following case styles:

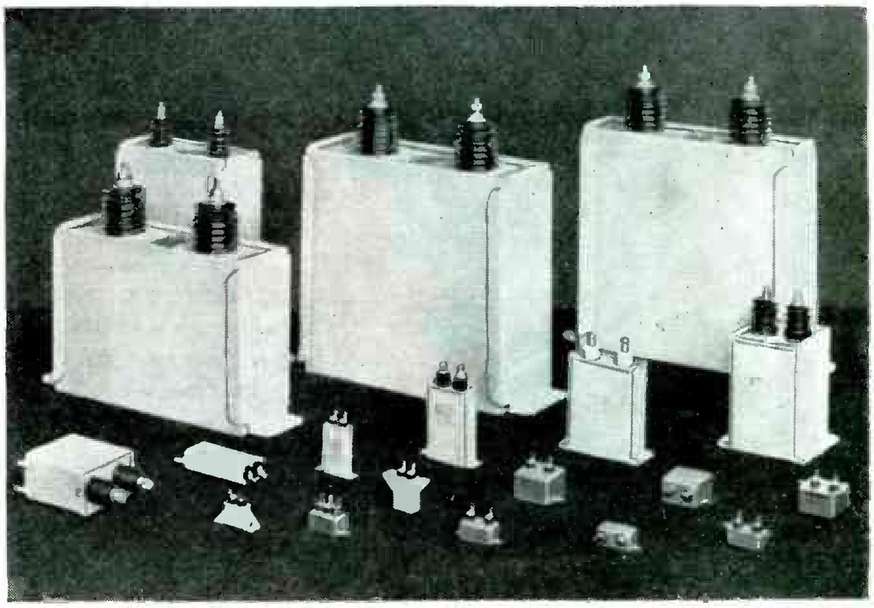
CP-50, -51, -52, -60, -62, -64, and -70.

The CP-70 units are available with B (solder lug) terminals, and with D and E (pillar insulator) terminals.

Removable mounting brackets of either the footed type or the screw-spade-lug type can be supplied for mounting the CP-70 units.

The service reliability of these G-E capacitors is backed by more than a quarter century's experience in the manufacture of capacitors of all types. For complete data, write for Bulletin GEA-4357.

Buy all the BONDS you can
—and keep all you buy



Some of the fixed paper-dielectric G-E capacitors that conform to American War Standard

STANDARD RATINGS

CP-50, -51, AND -52 — **CHARACTERISTIC F**

Voltage	Range of Capacitance Values in Mu f		
	Single Section	Dual Section*	Triple Section*
600	.05 to 2.0	.05 to 1.0	.05 to .5
1000	.05 to 1.0	.05 to .5	.05 to .25

CP-60, -62, AND -64 — **CHARACTERISTICS E AND F**

Voltage	Range of Capacitance Values in Mu f	
	Single Section	*Dual Section
600	.05 to 1.0	.05 to .5
1000	.01 to .5	.01 to .25
1500	—	.01 to .05

CP-70 (SINGLE SECTION) — **CHARACTERISTICS E AND F**

Voltage	Range of Capacitance Values in Mu f		
	B Terminals	E Terminals	D Terminals
600	.25 to 10	.25 to 10	—
1000	.1 to 15	.1 to 15	—
1500	.1 to 15	.1 to 15	—
2000	—	.1 to 15	—
2500	—	.1 to 12	.1 to 6
3000	—	.1 to 6	.1 to 6
4000	—	.1 to 4	—
5000	—	.1 to 4	—
6000	—	.1 to 2	—
7500	—	1.0 to 2	.1 to .5
10000	—	.1 to 2	—
12500	—	.5 to 2	.1 to .25

*Capacitance per section of dual and triple section units. Dual and triple section units have capacitance tolerance of plus 20 per cent, minus 10 per cent (V).

GENERAL ELECTRIC

DIGEST

Timely Highlights on G-E Components

A LOT OF INSTRUMENT

in a little space

These thin, internal-pivot panel instruments have high torque, good damping, and a lightweight moving element that withstands vibration. They respond rapidly and accurately. They give you more instrument in less space, because the internal-pivot construction makes the entire element assembly 20 per cent thinner than outside-pivoted types. Ask for details of the Type DW voltmeter or ammeter—milli, micro, or radio frequency. Bulletin GEA-4064.

TO KEEP TABS ON TIME

For applications in which it is desired to keep track of the total operating time of electronic tubes or other electric devices, our Type KT time meters can provide an accurate record—in hours, tenths of hours, or minutes. Powered by precise, long-lived Telechron synchronous motors, these meters are available for panel or conduit mounting, and in portable form. For use on 60-, 50-, or 25-cycle circuits of 11 to 460 volts, to match the operating characteristics of various machines. Bulletin GEA-3299.

VOLUME-LEVEL INDICATION

via vu standard

To standardize measurement of sound, and make broadcast monitoring more effective, these vu volume-level indicators were developed to meet the rigid electric, dynamic, and mechanical specifications formulated by NBC, Columbia, and Bell Telephone Laboratory engineers. This G-E instrument employs the vu, a new standard of measurement. The zero reference is one milliwatt in a load of 600 ohms, and the vu unit is numerically equal to the number of decibels above or below this reference level. Ask for Bulletin GEA-3145A.

Capacitors • Sensitive control and time-delay relays • Limit switches • Motors, dynamotors, amplidynes • Motor-generator sets • Alnico magnets • Small panel instrumens • Formex magnet wire • Radio transformers • Switchettes • Selsyns • Chokes • *also tubes, crystals, plastics products, insulation materials, and many others*

General Electric Company, SecB642-6,
Schenectady 5, N. Y.
Please send me

...... GEA-4357 (on fixed paper-dielectric capacitors)
...... GEA-4064 (on small panel instruments)
...... GEA-3299 (on time meters)
...... GEA-3145A (on volume-level indicators)

NAME ....
COMPANY ....
ADDRESS ....
CITY .... STATE ....

When a laboratory instrument goes to war ☆ ☆ ☆

- Use of mineral-oil-impregnated, hermetically-sealed, paper capacitors.
- Increase in voltage rating of certain capacitors for greater factor of safety.
- Addition of mounting straps on capacitors subject to breakage in transit.
- Use of high-voltage wire in high-voltage circuits in place of previous standard wire.
- Addition of tube clamps for tubes subject to jarring loose in transit.
- Addition of flange on chassis assembly to provide extra strength against rough handling.
- Addition of four bank supports to prevent breakage of banks during rough handling.
- Numerous mechanical refinements — better sockets, elastic stop nuts, rolled bead on cathode-ray tube shield, additional brackets.
- Change of negative rectifier from Type IV to Army-Navy preferred Type 6X5GT/G.
- Change from 1/4-watt neon tube to Army-Navy preferred Type 991 voltage regulator tube for greater stability.
- Inclusion of frequency range adjustment potentiometer in time base as a factory adjustment, for accurate time-base frequency setting.
- Change from Type 6F8G tubes to Army-Navy preferred Type 6SN7GT, with improved performance.
- All composition resistors operated at less than 40% of power rating; capacitors at less than 80% of voltage rating.

DuMONT Type 208B OSCILLOGRAPH

Out of the rigorous trials of military service there emerges a better Type 208 DuMont Oscillograph.

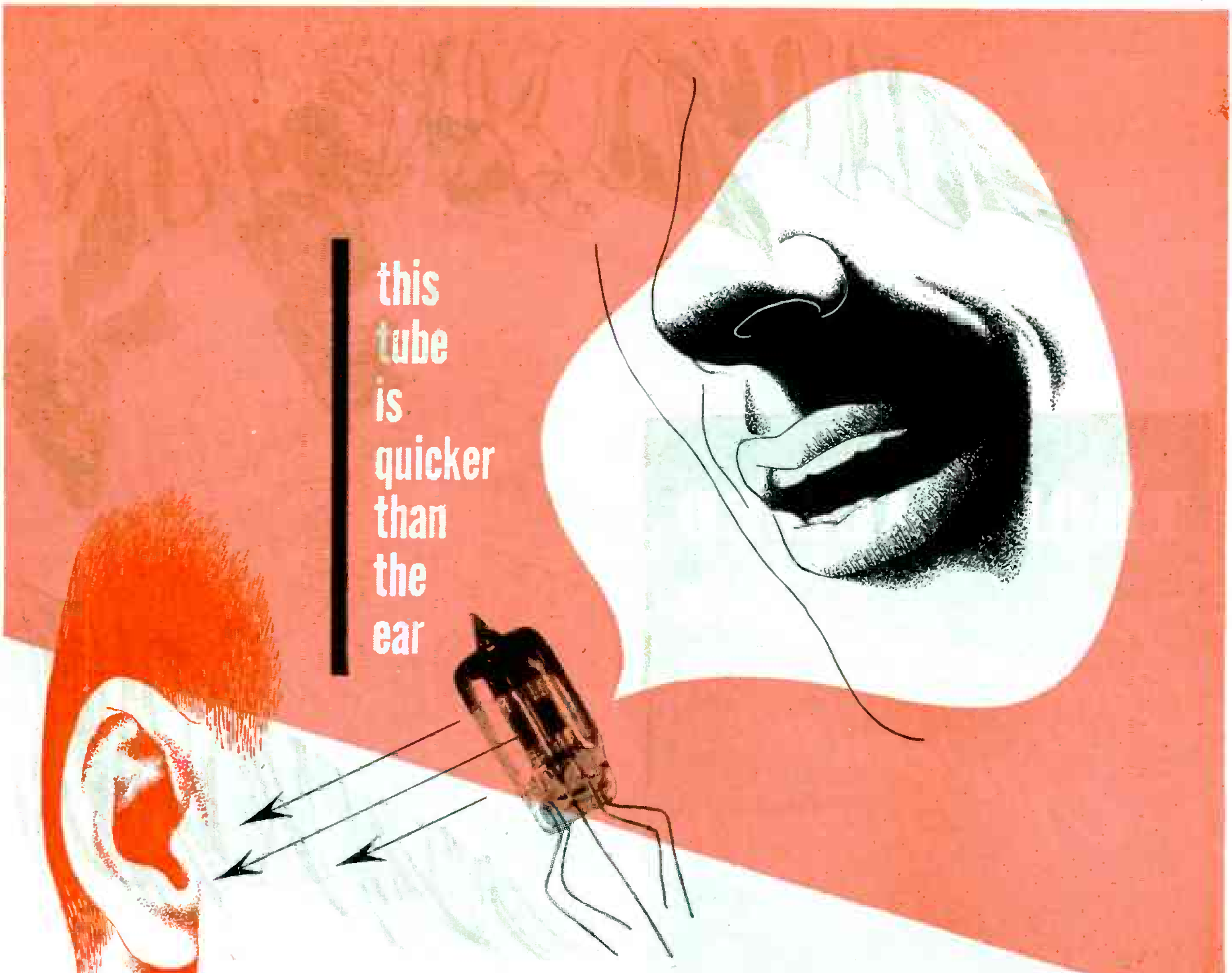
Listed herewith are some of the major design changes and refinements effected during the past two years and currently incorporated in the Type 208B. In every instance the change or refinement has been incorporated in order to improve electrical or mechanical performance.

Thus an already popular oscillograph which has found the widest usage in peace times becomes a better, more rugged, and more dependable instrument under the trying conditions of field service.

Write for literature

DUMONT *Precision Electronics & Television*

ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: WESPEXLIN, NEW YORK



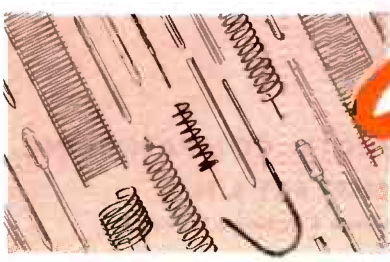
callite components are at work in this pocket-size miracle

The Sonotone hearing aid, with its midget air and bone conduction ear receiver, gives an acoustic output of 100 decibels in a device so small it fits into a vest pocket.

Designing 2 and 3-tube amplifier circuits with an associated microphone within such minute space involved the development of highly efficient tubes just about an inch long.

In these tubes, Callite fine molybdenum and tungsten grid and filament wires are specified by Sonotone—Callite "moly" for its excellent working properties and complete freedom from oxidation—Callite thoriated tungsten wire for its rugged strength, plus required electronic emission values.

For cooperation in designing and applying metallurgical components, call on Callite. Our specialized knowledge and experience may save you time and money. Callite Tungsten Corporation, 544 Thirty-ninth St., Union City, N. J. Branches: Chicago, Cleveland.



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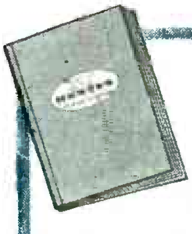
How to get UNIFORM Spring Performance



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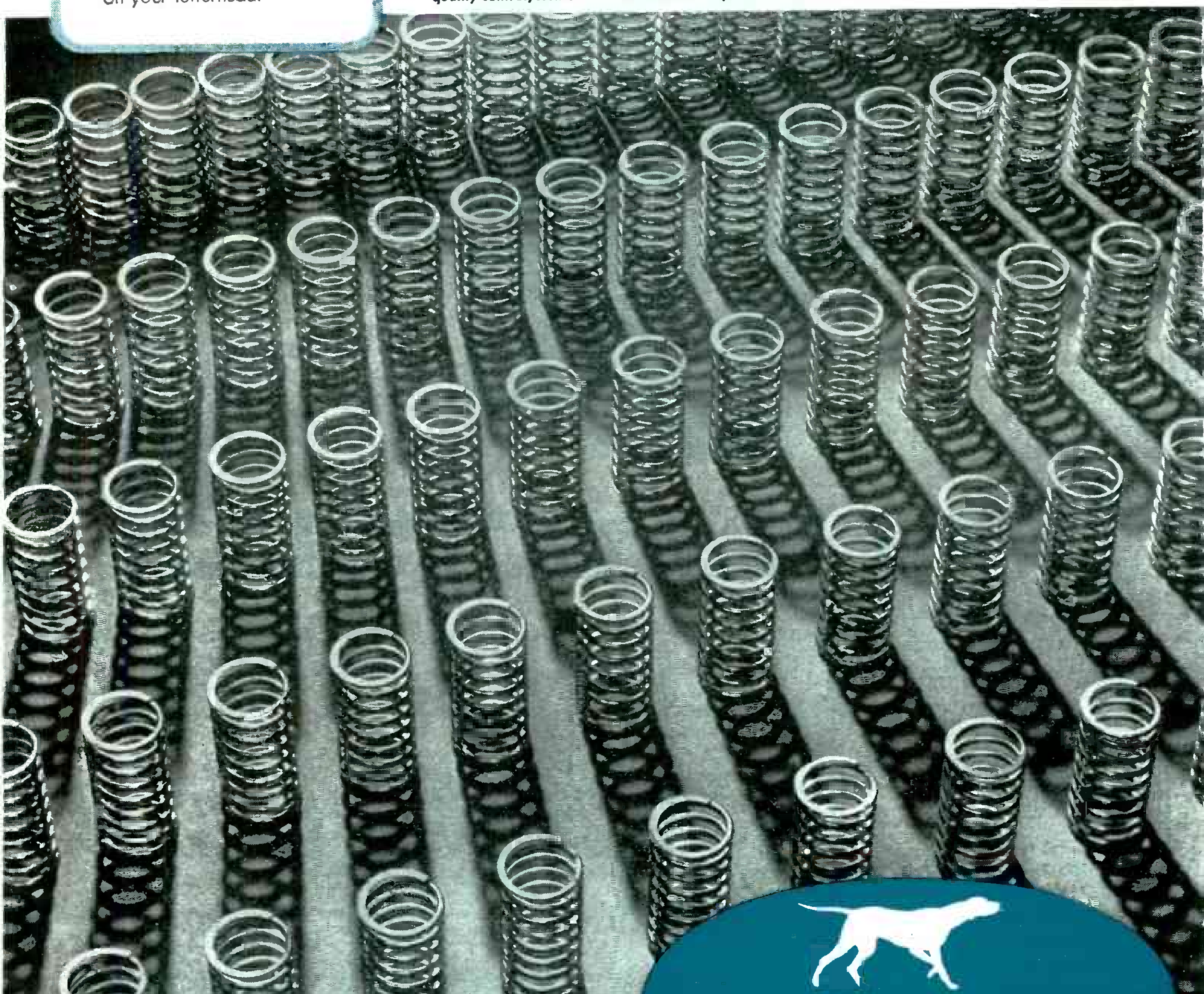

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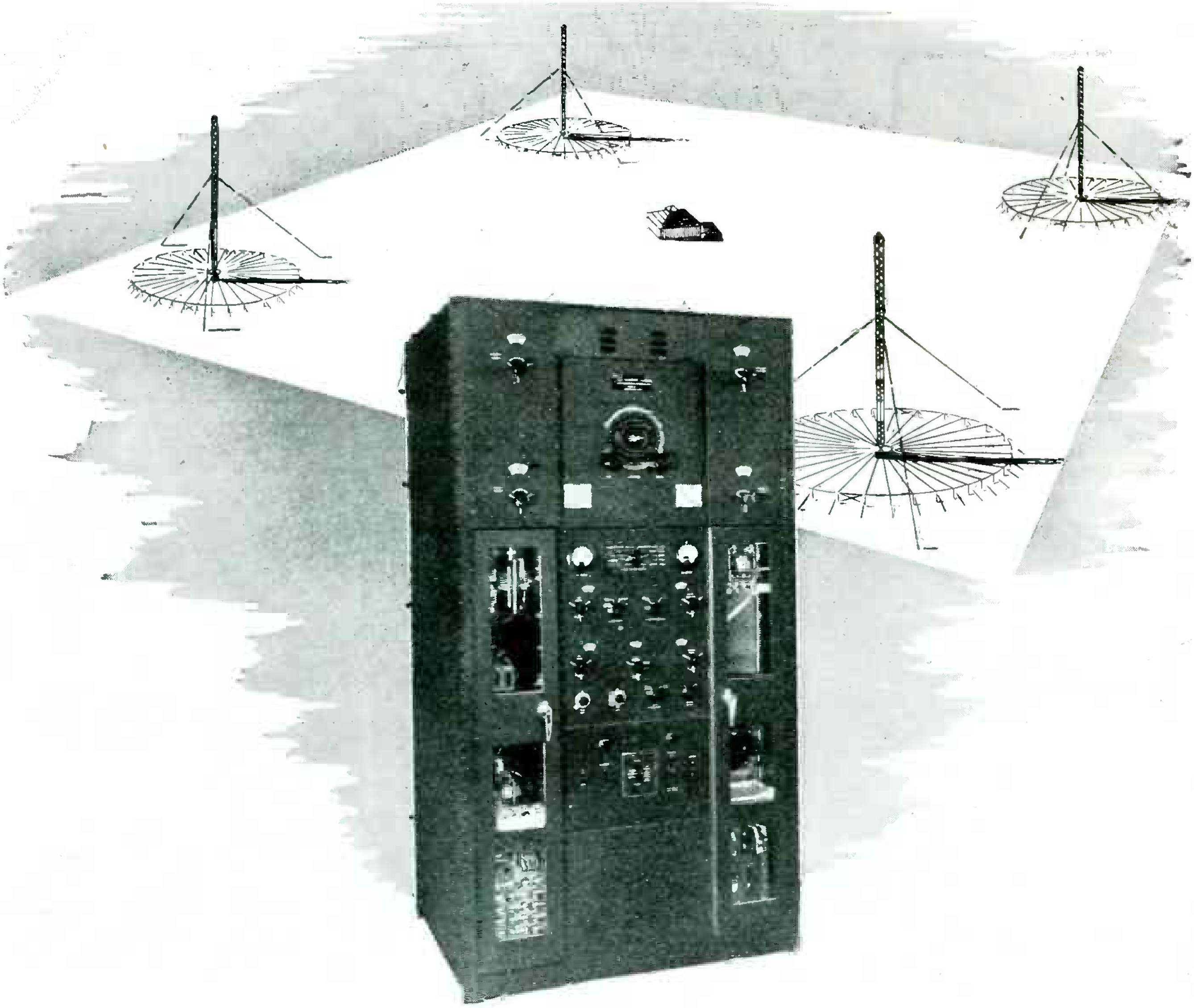

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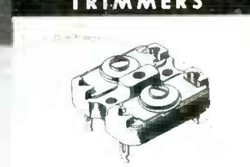

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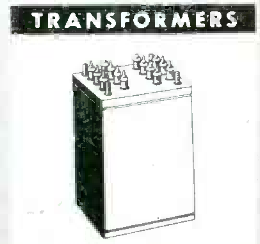

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AMERICA WANTS COMPETITION

Only American Initiative Can Preserve It in World Trade

AMERICANS generally agree upon what constitutes a desirable pattern of international economic relationships. We want an expanding world trade, with minimum recourse to government-imposed trade barriers and discriminatory trading arrangements, and offering ample scope for competitive private enterprise. Because they are necessary to such trade, we want also stability of exchange rates, and national currencies that are mutually convertible at least for the settlement of current accounts. We want, too, arrangements to facilitate long-term capital loans with security to the lender and advantage to the borrower.

Few other nations subscribe to these aims with enthusiastic conviction. Some reject them flatly as impractical under the conditions likely to prevail during the postwar period, or achievable only at prohibitive cost to their domestic economies.

Unless, therefore, we can formulate a practical and comprehensive program to carry out our aims, and convince other nations that we will take a sustained and responsible part in making it effective, the international trade of the world surely will be conducted under a system of exchange controls, bilateral agreements, cartel bargains, import quotas, and direct government purchasing arrangements that are the very antithesis of the competitive system that we favor.

To agree upon a concrete American **program**, and to convince other nations that it is to their advantage as well as ours to accept it, is a major task of economic statesmanship. It entails reversing a trend which has persisted since World War I, and which has been intensified during the depression years of the nineteen-thirties and by the exigencies of World War II.

Clearly, that is not a task to be assumed lightly. We can hope to be successful only if (1) we have a deep conviction that what we seek is fundamentally important to the American interest, and (2) if we will take pains to understand why other nations fear that such a program may jeopardize their interests, and then make whatever accommodations may be necessary to resolve their doubts.

An expansive foreign trade policy has been advocated so vigorously and repeatedly in America recently that The Economist (of London) comments wryly upon what it terms the ironic circumstance that "the acceptance of the principles of free trade by the more literate (American) public should come at a time when the doctrines in their simplest nineteenth-century form have been pretty generally emasculated in fact and repudiated in principle by the rest of the world".

☆ ☆ ☆

Why are we opposed to managed world trade, and for competitive world trade?

First, we are against rigged and managed international markets because we know that successful participation necessitates a comparable degree of control over the domestic economy as well. There is little debate of this fact, and those nations which accept a managed external trade as a necessary protective measure are generally willing to pay the price in internal regimentation. We are not. For us to do that would be as alien to our genius as it is repugnant to our conviction.

Second, we believe that the United States will be able to compete successfully in world markets, even though we have, and intend to maintain, wage scales far higher than those of the nations whose competition we must meet.

There is impressive evidence to substantiate the soundness of this conviction:

1. Wage scales, of themselves, do not determine the competitive position. They are meaningful only when translated into labor costs, by dividing wage rates by units produced. **A recent War Production Board study shows that in manufacturing industries generally, during the period immediately before the present war, production per man hour in the United States exceeded that in the United Kingdom, Germany and Soviet Russia by a ratio of more than 2½ to 1, and that of Japan by more than 4 to 1.** When comparison is made with available wage data, it appears that our labor costs are generally on a competitive plane.

2. Perhaps the best evidence of our ability to compete in export markets is the record of our demonstrated capacity to do so in the past. **During the entire period between World Wars I and II, the United States consistently commanded a greater share of the world's export trade than any other nation,** although the United Kingdom took a larger percentage of world imports.

3. We have been particularly successful in world trade competition in the export of machinery, vehicles, a variety of manufactured specialties, and certain agricultural products. Except in the last-named field, there is every evidence that we enjoy genuine competitive advantage over other nations, and this advantage will have been increased rather than diminished by developments during the Second World War. It is noteworthy that the goods in which we have been able to compete most successfully have generally been the products of our high wage industries rather than those in which low wages have prevailed.

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It is clear that, on a price basis, we shall be able to compete successfully in postwar markets in numerous lines. It is equally clear that such an opportunity is by no means of negligible importance to our own economy as a whole. During the years in which the censuses were taken between 1909 and 1939, our exports amounted to from 7 to 16 per cent of our entire production of movable goods. **In the year 1938 our exports in each of the following lines accounted for more than 10 per cent of total domestic production of the particular product.**

(The figures in parenthesis are the percentages of total production exported.)

CRUDE MATERIALS: Phosphate rock (51.5), cotton (30.5), tobacco (29.4).

FOODSTUFFS AND BEVERAGES: Linseed (49.4), dried fruits (36.2), canned sardines (29.4), rice (21.0), fresh pears (15.9), canned salmon (13.8), canned asparagus (13.2), canned fruits (13.0), wheat (12.2), lard (11.7).

SEMI-MANUFACTURES AND FINISHED MANUFACTURES: Refined copper (53.1), paraffin wax (46.3), gum turpentine (42.6), carbon black (40.8), gum rosin (38.0), borax (35.9), crude sulphur (35.6), aircraft and parts (26.8), office appliances (22.3), carbons and electrodes (21.8), printing and bookbinding machinery (18.2), agricultural implements and machinery (17.0), biologic pharmaceuticals (15.3), industrial machinery (14.4), dental instruments and supplies (14.3), automobiles (14.1), benzol (13.3), goat and kid upper leather (12.8), refined lead (12.0), radio apparatus (11.8), caustic soda (11.4), refined mineral oils (10.6).

It is of major concern to all engaged in these lines of activity and in many others that foreign markets be not closed to us. It is particularly to our interest to have export outlets for our war-expanded capital goods and equipment industries. Since we undertook an important percentage of such expansion in order to furnish munitions to our Allies, it is reasonable to ask their cooperation in cushioning what inevitably must be a drastic readjustment here. The case is strengthened by the fact that the postwar world will desperately need the equipment items that we, alone, can supply.

But our demonstrated ability to compete on a price basis will not, of itself, assure us of foreign market outlets. Transportation costs, quality of product, marketing skill, technical and repair service—all are basically important. Still more important are non-discriminatory open markets and the command of dollar exchange by prospective purchasers. Our export potentials will surely be cramped in a world organized on the basis of bilateral deals and exchange controls. The availability of dollar exchange must depend upon the level of American imports and the volume of American capital loans.

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How are we to explain the skepticism of other nations toward an order which to us seems so clearly to represent not only our interest but the long-range interest of the world as well?

Soviet Russia, of course, is committed to conducting its external trade through its central government. But what of the United Kingdom? Why are there so many British voices that counsel the abandonment of what has been Britain's traditional position for more than a century? If we can understand that, we shall understand the dissent from our position of most nations whose economic positions have weakened and whose fiscal problems have multiplied during the two World Wars and the ill-starred period between them.

Essentially, their case is this:

Partly, they were forced into managed external trade policies by the Axis self-sufficiency programs, adopted in preparation for aggressive war. That can be corrected only by crushing the Axis, and by establishing a world security system that will make self-sufficiency a less compelling need.

But primarily, the reluctance of peaceably inclined nations to forego restrictive controls over postwar foreign trade stems from a deep-seated fear that is even more difficult to resolve. They fear, on the basis of past experience, that their efforts to meet payment balances arising from normal foreign trade would force a deflation of their internal economies, affecting prices, credit, wages, and finally employment. Faced with the choice, as they see it, between making adjustments in foreign trade or in their domestic economies, they lean toward the former as, at worst, the lesser of two evils.

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Since the kind of world trade system we seek is dependent upon international arrangements to assure reasonable stability of exchange rates between national currencies, we are challenged to find a formula that both will provide this and at the same time allay what other nations believe are legitimate fears with respect to their domestic economies.

But at least two major steps toward resolving such doubts can be taken upon our own initiative without recourse to the intricate process of international negotiation.

One is the rational overhauling of our tariff system, to provide other nations with increased opportunity to export to us. We can, and should, do this in a way that avoids undue cost to any segment of our economy.

The other, and probably the greatest contribution we can make toward winning a reluctant world to our point of view, will be to offer ample and convincing evidence that we are ready and able to provide a high level of employment in the United States. If we can do that, the rest of the world will wish to expose itself to our influence rather than to insulate against it, since prosperity here is the greatest single contributing factor to worldwide prosperity.

Balance of payment problems are minimized in a world of thriving trade. Britain would have little reason to resort to exchange controls if the total of postwar world imports and exports reaches an 80 billion dollar level. She may well be in a desperate plight if it should revert to the 1935 level of 40 billions.

☆ ☆ ☆

The United States wants a world in which private enterprise and competition play a major role. To obtain such a world will require a wiser, more understanding and firmer world leadership than this nation, or perhaps any nation, ever has exerted heretofore.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Co., Inc.

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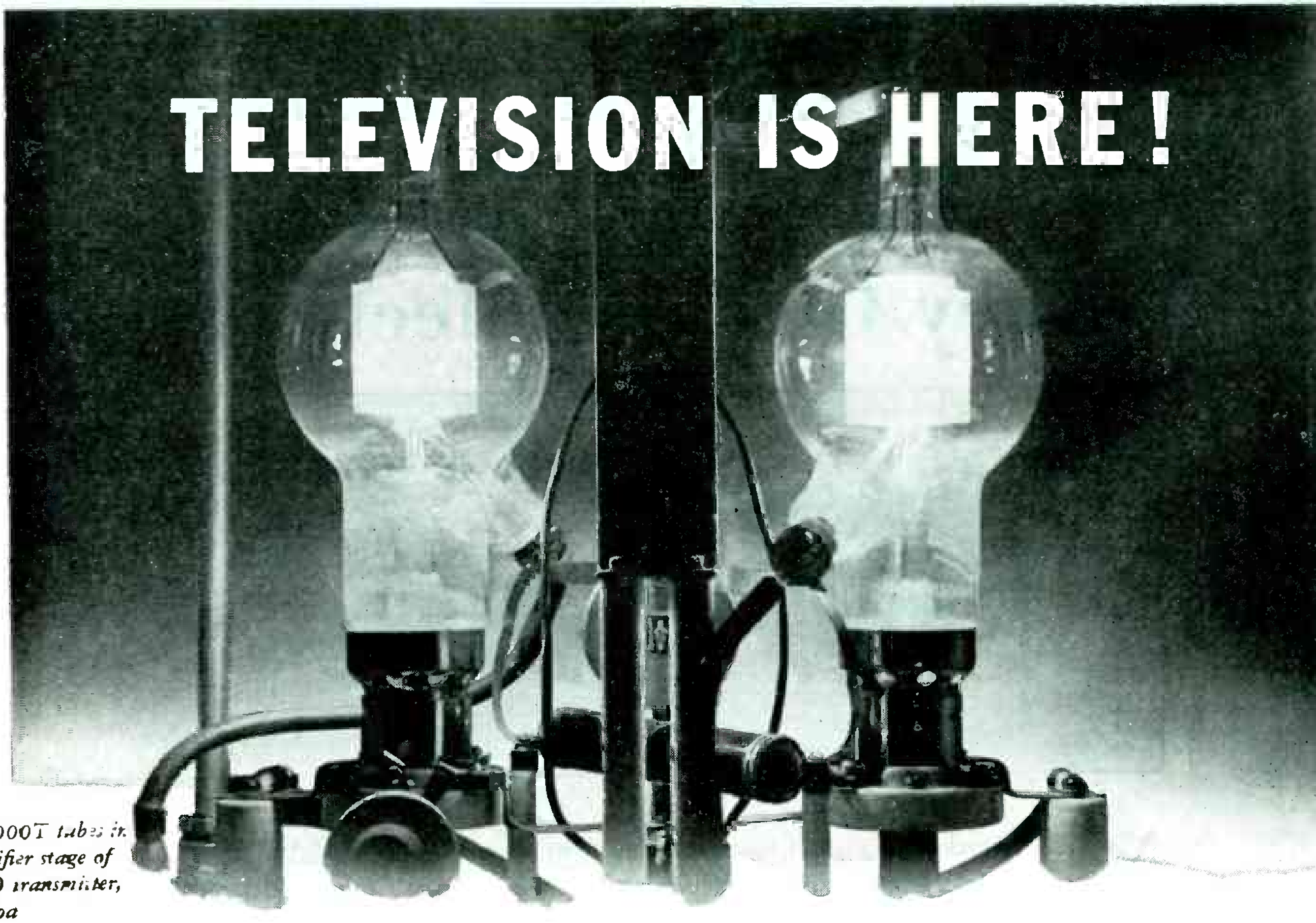

Eimac 1000T tubes in an amplifier stage of W6XAO transmitter, Hollywood

At Don Lee Hollywood...Station KTSL using EIMAC TUBES *since* 1938

Julia Lee Wright, noted Home Economics Director of "The Family Circle" magazine being interviewed, and telecast revealing tricks of her trade.

Two young comedians, Robert Sweeny and Hal March, currently on transcontinental radio show, give a preview of their talents for television broadcast over W6XAO.

Write for your copy of Electronic Telesis—a 64 page booklet fully illustrated—covering the fundamentals of Electronics and many of its important applications. In layman's language.

Work on television station W6XAO (Commercial station KTSL) began in November 1930; and thirteen months later, Dec. 23, 1931, it was on the air on the ultra high frequencies, the first present day television to operate on schedule. Today the station occupies elaborate copper sheathed studios which stand 1700 feet above Hollywood with an antenna on a 300-foot tower.

The program log shows almost every type of presentation. Highest in interest and achievement are the remote pick-ups and special event broadcasts made simultaneously or recorded on film for release later. Studio presentations, especially those directed to war activities, have become a duration standard.

Under the direction of Harry R. Lubcke, television station KTSL will be in daily schedule immediately after the war. Mr. Lubcke says: "We have been using Eimac tubes in our television transmitter since about 1938... We have found them good and reliable performers...their design is such that a favorable ratio of power output to tube and circuit capacitance is obtained... we look forward to using new Eimac tubes which may be forthcoming."

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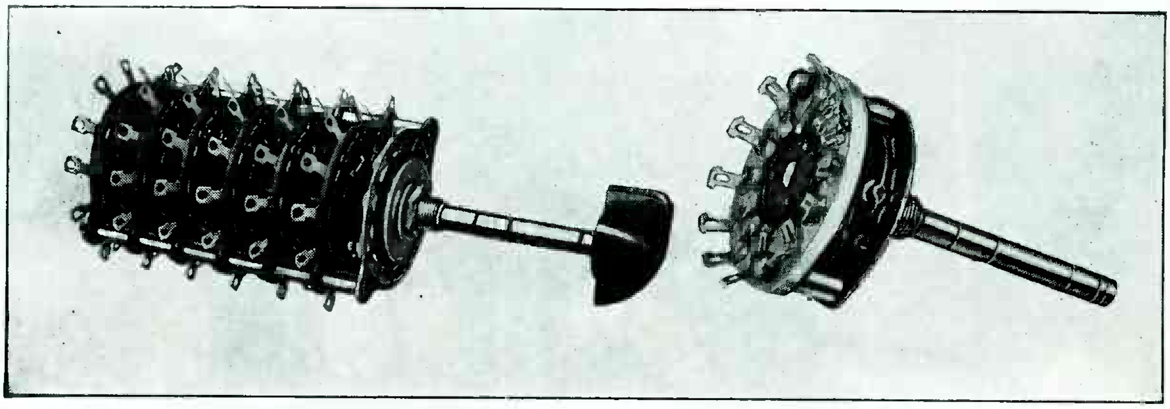
Mallory Circuit Selector Switch



NOTHING makes a product more saleable than ease of operation. And nothing will make your electrical or electronic circuits operate more easily . . . more dependably . . . over a longer lifetime . . . than a Mallory Circuit Selector Switch.

These switches, rotary types capable of handling an almost infinite number of circuits as well as both single and multiple push button switches, have *special advantages for use in export products.* They can be fully "tropicalized" to withstand extreme humidity and high temperatures and to prevent the growth of fungus. For aircraft use or export to frigid climates, special lubricants assure efficient operation in sub-zero temperatures.

Other advantages include:

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- "Hill-and-valley" indexing of rotary switches for smooth, positive action.

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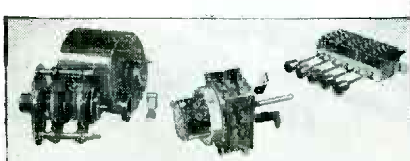

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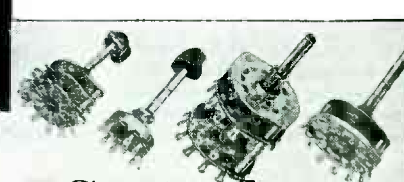


Industrial and Electronic Switches

CROSS TALK

▶ **CULTURE** . . . Before the present war, it was believed rather widely that the Germans led the world in scientific endeavor. Whatever the truth, there is no doubt that German text books were translated into all the languages of Europe and in this manner transmitted German culture and German ideals to all the people of that war-torn land. Even if the national spirit of the individual peoples into whose schools these texts found their way appeared in the translations, the illustrations were German and showed German apparatus. Laboratory equipment—microscopes, electrical instruments, research tools of all kinds—was invariably German.

At the end of the present conflict, it is extremely doubtful if Belgians, French, Scandinavians and other freed nations will wish to perpetuate this situation. Universities wrecked by the Nazis will hardly be reequipped with Nazi instruments—provided other apparatus is available. America has an incredibly important opportunity in this circumstance. Not only must the hated culture be removed from schools and scientific laboratories, but it must be replaced by one founded on more democratic ideals. Manufacturers of measuring equipment, upon which any scientific course of study is founded, must be prepared to engage in international distribution to a vastly greater extent that heretofore. Publishers of text books should have arrangements whereby American books are translated into the languages of Europe. The immediate value in terms of business is not the only one that will accrue by such preparedness; it is the long-term benefits that will be most important.

▶ **IRE** . . . After many years of "living around," first here, then there, the Institute of Radio Engineers is embarking on a campaign for funds from its members and from its friends in industry. The funds are to be used in purchasing a suitable headquarters in New York City and for maintaining those headquarters. This "once in a lifetime" campaign merits the support of every individual, every group which has a stake in the future of electronics.

Since the IRE has maintained its headquarters staff in the McGraw-Hill building for many years, opportunity has been provided for the staff of ELECTRONICS to get acquainted with the IRE staff and to know the difficulties under which that staff works. Cramped into quarters much too small for the volume of work to be done, the situation at present is critical. The time is ripe for a move. This time the move should be into a building owned by the Institute itself.

Since 1940 the membership of IRE has doubled; the volume of work connected with the mere job of keeping track of members so that they receive the *Proceedings* regularly cannot be conceived by anyone not experienced in the publishing business. In addition, the correspondence with Sections and with the many important committees is heavy and is growing.

Providing proper space and equipment and manpower for headquarters functions, however, is not the only reason which should impel members and industry to generously back this campaign.

No American enterprise owes more to engineering than does electronics; and if the engineer is to assume his rightful place in this vast new industry, he must be backed by a strong professional society. Proper housing is a most important step in the development of that society.

▶ **FCC** . . . The "blue" book report of the FCC giving the proposed allocation of frequencies from 25,000 kc to 30,000 Mc provides most stimulating reading. Regardless of how individuals may feel about specific allocations, the overall effect of reading the report is respect for the handling of such a tremendous job with such foresight and courage. This report, with subsequent modifications, will be a guidebook to the future of radio communication.

The FCC Allocation Plan

An appraisal of the technical and economic significance of the proposal. New and expanded services in the 25 to 30,000-Mc region present many opportunities for electronic industry expansion, in industrial as well as in communications applications

THE REPORT of the FCC on proposed allocations from 25 Mc to 30,000 Mc, issued January 16th, is in many ways a unique document in the history of governmental regulation. It is unique because it is strictly an engineering report. Nowhere in evidence is the government-vs-industry attitude which has often characterized such reports in recent years.

The report indicates that the electronic industry is not only expected but freely invited to produce goods required to make the allocation plan a reality, and to sell it to waiting consumers without fear of a sudden change of rules. The rules are set up to protect the consumer of goods and services.

The details of the proposed allocations are shown in the accompanying chart and table. The chart compares the FCC proposals with the recommendations made by Panel 2 of the Radio Technical Planning Board and the Interdepartment Radio Advisory Committee at the Allocations Hearing held last October (ELECTRONICS, December 1944, page 92). Generally speaking, the FCC has followed the RTPB and IRAC recommendations. The table serves as an index to the type of service, the number of channels, and channel widths, which cannot be shown in detail on the chart.

F-M Shifted to 84-102 Mc

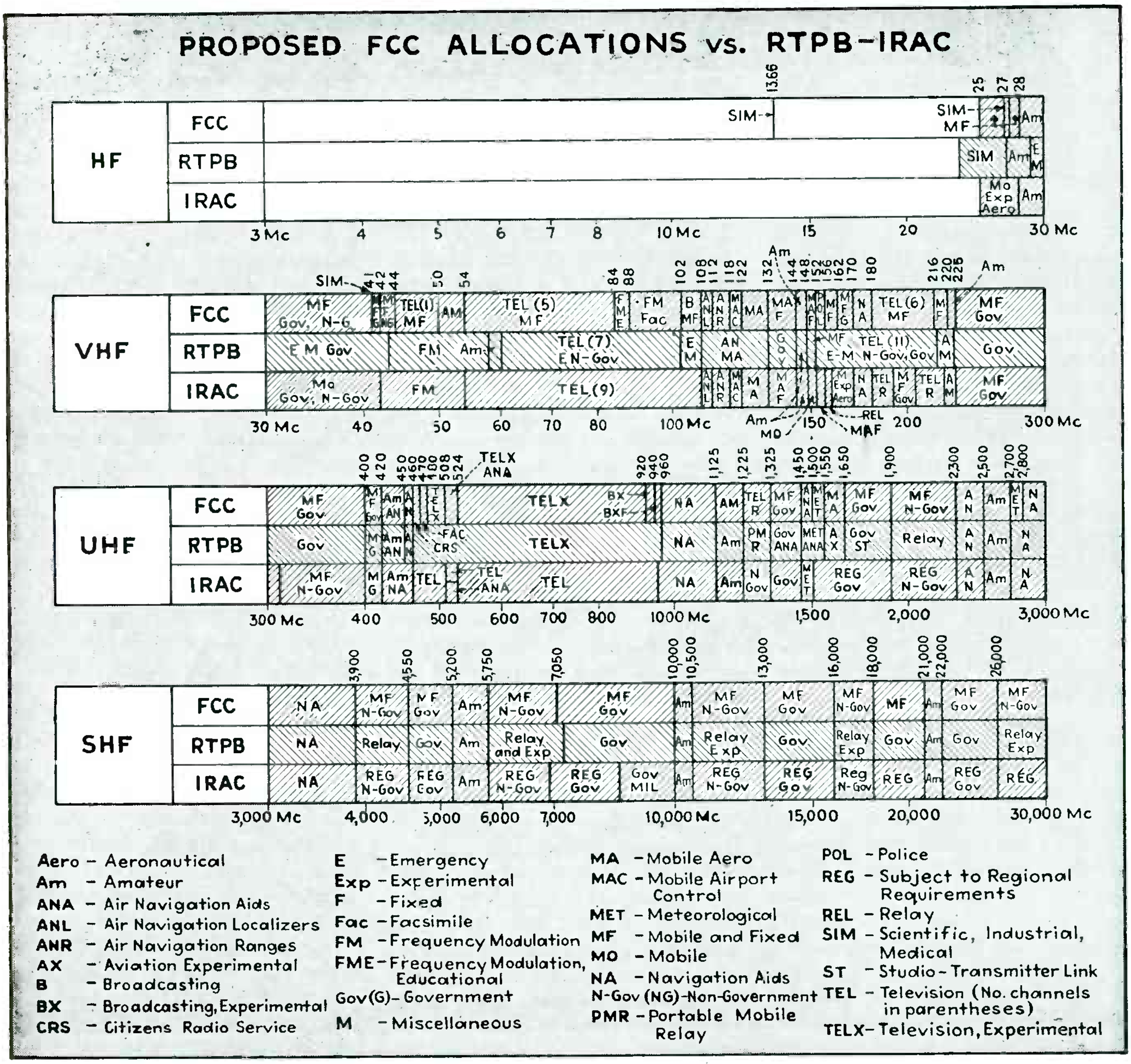
The outstanding difference between the RTPB-IRAC recommendations and the FCC proposals is the position in the spectrum of f-m broadcasting. The FCC proposes to allot 90 f-m channels in the region 84 to 102 Mc, rather than in the 40 to 60-Mc region suggested at the hearings. There is little quarrel with the proposed number of channels (RTPB had recommended 75 channels, IRAC 60). But the shift in frequency obsoletes all present f-m equipment, which includes 46 licensed stations, 7 stations operating under construction permits and some 100,000 to 500,000 receivers, the precise number of receivers in use being a controversial question. Applications for 248 additional station licenses, on file before the Commission in October and based on the old allocation, must be withdrawn, recomputed and resubmitted as soon as the FCC action becomes final.

This is a serious matter to the owners of equipment. The FCC justifies the change by citing evidence presented at the hearing, particularly that offered by Dr. K. A. Norton, a propagation specialist formerly on the Commission staff and now on leave to the War Department. Dr. Norton reported that long-distance interference, particularly from skywaves reflected from the E and F_2 layers of the ionosphere, is much more prevalent than had been realized when the original allocation of 42-50 Mc was made. He based this statement on measurements performed by the Interservice Radio Propagation Laboratory at the Bureau Standards, operated for the Army and Navy, as well as on measurements collected, as a military measure, from many other parts of the world. Dr. Norton's data had to do mainly with F_2 reflections. Computations based on IRPL measurements indicate that in years of sun-spot maxima a station on 44 Mc would receive interference some 1800 hours per year from a similar station 2500 miles away. L. P. Wheeler of the Commission staff also offered measurements showing that sporadic-E interference in Georgia, received from the Paxton, Mass. 44.3 Mc, 50-kw f-m station, had caused interference at the 50 μv/m contour 12 percent of the time in July 1944. The FCC points out that neither of these reports was available to RTPB and IRAC before they made their recommendations. The Commission stated that other interference effects, notably, the burst type of interference associated with meteorite tracks, and multi-path distortion, were not adjudged serious by the witnesses at the hearings and had been discounted in determining the position of the f-m band.

The industry is by no means convinced that the interference in the 40 to 60-Mc band is as serious as Drs. Norton and Wheeler believe it to be. At all events, the principal economic objection to the change was that facing the broadcasters. The public investment in receivers, mostly combination units, would have to be largely abandoned in any event as a result of enlargement of the band beyond its present limits, which all agree is needed.

The 90 channels assigned to f-m are divided three ways: 20 channels (84-88 Mc) reserved for non-commercial educational stations; 50 channels open to present holders of commercial f-m or standard broadcast station licenses, as well as existing applicants and 20 channels reserved for issue to other applicants who may not be in a position to join the mad scramble immediately after the new frequencies become effective but who should not be permanently ruled off the boards on that account.

The bandwidth is maintained at the value set down by Major E. H. Armstrong in his original work, 200 kc. The reasoning of the Commission follows Armstrong's very



closely: F-M should have fidelity up to 15,000 cps, room should be left for multiplex operation, and the signal-to-noise ratio should be at least 60 db over the major portion of the service area. Arguments that 10,000 cps sufficed for the audio band were dismissed by quoting Major Armstrong's dictum that "the difference between 10,000 cycles and 15,000 cycles is the difference between something which is good and something which is real."

Prompt action in vacating the 44-50 Mc region as soon as the FCC proposals become final was indicated, to permit television stations to enter that space. Existing f-m stations in this region are to be temporarily moved to the 42-44 Mc region until they are prepared to move to the new higher-frequency band. In certain cities, where the 42-44 Mc space is not sufficient for all stations now operating, time-sharing of the facilities will be necessary as an interim measure.

Status Quo for Television

The biggest controversy at the October hearings, whether commercial television should continue on the present frequencies or start over in a new band above 400 Mc, was decided by the Commission in favor of the status quo. The FCC proposes to allocate 12 channels, each 6 Mc wide, in the regions 44-50, 54-84, and 180-216 Mc. These eleven channels are to be shared with mobile and fixed services, both government and non-government, wherever needed, provided that the television service can be protected from interference. It was pointed out that low-power transmitters with low antennas may readily operate in the alternate channels between television assignments in any one city, and generally throughout rural regions.

Questioned concerning the interference effects on the 40-80 Mc channels (those which caused the f-m move), Commissioner Jett said the interference would be less serious to television because of the higher field-strengths required to give adequate service. He also stated that these channels were not the permanent home of television, in all probability, and would therefore have to suffer the interference as a temporary measure. F-M, on the other hand, was being put into a permanent home once and for all, and hence must be protected.

The largest ether space, expressed as a percentage of the center frequency, in the entire spectrum is that offered to television for future experimentation. This band comprises 440 Mc, from 480 to 920 Mc. This region, the Commission made plain, is looked upon as the eventual final home of television, with wideband channels, higher definition, color, etc. No bandwidth is specified, but the industry is urged to make full use of the band at the earliest opportunity to develop a new service. The widest band suggested (20 Mc, by Panel 6 of RTPB) would permit some 22 separate allocations. This is believed to be adequate for a national allocation, when and as the new service comes into being as a fully tested and economically feasible system.

The ticklish question of how to avoid obsoleting equipment, when the time for the new system arrives, was mentioned by Commissioner Jett at the press conference. Speaking for himself only and unofficially, he said that he believed that stations on the present channels would continue to operate alongside the improved service until the public had no further use for them. This point of view, however unofficial, was very heartening to the television group, who believe that the public must have some assurance of continuing utility on present frequencies before large-scale buying of television receivers begins.

All Aviation Requests Granted

One of the few services to receive all the space requested was aviation. The Commission, noting that post-war aviation is expected to expand far beyond pre-war levels and that radio is a prime necessity in high-density air traffic, proposes to allocate some 2140 Mc in 14 bands to this service. The allocations very closely follow the recommendations of RTPB and IRAC. The space from 108 to 132 Mc is divided into four bands, for instrument approach localizers, v-h-f radio ranges, airport traffic control and air-ground communications. An additional band at 225-400 Mc is reserved for air-ground and another at 1550-1650 Mc for experimental air-ground work.

By far the largest assignment goes for air navigation aids. In addition to the localizers and ranges previously mentioned, bands are allocated for this purpose at 170-180 Mc and 420-450 Mc, 450-460, 508-524 (the latter to make way for experimental television as soon as possible), 960-1125, 1450-1550, 2300-2500 and 2800-3900 Mc. It is no secret that these large bands of space are, at least in part, reserved for navigational devices now employed by the Army and Navy, many of which will be made available for commercial operation, possibly before the end of the war.

Mobile and Fixed Services

The large blocks of space marked MF in the chart are assigned to mobile and fixed services, that is, communication between mobile units (cars, trucks, trains, etc.) and fixed stations of the same system. The four most important blocks of space so assigned are (1) 30-44 Mc, (2) shared service on certain of the commercial television channels (54-78 and 192-216 Mc), (3) 156-162 Mc, and (4) the majority of the space above 1500 Mc. The table shows the approximate breakdown of this space assignment to specific mobile-fixed services (police, fire service, forestry, public utilities, provisional, geophysics, motion picture, railroad, general mobile). The channel widths are 40 kc in the 30-44 Mc region, and 60 kc in the 156-162 Mc region. Channels are shared among several services as a general rule. An exclusive band is allotted to police service, between 152 and 156 Mc.

The majority of these services are already established and are expected to continue, in expanded form, after the war. But two categories are new insofar as FCC regulations are concerned, the railroad radio service and the general mobile service. Special hearings on railroad radio had been held by the Commission previous to the allocation hearings. At these hearings it was established that carrier-current communication (pick-up in the induction field between rails and nearby telegraph wires) in use by railroads for some time, does not provide a complete answer to the problems, especially in regions where wire lines are impractical, and in freight yards and terminals. The most important use of the proposed v-h-f service is the so-called end-to-end radio, by which the conductor of a freight, in the caboose, can keep in constant touch with the engineer, warning him of impending trouble. Train-to-train communication is also envisaged, and contact with fixed stations would be available to report wrecks from remote localities. For this service, shared service with commercial television will be permissible in many parts of the country. Twenty such channels are set up in the television bands for terminal systems. Thirty-three adjacent channels, 60 Mc wide, are assigned for end-to-end, train-to-train and station-train service in the 156-162 Mc band. Bands above 1900 Mc open to general mobile-fixed service will also be available for further experimentation on railroad radio equipment.

The general mobile service is intended primarily as an aid to the dispatching of buses, trucks and taxicabs, and for emergency service in reporting accidents from locations where telephone service is not available. Common carrier telephone service to buses and taxicabs is also planned. The FCC allocation sets up two categories; urban mobile and land stations in the 156-162 Mc band, and highway mobile and land stations in the 30-44 Mc band.

Amateur and Citizen's Services

The amateurs lose none of their present space above 25 Mc and gain six new bands above 400 Mc. The 10-meter band stays as is; the 5-meter band is shifted to 50-54 Mc; the 2½-meter band is shifted to 144-148 Mc; the 1¼-meter band is shifted to 220-225 Mc, and the 400-401 band is shifted to 420-450. Five other bands, ending at 21,000-22,000 Mc, are set up. The latter frequency corresponds to 1.5 centimeters, a wavelength which before the war was considered the upper limit of the radio spectrum. The fact that the amateurs are to be encouraged to play with such microwaves is some indication of what has happened, meantime, behind the closed doors of war research.

A new service, somewhat akin to the amateur service, is the citizens radio communication service on 460-470 Mc. Transmitter and operator licenses will be available for this service merely upon presenting evidence of knowledge of the communications law. No technical knowledge will be required. The band is intended particularly for walkie-talkie low-power point-to-point and mobile service, and for use by the general public for any purpose except the carrying of toll messages for hire. In addition to the many short-haul uses in rural districts (tractor-to-farm, farm-to-farm communication) the service will also be available for doctor's calling service and similar professional activity. It may be used, in fact, for industrial and control purposes, such as the opening of garage doors by a gadget carried in the car. No bandwidth is specified, and since simple equipment is proposed, the frequency stability is not expected to be of a high order.

Other Services

Facsimile broadcasting will be permitted on any of the f-m channels, by station licensees, but not simultaneously with sound programs. The restriction to simplex operation, rather than the multiplex operation urged by Major Armstrong, may be removed when the technical feasibility of simultaneous transmission is demonstrated. The band from 470 to 480 Mc is reserved for experimental, facsimile broadcasting from which may develop a commercial service. Facsimile will not be permitted in the television channels.

Three assignments are set up for the use of scientific, industrial and medical oscillators, not used for communication but capable of causing interference, at 13.66, 27.32 and 40.98 Mc. The bands allotted are only plus or minus 0.05 percent of the center frequency. This implies crystal control of the oscillators and hence does not provide relief from the wandering type of a-c modulated diathermy interference. However, the setting up of these bands is a constructive step which will provide for many cases, particularly those in scientific and industrial establishments where economic factors permit crystal control.

The use of v-h-f and u-h-f radio for relaying signals of all types (telegraph, telephone, facsimile, television, etc.) in circumstances where wirelines are impractical, is provided in the assignment of shared facilities in the mobile and fixed bands, as follows: 1225-1325, 1900-2300, 3900-4550, 5750-7050, 10,500-13,000, 16,000-18,000, and 26,000-30,000 Mc. The initial assignments for relaying in these bands will be on an experimental basis, to be followed by regular operation as the need and technical feasibility is proved. Television relaying will also be permitted on the 192-216 Mc and 480-920 Mc bands until these frequencies are needed, in a given area, for broadcast service—D.G.F.

PROPOSED ALLOCATIONS, BY SERVICES

Type of Service	Number of Channels	Channel Width	Location in Spectrum (Mc)
Frequency Modulation (Commercial)	70	200 kc	88-102
Frequency Modulation (Educational)	20	200 kc	84-88
Television (Commercial)	12	6 Mc	44-50; 54-84, 180-216
Television (Experimental)	—	—	480-920
Television (Relay)	—	—	1225-1325
Aviation (Instrument Landing and Radio Ranges)	70	200 kc	108-118
Aviation (Traffic Control)	20	200 kc	118-122
Aviation (Air-Ground)	50	200 kc	122-132
Aviation (Experimental)	—	—	1550-1650
Aviation (Navigation Aids)	—	—	170-180; 420-460; 508-524; 960-1125; 1450-1550; 2300-2500; 2700-3900
Amateur	—	—	28-30; 50-54; 144-148; 220-225; 420-450; 1125-1225; 2500-2700; 5200-5750; 10,000-10,500; 21,000-22,000
Police	47	40 kc 60 kc	30-44 152-156
Police (Exp. facsimile)	—	—	940-960
Fire Service	15 20	40 kc 60 kc	30-40 156-162
Forestry	33 27	40 kc 60 kc	30-40 156-162
Electric, Gas, Water, Steam (Utilities)	15 5	40 kc 60 kc	25-44 156-162
Transit Utilities	10	40 kc	25-44
Special Emergency	4 6	40 kc 60 kc	30-40 156-162

Type of Service	Number of Channels	Channel Width	Location in Spectrum (Mc)
Provisional (Petroleum)	27 10 9	40 kc 40 kc 60 kc	25-28 30-40 156-162
Geophysics (Motion Picture) (Relay Press)	22 4	40 kc 60 kc	25-28 156-162
Facsimile (Commercial)	Any FM Channel (simplex)	200 kc	84-102
Facsimile (Experimental)	—	—	470-480
*Railroad	33 20	60 kc	156-162 44-50; 54-78; 192-216
*General Mobile (Taxicabs, etc.)	12 12 7	40 kc 40 kc 60 kc	30-40 42-44 156-162
*Citizens Radio Communication (Walkie-talkie)	—	—	460-470
*Rural Telephone	—	—	44-50; 54-78; 192-216
*Rural Telephone (Experimental)	—	—	1900-2300; 3900-4550; 5750-7050; 10,500-13,000; 16,000-18,000; 26,000-30,000
*Industrial, Medical (Scientific)	—	0.05%	13.66, 27.32, 40.98
Relay Systems	—	—	1225-1325; 1900-2300; 3900-4550; 5750-7050; 10,500-13,000 16,000-18,000 26,000-30,000
Fixed Public Services	—	—	44-50; 54-78; 192-216; 940-960; 1900-2300; 3900-4550; 5750-7050; 10,500-13,000; 16,000-18,000; 26,000-30,000
Coastal Ship	33 7	40 kc 60 kc	30-44 156-162
Relay Broadcast	22 4	40 kc 60 kc	25-28 156-162
Studio-Transmitter	—	—	940-960 192-216
Development Broadcast	—	—	920-960

* New class of service

A Square-Loop F-M ANTENNA

Built around the top of an a-m tower used by WJBO rather than on a flagpole extension, the 44.5-Mc radiator at WBRL added little weight and wind resistance. Theory, details of construction, and tuning procedures are described

THE SIX-LAYER square-loop antenna now in use at f-m station WBRL, Baton Rouge, Louisiana is of considerable interest because of its high gain, because it is supported by one of the towers of a-m station WJBO and, particularly, because it is built around the top of the tower rather than on an extension.

Where, as in this instance, the height of an existing tower is comparable with that of suitably-located tall buildings or natural terrain, it is of obvious advantage to a-m stations contemplating f-m service to utilize the tower for both services. First of all, there is an important saving in installation cost because there is no need to buy property, rent building-space or erect a supporting structure. Second, there is usually a saving in operating and maintenance cost since both transmitters may generally be located in the same building and operated by the same operator.

There are also some disadvantages to placing an f-m antenna on an a-m tower and these should be recognized and fully considered. First of all, there is some inconvenience to maintenance and operation in that work on either the a-m or f-m antenna will be dependent upon the program schedule of the other. Second, in the case of insulated towers provision must be made for bringing the feed line for the f-m antenna around the base insulators. For low-power transmitters this is not too difficult. For higher powers it involves fairly substantial coupling equipment.

FIG. 1—The three-tower directive system at a-m station WJBO in Baton Rouge. A six-layer square-loop f-m antenna was mounted around the top of the center tower for station WBRL

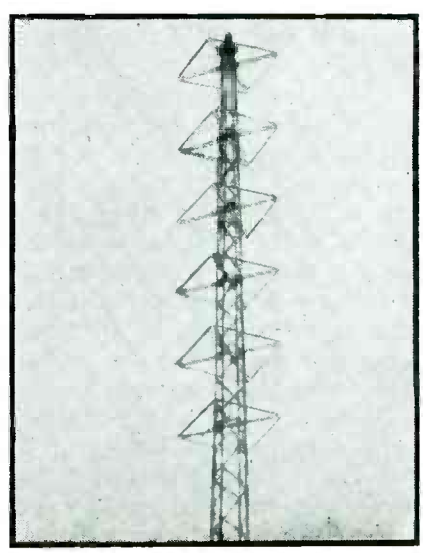


FIG. 2—The six-layer square-loop f-m antenna of station WBRL. Taken from the ground, this picture showing the antenna 500 ft up was retouched to more clearly show the position of the radiators

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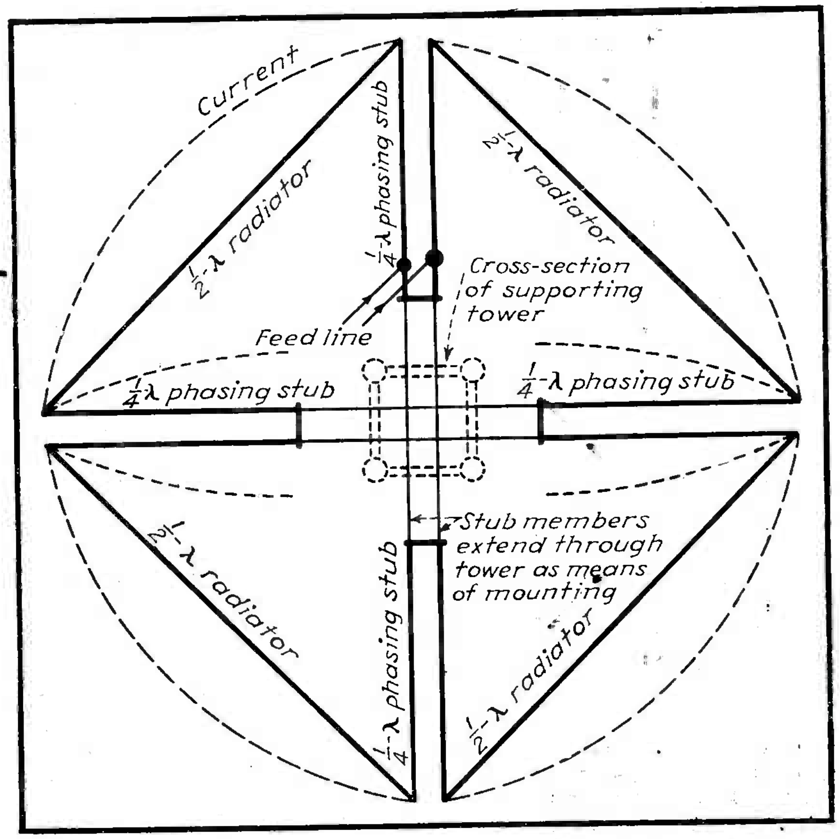

FIG. 4—Each of the layers of the antenna consists of four half-wave radiators arranged in a square. Phasing is provided by quarter-wave stubs which also form the radiator supports

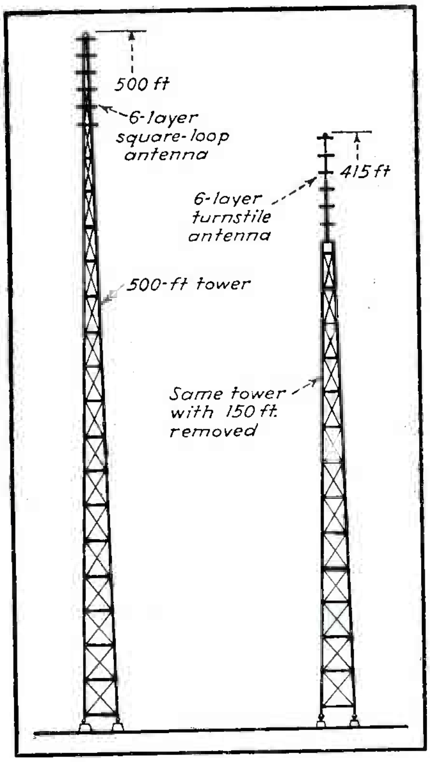

FIG. 3—Use of an antenna built around the a-m tower at WBRL rather than one mounted on an extension retained maximum height. It would have been necessary to remove 150 ft from the top of the tower in order to safely handle the extra weight and wind resistance of a turnstile

The biggest disadvantage, however, is the fact that it is usually found that the a-m tower, unless it is specially built for the purpose, is not well-adapted to mounting of the f-m antenna and will not bear the weight of a multi-layer array. A six-bay turnstile, for operation at 42-50 Mc, is mounted on a flagpole which is 64 ft high and 12 inches in diameter at the butt end. It weighs 3,500 lb and presents considerable wind-resistance, so that the upsetting moment exerted on the supporting structure is appreciable. A four-bay circular antenna requires a flagpole or mast of about the same dimensions, since in this type the layers are spaced a full wavelength (as against half-wavelength spacing in the turnstile).

The WBRL Installation

The WBRL installation is a typical example of the problem likely to be met. In this case it was desired to mount the f-m antenna on an existing 500-ft insulated tower which was the center structure of a three-tower array used by WJBO, a 5-kw standard-band a-m station. The three towers are pictured in Fig. 1.

When the manufacturer of the tower was asked how much weight and wind resistance could be added, it was found that 150 ft would have to be removed from the tower in order to make it capable of supporting a six-bay turnstile. This would have reduced the daytime (non-directive) coverage of the a-m station and would have required recalculating and retuning of the directive system. It was under these circumstances that the decision was made to construct a special antenna to fit the local requirements.

The WBRL f-m antenna as finally erected consists of six square-loops mounted horizontally and spaced a half-wave apart, as pictured in Fig. 2. It was feasible to mount these at the top of the 500-ft tower since their total weight, including feed system, is less than 1000 lb and the added wind resistance is very small. The result, as compared with the alternative of mounting a six-bay turnstile on a 350-ft tower, was a net gain of 85 ft in the height of the f-m antenna and somewhat more in the effective electrical height of the a-m radiator. This is shown in Fig. 3.

Each of the square-loops used in the WBRL antenna consists of four half-wave (44.5 Mc) radiators arrayed in a square and end-fed as shown in Fig. 4. This type of antenna was originated and developed by Dr. G. H. Brown of RCA Laboratories. The general mounting arrangement and the system of lines used to feed this array were also suggested by him.

How It Works

The manner in which a square-loop type antenna functions can be easily understood by examining

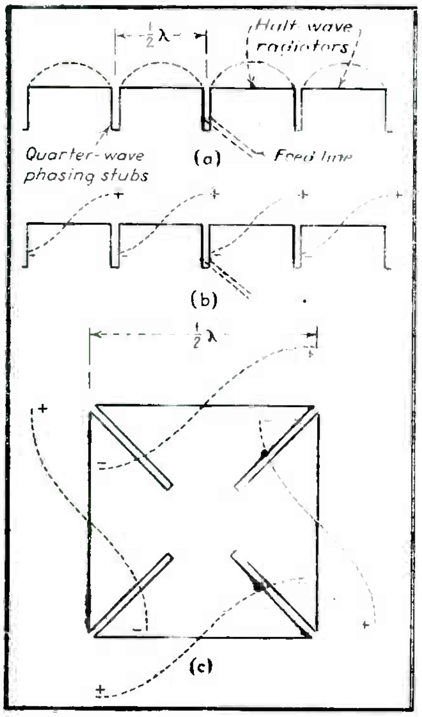

FIG. 5—When the radiators of a square-loop are bent out into a straight line for study they look like (a) and the currents are in phase. The voltages (b) are also in phase. But when the radiators are formed into a square (c) the voltages on opposite radiators are oppositely phased

Fig. 5. It will be noted in Fig. 5(a) that the currents are in phase in all four radiators, this result being accomplished by placing quarter-wave phasing stubs between each pair of radiators. The voltages in the four radiators are also in phase when these radiators are arranged in line, as in Fig. 5(b). However, when they are bent around into a square, as in Fig. 5(c), the voltages in oppositely placed radiators are 180 deg out of phase.

The resulting field-pattern can be visualized by noting the space relation of these radiators in Fig. 6. At point a, which is in the horizontal plane of the loops, the voltages arriving from radiating elements 1 and 3 will be in phase (since element 3 is a half-wave further away) and hence will be additive. The same is true at point c. Elements 2 and 4 similarly radiate in phase to points b and d. At other points in the same horizontal plane there will be voltages from all four radiating elements. These will be out of phase in an amount determined by the angle, but they add up to a final signal component such that the radiation is approximately equal in all directions.

On the other hand, at any point normal (vertical) to the loop (e or f in Fig. 6) the distance to the two oppositely placed radiating elements 1 and 3 is the same. The voltages from these arrive out of phase and thereby cancel each other. The same is true of the voltages from elements 2 and 4. Thus the radiation upward from the square-loop type antenna is theoretically zero. The net result is a higher signal along the horizontal, where it is wanted, and no signal vertically, where it is of no use.

Because the square-loop type antenna has, in effect, twice as many radiating elements as the turnstile, it has a somewhat higher gain-per-layer than the turnstile. Moreover, because the mutual impedance between layers is relatively low, spacings of one-half wavelength are practical. As a result, gain-per-height, which is the true criterion in an antenna of this kind (where weight and upsetting movement are the limiting factors), is greater than for the circular antenna. Comparative gains are shown in Fig. 7.

How It Is Fed

An antenna of this type can be fed in several ways. The simplest is to tap off, with an open-wire balanced line, from one of the stubs at a point which will reflect an impedance to match the line. In order to insure a balance of currents around the loop it is better to feed at two points as shown in Fig. 8(a). In the case of an f-m broadcast antenna mounted on a tower it becomes more convenient and practical to feed the array with concentric lines (oppositely phased) as shown in Fig. 8(b).

The feed arrangement for a single layer, as actually used at WBRL, is shown diagramatically in Fig. 8(b). Points on two diametrically opposed stubs are fed power through short lengths of concentric lines which are tapped on to two branch lines which run up through the full length of the array. The points where these short lines are connected to the stubs are chosen to reflect an impedance of 12 ohms to the line. The length of these short lines is such that they are electrically a quarter-wave long. Thus (from the relation $Z = \sqrt{Z_1Z_2} = 70$ ohms) each of these lines looks like 420 ohms at the point where it joins the branch lines. Since there are two such short lines coming in to the branch lines at each level, the impedance reflected on the branch lines is 210 ohms per layer.

Six layers are spaced one half-wave apart. The overall connections are shown in Fig. 9. Since each line looks into 210 ohms per layer, and the layers are effectively in parallel, the total reflected impedance may be considered as 210/6 or 35 ohms. At the bottom of the array, one line is connected to a main junction box by a quarter-wave line and the other by a three-quarter-wave line. The extra half-wavelength in the second provides the required 180-deg phasing. Each line looks like 140 ohms to the junction point and (since they are fed in parallel) like 70 ohms total to the main feed line which runs from this point down the tower to the transmitter.

Construction and Mounting

The mechanical design of an antenna of the square-loop type is

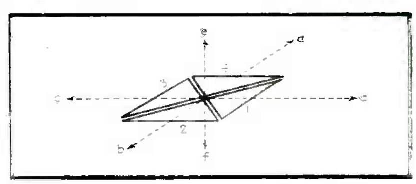

FIG. 6—The field voltages from oppositely-placed radiators are additive at points in the horizontal plane of the loop, (a,b,c,d), but cancel at points in the vertical plane (e,f), thereby providing desirable gain in the horizontal direction

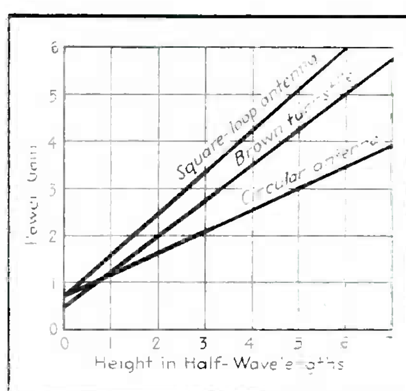

FIG. 7—Comparative gains of the square-loop, turnstile and circular antennas, plotted against height in half-wavelengths

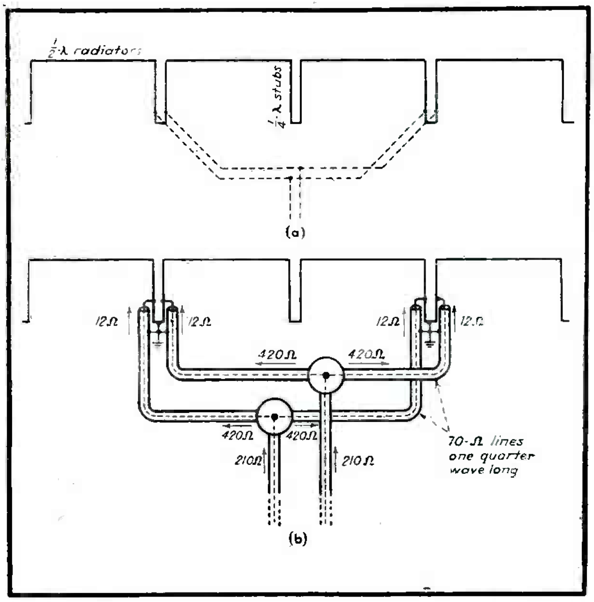

FIG. 8—Feeding power to two stubs (a) provides a more even current distribution. Concentric feed lines (b) are more practical for tower installations, and were used to feed power to the six layers of the WBRL f-m antenna

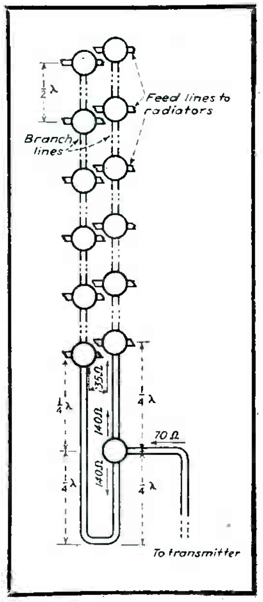

FIG. 9—Connections of branch lines, with reflected impedance at each junction

quite a problem. Fortunately, the inner ends of the quarter-wave stubs are at ground potential and hence the loop can be supported without the use of insulators by simply continuing these stubs inward to the tower. Even so, the supporting pieces must carry the weight of the radiating elements which are attached to their outer ends like outriggers. Thus they must be stronger, for instance, than the elements of a turnstile antenna which need support only their own weight. At the same time, they must be light in weight if the advantages are to be retained.

After a number of tests, it was decided to make the diagonals of 1¼-in. lightweight steel tubing as shown in Fig. 10. The radiators themselves were cut from ½-in. thin-wall steel conduit. The advantage in using copper would have been very small. Moreover, the use of steel allowed all joints to be welded, thereby adding strength and rigidity to the assembly. Each radiator was welded to two diagonals, an operation which could be performed on the ground. In addition, for each of the six layers a welded criss-cross of tubing was made up for center support. This was made of heavier tubing having an inside diameter of 1¼ in. so that the ends of the diagonals would fit in snugly.

In erecting the array, one of the welded criss-crosses was first mounted on angle irons (omitted from the drawing) attached to the tower at each layer level. Then the triangular sections, each consisting of a radiator and two diagonals, were hoisted and the ends of the diagonals slid into the openings of the criss-cross piece. The diagonals were then clamped to the tower and the lines were raised into place.

The construction of the feed lines also involved some interesting problems. Although only 1 kw was installed, provision was made in the design for possible later increase to 3 kw. Hard-drawn ⅞-in. concentric line was used throughout. This size line is large enough so that it will not flash over even if pressure is lost. Insofar as the short feeder-lengths were concerned, these were simply filled with dry air and sealed off at each end, thereby reducing the number of end seals to be made gas-tight from some seventy-five to less than ten. A photograph of the feed line arrangement at each level is shown in Fig. 11. Since the short feed lines had to be a quarter-wave long, while they tap on the stubs at a point less than that out from the tower, it was necessary to put elbows in them, as can be seen. Also, one pair had to be crossed over to maintain proper phasing.

The proper point for shorting the diagonals (in order to provide the correct length of matching stub) was found to be 23 in. out from the center of the tower. At this point, therefore, a heavy brass strap connects the diagonals together and also ties to the feed lines in order to provide a support for the latter. The inner conductors of the two lines are tied to the two diagonals at a point some 15 in. further out.

Tuning

Tuning an f-m array of this type is a matter of dimensioning. The first step is to determine the proper lengths of the radiating elements and their supports; the second, to locate the proper points for connecting the feed lines; and the third, to calculate or otherwise determine the proper length of the feed-line section. All of these steps must be taken before the antenna is mounted in its fixed position on the tower.

Lacking adequate information on velocity of propagation, effect of end seals, etc., it is almost necessary to determine final dimensions by cut-and-try methods. At WBRL doing this was made easier by the fact that the tower on which it was proposed to mount the array was being moved anyway and this fortuitous circumstance made it possible to borrow the top 25-ft section for a few days. This section was set up on the ground and used in making tests not only of the proper dimensions of the radiating system but also of the best means of mounting the system on the tower.

Three layers of the ultimate antenna were erected on the 25-ft section. Most tests were made on the center square-loop in order to approximate, as nearly as possible, the conditions of final operation. A small crystal-controlled power source capable of providing about 10 watts at the operating frequency of 44.5 Mc was used in making the tests. The first operation was to feed power into a phasing stub and determine (by checking the standing waves along the adjacent radiators) the proper length to cut the radiating elements. This length was found to be 10 ft, 6 inches. The length of the diagonal supports (7 ft, 5 in.) could then be determined. Using this information, the radiating elements for the three layers were constructed and mounted on the tower section. Shorting bars were placed equidistant on all four phasing-stubs of each layer. Feeding power to the center layer, the position of these shorting bars was varied simultaneously until a check of standing waves indicated the proper positions. These positions are such that the bars are 23 in. out from the center of the tower.

The next step was to determine the correct feed-points on the stubs. This was done by making use of the slotted-line method of measuring impedance. A piece of concentric line something over a wavelength long was used to feed power to the center layer of the array. This line had holes in the outer conductor at 3-in. intervals, through which a vacuum-tube voltmeter probe could be inserted. By this means, the standing-wave ratio on the line could be determined. A ratio of six-to-one indicated the desired impedance termination. The position of the feed points was, therefore, varied until such a ratio was obtained.

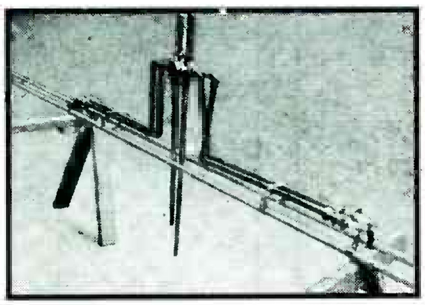

FIG. 11—Closeup showing the feeder arrangement required at each level. These lines are set up on the ground, hence the supporting element does not appear in the photograph

The point arrived at by this procedure, 15 in. out from the shorting bar, was assumed to be the correct feed point and a set of lines to fit this condition was then designed and constructed. As mentioned previously, the short lines had to have an elbow in them in order to obtain the desired electrical length. Incidentally, it should be noted that the physical length of these lines (to make them act like quarter-wave electrical lines) is considerably less than a physical quarter wave, not only because of the velocity constant of the lines, but also because the end seals add lumped capacitance which further reduces this length. As a result it is desirable to determine the proper length by experiment. This can easily be done (remembering that a true quarter-wave shorted at the far end reflects an infinite impedance at the near end) by starting with a length something over a quarter-wave, cutting off a half-inch at a time until the section, when shorted at the far end, presents a maximum impedance to a source of power at the near end. By this means it was determined that an overall length of 47 in. was correct for the WBRL short lines.

After the proper dimensions of the radiating and feed lines had been determined in this way, all pieces were cut and the system erected at the top of the 500-ft. tower. No further adjustments were attempted, on the assumption that any small improvements that might be made when working under such difficult conditions would not justify the effort.

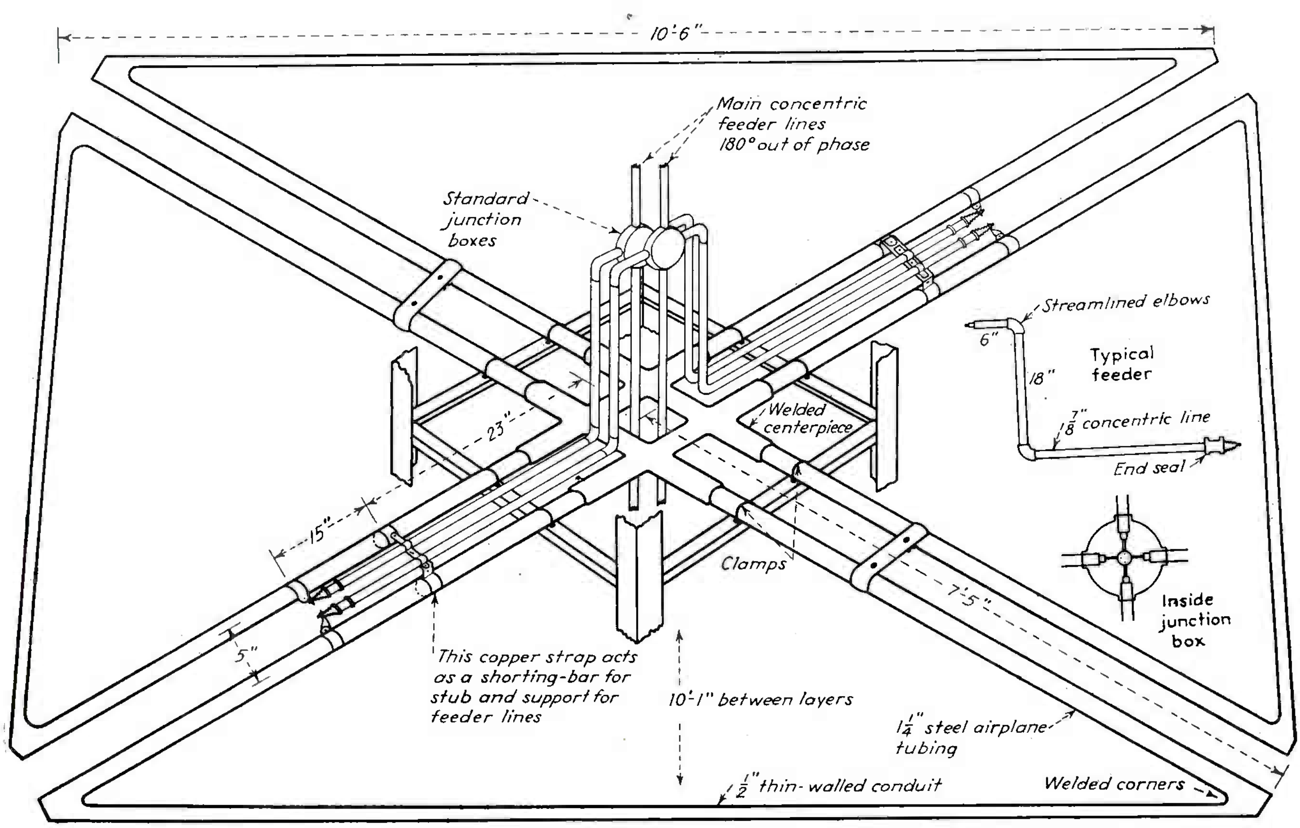

FIG. 10—Mounting arrangement at each layer. The diagonals which support the radiating elements, and whose outer ends form the matching stubs, are inserted into a welded center-piece and then clamped to the tower. R-F feeders are shown

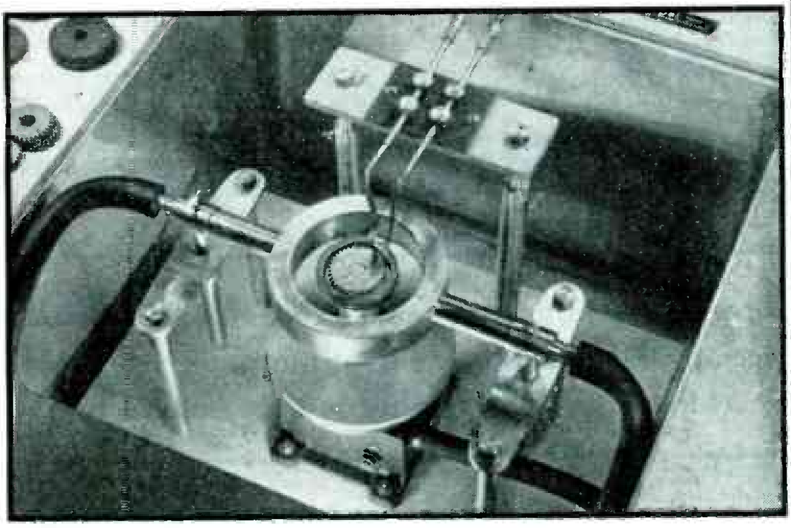

FIG. 1—Work-rotating and quenching arrangement used for hardening gear teeth. High-frequency power is obtained from the Lepel spark-gap converter unit in the background. The work coil is water-cooled, and has flattened turns

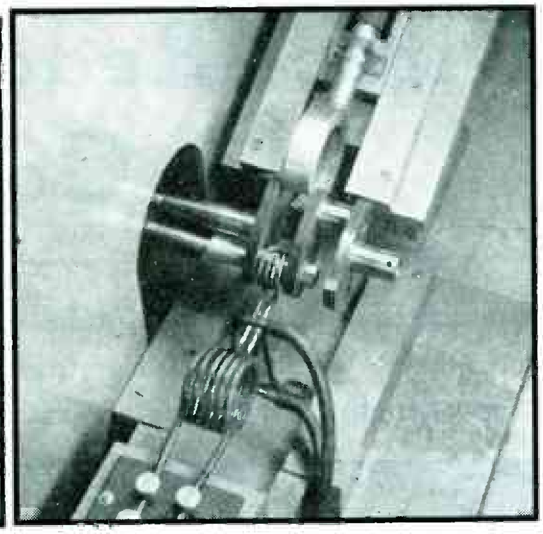

FIG. 2—Heating and quenching arrangement for hardening the bearing surfaces of a crankshaft. An air-core transformer feeds the work coil

INDUCTION HARDENING

Rotation of work eliminates surface irregularities caused by the coil pattern when heating steel rapidly by induction heating for shallow case hardening

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FOR HARDENING APPLICATIONS by induction heating, the work is generally placed within a load coil. The clearance between the work and coil is made small (about 1/16 inch clearance) for shallow case hardening. If the case depth is not too critical (above 1/32 inch), a spacing of 1/8 to 3/16 inch is satisfactory. With small clearances between the work and a load coil having one or two turns, the heat can be concentrated on a narrow portion of the part which moves through the coil at a given rate of speed. Through high concentration of power on such a small area, a hardening case of 0.007 inch can easily be obtained on diameters of 7/8 inch with 30 kw input from the line and at a frequency of 350 kc.

Such rapid and continuous heating and quenching results in very little distortion and there is practically no scale formation on the part. Shafts of any length can be hardened by this progressive method. The shaft must, however, rotate at a slow speed while passing through the heating coil to eliminate any irregularities in surface hardness due to cold spots produced by the coil turn pattern. A similar rotating procedure is followed in the heat treating of gears, illustrated in Fig. 1.

On parts where it is impractical to slip a coil over the surface, an arrangement like that shown in Fig. 2 is used. The part is slowly rotated against a semi-circular work coil, and quickly quenched as soon as it has reached the desired temperature. The quench ring is shown in both illustrations. The heating cycle and the quenching cycle are automatically controlled by a timer to assure uniform results on all parts treated.

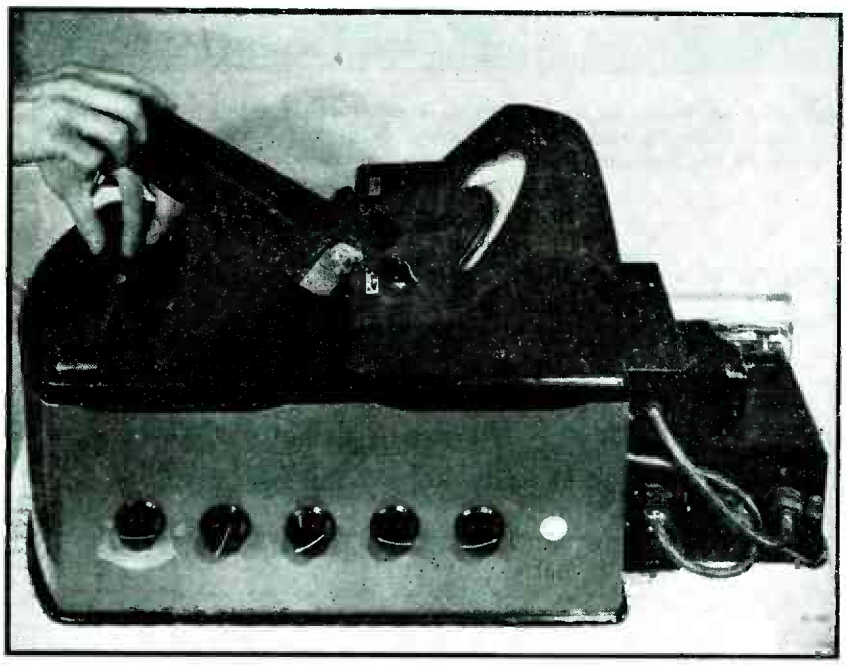
Tunable and highly flexible spark gap converters for induction heating have been in constant use in industry for over 17 years. Many have operated continuously for over 20 hours daily.

Their low maintenance cost is due primarily to improved spark gap and circuit designs. These units operate at unity power factor and are provided with a power control switch which permits a step-by-step power output reduction of 83 percent. Normally-loaded heating coils having one turn, with inside diameter as large as 48 inches or as small as 1/8 inch, can be connected to the converter output leads without requiring any auxiliary equipment or expense for reconversion. Starting is instantaneous and water consumption is low (2 gallons per minute). Power and water are used only while the converter is in actual operation.

From a paper presented at the Conference on Induction and Dielectric Heating, Chicago, 1945.

Direct-Reading Color Densitometer

Nine-stage multiplier phototube increases sensitivity of commercial black-and-white densitometer sufficiently for accurate measurements of modern color film at three different wavelengths, permitting accurate checking of product quality in film manufacture



Color densitometer in use, with multiplier phototube head raised to permit placing film in position over light-source aperture. The five knobs are zero adjustment controls. Power pack for amplifier tube is at right, behind meter

THE PROBLEM of density measurement on ordinary black-and white photographic silver images has been met by the use of reasonably straightforward optical and electronic designs. However, the sensitometric evaluation of modern reversible color film requires an enormous increase in instrument sensitivity because the density of the samples must be measured at each of three wavelengths for spectral density values up to 3.0.

By using a photomultiplier tube in conjunction with a simple logarithmic circuit, an instrument having the desired sensitivity was designed and built for routine laboratory use on all films. Before describing the final design, some of the problems encountered in designing reliable densitometers will be considered.

Optical Density

In sound engineering, the decibel is a more useful unit of measurement than the voltage or current ratio. For similar physiological reasons optical density is more useful in photographic practice than transmission or opacity. Over a remarkably wide range of values, the human eye discriminates equal changes in log B where B is the brightness of the area examined (Fechner's Law). Therefore, in optics it is customary to express the light-absorbing properties of films in terms of density $D = \log 1/T$, where T is the transmission. A density of 2.0 thus corresponds to a transmission of 1/100.

In a sense, this expression is incomplete because it does not specify the spectral character of the radiation nor the sensitivity of the receiver. Fortunately, ordinary black-and-white films (silver images) are reasonably non-selective in their spectral absorption, so that in most circumstances once an instrument is properly calibrated it will give readings which have a broad application to ordinary photographic problems. All specimens of modern color film, on the other hand, are distinctly selective in their spectral absorption. Even areas which appear gray (colorless) to the eye are not neutral (non-selective with respect to spectral absorption), as can be seen from Fig. 1. The curve of integral density shows the effective density of all three layers of the film together as a function of wavelength. The other curves show the spectral absorption characteristics of the individual layers of which the film is composed, Y being yellow (dense in the blue, transparent in the

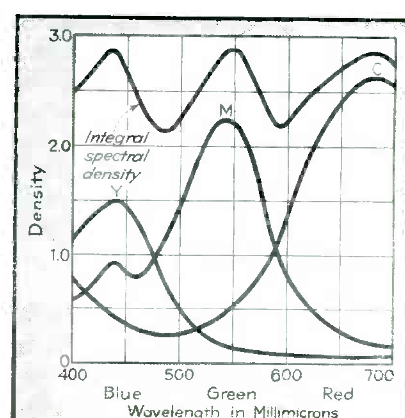


FIG. 1—Density-wavelength relations for a typical multi-layer emulsion of gray sample

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Interior view of color densitometer, showing 700-volt Minimax battery pack for dynodes and anode of multiplier phototube

green and red), M being magenta (dense in the green, transparent in the blue and red) and C being cyan (dense in the red, transparent in the blue and green).

The sample depicted in this graph appears gray to the eye and represents the closest approach to a non-selective specimen of which the color process involved is capable at that general density level.

Analysis of Color Film

Many problems associated with the manufacture and use of color film make it necessary to determine the density contribution of each individual layer of a given specimen, since the color of every elemental area of the film is determined by the densities of these three dye layers. For instance, in production control of the film itself, it is essential to know, quantitatively, the density contributed by each layer for specimens which have been exposed and processed according to specific standards.

It is evident that if spectrally pure density readings are made at 440, 540 and 680 millimicrons, the relative amounts of the three dyes present in the specimen can be estimated. There will obviously be some error, small for the magenta and cyan dyes and significant in the case of the yellow dye evaluation, but if the instrument is calibrated to read integral spectral densities at these three wavelengths, the extent of departure from gray for practical sensitometric specimens will ordinarily permit the individual dye densities to be measured directly with reasonable accuracy.

Further consideration of the problem will reveal that it is essential to use nearly pure monochromatic light in making the measurements. With ordinary black and white densitometers unfiltered light (from an incandescent lamp) is used and the total energy incident on the specimen may be a thousandfold greater than that incident on it when all but a narrow wavelength band of radiation is

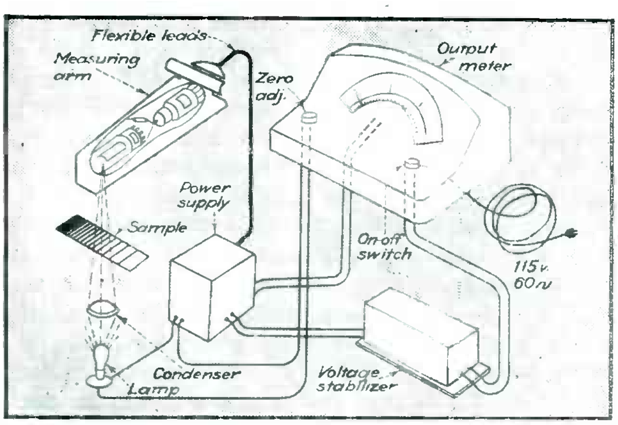

FIG. 2—Pictorial diagram of commercial Ansco Sweet black-and-white densitometer, with 0-3 density range

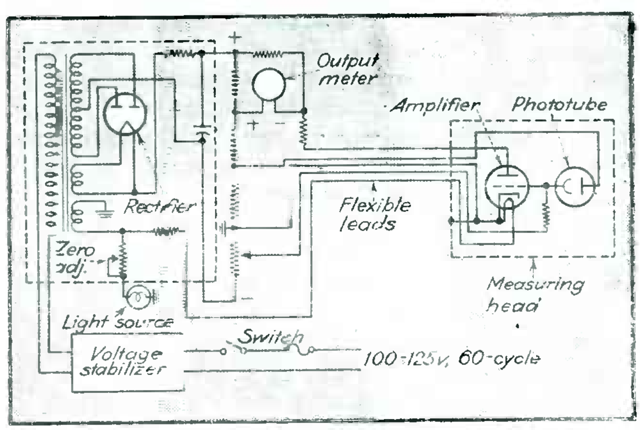

FIG. 3—Schematic diagram of black-and-white densitometer shown in Fig. 2, using ordinary phototube and amplifier tube

eliminated from the system. Therefore, in the analysis of color film the sensitivity of the instrument must be greatly increased to compensate for the radiation absorbed by the isolation filters.

Uniform-Scale Black-and-White Densitometers

Of the direct-reading densitometers commercially available, and giving an indication of the density of the specimen immediately upon the insertion of the sample in the photometric beam, one which had been previously developed by Ansco[1] seemed capable of adaption for use in measuring color densities with adequate spectral purity. This instrument is a reasonably compact unit possessing good stability and a uniform density scale over the entire density range of 0-3. Its operation may be understood by referring to Fig. 2 and 3. Light from a 15-cp auto lamp is condensed by an aspheric lens on an aperture (not shown) over which the sample is located. Light transmitted by the sample is absorbed by the surface of a type 929 phototube. The phototube is connected in series with the grid of the 6F5 triode so that the grid current is common with the phototube current for all except extremely low current values. A rugged 1-ma d-c meter having a long (8½-inch) scale, indicates the densities of the sample directly and is calibrated in 0.02 density per division.

From Richardson's equation, Russell[2] and others have shown that the relationship between log grid current and grid voltage (or plate current) is theoretically linear. Since $D = \log 1/T$, this circuit arrangement permits the design of an instrument whose scale is linear in terms of density. In practice, however, it has been found necessary to use a specific plate load resistance in order to maintain linearity of scale reading with respect to density at high grid currents (above 5 μa) and an extremely high grid resistor (1000 megohms) to maintain linearity at low grid current values (0.08 μa and less). Although the plate load resistor is effective at all density levels the grid bias is ineffective at grid current values corresponding to specimen densities lower than 2. The grid bias serves to buck out slight gas current and residual current from other causes which would otherwise result in too low an effective photo-current amplification in the high-density range.

A small constant-voltage transformer serves to stabilize the voltages applied to the lamp, triode and phototube. Under proper conditions an accuracy of $\pm$ 0.01 may be obtained over the whole density range.

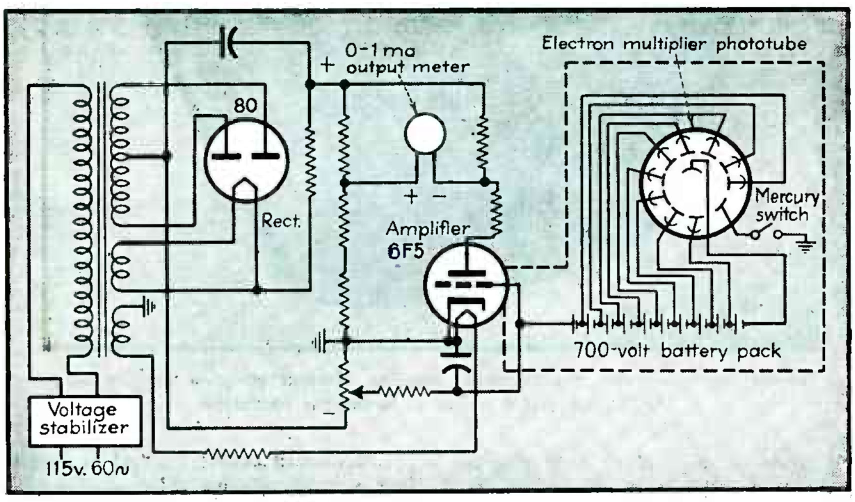

FIG. 4—Schematic diagram of densitometer as modified for evaluation of modern reversible color film

Use of Simple Densitometer for Color Analysis

In connection with an investigation of the spectral characteristics of photographic wedges[3] one of these instruments was equipped with a motion picture projection lamp (250 watt), a double-lens condenser, a heat-absorbing element and color filters. Without changing the electronic circuit, it was possible to measure the color densities of specimens over the same 0-3 density range with this system. However, the requirements for spectral purity are far more severe with integral tri-pack color film than when nearly neutral specimens are to be evaluated. The integral density curve in Fig. 1 shows that even the most nearly neutral specimens of color film have characteristic absorption bands.

An attempt to compensate for the absorption of monochromatic color filters by increasing the intensity of the light source to the point that would still excite the phototube failed. It would have been possible to use such a system for the green and blue spectral regions in which the S-4 photosurface is quite sensitive but in the red region this photo-surface has negligible relative sensitivity and the necessary phototube response at 660 millimicrons could not be obtained.

Method of Improving Sensitivity

For obvious reasons, it is impracticable to obtain increased sensitivity by amplifying the output voltage developed across the 6F5 load resistor. Improved sensitivity in this type of circuit must be developed in the photoelement if the desirable features of the original instrument are to be retained. The substitution of a photo-multiplier tube for the simple phototube was considered, but at first no satisfactory way could be found to couple it to the grid circuit of the 6F5. The 6F5 cannot be operated successfully at grid currents much above 20 μa and the grid impedance corresponding to 0.02 μa (this value represents the grid current which results when a density of 3 is measured and the maximum or zero-density grid current is 20 μa) is of the order of 1000 megohms.

Polarity relationships demand that the multiplier and its power pack be connected directly to the grid and that its anode be tied to the 6F5 cathode. Consequently, the

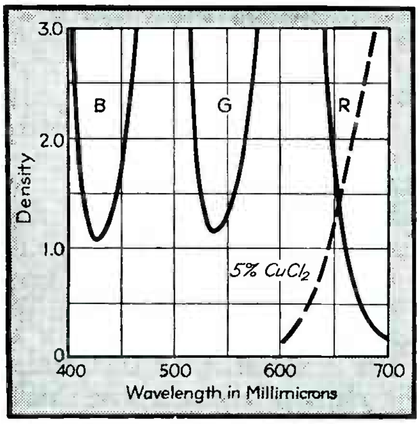

FIG. 5—Density-wavelength relations for the filter combinations used in the color densitometer

entire power pack has to be insulated with respect to ground, to an impedance value of the order of 1000 megohms. This is entirely out of the question for conventional methods of coupling. Furthermore, in mensuration circuits of this sort the stability demanded of the multiplier-tube power supply is excessive and the power supply circuits recommended in the literature for use with multiplier tubes would be relatively cumbersome in comparison with the remainder of the instrument.

In giving special attention to the requirements for a power supply of unusual stability, it became apparent that the recently developed miniature dry batteries intended for portable radio use form an ideal solution to this problem. Nominally, they yield 67½ volts per battery, and actually 71 volts when new. Other characteristics render them suitable from the standpoint of physical size, long life and ease of shielding.

Ten Minimax batteries were used in series, one for each dynode and one for the anode, as shown in Fig. 4. Operating at 70 volts per stage the multiplier tube gave an increase in sensitivity of about 20,000 over the simple phototube. The pack measured 4 x 5 x 7 inches and was supported on polystyrene cones for insulation inside a shielded wooden box. In order to minimize leakage the multiplier tube leads are guided by a single polystyrene bushing at the base of the measuring arm. Connections to the multiplier tube were soldered to avoid the leakage associated with a tube socket.

The stability of the battery pack is, of course, far better than necessary. The current drain for all dynode stages is negligible in comparison with the load for which the batteries were designed. The life is therefore the same as the shelf life and in practice the batteries can be used for up to two years without replacement.

The 6F5, normally located in the measuring arm, was remounted in the interior of the instrument case and the regular power supply was remounted behind the instrument. No difficulty had previously been experienced with oscillation in the production of the commercial model of the instrument. However, in this adaption a definite tendency to oscillate exists at density readings above 2.1 where the grid-to-cathode impedance becomes extremely high. This was suppressed by using a 0.01-μf capacitor between grid and ground. Although desirable from the standpoint of oscillation, a larger capacitor would have made readings sluggish at high densities.

The dark current of many commercial multiplier tubes is prohibitively high for use in the present instrument. Fortunately, there is a large individual variation and some tubes have been found with dark currents as low as 0.002 μa at 70 v per stage and room temperature. A dark current in excess of 0.005 μa cannot be tolerated because the dark current is inherently unstable and a variation of 20 percent of the total dark current would introduce inaccuracies in the higher density readings if the absolute value of dark currents were larger than about 0.005 μa.

A similar tube-to-tube variation exists with respect to the relative red-to-blue sensitivity of the photosurface. Since a tube of the highest possible red sensitivity is required, tubes are selected for this characteristic as well as for low dark current.

Optical System

In order to obtain the spectrally pure radiation necessary for valid measurements, relatively dense gelatin filters were used in three special combinations. Wratten filters 36, 2A and 38A isolated the blue and Wratten 62 and 16 the green. A Wratten 70 and 16 filter combination used in conjunction with a 2-percent solution of $CuCl_2$ 1 cm thick isolated the red radiation. The spectral quality of these combinations is shown in Fig. 5.

In Fig. 6 is a pictorial diagram of the optical system. It will be seen that the $CuCl_2$ filter is permanently interposed in the light beam. Since this filter has practically zero

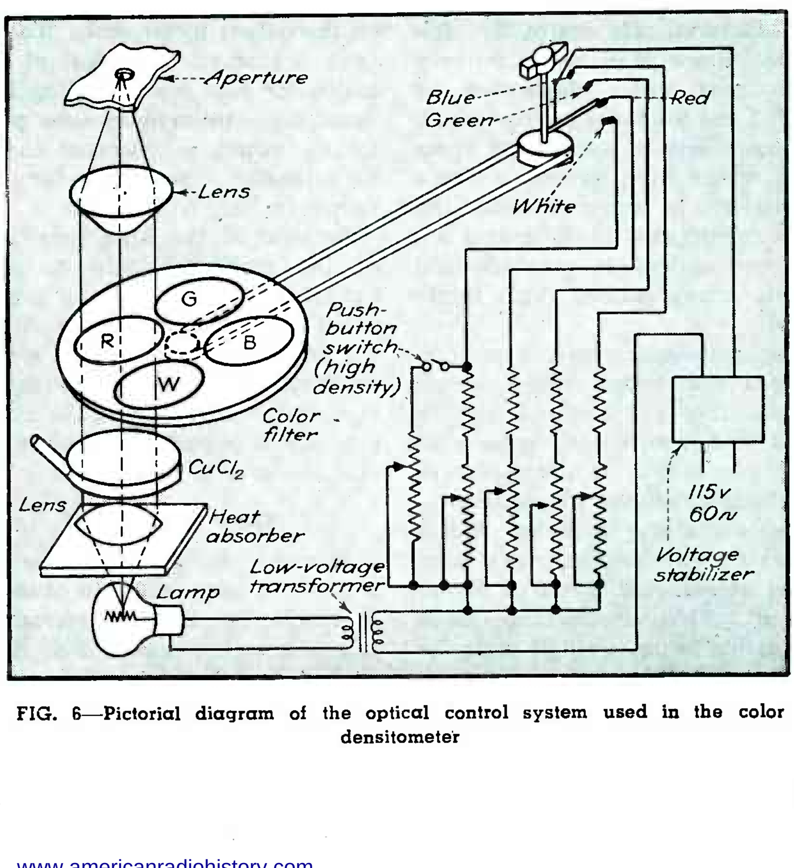

FIG. 6—Pictorial diagram of the optical control system used in the color densitometer

density to green and blue radiation it has no significant effect upon the spectral character of the radiation in these portions of the spectrum. However, in the course of using the instrument it was discovered that the solution became more dense during normal heating of the instrument as a whole. The insertion of a Jena BG 17 glass heat-absorbing filter on the source side of the $CuCl_2$ filter largely eliminated this difficulty with heat from the lamp.

When the different color filter combinations are interposed the intensity of the light source must be changed in order to maintain the same zero density reading. A tap switch, electrically and mechanically coupled to individual potentiometers and the filter disc, enabled the operator to set the potentiometers at the proper values and, thereafter, leave them undisturbed in spite of different color filter measurements.

Calibration

Commercial phototubes having different kinds of photo-surfaces, even though they may both be of the vacuum type, in general have markedly different relative illumination vs photocurrent relationships (non-linear). This is true, even at extremely low flux (and current) levels and when all of the special precautions advised by the manufacturer are carefully followed. Since this effect is very pronounced when phototubes of the S-2 and S-4 types are compared, the possibility of using both types (one where high green and blue sensitivity is required and the other for the red) is eliminated unless two scales are provided and circuit complications are introduced.

Fortunately, however, it was discovered that when only a single photosurface (at least of the S-4 type) was involved the same relative illumination vs photo-current relationship existed for monochromatic radiation, even at widely separated wavelengths, when compared at identical levels of photocurrent. This circumstance made it possible to use a single scale for all three color density readings.

The scale was calibrated to agree with a standardized silver wedge of known spectral density characteristics.

In the finished instrument, the on-off switch controls the power supply both for the 6F5 tube and the optical system. After three or four minutes warm-up the instrument is ready for use. Compared with the simpler black-and-white densitometer it is inherently somewhat less stable and there is a greater tendency to drift. However, it enables the operator to analyze the dye densities of large numbers of specimens quickly and reliably. In spite of its greater complexity it is still far simpler to use and much more sensitive than conventional colorimeters and spectrophotometers which would otherwise have to be used for these measurements.

High-Density Measurements

When the filter disc is oriented so that the beam is not intercepted by any filter, black-and-white densities can be measured directly. Due to the extremely high sensitivity of the multiplier tube the meter can be made to read zero when a density of 3.0 is interposed, by simply readjusting the intensity of the light source. Under these circumstances, the instrument will read densities between 3.0 and 6.0; the operator simply adds 3.0 to the scale reading. This general procedure can be extended to the point where a density of 7.3 reads 3.0 on the output meter scale. To prevent accidental overload of the multiplier tube when reading high densities, a momentary-close push-button switch is inserted in the high-density potentiometer as shown in Fig. 7.

Because of the high sensitivity of the multiplier tube to room light, when the measuring arm is lifted there is danger of overloading the 6F5 grid. Therefore, a mercury switch was mounted in the base of the arm to open the multiplier anode-to-ground circuit whenever the arm is raised.

Other Applications

In many respects the problem of measuring color reflection densities is similar to that of measuring color transmission densities. A reflection head has been made which can be secured to the measuring arm when desired. It accommodates a miniature lamp, light from which strikes the reflection specimen at an angle of 45 degrees. The vertical component of the reflected beam is received by the photomultiplier cathodes. Color filters are placed immediately in front of the multiplier tube. In this way the instrument has been used as a direct-reading reflection color densitometer in routine analysis of reflection color print materials.

The combination of a logarithmic response and extremely high sensitivity makes the instrument useful for other purposes than those already mentioned. For example, it has been used to record automatically the decay characteristics of phosphorescent substances. The fact that a 1-ma output meter is used in the basic instrument together with a 25,000-ohm plate load resistance made it unnecessary to alter the circuit to obtain these graphs. A standard model 1-ma Esterline-Angus ink recorder was substituted for the regular output meter and the curves were plotted directly.

Another example where the characteristics of the circuit are of considerable advantage is in microdensitometry for such purposes as the analysis of x-ray diffraction patterns and line spectrograms.

References

(1) Sweet, M. H., A Precision Direct Reading Densitometer, *J.S.M.P.E.*, **38**, p. 168, Feb. 1942.

(2) Russell, J., A Photoelectric Cell Circuit with a Logarithmic Response, *Review of Scientific Instruments*, **8**, p. 495, Dec. 1937.

(3) Sweet, M. H., The Spectral Characteristics of Optical Wedges, *J.O.S.A.*, p. 194, Apr. 1943.

Bibliography

(1) "Theory of the Photographic Process", Chapter XVII.

(2) Mees, C. E. R., "The Measurement of Density", MacMillan, 1942.

(3) Sweet, M. H., Density, *The Complete Photographer*, **18**, p. 1188.

(4) Dudley, B., "Handbook of Photography", Chapter VII—Photographic Sensitometry, McGraw-Hill Book Co., N. Y., 1939.

(5) Lindsay, W. W. & Wolfe, W. V., A Wide-Range Linear Scale Photoelectric Cell Densitometer, *J.S.M.P.E.*, 28, p. 622, 1937.

(6) Frayne, J. G. & Crane, G. R., A Precision Integrating Sphere Densitometer, *J.S.M.P.E.*, 35, p. 184, 1940.

(7) White, D. R., A Direct Reading Photoelectric Densitometer, *J.S.M.P.E.*, 33, p. 403, 1939.

(8) Tuttle, C., A Recording Physical Densitometer, *J.O.S.A.*, 26, p. 282, 1936.

(9) Sweet, M. H., A Precision Direct Reading Densitometer, *J.S.M.P.E.*, 38, p. 148, 1942.

(10) Tiedman, J. A., A Linear Densitometer, ELECTRONICS, p. 48, Mar. 1941.

(11) Heymer, G., and Sundhoff, D., Measurement of the Gradation of Color Film, *Veroeffentl. Wiss. Zentral-Lab. Agfa*, 5, p. 62, 1937.

(12) Evans, R. M., A Color Densitometer for Subtractive Processes, *J.S.M.P.E.*, 31, p. 194, 1938.

Engineering Aspects of TELEVISION PROGRAMMING

Up to thirty fixed-position television cameras per studio, all under finger-tip control of the program director at a compact control-room console, are considered essential to provide the frequent viewpoint changes to which moviegoers have become accustomed

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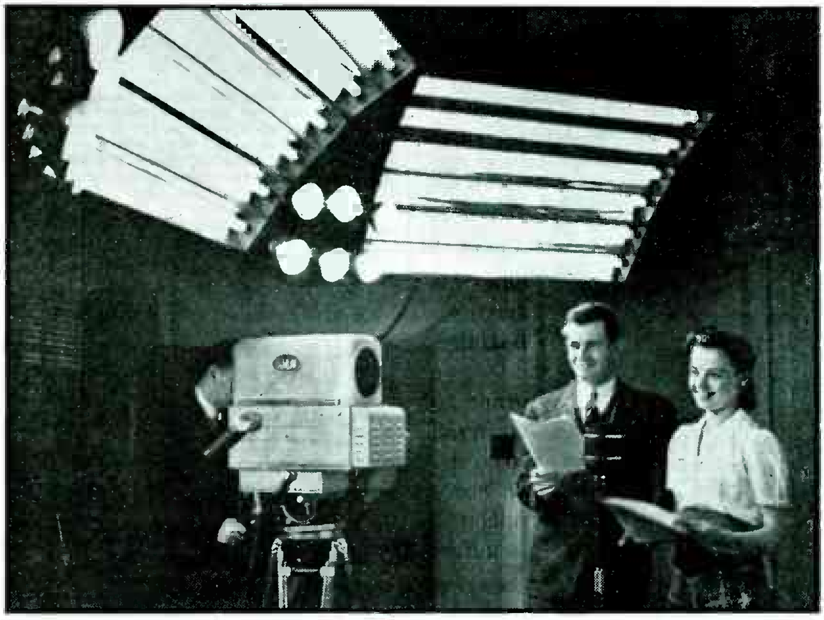
THE OPINION is often expressed, by those who have seen a large number of experimental telecasts, that successful commercialization requires more improvement in television programs than in picture quality. On first consideration it may seem that program production problems are the exclusive province of program directors. Such a viewpoint is contrary to good practice in other fields, where analysis of purpose and process are a part of the design engineer's job.

It is difficult for design engineers to apply thoroughly the principle of performance analysis to telecasting equipment; such analysis would require a knowledge of the complex, specialized field of programming. Pioneering program directors, on the other hand, are proceeding justifiably by trial and error methods. They are forging a new technique by borrowing from older arts—journalism, advertising, painting, broadcasting, motion picture production, and 3000 years' experience in theater arts. These men are artists struggling with elaborate technical equipment necessary for televising the subject material they create.

A specialist in engineering can rarely become a specialist in programming as well, but the design engineer must find working answers to two basic questions: What subject material is interesting when televised? What equipment is needed for the most effective and inexpensive handling of material?



This Westinghouse installation of large banks of fluorescent lamps and reflector spotlights provides illumination flexibility which would supplement the camera flexibility considered essential by the author

Future television programs fall into two main groups: (1) Live programs telecast as presented in a studio or by remote pickup; (2) canned programs recorded on still or motion picture film. The table on the following page indicates the general types of programs available for television use in each of these groups.

Audiences Expect Changing Viewpoints

Regardless of subject or origination point, television equipment must take into account the psychology of sight and man's seeing habits. In life the human eye is shifting from particular to particular in endless movement. This eye movement pattern is so strong it is extremely difficult for man to gaze steadily at one spot without blinking, for prolonged periods of time.

In a telecast the camera becomes the viewer's eye. Its picture-frame limits what he will see. Therefore, if the receiving screen is to hold his continuous attention, the camera must supply the movements which his eye cannot make. It can do so by (1) moving toward or away from the subject, (2) by following a moving subject, and (3) by changing the viewpoint.

The first two alterations can be made while the viewer is watching the picture. The last requires the use of a second camera whose picture must be framed, focused, and checked by a director before it can be broadcast to the viewer. Studio experience has shown that at least a minute and a half is needed to do this, and it must be done while the

TYPES OF TELEVISION PROGRAMS

LIVE SUBJECT MATERIAL		CANNED SUBJECT MATERIAL
Remote Origination	**Studio Origination**	**Special Effects Studio Origination**
NEWS: Accidents Fires Inaugurations Fairs Parades Conventions Political Meetings Legislatures Civil Courts "Town Hall" Meetings Brings inaccessible scenes to viewers. Faithfully transmits personality of local and national politicians.	NEWS: Commentators Television permits a more informal approach, with maps, sketches, diagrams and pictures being used as visual aids. Viewers, however, do not want to see the commentator discuss the news—they want to visualize what he speaks about.	NEWSREELS: Daily local news, by silent film with commentary Newsreel reports, in "March of Time" manner NEWS PHOTOS: Picture articles, with commentary similar to popular pictorial magazines Recorded local news can be presented for workers about dinner time, but regular newsreels and documentary films should come later in evening.
SPORTS: Archery Baseball Basketball Bowling Boxing Crew Racing Football Golf Hockey Ice Skating Horse Racing Horse Shows Lacrosse Polo Skeet Shooting Ski Jumping Swimming Tennis Winter Sports Wrestling High in viewer interest. No longer confined to small, brilliantly lighted spaces (sensitivity of camera pick-up tubes has been greatly increased as result of war-sponsored research).	SPORTS: Ping-Pong Billiards Wrestling Boxing Card games Sports commentators can employ visual aids. Television can give even greater enjoyment than on-the-spot viewing of many indoor as well as outdoor sports. Thus, in televising a card game with a multi-camera set-up, cards and facial expressions of each player in turn can be shown as play progresses around the table.	SPORT FILMS: Newsreels of sporting events too distant for remote pickup Films of complete events, taken for telecasting at a more convenient or desirable later time Documentaries of sport subjects, showing prowess and techniques of famous athletes Films of this nature can serve satisfactorily until such time as great national television networks are available.
PERSONALITY PROGRAMS: Roving Television Interviewer Interviews at special events "People are Funny" types of programs	PERSONALITY PROGRAMS: Interviews Special human-interest features	Personality Note: Televising pretty girls is a programming must. They will be employed as announcers and for purely decorative effect.
DRAMATIC PROGRAMS: Opera Operettas Plays Variety shows Vaudeville Mono-dramas Televising theatre bills by remote pickup takes the viewer where he would like to be, and brings dramatic events he might not otherwise enjoy. Drama produced especially for television will have its own special technique.	DRAMATIC PROGRAMS: Opera Operetta Plays Vaudeville Mono-dramas Marionettes Puppets Spontaneous Drama Spontaneous drama, popular in the theatre of the 16th and 17th centuries, involves impromptu dialog with prearranged plot outlines, and has unusual audience holding power.	MOTION PICTURES: Full-length feature pictures, shorts and cartoons Note: Marionettes are well suited for television, and provide a complete adult theatre requiring only a small space. Puppets, controlled by hand manipulation rather than strings, have identical advantages and are especially good for commercials.
DANCING: Ballet Night clubs Dancing, with its visual appeal, makes excellent television material.	DANCING: Ballet Chorus dancing Interpretive Folk dancing Dance pantomimes	
MUSIC: Opera Operetta Special Concert Artists	MUSIC: Musical programs, employing visual program notes Only music having added visual attractions should be televised. Pictures, scores, commentators, and close-ups of performing artists can be shown.	MUSIC: Mood music, employing visual commentary Need not be elaborate. Can be edited from film libraries or still pictures at which the viewer need glance only occasionally.
LECTURES: University lectures "Town Hall" series	LECTURES: Any subject—travel, art, science All lectures should be supplemented with still or motion pictures, diagrams, models, etc. Informal armchair approach can be used. Sketches can be drawn while speaking.	
DEMONSTRATIONS: Department stores Universities, on scientific subjects	DEMONSTRATIONS: Any art, craft or hobby capable of demonstration Many commercials will be in this form.	
EXHIBITS: Commercial shows Department store displays Museums Commercials here can well permit window-shopping at home. Remote pickups are almost essential for showing heavy merchandise like furniture and autos.	EXHIBITS: Fashion shows Collector's exhibits A well-informed announcer is required as master of ceremonies, to explain items.	
EDUCATIONAL PROGRAMS: University classes Public school classes	EDUCATIONAL PROGRAMS: Broadly speaking, all informational programs might be considered educational. True educational programs, however, would contain subject matter arranged for instruction only. Such programs would employ the techniques of illustrated lectures, demonstrations, exhibits, and all the devices of visual education.	

viewer is watching another picture.

Both in the motion picture and television the maximum duration of a viewpoint, without loss of viewer attention, is about one minute. Actually audiences are conditioned by current film practice where the average length of a shot is 10 to 15 seconds, and hence they expect another viewpoint before a minute has passed. Because a second camera cannot be prepared in this time interval, at least three cameras are essential.

Even a three-camera system is limited. Although any combination of two alternating viewpoints can be shown while a third is being set up, the pattern of changing these viewpoints must be continually repeated. An example of a three-camera sequence would be 1, 2, 1, 2 until 3 is set up, then 3, 2, 3, 2 until 1 is again ready, and so forth. This pattern is too monotonous to be satisfying.

Using a greater number of cameras, say from 4 to 8, offers more variety, but it also adds to studio confusion, increasing the margin for error, since each camera requires one to two operators.

Need For Visual Rhythm

Aside from these limitations and hazards, there is a still greater weakness of the system. Audiences are conditioned not only by the rapidly changing viewpoint as now used in the film, but by the rhythm created thereby. Although this rhythm is so subtle it escapes the viewer's notice, it nevertheless has a powerful emotional effect upon him similar to the rhythms in music or poetry. The effect of it is apparent in less artistic presentations. A radio listener is immediately aware whether the person he hears is reading or speaking extemporaneously. This subtle element is so important that announcers meticulously cultivate the patterns of impromptu speech. When a subject is presented with an inappropriate visual ryhthm, or even without one at all, the audience is conscious that something is lacking.

Television programs are comparable to the motion picture in this respect. The present equipment, even employing the maximum of six cameras, is too cumbersome to present subjects with any visual rhythm. Until more flexible equipment is designed this element, essential to satisfying programs, will be missing.

In order to create a visual rhythm of presentation, the program director must have a variety of viewpoints at his command without having to wait for any one to be set up during an actual telecast. Therefore, it is desirable to have from 15 to 30 cameras, mounted and fixed in positions predetermined by the director according to the subjects to be televised, and supplement these with an operator-controlled camera for viewpoints changed while being telecast.

Present television cameras are too bulky and heavy to be used in this manner, with the possible exception of follow shots. Instead, smaller cameras are needed, about the size of a standard theater spot light and easily carried and set up by one studio hand. All mounting fixtures should be standardized to permit multiple use of cameras in studios and at remote locations.

Greater sensitivity is urgently needed. Television, at present, compares unfavorably with the motion picture in its ability to present mood through the use of lighting, as in scenes lighted by an open fire. Greater sensitivity is also needed to televise theater productions by remote pickup.

Control Room Requirements

The control room preview panel for a system of many cameras in fixed positions need have no more pictures than are now contemplated. Five is a workable number: No. 1 for the picture being telecast, No. 2 to preview the next viewpoint to be broadcast, No. 3 for an additional previewing picture, No. 4 for preparing shots changed during presentation, and No. 5 for such special effects as motion picture cut-ins, titles, and models.

A switchboard for the director (perhaps patterned after a typewriter keyboard or an organ console) is another essential piece of control room equipment. The time lag between the director's verbal command for a switch of viewpoint and the actual change, when made by a second person, is extremely undesirable. Furthermore, the director's position to the preview panel should correspond to that of the average home viewer.

Advantages of Fixed Cameras

There are many desirable aspects of a fixed camera system. First of all, studio rehearsals can be eliminated, and performers will not need to rehearse before the cameras. Their only requirement is to practice lines, movement and business in a space equal in size and corresponding in shape to the actual studio. This is necessary because movements must be rehearsed on the exact scale to be used in the telecast. Forearmed with full details of the subject and business of a program, the director can choose camera viewpoints, plot the sequence of changes, and direct the telecast from his personal cue sheet.

Cameras can be set up and checked before a program goes on the air.

The director can function as critic. By fencing with a repertoire of ready viewpoints the director can place more emphasis upon his function as idealized spectator, continually anticipating the viewer's desire for a fresh angle of the subject. He can concentrate on the final result because he is not preoccupied with the mechanics of directing camera changes during the actual televising.

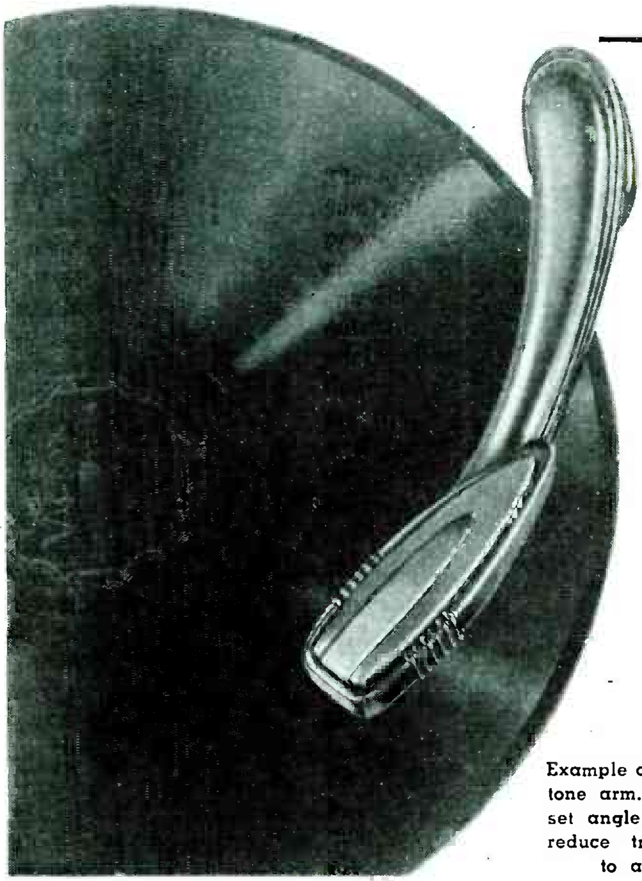
Staffs can be smaller. Cameras in fixed positions do not require operators, and a crew of camera hands can service more than one program.

Cameras in fixed positions are suitable for remote pickups. Mounted before a telecast, their use eliminates the activity and confusion of operator-controlled cameras, an objectionable feature of the present system.

Conclusion

New types of studio and camera equipment are needed to meet the demands for speed and flexibility of operation during television programs. The solution lies essentially in the development of a simpler television camera that can be economically used in large numbers in fixed positions, with corresponding changes in control room design to permit effective changing of viewpoints by the director.

Tracking Angle



Example of well-designed modern tone arm. Proper choice of offset angle and needle overhang reduce tracking-error distortion to a negligible value

Distortion due to tracking error can be minimized by bending the pickup arm and overhanging the needle. Equations are developed for determining optimum bending and overhang for any given conditions, and a design chart is provided for use with 12-inch records

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ALMOST EVERYONE conversant with phonograph reproduction is familiar with the fact that in a straight tone-arm the needle enters the groove laterally at an angle, which has some undesirable effects upon the record and upon the quality of reproduction. The exact nature and the quantitative amounts of these effects appear to be considerably less well known.

It is widely recognized that such effects can be corrected by offsetting the tone-arm head and adjusting its position in respect to the center of the turntable. Theory dealing with the actual amount of the necessary adjustments, however, is not generally available to tone-arm designers and users. The purpose of this article is to present to phonograph designers, in readily useful form, quantitative information regarding tracking angle and its effects, and means for minimizing these effects in modern phonograph equipment.

It is generally accepted that tracking angle produces the following effects: (a) Record wear; (b) Distortion; (c) Side-thrust upon the record grooves. Much has been written in the past ten years about these effects. Oftentimes only one of them has been emphasized at the expense of the others. This resulted in many offset arm designs which were inferior in performance to the equivalent straight arms.

Additional factors have entered the picture recently as a result of the introduction of home recording, light-weight pickups, permanent-point styli, and the widespread use of record changers. In order to deal with these subjects systematically the various effects will be treated in the following order: (1) Geometry of the tracking angle; (2) Record wear; (3) Side thrust; (4) Distortion; (5) Best arm offset; (6) Optimum arm design.

Definition of Tracking Angle

Let a tone arm having an effective length l inches (distance from the center of the pivot to the needle point) be mounted on a motorboard with its pivot d inches away from the center of the record, as shown in Fig. 1(a). When the needle point is r inches away from the center of the record the following relationships exist:

$$r^2 + l^2 - 2rl\cos\theta = d^2 \qquad (1)$$

$$r^2 + l^2 - 2rl\sin\phi = d^2 \qquad (2)$$

where θ is the angle included between the lines l and r, and ϕ is the tracking angle between l and a line tangent to the groove at the needle point. Solving for $\sin\phi$:

$$\sin\phi = \frac{r}{2l} + \frac{l^2 - d^2}{2lr} \qquad (3)$$

It will be seen that the amount of arm overhang D (swing of the needle point beyond the center of the turntable) is a significant parameter. Taking advantage of the fact that $d = l - D$, Eq. (3) may be rewritten as

$$\sin\phi = \frac{r}{2l} + \frac{2lD - D^2}{2lr} \qquad (4)$$

Equation (4) is precise in every respect, but does not lend itself to simple analytical treatment. We shall therefore make two simplifying assumptions, that D^2 is negligibly small compared with $2lD$, and that $\sin\phi = \phi$ in radians. When this is done, Eq. (4) can be rewritten as

$$\phi_{rad} = \frac{r}{2l} + \frac{D}{r} \qquad (5)$$

in Phonograph Pickups

$$\phi_{deg} = 57.3\left(\frac{r}{2l} + \frac{D}{r}\right) \qquad (6)$$

The approximations tend to be mutually compensatory, and Eq. (6) provides values of ϕ which are correct within approximately 1 deg, as can be readily demonstrated by substituting assumed values of variables in Eq. (4) and (6). This degree of approximation is ample for the problem on hand, and it is well justified in view of the labor saving which it affords. In all the derivations which follow, ϕ_{rad} is conveniently used. This is multiplied by 57.3 to obtain ϕ_{deg} for use in final calculations.

Tracking Angle Curves

Figure 1(b) shows graphically the values of ϕ_{deg} as a function of the radius for a 7½-inch arm and for various values of arm overhang D. The custom in the early '30s was to use straight tone arms pivoted in such a manner that the needle point passed through the center of the record. The tracking angle corresponding to this condition is represented by curve AA for $D = 0$. It is seen that ϕ at the 5.75-inch radius is 22 deg, and this gradually decreases to 7.6 deg at the inner radius of 2 inches. The thought of a needle point entering the record grooves at a substantial lateral angle, together with the fact that this angle changed throughout a wide range of values and thereby involved continuous regrinding of the tip, was not especially reassuring to phonograph designers.

The most obvious answer—that of greatly lengthening the tonearm—was found to be impractical because of motorboard space limitations. A study of curves similar to those of Fig. 1(b) indicated that the remedy might lie in performing two operations: (1) Swinging the arm beyond the center of the record, as exemplified by curves EE in Fig. 1(b); (2) Bending or offsetting the head through an angle β, approximately equal to the average angle over the range of radii (this is equivalent to raising the zero-degree ordinate on the graph to any given value of β). It should be noted that β is measured clockwise from the line connecting the needle point with the pivot point; it is not, as it is sometimes erroneously assumed, the angle between the body and the head of the tone arm.

As an example, if the needle point overhang D is $\frac{13}{16}$ inch as for curve EE in Fig. 1(b), the tracking angle varies from 32 deg at 6 inches through 27 deg at 3.3 inches back to 32 deg at the 2-inch radius. Now, if the pickup head is bent at a 29.5-deg angle, the departure of the needle from tangency is reduced to only 2.5 deg on either side. The difference between the tracking angle, ϕ, and the offset angle, β, has been termed tracking error α, for it indicates how short of perfect the scheme is.

The above procedure for tracking angle correction (giving minimum α) appeared to remedy all of the straight-arm objections, and it was widely adopted in many reproducers built in the years of 1938-1941. This was somewhat unfortunate, for it was shown later that minimum α is not a valid criterion of best tracking.

Record Wear

The theory behind record wear due to improper tracking angle was based upon the fact that the spherical point of a steel needle rapidly wears down to a chisel-point after the playing of the first few grooves. As the tracking angle varies throughout the playing of the record, the chisel-point turns with respect to the grooves and is constantly reground, thereby increasing record wear over and above that which would normally exist.[1, 2]

With rare-metal or sapphire-tipped needles, the point remains spherical for many hundreds or even thousands of plays. There is therefore little or no justification for fearing increased record wear due to moderate amounts of tracking angle with modern playback equipment if the permanent-point needles are not employed beyond their rated life.

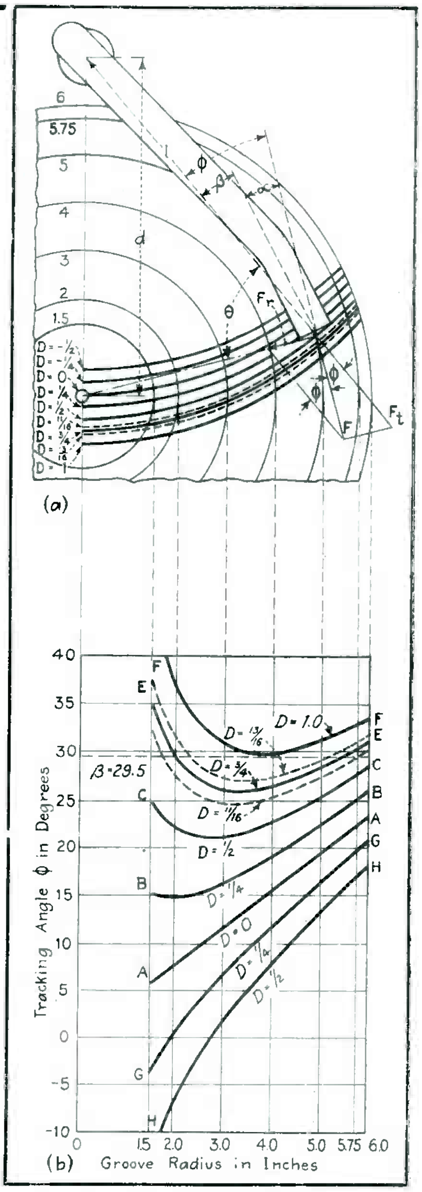

FIG. 1—Diagram showing dimensions and angles involved in tone arm design, and curves showing how tracking angle varies with groove radius for different values of needle overhang *D*. All linear dimensions are in inches

Side Thrust

Due to friction between the needle and the groove, there is a force F upon the needle point in the direction of the line tangent to the groove. This force is quite independent of the angle which the pickup head makes with the groove, and it depends only upon the vertical needle force F_r and upon the

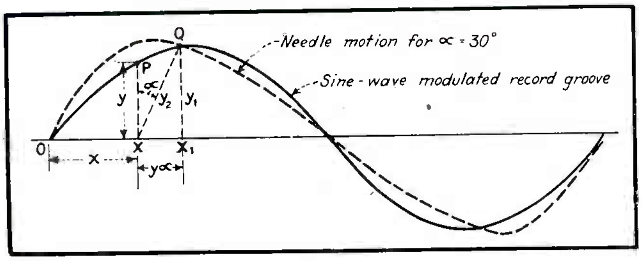

FIG. 2—Manner in which a sinusoidal wave form is distorted due to tracking error

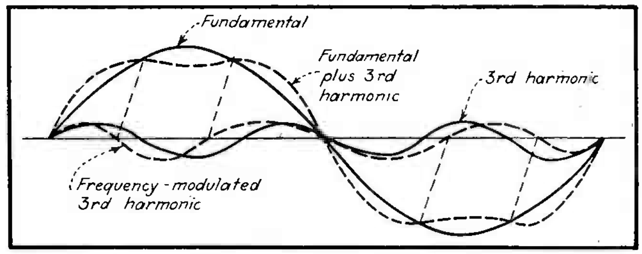

FIG. 3—Frequency modulation effect in phonograph pickup output due to tracking error

coefficient of friction μ between the needle point and the record ($F = \mu F_v$). The value of μ varies with the type of record material and also with the amount of groove modulation. For most record materials and light needle forces, μ is roughly $\frac{1}{3}$. With heavy pickups and soft records, μ may be considerably greater.

The force diagram at the needle point in Fig. 1(a) indicates the action of the frictional force. It is seen that F has a tangential component F_t which is borne by the arm pivot, and a radial component F_r which tends to pull the pickup toward the center of the record and which is borne by the inner side of the record groove. From the force parallelogram it is seen that $F_r = F \tan \phi$. This force is not altered by any conceivable twisting of the pickup head. For any given record and pickup, F_r is therefore a function only of r and D.

Take again the case of a 7½-inch arm with the needle passing through the center of the record, corresponding to curve AA in Fig. 1(b). The tracking angle is 22.5 deg ($\tan^{-1}$ 0.415) at the 6-inch radius and 7.6 deg ($\tan^{-1}$ 0.133) at the 2-inch radius. If μ is assumed to be $\frac{1}{3}$, the side thrust corresponding to these angles, in a 1-oz pickup, is 0.14 and 0.05 oz respectively.

If D is $\frac{1}{2}$ inch as for curve CC in Fig. 1(b), the angles are 28 deg ($\tan^{-1}$ 0.53) and 22 deg. ($\tan^{-1}$ 0.40) and the corresponding side thrust is 0.18 and 0.13 oz respectively. Swinging the arm beyond the center of the record thus increases the side thrust and keeps it more or less uniform throughout the playing of the record.

It has been pointed out that moderate side thrust may not be detrimental because it helps to overcome pivot bearing friction. On the other hand, the unduly large values of D employed in some instances increase F_r beyond the safe point. Some phonographs cannot reproduce home-recording records because the side thrust becomes large enough to pull the tone-arm out of the groove toward the center of the record.

Record Changer Requirements

The effect of arm placement upon the side thrust is most pronounced at inner radii of the record. This makes side thrust of special interest in connection with record changers. Some changers require a force directed away from the center of the record to actuate the tripping mechanism. In supplying this force, the tone arm is aided by the use of low and negative values of D. Other changers require a force directed toward the center of the record. This can be aided by the use of larger values of D. Such procedure may not be consistent with the conditions of minimum tracking-error distortion. In record changers, a slight compromise in distortion may be justified if reliable operation of the tripping mechanism is helped thereby.

An occasional source of greatly increased side thrust is found in some of the needles which have recently appeared on the market. Many of these needles are forwardly bent so that the effective value of D is increased by $\frac{1}{8}$ to $\frac{1}{4}$ inch. In general, there are no apparent ill effects due to the use of such needles; however, instances are known when tracking has been impaired because of increased sidethrust.

The effect of sidethrust can be kept within safe limits if it is recognized that the tone arm is often called upon to track at groove radii less than 2 inches. Because of this, a minimum radius of 1¾ inches is used in all the following calculations pertaining to 12-inch records. When this precaution is observed, side thrust developed with optimum values of D is quite harmless in low-weight pickups.

Distortion

When the axis of the pickup cartridge is not tangent to the groove, the needle motion is not perpendicular to the groove, giving rise to distortion. Mathematical analysis of this distortion has been made by Baerwald[3]. The simplified derivation given below helps to bring out the essential physical factors involved and yields results which are sufficiently accurate for all intents and purposes. The solid line in Fig. 2 represents a sine-wave modulated record groove, and the dotted line is the distorted sinusoid representing the needle motion when α = 30 deg.

When $\alpha = 0$, the equation of needle point displacement is the same as that of the groove. (Elastic deformation of the record material and pinch effect are neglected). Assume that initially the needle point is at O and $\alpha = 0$. When the groove travels a distance x (from O to X), the needle moves from O to P and its lateral displacement y in inches equals

$$y = A \sin 2\pi x/\lambda \qquad (7)$$

where A is maximum groove amplitude in inches, and λ is the wavelength of groove modulation in inches. However, if the tracking error $\alpha > 0$, the needle point moves to Q instead of P; in so doing it advances horizontally a distance approximately equal to $d = y\alpha$, where α is in radians. This is approximate, but close enough for our purpose. Instead of being at X, the horizontal projection of the needle point is now at X_1. The equation of the motion described by the needle point is

$$y_1 = A \sin x_1 = A \sin \frac{2\pi}{\lambda}(x + y\alpha) \qquad (8)$$

Substituting in Eq. (8) the expression for y in Eq. (7) now gives

$$y_1 = A \sin\left(\frac{2\,\pi\, x}{\lambda} + \frac{2\,\pi\, A\,\alpha}{\lambda}\sin\frac{2\,\pi\, x}{\lambda}\right) \qquad (9)$$

If the groove moves with a velocity of V inches per second, then $x = Vt$ and $f = V/\lambda$ cycles per second, and

$$y_1 = A \sin\left(\omega t + \frac{\omega\, A\, \alpha}{V}\sin \omega t\right) \qquad (10)$$

What is of interest is not y_1 but the lateral motion of the needle point, which is $y_2 = y_1/\cos\alpha$; therefore,

$$y_2 = \frac{A}{\cos\alpha}\sin\left(\omega t + \frac{\omega\, A\, \alpha}{V}\sin\omega t\right) \qquad (11)$$

Frequency-Modulation Effect

Examination of Eq. (11) shows that there is a slight increase in playback level due to the $1/\cos\alpha$ term, and frequency modulation of the signal. In Eq. (10), let $y_1 = A \sin \psi$. Differentiating ψ to obtain instantaneous angular velocity ω_i,

$$\omega_i = \frac{d\psi}{dt} = \omega + \frac{\omega^2 A\,\alpha}{V}\cos\omega t$$

$$\omega_i = \omega\left(1 + \frac{\omega\, A\,\alpha}{V}\cos\omega t\right) \qquad (12)$$

The instantaneous frequency of the signal is thus modulated at a rate equal to its own frequency and with a frequency deviation of $\omega A\alpha/V$. This is of special interest when the wave is complex, consisting of a large-amplitude, low-frequency fundamental f and a small-amplitude higher-frequency component f_1. This effect is indicated graphically in Fig. 3. It may be shown that f_1 is modulated at a frequency f by the amount given in parentheses in Eq. (12). In a manner identical to other frequency-modulation phenomena, this gives rise to inharmonic terms having frequencies $(f + f_1)$, $(f + 2f_1)$, etc. Analysis of the nuisance value of this distortion is somewhat complex[3] but the overall results may be roughly estimated from harmonic analysis of Eq. (11). This equation may be expanded algebraically into its harmonic components:

$$y_2 = \frac{A}{\cos\alpha}\left[\sin\omega t\cos\left(\frac{\omega\, A\,\alpha}{V}\sin\omega t\right) + \cos\omega t\sin\left(\frac{\omega\, A\,\alpha}{V}\sin\omega t\right)\right]$$

It will be shown later that normally $\omega A\alpha/V < 0.06$ radian; therefore, with an error not in excess of 1 percent, one may state that

$$\sin\left(\frac{\omega\, A\,\alpha}{V}\sin\omega t\right) \simeq \frac{\omega\, A\,\alpha}{V}\sin\omega t$$

$$\cos\left(\frac{\omega\, A\,\alpha}{V}\sin\omega t\right) \simeq 1$$

Substituting these simplifications in the expansion of Eq. (11) gives

$$y_2 = \frac{A}{\cos\alpha}\left(\sin\omega t + \frac{\omega\, A\,\alpha}{V}\sin\omega t\cos\omega t\right)$$

$$y_2 = \frac{A}{\cos\alpha}\left(\sin\omega t + \frac{\omega\, A\,\alpha}{2V}\sin 2\,\omega t\right) \qquad (13)$$

Second Harmonic Distortion

Equation (13) consists of a fundamental and a double-frequency term, representing second harmonic distortion. Distortion is given by the modulus of the second term in parentheses:

$$\text{Percent 2nd harmonic (amplitude)} = \frac{\omega\, A\,\alpha}{2V} \times 100 \qquad (14)$$

This is on an amplitude basis; on a velocity basis harmonics are accentuated in proportion to the frequency, hence

$$\text{Percent 2nd harmonic (velocity)} = \frac{\omega\, A\,\alpha}{V} \times 100 \qquad (15)$$

For ease in interpreting Eq. (15) let the angular velocity ω_r of the record be 2π times speed in rps. Then the linear groove velocity is proportional to the radius, and hence $V = \omega_r r$. Inserting this in Eq. (15) gives

$$\text{Percent 2nd harmonic} = \frac{\omega\, A\,\alpha}{\omega_r\, r} \times 100 \qquad (16)$$

From Eq. (16) the following is concluded:

(a) Distortion is proportional to the ratio between tracking error α and groove radius r. The ratio α/r may therefore be considered as an index of distortion. If distortion is not to exceed a given value throughout the playing of the record, this value of α/r must not be exceeded.

(b) Differentiating Eq. (7) with respect to time, it is found that maximum groove modulation velocity equals ωA. Distortion is therefore directly proportional to the velocity of groove modulation.

(c) Distortion is inversely proportional to the speed of the record. For equal distortion, more careful tracking angle correction is required in 33-rpm discs than in 78-rpm discs, other factors being the same.

Example of Distortion

As a specific example of distortion due to straight arms, assume a modulation amplitude of 0.0017 inch and a frequency of 250 cps, equivalent to a modulation velocity ωA of 2.67 inches per second. These conditions are chosen because they constitute a maximum velocity on an Audiotone test record which has a constant amplitude characteristic from 50 to 250 cps and a constant velocity characteristic thereafter. In a 78-rpm record $\omega_r = 2\pi(78/60) = 8.16$ radians per second. Now, take the case of a

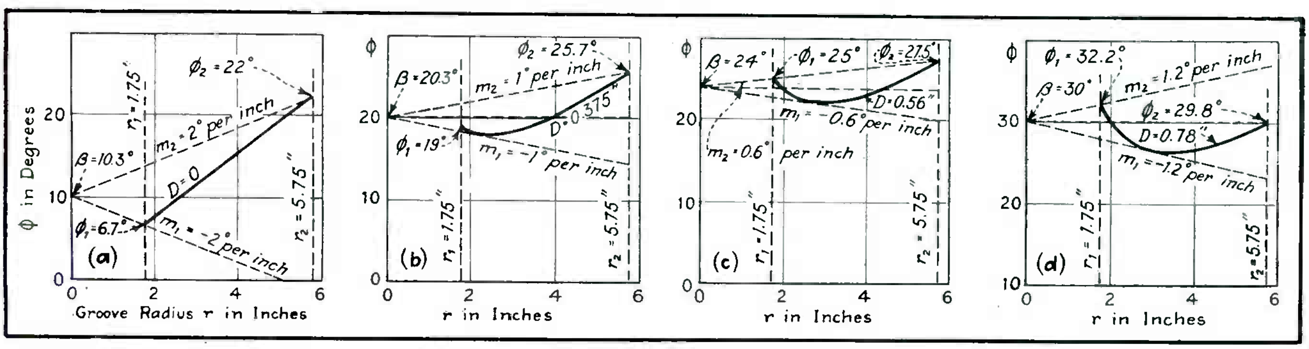

FIG. 4—Graphical procedure for determining the best arm offset angle for various overhang values ranging from no overhang (a) to 0.78-inch overhang (d)

straight pickup with the needle passing through the center of the record. From Eq. (5), tracking angle (and, in this case, tracking error α) equals $r/2l$ radians and α/r equals $1/2l$ radians per inch. Substituting these values into Eq. (16), it is found that, in the constant-velocity portion, distortion is constant at all radii and equals 2.2 percent. This constancy is to be expected from considerations made in connection with Eq. (16).

It is doubtful that this amount of distortion is significant in the majority of phonograph apparatus. However, questions arise regarding distortion on records with levels higher than the Audiotone.

The relative levels of modulation velocity may be determined by examination of the width of reflected light patterns.[4] Comparison of pattern width of commercial pressings with the Audiotone record indicates that the former exhibit modulation levels 2 to 2½ times greater than the latter. Therefore, in playing commercial recordings, a tracking error distortion of 4 to 6 percent may be expected with straight-arm reproducers. These values are comparable to other distortions found in phonograph reproduction; no one should expect, therefore, startling improvements in fidelity due to elimination of tracking error. However, even a moderate amount of distortion added on top of other distortions in the system may become greatly annoying, especially in extended-range systems.

Determining Arm Offset

To determine the proper arm offset for any given D, we use tracking angle curves like those in Fig. 1(b). Curves for four selected values of D have been drawn in Fig. 4. In each instance we shall find the value of β for the least α/r, corresponding to the least distortion possible with the given D. In so doing we shall also have solved the converse problem: "What should D be for an arm of given β"?

In Fig. 4(a), ϕ is shown for the condition of $l = 7.5$ inches and $D = 0$. Tracking angle ϕ varies from 22 deg at the 5.75-inch radius to 6.7 deg at the 1.75-inch radius. For straight arms $\alpha = \phi$, and $\alpha/r = 22/5.75 = 3.8$ deg per inch. This has been found to produce distortion of from four to six percent.

Consider now the arm which is offset at an angle of 10.3 deg. Here α at 5.75-inch radius is $22 - 10.3 = 11.7$ deg; α at 1.75-inch radius is $10.3 - 6.7 = 3.6$ deg. For both radii, α/r is now 2 deg per inch. Offsetting the arm 10.3 deg has reduced distortion by a ratio of almost 2:1.

An offset of 10.3 deg produces lowest distortion in a 7.5-inch arm, if D equals zero. This can be easily verified by repeating the above calculations for values of β other than 10.3 deg. If one extends two lines from the 10.3-deg point on the zero-inch ordinate to the two terminals of the ϕ curve, as shown in dotted lines in Fig. 4(a), it becomes apparent that the slopes m_1 and m_2, in degrees per inch, are equal and opposite. It is not difficult to reason out that this is a necessary and sufficient condition for least α/r. Therefore, in determining the arm offset for any given D, the following procedure may always be employed:

Draw the ϕ-curve corresponding to the given l and D between the limits r_1 and r_2. Extend straight lines just bounding the ϕ-curve on each side from a point β on the zero-inch ordinate such that the slopes m_1 and m_2 are equal and opposite. Angle β is then the offset angle yielding least tracking error distortion. This procedure is valid for any and all values of l, D, r_1 and r_2.

In the instance when the slope lines touch the two extremities of the ϕ-curve (as in the above example), β can also be found analytically without any difficulty. Tracking angles ϕ_1 and ϕ_2 in radians at radii r_1 and r_2 are

$$\phi_1 = r_1/2l + D/r_1 \qquad (17)$$

$$\phi_2 = r_2/2l + D/r_2 \qquad (18)$$

If the two slope lines are equal,

$$(\beta - \phi_1)/r_1 = (\phi_2 - \beta)/r_2 \qquad (19)$$

Substituting Eq. (17) and (18) into (19) and solving for β, radians,

$$\beta = \frac{\left(\frac{1}{r_1^2} + \frac{1}{r_2^2}\right) D + \frac{1}{l}}{\frac{1}{r_1} + \frac{1}{r_2}} \qquad (20)$$

If $D = 0$,

$$\beta = \frac{1}{l\left(\frac{1}{r_1} + \frac{1}{r_2}\right)} \qquad (21)$$

This gives the best arm offset when the needle passes through the center of the record. If $\beta = 0$,

$$D = -\frac{1}{l\left(\frac{1}{r_1^2} + \frac{1}{r_2^2}\right)} \qquad (22)$$

This indicates that straight arms should be underhung for least distortion.

Equation (20) represents a family of straight lines. This family, for 12-inch discs, is given in Fig. 5, and it extends from the 0-deg ordinate to the inclined dotted line labelled "Limit of simple placement equation."

For values of D greater than indicated by the limit line, Eq. (20) is no longer valid because the lower slope-line m_1 touches the ϕ-curve at a point other than ϕ_1. Such a situation is shown in Fig. 4(b) for a 7.5-inch arm when $D = 3/8$ inch. For the least α/r, β is now found to be 20.3 deg by employing the graphical method given before. The analytical relation between β and D is given in this instance by

$$D = \frac{r_2}{2}\left(\frac{r_2}{l} - \beta\right)\left(\sqrt{1 + \frac{\beta^2}{\left(\frac{r_2}{l} - \beta\right)^2}} - 1\right) \qquad (23)$$

The derivation of this equation is not difficult, but it is tedious enough to be relegated to the Appendix. The family of curves represented is a set of curved lines which are extensions of the straight lines of Eq. (20).

A careful study of Fig. 1(b) or Fig. 4 reveals that progressive increase of D (and use of the corresponding best β) diminishes the distortion index α/r. This is shown by the diminishing angle between the two bounding lines m_1 and m_2. In the instance of $D = 3/8$ inch given above, α/r is 1.0 deg per inch, which is a 4:1 decrease compared with a straight arm.

As D is increased further, the point is finally reached when α/r is minimum and, distortionwise, optimum arm design is achieved. This is shown in Fig. 4(c) where α/r is only 0.6 deg per inch. In Fig. 5, the relation between β_{opt} and D_{opt} is given by the straight dotted line labeled "Line of optimum arm design."

Example of Excessive Offset

Beyond the optimum point, the upper slope-line m_2 passes through

ϕ_1, and the angle between m_1 and m_2 again increases—and so does distortion and side thrust. This condition occurs in a number of pre-war arms.

Figure 4(d) shows proper placement of a 7½-inch arm having an offset angle of 30 deg. The best value of D here is 0.78 inch.

The derivation of the best placement equation is given in the Appendix. For least distortion, the relation between β (radians) and the corresponding D (inches) is as follows:

$$D = \frac{R_1}{2}\left(\beta - \frac{r_1}{l}\right)\left(\sqrt{1 + \frac{\beta^2}{\left(\beta - \frac{r_1}{l}\right)^2}} + 1\right) \quad (24)$$

This equation represents a series of lines which are practically straight and which are shown in Fig. 5 extending beyond the "Line of optimum arm design." Figure 5 can be used, therefore, as a universal chart for properly locating arms with pre-determined β, or for determination of β in arms requiring a given amount of overhang because of tracking reasons.

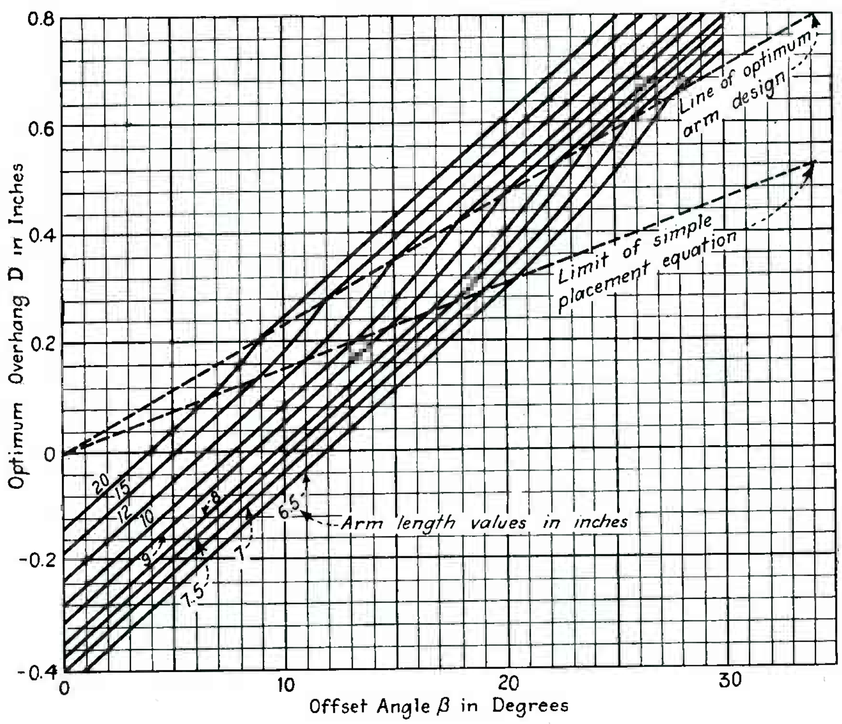

FIG. 5—Design chart for tone arms used with 12-inch records, in which minimum groove radius r_1 is 1.75 inches and maximum groove radius r_2 is 5.75 inches

Optimum Arm Design

Keeping in mind the procedure for obtaining best β, the following conditions are fulfilled when α/r is minimum: (1) Both extremities of the ϕ-curve touch the upper slope-line m_2; (2) The lower slope line m_1 is equal and oppositely slanted ($m_1 = -m_2$) and just touches the lower side of the ϕ-curve.

This situation is shown in Fig. 4(c). The relation between l, r, r_2, D, and β corresponding to this instance will now be derived.

The slope of the line tangent to the ϕ-curve and passing through β is given in the Appendix as

$$m = 1/2l - \beta^2/4D \text{ radians per inch} \quad (25)$$

From condition (1) above,

$$\frac{\phi_1 - \beta}{r_1} = \frac{\phi_2 - \beta}{r_2} \quad (26)$$

Substituting values of ϕ_1 and ϕ_2 from Eq. (17) and (18) and solving for β gives

$$\beta = D\frac{r_1 + r_2}{r_1 r_2} \quad (27)$$

From condition (2), $\beta - mr_1 = \phi_1$. Substituting the values of β from Eq. (27), m from Eq. (25), and ϕ_1 from Eq. (17) and solving for D,

$$D = \frac{r_1^2}{l\left[\frac{1}{4}\left(1 + \frac{r_1}{r_2}\right)^2 + \frac{r_1}{r_2}\right]} \text{ inches} \quad (28)$$

Substituting this expression for D in Eq. (27) now gives

$$\beta = \frac{r_1\left(1 + \frac{r_1}{r_2}\right)}{l\left[\frac{1}{4}\left(1 + \frac{r_1}{r_2}\right)^2 + \frac{r_1}{r_2}\right]} \text{ radians} \quad (29)$$

The values of β and D as given by Eq. (28) and (29) provide the minimum distortion attainable in a pivoted tone arm, and they should always be employed in tone-arm design unless this is not feasible because of other considerations. The reduction in distortion over the straight-arm situation is roughly 6:1. This renders tracking error distortion completely negligible.

APPENDIX

To derive the equation of arm placement in the region of tangency, it is first necessary to find the slope m_1 of the lower slope-line tangent to the ϕ curve and passing through the point β on the zero-inch ordinate. The slope of the line connecting β with any point on the ϕ-curve is

$$m = \frac{\phi - \beta}{r} = \frac{\phi}{r} - \frac{\beta}{r} \quad (30)$$

Substituting the value of ϕ from Eq. (5) gives

$$m = \frac{1}{2l} + \frac{D}{r^2} - \frac{\beta}{r} \quad (31)$$

The point of tangency occurs when the slope is minimum; differentiating Eq. (31) gives

$$\frac{dm}{dr} = \frac{\beta}{r^2} - \frac{2D}{r^3} \quad (32)$$

For minimum slope m_1, $dm/dr = 0$, and

$$\beta = 2D/r \quad (33)$$

Substituting Eq. (33) in Eq. (31),

$$m_1 = 1/2l - \beta^2/4D \quad (34)$$

In order to fulfill the procedure for least α/r, m_2 must equal $-m_1$, or

$$m_2 = \beta^2/4D - 1/2l \quad (35)$$

But the upper slope m_2 equals

$$m_2 = (\phi_2 - \beta)/r_2 \quad (36)$$

Substituting ϕ_2 from Eq. (18) and m_2 from Eq. (35), Eq. (23) is obtained.

Beyond the point of optimum arm design, m_2 makes contact with ϕ_1 instead of ϕ_2. Equation (36) becomes

$$m_2 = (\phi_1 - \beta)/r_1 \quad (37)$$

Substituting ϕ_1 from (Eq. (17) and m_2 from Eq. (35), Eq. (24) follows.

REFERENCES

(1) Glover, Ralph P., A Record Saving Pickup, ELECTRONICS, Feb., 1937, p. 31.

(2) Olney, Benjamin, Phonograph Pickup Tracking Error, ELECTRONICS, Nov., 1937, p. 19.

(3) Baerwald, H. G., Analytical Treatment of Tracking Error and Notes on Optimal Pickup Design, *Journal of the Society of Motion Picture Engineers*, XXXVII, Dec., 1941, p. 591.

(4) Buchmann, G., and Meyer, E., A New Optical Method of Measurement for Phonograph Recordings, *E.W.T.*, 7, p. 147, 1930. Reviewed in *Journal of the Acoustical Society of America*, 12, Oct., 1940, p. 303.

Effects of Humidity on

Moisture absorption decreases leakage resistance and changes dielectric constant of a terminal strip. Resulting adverse effects on circuit operation can be avoided by the design and layout techniques which are discussed and illustrated

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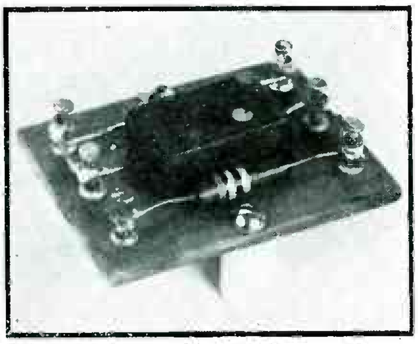
DEPENDABLE and accurate operation of radio and other electronic equipment under extreme conditions of high temperature (+50 deg C) and relative humidity (95 percent) requires, among other factors, careful consideration of terminal-strip design. Most failures experienced during tests conducted on a variety of equipment under these extreme conditions have been traced to faults either in the design or dielectric material of terminal strips. If an analysis is made of the circuit and the particular terminal strip in question, it is possible to develop a good design and so considerably reduce failures of this type.

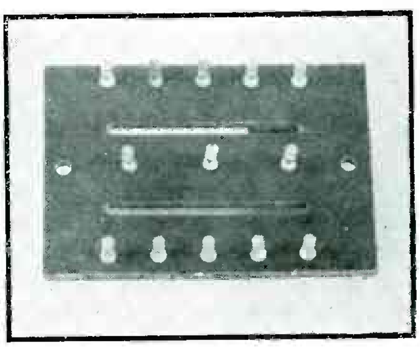
Effects of Leakage

Leakage resistance may be decreased by moisture absorption in the material itself or by a moisture film on its surface. Capacitance changes are also present since the dielectric constant of the material will also change with moisture content. This will disturb the frequency stability of a tuned circuit. For example, the resulting equivalent circuit of a parallel *LC* circuit is shown in Fig. 1, *L* and *C* being shunted by the capacitance C_1 in series with the leakage resistance R_1. Thus the circuit *Q* and the resonant frequency will be subject to change.

In the case of a terminal strip upon which are mounted resistors and fixed capacitors, leakage may exist not only to ground but from lug to lug. The effect upon circuit operation in the presence of leakage in a strip upon which these components are mounted is frequently serious. For example, the time constant of an *RC* network can be materially changed.



Mounting terminal strip on half-inch standoff insulators prevents leakage to ground



Although the moisture absorption of this material is high, slotting the strip provides satisfactorily low leakage

A variation in time constant can upset the desired circuit operation by affecting frequency response and phase shift. If the circuit is to pass a square wave, the leakage may actually differentiate it. The reverse condition may also occur in an integrating circuit.

Figure 2(a) shows examples of leakage paths that can exist in a resistance-coupled amplifier. Low leakage resistance from plate to ground will limit the positive plate-voltage swings and cause distortion if the plate load resistance is high. A voltage divider is formed by the plate load resistance R_L and the leakage resistance R_1 in parallel with R_2, so that the maximum voltage applied to the plate depends upon the relative values of these resistances. For instance, with the values shown, the plate voltage cannot exceed 150 volts.

It is also evident that if leakage exists between plate and grid, a d-c potential will be applied to the grid by the voltage-divider action of the leakage resistance R_3 and the grid resistor R_g. Again, its magnitude will depend upon the relative values of these resistances. A small amount of leakage at this point can, of course, greatly disturb the grid bias and cause improper operation. Similar action can take place between the plate and screen grid when the tube is a pentode.

Moisture Increases Leakage

The amount of moisture absorption by a terminal strip varies with the material used. Wax impregnation of the strip will reduce absorption, but it must be remembered that it is not by any means a cure-all. None of the commonly used impregnating agents afford 100 percent protection; they merely retard the process of absorption, and once moisture is absorbed the impregnation tends to retain it.

When equipment is subjected to high temperature and humidity conditions for long periods of time, say two months, the amount of absorption may be considerable. While it is true that when the equipment is operated heat dissipated within the unit will tend to dry it, the time

Terminal-Strip Design

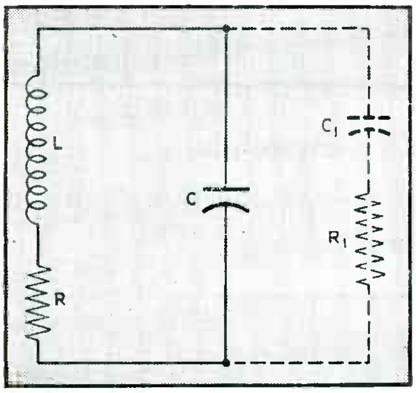


FIG. 1—Leakage can change both the Q and f_0 of a resonant circuit

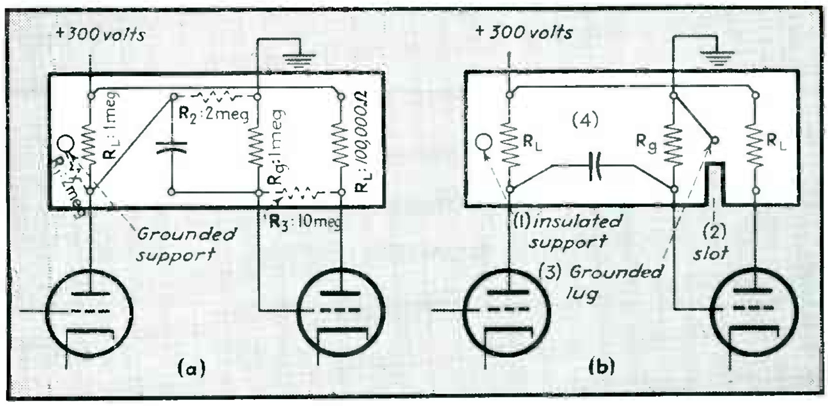


FIG. 2—Leakage paths to ground supports and between mounting lugs, shown dotted at (a), can be minimized by rearranging and changing as indicated at (b)

required for this process can be excessively long, sometimes a matter of hours. Selection of a material possessing high resistance to moisture absorption is therefore of prime importance.

Surface leakage will also be present regardless of the strip material. This type of leakage results from a film of moisture on the surface of the strip and is aided in formation and maintained by the accumulation of dust particles.

Layout Reduces Leakage

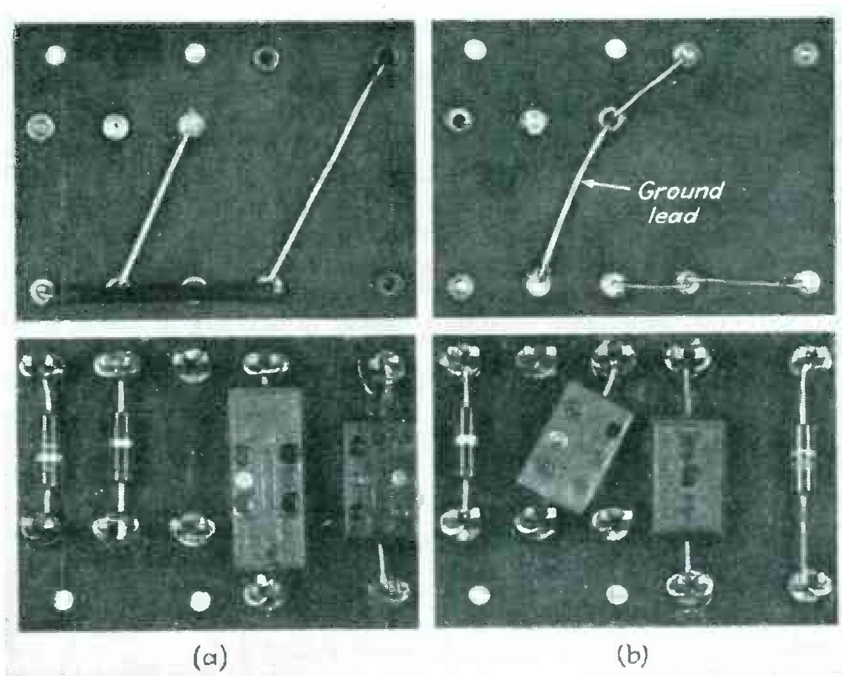
Figure 2(b) shows means that may be used in combating leakages. Obviously, if the spacing between lugs is increased, less leakage may be expected. Slotting of the strip will provide long paths between lugs and at the same time enable the terminal-strip size to be maintained within reasonable proportions. Leakage to grounded terminal-strip supports may be eliminated by using small stand-off insulators for mounting. Another method sometimes used to prevent d-c leakage from plate to grid is the insertion of a grounded lug between these two points. Any leakage existing in that path will then be to ground instead of to the grid. Care must be taken with this application, however, since leakage from grid to ground may be introduced, which may or may not interfere with correct circuit operation, depending upon the circuit.

When designing a terminal strip it is advisable to keep high-impedance points on it removed as far as possible from low-impedance points as well as grounds. The same precaution should also be taken with points of high d-c potential differences. In this way the possibility of a voltage breakdown due to leakage, may be prevented or at least reduced.

Also, leads from high impedance circuits should be dressed. The insulation on the lead itself can provide a leakage path between two adjacent points. When leads are cabled together, leakage through the insulation to other leads can occur if they are not satisfactorily protected against humidity. If insulation is not protected against moisture, leads to the affected circuit should be run directly instead of by cabling.

The effect of leakage in a terminal strip can easily be observed by simulating leakage resistance with fixed resistors of one or more megohms and connecting them between points on the strip where leakage is suspected or probable.

In any event, if impedances are kept as low as can be tolerated in the circuit design, effects of extreme conditions of high temperature and humidity may be dealt with more easily.



Direct-current leakage with the arrangement at (a) is prevented by rearranging components to interpose a ground lead as at (b) between high and low-voltage lugs

FREQUENCY-RESPONSE

Details of a laboratory unit capable of directly drawing frequency-response curves of microphones and loudspeakers. Electronic warbling is used to give constant cycles or constant percent bandwidth as required

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ACOUSTIC measurement of frequency response of microphones and loudspeakers is severely hampered by: 1. Standing waves in the medium; and 2. Sharp resonances in the standard pressure source.

Over a long period of years, the first source of error has been attacked by making sound rooms with walls having a low percent of the energy reflective. This results in standing waves of low intensity and consequently the pressure at any given point can be predicted. The rooms are nevertheless expensive to build when it is desired to keep the percentage of error low. If standing waves exist, changes in position from node to antinode may produce errors of 10 db.

The second source of error difficult to compensate for is the sharp dip or peak in the pressure generator. Practically speaking, only the smooth variations can be accounted for by equalizing circuits.

A statistical method of obtaining the most probable frequency response when standing waves or sharp dips or peaks occur, is to average the pressure—frequency response over small and overlapping bandwidths. If the signal is slightly warbled or frequency modulated, the process can be performed with standard meters and curve drawing equipment. This is due to the fact that warbling gives a saddle-shaped energy distribution of the frequency. In the past this type of warbling was obtained mechanically by rotating a capacitor in parallel with the tank circuit of the oscillator.

With this method it is difficult to change the percentage and the rate of warble and to obtain sinusoidal modulations. Furthermore, it is very difficult to obtain constant-percent bandwidth by the mechanical method. In order to average out standing-wave errors, constant-cycles bandwidth is required. In order to cancel out dips and peaks in a pressure generator, constant-percent bandwidth is required. This flexibility is difficult to achieve with a mechanical method of warbling, but has been solved by electronic methods.

Laboratory Unit

The method of obtaining the frequency response curve is shown in Fig. 1. A sheet of standard linear-log paper is wrapped around the drum and adjusted so its frequency is aligned with the frequency of the oscillator dial. The gain of the microphone amplifier is adjusted so the master attenuator which drives the pen is set at a desired point on the paper and gives a convenient meter reading. When the hand operated drum is rotated, the frequency is changed in synchronism with the rotation of the paper.

Changes in level of the device under test are compensated by rotating the master attenuator so that the meter is returned to the original value. Thus, since the attenuator controller keeps the meter reading constant while the paper is driven, the pen records the level of the device directly on the paper. Since the controller is a db attenuator, and the paper is linear-log, the frequency response is recorded in db versus frequency.

The basic idea involved in electronic warbling is the use of the audio frequency of the oscillator itself to determine the extent of the cycles of warble.

The method of achieving this result is shown in Fig. 2. Beat oscillator (A) has an incremental variable inductance tube (B) across the fixed-frequency tank. The grid of the variable inductance tube is driven by both the 180-kc fixed-tank frequency and the low frequency of the warble rate.

Amplitude of the low-frequency signal is determined by the warble-extent controller, (C). Two signals are applied to the grid of the warble-extent controller. One is a d-c signal from the frequency discriminator (D) and the other is an a-c signal from the low-frequency generator, (E). The frequency discriminator is fed from the audio output at constant voltage, independent of frequency.

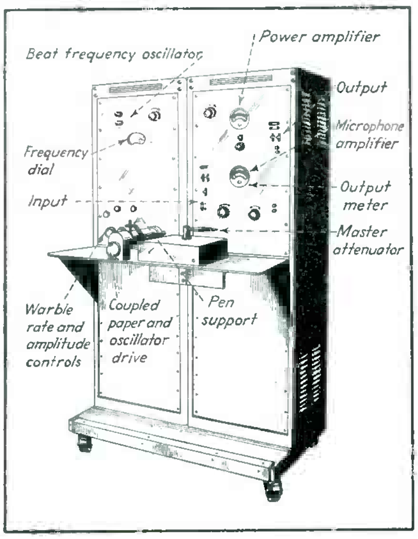
Thus all circuit blocks operating in unison produce a warbled audio output whose warble is a prescribed function of the audio frequency as determined by the frequency discriminator circuit.

A detailed examination of each block will show the pitfalls and merits of this system.

Beat Oscillator

The oscillator is a General Radio —type 713. A beat oscillator type of audio signal generator allows simple control of the warble, since all the operations are performed on a tank whose frequency remains constant. Thus, the circuit elements can be calculated for fixed constants. The oscillator employed must be such that the shunting

CURVE TRACER



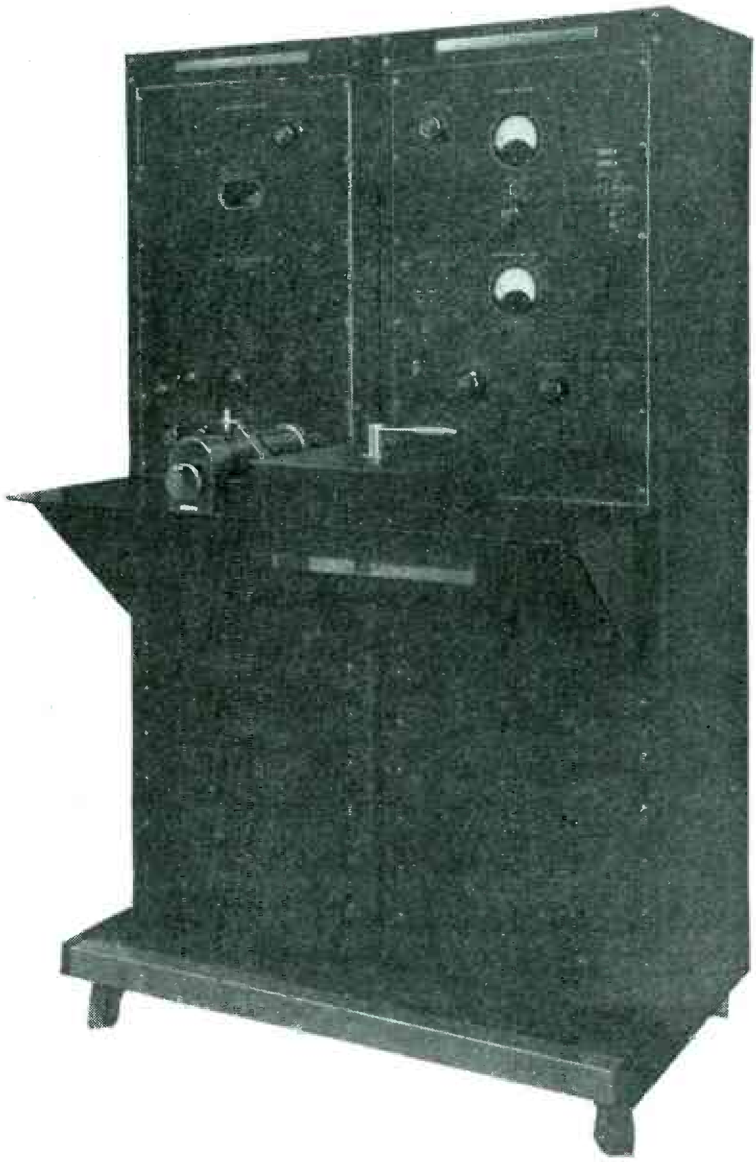


FIG. 1—Laboratory model of frequency-response curve tracer has parts arranged as labelled. Linear-log paper is wrapped around drum and master attenuator is used to maintain constant output as frequency run is made with coupled paper and oscillator drive

variable element can change the frequency and yet not load the tank to produce amplitude distortions.

In other words, an operating point must be found such that a high-impedance pentode will not materially load it with a resistive component while reflecting a variable capacitance or inductance. This particular oscillator has a logarithmic frequency dial. This makes for a simple paper drive, since the paper can be standard linear-log paper, giving a db level versus a logarithmic frequency scale.

Variable Inductance

There are a number of means of obtaining a controlled variable reactance. The circuit selected was the simplest. It was possible to mount the 956 tube and related component parts directly in the oscillator housing. This eliminated any stray field pickup and long leads. The leads to the tank must be connected in an extremely rigid fashion or small vibrations will introduce spurious frequency drifts.

This simple method of obtaining a controlled variable inductance, however, requires a regulated B supply. If a push-pull arrangement is used—namely, having in parallel a variable inductance tube and a variable capacitance tube, and if the two reactance-tube grids are driven in push-pull—wider swings can be obtained with better stability for line voltage fluctuations.

In the arrangement shown in the variable inductance, the tank-frequency signal delivers a quadrature leading current to the 0.00003-μf capacitor and the 1500-ohm resistor, since the latter is an order of magnitude smaller than the capacitive reactance of the former at 180 kc (0.00003-μf or 30,000 ohms.) However, the voltage across the resistor is in phase with the current and leads the voltage of the 180-kc tank. This voltage causes the 956 plate to draw lagging current from the tank; or in other words the tube is an inductance across it.

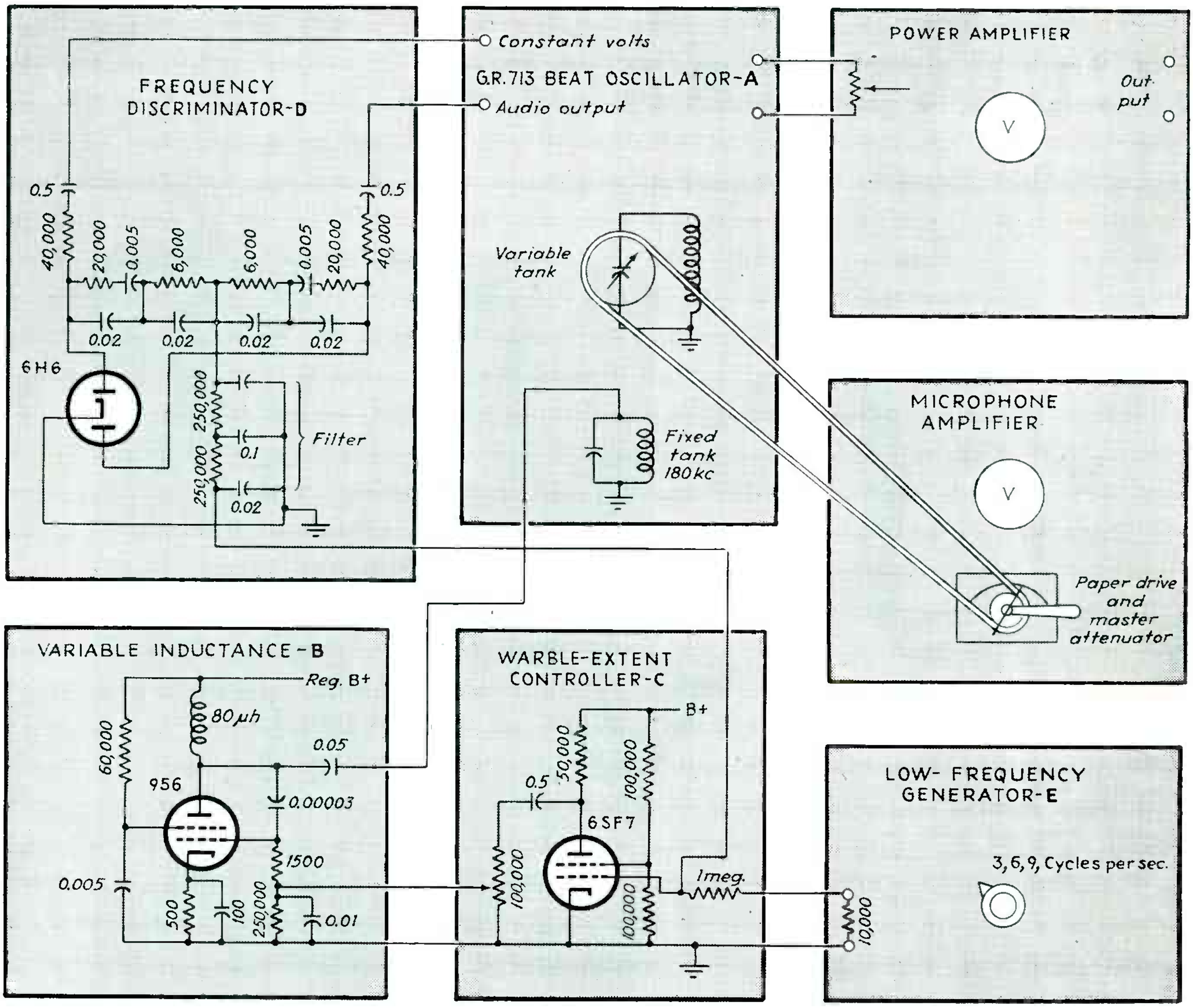


FIG. 2—Interaction of component sections of curve tracer results in a warbled audio output whose modulation is determined in extent by the audio frequency of the oscillator itself. Completely automatic motor-driven versions have been built for production use

Now, since the 956 is a variable-mu tube, the current drawn will depend on the grid bias. If the grid is now swung at a low frequency rate over a wide grid bias voltage, the lagging current will vary in magnitude or effectively become a variable inductance proportional to the low frequency swings. For small changes in inductance the frequency swing is linear since

$$f_o = \frac{1}{2\pi} \cdot \frac{1}{\sqrt{\frac{LL_s}{L + L_s} C}} \qquad (1)$$

where f_o is the fixed frequency, L_s is the inductance reflected by the pentode, and L and C are the tank elements.

Now, if the tube inductance L_s is caused to vary by a value Δ

$$f_v = \frac{1}{2\pi C^{1/2}} \left[\frac{L + (L_s + \Delta)}{L\,(L_s + \Delta)} \right]^{1/2} \qquad (2)$$

where f_v is the variable frequency or

$$f_v = \frac{1}{2\pi C^{1/2}} \left[\frac{L + L_s}{LL_s + L\Delta} + \frac{\Delta}{LL_s + L\Delta} \right]^{1/2} \qquad (3)$$

Since Δ is small compared with L,

$$f_v = \frac{1}{2\pi C^{1/2}} \left[\frac{L + L_s}{LL_s} + \frac{\Delta}{LL_s} \right]^{1/2} \qquad (4)$$

Expanding Eq. (4) to the first approximation

$$f_v = \frac{1}{2\pi C^{1/2}} \left[\left(\frac{L + L_s}{LL_s} \right)^{1/2} + \frac{1}{2} \frac{\Delta}{LL_s} \left(\frac{L + L_s}{LL_s} \right)^{-1/2} + \ldots\ldots\ldots \right] \qquad (5)$$

Substituting back f_o

$$f_v = f_o + \tfrac{1}{2} \frac{\Delta}{L + L_s} f_o \qquad (6)$$

Thus a change in shunt inductance causes a linear change in frequency provided the change is a small one. Since the change in grid bias (over a selected portion) produces a change in g_m proportional to the bias, the frequency swing will be linear with the amplitude of the low frequency signal.

Warble-Extent Controller

In this section a variable-mu tube provides the automatic change in level of signal supplied to the variable inductance. A d-c signal from the frequency discriminator controls the level of a-c output.

In another application where even wider range of control was desired, two stages were successfully used. The same frequency discriminator produced a square of the change in low frequency amplitude over that of a single stage.

For this laboratory curve tracer, the variation in low-frequency signal required was such that logarithmic change in amplitude was obtained from 100 cycles to 10,000, or 100:1. This is just about the limit of control realizable for a single stage of variable-mu tube. However, to get logarithmic control a special function of d-c bias voltage must be obtained from the frequency discriminator since the characteristic of the tube is not logarithmic. The a-c low-frequency signal is kept constant throughout a frequency run.

Once a logarithmic a-c output is obtained and fed to the volume control in the warble-extent controller, then settings of any value of constant percent are obtained from zero up to 10 percent by simply setting this potentiometer at any desired value. In the event that constant-cycle bandwidth is required, the discriminating circuit is reduced to a set of resistors, and fixed d-c independent of frequency, is fed to the warble-extent controller grid.

Frequency Discriminator

The d-c voltage fed to the grid of the warble-extent controller must have a function of frequency such that a prescribed a-c low-frequency signal is fed to the grid of the variable inductance. Since the variable-mu tube varies in accordance with some arbitrary function, the equalizing circuit is so adjusted that a d-c voltage is obtained such that its product with the tube characteristic produces at any specific oscillator audio frequency, the required frequency swing. In this case the audio voltage was taken from the 6L6s of the beat oscillator. The audio voltage is essentially constant-amplitude with frequency and fairly independent of line voltage.

The procedure for selecting the required d-c is: 1. Place a known a-c on the grid of the 956 and plot warble-extent versus a-c signal. This can be done at any audio frequency with a narrow-band meter such as the GR wave analyzer. 2. Vary the d-c on the grid of the 6SF7 until it produces the required a-c low-frequency amplitude. 3. Produce the required d-c from the frequency discriminator which will give logarithmic control versus frequency. 4. Filter the a-c signal from the equalizer section as shown.

An *RC* oscillator is used in the low-frequency generator unit because low frequencies of 3, 6, and 9 cycles are easily obtainable with two tubes and simple components. In addition, an *RC* oscillator is inherently stable enough for the low frequency requirement.

Three, 6, and 9 cycles are made available since amplitude variations occur in the warble band under test due to sharp dips or peaks. An amplitude variation might occur at the resonant frequency of an auxiliary meter and cause difficult reading. All that is necessary in this case is to switch to a different low frequency and avoid the meter resonance.

Higher frequencies of warble cannot be used since at the low frequency end of the audio—say 20 cycles—the warble rate would introduce large frequency errors. Hence for low-frequency audio measurement the 3-cycle rate must be used. At higher frequencies of 1000 cycles or more, even higher rates than 9 cycles could be used but there is no advantage in this direction as far as accuracy is concerned.

Microphone Amplifier

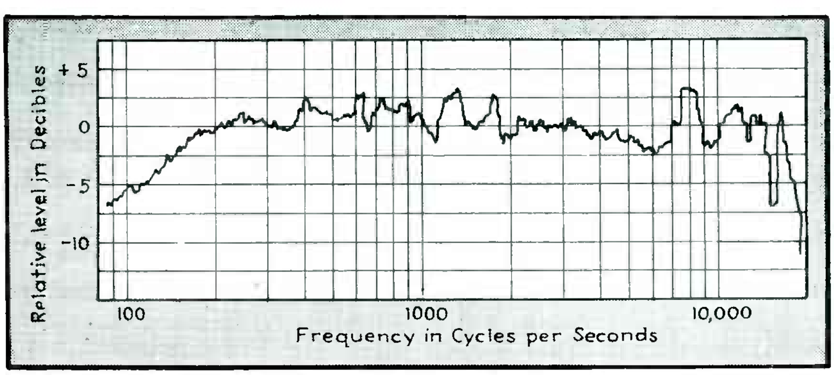
The amplifier used here is a stabilized amplifier which gives a reading at 10 microvolts and reads full scale on the meter at 100 microvolts. The master attenuator, coupled to the pen drive, is in the output stage. It controls the meter reading. The recording paper is wrapped around the drum and set so that its frequency is aligned with the frequency of the oscillator dial. The amplifier gain is so set that, with the attenuator at some arbitrary db level, the meter gives a convenient reading—say 500 microvolts in the input.

As the drum driving the beat oscillator is rotated through the audio band, the meter is kept at constant reading by means of hand adjustment on the master attenuator controller. In this particular model, the attenuator provides 40-db attenuation in ½-db steps with the shorting position providing ¼-db steps.

Conclusions

This unit has been satisfactory for frequency-response runs from 40 cycles to 15,000. A fully-automatic frequency-response curve tracer for supersonic testing at frequencies of 100 cycles to 150 kilocycles is now in use. Either constant cycles or constant percent band-width is obtained, varying smoothly from zero to 3000 cycles or zero to 10 percent respectively.

For laboratory use the hand-driven unit is more useful because it is possible to obtain greater accuracy. Hand operation also permits careful exploring around any frequency point. In the motor-driven system, errors are encountered as soon as rapid excursions are required in curve drawing. This is avoided in hand operations because the operator stops rotation of the frequency dial while he carefully sets the attenuator to the correct reading. For production runs, however, the motor-driven automatic system is preferable—some of the human element in setting the attenuator for constant meter-reading being avoided.



Frequency-response curve drawn by tracer. Control of hand-operated model is such as to permit detailed exploration around critical breaks in the curve

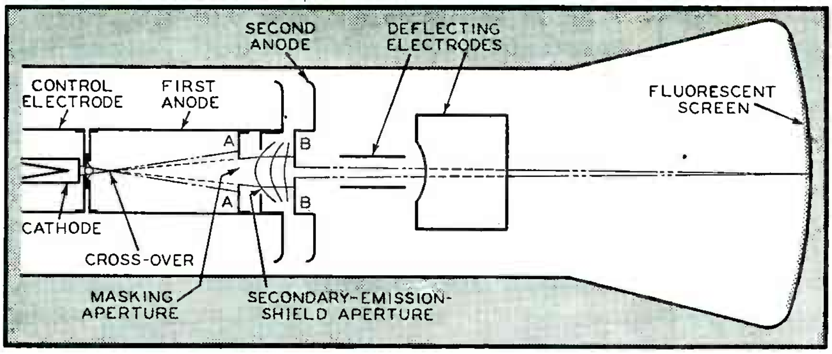


FIG. 1—A conventional cathode-ray tube electron gun, in which the first anode operates at a positive potential and contains a masking aperture which is shown at AA

Improved ELECTRON

Gun design involving zero current for first anode simplifies power-supply problem and gives sharper focus. The beam is also less subject to stray fields capable of causing variation in spot brightness. Several constructional advantages are inherent in the design

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CATHODE-RAY oscilloscope tubes that provide improved operating characteristics have recently been designed. The improvement is achieved by the use of a modified electron gun which requires no first-anode current and gives sharper focus.

Figure 1 is a conventional gun. The oxide-coated cathode provides a supply of electrons that pass through the control-electrode aperture. The first anode, which operates at positive potential, accelerates the electrons toward the gun axis and causes them to cross over at the point indicated. It is this cross-over, rather than the cathode surface, which is imaged on the fluorescent screen.

The cross-over size and intensity depend on the control-electrode bias voltage. The electrons travel through the first-anode cylinder in straight lines and at a uniform velocity until they reach the end of the cylinder. Near the end of the cylinder the electron-beam diameter is limited by a masking aperture shown at AA. The central section of the beam passes into the accelerating and focusing field between the end of the first anode and the second anode. This field constitutes another electron lens, often called the final focusing lens. Its strength, or focal length, is varied by varying the first-anode voltage.

The beam is usually limited in diameter again at the second-anode aperture, as indicated at BB. This procedure insures that the beam is small and well centered as it passes the deflecting electrodes. The deflecting electrodes are used to apply an electric field at right angles to the beam. This field bends the beam proportionately to the potential applied. The set of deflecting electrodes nearer the gun provides deflection at right angles to that of the other set. The beam converges to a focus, or second cross-over, at the fluorescent screen.

Desirable Characteristics

A gun approaching ideal performance for an electrostatic-deflection type of cathode-ray tube should have the following characteristics:

(1) A small, focused electron spot of high brilliance which exhibits only a small increase in size as it is deflected across the screen.
(2) The ability to operate at low final-anode voltage.
(3) High deflection sensitivity.
(4) Short overall length.
(5) Sensitive control of spot brightness.

A small brilliant spot can be achieved by operating the final anode at as high a voltage as possible, by making the gun long and the gun-to-screen distance short, by using a high-emission cathode, by forming the first cross-over at as high a voltage as possible, and by permitting a wide beam divergence angle.[1] On the other hand, to produce a small change of spot size with deflection, the beam should have a small diameter in the deflecting field; that is, the beam divergence angle should be small, and it should be deflected through only a small angle, thus requiring a long gun-to-screen distance.[2]

Deflection distortion occurs in electrostatic deflection cathode-ray tubes because the electric field which deflects the beam also accelerates one side of it more than the other. The side nearest the posi-

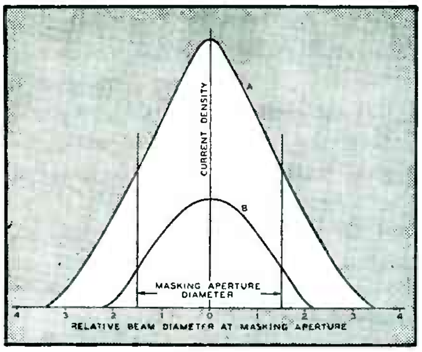


FIG. 2—Current density across beam before it enters masking aperture, for two different operating conditions

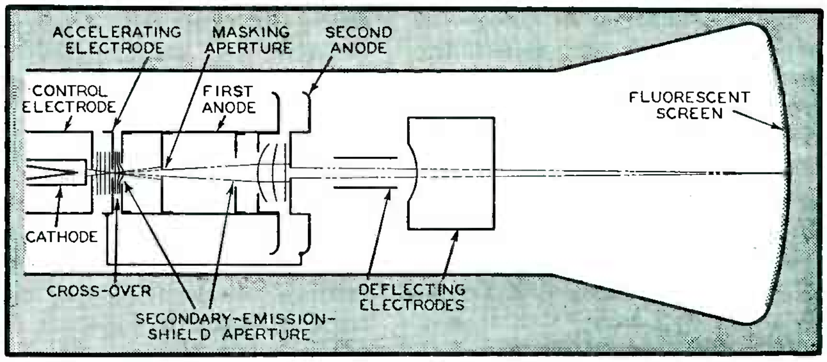


FIG. 3—Gun design introduced in 1937, in which the gun shown in Fig. 1 was modified by placing adjacent to the control electrode an accelerating electrode connected to the second anode

GUN for C-R TUBES

tive deflecting electrode is deflected less than the side nearest the negative deflecting electrode. The result is that the focused spot is elongated in the direction of deflection in proportion to the square of the deflection. This spot distortion is inversely proportional to the diameter of the beam in the deflecting region.

Operation at low final-anode voltage is desired because it results in a compact, low-cost, anode power supply and high deflection sensitivity. However, as the anode voltage is increased, the beam current rises as the 3/2 power of the voltage, the spot size decreases due to less space-charge effect, and the fluorescent screen becomes more efficient, giving the overall result that the spot brightness for a given spot size goes up somewhat faster than the square of the anode voltage. Thus, the anode voltage must be high enough to provide sufficient sharpness of focus and brilliance for the maximum required spot-displacement velocity. It generally cannot be less than 500 volts and may be as high as 15,000 volts.

It is to be noted that space charge increases spot size because of the mutual repulsion of the electrons in the beam.

High deflection sensitivity requires long, closely spaced deflecting electrodes and long gun-to-screen distance. These requirements tend to produce a spot of low brilliance.

Short overall length permits a design for small spot size but at the expense of deflection sensitivity and increased distortion with deflection angle.

Sensitive control of spot brightness, sometimes called small grid drive, requires that as large a portion of the current from the cathode as possible go to the screen. In the past, brightness control has usually been a semi-permanent manual adjustment. Sharper focus was secured at the expense of small grid drive. Now the brightness is often modulated at high frequency by an amplifier so that sensitivity is important.

Beam Considerations

The maximum deflection angle, the length of the deflecting electrodes, and the amount of distortion with deflection that can be tolerated determine the maximum permissible diameter of the beam at the end of the gun. Since even with this limitation the current in the beam should be as high as possible, it is an important gun-design consideration to make the current high without at the same time producing a large focused spot.

It is possible to generate a narrow enough beam to pass through the masking aperture without limiting, but usually a large beam is masked down to the desired size. Generation of a narrow beam without masking provides better utilization of the high-voltage current and sensitive control of the beam current but has the disadvantage of providing lower maximum current to the screen. The reason for this is that the beam is more intense at the core than at the edge and this core density rises rapidly with beam size.

The current density across the beam before it enters the masking aperture is shown graphically in curve A of Fig. 2. If the aperture diameter of the control electrode is reduced or the bias voltage of the control electrode is increased, or the accelerating-electrode aperture is moved farther away, the distribution becomes similar to curve B. The beam diameter is reduced but the total current is reduced much more.

By placing a masking aperture in the beam, usually in a region which is field-free, as shown at AA (Fig. 1), only the intense central core of the beam is passed through the gun to the deflecting electrodes. The beam is also usually masked in the second-anode aperture as shown at BB. The latter arrangement prevents the beam from striking the deflecting electrodes in case of misalignment. In addition, current masked at this electrode reduces the amount which has to be handled in the first-anode circuit.

By enlarging the control-electrode aperture diameter, it is possible to increase the current density at the center of the beam. This enlargement must not be carried very far because it increases the amount of masked current and the size of the cross-over. The latter, since it is imaged at the screen, produces a larger focused-spot size. However, as the control-electrode bias is increased, the control-electrode-aperture diameter is in effect decreased and, therefore, at lower currents a smaller spot size is obtained.

By proper design it is thus possible to have a small spot for fine detail as well as a brighter large spot for high-speed traces.

Modified Gun Design

Figure 3 shows a sectional view of a gun design introduced when the RCA-902 was announced in the autumn of 1937. The gun structure of Fig. 1 was modified by placing adjacent to the control electrode an accelerating electrode connected to the second anode. This arrangement overcame the interaction between focus and brightness control. It also permitted the electron cross-over to be formed at a higher voltage with the result, as developed in Langmuir's paper,[1] that a smaller focused spot was obtained at the screen.

Because high voltage was used on the accelerating electrode, its spacing to the control electrode could be made greater. The increased spacing offered two important advantages: first, a narrower beam was generated, and second, mechanical alignment of the apertures was not as critical. The latter resulted because the electrostatic fields acted to pull the beam through the centers of the apertures. Thus, the closer the spacing the farther the beam was bent away from the axis for a given amount of misalignment.

In Fig. 4 a gun construction is shown in which the accelerating electrode has been lengthened to carry a masking aperture and the first anode shortened to a disc which is used only for focusing. This structure is known as a zero-first-anode-current gun. It offers design possibilities of better focus and has the important circuit advantage of requiring no current from the focusing connection on the power-supply bleeder.

Since cathode-ray oscilloscope tubes require relatively small currents, it is cheaper and simpler to supply the first-anode circuit from a bleeder across the second anode supply than to provide a separate first-anode supply. However, if the first anode requires a current greater than that required by the second anode, which is now often the case, a large percent of the current from the supply must flow through the bleeder to furnish reasonably good voltage regulation in the first-anode circuit.

It so happens that poorer first-anode voltage regulation than second-anode voltage regulation can be tolerated because the first-anode voltage for optimum focus decreases slightly with increased values of beam current. Generally, however, enough current can not be used in the bleeder to provide the desired regulation. Moreover, the first-anode current varies too much from tube to tube to make such compensation entirely satisfactory. The result is that the focus has to be corrected even for fairly small changes in current.

On the other hand, with the zero-first-anode-current gun, the focus ratio of first-anode voltage to second-anode voltage is determined only by the bleeder tap instead of being influenced by first-anode current, and thus larger changes in beam current can be made without refocusing. In new equipment designs, it may be possible to decrease the bleeder current enough to use less filter capacitance than now required, but even without any decrease in bleeder current, there is still the advantage of less change in focus with beam-current change.

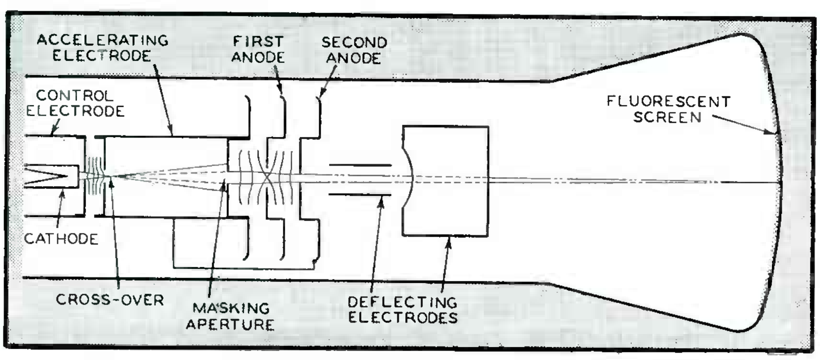


FIG. 4—Gun design based on zero first-anode current, in which the accelerating electrode has been lengthened to carry a masking aperture and the first anode shortened to a disc which is used for focusing

Constructional Advantages

From the viewpoint of tube construction, this gun offers several advantages. The longer accelerating-electrode cylinder is easier to support accurately. The beam is reduced to a small size before reaching the final focusing field. Because of this feature, badly aberrated rays from the edge of the focusing field are prevented from entering the second-anode aperture and thus causing stray current to the deflecting electrodes and the screen. The first anode can be made either as a cylinder or an apertured disc. By changing the length and diameter of the cylinder or the diameter of the aperture, it is possible to vary the focus voltage over a wide range. Therefore, it is easy to match focus-voltage specifications set by previous designs. There is also freedom from reverse currents due to secondary emission from low-voltage electrodes since they are not required to mask the beam. Consequently, aperture discs previously used in the first anode as electrostatic shields against secondary emission can be removed.

Other designs which are practical have been proposed.[3]

An application of a zero-voltage, zero-current focusing electrode to an electrostatic-focus electron microscope is also of interest.[4] In this case, fine adjustments of focus are made by moving the image surface.

REFERENCES

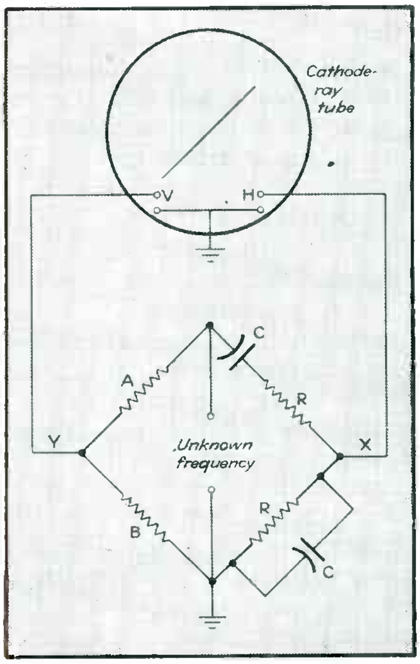
(1) Langmuir, D. B., Theoretical Considerations of Cathode-Ray Tubes, *Proc. I.R.E.*, 25, No. 8, p. 977, Aug., 1937.

(2) Deserno, P., *Archiv fur Electrotechnique*, 29, No. 2, p. 139, 1935.

(3) Iams, Harley, A Fixed-Focus Electron Gun for Cathode-Ray Tubes, *Proc. I.R.E.*, 27, No. 2, p. 103, Feb., 1939.

(4) Bachman, C. H., and Ramo, Simon, Electrostatic Electron Microscopy, *Jour of Applied Physics*, 14, p. 8, 69 and 155, 1943.

Cathode-Ray Null Detector
For WIEN BRIDGE



Circuit of Wien bridge for determining frequency and connections to the vertical and horizontal amplifiers of the oscilloscope

An accuracy of better than 0.1 percent is obtainable when a cathode-ray tube is used as the phase-detecting element of a Wien bridge circuit for determining frequency. An elliptical pattern on the fluorescent screen of the tube gradually changes to a straight diagonal line as balance is reached

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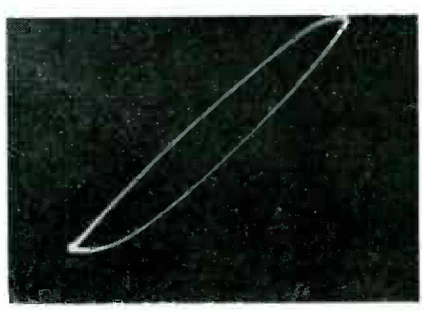
THE following method was developed to determine small changes in frequency. The frequencies under test were of the order of 5000 cycles per second and the changes were between plus and minus 5 cycles. The Wien bridge was used and the usual null detectors were tried, but a balance was difficult to obtain because of the large percentage of harmonics.

The cathode-ray tube was used as a phase-detecting device by connecting its horizontal axis to one of the detector terminals (X), and its vertical axis to the other detector terminal (Y). The bridge was grounded as shown and a ground was placed on the cathode-ray tube. When the bridge is balanced, indicating a zero phase shift between the detector terminals, a straight line is formed on the screen. By adjusting the X and Y amplifiers of the cathode-ray tube, this line is inclined to a 45-degree angle with the horizontal. When the bridge is unbalanced, an ellipse is formed, indicating a phase shift. At balance, the two sides of the ellipse come together and the line formed becomes twice as brilliant.

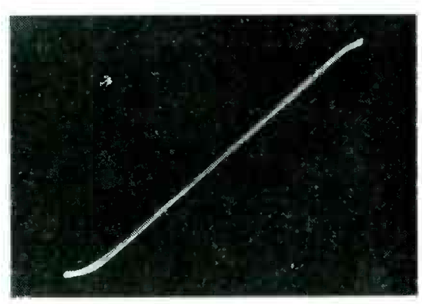
A desirable feature of this arrangement is that the oscillator is grounded, which is usual in practice. A Wagner ground or a bridge transformer is not necessary.

When the Wien bridge was first tried with only the vertical axis of the cathode-ray tube as the null indicator, the screen showed a large 60-cycle pattern in addition to the harmonics present. This occurred even at balance of the bridge. When the cathode-ray tube is used to indicate phase shift as described, with the bridge unbalanced, the ellipse is perfectly formed with no indication of any disturbance.

The Wien bridge was used as a frequency meter as follows: When the ratio arms are made such that A is twice B and the resistances R are equal (identical slide wire resistors mounted on the same shaft), and with the two capacitances C equal, the frequency at balance will be $f = 1/2\pi RC$. The variable resistors R can be calibrated directly in terms of frequency. For detecting small changes in frequency, the accuracy obtainable was better than 0.1 percent.



Trace obtained on the screen of the c-r tube when the bridge is unbalanced. Phase shift is indicated by ellipse



When the ellipse draws together to form a straight line, the bridge is balanced and there is zero phase shift

Contours Of

Development of equations specifying the shape of rotor plates to give constant change of frequency with rotation, and constant rate-of-change of frequency with rotation. The analytic technique is also applicable to the design of other types of variable capacitors

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THE change of capacitance with angular rotor position of variable capacitors depends on the contour of the capacitor plates. Where the change in capacitance vs. angular position is specified, the shape of the rotor plate necessary to produce this variation must be determined. The steps involved in deriving an expression for the required shape are to be indicated by solving three typical cases.

In each case it is assumed that the stator plates are large compared to the rotor plates. Also, end effects will be disregarded throughout these developments. However, both of these simplifications are justifiable; the stator plates are usually made considerably larger than the rotor plates, and the spacing between plates is usually small compared to the other dimensions of the plates.

Explanation of Symbols

θ = angular position of the rotor in radians. It can have values between the limits of zero and π radians

f_x = resonant frequency in cps

f_0 = upper limit of f_x, corresponding to an angular rotor position of zero radians

f_π = lower limit of f_x, corresponding to an angular rotor position of π radians

C_0 = minimum capacitance of the circuit, including the minimum capacitance of the variable capacitor, in farads

C_x = incremental capacitance of the variable capacitor, in farads

L = circuit inductance in henrys

Straight-Line Frequency

Although the formula for straight-line frequency capacitors is given in handbooks, the derivation is usually missing. In this capacitor the plates are so shaped that in an L-C circuit it will cause the resonant frequency to change a constant amount for each unit change of the rotor's angular position. Expressed mathematically, this criterion is

$$df_x/d\theta = K_1 \qquad (1)$$

Solving this differential equation yields an expression for f_x as a function of the rotor's angular position,

$$f_x = K_1\theta + K_2 \qquad (2)$$

where K_1 is a proportionality factor and K_2 is a constant of integration. Knowing that when $\theta = 0$ radians, $f_x = f_0$, and when $\theta = \pi$ radians, $f_x = f_\pi$, the two constants can be evaluated.

$$K_1 = \frac{f_\pi - f_0}{\pi} \qquad K_2 = f_0$$

K_1 is the rate of frequency change in cps per radian.

Replacing the constants in Eq. (2) by their values gives

$$f_x = \frac{f_\pi - f_0}{\pi}\,\theta + f_0 \qquad (3)$$

Now from circuit theory

$$f_x = 1/2\pi\sqrt{L\,(C_0 + C_x)} \qquad (4)$$

TABLE I. DESIGN SPECIFICATIONS

	f_0 in kc	f_π in kc	C_π in $\mu\mu f$
Type 1: Straight-line frequency. K_1 = 350 kc/radian	1600	500	370
Type 2: Constant rate of frequency change. K_2 = 37.1% radian	1600	500	370
Type 3: Capacitor in R-C oscillator. K_3 = 37.1% radian	$f_0, f_\pi = 11.0$		400
n = 20; d = 0.027 in.; r = 0.25 in.; C_0 = 40 $\mu\mu f$			

Equation (4) is exact for series resonant circuits, and only slightly in error for parallel resonant circuits having Q values upwards of ten.

Solving Eq. (4) for C_x,

$$C_x = [1/4\,(\pi f_x)^2 L] - C_0 \qquad (5)$$

When $C_x = 0$, $f_x = f_0$, and

$$L = 1/4\,(\pi f_0)^2 C_0 \qquad (6)$$

Replacing L in Eq. (5) by the value of L given in Eq. (6)

$$C_x = C_0\,(f_0/f_x)^2 - C_0 \qquad (7)$$

Substituting in Eq. (7) the value of f_x given by Eq. (3)

$$C_x = \frac{C_0 f_0^2}{[f_0 + (f_\pi - f_0)\,(\theta/\pi)]^2} - C_0 \qquad (8)$$

Consider the geometry of the capacitor plate shown in Fig. 1. Here $\rho = F(\theta)$ describes the contour of the rotor plate, where ρ is the distance from the center of rotation to the edge of the plate, and r is the radius of the section removed from the stator plate to accommodate the rotor shaft. Obviously this section can contribute nothing to the capacitance. Let $d\theta$ be a differential angle; then the difference in the magnitudes of ρ and ρ' is infinitesimal. Let ds be the length of the curve $\rho = F(\theta)$ between ρ and ρ'. It follows that ds is infinitesimal and therefore is essentially the same as a straight line drawn between the extremities of ds. The differential area, dA', inclosed by ρ, ρ' and $\rho = F(\theta)$ is that of a triangle $dA' = \rho ds/2$. But $ds = \rho d\theta$ and $dA' = \rho^2 d\theta/2$.

Similarly, the area dA'' inclosed by ρ, ρ' and $\rho = r$ is $dA'' = r^2 d\theta/2$. Then the area effective in accounting for C_x is

$$dA = dA' - dA'' = \frac{\rho^2 - r^2}{2}\,d\theta$$

Hence

$$dA/d\theta = (\rho^2 - r^2)/2 \qquad (9)$$

From the properties of capacitors in general it can be written that

Capacitor Rotor Plates

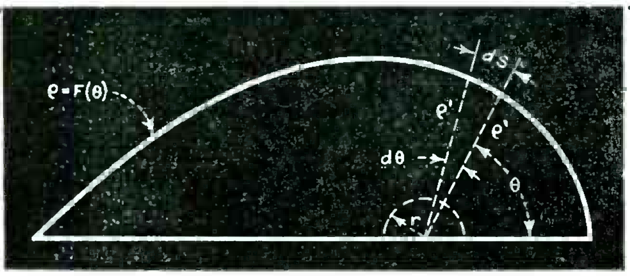

FIG. 1—Rotor plate, showing the manner in which the plate is broken into differential areas. Distance ds along the plate edge is subtended by the differential angle $d\theta$. The semi-circle with radius r is cut from the stator plate to accomodate the rotor shaft. The variable radius, ρ, of the rotor plate is to be determined as a function of θ

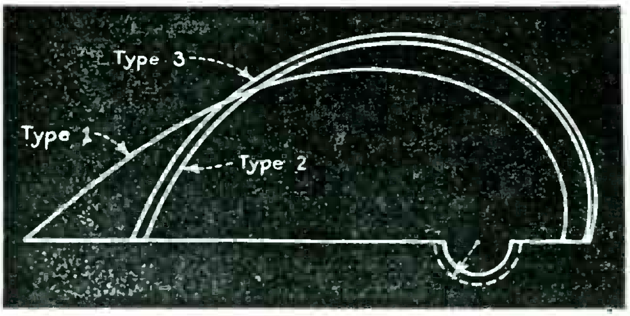

FIG. 2—Contours of the three types of capacitors discussed in the text

$C_x = K_cA$, where K_c is a constant relating area A in sq cm to capacitance in farads and has the value

$$K_c = \frac{(n-1)a}{(36\pi d)10^{11}} \text{ farads/cm}$$

where

n = total number of rotor and stator plates

a = dielectric constant (unity for air)

d = separation of the rotor and stator plates in cm.

Differentiating $C_x = K_cA$ with respect to θ,

$$\frac{dC_x}{d\theta} = K_c\frac{dA}{d\theta} = K_c\frac{\rho^2 - r^2}{2} \qquad (10)$$

Differentiating Eq. (8) with respect to θ

$$\frac{dC_x}{d\theta} = \frac{2f_0^2C_0(f_0 - f_\pi)}{\pi[f_0 + (f_\pi - f_0)(\theta/\pi)]^3} \qquad (11)$$

Equating the right sides of Eq. (10) and (11) and solving for ρ gives the polar equation for the contour of the straight-line frequency capacitor plate

$$\rho = \sqrt{\frac{4f_0^2C_0(f_0 - f_\pi)}{\pi K_c[f_0 + (f_\pi - f_0)(\theta/\pi)]^3} + r^2} \qquad (12)$$

where ρ and r are measured in centimeters, and K_c is in farads/cm.

Constant Rate of Frequency Change

The plates of this capacitor are designed so as to change the resonant frequency of an L-C circuit an amount (per unit change of rotor angular position) proportional to the resonant frequency. To illustrate: if the rotor position was originally 10 degrees and is changed to 15 degrees, or if the rotor position was 160 degrees and is changed to 165 degrees, the percentage change of frequency with reference to the respective original frequency will be the same in both instances.

The method of development is the same as above and, therefore, some details will be omitted. A mathematical statement for this manner of frequency variation is

$$df_x/d\theta = K_3f_x \qquad (13)$$

Solving Eq. (13) yields

$$\log_e f_x = K_3\theta + K_4 \qquad (14)$$

The constants are evaluated by the use of the same limits defined in evaluating K_1 and K_2 in the previous derivation.

$$K_3 = \log_e (f_\pi/f_0)^{1/\pi};\ K_4 = \log_e f_0$$

Substituting these values of K_3 and K_4 in Eq. (14),

$$f_x = f_0\,(f_\pi/f_0)^{\theta/\pi} \qquad (15)$$

The value of f_x as given by Eq. (15) is now substituted in Eq. (7):

$$C_x = C_0\,(f_0/f_\pi)^{2\theta/\pi} - C_0 \qquad (16)$$

Differentiating Eq. (16) with respect to θ and equating the result to the righthand side of Eq. (10),

$$\frac{2C_0}{\pi}\left(\frac{f_0}{f_\pi}\right)^{2\theta/\pi}\log_e\left(\frac{f_0}{f_\pi}\right) = \frac{K_c}{2}(\rho^2 - r^2) \qquad (17)$$

Solving Eq. (17) for ρ and using metric units,

$$\rho = \sqrt{\frac{4C_\theta}{\pi K_c}\left(\frac{f_\theta}{f_\pi}\right)^{2\theta/\pi}\log_e\left(\frac{f_\theta}{f_\pi}\right) + r^2} \qquad (18)$$

Capacitor in an R-C Oscillator

The capacitor to be designed in this section is to give a constant rate of frequency change, as was the capacitor previously considered, but in this case the circuit in which the capacitor is to operate is a resistance-tuned sine-wave oscillator of the feedback type wherein the two resistive components are equal, as are the two capacitive components. For such an arrangement, the frequency of oscillation is given by

$$f_x = 1/2\,\pi\,R\,(C_0 + C_x) \qquad (19)$$

where R is the value of one of the resistances, C_0 is the total minimum capacitance, and C_x is the incremental capacitance of one of the capacitors. Solving Eq. (19) for R at f_0,

$$R = 1/2\pi f_0C_0 \qquad (20)$$

Replacing R in Eq. (19) by the righthand side of Eq. (20),

$$f_x = \frac{C_0f_0}{C_0 + C_x} \qquad (21)$$

Equating the righthand sides of Eq. (15) and (21) and solving for C_x,

$$C_x = C_0\left(\frac{f_0}{f_\pi}\right)^{\theta/\pi} C_0 \qquad (22)$$

Differentiating Eq. (22) with respect to θ, equating the result to the righthand side of Eq. (10) and solving for ρ yields

$$\rho = \sqrt{\frac{2C_0}{K_c}\left(\frac{f_0}{f_\pi}\right)^{\theta/\pi}\log_e\left(\frac{f_0}{f_\pi}\right) + r^2} \qquad (23)$$

Examples

The three types of capacitor contours are shown in Fig. 2. Design values for a specific application of each type are given in Table I.

The CAA Instrument Landing System...

Details of localizer transmitter, sideband generators, marker transmitters, monitor units, and receivers used in planes to feed the cross-pointer indicator for the blind landing system now officially adopted for civil aviation in this country. This concluding part also analyzes effects of nearby hills and buildings on localizer performance

THE INSTALLATION PROGRAM for the radio instrument landing system adopted by the Civil Aeronautics Administration for use throughout the United States is already under way, and will attain full volume after the war. The resulting new equipment requirements at airports and for localizer and marker receivers in planes constitute an important post-war market for radio equipment and component manufacturers. With standardized facilities throughout the country, civilian flying can become increasingly independent of weather conditions and thereby achieve greater popularity.

In the first part of this article, in the February 1945 issue of ELECTRONICS, an overall picture of the new system was given, including general descriptions of the three main elements at an airport—the runway localizer, the marker transmitters and the glide path localizer. Technical features of the runway localizer will now be taken up in detail.

Localizer Transmitter

The localizer transmitter proper is an ordinary crystal-controlled type with the usual frequency multipliers, producing about 200 watts of carrier which can be plate modulated. Connections are made to the grid tank of the power amplifier, for exciting the sideband generator, by means of ⅜-inch coaxial line (air dielectric). The power taken for this purpose is between five and ten watts, of which only a small portion is used to drive sideband generator tubes (type 8001); most of it supplies losses in the circuits necessary to build up the grid voltage to the required value. In one particular arrangement used, the grid circuit of the sideband generator is tuned to parallel resonance and the line from the transmitter is made effectively a half-wave to reflect as high an impedance as possible to the p.a. grid tank, thereby minimizing the disturbing effect on this tank.

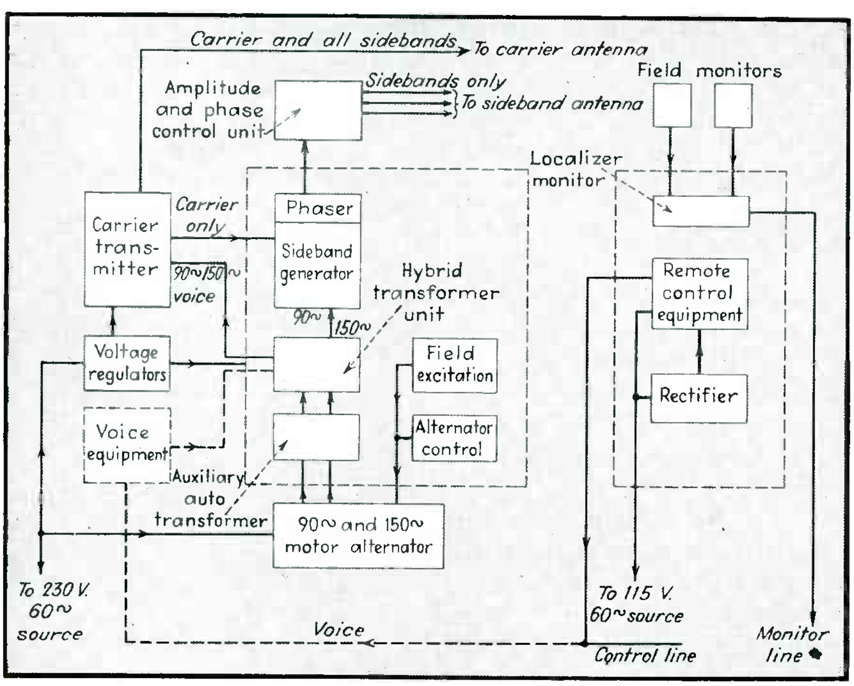

FIG. 13—Block diagram of overall localizer system with associated units

The design of a satisfactory sideband generator presents the usual problem of a class C amplifier for the frequencies involved, but in this case some of the factors are more critical. Thus, it is imperative that the plate circuit have very low losses and be balanced if a satisfactory value of plate efficiency is expected. Small unbalances cause considerable drop in efficiency due to the carrier current introduced as well as due to the drop in sideband power. A low efficiency in turn results in larger alternators, which is undesirable for obvious reasons. The efficiency of the units now in use is of the order of 40 percent.

The efficiency of the grid circuit

. . . Part II

By PETER CAPORALE

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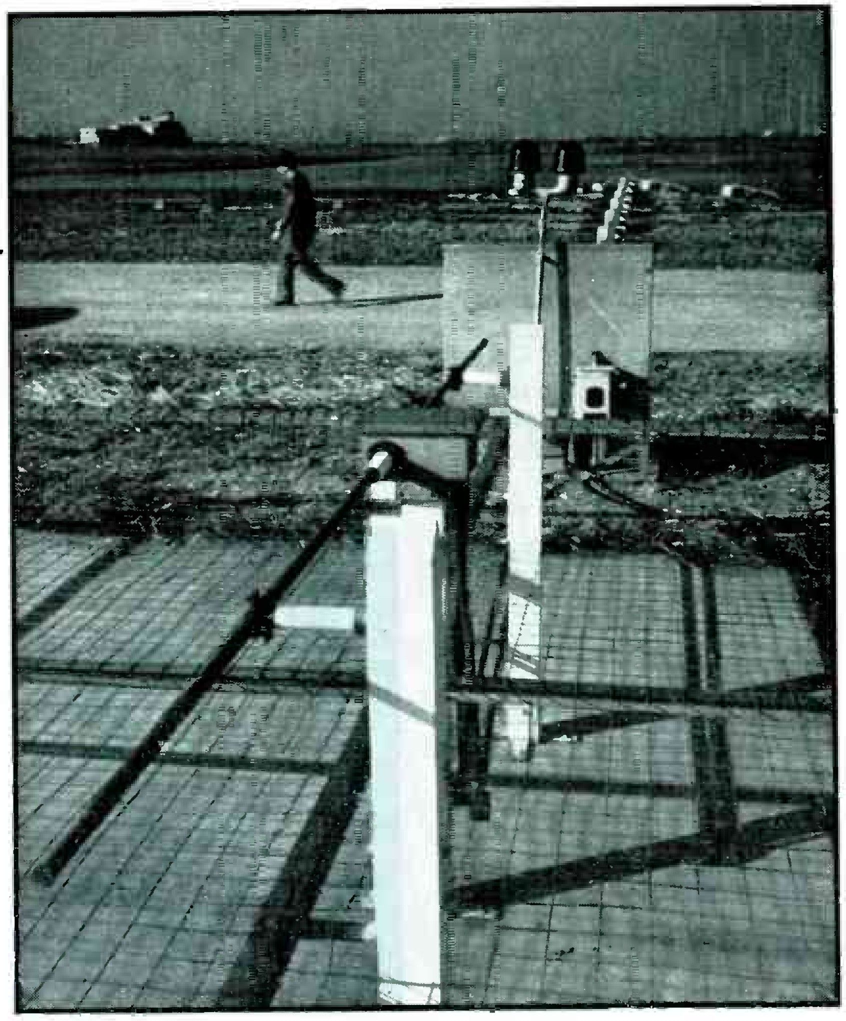


Marker station with antennas and counterpoise

is also important from the standpoint of minimizing the power absorbed from the transmitter. An important consideration in the design of the sideband generator is that of stability (and its associate, resetability) over the range of service conditions. In practice the equipment is adjusted properly and then permitted to operate unattended. Variations in temperature, humidity or line voltage which may occur during such operation should not affect the tuning of the unit appreciably. If it becomes necessary to readjust the tuning controls for any reason, it should be possible to set them properly without having to readjust the antenna system. To this end, the tuning elements have been made heavy and rigidly mounted and the controls provided with very slow drives.

Associated Units

A phaser unit is included as an integral part of the sideband generator to assist in phasing the sideband antennas, as a whole, with respect to the carrier antennas. A monitor, consisting of a 6H6 rectifier with a d-c milliammeter, is capacitively coupled to the r-f output of the sideband generator, and is used also to assist in tuning. A block diagram of the localizer transmitter with its associated units is given in Fig. 13.

The phaser used is made up of a variable length of coaxial line folded back on itself. The total range of variation of phase is 45 deg for each phaser, or a total of 90 deg for the sideband antennas since they have two of these in series. By using the proper fixed lengths of transmission lines, the phasing adjustments for the sideband antennas (relative to the carrier) are brought within the range of the phaser units.

In the same rack with the sideband generator are mounted the amplitude and phase control unit, the hybrid unit and the controls for the alternators supplying 90 cps and 150 cps. These latter controls permit the voltages of the two machines to be varied simultaneously and also permit the ratio of the two voltages to be varied. This latter is convenient as it provides compensation for any slight discrimination, in the system, between the two frequencies; it also provides a means for correcting a slight misalignment of the course (say one-half degree). The alternators themselves are driven by and mounted on a common shaft with a synchronous motor to stabilize both frequency and output voltage.

The only other equipment in the localizer building is the control rack and an engine generator (for standby power) in an adjacent room. The rack contains Strowger equipment for remote operation and a monitor panel which provides visual indication of the output of the course monitor, and contains a jack for checking the output of the clearance monitor. This is mainly used in the tuneup process as described later.

Figure 14 shows a typical layout of a localizer without standby equipment. The equipment itself is, however, all designed for adaptation into a main-and-standby arrangement with means for remote (but not automatic) changeover.

Coaxial Lines and Radiators

All transmission line (except that used between transmitter and sideband generator) is of the ⅞-inch coaxial, air-dielectric type filled with nitrogen at a pressure of about five pounds. The balanced line originally used was practically impossible to keep balanced and resulted in variable and haphazard phase relationships that made of the system an amorphous complex very difficult to adjust. Coaxial line does away with all this trouble and is easier to handle. The transformation from unbalanced to balanced line, to feed the balanced radiators, is done very close to the radiators themselves by a quarter-wave section of balanced line. The coaxial line is then matched by an appropriate stub on the generator side of the balancing section.

The radiators themselves are mounted on pipe pedestals set in concrete and are about four feet above the effective ground plane. This is the plane on which occur reflections which reach the aircraft making a normal approach, and is usually the level of the runway. The actual height of the antennas above ground frequently is considerably greater than four feet.

The array is mounted in a long wooden shelter (for protection against the weather) either integral with or separate from the main building. Eight loops covering a span of 1600 electrical degrees are used in most installations, though ten loops are used where it is necessary to increase directivity (to clear obstructions). In either case, however, the height of the structure is such as to clear a 40:1 angle with respect to the nearest end of the runway as a safety precaution for aircraft making low-angle landings or take-offs.

Marker Transmitters

The marker transmitters (which are all alike except in the modulation frequency) are straightforward crystal-controlled affairs with an output of some 4 to 6 watts at 75 Mc. They were designed as standard units to be used either independently (as in this case) or as driver units for multipliers or power amplifiers. Three of these markers are usually employed at distances of approximately 200 ft (inner marker), 4800 ft (middle marker) and 4.5 miles (outer marker), all from the approach end of the runway. These are modulated respectively at 3,000 cps (unkeyed), 1,300 cps (keyed at six dots per second) and 400 cps (keyed at two dashes per second). The aircraft generally starts the approach glide over the outer marker at an altitude of approximately 1,000 ft and a glide angle of roughly two degrees. This brings it over the inner marker at about fifty feet.

The marker antenna is simply a linear horizontal radiator, one wavelength long, fed at the center

Instrument console used in control tower for operation and supervision of localizer

and supported above a counterpoise at a height of 47 deg for the boundary marker and 90 deg for the middle and outer markers. The radiator is aligned with the axis of the runway and its radiation pattern is relatively narrow in a direction parallel to this axis and considerably broader in a direction at right angles to the runway; it further has an appreciable gain in the vertical direction. The exact pattern shape is unimportant and in general, not more than one or two watts are used to drive the antenna.

Monitor and Control Units

Of some interest is the monitor and control equipment used with the system. It has two basic purposes: to permit the various facilities to be turned on or off from the control room, and to provide visual, aural and graphic indication of the performance of the system. To accomplish this, a set of control lines connects each part of the system with the control room. Signals (from field monitors at the localizer and from the equipment itself at the markers) are brought in over these lines and amplified, filtered and rectified so they can operate the various instruments. In many cases, it is undesirable to place this rack in the control tower and a separate instrument console is used in the latter position. This console carries only indicating instruments and start-stop switches.

To minimize the size and cost of the equipment, a single recorder and a single alarm circuit are used to monitor all parts of the system. This is accomplished by a commutator device which scans the various functions at the rate of one minute per function for the recorder and 10 seconds per function for the alarm.

The operator thus has continuous indication of levels and clearance and at the same time, a loud gong will warn him of faulty operation even if he does not happen to notice his instruments. The graphical record is of value in controlling the operation and maintenance of the system.

The localizer portion really monitors clearance off course, as already stated, and only indirectly monitors course alignment and signal level. Clearance is measured by filtering and separately rectifying the 90-cps and 150-cps components and then applying them through a differential circuit to a microammeter (see Fig. 15). The sum (instead of the difference) of these components is applied to another microammeter for indicating level. An essentially similar circuit is used in the aircraft receiver, except that the level indicator is omitted.

The two audio filters present a problem of design due to the wide range of temperature over which they are expected to operate. Without special precautions, their insertion loss varies with temperature (due mostly to capacitor variation) and not at the same rate for the two filters. Both clearance and level indications would thus be seriously affected. Special capacitors and special inductor construction are used to minimize these variations. To the same end, all rectifiers (of the copper-oxide or selenium type) are kept in an automatic oven at practically constant temperature.

Receivers Used in Planes

The localizer aircraft receiving equipment consists chiefly of a straightforward superheterodyne receiver covering the necessary frequency band. The output of the receiver may either be used aurally or visually. For the latter case, the output is separated into its 90-cps and 150-cps components by band-pass filters, rectified and the difference between the two rectified voltages applied to the visual indicator (see Fig. 16).

The receiver used in the plane has provision for manual tuning as well as push-button tuning. A meter is used to measure the avc cathode current to indicate to the pilot whether or not an adequate r-f signal is being received. Without this, it would be difficult to tell whether zero indication of the visual indicator was due to an equi-signal zone or merely no signal. Furthermore, if the receiver is not sufficiently controlled by avc, it will respond to variations in r-f field strength and the resulting variable a-f signal will cause the operation of the visual indicator to be erratic. As noted previously, the apparent clearance is a function of the absolute values of the two voltages as well as their difference.

The antenna is a horizontal V of which each leg is approximately $\lambda/4$ long and the included angle is about 80 deg. It feeds a balanced line connected to points several inches from the apex (selected to obtain a reasonable impedance match).

The marker receiver is also a superheterodyne receiver, but with a crystal-controlled oscillator. Figure 17 shows the manner in which the audio output of this receiver is utilized to operate one of three small lamps (on the instrument board) depending on which of the three markers is being received. These lamps are actually operated from the a-c power supply, and the receiver output serves merely to control the current through the lamps. Within narrow limits, the brilliance of the lamps varies with the intensity of the received signal.

Effect of Mountainous Terrain

Of considerable importance in the operation of the localizer is the topography of the surrounding terrain as well as the presence of large objects (such as trees, hills, buildings) in the vicinity of the antenna array. These factors can introduce signal reflections that interfere seriously with the production of a desired pattern. The effects of these factors may be to distort or otherwise affect the course, or to affect the clearance at various values of azimuth, or both.

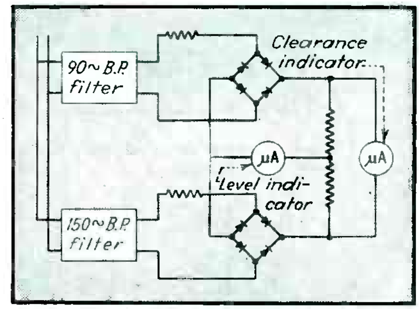


FIG. 15—Differential circuit used in monitor for localizer

The effect of topography may be seen by reference to Fig. 18, which shows the ground profile along some particular value of azimuth. With such ground there is more than one point (Q, Q′, etc.) from which the reflected ray reaches the point P. Consider first, the reflection at Q. This can be replaced by the image antenna b below the plane AB of the reflecting surface. The field at P is then, for small values of ϕ, approximately equal to

$$(2\pi k/\lambda)\,(hH/r^2).$$

If an additional reflecting point Q′ exists, it will introduce another image at a different position in space, and the radiation from this image is to be added (with proper consideration of phase) to the above. The only effect of these reflections, however, is on the absolute amplitude of the field. The various components of the field (carrier, 90-cps sidebands and 150-cps sidebands) are all equally affected and their relationships are not disturbed. There will therefore be no changes in clearance (or course bends) due to the vertical profile of the ground. The changes in field strength can, however, be quite large in certain extreme cases, resulting in surges and fades which may take the receiver completely out of avc. This is found in certain vhf ranges located in mountainous territory, but not usually

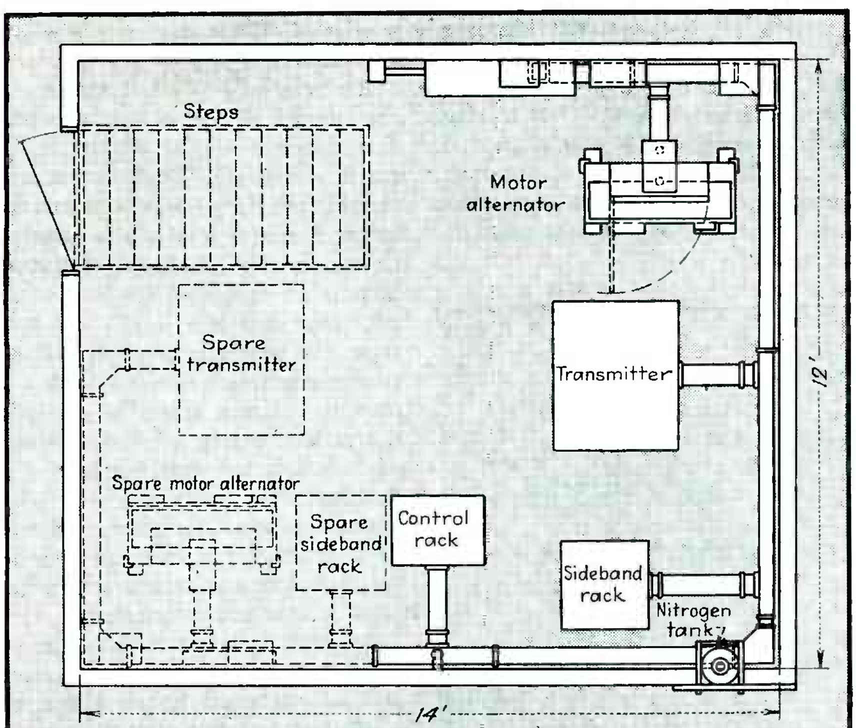


FIG. 14—Typical layout of equipment in localizer transmitter building

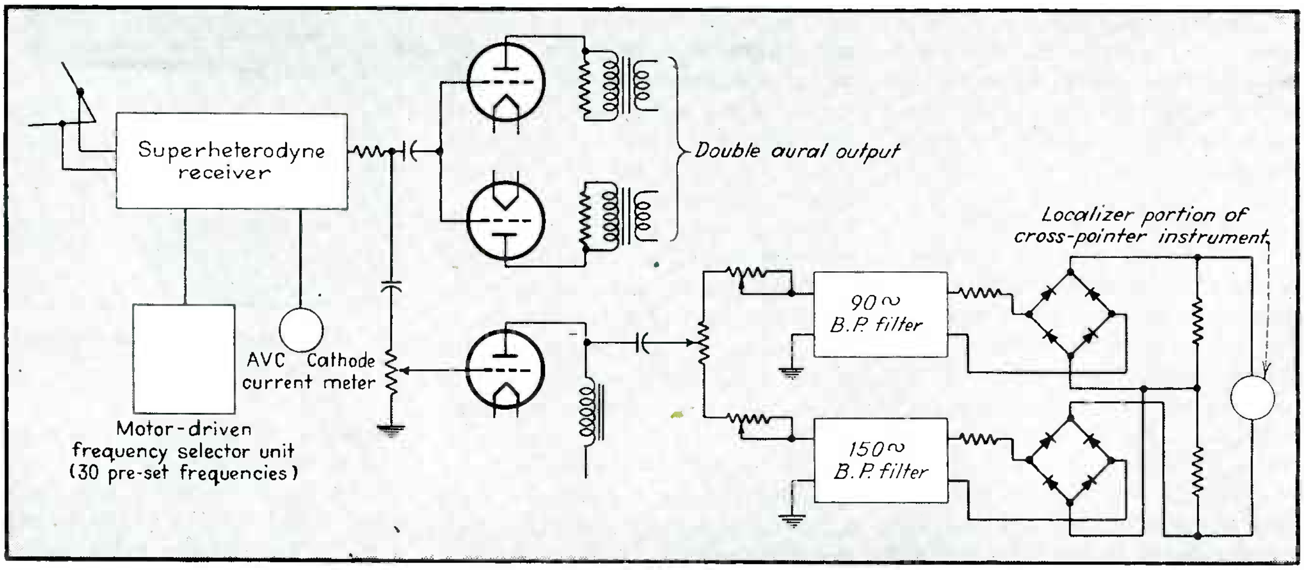


FIG. 16—Simplified diagram of aircraft receiver used in planes to feed one section of the cross-pointer instrument that guides the pilot down along the glide path

in instrument landing facilities where the usable zone is not too rough in contour. It is, of course, necessary to avoid protubrances or large vertical objects which might interfere with line of sight.

Effect of Reflecting Structures

Reflections which are not wholly in a vertical plane are far more important since the horizontal radiation patterns are involved. A reflecting surface will receive two signals of different magnitude for the two modulation frequencies. It will reflect these unequal signals to some point where they will be superimposed on the signals normally present at this point, and thereby disturb the ratio between the two modulation frequencies. In other words, the reflector affects the clearance at points receiving the reflected signals. In particular, if one of these points is on course, where clearance is normally zero, the reflector will introduce a course bend.

In Appendix II is given the analysis of the effect of a reflector parallel to the course and located θ deg. off course. The use of this particular orientation for the reflector does not cause any loss in generality since the form of the resulting equation is not affected (the magnitudes of the results, however, are). Consider, for example, a reflecting surface 4,000 feet away from the antenna at $\theta = 10$ deg. In this case $\beta_2 = 180$ deg, $G_1 = 2.05$, $G_2 = 0.475$ (see Fig. 4, Part I), hence at a point 8,000 ft away from the antenna along the normal direction of the course, the ratio of 90-cps field to 150-cps field is, by using Eq. (4) of Appendix II, $e_{90}/e_{150} = 2.06$ instead of unity as it should be. From Fig. 4, it is evident that an aircraft at this point would have to move about 2.5 deg away from the normal course, and on the 150-cps side, to find an actual course again. The magnitude and position of this course shift are obviously not tolerable. A hangar or building so situated with respect to a localizer would thus constitute a serious interference to its proper functioning.

As pointed out in Appendix II, the height of the reflecting structure determines the height of the point affected. Such structures should therefore be kept as low and as far from the antenna as possible. Consider, for example, a typical airport as indicated on Fig. 19. A fifty-foot structure 1,250 feet away from the localizer antenna will affect the entire approach path. By moving it away from the antenna, a smaller portion of the approach path is affected until at 4,000 feet it affects the path up to a point slightly beyond the inner marker. This maximum altitude at which a structure causes interference is the same all around a station.

Actually, the probable effect of the reflector would not be as serious as indicated above since the coefficient of reflection is not always unity. In practice, it would be usually smaller—and possibly much

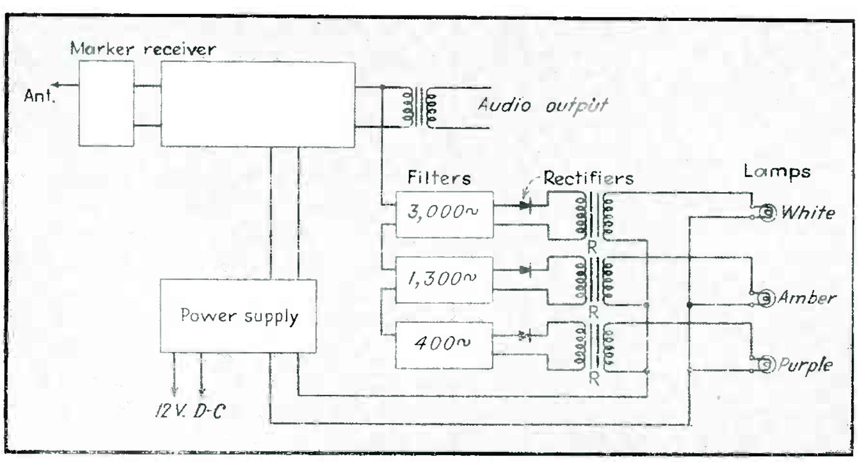


FIG. 17—Receiver arrangement used in planes to pick up the three marker signals

smaller—due chiefly to the geometric and electrical characteristics of the surface, and the angle of incidence. A rigorous analysis of any specific structure is obviously impracticable, but the above calculations give an approximation which permits quantitative estimate of the effects of reflecting structures and terrain with useful accuracy.

APPENDIX II

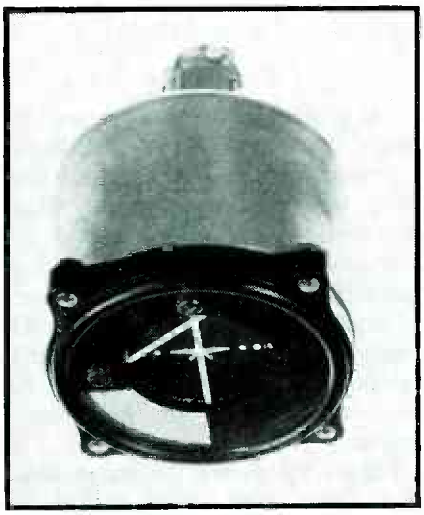
A radiator over a reflecting surface, such as the earth, acts mathematically as though it were associated with an image on the other side of the surface. If it also has a reflecting surface on its side, it acts as though it were associated with *three* images. To avoid needless complexity, in the application to the localizer, it is assumed that the reflecting surface is a vertical plane parallel to the course. There is no loss of generality in this assumption since the orientation affects the magnitude of the interference phenomenon, through the geometry of the system, but not the form of the mathematical expressions.

Referring to Fig. 20 and assuming that G is the horizontal pattern of the array as shown in Fig. 4 and is taken as unity at $\theta = 0$, the fields at the point P due to the system are

$$\left.\begin{aligned} e_a &= \cos \omega\,(t - r_a/c) \\ e_b &= -\cos \omega\,(t - r_b/c) \\ e_c &= -G \cos \omega\,(t - r_c/c) \\ e_d &= G \cos \omega\,(t - r_d/c) \end{aligned}\right\} \begin{aligned} r_a &\equiv aP \\ r_b &\equiv bP\text{, etc.} \end{aligned} \qquad (1)$$

If $r \equiv OP$, $h \equiv OA$ and $f \equiv OQ$, then

$$\left.\begin{aligned} r_a &= r - h \sin \phi \\ r_b &= r + h \sin \phi \\ r_c &= r_a + 2f \sin \theta \\ &= r - h \sin \phi + 2f \sin \theta \\ r_d &= r_b + 2f \sin \theta \\ &= r + h \sin \phi + 2f \sin \theta \end{aligned}\right\} \qquad (2)$$



Cross-pointer instrument used with new CAA instrument landing system

If $\beta_1 \equiv (2\pi h/\lambda) \sin \phi$ and $\beta_2 \equiv (4\pi f/\lambda) \sin \theta$, the sum is $e = B \cos (\omega t' - \psi)$ where

$$B^2 \equiv 4 \sin^2 \beta_2 \,(1 - G \cos \beta_2 + G^2)$$
$$\psi \equiv \tan^{-1} [(1 - G \cos \beta_2)/G \sin \beta_2]$$
$$e = 2 \sin \beta_1 \,(1 - G \cos \beta_2 + G^2)^{0.5} \cos (\omega t' - \psi) \qquad (3)$$

For a given reflecting surface, the value of G will be different for 90-cps and 150-cps modulation. If subscript 1 is used for the first and 2 for the second of these, then

$$(e_{90}/e_{150})^2 = \frac{(1 - G_1 \cos \beta_2 + G_1^2)}{(1 - G_2 \cos \beta_2 + G_2^2)} \qquad (4)$$

It should be noted that the height of the reflection point H_s is such that $H_s/gO = \tan \phi$. Reflections at higher points will affect higher points P, and vice versa.

The above analysis is obviously elementary and is intended solely to provide a basis for estimating the probable effects of certain obstructions. For more accurate work, it would be necessary to consider the attenuation of the incident signal because of distance, the detailed electrical characteristics of the reflecting surface, etc. The former of these can easily be accounted for by an appropriate modification of the factor G. The other factors introduce complexities beyond the purpose of this paper.

APPENDIX III

The operation of the radiating system as described above (and in Appendix I) is predicated upon zero mutual inductance between the various radiating elements. This is obviously an impossible condition. At the center of the array, especially, where the loops are close together and the current amplitudes are highest, there is a considerable amount of parasitic action. This is of two types: induced voltages in one or more sideband pairs due to currents in the carrier pair, and induced voltages in sideband pairs due to currents in a sideband pair. Parasitic currents in the carrier pair due to currents in any sideband pair are similar to the second of these two types and minimized in the same manner described below.

The parasitics in the sideband pairs must be reduced to a minimum in order to obtain the desired space patterns. This is accomplished by choosing the proper length of transmission line to connect the two loops of a pair. The operation of this adjustment may be understood from the following considerations.

Figure 21 represents, in simplified schematic form, the equivalent circuit of the combination of car-

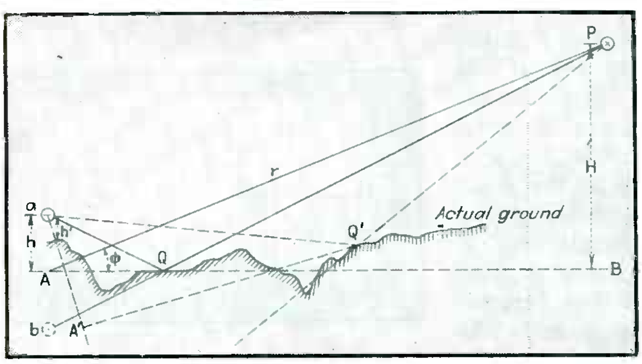


FIG. 18—Effect of ground profile on signal produced at *P* by localizer transmitter at point *a* near an airport

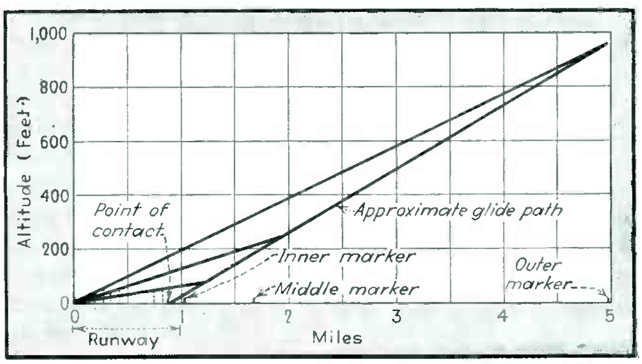


FIG. 19—Effect of structures of various heights (dotted profiles) on localizer signal

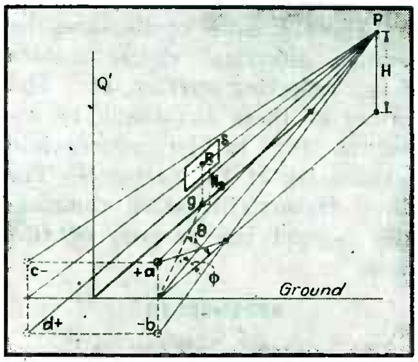


FIG. 20—Effect of reflecting surface on localizer signal

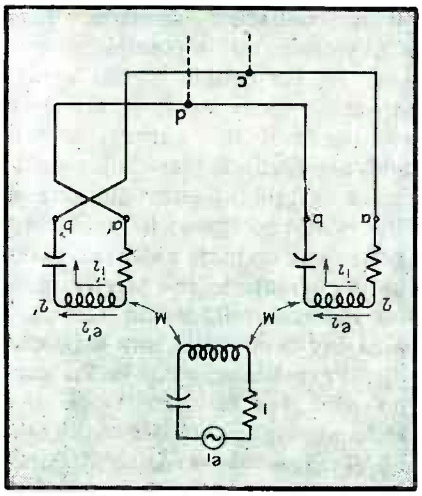


FIG. 21—Equivalent circuit for carrier loops and one sideband pair

rier loops and one (any) sideband pair. The former (the center mesh) are considered to be driven from a source e and the latter are driven only by induction from the center loops. The induced voltages in the sideband loops are in the same direction, as shown, and effectively in series. If the interconnecting line were an integral number of wavelengths long, the two induced voltages would effectively be in series-aiding (by virtue of the reversal in connections to one of the loops to permit feeding them out of phase). This would result in maximum parasitic current. By making the tie-line an odd number of half-waves long the voltages are effectively in series-opposing, and if the two loops are identical and symmetrically placed with respect to the center loops the parasitic current will be zero. The parasitic current in either loop is

$$i_p = k\,(e_1 - e_2/\psi)$$

where ψ is the phase shift introduced by the tie line. If the induced voltages are equal, the above expression can be written

$$i_p' = k\,(2 - 2\cos\psi)^{1/2}\cos(\omega t - \epsilon)$$

It is evident that if ψ is $n\pi$ (n even), the magnitude of i_p' is zero, whereas for n odd, the magnitude of i_p' is a maximum, or $2k$. Had the two loops been connected so they could be driven in phase the parasitic action would have been minimized by making ψ an odd number of half-wavelengths, and maximized by making ψ equal to an even number of half-wavelengths.

Figure 22 shows the magnitude of i_p (in percent of its maximum value $2k$) for various values of ψ. A departure from the optimum value of ψ by five or six degrees (slightly over an inch for ⅞-inch coaxial line, air dielectric, at 110 Mc) results in a parasitic current equal to four or five percent of maximum, and this can readily be observed. The length of tie line can therefore be adjusted quite accurately (to within several degrees).

The adjustment of the length of the line can, of course, be made by observing the parasitic currents as the length is varied. In practice, this is tedious and a much simpler procedure is used. This is based on the fact that the induced voltage in each loop causes a voltage wave to travel along the tie-line toward the other loop. In the case of parasitics in sideband loops due to current in the carrier loops there are thus two voltage waves traveling in opposite directions. At the center of the line these voltages will be equal and opposite so that the effective voltage across the line is zero. This is, in effect, a short-circuit and an actual short-circuit can be placed at that point without changing anything. The procedure then is to connect slightly more than half the anticipated tie-line to one of the loops, with a short circuit at the free end. This simulates the presence of the other half of the system, and the position of the short is adjusted until the parasitic current in the loop is a minimum. (A tuned thermocouple meter is used to read this current.) The final position of the short represents the exact center of the system; the feed line is connected at this point, and the line to the other loop is made an exact duplicate of that used for the measurement.

In the case of parasitics in one pair of sideband loops due to current in another pair, the voltages at the center of the line (due to parasitics) are in phase and hence the above procedure is not applicable. The more direct procedure is in this case also the simplest, and the two loops are set up and the length of the tie-line adjusted for minimum induced currents. The feed line is then connected to the exact center of the tie-line.

It is obviously impossible to minimize both types of parasitic currents by the adjustment of a single parameter since the requirements are conflicting. The second type described has been neglected in the tuning procedure so far used, with no serious ill effects. Further work may reveal the desirability of eliminating this form of coupling, of which the chief objection is its influence on the effective phase of radiation from the loops affected.

The placement of the feed point at the exact center of each sideband pair is quite important since it affects the angles at which radiation nulls occur (as well as parasitic currents). If the distances from the feed point to the two loops differ from each other by υ electrical degrees, the pattern is given by $p = k \sin(\upsilon + \delta \sin\theta)$, so that nulls occur for values of θ satisfying the relation $\upsilon + \delta \sin\theta = n\pi$, where $n = 0, 1, 2$, etc. If $\upsilon = 0$ and $n = 0$, then $\theta = 0$ for all the sideband pairs, so that on course ($\theta = 0$) no contribution is made by the sideband loops. This is as it should be. If $\upsilon \neq 0$, the null will occur at some value of θ other than zero. If all the sideband pairs had nulls at this same value of θ, the

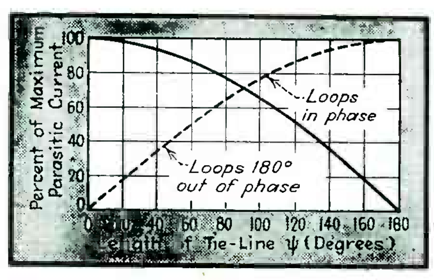
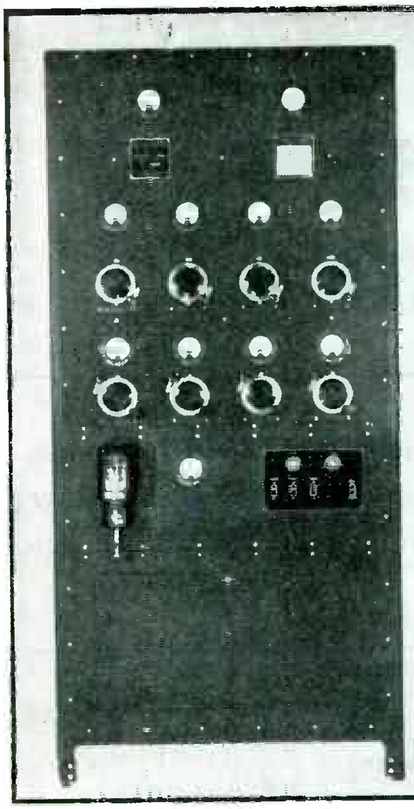
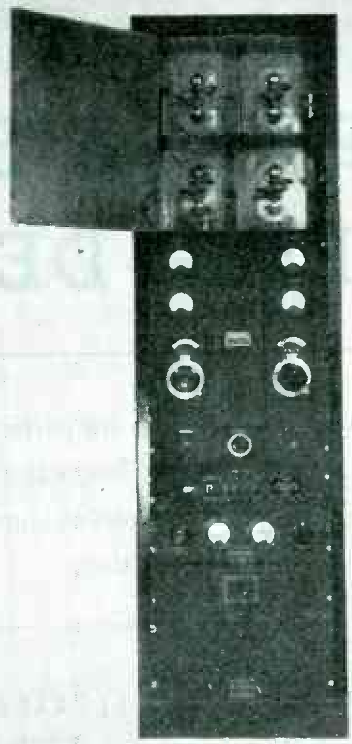


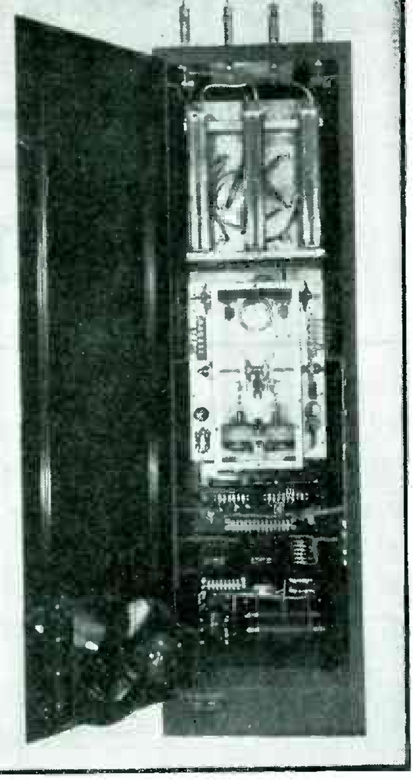
FIG. 22—Variation of parasitic current in a loop with the length of the tie-line



Crystal-controlled localizer transmitter



Sideband generator



Rear of sideband generator

course would also be at this angle. It is more likely that the nulls will occur at different angles. In either case, at $\theta = 0$ there will be unequal amounts of the two modulation frequencies due to the unsymmetrical contribution from the sideband loops. To establish a course at this position, therefore, it will be necessary to unbalance the outputs of the 90-cps and 150-cps sources by a corresponding amount. Under these circumstances, the course may be ill-defined and broad. Furthermore, it will be less stable than normal since now its alignment is determined by more factors than in the normal arrangement where the sideband loops contribute nothing to the on-course signal.

Bibliography

(1) Breit, G., Localized Radio Landing Signals for Airplanes. *B.S. Scientific Paper,* No. 431: *Radio Service Bulletin,* No. 60, p. 14-15, Apr. 1, 1922.

(2) Diamond, H. and Dunmore, F. W., A Radio Beacon and Receiving System for Blind Landing of Aircraft. *B.S. Jrl. Research,* 5, p. 897-931, Oct. 1930: Research Paper, No. 238; *Proc. IRE,* 19, p. 585-626, Apr. 1931.

Über ein elektrisches Verfahren fur Flugplatzbegrenzen zur Erleichterung von Blindlandungen (On an electrical method for designating boundaries of landing fields for facilities of blind landing). *Hochfrequenztechnik und Elektroakustik* 40, p. 41-47, Aug. 1932.

(4) Blee, E. H., A System of Radio Aids for Fog Landings. *Aero Digest,* 22, p. 27-29, Mar. and p. 17, Apr., 1933.

(5) Johnson, S. P., Down the Landing Beam. *Aviation,* 82, p. 162-163, May 1933.

(6) Fog Landing by Wireless: Ultrashort Waves at the Aerodrome. *Wireless World,* 33, p. 151-152, Aug. 25, 1933.

(7) Blind Landing Aids for Weather-Proof Flying (description of Newark, N. J. blind landing installation). *Literary Digest,* p. 18, Sept. 16, 1933.

(8) Diamond, H., Performance Tests of Radio System of Landing Aids. *B.S. Jrl. Research,* 11, p. 463-490, Oct. 1933; Research Paper No. 602; *Proc. IRE,* 22, p. 120-121, Jan. 1934.

(9) Kramar, E., Ein Beitrag zur Gleitwegblindlandung von Flugzeugen (A contribution on blind landing path for aircraft) *Elektrische Nachrichten Technik,* 10, p. 451-453, Nov. 1933.

(10) Gibbons, A. B., Landing in Fog by Short Wave Radio. *The Aeroplane* (London), 48, p. 68-70, Jan. 16, 1935.

(11) Denman, R., The Lorenz Blind Landing System. *Wireless World,* 36, p. 332-335, Apr. 5, 1935.

(12) Simon Radio Guide for Aircraft. *Aero Digest,* 26, p. 40-44, May 1935.

(13) Kramar, E., The Present Status of the Art of Blind Landing of Airplanes Using Ultra-Short Waves in Europe, *Proc. IRE,* 23, p. 1171-1182, Oct. 1935.

(14) Bauman, K., and Ettinger, A., A New System for Blind Landing of Airplanes. *Proc. IRE,* 24, p. 751-754, Nov. 1936.

(15) Roberts, H. W., The Simon System of Instrument Landing and Collision Warning, *Communication & Broadcasting Eng.,* 3, p. 14-15, Oct. 1936.

(16) Lorenz Instrument Landing System as Demonstrated at Indianapolis. *Communication & Broadcast Eng.,* 4, p. 12-13, June 1937.

(17) Diamond, H. and Dunmore, F. W., Experiments with Underground Ultra-High-Frequency Antenna for Airplane Landing Beam, *Jrl. Research NBS,* 19, p. 1-19 July 1937: Research Paper No. 1006; *Proc. IRE,* 25, p. 1542-1560, Dec. 1937.

(18) Kramar, E. and Hahnemann, W., The Ultra-Short Wave Guide-Ray Beacon and its Application, *Proc. IRE,* 26, p. 17-44, Jan. 1938.

(19) Jackson, W. E., Status of Instrument Landing Systems, *Proc. IRE,* 26, p. 681-699, June 1938.

(20) Dingley, E. N., Jr., An Instrument Landing System, *Communications,* 18, p. 7-9, June 1938.

(21) Instrument Landing System, *Communications,* 19, p. 9, Nov. 1939.

(22) The CAA-MIT Micro-Wave Instrument Landing Instrument. *Elec. Eng.* Transactions, 59, p. 859, 1940.

(23) Instrument Landing of Aircraft, *Elec. Eng.,* 59, p. 495-502, Dec. 1940.

(24) Barrie, A. A., Standardized Let-Down Procedure; Barrie Instrument Approach Guide. *Aviation,* 40, p. 39, Jan. 1941.

(25) Instrument Landing of Aircraft. *Engineer* (London), 171, p. 255-256, 271-272, Apr. 18 and 25, 1941.

(26) Little, D. S., Controlled Approach Lighting: Element of an Airport Instrument Landing System. *Aero Digest,* 39, p. 72, 74, 79, Aug. 1941.

(27) Blind Landing of Airplanes; Low-Power Low-Frequency Transmitter, *Science,* Jan. 20, 1942.

(28) Blind Landing of Planes Facilitated by Invention. *Science News Letter,* 41, p. 72, Jan. 31, 1942, and *Science,* 95, Jan. 30, 1942.

(29) Wing Talk: Blind Landing Systems, *Collier's,* 109, p. 52, Mar. 21, 1942.

(30) Defying Ceilings: Instrument Landing Facilities Provide Job for Radio Equipment Makers. *Business Week,* p. 66, Apr. 25, 1942.

(31) Preil, A. C., Instrument Landing Systems Will Aid War Effort. *Aviation,* 41, p. 197, 199, June 1942.

(32) Der Akustische Landehoehenmesser (Illustrated description of acoustical instrument for measurement of small ground elevations during flight, of particular importance during blind landing). *VDI Zeitung,* 87, No. 19/20, p. 298-299, May 15, 1943.

(33) McIntosh, C. H., Instrument Approach by Radio Direction Finder. *Aviation,* 42, p. 224, May 1943 and p. 206-207, 209, June 1942.

(34) Caporale, P., Instrument Approach System, *Radio News,* 29, p. 121-125, June 1943.

(35) Aircraft Instruments (Instruments included in standardized blind flying panel dealt with), *Flight* (London), 44, 534-539, Nov. 11, 1943, and p. 559-563, Nov. 18, 1943.

(36) Flight Paths of Radio Instrument Landing System, *Electronics,* 17, p. 236, Mar. 1944.

NOTE: On page 121 of Part I of this article in the Feb. 1945 issue, in the right-hand column just under Fig. 9, is a statement concerning percent modulation at various azimuth values. The author points out that actually the modulation percentage is always at least 100 percent, although for most values of azimuth it is not greatly in excess of this value.

ZERO PHASE SHIFT AMPLIFIER DESIGN

Equations and circuits for design of wide-band amplifiers having extended frequency ranges of flat phase and amplitude response. Negative feedback between successive stages is shown to be simpler and as effective as conventional shunt inductive and capacitive compensation

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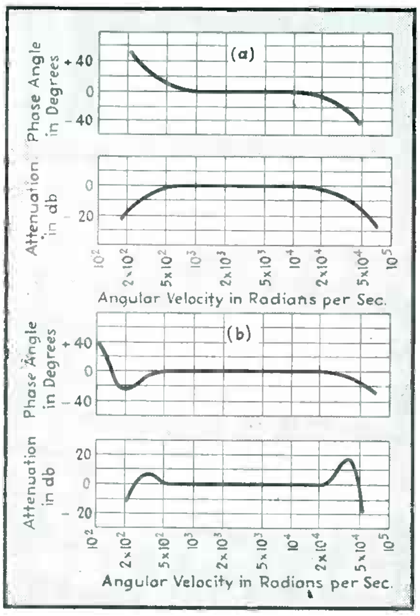


FIG. 1—The two curves at (a) show phase and amplitude characteristics of a typical RC-coupled amplifier. When negative feedback is applied to this amplifier, its characteristics become those shown at (b)

NEED for faithful reproduction of the input signal both in phase and amplitude in wide-band amplifiers necessitates rigid control of amplifier phase characteristics. The purpose of this article is to show how this requirement may be met in wide-band amplifier design by employing negative feedback for phase control, provided certain precautions are observed.

Video Amplifier Design

Amplifiers having zero phase characteristics should not be confused with video-frequency amplifiers having linear phase-shift characteristics with frequency. These latter amplifiers do not preserve the phase relationship between voltage and current existing at their input terminals nor is any attempt made to do this. Designers of video-frequency amplifiers have had recourse to the principle of constant time delay of transmitted signals to overcome difficulties of designing phase distortionless amplifiers.[1]

In the typical video amplifier the phase relation between the input and output signals might rotate through several hundred degrees over the frequency band. Such a characteristic with certain reservations has proven to be satisfactory for television picture reproduction. The most useful criterion of performance for a television amplifier has thus become related not to the phase characteristics but to the time of transmission through the amplifier. An amplifier which has constant time of transmission over the desired frequency band is obtained when the angular rotation of phase is kept constant with respect to frequency or when $t = \theta/\omega$, where t is the time of transmission, θ is in radians and ω is in radians per second. If an attempt were

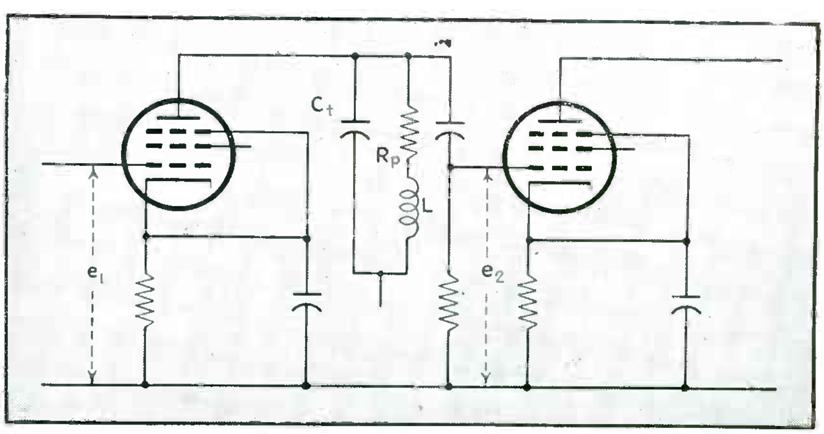
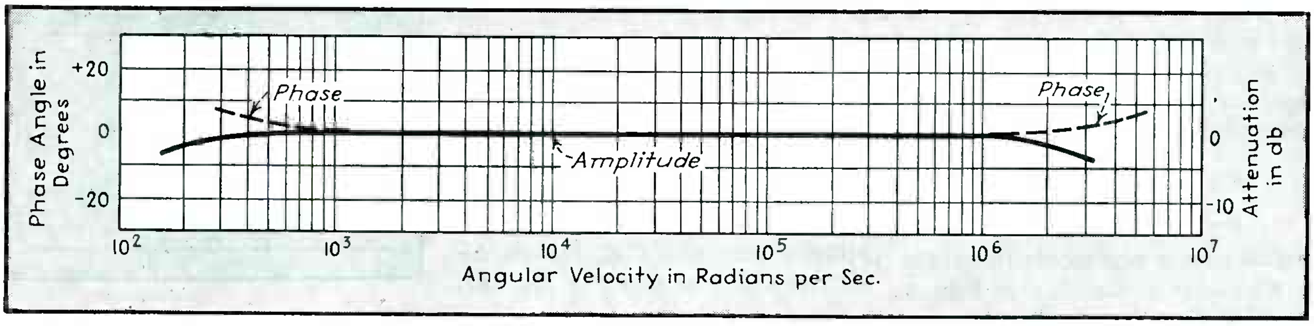


FIG. 2—At high frequencies the coupling network of an amplifier contains an effective shunt capacitance C_t



Typical amplifier characteristic obtainable with stabilized negative feedback shows wide, flat phase as well as frequency response

made to obtain a television amplifier having zero phase characteristics there would not only be little appreciable gain in fidelity of picture reproduction but also a great increase in complexity because simple amplitude filters could not be used without corresponding phase shifting devices. These difficulties would be particularly apparent in the design of the radio and intermediate-frequency channels.

However, in measuring equipment such as oscilloscopes for use in transient analysis or in observing non-linear characteristics[2] it is frequently necessary and generally desirable that the system have zero phase shift and flat response.

Requirements for Zero Phase-Shift Amplifiers

When considering the design of zero phase-shift amplifiers, it should be borne in mind that each tube in a multi-stage amplifier will rotate the phase 180 degrees. Two tubes in tandem will give a 360-degree change or effectively restore the phase to its original position. No time delay is involved in such a phase reversal where the frequency is such that tube transit-time effects can be neglected, and this will always be the case within the frequency band under discussion.

As with video amplifiers, transformer couplings cannot be tolerated owing to their inherently poor phase transmission characteristics. Thus resistance coupling and cathode followers for impedance transformations are the major design features of zero phase-shift amplifiers.

Conventional RC-coupled amplifiers are characterized by a lagging phase angle at high frequencies due to shunt capacitances and a leading phase angle at low frequencies due to the finite time constant of the coupling capacitance and grid resistance. Figure 1 shows representative curves for the phase and amplitude characteristics of a typical RC-coupled amplifier, and the effect of feedback on these characteristics when no attempt is made to stabilize the phase and amplitude at the extreme edges of the required frequency spectrum.

Some compromise is usually necessary in a zero phase-shift amplifier between the conflicting factors of flat amplitude response and flat phase characteristic. An amplifier having flat amplitude response within a fraction of a db may have phase errors as high as 20 or 30 degrees. Similarly, a flat-phase amplifier may have amplitude variations of the order of a db or more. Because the purpose of this article is to bring out the salient points in the design of amplifiers having flat phase response, the conventional viewpoint of designing for flat amplitude will be dropped in favor of designing for flat phase characteristics with the best possible amplitude response.

In general, application of negative feedback will considerably reduce phase distortion from some undesirable amount, but not necessarily to zero.[3] Additional techniques must be applied to insure a completely flat phase characteristic and methods will be suggested to advance or retard phase the required degree. This additional compensation required to correct for the angular displacements at the extreme edges of the pass-band extends the effective working range of the amplifier. Correction of phase distortion of this type in negative-feedback amplifiers will also improve the amplitude response in the same regions.

High-Frequency Phase Equalization

A typical two-stage RC-coupled amplifier is shown in Fig. 2. The phase shift between the input and output terminals is determined, in

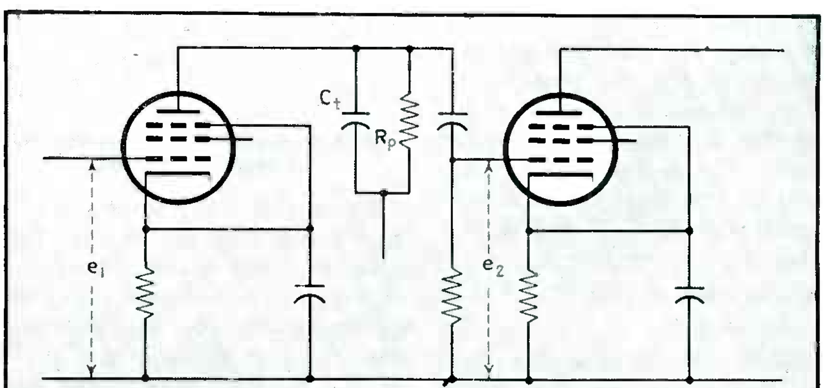


FIG. 3—Shunt inductive compensation improves high-frequency response of resistance-capacitance coupled amplifier

the absence of feedback, by the time constant of the plate resistor R_p and the sum of the tube and stray capacitances C_t. Gain and phase angle are given by

$$A = g_m \frac{R_p(1 - j\omega C_t R_p)}{1 + (\omega C_t R_p)^2} \quad (1)$$

$$\phi = -\tan^{-1}\omega C_t R_p \quad (2)$$

In this case ϕ represents the angle by which the voltage e_2 lags behind the applied voltage e_1 (Fig. 2).

For a small phase-angle departure and constant amplitude it can be seen that the product $\omega C_t R_p$ must be kept to a minimum. Assuming for example that $\omega = 10^6$, for a phase shift of the order of one degree the product $C_t R_p$ should not be greater than 10^{-8}. Because it is difficult to keep the total capacitance C_t below 20 $\mu\mu$f, R_p, can be only 500 ohms for a phase lag of $\phi = 0.6$ degrees, or much too low for useful stage gain.

If a small inductor L is added in series with R_p, the phase error may be reduced to zero and at the same time a higher plate load can be used. Figure 3 shows the addition of L. The phase angle for such a combination of L, C_t and R_p is

$$\phi = \tan^{-1}\omega\,[L(1 - \omega^2 LC_t) - C_t R_p^2]/R_p \quad (3)$$

If L is made equal to $C_t R_p^2$, then

$$\phi = \tan^{-1}(\omega C_t R_p)^3 \quad (4)$$

As $\omega C_t R_p$ will in general be less than unity, this residual phase error, being very much less than one degree, may be neglected. With tubes having a g_m of 5000, R_p may be 5000 ohms and with $C_t = 20\ \mu\mu f$ and $L = 500\ \mu$h the gain is 25 per stage with negligible phase distortion.

A more complete idea of the circuit performance can be gained and the effect of frequency upon stage gain estimated from the plate impedance for the LC_tR_p circuit described above as given in Eq. (5).

$$Z = \frac{R_p + j\omega\,[L(1 - \omega^2 LC_t) - C_t R_p^2]}{(1 - \omega^2 LC_t)^2 + (\omega C_t R_p)^2} \quad (5)$$

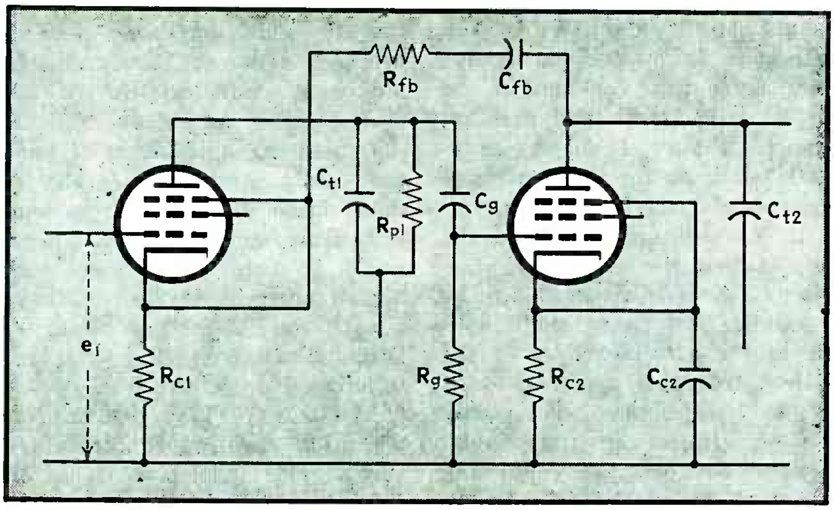


FIG. 4—Negative feedback from grid of following stage to cathode of preceding stage improves the phase response of the coupling network

We are only interested in the real part of this equation, which is

$$Z = \frac{R_p}{(1 - \omega^2 LC_t)^2 + (\omega C_t R_p)^2} \quad (6)$$

Substituting $L = C_t R_p^2$ and solving for the stage gain we obtain

$$A = \frac{g_m R_p}{1 - (\omega C_t R_p)^2} \quad (7)$$

Equation (7) shows that amplitude is substantially flat over the frequency band of interest because $(\omega C_t R_p)^2$ is considerably less than unity for the previously chosen values.

High-Frequency Compensation by Negative Feedback

The reduction of phase errors at high frequencies by negative feedback is done by means of the circuit of Fig. 4. The response ratio, middle-frequency to high-frequency gain ratio, is given by Eq. (8) if $\omega C_t R_p$ is less than unity and $C_t = C_{t1} = C_{t2}$.

$$R_{high} = \frac{1 - A_0\beta_0}{1 - A_0\beta_0 + j2\omega C_t R_p}$$

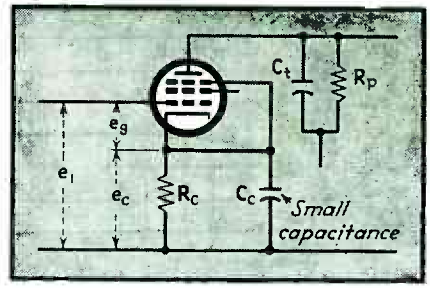


FIG. 5—A small capacitance in the cathode circuit advances the phase angle of the high-frequency voltage applied to the grid

$$= 1 - \frac{j2\omega C_t R_p}{1 - A_0\beta_0} \quad (8)$$

The phase distortion is thus reduced by the factor $1/(1—A_0\beta_0)$ and the amplitude will remain constant for the above assumption.

Taking the figures given for the amplifier in the previous example and assuming a feedback factor of $A_0\beta_0 = -5$, the phase error will be reduced by a factor of six. Thus a phase error of -11.6 degrees is reduced to a phase error of -1.9 degrees at $\omega = 10^6$. Additional phase correction must be used to reduce this angle to zero.

One very convenient method of doing this is to add a small capacitance across a normally unbypassed cathode resistance as in Fig. 5. This capacitance effectively advances the phase of the signal applied to the tube grid in relation to the signal applied to the input circuit. The voltage applied to the grid is $e_g = e_1 - e_c$ and assuming $\omega R_c C_c$ to be less than unity, the impedance of the cathode circuit can be expressed as $R_c\ (1 - j\omega C_c R_c)$ so that

$$e_g = e_1 - g_m R_c\,(1 - j\omega C_c R_c)$$
$$e_g = (e_1 - g_m R_c) + j\omega C_c R_c^2 g_m \quad (9)$$

Thus it can be seen that an effectively leading phase angle is applied to the tube grid voltage. In the case of the two-stage feedback amplifier, the capacitor C_c is shunted across the cathode feedback resistor. The effect of this capacitor on the phase of the output signal is exactly equivalent to the addition of an inductor in series with the plate resistor. The capacitor is advantageous in its ease of application and adjustment.

Minimum phase distortion is obtained at low frequencies when the time constant of the coupling capacitor and grid resistor is made a maximum. Ideally a direct coupling would be used. Limitations to increasing the time constant arise from physical bulk of the coupling capacitor, which due to stray capacitance causes considerable phase shifts at the high frequencies and gas currents in the vacuum tube which prevent the grid resistor from being increased. An insufficiently large time constant will cause the phase to become advanced as the signal passes through the amplifier.

Low-Frequency Phase Equalization

A convenient method of retarding the phase to its normal value is to shunt part of the anode load with a capacitor as in Fig. 6. R_gC_g will cause e_2 to lead e_1. R_1C_1 will give a corresponding lagging phase which, by suitable choice, will counteract the lead introduced by R_gC_g. The gain without compensation is

$$A = g_m R_p \left(1 + j/R_g\omega C_g\right) \quad (10)$$

The phase angle of the equalized plate circuit impedance is

$$\phi = -\tan \frac{C_1R_1^2}{R_1 + R_p[1 + (\omega C_1R_1)^2]} \quad (11)$$

However R_1 may be regarded as a high-impedance shunt provided for d-c feed across the capacitor C_1 and in most cases can be neglected. Thus C_1 may be considered simply as in series with R_p, giving an effective impedance Z.

$$Z = R_p - j/\omega C_1 \quad (12)$$

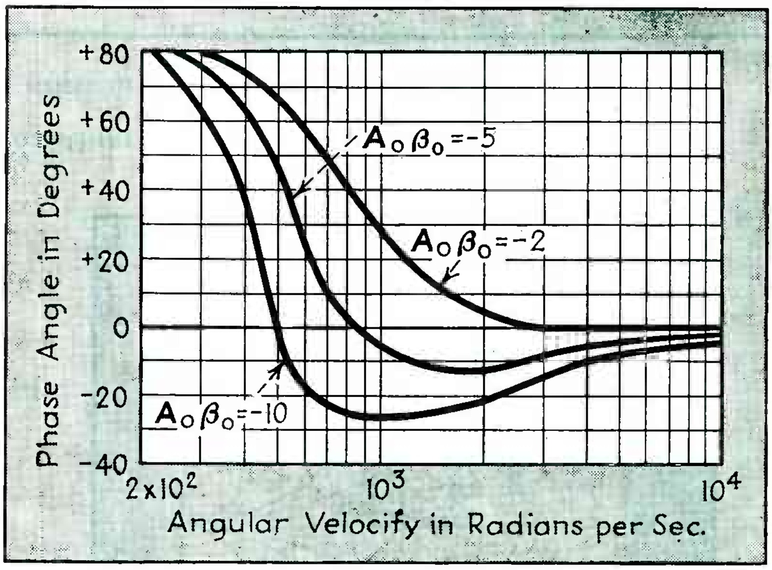


FIG. 7—If the feedback network time constant is twice the grid coupling network time constant, the phase characteristic at low frequencies varies with feedback factor as this family of curves shows

The phase angle of Z is

$$\phi = -\tan^{-1}(1/\omega C_1R_p) \quad (13)$$

It can be seen from Eq. (10) and (13) that an effective cancellation of low-frequency phase errors is obtained when the time constant of R_pC_1 is made equal to the grid coupling time constant R_gC_g.

Low-Frequency Compensation by Negative Feedback

As in the case of high-frequency correction, feedback may also be used for phase correction at low frequencies, with the corresponding advantages of gain stabilization by the circuit of Fig. 4. Thus, although two types of circuit are required for phase compensation, one for high-frequency and one for low-frequency compensation, a single feedback network, if properly designed, provides both high and low-frequency phase correction. However, unless care is exercised in the choice of coupling components, the phase errors may be seriously increased. The greatest difficulty is maintaining in circuits of this type a high enough time constant in the feedback loop without adversely affecting the high-frequency characteristics.

For high feedback factor $A_0\beta_0$ it is essential to keep the ratio of feedback time constant to the coupling time constant high. The response ratio for low-frequency amplification compared to mid-band-frequency amplification is

$$R_{low} = \frac{\omega T(\omega T - j)}{(\omega T)^2 - \dfrac{P}{1 - A_0\beta_0} - j\omega T\left(\dfrac{1 + P}{1 - A_0\beta_0}\right)} \quad (14$$

where T = feedback time constant $C_{fb}R_{fb}$
$P = C_{fb}R_{fb}/C_gR_g$

Figure 7 shows the effect of increasing the feedback without increasing the time constant ratio P.

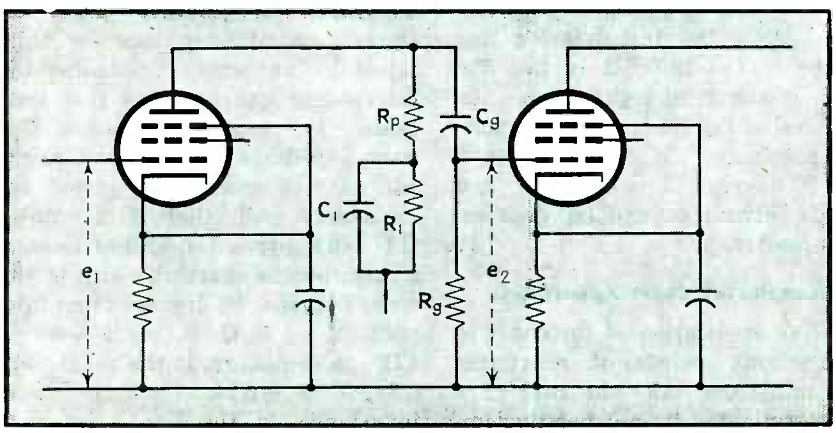


FIG. 6—Shunting a part of the plate load improves low-frequency response of an amplifier

REFERENCES

(1) Terman, F. E., "Radio Engineers' Handbook", McGraw-Hill Book Co., 1943, p. 418.
(2) Millman, J., and Moskowitz, S., Tracing Tube Characteristics on a Cathode Ray Oscilloscope, ELECTRONICS, March 1941, p. 36.
(3) Everest, F. A., and Johnston, H. R., Feedback in Wide-Band Amplifier, *IRE*, Feb. 1940.

TRANSMISSION-LINE

Impedance along transmission line or length of line necessary to transform one impedance to another are quickly determined

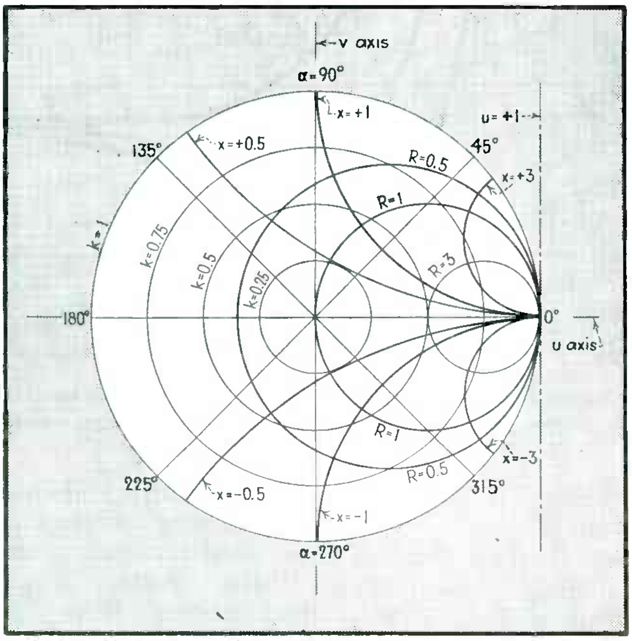


FIG. 1—Basic coordinate system from which transmission-line calculator is derived

THE CURVES for this vhf calculator were derived from the equation for the voltage reflection-coefficient $K = (Z_L - Z_0)/(Z_L + Z_0)$. This equation is transformed to $Z_L/Z_0 = (K+1)/(1-K)$ in which $Z_L/Z_0 = R + jX$ is the ratio of load impedance to characteristic line impedance, and K is a complex number which can be represented by its rectangular coordinates $u + jv$.

Chart Construction

Equating the real components of this equation, we obtain the equation of a circle for a fixed value of R with center at $u = R/(R+1)$, $v = 0$ and radius $1/(R+1.)$ Because R cannot be negative, none of these circles can have a radius greater than unity.

In a similar manner, the imaginary components yield an equation for two circles, because jX can be either positive or negative for a given arithmetic value of X, with centers at $u=1$, $v=1/X$ and $u=1$, $v= -1/X$ and with radius $1/X$.

These two families of circles are plotted in Fig. 1. Superimposed on these circles are the polar coordinates which locate the complex number K—that is, $K=u+jv=k\alpha$.

The transmission-line chart in Fig. 2 is a modification of this diagram. Concentric k circles from Fig. 1 are used on the chart to represent standing wave ratio Q, where $Q=(1+k)/(1-k)$, and the radial α lines are used to give distance along the transmission line where $\theta=(\alpha+180°)/2$ is the distance in electrical degrees from the load end of the line to the first voltage minimum. If θ is between 0 and 90 degrees, X is negative; and if θ is between 90 and 180 degrees, X is positive.

Examples of Chart Applications

As an application of the chart in determining points of maximum and minimum, take the case of a line terminated by a capacitive impedance such that $Z_L/Z_0=1-j1.2$. On the chart this point is located at $R=1$, $X=1.2$ which has an angular coordinate of about 60.5 degrees (for a negative reactance) indicating that the first voltage minimum is 60.5 electrical degrees from the load. Had the load been inductive, Z_L/Z_0 would have been $1+j1.2$ and the first voltage minimum would have been 119.5 electrical degrees from the load. There would have been a voltage maximum $119.5°-90°=29.5°$ from the load. In either case, since the point falls on the $Q=3.1$ circle, the ratio of maximum to minimum voltage is 3.1.

An unknown load impedance can be determined from measurements on a line of known characteristic impedance, using the chart. As a specific illustration, the standing wave ratio is 3 and the voltage minimum or current maximum is 50 electrical degrees from the load. This data locates a point at $Q=3$, $\theta=50°$ on the chart. At this point $R=0.7$, $X=0.9$. Here X is negative because $\theta<90°$. The load impedance is $Z_0(0.7 - j0.9)$. Had the voltage minimum occurred 130 degrees from the load, the load impedance would have been numerically the same but inductive because $\theta<90°$ in this case.

Another useful application of this chart is in determining impedance at one point on a line if impedance at another point is known. A problem such as this arises in matching impedances by interposing quarter-wave line sections. For example, what is the wave impedance on a line at a point one quarter wave length from an impedance such that $Z_L/Z_0=2.5-j1$? This given impedance locates a point on the chart at which $Q=3$, $\theta=81$ degrees; 90 degrees from this point, i. e., at $Q=3$, $\theta=81°+90°=171°$ on the chart, is the point $R=0.34$, $X = +0.14$. Thus the wave impedance on the line a quarter wavelength from Z_L is $Z_0(0.34+j0.14$.

CALCULATOR

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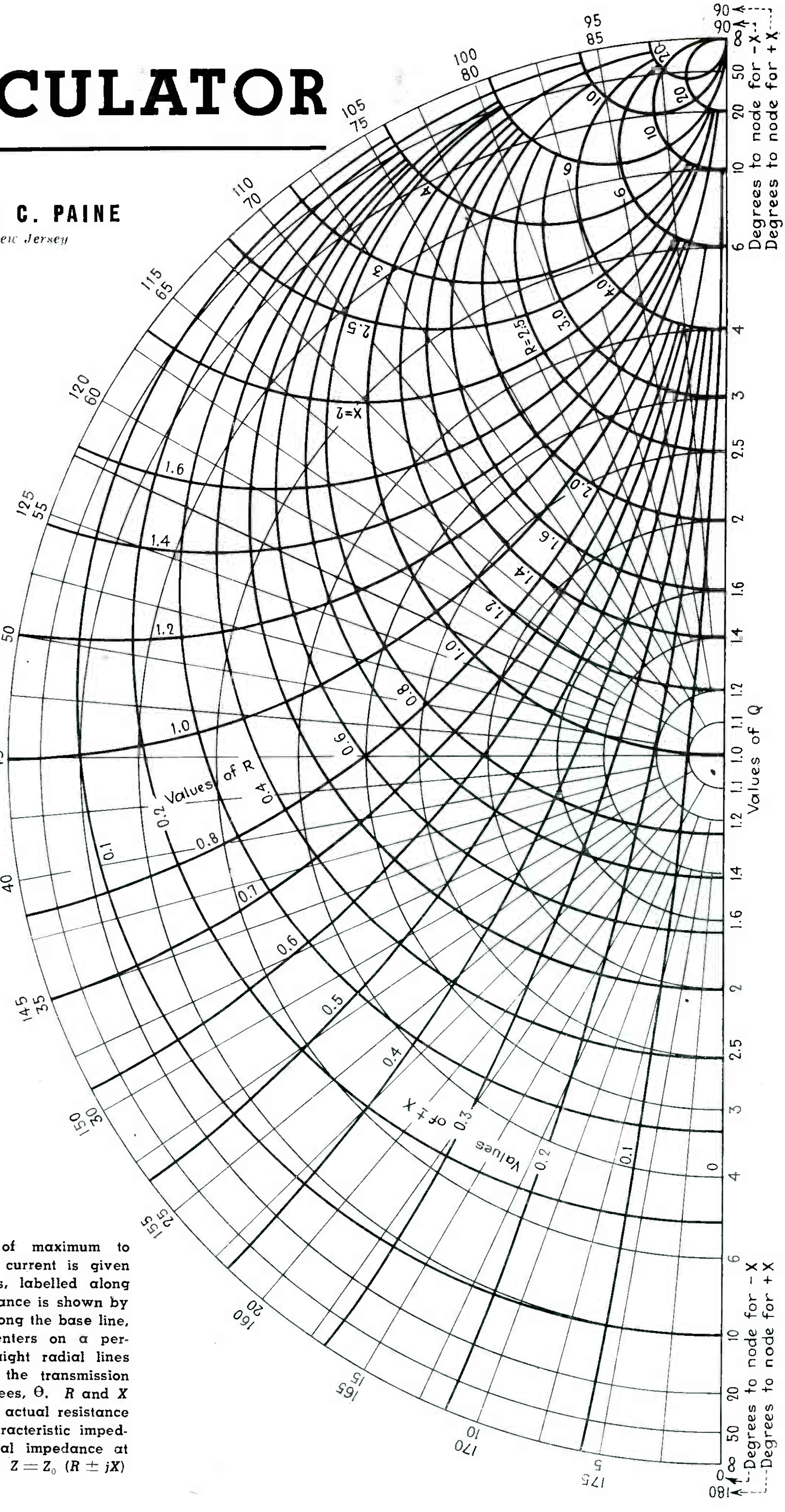

FIG. 2—The ratio of maximum to minimum voltage or current is given by concentric Q arcs, labelled along the base line. Impedance is shown by *R* arcs with centers along the base line, and *X* arcs with centers on a perpendicular. The straight radial lines give distance along the transmission line in electrical degrees, Θ. *R* and *X* represent the ratio of actual resistance and reactance to characteristic impedance. Thus the actual impedance at a point on the line is $Z = Z_0 (R \pm jX)$

DISCRIMINATOR

The correlation of electrical characteristics in resonant coupled circuits and staggered cascade circuits is demonstrated. From this result discriminator action is explained and conditions for best linearity established. Theoretical linearity curves are plotted

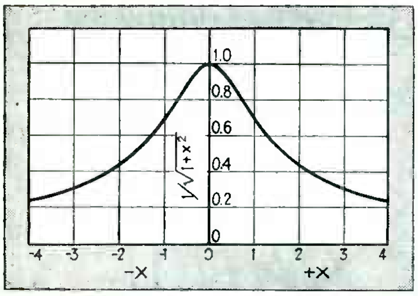

FIG. 1—Relative resonance characteristic showing absolute value of impedance as a function of Q and the ratio of frequency off resonance to the resonant frequency

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DISCRIMINATOR CIRCUITS are widely used to convert frequency-modulated signals to audio-frequency voltages. For this purpose it is desirable that the direct output vary linearly with the input frequency. This article discusses that linearity.

Logically we might write down the equations governing discriminator action without preliminary work. However, the relationships in a discriminator can be obtained as an extension of the problem of tuned coupled circuits. The response curves for tuned coupled circuits are, in turn, very closely related to those for simple tuned circuits. For these reasons it seems easiest to treat these three problems as a unit. In explaining discriminator action we shall therefore begin with a brief review of simple parallel resonance and of coupled circuits.

Review of Resonant and Coupled Circuits

The impedance of a resonant circuit of parallel R, L and C is given by:

$$\frac{1}{Z} = \frac{1}{R} + \frac{1}{j\omega L} + j\omega C \qquad (1)$$

It is customary to simplify this expression by normalizing the frequency variation in terms of the bandwidth of the tuned circuit between half-power points. On this basis the impedance becomes:

$$Z = \frac{R}{1 + jx} \qquad (2)$$

or

$$\left|\frac{Z}{R}\right| = \frac{1}{\sqrt{1 + x^2}} \qquad (3)$$

where

$x \cong 2Q\,\Delta f / f_0$

Δf = frequency off resonance

Figure 1 is a plot of the well-known normalized resonance curve.

To get a physical picture of what takes place in coupled circuits we can think of the response curve as the product of two resonance curves staggered in frequency a certain number of bandwidths.

For example, two resonant circuits can be regarded as the coupling impedances in a two-stage amplifier as indicated in Fig. 2.

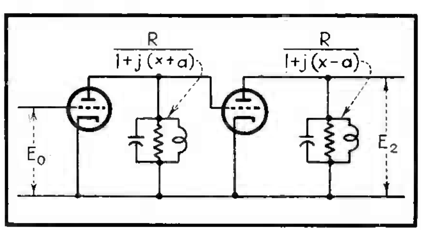


FIG. 2—Staggered resonant circuits used as coupling elements in cascade amplifier

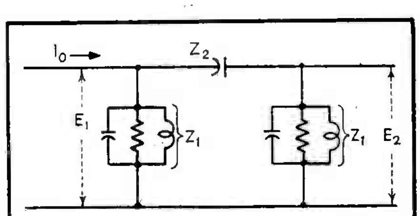


FIG. 3—Identically tuned coupled-resonant circuits could be used as a coupling element

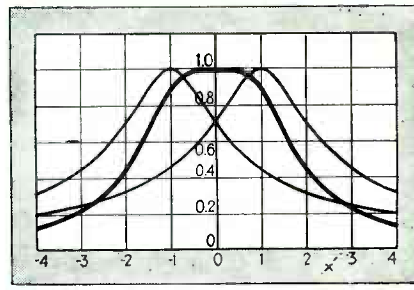


FIG. 4—Symmetrically detuned resonant circuits combine to give critical flatness at $a = 1$. The ordinates of the product curve are multiplied by two to improve readability

The voltage amplification is given by:

$$\frac{E_2}{E_0} = g_m^2 R^2 \frac{1}{[1 + j(x + a)][1 + j(x - a)]} \qquad (4)$$

or

$$\left|\frac{E_2}{E_0}\right| = \frac{g_m^2 R^2}{\sqrt{[1 + (x + a)^2][1 + (x - a)^2]}} \qquad (5)$$

Here each circuit is resonated a half-bandwidths from the mean frequency.

In the case of the coupled circuits shown in Fig. 3, we try to obtain an analogous expression for the transfer impedance, E_2/I_0. It will be worth working this out in detail because the results are directly applicable to the discriminator. In Fig. 3 we have:

$$E_1 = \frac{Z_1(Z_1 + Z_2)}{2Z_1 + Z_2} I_0 \qquad (6)$$

and

$$E_2 = \frac{Z_1}{Z_1 + Z_2} E_1 \qquad (7)$$

Combining Eq. (6) and (7) we have:

$$\frac{E_2}{I_0} = \frac{Z_1^2}{2Z_1 + Z_2} \qquad (8)$$

The impedance Z_2 is that of a physical capacitor. It is very convenient, however, to neglect the variation of this capacitance over the small percentage range of frequencies considered in the resonance curves. This enables us to simplify Z_2 to

$$Z_2 = -jkR. \qquad (9)$$

LINEARITY

Substituting Eq. (2) and (9) in Eq. (8), we obtain

$$\frac{E_2}{I_0} = \frac{[R/(1 + jx)]^2}{[2R/(1 + jx)] - jkR} \quad (10)$$

or

$$\frac{E_2}{I_0R} = \frac{1}{(2 - jk + kx)(1 + jx)} \quad (11)$$

Comparison of Symmetrically Detuned Cascaded Circuits with Identically Resonated Coupled Circuits

It would be desirable to reduce Eq. (11) to a form similar to that of Eq. (4). In order to do this it is clearly necessary to get the coefficient of x in the second factor of Eq. (11) changed from k to j. This is accomplished by multiplying numerator and denominator by j/k:

$$\frac{E_2}{I_0R} = \frac{j/k}{[1 + j(x + 2/k)][1 + jx]} \quad (12)$$

If we measure normalized frequency deviations from $1/k$ instead of from zero by changing the variable, so that $x + 1/K = y$, Eq. (12) becomes

$$\frac{E_2}{I_0R} = \frac{j/k}{[1 + j(y + 1/k)][1 + j(y - 1/k)]} \quad (13)$$

Except for a multiplying factor and a shift of abscissas this is identical to Eq. (4), the equation for staggered circuits. In Eq. (13) $1/k$ is to be identified with a, the half bandwidths off resonance, of Eq. (4).

The choice of direct capacitive coupling rather than mutual inductive coupling was made to simplify the computation. If inductive coupling had been used the results would have been the same except that no shift in abscissas would have occurred.

The relationship between staggered and resonant circuits provides the physical interpretation of the resultant curves. The product of two widely-spaced curves gives a double resonant peak while the product of two coincident peaks yields a single sharp peak. Thus we are led to investigate the possibility of choosing the spacing between peaks in such a manner as to make the two peaks coalesce to give a critically-flat curve.

One way of determining the conditions of this consists of differentiating Eq. (5) with respect to x and determining the value of a that would make the two peaks just meet. A second method consists of setting the second derivative of the curve equal to zero at $x = 0$ and solving for a. As is well-known, these conditions lead to the choice of $a = 1$ for critical flatness. Curves showing the two resonant curves and their product for this condition are shown in Fig. 4.

Discriminators

We found it convenient to obtain a physical picture of coupled circuits by means of cascaded staggered circuits. In just the same way it is useful to consider a very simple discriminator circuit before considering the general case. Figure 5 shows an idealized discriminator circuit of this sort.

Detectors are arranged to provide two opposing direct voltages one of which is proportional to the magnitude of the impedance of one circuit while the other is proportional to the impedance of the second circuit. As before the resonant frequency of each circuit is staggered from a mean value by a half-bandwidths. Thus we have

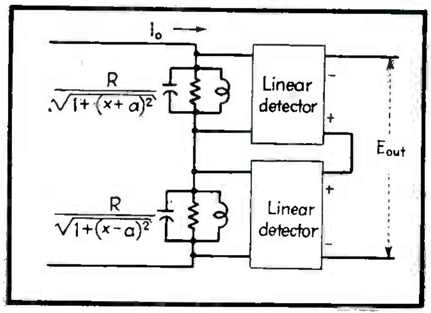


FIG. 5—Simple staggered resonant-circuit discriminator

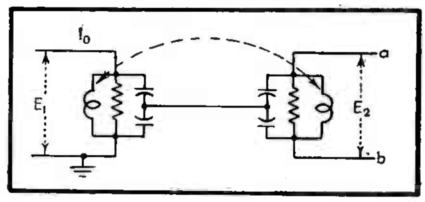


FIG. 6—Basic coupled resonant-circuit discriminator

$$\left|\frac{E_{out}}{I_0R\sqrt{2}}\right| = \frac{1}{\sqrt{1 + (x - a)^2}} - \frac{1}{\sqrt{1 + (x + a)^2}} \quad (14)$$

It has been pointed out by Travis[1] that the more conventional type of discriminator has a characteristic expressible in this form. Let us consider the circuit shown in Fig. 6. From our previous analysis, we see that while the frequency discrimination of the circuit of Fig. 5 corresponds to that of the circuit in Fig. 2, the discriminator of Fig. 6 behaves like the coupled circuits of Fig. 3.

The voltages E_a and E_b in Fig. 6 are fed to separate linear rectifiers whose outputs are opposed. It is assumed that the coils in Fig. 6 are

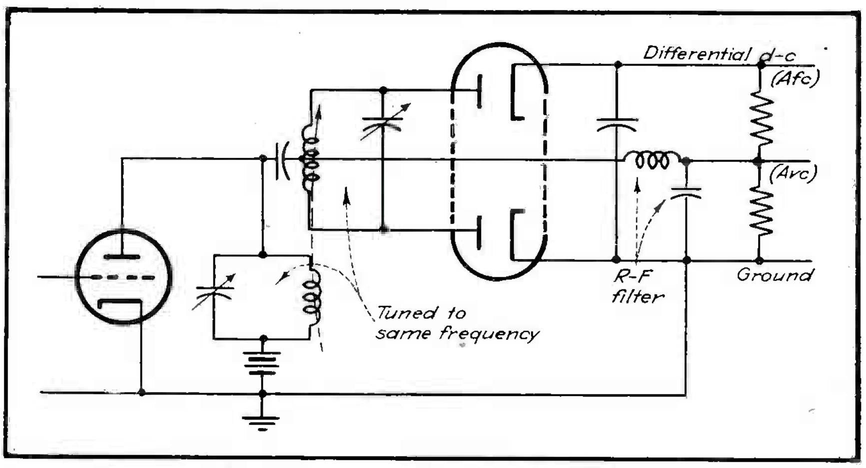


FIG. 7—Practical discriminator circuit which has the same action as the basic coupled resonant circuit of Fig. 6

inductively coupled. If negligible load current is drawn from the points a and b the voltage E_a is made up of half the difference between the primary and secondary voltages. Similarly the voltage E_b is made up of half the sum of these two voltages. Whether the primary and secondary circuits are inductively coupled or capacitively coupled makes no essential difference. Hence except for a shift in the variable and a constant factor, the primary and secondary circuits of Fig. 6 are related in the same way that the corresponding circuits in Fig. 3 are related. Thus we are led to consider the magnitudes $|E_1 + E_2|$ and $|E_1 - E_2|$ in Fig. 3. Combining Eq. (6) and (8) we write:

$$\frac{E_1 + E_2}{I_0} = \frac{Z_1 (Z_1 + Z_2) + Z_1^2}{2Z_1 + Z_2} = Z_1 \quad (15)$$

and

$$\frac{E_1 - E_2}{I_0} = \frac{Z_1 (Z_1 + Z_2) - Z_1^2}{2Z_1 + Z_2} = \frac{Z_1 Z_2}{2Z_1 + Z_2} \quad (16)$$

Substituting the equivalent expressions for the impedances, we have

$$\frac{E_1 + E_2}{I_0 R} = \frac{1}{1 + jx} \quad (17)$$

and

$$\frac{E_1 - E_2}{I_0 R} = \frac{\frac{1}{1 + jx}(-jk)}{\frac{2}{1 + jx} - jk} = \frac{-jk}{2 - jk + kx} \quad (18)$$

Forming the difference between the magnitudes of Eq. (17) and (18) we write

$$\frac{|E_1 + E_2| - |E_1 - E_2|}{|I_0| R} = \frac{1}{\sqrt{1 + x^2}} - \frac{1}{\sqrt{1 + (x + 2/k)^2}} \quad (19)$$

Making the substitution $y = x + 1/k$ as before and writing $h(y)$ for the value of the function we obtain

$$h(y) = \frac{1}{\sqrt{1 + (y - a)^2}} - \frac{1}{\sqrt{1 + (y + a)^2}} \quad (20)$$

where $a = 1/k$.

This has the same form as Eq. (14).

The practical discriminator shown in Fig. 7[2] can be made the same as that shown in Fig. 6 provided that proper turns ratios are used between the primary and secondary windings and provided the two windings have the same Q. The two rectifier outputs are proportional to $|E_b|$ and $|E_a|$.

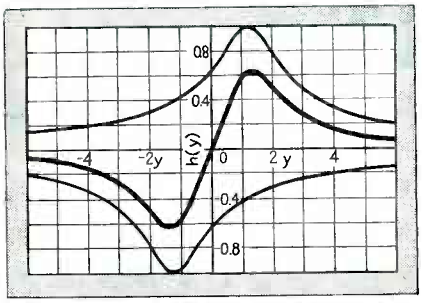


FIG. 8—Discriminator characteristics which result from a coupling equivalent to a frequency spacing between circuit resonances which corresponds to $a = \sqrt{3/2}$

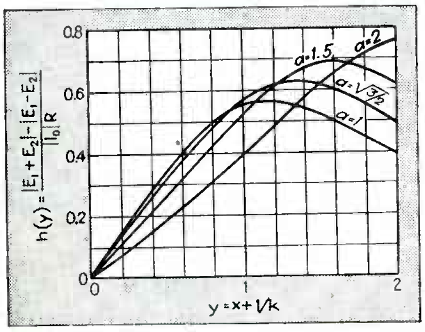


FIG. 9—Discriminator curves for various values of a

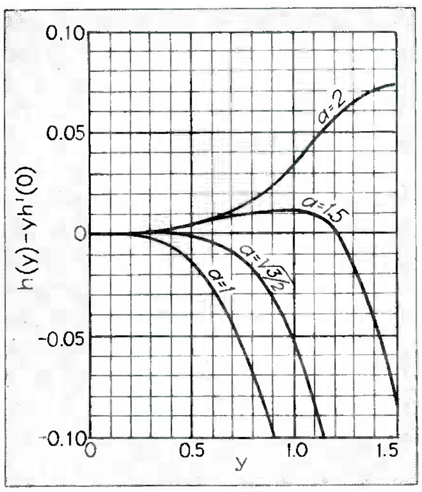


FIG. 10—Deviations of discriminator curves from tangents at their cross-over point

The symmetrical conditions assumed in Fig. 2 in deriving coupled-circuit relationships are by no means necessary but are mathematically convenient. Similarly it is likely that symmetrical conditions are not necessary in the case of discriminators. Nevertheless the assumption of such conditions is very helpful in carrying out the arithmetic in each case. The writer has not tried to get a solution of unsymmetrical cases.

Condition for Best Linearity

Let us investigate the shapes of the curves given by Eq. (20). Clearly if we let the two generating resonance curves be spaced by too great a frequency the resultant curve will be badly nonlinear. Similarly the curve for an opposite extreme will have a reverse curvature and will be just as undesirable. If we investigate the linearity at the center by considering the derivatives at the point $y = 0$ we find,

$$h^{I}(0) = \frac{2a}{(1 + a^2)^{-3/2}}$$

$$h^{II}(0) = 0$$

$$h^{III}(0) = \frac{6a\,(2a^2 - 3)}{(1 + a^2)^{7/2}}$$

$$h^{IV}(0) = 0$$

$$h^{V}(0) = \frac{30a\,(8a^4 - 40a^2 + 15)}{(1 + a^2)^{11/2}}$$

$$h^{VI}(0) = 0$$

$$h^{VII}(0) = \frac{630a\,(226a^6 - 78a^4 + 90a^2 - 35)}{(1 + a^2)^{13/2}}$$

It will be noticed that for $a = \sqrt{3/2}$ the second, third, and fourth derivatives are all zero, making for exceptionally good linearity.

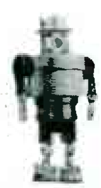
Figure 8 shows the discriminator characteristic for this critical case where the third derivative vanishes. Figure 9 shows a family of curves for various values of a between 1 and 2. For convenience the lower halves of these curves have been omitted.

It would have been useful to permit the frequency deviation y to vary sinusoidally and to expand the resultant curve for $h(y)$ as a Fourier series. This would permit the computation of distortion factors for various values of a and frequency swing. Unfortunately lack of time has prevented the completion of this numerical work. However, some estimates of the distortion can be obtained from a study of the curves in Fig. 10. These curves show the difference between the discriminator curves of Fig. 9 and tangents drawn to them at the origin. It will be noticed that the curve for $a = \sqrt{3/2}$ differs from its tangent by less than 0.2 percent for values of y less than 0.5. However, the curve for $a = 1.5$ lies close to its tangent over a considerably larger interval.

REFERENCES

(1) Travis, Charles, Automatic Frequency Control. *Proc. IRE.* 23, Oct. 1935, p. 1125.
(2) Foster, D. E. and Seely, S. W., Automatic Tuning, Simplified Circuits, and Design Practice. *Proc. IRE*, 25, Mar. 1937, p. 289.

IT'S "KNOW HOW"



"Objective gained"; It's Know How that gets them there. CINCH set out some years ago to make a socket for every need in communications; every size and type. Today "more often than not the socket in service is a CINCH".

Such dependability *must* be attributed to the "Know How" in the manufacture. Cinch was first in the field with a complete line of miniature socket assemblies, together with nut straps and associated items.

CINCH *Fasteners* ★ *Miniature Sockets*
Filler Necks ★ *Octal Sockets* ★ *Lugs*
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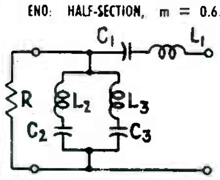
2335 West Van Buren Street, Chicago 12, Illinois
Subsidiary of UNITED-CARR FASTENER CORPORATION, Cambridge, Mass.

BAND-PASS Filter Design

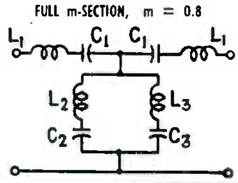
By C. J. MERCHANT
The Brush Development Co.
Cleveland, Ohio

BAND-PASS: T-SECTIONS

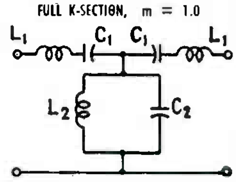
END: HALF-SECTION, m = 0.6



FULL m-SECTION, m = 0.8



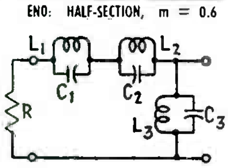
FULL K-SECTION, m = 1.0



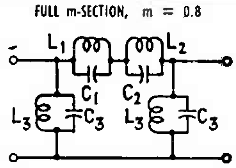
$\left(\frac{f_2}{f_m}\right)$	END: HALF-SECTION, m = 0.6						FULL m-SECTION, m = 0.8						FULL K-SECTION, m = 1.0			
	X_L at $f = f_m/R$			X_C at $f = f_mR$			X_L at $f = f_m/R$			X_C at $f = f_mR$			X_L at $f = f_m/R$		X_C at $f = f_mR$	
	L_1	L_2	L_3	C_1	C_2	C_3	L_1	L_2	L_3	C_1	C_2	C_3	L_1	L_2	C_1	C_2
1.05	6.12	20.4	22.1	6.12	22.1	20.4	8.15	4.23	4.98	8.15	4.98	4.23	10.2	0.049	10.2	0.049
1.10	3.16	9.87	12.7	3.16	12.7	9.87	4.21	2.04	2.78	4.21	2.78	2.04	5.26	0.095	5.26	0.095
1.15	2.14	6.49	9.20	2.14	9.20	6.49	2.86	1.31	2.04	2.86	2.04	1.31	3.57	0.140	3.57	0.140
1.20	1.63	4.72	7.40	1.63	7.40	4.72	2.17	0.935	1.73	2.17	1.73	0.935	2.72	0.183	2.72	0.183
1.25	1.33	3.70	6.48	1.33	6.48	3.70	1.78	0.736	1.53	1.78	1.53	0.736	2.22	0.225	2.22	0.225
1.30	1.11	3.03	5.80	1.11	5.80	3.03	1.48	0.588	1.41	1.48	1.41	0.588	1.88	0.265	1.88	0.265
1.35	0.984	2.56	5.42	0.984	5.42	2.56	1.31	0.506	1.34	1.31	1.34	0.506	1.64	0.304	1.64	0.304
1.40	0.876	2.22	5.12	0.876	5.12	2.22	1.17	0.438	1.30	1.17	1.30	0.438	1.46	0.342	1.46	0.342
1.45	0.792	1.96	4.95	0.792	4.95	1.96	1.06	0.385	1.27	1.06	1.27	0.385	1.32	0.380	1.32	0.380
1.50	0.720	1.75	4.71	0.720	4.71	1.75	0.96	0.340	1.25	0.96	1.25	0.340	1.20	0.417	1.20	0.417

BAND-PASS: π-SECTIONS

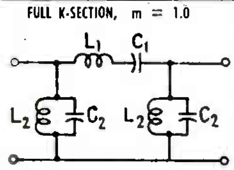
END: HALF-SECTION, m = 0.6



FULL m-SECTION, m = 0.8



FULL K-SECTION, m = 1.0



$\left(\frac{f_2}{f_m}\right)$	END: HALF-SECTION, m = 0.6						FULL m-SECTION, m = 0.8						FULL K-SECTION, m = 1.0			
	X_L at $f = f_m/R$			X_C at $f = f_mR$			X_L at $f = f_m/R$			X_C at $f = f_mR$			X_L at $f = f_m/R$		X_C at $f = f_mR$	
	L_1	L_2	L_3	C_1	C_2	C_3	L_1	L_2	L_3	C_1	C_2	C_3	L_1	L_2	C_1	C_2
1.05	0.045	0.049	0.163	0.049	0.045	0.163	0.236	0.201	0.123	0.201	0.236	0.123	20.4	0.098	20.4	0.098
1.10	0.079	0.101	0.316	0.101	0.079	0.316	0.490	0.360	0.238	0.360	0.490	0.238	10.5	0.190	10.5	0.190
1.15	0.109	0.154	0.467	0.154	0.109	0.467	0.763	0.490	0.350	0.490	0.763	0.350	7.14	0.280	7.14	0.280
1.20	0.135	0.212	0.613	0.212	0.135	0.613	1.07	0.578	0.461	0.578	1.07	0.461	5.44	0.367	5.44	0.367
1.25	0.154	0.270	0.750	0.270	0.154	0.750	1.36	0.653	0.562	0.653	1.36	0.562	4.44	0.450	4.44	0.450
1.30	0.172	0.330	0.900	0.330	0.172	0.900	1.70	0.709	0.675	0.709	1.70	0.675	3.76	0.531	3.76	0.531
1.35	0.184	0.391	1.02	0.391	0.184	1.02	1.98	0.746	0.763	0.746	1.98	0.763	3.28	0.609	3.28	0.609
1.40	0.195	0.450	1.14	0.450	0.195	1.14	2.28	0.769	0.855	0.769	2.28	0.855	2.92	0.685	2.92	0.685
1.45	0.202	0.510	1.26	0.510	0.202	1.26	2.60	0.787	0.943	0.787	2.60	0.943	2.64	0.760	2.64	0.760
1.50	0.212	0.572	1.39	0.572	0.212	1.39	2.94	0.800	1.04	0.800	2.94	1.04	2.40	0.834	2.40	0.834

Generalized impedance tables from which filter impedances are quickly calculated with a reactance slide-rule if the upper cut-off frequency, mid-band frequency and terminating impedance of a band-pass filter all are known. These dimensionless impedance tables are obtained by specifying filter component values as functions of mid-band frequency and terminating impedance for various values of upper to mid-band frequency ratio

Low- or high-pass filters can be completely specified in terms of two quantities, the cut-off frequency and the terminating impedance. Band-pass filters introduce an additional quantity, the bandwidth, and therefore require three quantities to specify their performance, but their calculation can be simplified by means of a reactance slide-rule technique similar to that described in a previous reference sheet (February 1945 issue of ELECTRONICS).

The accompanying charts give the reactance constants, in ohms, of T and π band-pass sections in terms of the terminating impedance R, the upper cut-off frequency f_2, and the mid-band frequency f_m, which is the geometric mean of the upper and lower cut-off frequencies and is given by $f_m = \sqrt{f_2 f_1}$.

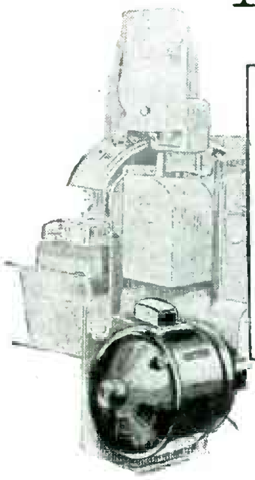
For example, to design a 3-section filter of π-sections with cut-off frequencies at 770 cps and 1300 cps and terminated in 1000 ohms, first find $f_m = \sqrt{770 \times 1300} = 1000$ cps. Find $f_2/f_m = 1300/1000 = 1.30$. Then set the reactance slide-rule at $f_m/R = 1000/1000 = 1$ cps, and find the inductances whose reactances in ohms at 1 cps are the values given on the chart opposite $f_2/f_m = 1.30$. Then reset the rule at $f_mR = 1000 \times 1000 = 1$ Mc and find the capacitances in like manner.

When f_2/f_m is greater than 1.50, the filter can be more economically designed by cascading low and high-pass sections whose pass-bands overlap.

In specifying values for the actual filter design, elements appearing directly in parallel or in series after cascading should be combined.

A Fine Example of Versatile Contact Material

MALLORY D-54*



TYPICAL PHYSICAL PROPERTIES
(Annealed)

Conductivity %IACS		75-85
Hardness (Rockwell)		35-45 F
Tensile Strength PSI		16,000
Density	Grams per CC	9.6-9.8
	Tr. Oz. Per In.³	5.07-5.17

AN electrical contact material must have versatility to be specified by design engineers for many electrical contact applications. The complete versatility of Mallory D-54 contacts is demonstrated by their use in a broad range of voltage and current applications. This heavy-duty, current carrying contact material offers all of the many unusual mechanical and electrical advantages of silver and cadmium oxide.

Mallory D-54 is also adaptable to the main contact of heavy-duty circuit breakers where occasional arcing proves so destructive to silver contacts.

One manufacturer of motor-starting controls uses Mallory D-54 contacts to carry and interrupt a 600-ampere maximum load—100-ampere normal load—with a maximum operating voltage of 460 volts AC. Another application requires contacts of this material to close on inrush currents of 2,400 amperes at 28 volts DC.

Still another manufacturer has bought in the last year over 1,150,000 pieces of Mallory D-54 for fifteen different applications. Mallory D-54 has been tried—and not found wanting.

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ELECTRICAL CONTACTS AND CONTACT ASSEMBLIES

INDUSTRIAL CONTROL

Chicago Conference on Induction and Dielectric Heating

ALMOST 5,000 REQUESTS were received for tickets to attend the afternoon and evening technical sessions of the Conference on Induction and Dielectric Heating, sponsored by the Great Lakes Power Club in cooperation with the Chicago Lighting Institute and held January 16, 17 and 18, at the Marquette Assembly Hall, Chicago. Average attendance per session was over 380.

Fundamentals of High-Frequency Heating

In opening the technical session Tuesday afternoon, J. P. Jordan of General Electric Co. stated: "There is great need for better understanding of what electronic heating—and induction heating in particular—can do and what it cannot do." After outlining the fundamental principles of operation, he pointed out some of the advantages and limitations of induction heating equipment. It was shown, for example, that materials of reasonably high resistivity could be heated more efficiently than materials such as aluminum, copper or silver, having very low resistivity. Electronic heating is, according to Mr. Jordan, expensive compared to other types of heating because the initial equipment and the power required are both expensive. For this reason induction heating is not economically applicable for all purposes. However, it does have many applications in hardening, heat-treatment, brazing, soldering, and similar applications. The user should not expect induction heating equipment to solve all of his headaches. The industrial engineer should consult with the induction heating engineer to ascertain the most economical and suitable applications in a given plant.

Under the title, "Heat Treatment of Metals With High Frequency" Otto Weitmann of Lepel High Frequency Laboratories gave a general talk on this subject, illustrating his remarks with slides showing the construction of output coils for various applications and outlining the water-quenching technique which is commonly used in heat treatment of metals. (A condensed version of his paper appears on page 101 of this issue of ELECTRONICS.)

Electronic Brazing and Soldering

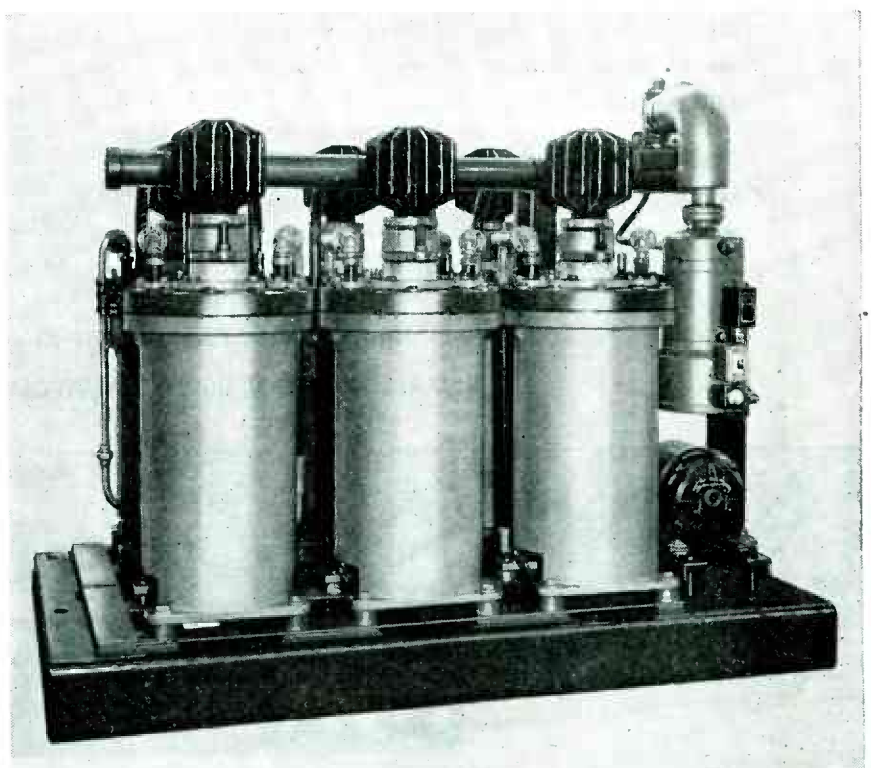
H. U. Hjermstad of Federal Electric Co., speaking on "Applications of High Frequency Heating to Brazing and Low Temperature Soldering," gave practical pointers for proper preparation of joints and connections which are to be brazed or soldered. Proper spacing between joints is necessary so solder will flow to all portions of the joint by appropriate capillary action after suitable fluxing. In general, clearances of about 0.001 or 0.002 inch were found to give the strongest bonds between the two metals. Cleanliness in preparing the surfaces to be joined cannot be too greatly emphasized. A series of slides was given showing recommended and poor practices in preparing materials for joining by soldering or brazing.

Molecular Friction Makes Heat

J. W. Cable of the Induction Heating Corp. discussed "Fundamentals of High Frequency Heating." Principles involved in heating by alternate stress of the molecules within dielectric materials were brought out. The advantage of dielectric heating in providing uniform temperature rise throughout the material (neglecting radiation losses from the surface of the material) was shown to be a distinct advantage over other methods of heating.

New Frequency-Changer Unit

A brief talk was given by F. R. Durand of the Allis-Chalmers Mfg. Co. on "Mercury Arc Frequency



Designed for induction-heating applications, this Allis-Chalmers Excitron-type mercury arc unit electronically multiplies the frequency of a-c power

NO. 5 IN THE IRC NEW PRODUCT PARADE

IRC PRESENTS

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Five standard sizes, covering the 0.1 to 22,000 ohm range, are now being built to JAN-R-26 specifications for RW20, RW21, RW22, RW23 and RW24 requirements.

Non-magnetic mounting brackets extending through the resistor allow easy and economical mounting, aid in uniform heat distribution along the entire length of the resistor, and serve as conductors to transfer internal heat to the chassis.

FRW's may be mounted vertically or horizontally, either singly or "stacked." Although light in weight, they have exceptional mechanical strength and withstand severe vibration. They reflect in every detail IRC's traditional high quality.

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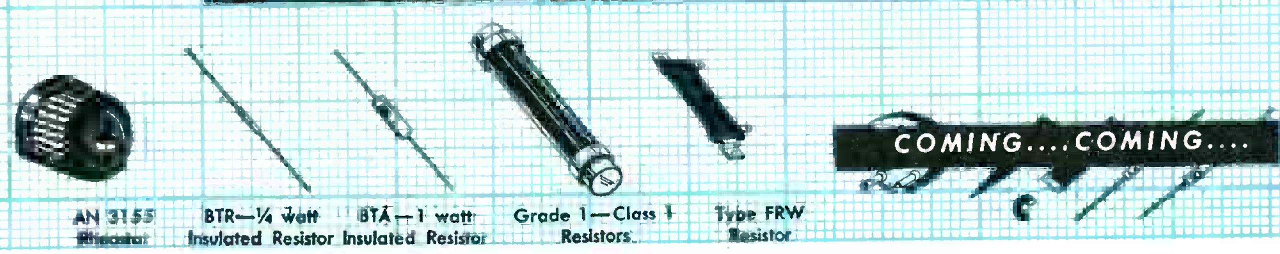


Changers for Induction Heating," describing a new method of providing high power and high efficiency at frequencies in the range of about 500 to 3000 cycles per second. The method developed by Allis-Chalmers is still quite new so that field experience is based on the installation of only a few units whose power outputs have been in the range from 200 to 300 kw. Efficiencies of 90 percent or more may be obtained with this unit for loads which are 50 percent or more of the rated capacity of the unit.

Fundamentally the mercury arc frequency changer for induction heating consists of a bank of Excitron rectifiers supplied from a 60-cycle power source, a means for providing power transfer from the rectifier circuits to the load circuit, a means for tuning the load circuit to frequencies in the range of from about 500 to 3000 cycles, and an electronic firing and control mechanism operating on the grids of the Excitrons to multiply the frequency. The frequency changing is accomplished by operating on the grids of the Excitrons at a rate dependent on the LC constants of the work circuits. Since these vary with the load on the generator, the frequency of the frequency changer varies likewise.

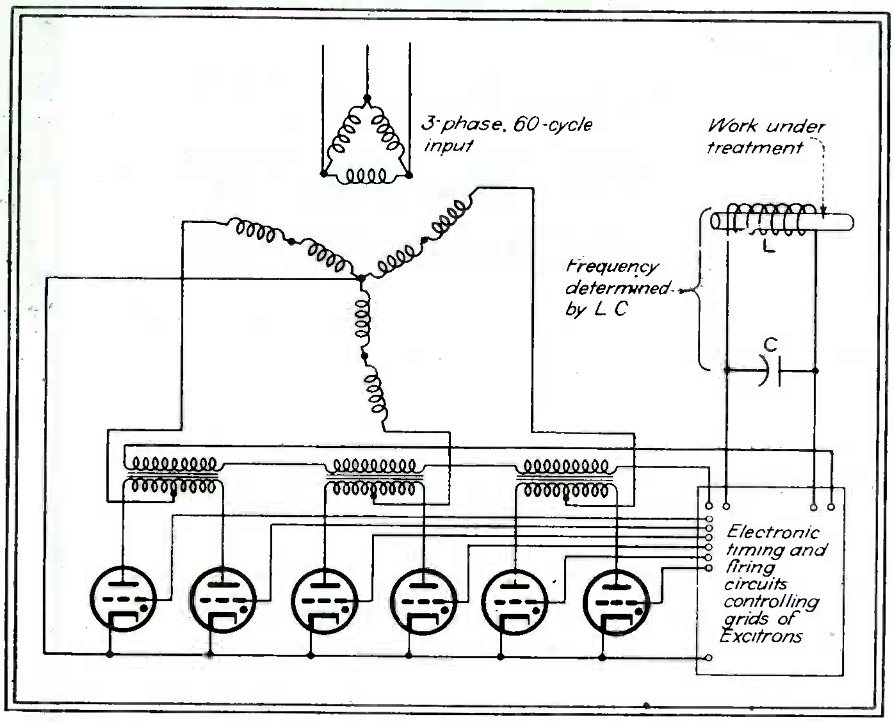
Dielectric Heating of Plywood

Paul D. Zottu of The Girdler Corp., spoke on "Application of Dielectric Heating to Wood Products." In tracing the history of this technique, Mr. Zottu pointed out that a paper delivered by von Siemens in 1864 before the Academy of Science in Berlin anticipated dielectric heating in the following paragraphs:

"As it appeared probable to me that the glass wall of the Leyden jar must be heated by its charge and discharge, I have arranged an apparatus, by which very slight heatings can be observed with certainty. The result of the experiments made with it fully corresponded with my anticipations.

The heating observed cannot arise through conduction of the mass of the glass, nor through its compression by the attraction of the coatings, nor lastly, through the penetration of electricity into the mass of glass lying next to the coatings.

If, on the other hand, we assume with Faraday that the charge and discharge depend on the occurrence of molecular motion in the insulator separating the coatings, there remains nothing remarkable in the fact of the heating of the insulator."



Schematic diagram illustrating principle of Allis-Chalmers Excitron frequency changer for electronic induction heating. It multiplies the power-line frequency to any desired value in the range from about 500 to 3000 cps

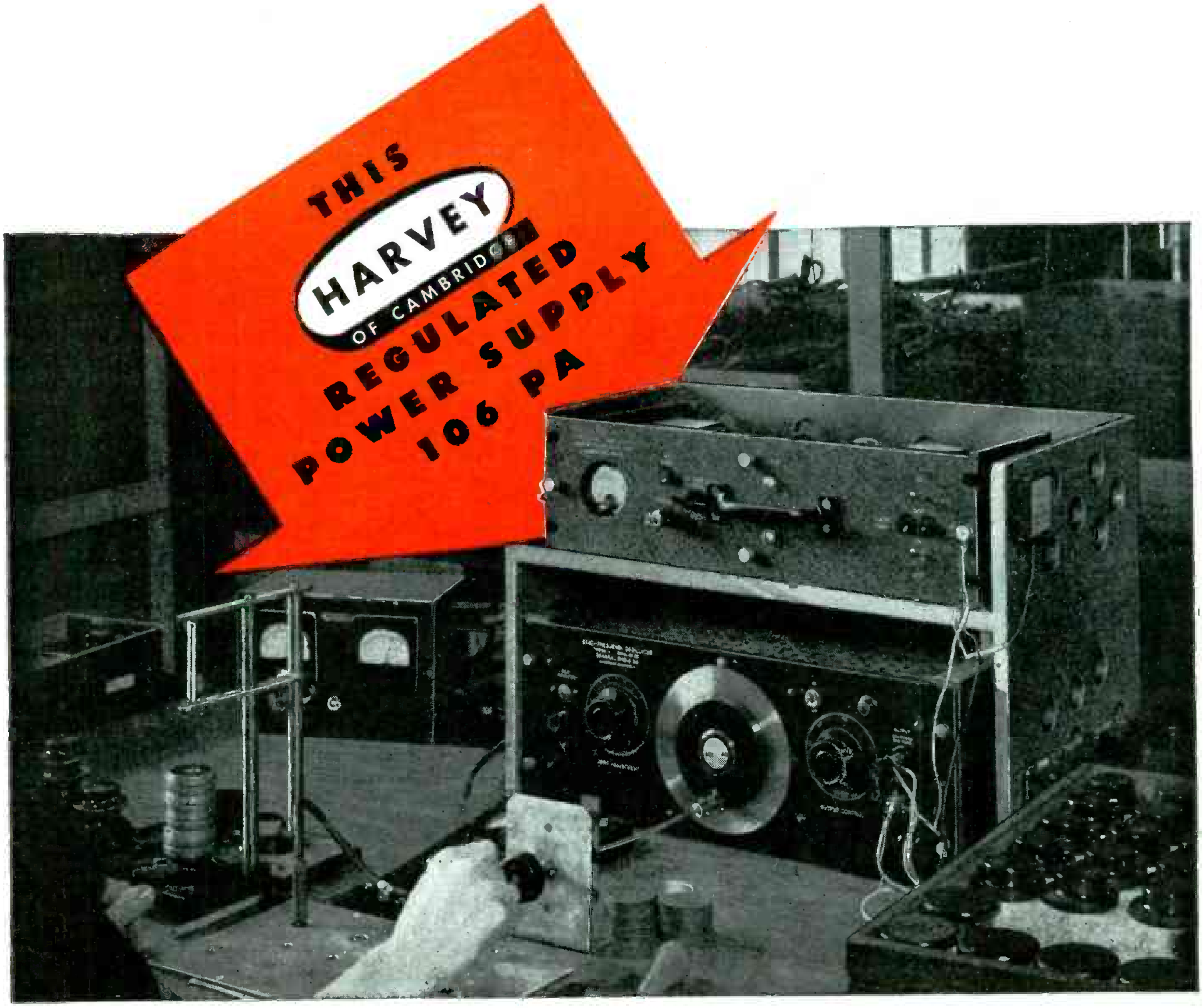
Up to 1880, a few experiments were conducted verifying the results of von Siemens. From 1890 to 1900 Tesla performed a number of induction and dielectric heating experiments with higher r-f.

The invention of the vacuum tube and its development during and after the last war resulted in an extensive use of high-frequency medical diathermy equipment in the period of 1920 to 1935, along with some experimental use of high-frequency equipment in industry. Serious industrial utilization started along about 1935 to 1937. By 1940, Girdler Corp. engineers were demonstrating repeatedly the use of high-frequency equipment in connection with drying of wood and setting of glues. The first commercial plywood installation of industrial dielectric heating, involving two 300-kw units, has been in continuous operation ever since its installation in 1942.

There are very many applications of high-frequency heating in the wood-working industry according to Mr. Zottu. Here, as in the case of induction heating, careful consideration **must be given** to the economics of the problem. Uniform heat treatment throughout the work is one advantage. Drying of wood products is a legitimate application only where the reduced time of drying is important or where economy of power is not an important consideration, because the same amount of heat is required to dry a given quantity of wood, and electronically generated power for heating is more expensive than other types.

The following questions were asked and answered:

Q. Is dielectric heating equipment for industrial use regarded as safe for inexperienced personnel, and does the use of such equipment increase fire hazards for insurance rates? A. The only danger of electrocution in high-power units comes from the d-c source of supply used to operate the oscillators. It is common practice for all manufacturers of equipment to provide suitable safety locks and interlocking doors so that operating personnel could not possibly come in contact with dangerous circuits. High-frequency energy used in heat treat-



Helps Check The Quality of MURDOCK-Made Head Sets

The *W. J. Murdock Company* of Chelsea, Massachusetts, relies on a HARVEY Regulated Power Supply 106 PA to determine that head sets manufactured by them for the Armed Services meet Signal Corps and Navy Department Specifications.

The HARVEY 106 PA, teamed with a wide range beat frequency oscillator, supplies a constant D.C. voltage for an amplifier testing the output of Murdock type R14 head sets. Input is three volts. Earphones are tested at four frequencies within the range of 500 to 2500 kc., to check various decibel readings within that range.

The HARVEY Regulated Power Supply 106 PA is operating successfully with constant frequency oscillators, amplifiers, pulse generators, measurement equipment and other apparatus requiring a constant source of D.C. current. It operates on 115 volts, 50–60 cycles A.C., and has a D.C. output variable from between 200 to 300 volts that is regulated to within one per cent.

If you need a constant, thoroughly dependable source of D.C. power, better look into the HARVEY Regulated Power Supply 106 PA. The whole story is contained in a new bulletin. We'd be pleased to send it.

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439 CONCORD AVENUE • CAMBRIDGE 38, MASSACHUSETTS

ment can produce burns if the operator comes in contact with the electrodes, but this would not produce shock. Commercial dieelectric heating equipment is generally provided with safety guards which cover the electrodes during operation of the machine.

It was also disclosed that the only physiological effect of exposure to the electric field is a slight rise in temperature, but the operator is not ordinarily in a sufficiently intense field to be affected. Dielectric heating equipment is as safe as a properly protected punch press or any other piece of industrial equipment.

Arcing sometimes occurs between the electrodes of dielectric heating units, and for this reason dielectric heating units should not be operated in areas subject to explosive and volatile vapors.

Q. Is it practical to use one centralized generating system to feed a number of outlets distributed throughout the plant? A. Yes, provided all of the loads are identical and do not have to be heated simultaneously. The output of the generator is fed to one load at a time, in sequence. Such centralized operation does not appear to be feasible for loads which are operated in parallel indiscriminately, since each additional increase in load would reduce the available voltage and thereby alter the time required for suitable heat treatment. Operators cannot be expected to compensate for such frequent and unpredictable variations in loads.

Q. What are the possible uses of dielectric heating in the food industry? A. Milk has been successfully pasteurized. Sterilization of bottles is not regarded as a good application, however, because the heat generated by the dielectric heating equipment does not produce a sufficiently high temperature to kill all of the bacteria.

More promising applications are processing wheat and cereals and killing germs in fresh cereal. The slight increase in cost is an objection in the processing of cereals, but sterilizing of packaged products appears to be economical. Psychological and advertising advantages of sterilization should more than offset any slight increases in processing cost.

Q. Is dielectric heating well suited to the drying of dielectric products? A. Although technically this application is entirely feasible, economical aspects are unfavorable except where factors like uniform heating or fast dehydration are important. One manufacturer reports considerable success in drying skeins of rayon, a high-value product that can absorb the slight increase in cost because processing time is reduced by dielectric heating. Power cost per Btu is at least twice as much for high-frequency heating as for 60 cycle heating, and much more than for steam heating.

Q. Does variable density in certain sections of a plywood press cause uneven heating? A. Theoretically, yes, but in practice no such effect has been observed. The loss factor of the material is much more important than the density.

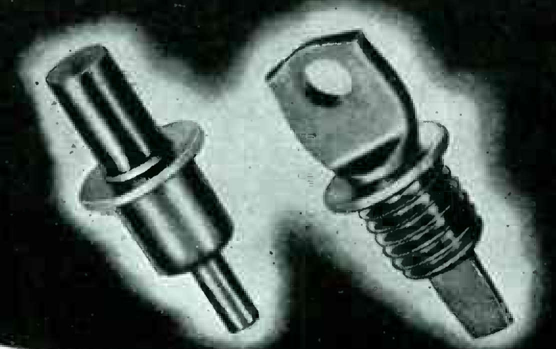
Q. Is the temperature of the plates of a dielectric heating unit uniform? A. The plates do not show any temperature rise of themselves except what is caused by conduction or radiation from the mass of material undergoing heat treatment between the plates.

Q. What is the cost of operating dielectric heating units? A. The cost depends upon the cost of electric power. Dielectric heating units operate at approximately 60 percent efficiency, which gives some indication of the power requirement for a specified output. Small-size units are relatively higher in initial cost. For units up to about 3 kw rating, the equipment cost is approximately $1,200 per kw. One 1½-kw unit has a price of $2,100, while a 200-kw unit has been sold for $60,000.

Accelerated Transfer of Heat

Stanley Schneider of Westinghouse Electric & Mfg. Co. pointed out that with dielectric heating we can increase the rate of heat transfer from about 6 Btu per minute

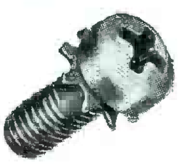
Choose the Right Fastenings–
PLAN THEM EARLY
In the Product Design Stage



3 Standard Fastenings for Production Efficiency

1 Phillips Recessed Head Screws—The modern, effective, time-saving fastening device proven in tens of thousands of assembly lines. Other standard head styles are also available.

2 Self-Tapping Machine Screws—Eliminate separate tapping operations for fastenings to castings, heavy gauge sheet metal, and plastics. Also available with Phillips Recessed Head.



3 Washer-Screw Assemblies—When use of lock washers is indicated, the time-saving of pre-assemblies is obvious. Also available in standard slotted head styles.

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. . . more each month

The degree of perfection you will obtain on that vital fast assembly job may very well depend on the fastenings chosen for your product. That's why it is important to play safe by making your precise choice early in the design stage. Remember—no assembled product can be better than its fastenings.

Whether your need be a featured standard fastening or a part especially designed to meet your specific requirements—Scovill can help you. Our broad experience in fastenings and our demonstrated ability in special design make Scovill your logical choice.

The special purpose item featured above (in intermediate and finished stages) is one of many examples of our ingenuity in special design and cold-forging. Our special processing of this part, too, meant substantial savings in money—materials—motions.

Call our Fastenings Expert to help you choose—profit by Scovill skill in design and cold-forging. Call *today*.

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per square inch for older methods of convection and conduction to 100 or even more Btu per minute per square inch of material. Among the applications of dielectric heating utilizing this important factor are drying of yarn, ropes, curing of agricultural products such as tobacco, and heating of preforms in plastics to make possible the utilization of smaller presses and at the same time provide a better product because of the uniform heat treatment.

Electronic Cooking Possibilities

A paper, "Use of Dielectric Heating For Sterilization, Pasteurization, Cooking and Enzyme Control in Foods and Drugs" was given by Wiley Wenger, Radio Corporation of America. Mr. Wenger pointed out that 60-cycle power had originally been used for the cooking of hot dogs more than a decade ago but that bursting due to generation of steam and electrolysis from contacts which became contaminated were not favorable to the process. Undesirable effects of electrolysis could be made negligible by going up to 50 kc in frequency. It is generally inadvisable to attempt to heat non-homogeneous materials; for food products, particles not larger than about ⅛ inch in diameter might be regarded as being reasonably homogeneous. Thus, radio frequency heating may be successfully applied to ground meat but might not be successful for heat treatment of solid meat such as ham, chicken, steak, nor would it be particularly well adapted to the processing of meat having bone and both lean and fat portions.

Q. What is the method in measuring temperature in food processed by electronic heating? A. Liquid thermometers are too sluggish in operation and may be of appreciable size compared to the sample under test. Reasonably satisfactory results have been obtained by using small thermocouples so placed in the electric field as to be perpendicular to the electric field so that the heat generated in the thermocouple itself is a minimum. The leads for the thermocouple should not be longer than 1 inch if this is at all feasible. During heating, the thermocouples are disconnected, and relays are used to make connections immediately after r-f power is cut off.

Q. Is it possible to kill bacteria in starch without affecting the starch particles themselves? A. Experimental results to date have not been undertaken on a sufficient scale to make a positive statement. Undesired living objects must have sufficient mass to absorb power to raise their body temperature beyond that which will sustain life. For this reason the process appears to be more suitable for the killing of insects than for the killing of bacteria.

Q. Will a single treatment of radio-frequency energy kill larva as well as insects

ELECTRONIC PREHEATING STEPS UP OUTPUT AT CHICAGO DIE MOLD PLANT

CASE HISTORIES SHOW BIG PRODUCTION GAINS WHEN NEW METHOD AIDS MOLDING

Chicago Die Mold Company's first RCA electronic generator was installed many months ago to break a bottleneck in the production of a highly important molded piece for the armed forces. Output from the molding press was immediately stepped up from 18 shots per hour to 32! Here are the details:

THE PART: See photo, lower right.

MATERIAL: Bakelite XM-15000 (very hard; medium-high impact resistance).

MOLDS: A 16-cavity mold. Washer-shaped preforms were placed in the cavities flatwise.

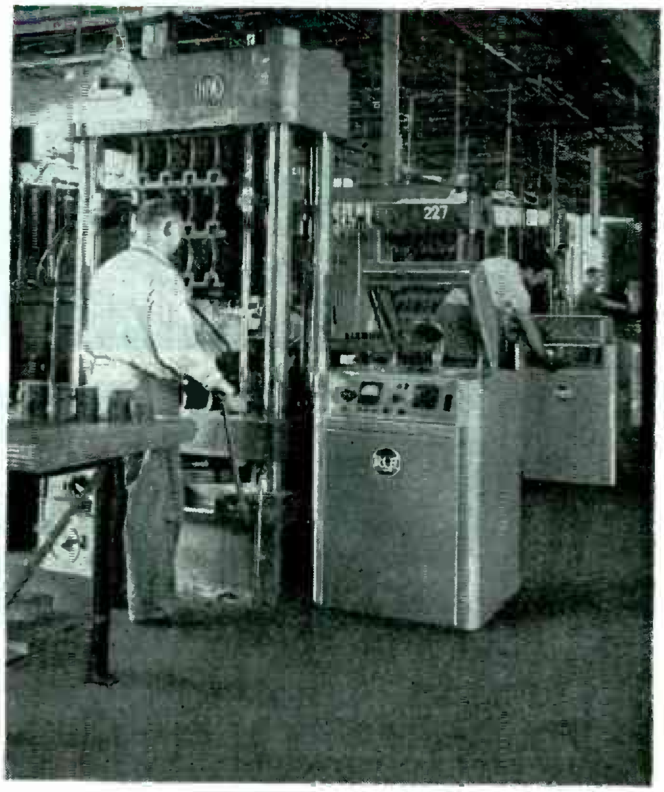
PREHEATING: Previously, preforms were heated in an electric oven.

PROBLEMS: The high-impact material tended to damage the hobbed cavities badly. A number of sunk cavities resulted from attempts to mold this part. Rejects were high. All these things put production behind schedule.

SOLUTION: One RCA, 2000-watt, electronic preheating unit was installed. Applicator was arranged to heat 16 preforms simultaneously. As mentioned above, production was greatly increased. Rejects were substantially reduced.

ADDITIONAL UNITS INSTALLED: The success of this first installation led to the purchase of seven additional units—the most recent being two RCA Model 2B generators especially designed for the plastics industry. According to Mr. E. A. Petersen, President of Chicago Die Mold, "we long ago ceased thinking of electronic preheating as 'experimental' and are using it extensively in a wide variety of molding work. The results obtained more than justify the cost of the equipment."

WHAT IS YOUR PROBLEM? If quick, uniform preheating and the resulting ideal plasticity can help you, or if you see other possible benefits to you, be sure to get in touch with us. Our engineers have had wide experience in the application of electronic heating to plastics; our plastics-molding operations in our own plant serve as an excellent "proving ground" for RCA equipment. Address inquiries to: RCA, Electronic Apparatus Section, Box 70-190H, Camden, N. J.



View of latest RCA 2B units in plant of Chicago Die Mold Co., molding cover plate of BM-021. RCA electronic preheating unit beside press preheats complete charge (2 preforms weighing 204 grams) in 30 seconds.

Electronic preheating stepped output from 23 to 33 plates per hour, and reduced rejects to less than 10%.

◀ Note thick sections in this microphone case which is successfully molded with RCA electronic preheating. Material: BM-3510. Charge: ½ pound for 2 cavities. Preheating time: 22 seconds. Cure time: 2 minutes.

Production on this piece was ▶ increased from 18 to 32 shots per hour (16 pieces per shot) by electronic heating. See text for details.

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RCA VICTOR DIVISION, CAMDEN, N. J.

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Please send me "Electronic Heating Speeds Plastics Molding" and "RCA Electronic Power Generator, Model 2B."

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in grain? A. Yes. It is possible to kill all stages of insect life with temperatures between 135 deg and 140 deg. No caking or redistribution of moisture has been observed.

Q. Are mold conditions created by the distribution of moisture when packaged products are subjected to dielectric heating? A. No, so far as is known.

Q. Are mold spores killed by the application of radio-frequency energy? A. Usually they are not, because they are much harder to kill than insects.

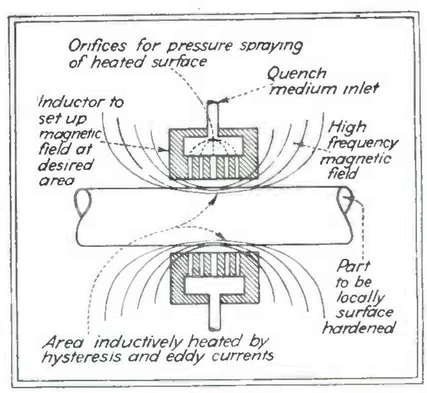
Q. Can paper to be used for packaging food be sterilized? A. Yes. The temperature of the paper can be raised beyond the scorching point for a few seconds without actually damaging the paper. It is believed that such a temperature rise would produce sterilization.

Q. Is it possible to use dielectric heating to replace the cumbersome steam-heating now required in government specifications for the sterilization of cotton and bandages? A. It is possible to raise the temperature of bulk cotton to 300 or 330 deg F in ten minutes or less, and this would appear to be satisfactory for purposes of sterilization. Adequate experimental evidence would be required to get government specifications revised. With packaged cotton products, however, the paper would heat more rapidly and to higher temperature than the cotton and consequently might char before the cotton was completely sterilized.

Q. Can macaroni be dried as it comes from the extrusion tube? A. Considerable power would probably be required, and consequently such an application may not be justified on economic principles. The rate at which heat is applied must be sufficient to produce satisfactory drawing, but it must not be carried to the point where steam is generated since this would crack open the macaroni.

Rotating Equipment for Induction Heating

Dr. Harry B. Osborn, Jr. of the Ohio Crankshaft Co. emphasized that the temperature rise in induction heating is produced by power induced into the work circuit or secondary instead of directly by



Schematic diagram of an inductor turn and integral quench for hardening a cylindrical section

conduction as in electrical heating. The three chief sources of high-frequency current for induction heating are (1) Rotating equipment (motor generators) with frequencies of 1,000 to 10,000 cycles and ratings up to 1,000 kw, (2) Spark oscillator equipment generating frequencies in the range of

A ZIRCONIUM METAL POWDER ESPECIALLY PURIFIED FOR YOUR ELECTRONIC TUBE APPLICATIONS

Although there are several grades of zirconium metal powder sufficiently free from impurities for most commercial applications, Foote, however, recognizing the special requirements of electronic tubes has developed a special "G" grade for these purposes.

IMPURITIES LESS THAN .08%

A typical analysis of "G" grade Foote Zirconium Metal Powder shows .028% acid soluble calcium, .005% iron, and .04% aluminum or a total of less than .08% of objectionable impurities.

In addition to the acknowledged benefits of zirconium metal powder as a continuous getter, "G" grade has other advantages:

SIX OTHER ADVANTAGES

1. A surface sprayed with "G" grade zirconium metal powder approaches a perfect black body in heat radiation.

2. It shows little or no tendency to deposit a mirror-like film on the tube wall or insulating parts and thus eliminates inter-element leakage and losses, raises the maximum load limit of the tube, decreases shrinkage and increases tube life.

3. It does not readily alloy with a molybdenum plate and thereby impair it's efficiency as a getter.

4. It does not release large volumes of gas when heated.

5. Its use in certain tubes with carbon or graphite anodes has reduced pumping time more than 50%.

6. It will act as a continuous getter at temperatures of less than 400°C., although it is most active above 600°C.

Write for information on Foote Zirconium Metal Powder for power and transmitting tubes or other similar applications.

THE BOMB THAT BECAME A SEED

In a glass bomb such as this, Foote produces pure Ductile Zirconium by deposition. Ductile Zirconium is rapidly increasing in use, becoming the seed of many new and interesting developments. The deposition process, improved and perfected by Foote engineers, is only one example of Foote's forward march in ores, minerals, alloys and chemicals.

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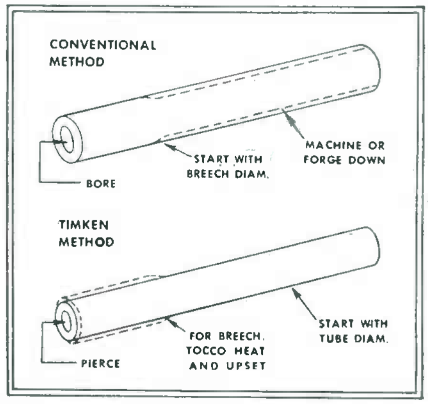
100 to 200 kc, with ratings up to about 30 kw, and (3) Vacuum-tube oscillators generating frequencies usually around 500 kc, with ratings up to 50 kw and higher.

With rotating equipment, the cost per kw decreases as the output of the motor-generator is increased. In induction hardening it is necessary to heat the piece fast enough to prevent too rapid conduction of heat, but it is not practical to use a



By means of induction heating, gun barrels are made from seamless steel tubing. At Timken Ordnance plant, Tocco equipment heats the gun breech, which is then upset to size. In the conventional method, the longer barrel is machined or forged down

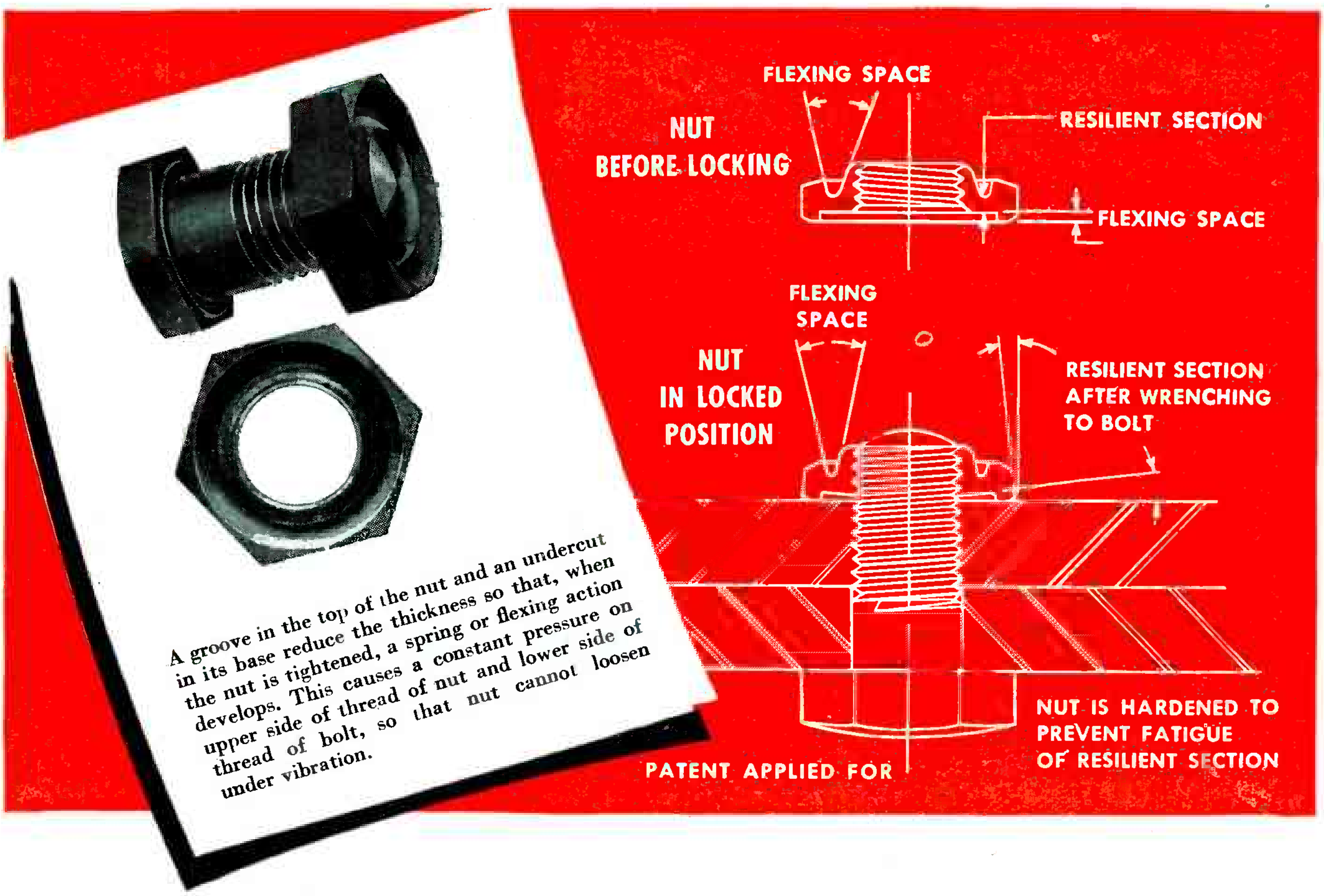
heating time less than about 1 second duration. Between 5 and 15 kw of power are required for each square inch of surface for shallow depth of hardening. On the basis of this calculation a 50-kw generator can surface-harden only about 10 square inches of metal at one time.

Melting

Frank T. Chestnut of the Ajax Electrothermic Corp. spoke on "Melting and Heat Treating of Large Masses of Metal." This talk was devoted almost exclusively to the development and application of rotating equipment for induction heating.

Forging

Harold A. Strickland of the Budd Wheel Co., speaking on "Forging of Metals," pointed out that the application of induction heating to forging is not new, but technical improvements and lowered equipment prices have brought such equipment into general use within the past five years. With induction heating no appreciable scale is



MAKE SURE *YOUR* PRODUCT WON'T HAVE THE

"WOBBLES"

This is no ordinary bolt and nut. It is new and unique . . . a custom-made cure for the "wobbles". It illustrates how manufacturers are improving their products by consulting with National *on fasteners:*

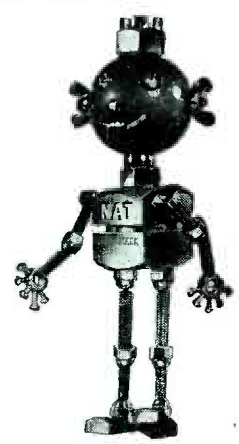
The American Fork and Hoe Company, in redesigning their new line of "True Temper" products, needed a bolt and nut assembly for certain applications that would lock up tight, yet permit delicate adjustment for proper functioning of the tools, and be capable of easy disassembly for sharpening.

The nut had to be thin, light in weight, one-piece construction. Existing types of lock nuts were too cumbersome.

They put it up to us to find the answer. We designed a new type of lock nut (patent applied for) which, when tightened, develops a *spring* or *flexing* action that eliminates the possibility of the nut loosening in action.

Appearance was a factor, too. This was improved by making the top of the bolt slightly oval, and rounding the point so as to blend in assembly with the radii of the nut.

Let us diagnose *your* products for possible fastener improvement. It's often surprising what can be done.



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ELECTRICAL INSTRUMENT CO. BLUFFTON, OHIO

formed on the surface, whereas in gas furnaces 4 percent of the material is scale and in oil-fired furnaces about 6 percent of the total mass is scale. Elimination of scale saves materials, eliminates scale-removing operations, and extends the life of dies.

Production of a high temperature for heat-treating in a short time is particularly advantageous for short runs or experimental work where it may not be economical to fire a furnace. The space requirements for induction heating are approximately a third of that required for conventional forging furnaces, and the cleanliness of induction heating units is an important, if indirect, factor in promoting its use. Both temperature and heat pattern can be duplicated with a high degree of precision that is difficult to obtain in furnaces. By suitable coil design it is possible to get a sharp change in temperature with radio-frequency heating, and this also is impossible with furnace firing.

Q. Why has not rotating generating equipment been applied to the heating of nonferrous metals? A. Brass has been melted by this process since 1926. Silver has been melted since 1921. Gold and other precious metals used by various government mints use this method of melting metals. The process is particularly suitable for these applications because it introduces no contamination and is much cleaner than other methods of melting metals. Zinc and lead have melting points which are too low to make the process economically feasible, but recent work shows promise for the melting of magnesium.

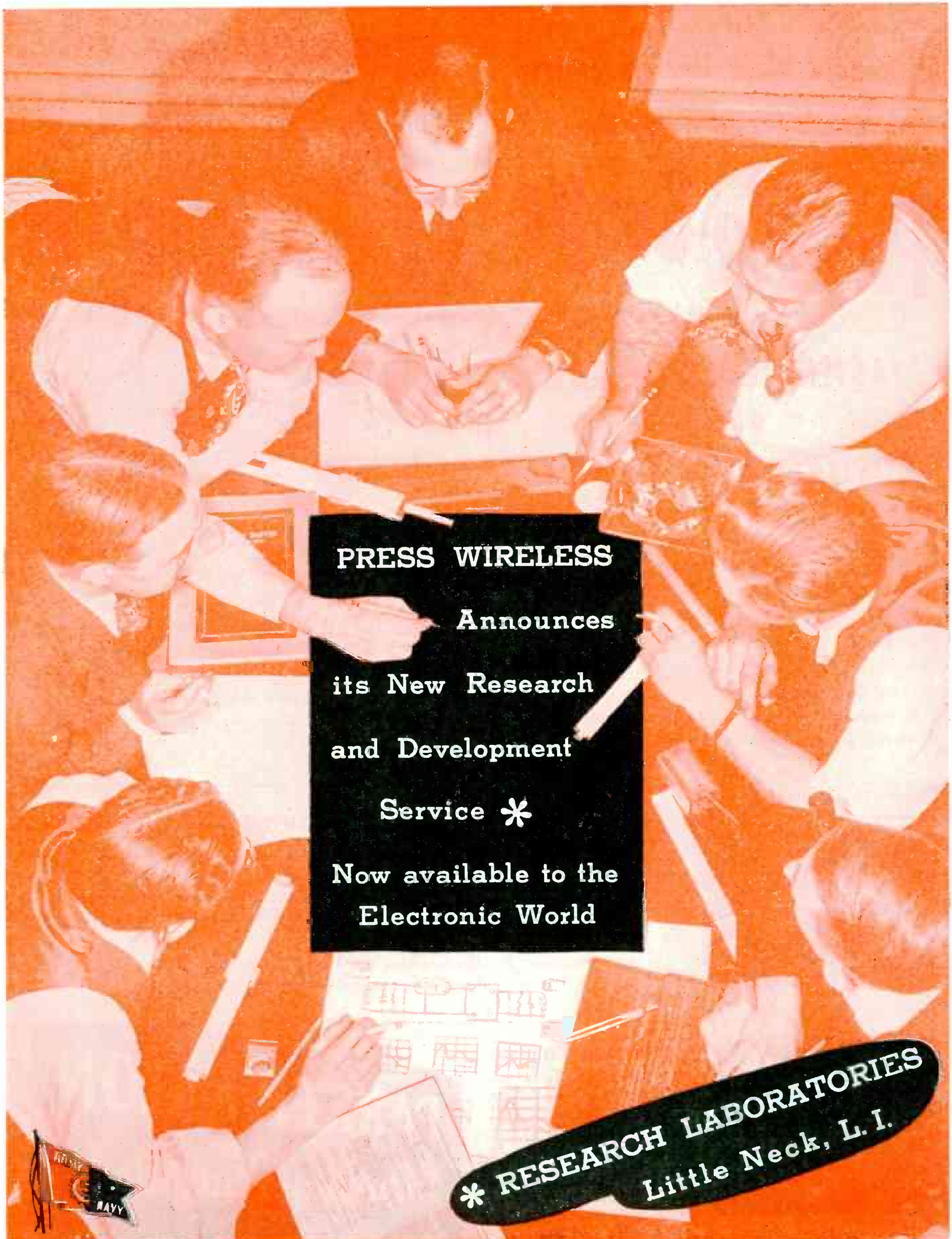
Q. Is it possible to heat uniformly, to temperatures of 1200 to 1300 deg F, strap steel 0.0015 to 0.0025-inch thick and 8 inches wide when the steel is traveling at 800 feet per minute? A. While such a method is distinctly possible, it does not appear to have sufficient commercial advantages. The process required is similar to that developed by Westinghouse for flowing tin on steel strips.

Q. Why are some units built in wood cabinets, while others use metal? A. Because greater efficiency, greater flexibility, and lower cost can often be achieved with wood housings.

Q. What are the relative merits of spark and tube equipment? A. With the present designs, greater power output can be obtained from tube equipment. The efficiency in both cases is approximately the same. The spark equipment appears to have some advantages in flexibility, ruggedness, economy of initial cost and low maintenance.

Electronic Heating Laboratory

W. M. Woll of the Commonwealth Edison Co., talking on "Function of the Electric Utility in High Frequency Heating," described numerous ways in which a public utility could help customers apply high-frequency heating. Commonwealth Edison has maintained a laboratory for many years, and last year ran



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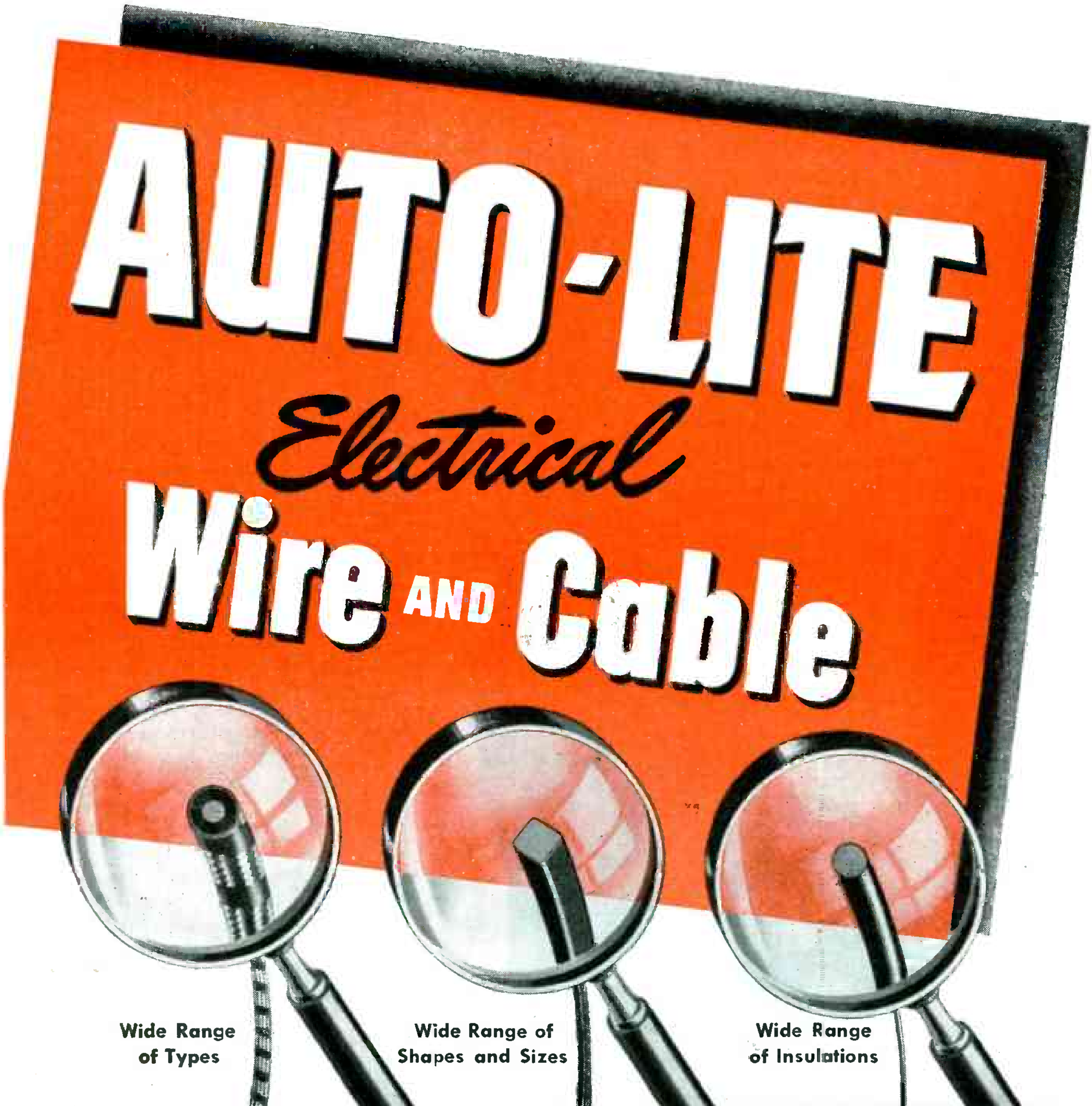

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BUY WAR BONDS

TUNE IN "EVERYTHING FOR THE BOYS" STARRING DICK HAYMES — EVERY TUESDAY NIGHT — NBC NETWORK approximately 200 tests with their electronic heating unit for customers desiring to investigate applications to their particular problems. Customers appear more willing to discuss their problems with a public utility than with manufacturers, because of the absence of direct sales pressure.

Unusual Applications

Speaking on "Uncommon Fields of Application of High Frequency," Edwin D. Tillson of the Commonwealth Edison Co. outlined some of the problems investigated by their laboratory during the past year. One manufacturer brought in small armatures which were to be preheated before enameling and subsequent baking of the enamel. In another instance, heating and quenching of permanent magnets were investigated. A method was developed for fixing the head to the shaft of a golf club. Drying of paint on tubes of tooth paste, folding and fastening of the ends of toothpaste tubes, bluing of band straps for wooden cases, melting of polystyrene patterns from molds, curing of cores and molds, melting of thorium oxide, forming of cork inserts in leather sport shoes, polymerization of binding resins and plastic molds for artificial teeth, preheating brake lining for automobiles, curing neoprene shoe soles, drying nylon, killing insects in mechanics soap, sterilizing ampoules, cases hardening of sheep gut for surgical operations and preheating of peanuts in the manufacture of peanut brittle were also subjects for investigation.

Q. Has any roughening of the surface of metals or non-conductors during electronic heating been observed? A. Ordinarily no such action takes place. It is possible to harden polished surfaces without requiring repolishing. Electronic heating produces only effects due to heat, so will cause roughening only when other of the heating methods do.

Q. In sterilizing ampoules is the glass heated? A. Yes; this is necessary to evaporate the water from the ampoules prior to their sterilization.

Q. Is it desirable to rotate work during electronic heating? A. More uniform case hardening can sometimes be achieved by this procedure, especially at low frequencies and with a single-turn output coil that cannot provide uniform heating throughout a complete angle of 360 deg. Rotation should not be too rapid. It is believed that uniform quench of the case-hardening metal is more important than rotation of the heated piece.

Q. Has induction heating been applied to sintering of powdered metallurgical products? A. Yes, metallic powder can be sintered. Some applications have already been made using tungsten, for example. Bullet cores and bushings have been successfully made this way.

Q. Is there any selective heating when a

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CAN'T BE SCORCHED!

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Hold a match under a piece of BH *Extra Flexible* Fiberglas Sleeving. The flame does not burn, char or otherwise affect it. And temperatures much higher than usually encountered electrically are just as readily resisted by the inorganic Fiberglas!

BH EXTRA FLEXIBLE FIBERGLAS SLEEVING

2 WAYS BETTER

NON-FRAYING • NON-STIFFENING

Few electrical insulations can double in brass as heat insulations. Yet so effectively heat resistant is BH *Extra Flexible* Fiberglas Sleeving that actual service records show it refuses to burn even in direct contact with heat units. The reason—both yarns *and* impregnation are non-inflammable!

A special gum base and dye applied by an exclusive BH process is responsible for many more features. It permanently *prevents fraying, stiffening and abrasive wear*. The sleeving is unusually flexible and takes the roughest handling without fraying. It does not harden and crack with age—lasts indefinitely without deterioration. It is also non-crystallizing at low temperatures.

Fiberglas is non-absorbent and unaffected by moisture, oil or grease—qualities ideally suited to appliance manufacture for instance. And it has high dielectric and tensile strength.

"Punishment" tests prove that BH *Extra Flexible* Fiberglas Sleeving is the most logical insulation for a host of tough jobs. Why not see for yourself? It's available in all standard colors and all sizes from No. 20 to ⅝", inclusive. Write for samples today and compare!

BH SPECIAL TREATED FIBERGLAS SLEEVING UNAFFECTED BY HEAT UP TO 1200°F!

This is a high quality sleeving that will not fray when cut and withstands heat up to 1200°F. Yet no saturant is used in the exclusive BH process! Flexible as string, too. Made in natural color only—all standard sizes. Try it!

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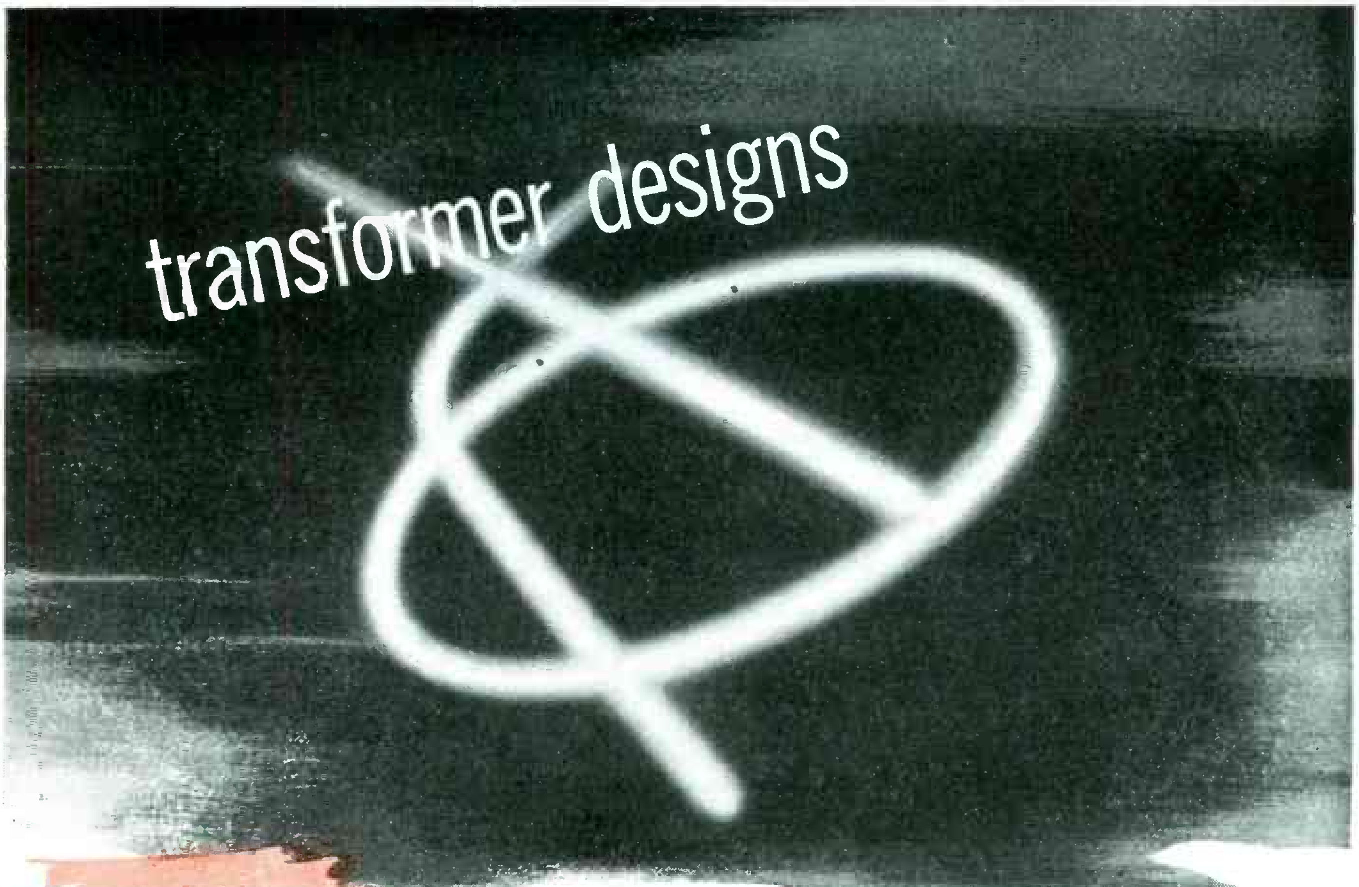

transformer designs

group of needles, all pointing the same way, are subjected to electronic heating? A. Ordinarily the orientation would have no effect if all of the needles are in contact with one another and if the mass may be considered homogeneous. However, there may be some local heating at contact points when only a small number of needles is involved. Steel wool is not homogeneous, and flare-ups due to local heating may be expected.

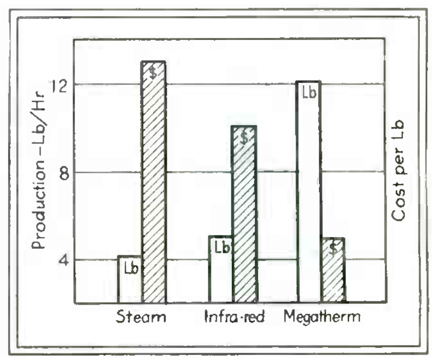
Q. Will the rapid evaporation of water from nylon yarn affect the tensile strength? A. No. In a number of instances the tensile strength was actually increased by the application of electronic heating methods.

Heating Effects Can Be Predicted

Dr. Eugene Mittelmann spoke on "Fundamentals of High Frequency Heating," giving basic equations for both dielectric and induction heating, discussing problems of heating magnetic materials beyond the Curie temperature, and outlining advantages of dielective heating for plastic preforms.

Economic Studies Are Essential

V. W. Sherman of Federal Telephone & Radio Corp., covering "Use of Dielectric Heating For Plastics, Rubber and Rubber Substitutes," discussed advantages of electronic heating, and emphasized the need



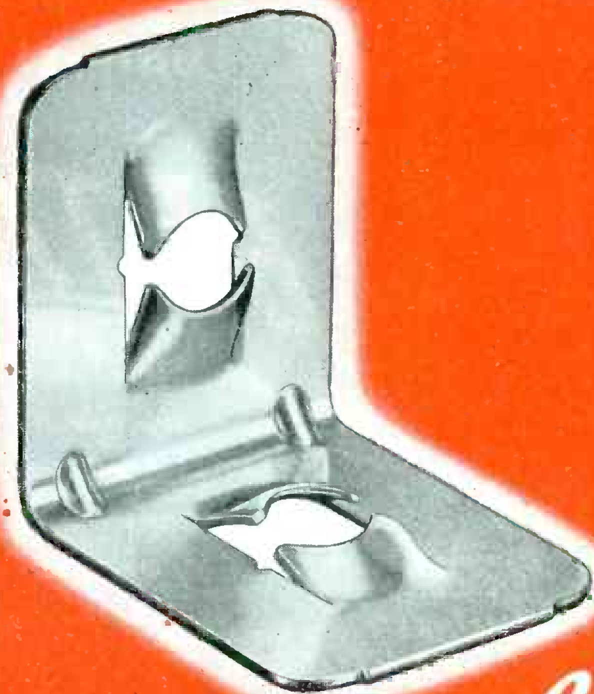
Three different methods of pre-heating phenolic material, compared in terms of heating cost per pound and production in pounds per hour. Arbitrary units are shown on the cost per pound scale. Supplied by a leading molding plant, the data applies to phenolic material in a 7-in. press under a load of 1/3 lb. A Federal Megatherm unit was used for electronic heating

for a fair and complete economic study before installing such equipment, particularly if electronic devices are to supersede other methods of heating. Preheating of plastic preforms makes it possible to mold larger parts and do precision molding. Frequencies as high as 10 megacycles or even higher may be used to get power into the work at reasonable voltages across the electrodes.

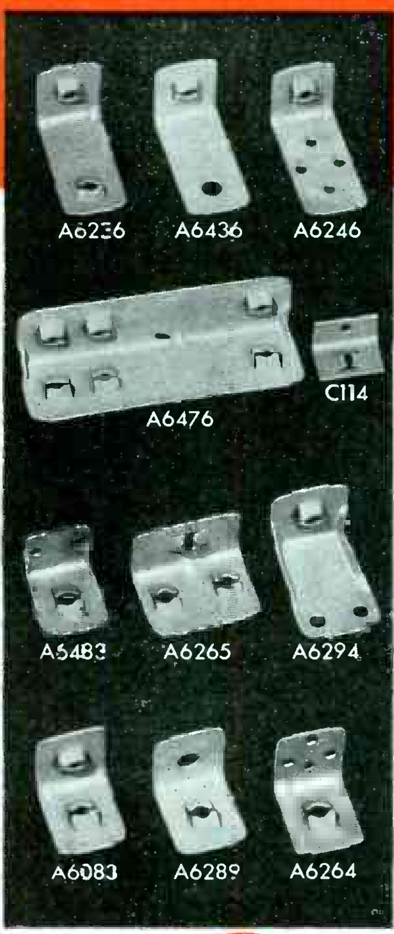
Q. Has dielectric heating been applied to

ONE OF A SERIES PORTRAYING "THE SPEED NUT FAMILY OF FASTENERS"

ANGLE BRACKET SPEED NUTS



BRACKET AND NUT *Combined* INTO ONE!



● If your product requires brackets for assembly, why not use brackets with self-locking nuts *built right in them?* Why fumble around with separate lock washers and threaded nuts and use a wrench besides to keep them from turning? Why handle 9 parts (bracket, 2 screws, 2 lock washers, 2 nuts, screw driver and wrench), when 4 parts will do a better job? (SPEED NUT, 2 screws, and screw driver). Think of the savings in manhours and materials this could mean in *your* plant!

These SPEED NUTS lock with a firm spring tension that permanently prevents vibration loosening. They reduce weight, speed up assembly, and strengthen the structure. And since they are produced on high speed automatic machines, these self-locking brackets are not expensive.

Hundreds of manufacturers have improved both their products and assembly methods by changing over to Tinnerman angle brackets. Write for samples, mentioning part numbers of the type that interests you most.

TINNERMAN PRODUCTS, INC.
2106 Fulton Road, Cleveland 13, Ohio
In Canada: Wallace Barnes Co., Ltd., Hamilton, Ontario
In England: Simmonds Aerocessories, Ltd., London

THE BASIC PRINCIPLE
of Spring-Tension Lock is
Embodied in all Speed Nut Designs

Speed Nuts
PATENTED
*Trade Mark Reg. U. S. Pat. Off.

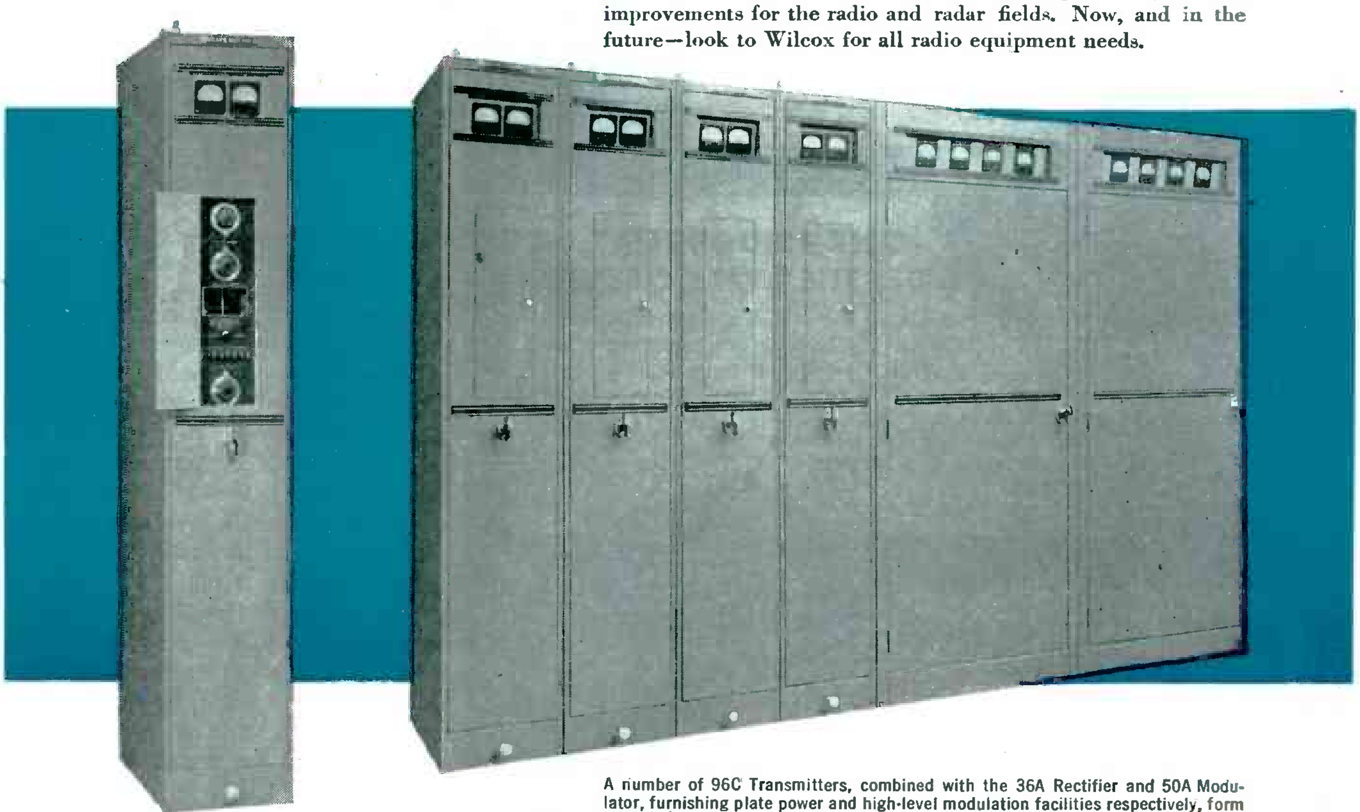
FASTEST THING IN FASTENINGS


A newcomer in the ballast tube field..
3-16
E-E TYPE 3-16
A direct result of large-scale engineering and research in the electronic tube design and manufacture, this E-E Ballast Tube type 3-16 embodies the ruggedness and quality characteristics associated with this specialized vacuum tube line.
Especially suited for use in series with a string of 300 M.A. filament tubes fed from a fluctuating voltage supply. Satisfactory operation is assured under voltage variations normally causing faulty operation.
E-E engineers are available for collaboration in ballast tube problems. Inquiries are invited—no obligation is incurred.
WRITE FOR DATA BOOK
A complete volume, describing E-E power and transmitting tubes—mercury and high vacuum rectifiers, power and amplifiers, modulators, oscillators, grid control rectifiers, etc. Maximum ratings, characteristics, mechanical dimensions, circuit information are included.
ELECTRONIC e ENTERPRISES
ELECTRONIC ENTERPRISES • INC
GENERAL OFFICES: 65-67 SEVENTH AVENUE, NEWARK, 4, N. J. — EXPORT DEPT. 25 WARREN STREET, NEW YORK CITY, N. Y., CABLE ADDRESS: SIMONTRICE, N. Y.

Look to Wilcox for Quality

...IN RADIO COMMUNICATIONS EQUIPMENT

For many years, the quality of Wilcox communications apparatus has been relied upon by broadcasting stations, commercial airlines and governmental agencies. Throughout the United States and over the world flight schedules have been accurately and safely maintained through use of Wilcox ground and aircraft transmitters, receivers and control equipment. From the urgency and new demands of war have been developed many Wilcox improvements for the radio and radar fields. Now, and in the future—look to Wilcox for all radio equipment needs.



Engineered to the needs of those services requiring reliable radio communinications, the Wilcox Electric Company 96C equipment represents an advanced stage of design in the field of medium frequency, medium power transmitters. Each unit is a complete, fixed-frequency 2.5 KW RF transmitter, for either telegraph or telephone operation in the range of 2-20 MC.

A number of 96C Transmitters, combined with the 36A Rectifier and 50A Modulator, furnishing plate power and high-level modulation facilities respectively, form a flexible, multi-frequency station for either simultaneous transmission on a number of frequencies, or the selection of an individul frequency best suited to the particular communication problem. The use of an individual channel for each frequency avoids the complications of frequency shifting mechanisms.

WILCOX ELECTRIC COMPANY, INC.

Manufacturers of Radio Equipment

Fourteenth and Chestnut — Kansas City, Mo.

the vulcanization of cables? A. Yes, with materials to be vulcanized as they are extruded, and with two pieces of sheet to be vulcanized. In such cases, heating electrodes are clamped in place to become part of a mold as well as the electrodes. Such electrodes are frequently made of copper.

Q. In heating materials by electronic means, are the physical characteristics changed as the result of molecular friction? A. No, unless such physical characteristics would be altered by the application of heat in any other form.

Heating Units On Display

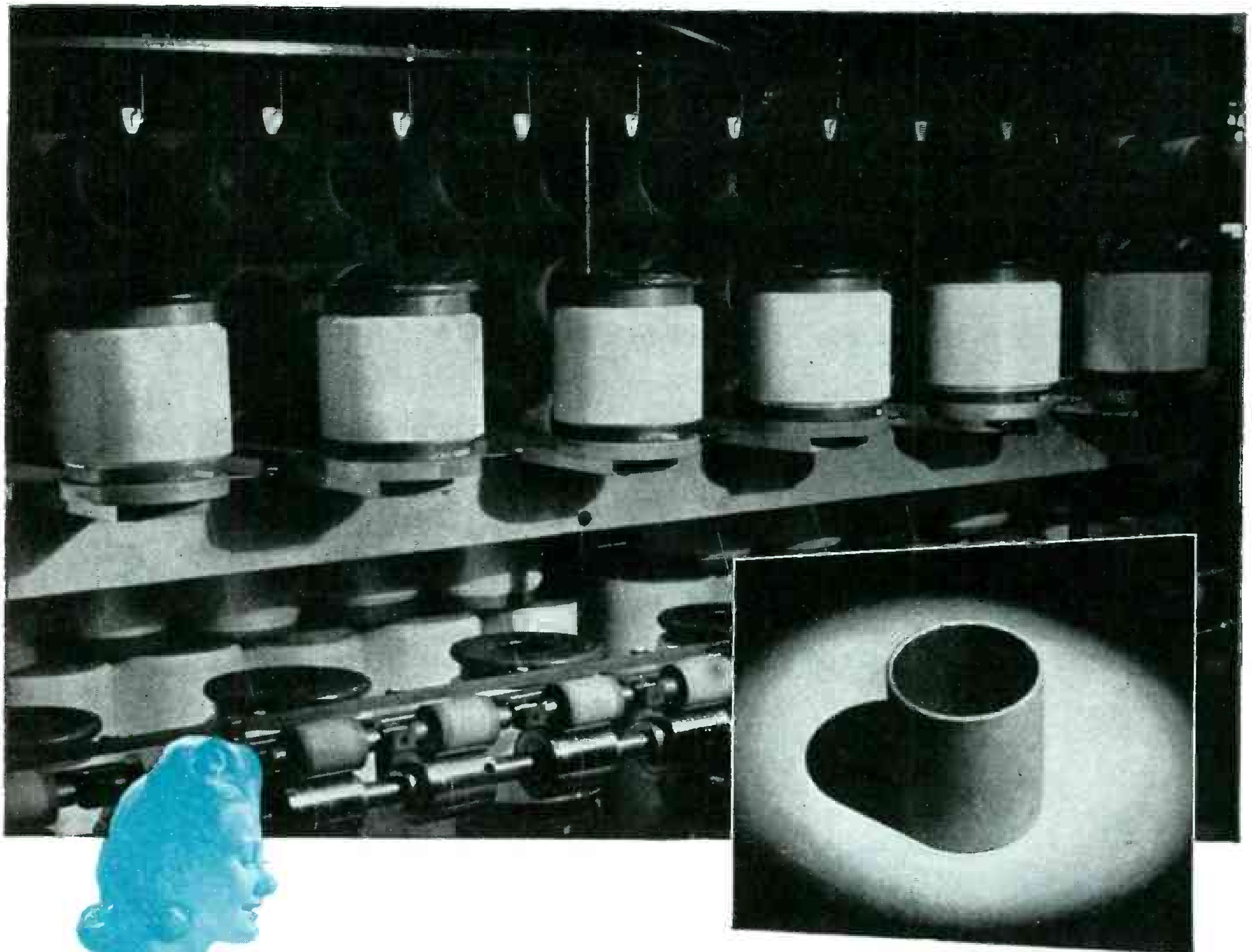
The following manufacturers of induction and dielectric electronic heating equipment had working units on display and in operation at the conference:

Ajax Electrothermic Corp., Ajax Park, Trenton, N. J.
Allis-Chalmers Mfg. Co., Milwaukee, Wisconsin
Budd Wheel Co., Detroit, Michigan
Federal Electric Co., Chicago, Ill.
Federal Telephone & Radio Corp., Newark, N. J.
General Electric Co., Schenectady, N. Y.
The Girdler Corp. (Thermex Div.), Louisville, Ky.
Illinois Tool Works, Chicago, Ill.
Induction Heating Corp., New York, N. Y.
Lepel High Frequency Laboratories, New York, N. Y.
Ohio Crankshaft Co., Cleveland, Ohio
Radio Corporation of America, Camden, New Jersey
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
Westinghouse Electric & Mfg. Co., Radio & X-Ray Div., Baltimore, Md.

• • •

Electronic X-Ray Current Regulator

A NEW ELECTRONIC REGULATOR insures constant current in x-ray tubes where a small change in power-supply voltage makes a large difference in current delivered. The unit connects into the high-voltage circuit of the x-ray tube and hence is sensitive directly to changes in the quantity desired constant—the x-ray tube current. The regulator holds the current constant by operating on the x-ray tube filament through a stepless saturable reactor. Tube current is held within two percent plus or minus over, for example, the current range of 4 to 30 milliamperes and a voltage band of 30,000 to 150,000 volts. The regulator makes possible precalibrated current dials and reduces the work of the operator to making the current selection and pressing a button. It makes sure that the tube delivers the current ordered, regardless of any fluctuation in supply-line voltage or whether the set has been operating and is hot or whether it is starting cold, regardless of the anode-cathode voltage.



Phenolite Bobbins

help speed the production of high strength NYLON Yarn

No, not for ladies' hosiery right now, but for Uncle Sam's war needs—such as parachute fabrics and glider tow ropes—Phenolite laminated Bakelite Bobbins play an important role. Their exceptional resistance to deformation at high speeds and stresses—combined with their lightness in weight—contributes to the uniformity of the nylon yarn in the high speed "spinning" and "throwing" operations.

This application of Phenolite is typical, illustrating how the unusual combination of properties of this laminated plastic may be utilized in practically every industry to good advantage.

National Engineers are at your service to assist in the design of your improved products . . . in which Phenolite may have an advantageous application. Wire, phone or write today!

NATIONAL VULCANIZED FIBRE CO.

Wilmington, Delaware — *Offices in Principal Cities*

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STEEL EQUIPMENT COMPANY

Experience and "know-how" are why so many of America's leading manufacturers depend upon "Cole Steel Equipment" for

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We welcome tough assignments . . . instrument housings . . . water-test boxes . . . chassis; some made to extreme precision, others to gauge limits. Send us your blueprints!

Send for our Brochure
"The Plant Behind Your Plant"

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Factory: Brooklyn, N. Y.

COLE STEEL OFFICE EQUIPMENT

will again be available after the war

Here's 31 pounds of long range radio performance

FOR

- **LIGHT AIRCRAFT**
- **PORTABLE GROUND STATIONS**
- **GENERAL MOBILE INSTALLATIONS**

ALTAIR MODEL LY-1 COMMUNICATION SYSTEM — designed to give the highest performance with the least size and weight — has demonstrated its outstanding ability for use in light aircraft, in secondary equipment in large aircraft, portable ground stations and general mobile installations. Under the most severe operating conditions, Model LY-1 continues to give reliable communication in both the military and commercial fields.

Besides three crystal controlled transmitter frequencies and two-band reception, the LY-1 provides interphone for two or more stations. For compactness and easy installation only the r-f components are built in with the transmitter-receiver; audio and intermediate frequency amplifiers being housed with the power supply which can be remotely located using only one interconnecting cable. For complete details write Pacific Division, Bendix Aviation Corporation, North Hollywood, California. Sales Engineering offices, New York and St. Louis.

Pacific Division

BENDIX AVIATION CORPORATION

NORTH HOLLYWOOD, CALIFORNIA

TUBES AT WORK

Radar Principles Described by R. L. Smith-Rose

FOR THE FIRST TIME in print, the fundamental principles of radar are described in the February, 1945 issue of the British magazine, *Wireless World* (Dorset House, Stamford Street, London, S.E. 1). The paper was written by R. L. Smith-Rose of the National Physical Laboratory and is abstracted in the following paragraphs:

Radiolocation or radar may be described as the art of using radio waves for the detection and location of an object, fixed or moving, by the aid of the difference of its electrical properties from those of the medium adjacent to or surrounding it . . .

An aeroplane, ship, building or human being, is merely required to reflect or scatter some of the radiation which reaches it from a radio transmitter forming part of the whole radar installation. The detected object is thus merely a source of secondary radiation which results from its being illuminated, as it were, by the incident radiation from the primary sending station . . . When electric waves, of whatever length, impinge on the boundary separating two media of different electrical properties, the path of transmission of the waves is altered; some of the wave energy passes across the boundary, but in doing so its path is bent or refracted; another portion of the wave energy is turned back from the boundary, and forms the reflected portion of the waves on the same side as the incident waves.

The relative magnitudes of the reflected and refracted waves depend upon the electrical properties of the media on the two sides of the boundary, the angle of incidence, and the frequency or wavelength of the waves. If these quantities are known, the reflecting power of the surface of separation of the two media can be calculated; and in many practical cases, this calculation is made easier by the fact that the first medium is air under normal atmospheric conditions, when its electrical conductivity is very small and its dielectric constant is approximately unity.

Reflection

If the second medium is a sheet of copper, of which the conductivity is very high, nearly all the incident energy in the arriving waves will be reflected; this is the result of the re-radiation from the conduction currents set up in the copper sheet by the arriving waves. Alternatively, the same result will be obtained with radio waves if the second medium consists of fresh water; for although in this case the conductivity is low, its permittivity is high and thus strong dielectric currents will be set up, particularly at high radio frequencies.

In the case of soil or earth, which has both a moderate conductivity and an intermediate value of permittivity, a portion only of the incident wave energy will be reflected, the remaining energy passing into the medium to form the refracted waves.

From these considerations, it is seen that reflection of radio waves is caused at a discontinuity or boundary between two media, and when waves in air strike a surface, which may be either a metallic conductor or an insulating medium, the waves are reflected in some degree by the surface. If this surface is smooth in the sense that it is free from irregularities of a size approaching the wavelength, then the reflection is of the specular type such as we meet with in light waves; and in such cases if the waves impinge normally on the surface, they will be reflected back along the original direction towards the source of the incident waves. If the surface is not sufficiently smooth the reflection will take place in various directions, or the incident waves are scattered, as it is termed; and in this case only a portion of the reflected or scattered energy is returned along the path of the incident waves. . . .

A complete station consists of a

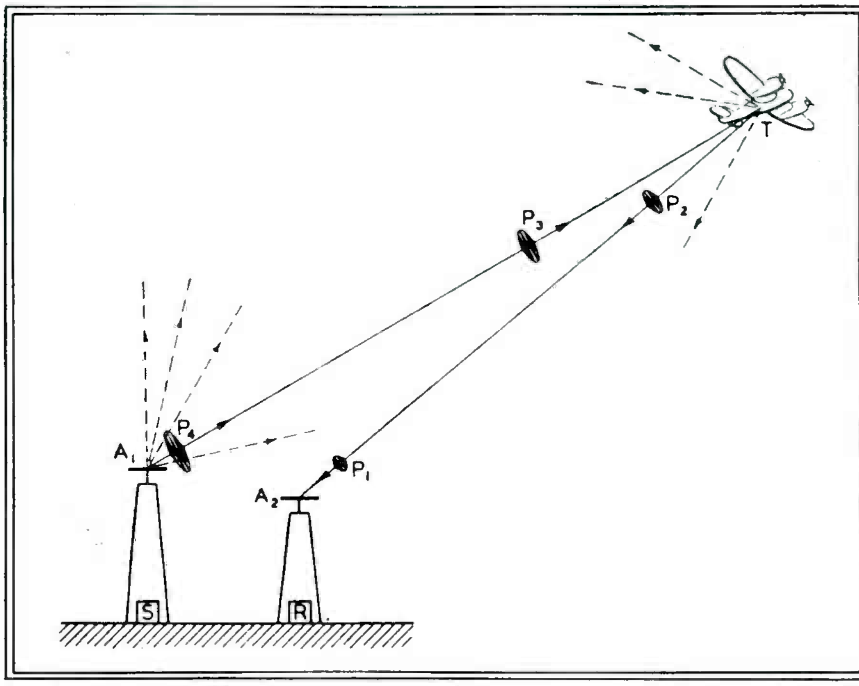
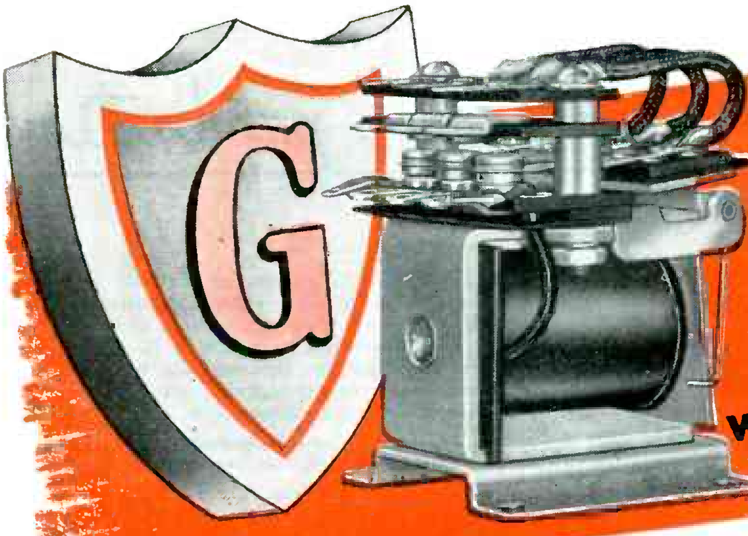


Fig. 1—Radar makes use of pulses of radio waves marked P_1 to P_4 which are emitted at regular intervals to determine the distance of the target T from the sending and receiving antennas A_1 and A_2 by measuring the time of travel of the pulses along the path A_1TA_2



GUARDIAN Series 345 RELAY
a "Basic Design" with many variations

meets special applications
saves time . . . saves tooling . . . speeds delivery!

If your application requires a specially designed relay Guardian engineers can be of great help to you. But, as a result of their wide experience in designing "specials" they have evolved a standard design so flexible that it is now specified in numerous applications that would ordinarily require a specially designed unit. Perhaps you can use it in your "special" application . . . with a saving in money and delivery time. This unusually flexible relay is the SERIES 345. Its chief features are the large coil winding area, numerous contact combinations, the non-binding pin type armature hinge pin, its resistance to shock and vibration, and an ability to operate in extremes of temperature. It is now being used in aircraft, radio, and other exacting applications to insure dependable performance.

STANDARD SERIES 345—The ample coil winding area of the SERIES 345 gives you a wide range of windings for various voltages and currents. Coil winding area is approximately .75 cubic inches. Average power required is 3.56 watts with three pole, double throw contacts of 12½ amp. capacity. Coils are available for either A.C. or D.C. operation.

The maximum switch capacity of the Standard Series 345 is three pole, double throw. Contacts are rated at 12½ amperes at 110 volts, 60 cycles, non-inductive A.C. Moving contacts are attached to but insulated from the armature by a bakelite plate. Terminals are solder lugs. Weight is 6½ ounces.

VARIATIONS OF THE SERIES 345 RELAY

TIME DELAY

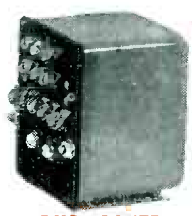
WINDING—Multi-wound coils are available for operation on two or more circuits. Or coil may be wound to operate on the discharge of a 3 mfd. condenser.

CONTACTS—Normal switch capacity is three pole, double throw; maximum switch capacity may be up to six pole double throw with 12½ amp. contacts, or any variation of contact combinations within this range, including the operation of contacts in sequence. The flexibility of the contact springs may be increased through the use of coil spring rivets.

TIME DELAY—On D.C. coils a time delay of 0.25 seconds on release or 0.06 second on attract may be achieved through the use of copper slugs which require these time intervals for saturation or de-energizing depending on whether they are used on the heel or head of the coil.

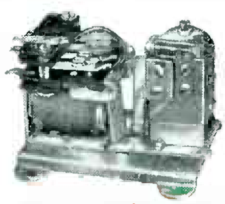
DUST COVER—For applications where this relay may be subject to injury or in atmosphere where dust may be present in sufficient quantity to impede operation, the SERIES 345 may be equipped with a metal dustproof cover.

SCREW TERMINALS—Screw type terminals are optional for applications where terminals must be disconnected occasionally or where solder lug terminals are not otherwise practical.



DUST COVER

INTERLOCKING—The SERIES 345 may be used in combination with various coils to achieve a mechanical interlock. One of the most recent developments is the use of the SERIES 345 in an overload application. Excessive current energizes the SERIES 345 coil. The armature is then mechanically locked in the energized position by an arm attached to a Series 405 coil and is held in the locked position until the Series 405 coil is energized by a push-button arrangement. If current through the Series 345 is still excessive, relay remains in locked position even though released by push-button control.



INTERLOCKING UNIT

SERIES 345 RELAY DATA

Normal Volts	Minimum Volts	Normal M.A.	Minimum M.A.	Coil Resist.	Normal Wattage
6	4.8	600	480	10	3.56
12	9.8	300	245	40	3.56
24	18	148	111	162	3.56
32	25.6	112	89	287	3.56
115	92	31	25	3720	3.56

Minimum operating wattage........................2.3

If you will write us about your relay problems our engineers will be glad to make recommendations which may save you time and money. Should you desire a quotation, please mention quantity.

GUARDIAN G ELECTRIC
1625-C W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

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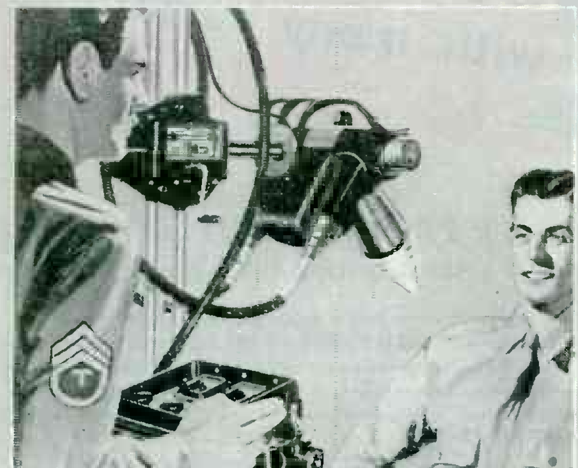
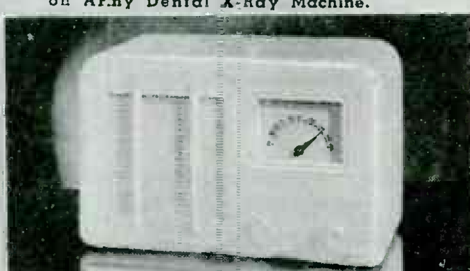
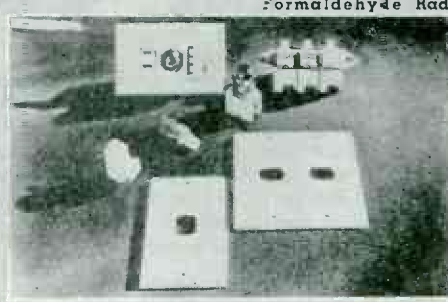
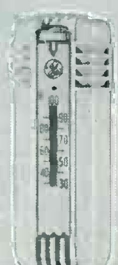
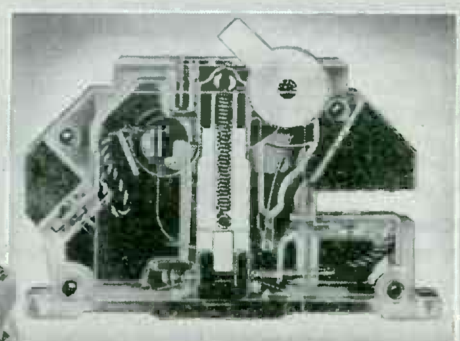

Plaskon Molded Color Adapter Cone on Army Dental X-Ray Machine.


Attractive Molded Plaskon Urea-Formaldehyde Radio Cabinet.


Molded Plaskon Widely Used for Electrical Service Parts.


Household Thermostat Housing of Plaskon Molded Color.


Plaskon Low-Pressure Laminating Resins for Heavy Duty Structural Members.


Electrical Circuit Breaker Parts of Plaskon Molded Color.

THE UNUSUAL properties inherent in Plaskon Materials make them especially suitable for the molding of parts, complete units, or assembly of, attractive and serviceable products in wide variety. Plaskon Materials for molding are high in utility and decorative properties, giving products made from them impressive sales advantages.

Plaskon Urea-Formaldehyde Compound

1. Wide range of lightfast hues, from translucent natural and pure white to jet black.
2. Smooth surface, eye-catching, warm to touch.
3. Completely resistant to common organic solvents, impervious to oils and grease.
4. Possesses extremely high flexural, impact and tensile strength.
5. Highly resistant to arcing and tracking under high voltages and high frequencies.

Plaskon Grade 2 Compound

1. A Plaskon urea-formaldehyde of good quality, lower in price than regular Plaskon, and adaptable to economy production requirements.
2. High resistance *to,* and retains lustre, surface and color *in,* presence of water, common organic solvents, soaps, etc.
3. Identical unusual dielectric strength and freedom from arcing and tracking as regular Plaskon.
   Furnished in one shade of black and brown only.

Plaskon Melamine Compound

1. Assures ample protection where water or high humidity prevent the use of urea compounds.
2. Exceptional resistance to acids and alkalies. Non-porous, non-corrodible.
3. Under extreme conditions of heat and humidity, is non-tracking, highly resistant to arcing, and has high dielectric strength.
4. Highest heat resistance of all light-colored plastics.

Plaskon Resin Glue

1. Materials bonded by Plaskon Resin Glue cannot be separated at glue line—the material fails first.
2. Plaskon glue line is completely moisture-resistant, cannot be weakened by mold or fungi.
3. Maintains its tenacious grip in heavy-duty service for years, under water, on land, in the air.

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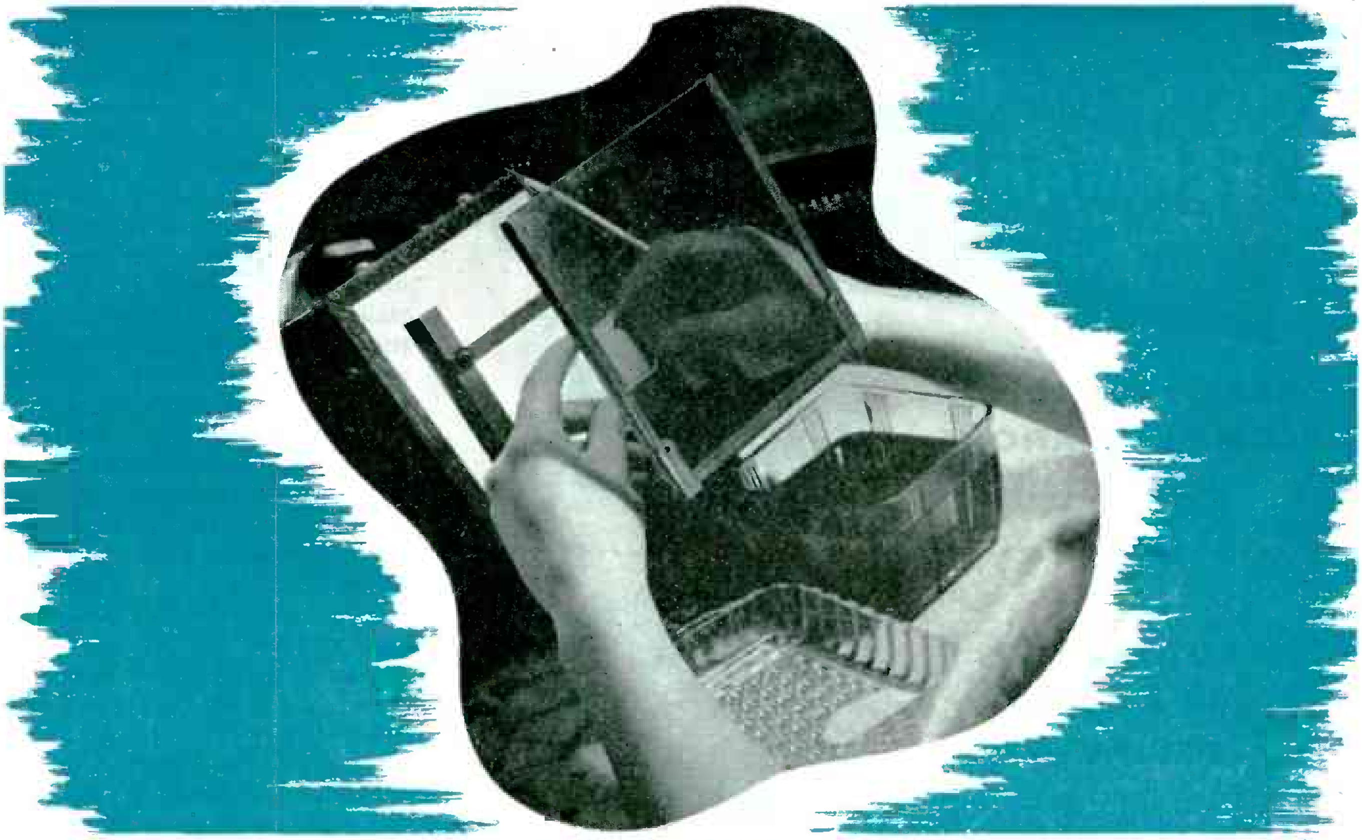
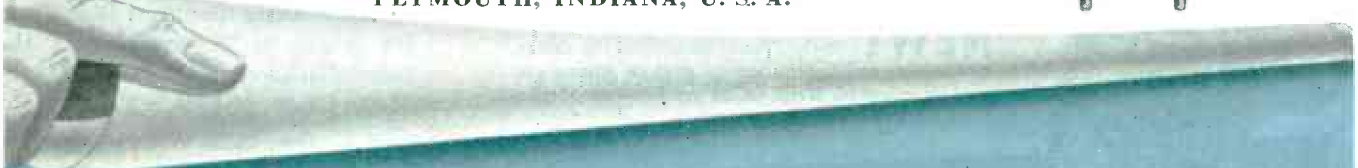


MECK

★ ★ MEANS PERFECTION ★ ★

John Meck crystals are now—and always will be—characterized by high quality and rigid precision. In an industry as exacting in mechanical design and as intricate in conception and execution as the field of sound electrically controlled and amplified, the engineering staff must work to standards of "absolute" precision. This devotion to accuracy is reflected in the attitude and work of every individual contributing to the completion of John Meck products. The low percentage of final test rejections at John Meck Industries is a tribute to the splendid, conscientious personnel and their ability.

JOHN MECK INDUSTRIES, INC.
PLYMOUTH, INDIANA, U. S. A.



John Meck Industries, Inc., will produce radio receivers and phonographs on the resumption of civilian production. Your salesmen will find that our purchasing department is interested in establishing dependable sources for parts and supplies. Our requirements will represent a growing volume of business through the years.

John Meck

combination of a transmitter and receiver. The transmitting or sending portion emits radiation over a broad arc in the approximate direction it is desired to explore. When this radiation strikes an object having an appreciable conductivity or dielectric constant, some of the energy is reflected or scattered back towards the receiver which is installed moderately close to the transmitter. If the latter emits the radio waves in short trains or pulses, the time of transit of these to the reflecting target and back to the receiver can be measured, by displaying the received signals on the screen of a cathode-ray tube.

The arrangement is indicated schematically in Fig. 1, where successive pulses $P_1P_2P_3P_4$ have been emitted from the sending aerial A_1, the first two pulses having already reached the target and been reflected back towards the receiving aerial A_2. It is now required to determine the time of transit of any one of the pulses over the path A_1TA_2.

The pulses of radio-frequency oscillations arriving at the receiving aerial are suitably amplified and rectified, and then applied to the vertical deflecting plates of a cathode-ray tube. If the horizontal deflecting plates are connected to a suitable time-base circuit operating in synchronism with the pulse generating circuit in the transmitter, then for a fixed distance A_1TA_2, the received pulses will appear superimposed on one another as vertical deflections from the horizontal time-base. If, furthermore, the time-base is made to start its deflection from the left-hand side of the screen at the same instant as the pulse of radiation leaves the sending aerial, then the distance along the time-base from its origin to the position of the pulse displayed on it is a measure of the length of path A_1TA_2.

One Type of Trace

The type of picture obtained on the screen of the cathode-ray tube is illustrated in Fig. 2, in which the line OA represents the time-base which is locked to the transmitter in such a way that the length OT_1 represents the time taken by an emitted pulse to arrive back at the receiver after reflection from a target T_1. As we know that

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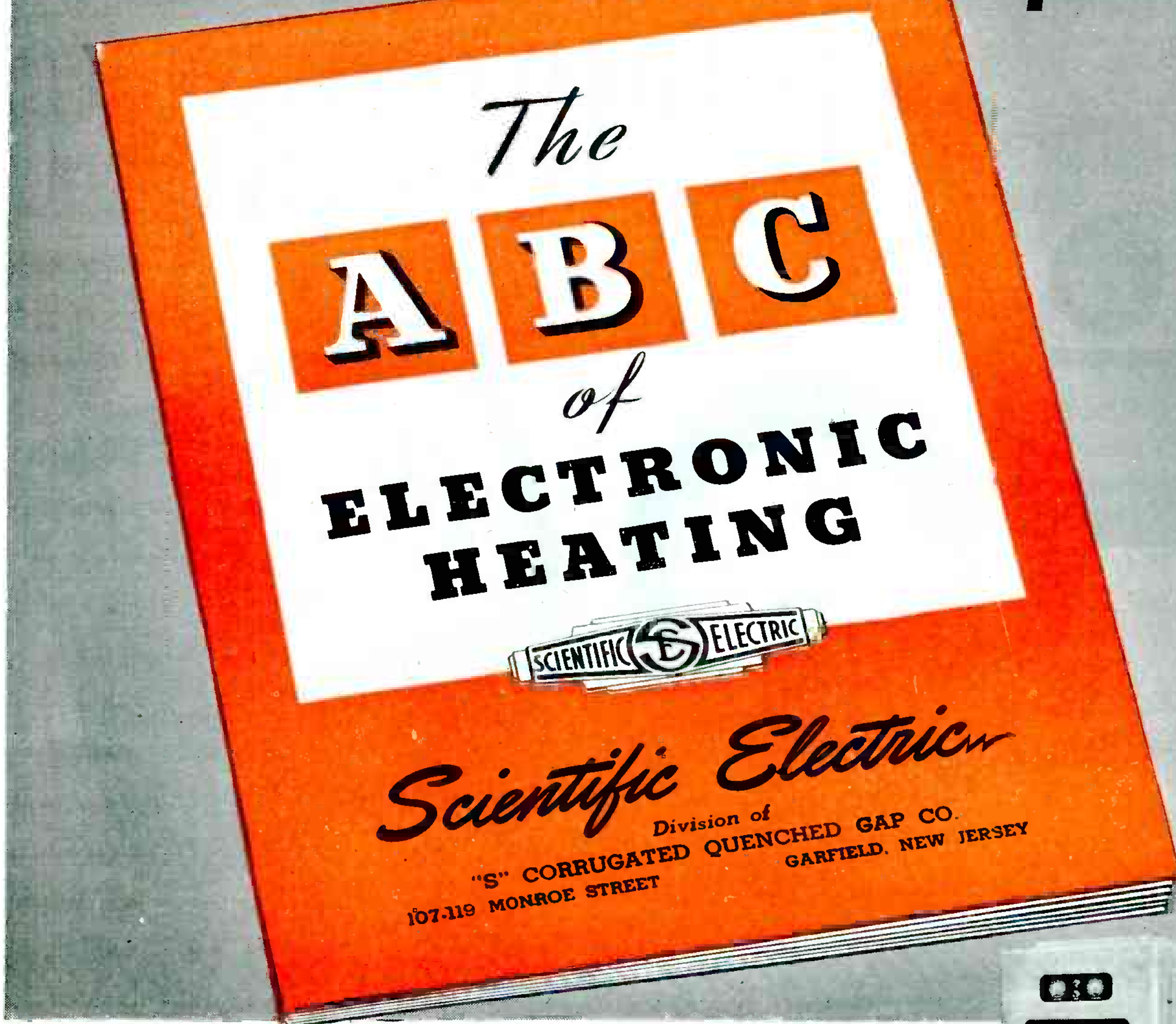

At last! Industries' *new* and *revolutionary heating process* explained in a language understandable to everyone. In fifteen minutes reading time, you will gain a complete basic knowledge of Electronic Heating. This important handbook discusses all the essential facts you have to know in considering the application of Electronic Heating to your own manufacturing methods.

It contains a brief record of the historical background and development of the process — explains the principle of its operation — describes the two chief methods and fields of application and lists many proved present-day uses.

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DIVISION OF "S" CORRUGATED QUENCHED GAP COMPANY

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Please rush my complimentary copy of *The ABC of Electronic Heating* today to:

Name .... Title ....

Company Address ....

City .... State ....

known Performance

for destinations known or unknown

Today, our electrical equipment encircles the globe; some serving at Greenland's ice cap or in Kiska's fogs . . . others stewing in the swamps of a Pacific atoll.

With the destinations of war-products totally unknown, manufacturers logically have preferred "building-in" WESTONS on their control panels. They know that a WESTON will perform dependably *anywhere* . . . that there is sound reason behind WESTONS acceptance as the *international standard.*

And tomorrow, with equipment reaching known markets, instrument preferences will remain unchanged. For while human life no longer will be at stake, *reputations will.* So manufacturers will continue to "build-in" the instruments which consistently tell-the-truth . . . to build broader market acceptance and customer good-will, and assure highest efficiency from the machines which bear their name.

- Laboratory Standards
- Precision DC and AC Portables
- Instrument Transformers
- Sensitive Relays
- DC, AC, and Thermo Switchboard and Panel Instruments
- Specialized Test Equipment
- Light Measurement and Control Devices
- Exposure Meters
- Aircraft Instruments
- Electric Tachometers
- Dial Thermometers

Weston

WESTON ELECTRICAL INSTRUMENT CORPORATION
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YES, you can obtain both molded plastic parts and small motor drives or assemblies from General Industries. Under one roof and one general management we have long supplied them to leading manufacturers in a wide range of industries.

INQUIRE ABOUT BOTH FROM GENERAL INDUSTRIES

Few things "stump" our molded plastics division. Whether it's a big job or a little one, we have the facilities and the "know-how" to turn it out in any quantity. Our engineers and mold makers have a habit of reading *between* your blueprint lines, to dig out some way to do the job better, more economically or faster. Our operators are skilled from many years of experience in compression, transfer or injection molding, to deliver work 100% to specifications and on time.

You'll find that same thorough competence in our small motors division. For many years our *Smooth Power* drives have been standard for leading makers of phonograph and radio equipment, automotive devices and other low-torque requirements. Many buyers obtain exactly what they need in our standard line, but if made-to-order units are called for, our engineers and plant can deliver them.

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ARMY E NAVY

the velocity of radio waves is substantially 186,000 miles per second, the scale of the time-base can be graduated in miles, so that the distance of the target T_1 is seen to be about 19 miles. A second received pulse is seen at T_2 returned from another target at a range of about 35 miles. If one or both of these targets are moving, their changes

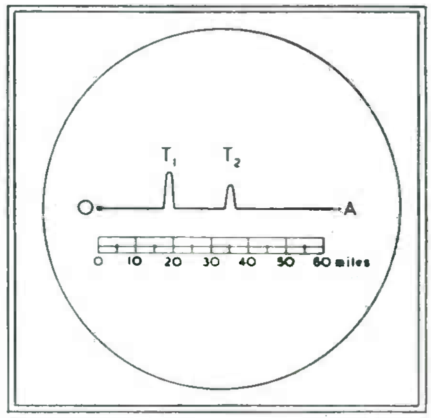

Fig. 2—Type of trace seen on radar screen. The fluorescent spot sweeps along the time base *OA* in synchronism with the transmitted pulses. The received echoes from two different targets are seen at a distance from O corresponding to the time taken for the pulses to travel to and from the targets T_1 and T_2. The time base can be provided with a range scale as shown

in position are indicated by the movement of the pulses along the base-line on the screen of the cathode-ray tube towards or away from the point *O*.

The amplitude of the pulse on the tube is proportional to the strength of the received signal, so that this naturally increases as the target from which the echo is returned approaches the receiver. When other conditions remain the same, the amplitude of the echo is also a measure to some extent of the reflecting properties of the target, for example, its size; and an experienced observer may be able to guess the nature of the target from the echo pulse seen on the tube screen.

Direction

This measurement of the distance of the reflecting body responsible for the echo signals must be supplemented by a determination of the direction of arrival of the waves in both the horizontal and vertical planes, before the actual position of the reflector in space is completely known. These


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55	63	77	120	160
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60	68	112	149	

PLP		PLQ		PLS	
56	65	56	65	56	64
59	67	59	67	59	65
60	74	60	74	60	74
61	76	61	76	61	76
62	77	62	77	62	77
63	104	63	104	63	104
64		64			

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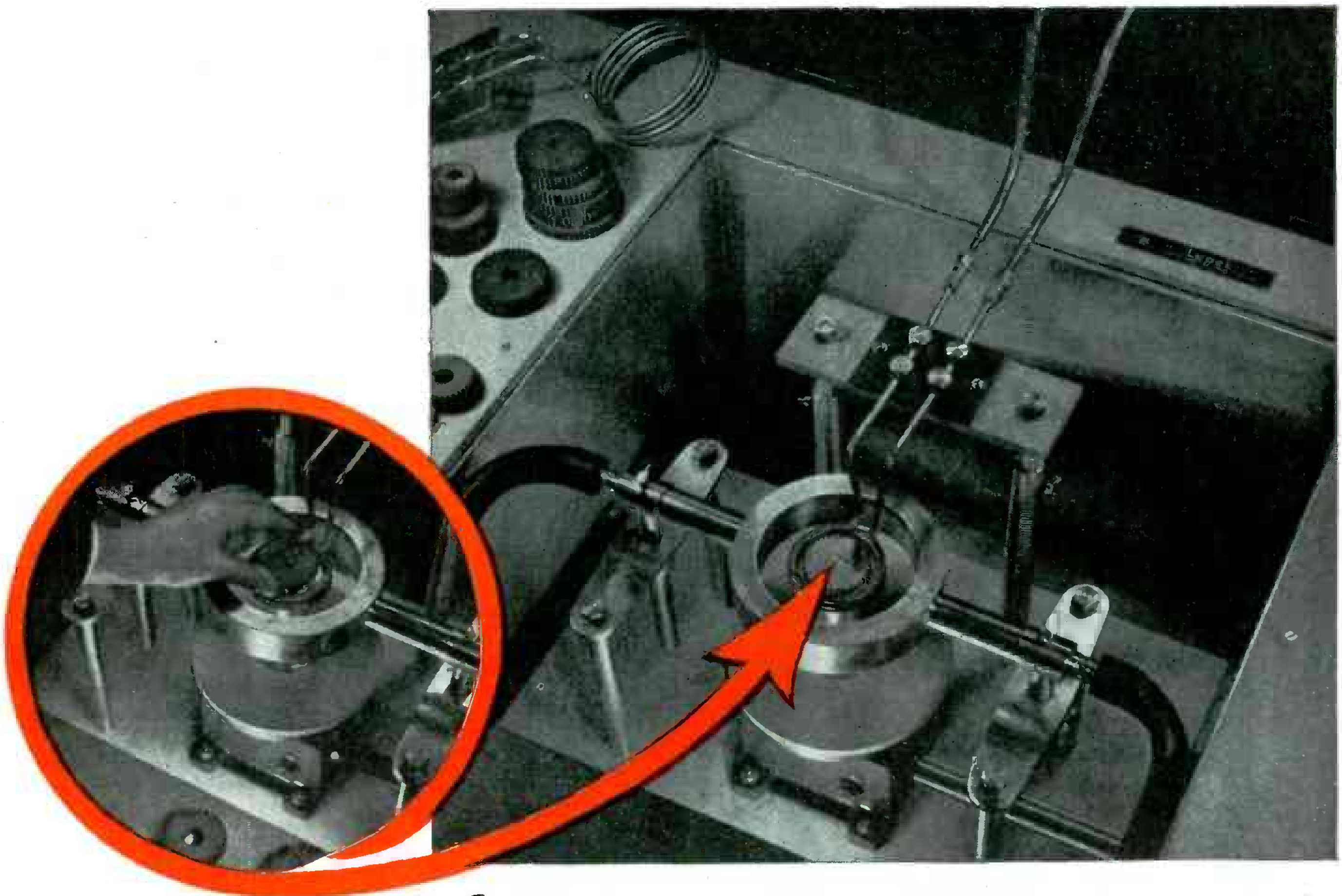

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measurements can be made by well-established methods for observing the bearing or azimuth (ϕ in Fig. 3) and the angle of elevation above the horizontal (θ, Fig. 3). The first observation can be made by rotating the receiving aerial, which may at certain wavelengths be a horizontal dipole, about a vertical axis until the amplitude of the corresponding pulse decreases to zero; it is then known that the bearing is in

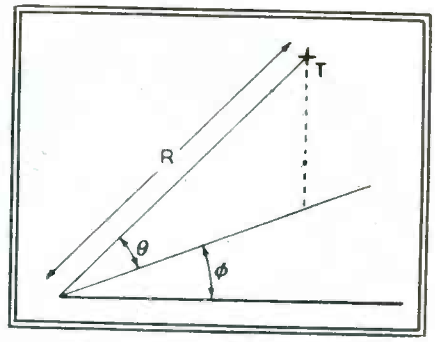

Fig. 3—The position of the target is defined by its range R, angle of elevation θ, and bearing or azimuth ϕ

line with the direction of the dipole. Alternatively, a pair of fixed aerials at right angles to one another can be used, connected to the field coils of a radio goniometer in the usual manner of a direction finder. Rotation of the search coil to the signal minimum position again enables the bearing to be determined.

Height

The angle of elevation of the arriving waves can be measured by comparing the amplitudes of the voltages induced in two similar aerials mounted one above the other at a known distance apart, depending upon the wavelength in use and the range of angles of elevation it is desired to cover. This technique has been used for many years past by several investigators for measuring the angle of arrival of radio waves over long-distance communication paths, and it is directly applicable to the problem now under discussion. If the reflecting object being observed is an aircraft, then a knowledge of the range R and elevation θ enables the altitude at which the craft is flying to be determined. If the object of interest is a ship, then the angle of elevation is negligible, and the range and bearing determine its position.

The above considerations all apply to the use of wavelengths of the

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The TURBO group of quality insulations is widely applicable in the electrical product and equipment field—in appliances, machines, motors, generators, wiring communication equipment, etc. Numerous electrical and mechanical advantages are embodied in the diversity of types. Each offers specific characteristics to meet particular application requirements.

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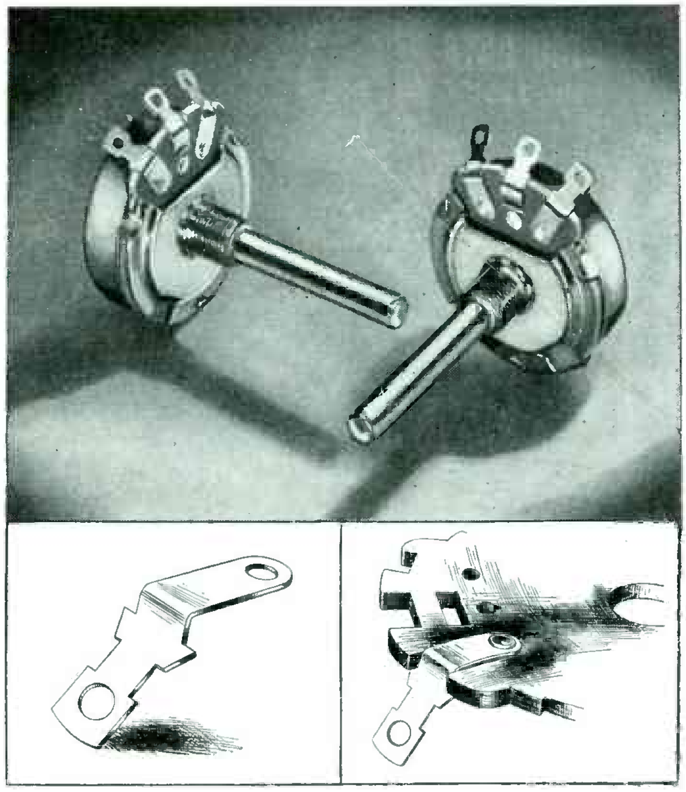
New Terminal Design for MALLORY VARIABLE RESISTORS

Makes Your Assembly Easier, More Durable



THIS new design for terminal lugs of Mallory Variable Resistors permits speedier, easier, more solid attachment of circuit leads, because each lug is locked in and may be formed or bent to any desired angle without loosening the rivets.

The lug is designed with a spring action and in a patented shape that grips the laminated plastic insulator. This maintains a constant spring pressure and prohibits loosening of the spring caused by bending. This new Type 3U Mallory Variable Resistor is available in 1½" diameter and in resistances from 5000 ohms to 9 megohms.

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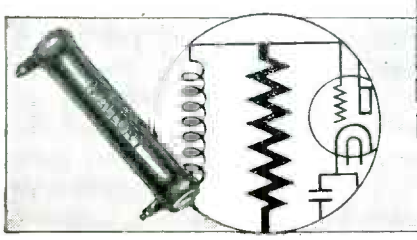

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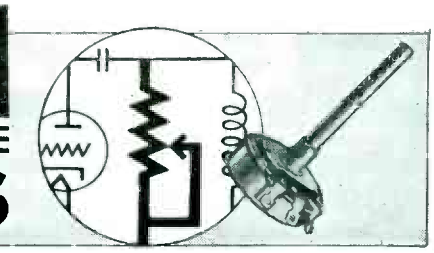
MALLORY

FIXED AND VARIABLE

RESISTORS



order of, say, 5 to 50 meters, for which the dimensions of the aerials are such as to make it impracticable to obtain very concentrated beams of radiation by the use of local reflectors. If, however, much shorter wavelengths are used, then it becomes possible to arrange what is, in effect, a radio searchlight, but with the addition of the facility for determining distance. . . .

• • •

Quartz Blanks Multiplied by Division

BEFORE THE WAR, a radio amateur in South Africa, a minister, dropped and broke a one-inch quartz crystal. Anxious to stay on the air, he tried the three fragments that resulted and found that each one still oscillated satisfactorily. On ordering a new plate from a concern in the U. S., he forwarded the information that the pieces of the old one were still operating. The letter, still on file with the company, aroused a lively discussion among the engineers although the information was not entirely new.

War needs of quartz plates has forced replacement of the one-inch square blanks by tiny units averaging less than 0.3 sq in. in area. Some measure only 0.125 sq in.

Reduction in size has resulted in the production of more plates per pound of raw material and also in the use of quartz of a size and quality formerly considered non-adaptable. The estimated saving of quartz in bulk amounts so far to 1200 tons, and the estimated saving in cost is $24,000,000. Standardization has made possible fewer electrode sizes, simpler sockets and holders, and fewer crystal specifications. Ninety-five percent of all crystals procured by Signal Corps are now in four types of holders.

Prior to Pearl Harbor, there were some fifteen or twenty firms in America which could produce not over a hundred thousand units a year, and this by laboratory methods that now seem clumsy. War raised the military needs alone to millions of crystals yearly. It seemed impossible that the Signal Corps could get them but they did get them—from plants that had been making lamp shades, coils, radio cabinets and innumerable other products.

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THE ELECTRON ART

IRE 1945 Winter Technical Meeting Includes Discussion of Proposed F-M Allocation

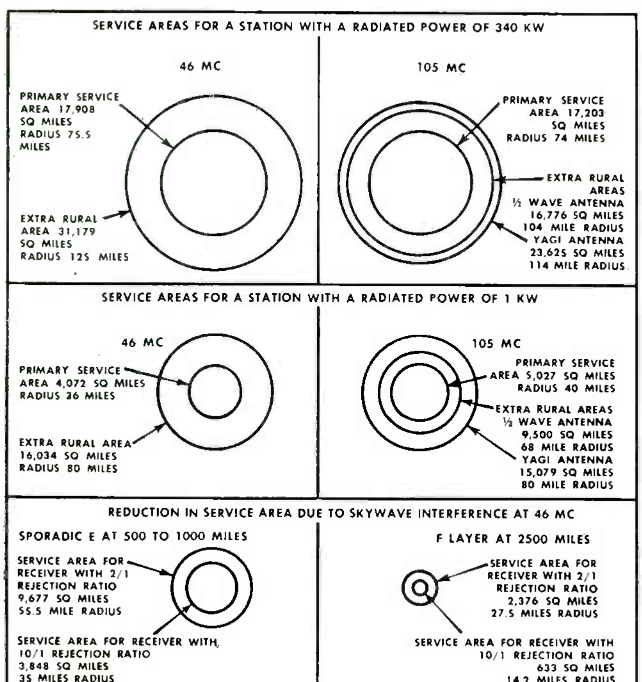
SUBJECTS IN JUST ABOUT every phase of radio and electronic engineering were covered by technical papers presented at the 1945 Winter Technical Meeting, held in New York from January 24 through January 27 at the Hotel Commodore. The total of 42 papers delivered by leading engineers included such topics as exalted-carrier reception, vacuum-contained transmitters, fractional-mu tubes, quartz crystal x-ray radiation and quality determination of quartz plates. A number of papers on industrial applications of electronic equipment and techniques were also delivered.

One of the highlights of the meeting was the interest aroused in f-m frequency allocations by a paper delivered on the opening day by E. W. Allen, Jr., FCC engineer, and prepared in conjunction with K. A. Norton, former FCC engineer now with the War Department. The paper, entitled "Very-High-Frequency and Ultra-High-Frequency Signal Ranges as Limited by Noise and Co-Channel Interference", considered the theoretical ranges of ground-wave signals for broadcast and land-mobile services in the frequency band from 30 to 3000 Mc.

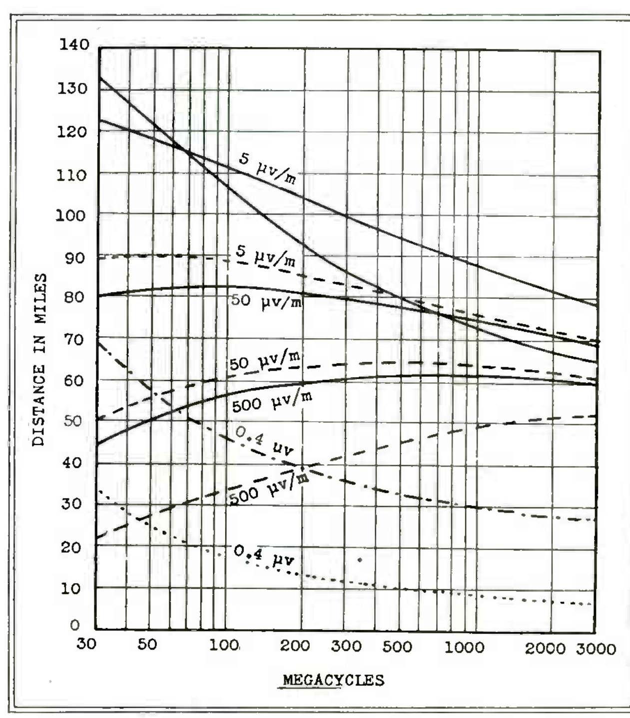
The crowded program did not permit discussion of the paper after presentation but space was made available to Major E. H. Armstrong on the afternoon program of the same day for presenting some figures obtained under operating conditions. Because of the intense interest shown by attending engineers, a special 2½-hour session was also held at the close of the meeting on Saturday afternoon. Besides Mr. Allen and Major Armstrong, the following were among the speakers at this session: H. H. Beverage of RCA Laboratories; Harlan T. Stetson of MIT; J. H. Dellinger of Bureau of Standards; C. M. Jansky, Jr., chairman of Panel 5, RTPB; R. A. Hackbush of Canada's RTPB; D. G. Fink (on leave from ELECTRONICS), and K. A. Norton of the War Department. In Mr. Allen's paper, it was shown that the distances to the theoretical broadcast contours which are to be protected from co-channel and adjacent channel interference increase with increasing frequency, whereas the broadcast interfering range and the extended rural broadcast range and mobile ranges, which are limited by receiver noise, decrease with increasing frequency.

The possibilities of increasing the service ranges by the use of transmitting and receiving antennas that provide gain were discussed and practical limits of application indicated for both services.

Ambient noise levels, terrain,



Comparison of service areas expected at 46 and 105 Mc for transmitting antennas 500 feet high and receiving antennas 30 feet high. Six db were allowed for irregularities of terrain line loss, and other factors. The outer circle at 46 Mc and the middle circle at 105 Mc give the service limits in quiet rural areas where set noise is the limiting factor, a receiver capable of good performance at 2 μv input is used, and negligible interference is had from other stations

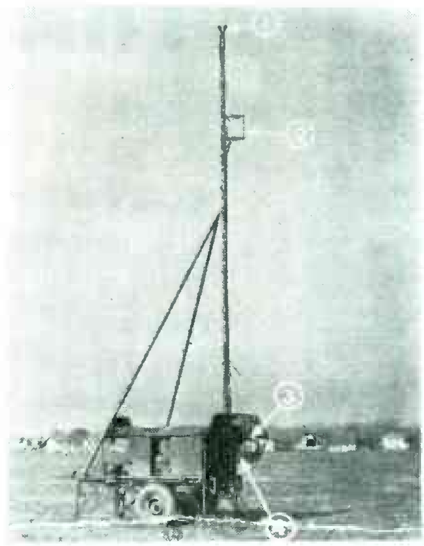


Distance in miles vs frequency for the 500, 50, and 5 μv per meter contours. The transmitting antenna is considered as a horizontal dipole 1000 feet high; the receiving antenna is 30 feet high. Solid lines designate a station of 50 kw; dashed lines show contours for a 1-kw station. The dash-dot curve applies to a 250-watt land station in the mobile service using a vertical dipole 100 feet high. The dotted curve fits a 50-watt mobile station with a quarter-wave antenna atop the roof

tion patterns defines a line or plane in space, which furnishes the pilot with guidance down the center line of the runway from any distance up to approximately 75 miles at 8000 feet.

A cross-pointer meter on the instrument panel indicates the position of the airplane with respect to the localizer line by movement of the vertical needle. This needle moves in a direction to point toward the course line when the airplane is inbound to the field for a landing. One side of the localizer is designated the blue side and the other the yellow side.

The localizer is flown with the aid of the directional gyro, heading corrections being limited to a very few degrees because of the sharp-

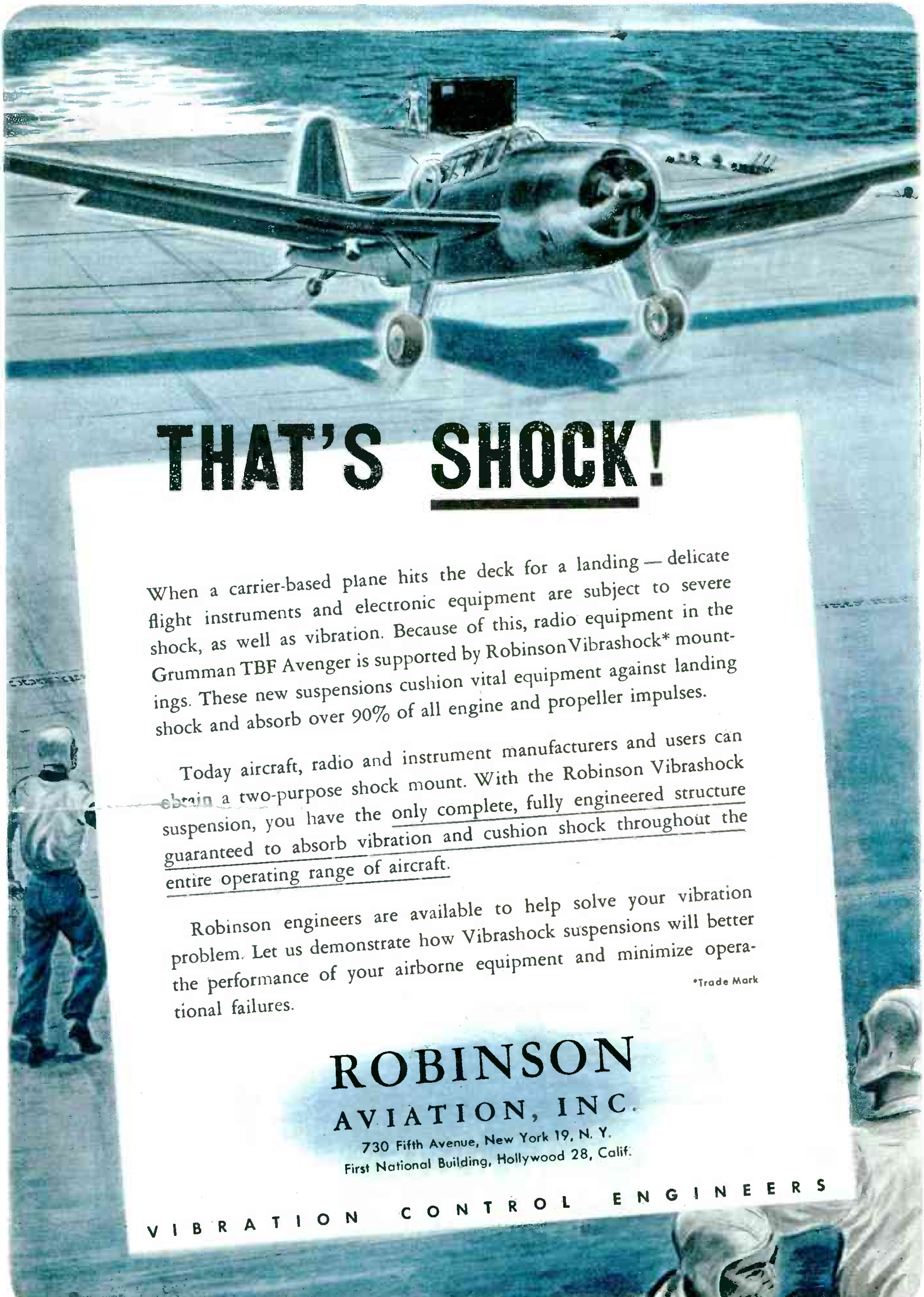


The glide-path transmitter is installed in this trailer. The mast supports an obstruction light (1) and the upper antenna (2). The lower antenna (3) and a screen reflector (4) are mounted at the trailer level

ness of the localizer course. (A departure of approximately 3 deg from the course line on either side will give full-scale indication.)

Markers consisting of small 75-megacycle transmitters are located at three places along the localizer course. The outer marker is placed $4\frac{1}{2}$ miles from the field and is identified by a flashing rate of two dashes per second. The middle marker is located one mile from the field and flashes six times per second. The boundary marker is located approximately 200 feet from the end of the runway and gives a steady light.

The glide path is a radio beam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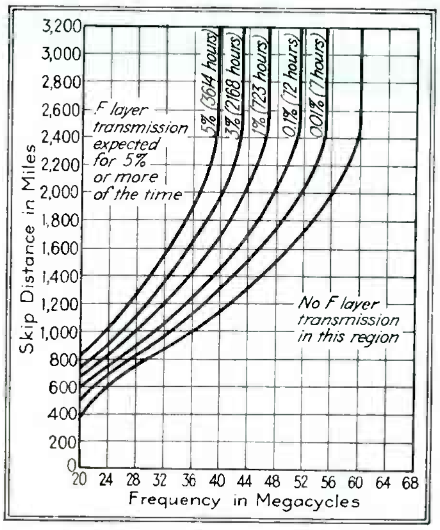
tropospheric propagation effects, long distance F layer and sporadic E layer interference, all factors which may modify the theoretical ranges, were then considered.

The combined effects of such of the above factors as may be generalized was given by a comparison of the expected service areas of two f-m broadcast stations of equal power operating at 46 Mc and 105 Mc, when the service range is limited by (1) set noise, (2) the $50/\mu v/m$ protected contour (3) F layer interference and (4) sporadic E layer interference.

As given in the chart, it was shown that the noise-limited service range is greater at 46 Mc than at 105 Mc for stations of 1 kw and 340 kw effective radiated powers. For the large station, the area within the 50 $\mu v/m$ contour is greater. Under conditions of interference via sporadic E from a station of equal power, the large station at 46 Mc is expected to have a reduction in its protected area for 0.1 percent of the time amounting to 46 percent for a good receiver (2/1 rejection ratio) and to 78 percent for an average receiver with a 10/1 rejection ratio. The 1-kw station at 46 Mc will suffer a 5-percent reduction in its protected area 0.1 percent of the time for a poor receiver while for a good receiver, reduction in area occurs for less than 0.1 percent of the time. For F layer interference, the area of the large station is estimated to be reduced for 5 percent of the time by 86 percent for a good receiver and by 96 percent for the average receiver. The small station area for 5 percent of the time will be reduced by 41 percent for the good receiver and by 84 percent for the average receiver. The times during which the reduction in area is effective is expected to increase materially with increase in the number of co-channel stations. In contrast to the serious interference situation at 46 Mc, sporadic E and F layer interference is expected to be negligible at 105 Mc.



Estimated from National Bureau of Standards ionosphere measurements, this graph show the percentage of listening hours and the number of listening hours (6 a.m. to midnight) during the last sunspot cycle from 1933-1944 for which the F layer skip distance was less than the values shown for particular frequencies

In commenting on the data given in Mr. Allen's paper, Major Armstrong referred to the circles showing the expected service areas at 105 Mc and stated that under similar conditions of antenna height, distance, and station power, that he never dared to demonstrate f-m performance using a dipole antenna. Although his transmissions were made over what is considered favorable terrain between Yonkers and Westhampton, L. I., it was necessary to use a V antenna with 150-ft legs for satisfactory demonstrations. Otherwise, fades occurred for two or three minutes every hour and at times the signal dropped out completely. He further stated that sporadic E interference seemed to offer no problem along a 50-μv contour.

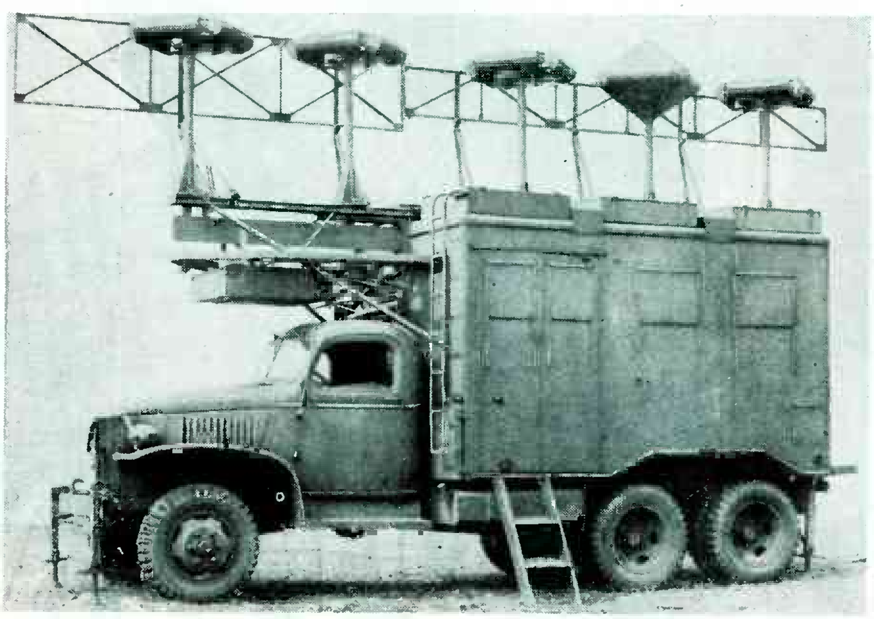
Similar facts were brought out at the Saturday session and several speakers urged that further study of the conditions to be encountered in the proposed f-m band from 84 to 102 Mc be made.

AAF Instrument Approach System

A description of electronic equipment now being furnished to war theaters and the Air Transport Command was given in a paper by Lieutenant-Colonel F. L. Moseley, Air Technical Service Command, Wright Field. The equipment forms the AAF instrument approach system which picks a pilot up at about 15 miles distant and 3000 feet up from a landing field and turns him loose at 50 feet and ¼ mile, in line with the end of the runway and all set for landing.

Three facilities are used to provide this, a localizer, marker and glide path. The localizer is similar to an ordinary range with two important differences; it indicates the course line to the pilot visually instead of aurally, and it operates at ultrahigh frequencies where it is out of the range of ordinary static.

The localizer course is defined by the overlapping of two tone-modulated radio patterns. The continuous intersection of the two modula-



With antennas mounted on the roof of the truck, the localizer transmitter is run out to a point about 1000 feet from the upwind end of the runway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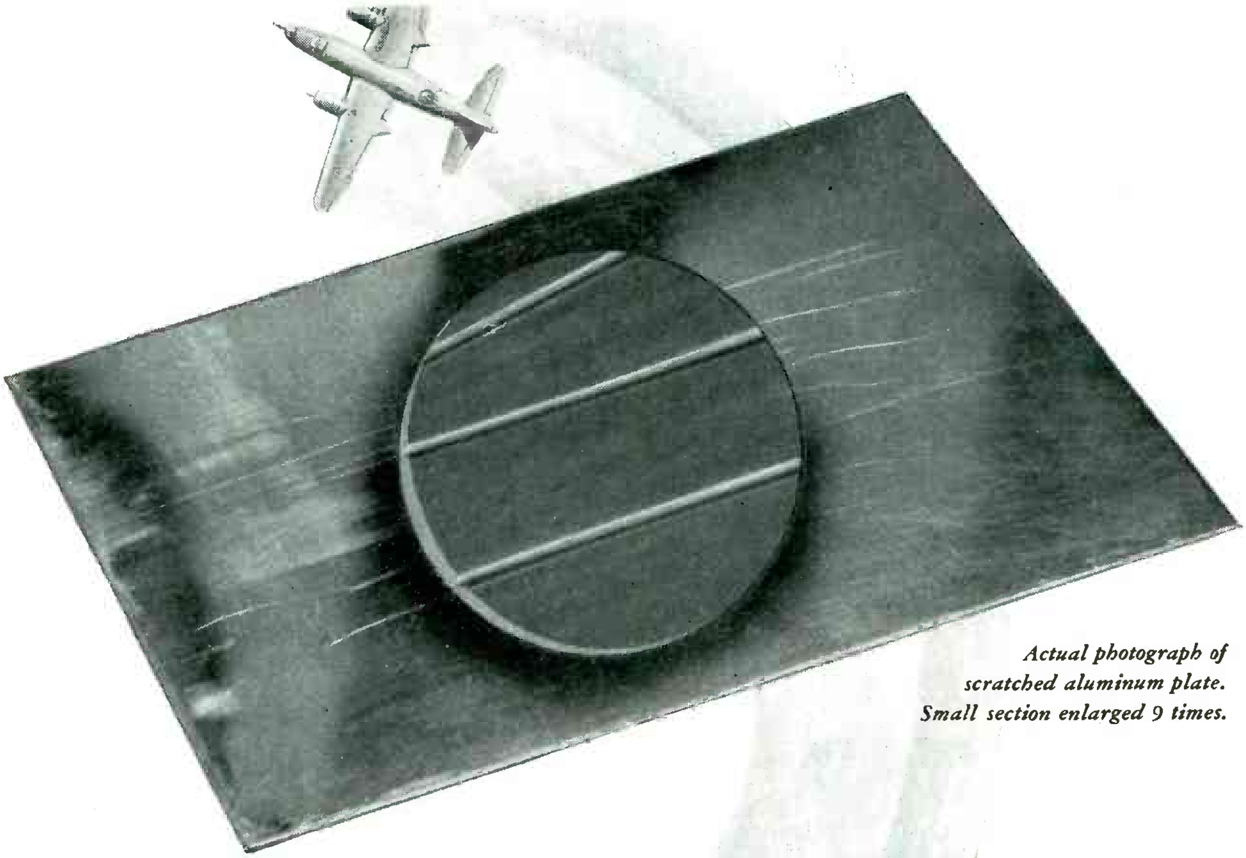

Actual photograph of scratched aluminum plate. Small section enlarged 9 times.

what happens to a SCRATCH ...at 400 miles per hour?

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Laminated INSUROK does not mar materials; it is approximately half the weight of aluminum; therefore easier to handle regardless of size; and oils, greases and other lubricants have no deteriorating effects. Grade T-601 can be fabricated with high-speed tools. Grade CG, because of its graphitic content, gives longer life than T-601 or usual canvas laminates, hardwoods or hardboard materials. It can be fabricated with Carboloy tools.

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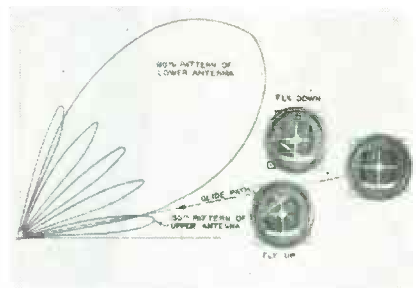
descending at a low angle in the vertical plane. This path starts from the landing point on the runway and projects out into space at an angle of approximately 2½ deg to a distance of 15 miles or more. Indications to the pilot are given by the horizontal needle of the course-pointer instrument. When the plane is above the glide path, the needle points down and when the airplane is below the glide path the needle points up. Both needles of the cross-pointer indicator are



Glide-path antenna pattern (equi-signal path) and cross-pointer meter indications

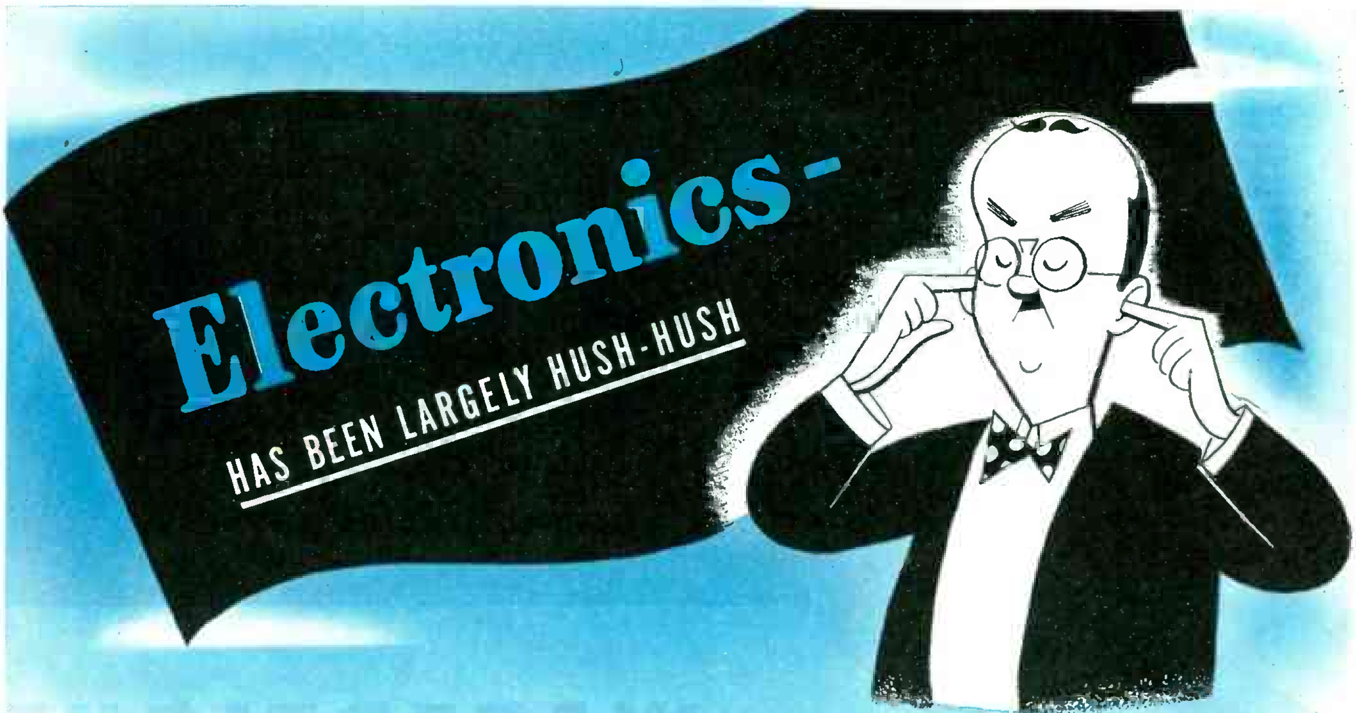
sensed alike when the airplane is inbound for a landing. The interception of the two needles on the indicator face represents the position of the proper flight path in space.

The localizer transmitter is installed in a K-53 six-wheel truck which is located approximately 1000 feet from the upwind end of the runway. The glide path equipment is mounted in a small trailer and is located at a point approximately 400 feet off the runway and 750 feet in from the approach end of the runway. The marker transmitters are installed in jeeps.

Although a skilled pilot can use the instrument approach system to make a complete blind landing on the runway, it is believed that operationally this will not be initially attempted, but rather the system will be used as an aid to low approach. The final landing would be completed visually with the aid of landing lights.

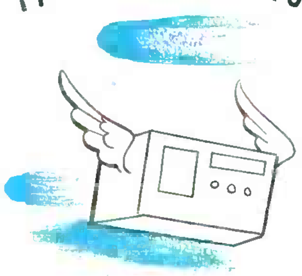
Aging of Quartz Plates

Etching in the final stage of crystal manufacture has resulted in better quality crystals for operation above 6 Mc along with faster and cheaper production. Virgil E. Bottom, physicist for the Signal Corps, reviewed the causes for

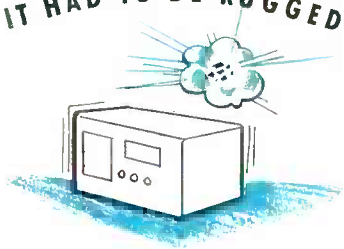


but this is no secret about Aluminum

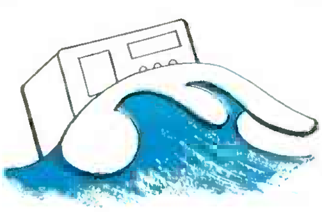
IT HAD TO BE LIGHT



IT HAD TO BE RUGGED



IT HAD TO BE CORROSION-RESISTANT



Much of the wartime electronic equipment has to fly. This necessarily means light weight, and, naturally, Alcoa Aluminum Alloys. Whether toted on a soldier's back, in a plane or tank, or behind the big guns of a battleship, it has to withstand severe shock. This requires sturdiness, a property readily built in with aluminum.

Electronic equipment goes ashore with landing parties, through steaming swamps and deep into jungles. Certainly no spot for a sissy. The normal corrosion-resistance of aluminum and the protective coatings that can be added to it, keep this apparatus on the job.

Alcoa engineers will gladly help in postwar employment of Alcoa Aluminum Alloys. Write ALUMINUM COMPANY OF AMERICA, 2136 Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA FIRST IN ALUMINUM

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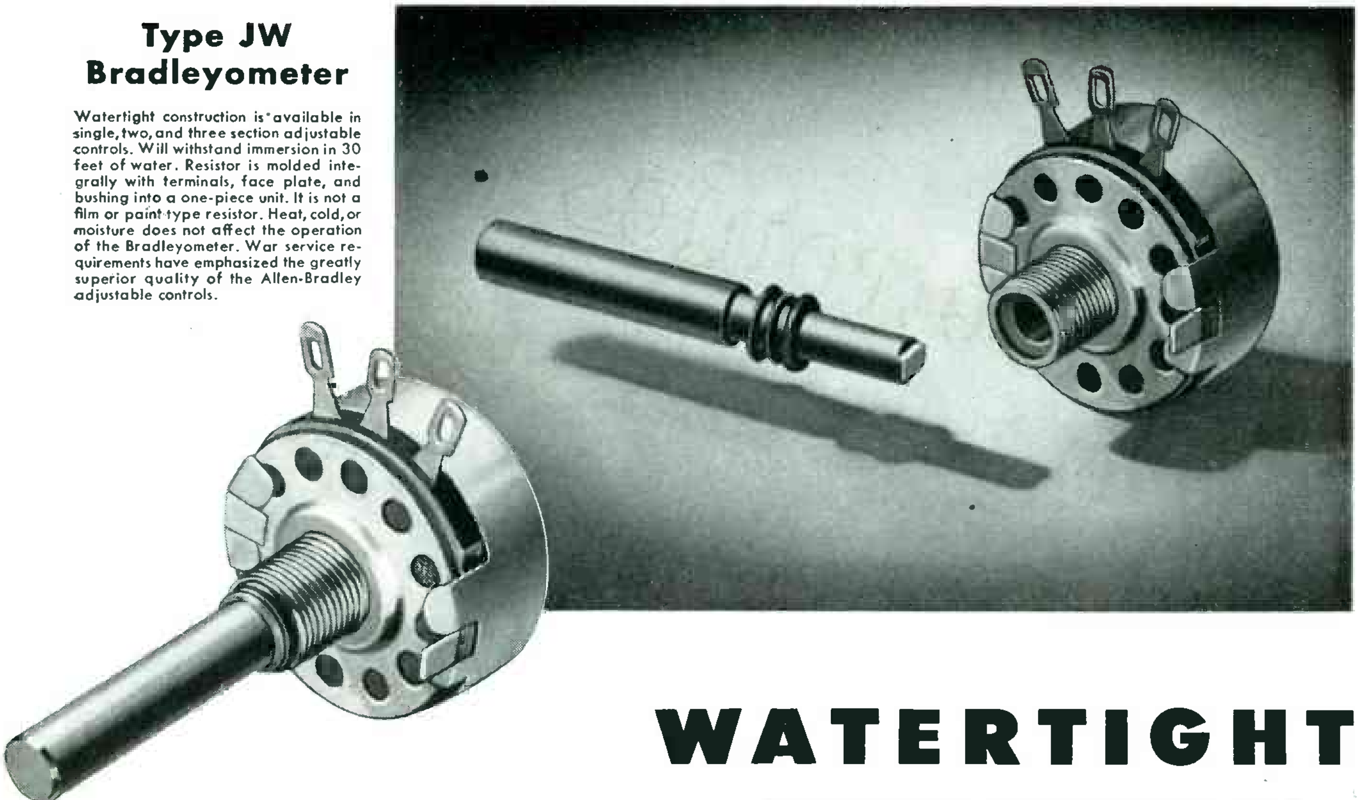
Type JW Bradleyometer

Watertight construction is available in single, two, and three section adjustable controls. Will withstand immersion in 30 feet of water. Resistor is molded integrally with terminals, face plate, and bushing into a one-piece unit. It is not a film or paint type resistor. Heat, cold, or moisture does not affect the operation of the Bradleyometer. War service requirements have emphasized the greatly superior quality of the Allen-Bradley adjustable controls.



WATERTIGHT

ADJUSTABLE RADIO CONTROLS

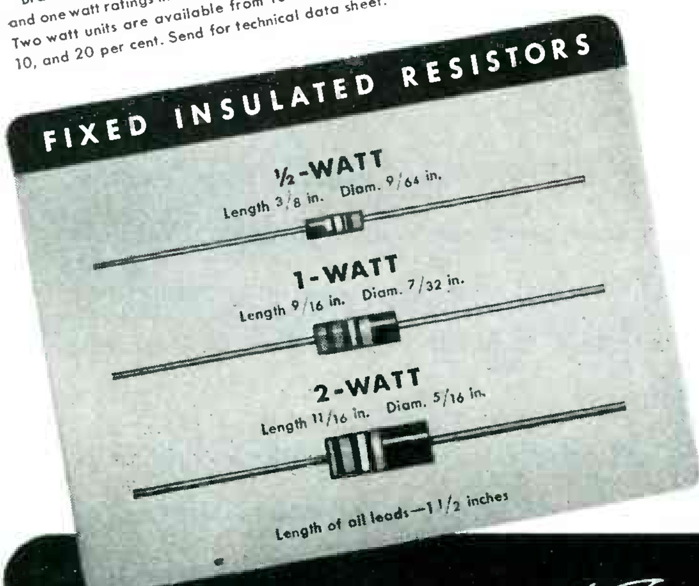
The new type JW Bradleyometer is made expressly for extremely bad war service conditions. It is a watertight adjustable control for radio and radar equipment which may be subjected to immersion in water, accidental or otherwise.

The threaded mounting bushing is counterbored to provide a space around the Bradleyometer shaft. A resilient packing ring is forced tightly into this space by two washers riding on the shaft. The illustration above shows the construction of the shaft, the washers, and the resilient packing ring, and also the counterbored mounting bushing.

When the Bradleyometer shaft is inserted into the bushing, the washers force the packing ring tightly against the face of the bushing and around the shaft, thus making a watertight seal. If your application warrants this additional protection, write for prices and engineering blueprints giving complete dimensions.

Allen-Bradley Company, 110 W. Greenfield Ave., Milwaukee 4, Wisconsin

Bradleyunits—the quality molded resistors—are available in one-half watt and one watt ratings in all R.M.A. standard values from 10 ohms to 10 megohms. Two watt units are available from 10 ohms to 0.47 megohms. Tolerances—5, 10, and 20 per cent. Send for technical data sheet.



ALLEN-BRADLEY

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QUALITY

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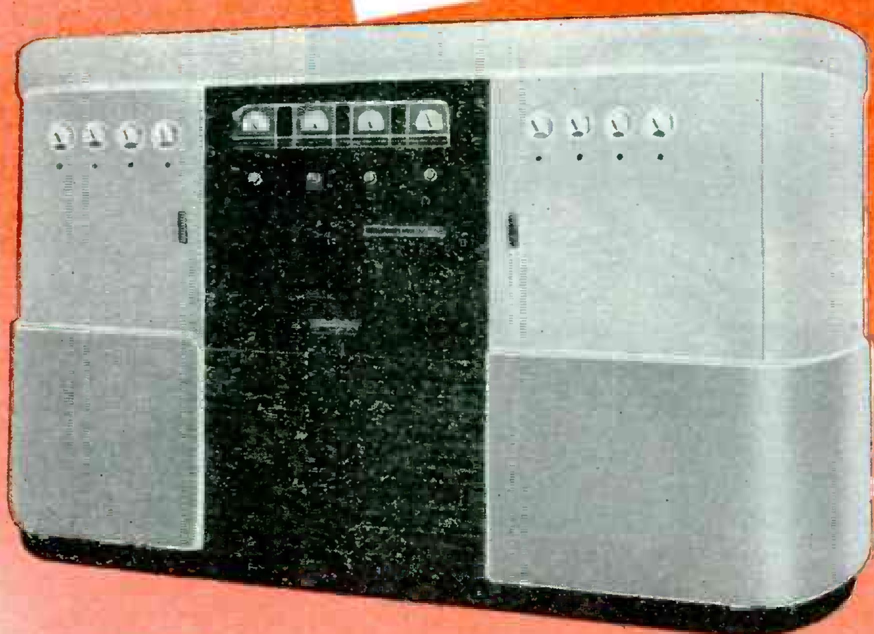

PLUS ALL THE EXTRAS OF SPECIAL WESTINGHOUSE RESEARCH FOR FM

Here in a smartly-styled package is a basically new approach to FM transmitter design .. combined with all the performance extras of special Westinghouse research for frequency modulation.

Built in 1, 3, 10 and 50 kw ratings, this new design provides direct generation of the modulated carrier by a simple and straightforward circuit. Frequency corrections are independent of critical tuning. Distortion is low.*

Metal-plate rectifiers—first introduced by Westinghouse for high-voltage, high-current AM applications—virtually eliminate outages caused by rectifier (tube) failures. Space and cooling requirements are reduced, operating costs are lowered.

Your nearest Westinghouse office has complete details of this new triumph in FM transmitter design in booklet B-3529. Or write Westinghouse Electric & Manufacturing Company, Radio Division, Baltimore, Maryland.

J-08103

*For harmonics up to 30 kc/s at ± 75 kc/s swing, distortion is less than 1.5% rms for modulating frequencies between 50 and 15,000 cps.

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Electronics at Work

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changes in activity and frequency with crystal aging and showed how etched crystals in water-tight holders did not have these objectionable features.

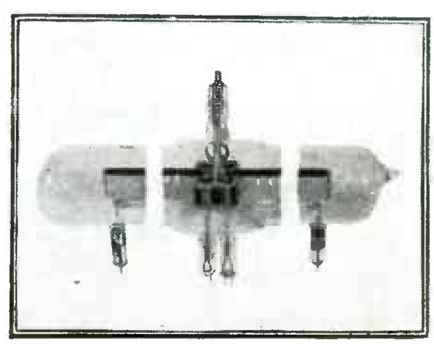
Crystals cut from quartz by diamond saws and mechanically lapped usually increase in frequency and decrease in activity with age. Examination shows that the surface has been permanently stressed by the lapping and eventually the crystal surface becomes loose powder. Etching in machines into which semi-finished crystals are fed and from which they come ready to be assembled into complete units has eliminated this trouble with crystals.

Moisture condensing inside the holder, or causing it to warp, and the loading of the crystal plates by substances given off by the usually used phenolic holders, cause failure of the unit. To make full use of AT cuts, where formally the thicker BT cuts had to be used, the holders should be hermetically sealed.

Vacuum-Contained Triode Transmitter

Pulse and c-w operation in the region of 200-700 Mc operation is provided by a triode with the transmission line built into the vacuum tube. The design and operation of this tube were presented in a paper prepared jointly by Major H. A. Zahl, J. E. Gorham and G. F. Rouse of Signal Corps Ground Signal Agency, Asbury Park, N. J.

The tube illustrated contains four triode sections. Tantalum shorted parallel-wire transmission lines are attached to plate and grid. The coupling between the plate and grid loops provides the feedback for the oscillator. The dimensions



Shorted grid and plate resonant lines are built within the glass envelope of this "tube" to obtain the shortest possible electrode connections for operation between 200 and 700 Mc

Every MANUFACTURING CUSTOMER Will Benefit

Industrial users of WILCO Products will find the increased facilities, the new products and techniques developed by WILCO for war service of great advantage to their own postwar products.

As the Hourglass indicates . . . with the coming of peace, many WILCO products now making for precision performance in airplanes, ships, tanks, guns and instruments of the Army and Navy will play an equally important role in meeting civilian needs for hundreds of useful and reliable products.

The demand of all branches of the service for Thermostatic Bimetals and Electrical Contacts has motivated many WILCO developments of great potential value to postwar industry. New products added to an already extensive line; increased facilities for refining and fabricating precious metals; greatly extended rolling mill facilities—these new additions and improvements, now devoted principally to the war effort, will prove equally helpful to manufacturing customers in meeting their peacetime production and marketing problems.

WILCO PRODUCTS ARE: *Contacts* – Silver, Platinum, Tungsten, Alloys, Sintered Powder Metal. *Thermostatic Bimetal* – High and Low Temperature with new high temperature deflection rates. *Precious Metal Collector Rings* for rotating controls. *Silver Clad Steel* – for bearings, shims, reflectors. *Jacketed Wire* – Silver on Steel, Copper, Invar, or other combinations requested. Rolled Gold Plate. Special materials.

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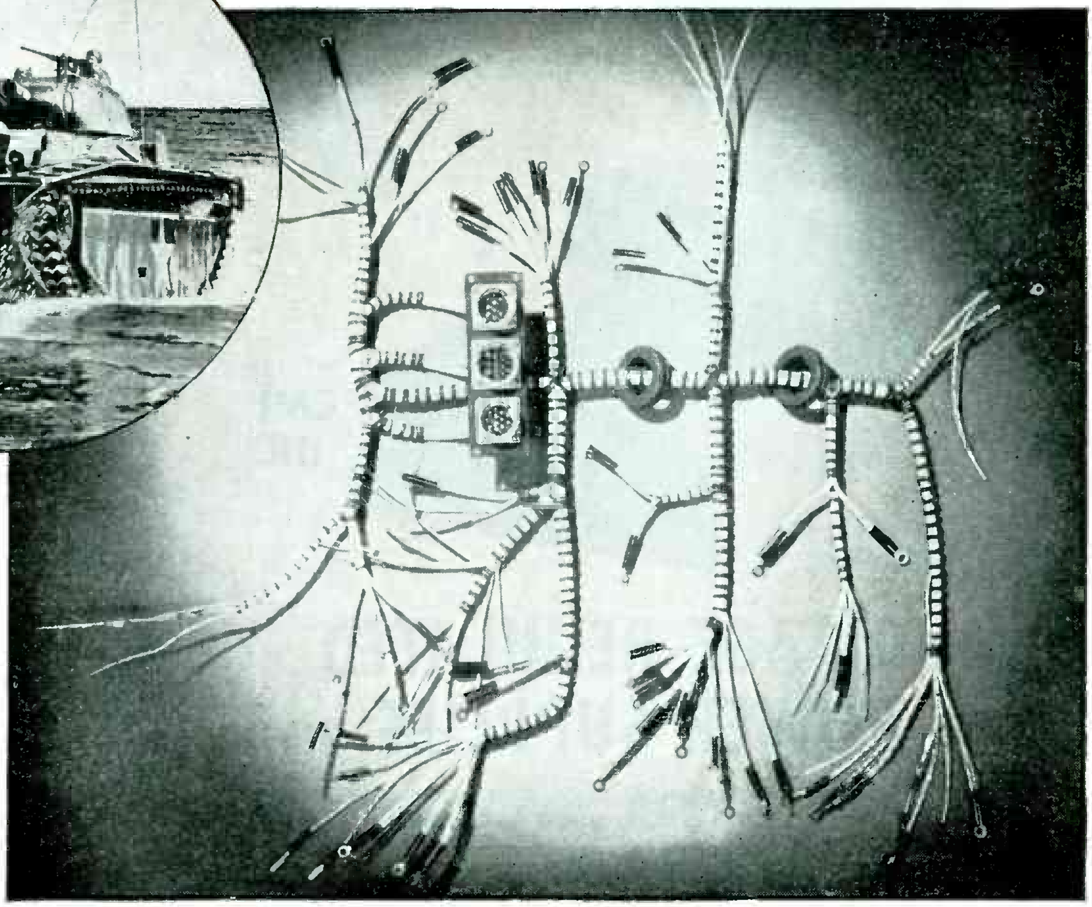

Illustration at right shows one of many Whitaker Harnesses being used in the production of Water Buffalos made for our fighting forces by Food Machinery Corp.

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of the two transmission-line circuits determine the frequency of operation of the tube. However, by tuning the external filament lines an approximate range of 30 Mc can be obtained between half-power points. The tube operates at approximately 25 percent efficiency with several kilovolts applied to the plate.

Filament leads are run out perpendicularly to the plate and grid transmission lines to reduce the corona. The plate output leads are also brought out from the transmission line in such a way as to provide reduced r-f voltage at the point of connection, thereby reducing the tendency toward r-f corona at the points of connection.

In operation, a shield box surrounding the tube was found to increase the available power output. The shield consisted of a rectangular metal box with a transverse shelf which held the tube and separated the cavity of the filament line from the cavity containing the tube and output circuit. This latter cavity acts as a bazooka or r-f choke at the end of the concentric output line, thus accomplishing transition from the balanced output of the tube to the unbalanced concentric transmission line.

Chesapeake Bay Radio Relay

That the trend in operation of radio relay stations has been toward the higher frequencies was illustrated by a series of comparative tables shown by Ralph Bown of Bell Laboratories.

He explained that ideal requirements for radio relay performance are sharp directivity, a low and steady noise level, small and low transmission disturbances and unlimited frequency space. The comparative table showed that from 1915 onward each of these four requirements was more closely met by going continually to higher frequencies.

Following this introduction four papers were presented by men of Bell Laboratories describing the Cape Charles-Norfolk multiplex radio relay system. The first of these papers by N. F. Schlaack and A. C. Dickieson dealt with the engineering economics afforded by multiplex telephone transmission. In the second paper, Charles R. Burrows and Alfred Decino considered

RELAYS

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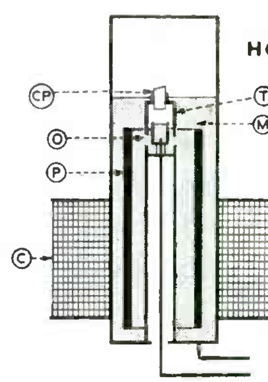
Under the most exacting conditions . . . heat or cold, dirt, dust or moisture . . . Adlake Plunger-type Relays are ready on the job. Their mechanism, encased in armored glass or metal cylinders and then hermetically sealed, is impervious to the elements and oxidation.

Adlakes are prompt to give instant contacts, clean break-offs, because they use fast-moving, liquid metal mercury . . . positive in operation; silent and chatterless; will not burn, pit or stick. Yes, Adlake Relays have snap action that stays snappy . . . absolutely no tendency toward lazy, snail-pace motion.

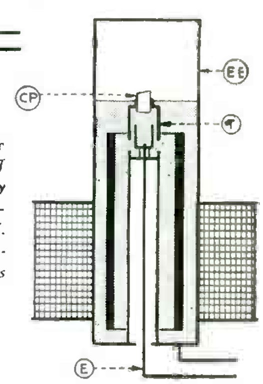
No other relays are as simple, rugged, dependable. For timing, load or control circuits, you can design them into every kind of equipment and be assured of continuous, trouble-free service.

There's an Adlake Relay for all needs. May we suggest the type best suited for yours? Write for free bulletin.

HOW THEY WORK



ENERGIZED—
Coil C has pulled plunger P down into mercury. Mercury thus displaced enters thimble T through orifice O. Inert gas in thimble gradually escapes through ceramic plug CP —thus producing time delay.



ENERGIZED—
Mercury now fills thimble T, is completely leveled off and mercury-to-mercury contact established between electrodes E and EE. Degree of porosity of ceramic plug CP determines length of time delay.

Adlake TRADE MARK

THE ADAMS & WESTLAKE COMPANY

ESTABLISHED IN 1857 — ELKHART, INDIANA — NEW YORK · CHICAGO

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RESINOX-7934

for electrical applications
for military and naval end use

1. Low dielectric constant and power factor

Dielectric constant at 1 K.C.
— 4.35 to 4.50
Dielectric constant at 1 M.C.
— 4.20 to 4.50
Power factor at xx 1 K.C.
— 0.015 to 0.017
Power factor at xx 1 M.C.
— 0.0080 to 0.0085

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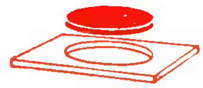
—only 0.030% by weight after 24 hours' immersion

3. Heat resistance

Relatively high heat resistance—important where leads are assembled to molded parts by a hot soldering iron.

4. Molding Superiority



Ease and economy in molding superior to ordinary mica-filled phenolics heretofore available to compression molders.

To provide unfailing insulation for medium and high frequency apparatus, under the severest operating conditions, including especially, high humidity . . . that's the war assignment of Resinox 7934.

This compound (mica-filled), based on a new phenol formaldehyde resin developed by Monsanto's plastic research, is *available now* in commercial quantities to molders of apparatus for military and naval end use. Resinox 7934 is suitable for both transfer and compression molding.

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MONSANTO PLASTICS
SERVING INDUSTRY...WHICH SERVES MANKIND

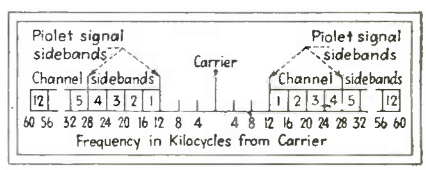
the effect of system non-linearity on distortion and cross-talk, and the methods for combating nonlinearity. The last two papers prepared by D. M. Black, G. Rodwin, W. T. Wintringham, and R. J. Kircher, R. W. Friis respectively, described the recieving and transmitting equipment.

Engineering Economics

Multiplex radio transmission promises the same savings afforded by multiplex wire transmission. However even with directive antennas, the required radio frequency power is large and costly. Efficiency is therefore of great importance. It is impractical to reduce intermodulation by operating transmitter output tubes at low-signal amplitudes. Schemes for spreadband operation have been used to avoid the most serious intermodulation products but at the cost of greater bandwidth. However, negative feedback can be applied to reduce intermodulation to a satisfactory value even at signal amplitudes approximating the rated output of the tube in the final transmitter stage.

The path across the mouth of Chesapeake Bay is particularly suitable for multiplex radio. Telephone traffic to and from Cape Charles had been routed by wire circuits 450 miles around the bay. Locating radio equipment at Cape Charles and East Ocean View, Va., replaced this circuitous land route by a radio link of 26 miles and 12 miles of wire.

The radio transmitters and re-

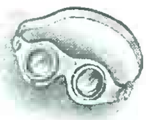
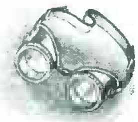


Double sideband transmission of the multiplex signal

ceivers were designed to accept and deliver the twelve channels of the type K carrier system which lie in the range from 12 to 60 kc. The arrangement of sidebands in the radio transmission is shown in the illustration.

The radio link was engineered on the basis that it should be at least as good in performance as 1000 miles of the type-K system. This imposed unusual requirements·

SUN GLASSES  SKIING GLASSES  SWIMMING GOGGLES  WELDING GOGGLES 

IN METALS TOO
It all depends on what you want to do

SELECTION GUIDE TO INCO NICKEL ALLOYS

PROPERTY:	MONEL	"R" MONEL	"K" MONEL	"KR" MONEL	"S" MONEL	NICKEL	"Z" NICKEL	INCONEL
CORROSION RESISTANCE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
STRENGTH	GOOD	GOOD	HIGH	HIGH	GOOD	GOOD	HIGH	GOOD
TOUGHNESS	GOOD	GOOD	HIGH	GOOD	GOOD	HIGH	HIGH	HIGH
HARDNESS	GOOD	GOOD	GOOD	GOOD	HIGH	FAIR	HIGH	GOOD
MACHINABILITY	GOOD	HIGH	GOOD	HIGH	GOOD	GOOD	GOOD	GOOD
NON-GALLING	NO	NO	NO	NO	HIGH	NO	NO	NO
SPRING PROPERTIES	GOOD	NO	HIGH	NO	NO	GOOD	HIGH	HIGH
ELEC. CONDUCTIVITY	POOR	POOR	POOR	POOR	POOR	GOOD	GOOD	POOR
HEAT RESISTANCE	GOOD	GOOD	GOOD	GOOD	HIGH	GOOD	GOOD	HIGH
HEAT TREATABLE	NO	NO	YES	YES	YES	NO	YES	NO
NON MAGNETIC	NO	NO	YES	YES	YES	NO	NO	YES

When it's a question of finding a metal for some tough job you have in mind there is a quick way to look for a ready answer...

Take a look at the family of Inco Nickel Alloys—strong, hard, corrosion-resisting and absolutely free from rusting, every one of them. Those are the family characteristics of the eight Inco Nickel Alloys.

Which one should you choose for your particular job?

It all depends on what you want to do.

From this "Selection Guide" you can see how each one provides a different combination of advantages for different types of work.

Then write for a copy of our List "B-100" which lists more than 100 technical bulletins and publications that explain the properties, corrosion-resisting characteristics and practical applications of these INCO Nickel Alloys. It is yours for the asking.

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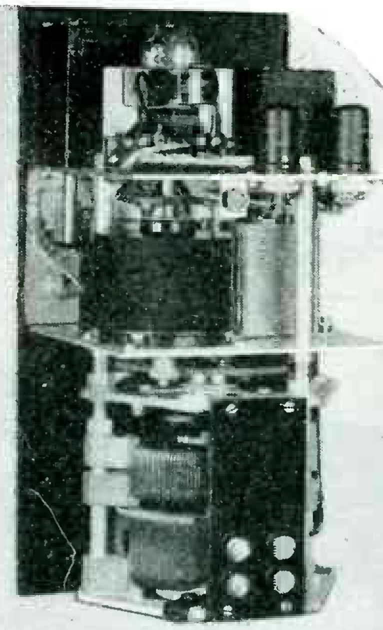
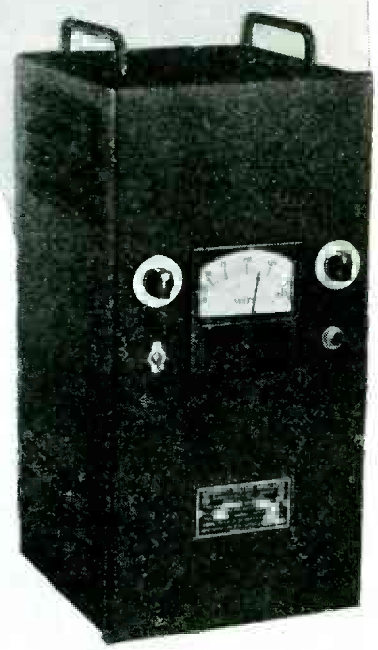
AUTOMATIC REGULATORS by SECO

**RACK OR CABINET MODELS —
NO WAVE-FORM DISTORTION —
LOW COST PER KVA —
COMPACT — LIGHT WEIGHT**





In the past, SECO Automatic Voltage Regulators have found wide use in maintaining constant voltage to equipment of 6 KVA capacity and greater. The introduction of SVR 4101 and SVR 4102 provides the SECO type of electronic voltage control for 1 and 2 KVA applications.

These new models possess many notable improvements to supplement the remarkable characteristics of larger SECO regulators. In addition to such features as zero wave-form distortion, high efficiency and adjustable output voltage, the SVR 4101 and SVR 4102 are compact and light weight. As illustrated, these models are available in self-contained cabinets and in rack units for installation as a component part of existing equipment.

SPECIFICATIONS

*Type	Input Voltage Range	Nominal Output Voltage	Output Voltage Range	Phase	Output Current	Output KVA	Over-all Dimensions
SVR 4101	95-135	115	100-120	1	10	1	9½" x 10" x 19⅝"
SVR 4102	95-135	115	100-120	1	20	2	9½" x 10" x 21½"
SVR 4106	95-135	115	100-120	1	52	6	9½" x 10" x 26½"

*When the regulator is used for mounting in customer's rack, add the letter "R" to the type number. For table or wall mounting add the letter "H".

Detailed information is gladly given by SECO engineers upon request.

Send for Bulletins 149 LE and 163 LE

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These same glass qualities are ready to help *you* produce better postwar electronic products. Which do you need?

1. High dielectric strength—high resistivity—low power factor—wide range of dielectric constants—low losses at all frequencies.

2. Permanent hermetic seals against gas, oil and water between glass and metal or glass and glass.

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in respect to noise, distortion and intermodulation on both transmitter and receiver.

At the southern end of the circuit, the carrier equipment is installed in the Norfolk toll office so that transmission to East Ocean View, a distance of about eleven miles, is at the K-carrier frequencies. At Cape Charles, the carrier equipment is located at the radio station so that transmission to the Cape Charles Central Office, a distance of 1.5 miles, and to the Onancock central office 40 miles away is at voice frequencies.

Complete unattended remote controlled transmitter

Radio transmission from Cape Charles to East Ocean View is on a frequency of 156,300 kc and in the reverse direction on 160,650 kc. This does not represent the minimum possible frequency spacing for this equipment.

The transmitters are crystal controlled and have a carrier power output of 50 watts. The crystals are temperature controlled to improve frequency stability and thereby minimize the bandwidth and hence the noise acceptance of the receiver. Both transmitters are designed to operate into a balanced impedance of 140 ohms.

The input circuits of the receivers were designed to connect to a single 72 ohm coaxial transmission line. Triple detection was

☆ TOLL CALL TO TOKYO . . . Collect!

PHOTO U. S. SIGNAL CORPS.

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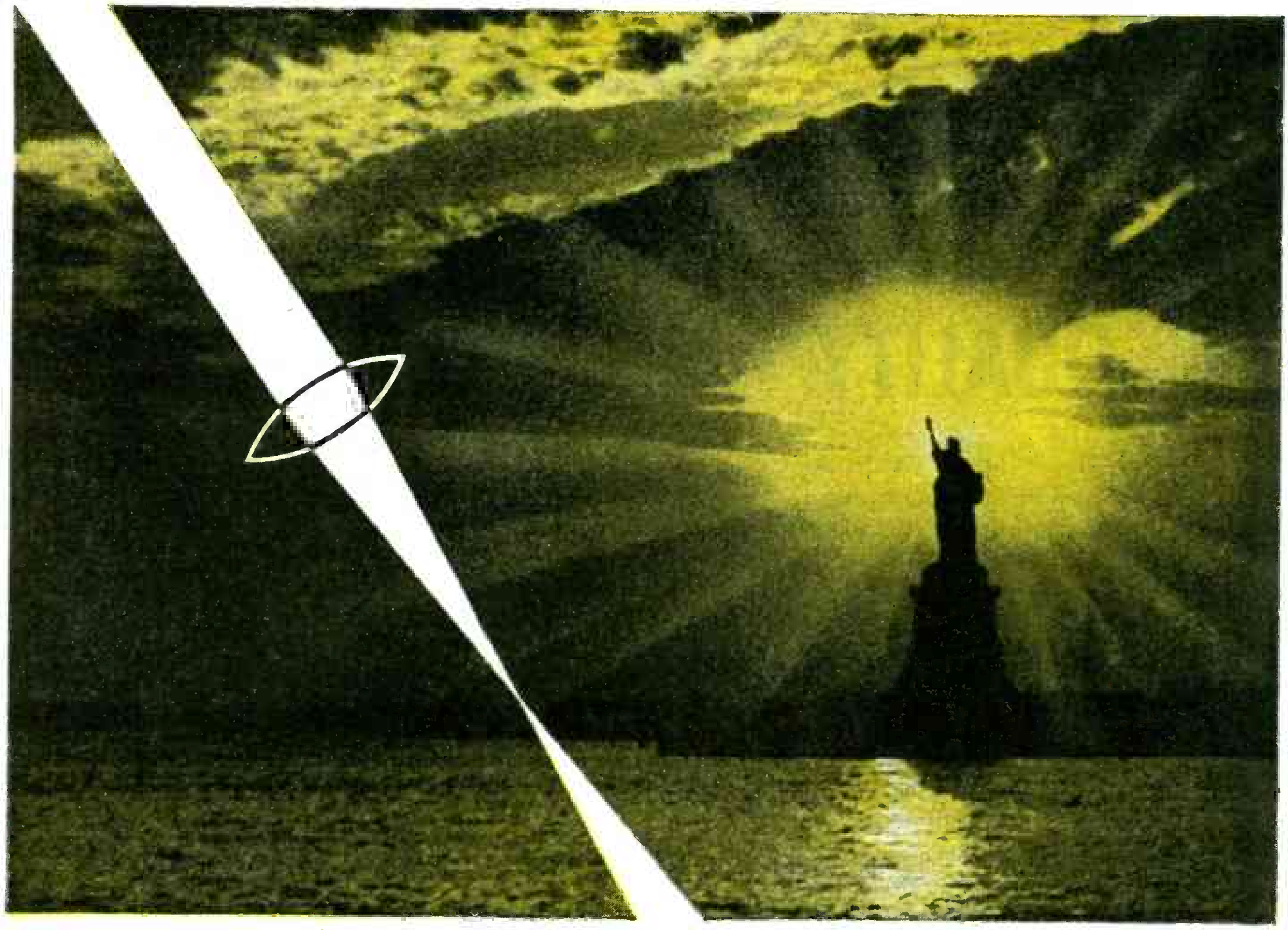

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Precision optics for war keep us busy — very busy.

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Manufacturers who bring their post-war optical problems to us, find a cooperative attitude and a rich background of experience that are a great aid to sound product planning. Our compact group of precision lens technicians have been trained in a plant that specializes in supplying optical components to those who make complete products. Nothing else is made here.

We have done much development work in electronic optics and in other optical fields. Possibly you have a problem for which we already have a solution.

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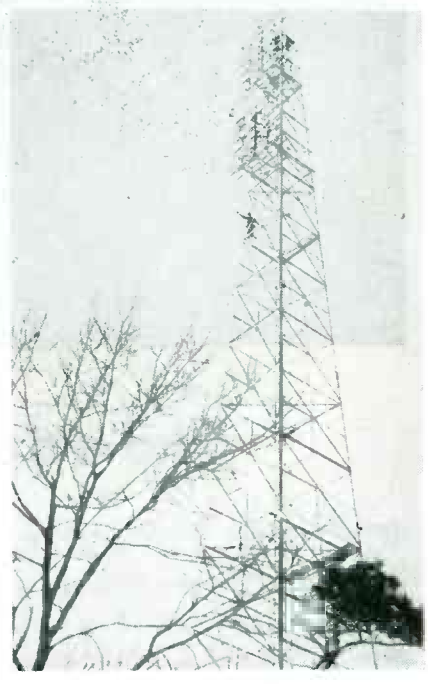
The arrays consist of forty-eight one-half-wave elements arranged in two parallel vertical planes one-quarter wavelength apart. The elements in the plane farthest from the tower are driven in phase whereas those in the rear plane act as reflectors.

The elements are made of one-half inch diameter copper tubing supported on a wooden framework by stand-off insulators. The wooden framework for each antenna is in turn supported by six horizontal timbers which extend across the sides of the tower and are bolted to the legs of the tower. The upper antenna framework is somewhat larger than the lower in order that it can support four additional rods on the bottom to give additional attenuation between the two antennas. A long ground rod across the top is for lightning protection. Each antenna has a gain of 17 db over a single half-wave element at the same mean height.



Antenna towers carry directional receiving and transmitting arrays

A pair of ⅞-inch coaxial transmis-

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Official U. S. Navy Photograph

A giant four-motor bomber, its mission completed, settles down for a safe landing atop one of the "miracle" steel runways, set up at breathtaking speed by Navy Seabees at a Pacific base.

Electronics has made a note-worthy contribution to the effectiveness and safety of our fighting planes. Mec-Rad's part in this program is to supply certain vital, highly precise mechanical and electro-mechanical components for electronic units. Today —and as long as they are needed,— our services will be given over 100% to this work.

Our work includes "fancy brass plumbing" of all types involving soft and hard soldering, close tolerances, precision machining, careful assembly and finishes ranging from lacquer to silver and rhodium plating.

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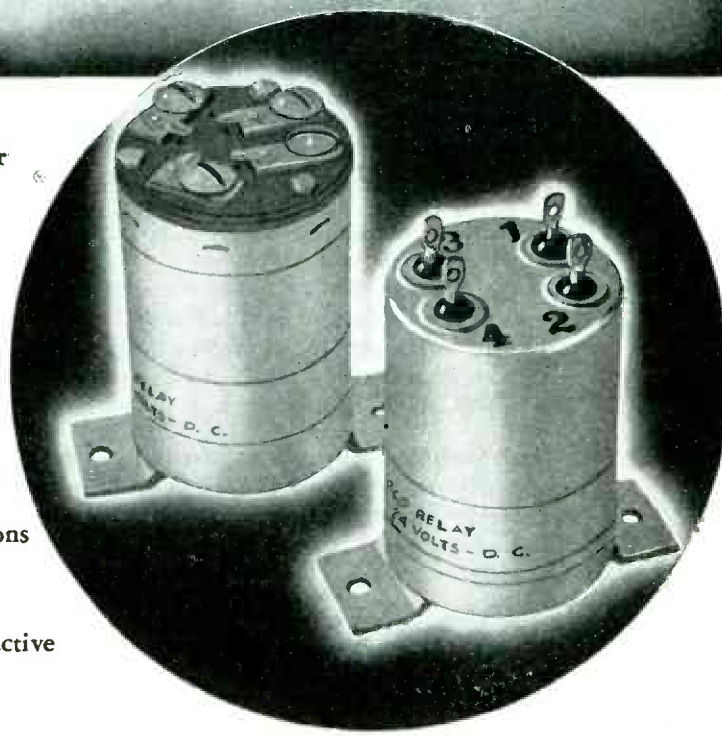

At last . . a high capacity Relay engineered for high altitude performance . . . HERMETICALLY SEALED against MOISTURE, HUMIDITY, EXPLOSIVE VAPORS, DUST, PRESSURE CHANGE, and CORROSION.

Regardless of how high aircraft ceilings are bumped . . . this is a relay that can take the ride.

Laboratory models have been completed and tested . . . CEILING UNLIMITED.

LIGHT and COMPACT — models illustrated weigh approximately 5 ounces; overall dimensions approximately: Height, 2″; width, 1⅜″.

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CONTACT RATING — 20 to 25 amps inductive load at 30 volts.

Meets winterization requirements.

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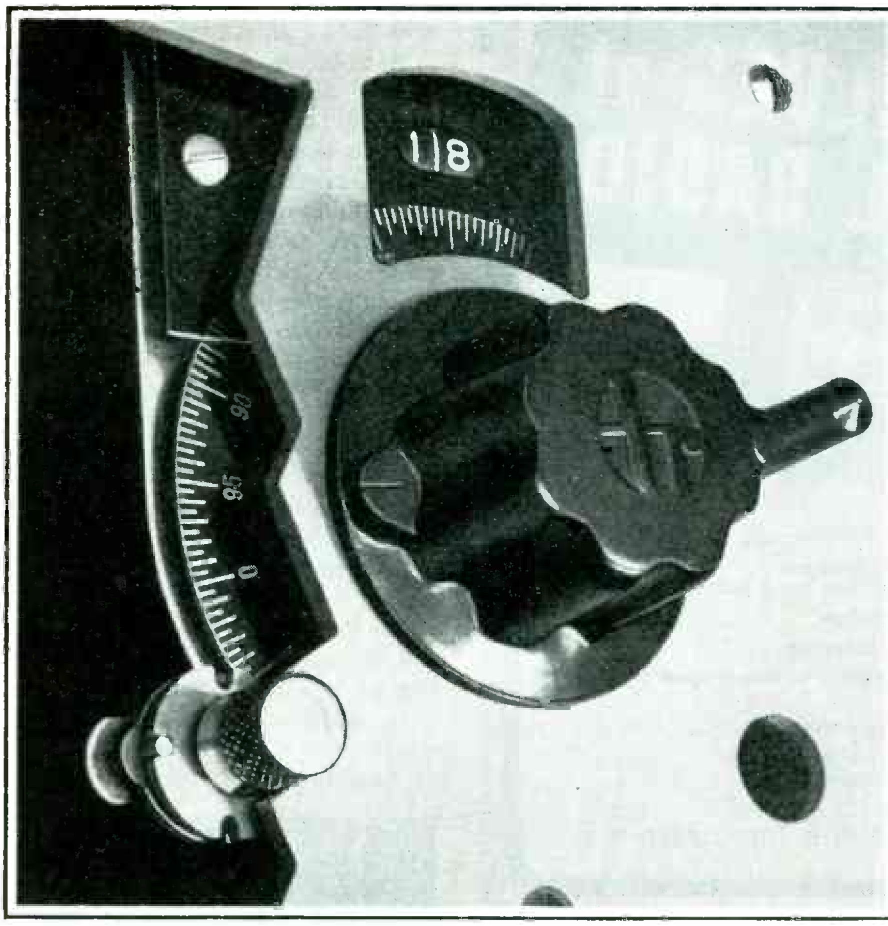
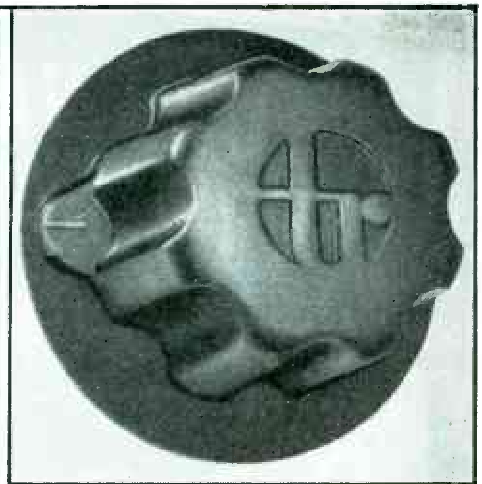
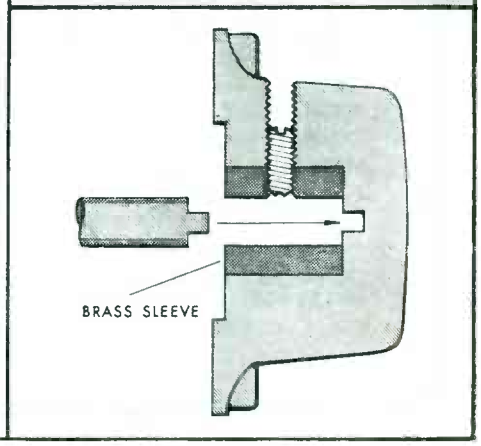
Unit has withstood Army test, including overload; vibration 55 cycles per second with .06′ excursion; acceleration of 10 gravity units; salt spray tests of 240 hours duration.

★ ★ ★

This is the Relay of the future . . . also worth your consideration in many commercial installations.







TEAM WORK...FOR PANEL PRECISION

1—New Techrad Knob . . . 2—Techrad Interpolating Counterdial . . . 3—Techrad Dial Lock

The new Techrad Knob together with the Techrad Interpolating Counterdial and the Techrad Dial Lock form a team to insure precision tuning.

Every detail is master engineered. Every feature of this new Techrad Knob is carefully planned for ease of operation. As illustrated, the knob is slotted to fit the male end of the shaft...a feature which completely absorbs rotary pressure. The knob is available with a built-in crank-handle at no additional cost for use where rapid spin-setting of the dial is required. Stock sizes are of molded bakelite with a 2" skirt and fit a ¼" or ⅜" shaft.

The Techrad Interpolating Counterdial combines the familiar drum counter with a flat interpolating disc scale to provide: 200 accurate settings with each turn of the dial; an accurate log of any position, making it possible to return to a previously established setting; together with many other important advantages.

The Techrad Dial Lock is a superior lock for use with flat disc dials of various thicknesses. It will not drag or scrape when disengaged nor distort or bend the dial scale when locked. The locking discs *do not rotate* which insures positive settings.

Originally designed as a *team,* each unit is readily adaptable to individual application and may be purchased separately or as a unit. Write today for complete information and price data. Whether your problem is that of a complete installation or the need of a better knob... Techrad will gladly offer advice and engineered assistance. A letter or sketch outlining your requirements will be treated confidentially and receive prompt attention.

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sion lines connect the transmitter to its antenna while a single ⅞-inch line is used in the case of the receiver. These lines are kept under gas pressure.

A control over cable circuits enables the radio operator at Norfolk to shut off the Ocean View transmitter. By communication with the switchboard operator at Cape Charles, either over these circuits or via an overland wire circuit, orders to shut off the Cape Charles transmitter can be given. This transmitter power is controlled over wire circuits by a key in the Cape Charles switchboard.

A continual check on the distant transmitter is supplied at both attended locations. An alarm is given if the frequency deviation exceeds ±0.002 percent or if the distant carrier is absent altogether.

In addition to these features which give the technical operators at Norfolk control over the system,

Unattended crystal controlled receiver for the radio link

there are transmission alarms and controls to facilitate maintenance. By means of piolet signals, indication is given of an open in the system and on which side of the water barrier it has occurred.

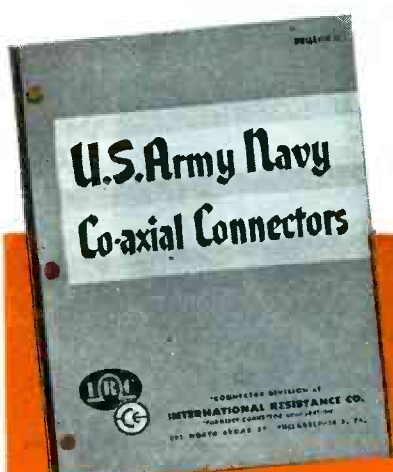
At the western end of the circuit, alarms are provided both at Ocean View and the Norfolk toll office for an open radio station door, high radio cabinet tempera-

An IRC Adapter You'll Want to Adopt

CONNECTOR #50.394-1
U. S. SIGNAL CORPS #M-358
NAVY PART #CI-49192

U. S. ARMY-NAVY RIGHT ANGLE PLUG

HERE'S an UHF elbow adapter that will prove to be your answer to many a coaxial cable problem. Engineered and tested to surpass the rigid Army-Navy specifications for this type unit, it will find many applications where a change in cable direction is desirable. • The die-cast zinc housing, as well as all other metal parts, is heavily silver plated. Contact parts, both pin and socket, are made of special spring-brass and engineered so as to insure positive, vibration-free contact. Insulation is polystyrene. • Plug is designed to take the following cables: Army-Navy types RG—7/U, RG—8/U, RG—9/U, RG—10/U, RG—11/U, RG—12/U, RG—13/U, RG—63/U, RG—65/U.



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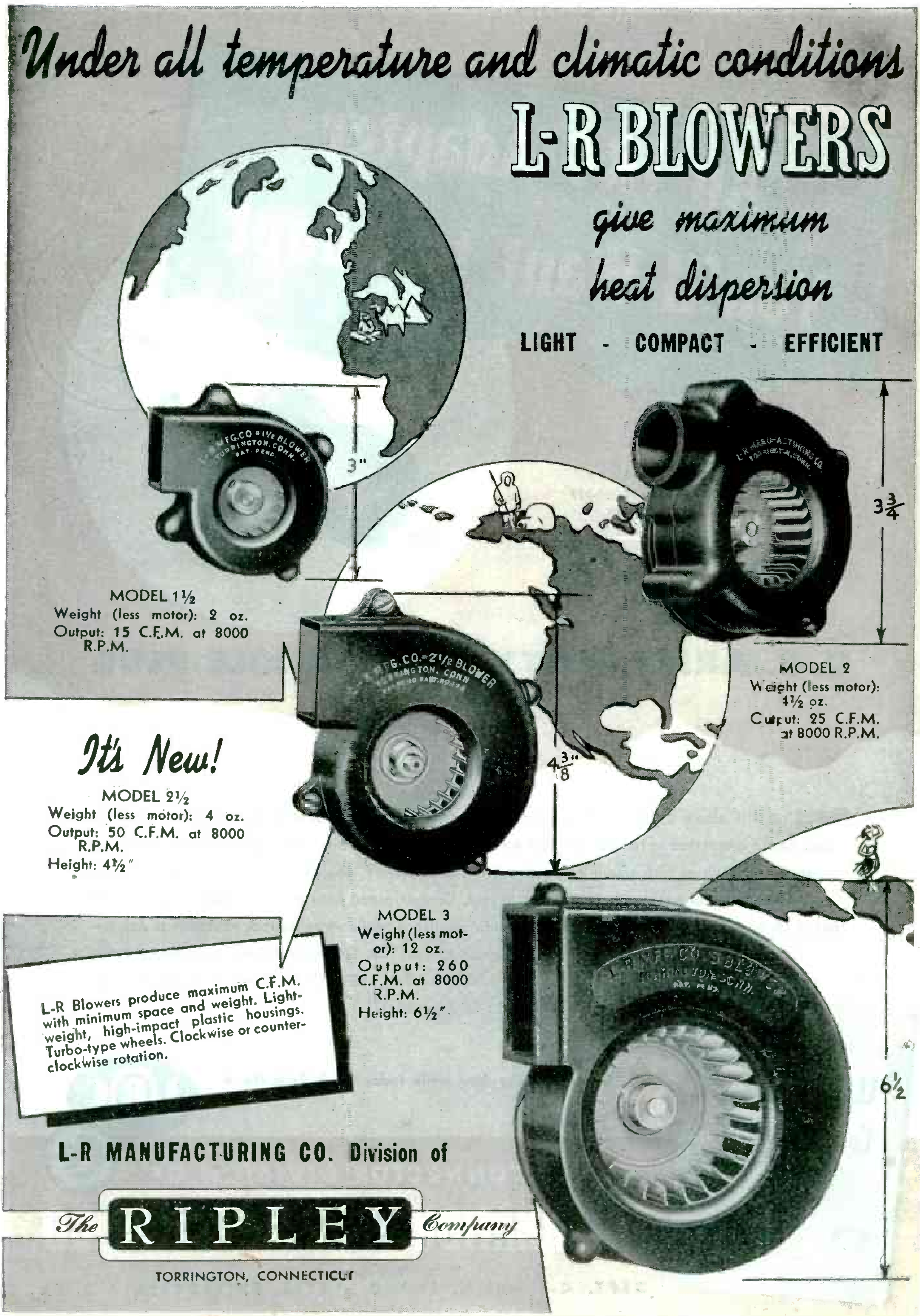
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L-R Blowers produce maximum C.F.M. with minimum space and weight. Light-weight, high-impact plastic housings. Turbo-type wheels. Clockwise or counter-clockwise rotation.
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LUMARITH C.A. (cellulose acetate) insulation is effective protection against electro-chemical corrosion, the greatest cause of electrical failure. It is another example of how synthetic materials can frequently do a better job than natural materials, because they can be created from the start to meet definite objectives.

Lumarith C.A. is not subject to the built-in hazard of organic decomposition. It resists moisture and contains no substances which combine with moisture to form free acids. Applications involving fine wire, humidity and direct current are particularly well served by Lumarith C.A. insulation.

Lumarith C.A. films' and foils' high dielectric strength (2800-3300 volts/mil.) and high softening point (146-177° C. depending on formulation) recommend them for many types of coil insulation. Available also in sheets, rods, tubing, and molding materials. Films and foils are furnished plain or with special mat finish that's easy to see and slip resistant. Write for the reference booklet "Lumarith for the Electrical Industry." Celanese Plastics Corporation, a *division of Celanese Corporation of America*, 180 Madison Avenue, New York 16, N. Y.

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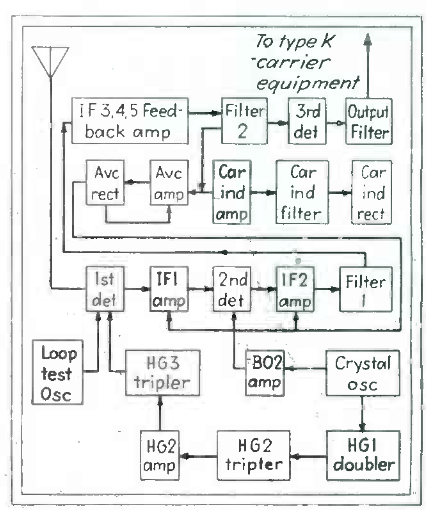
ture, a-c power failure, low or high radio station room temperature, and fire. At Norfolk, the first three are grouped together to light a major-alarm lamp, the fourth lights a minor-alarm lamp, and the fifth lights a fire-alarm lamp. Two pairs in the cable between Ocean View and the Norfolk toll office are required for the transmission of these alarms. An additional pair is used for loop tests and to shut down the radio transmitter from Norfolk.

At the eastern end of the circuit, similar alarms are provided both at the radio station and the Cape Charles Central Office.

This new link was placed in service in October, 1941, with two of the channels used for traffic between Norfolk and Cape Charles and three others used between Norfolk and the toll center at Onancock. All channels are now in service, five between Norfolk and Cape Charles, four between Norfolk and Onancock and three for private-line telephone circuits.

Multiplex Radio Relay Receiver

The receiver circuit of the Chesapeake Bay system, is shown in block schematic form. The signal is supplied to the first detector from the antenna system and is



Block diagram of triple-detection type of receiver used in the multiplex radio relay system

there converted to the first i-f value of approximately 10 Mc. After one stage of amplification, it is converted to 1,500 kc in the second detector. The heterodyne frequencies applied to the first and second detectors are obtained from a single temperature controlled

ELCO meets the challenge of the Jungle with FUNGUSIZED* PRECISION *wire-wound* RESISTORS!

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PROMPT DELIVERIES as usual!

SPECIFICATIONS:

"A-1"—15/32 long x 1/2" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 300,000 ohm value—1/2% standard accuracy—non inductive pie wound—1/2 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—200 D. C. maximum operating voltage. Baked varnish finish.

"A-R"—Same as A-1, with leads reversed.

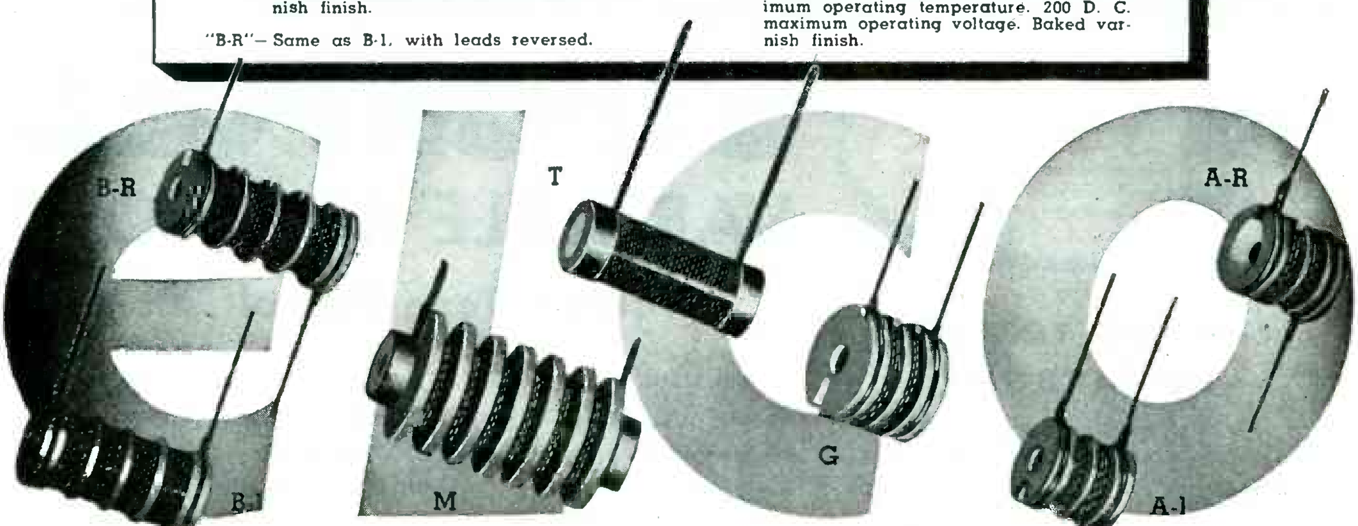
"B-1"—15/16 long x 1/2" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value—1/2% standard accuracy—non inductive pie wound—1 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—300 D. C. maximum operating voltage. Baked varnish finish.

"B-R"—Same as B-1, with leads reversed.

"T"—1-1/32 long x 7/16" dia.—Inductively wound—1/8 x .015 strap terminals—35 to 35,000 ohms—2 watts, 100° C. maximum operating temperature—normal accuracy 1%. Baked varnish finish.

"M"—1-13/32 long x 1/4" dia.—Mountable with 6-32 screw—1/8 x .015 thick strap terminals—non inductive wound—1 meg ohm maximum resistance—600 volts maximum operating voltage—100° C. maximum operating temperature—1.5 watts—1% normal accuracy Baked varnish finish.

"G"—15/32 long x 1/2" dia.—Mountable with 6-32 flat or filester head screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value. 1/2% standard accuracy—non inductive pie wound .8 watts, 30° temperature rise in free air. 100° C. maximum operating temperature. 200 D. C. maximum operating voltage. Baked varnish finish.



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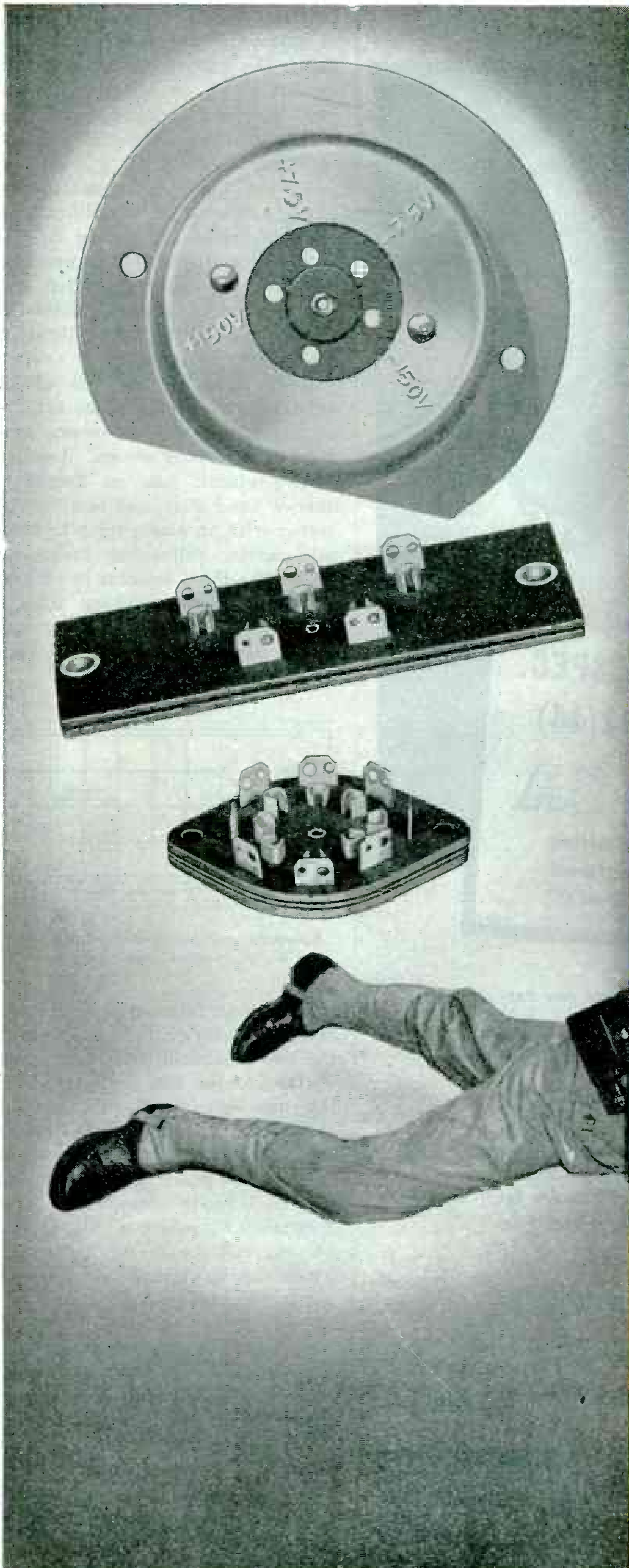
Telephone - Watkins 9-4774-5



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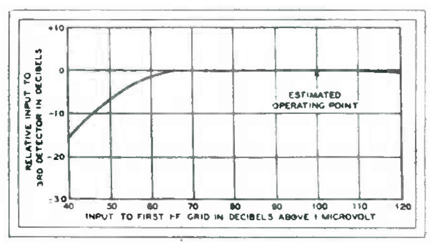
crystal oscillator through a series of harmonic generators and amplifiers. The output of the loop test oscillator can be supplied to the first detector for making local tests when the distant transmitter is not operating.

At the 1,500-kc frequency, another single stage amplifier has its gain varied by the avc circuit. In addition, there is a three-stage fixed-gain feedback amplifier and two sections of band-pass filters to provide the additional amplification and selectivity required.

The avc circuit consists of an amplifier and rectifier that are arranged to give the flat volume control characteristic shown. Another branch circuit has an amplifier, narrow band filter, and rectifier together with an alarm relay to indicate carrier failure or frequency drift. The third detector is a high-amplitude diode working into a low-pass filter whose output is connected directly to the type-K carrier telephone equipment.



Automatic volume control characteristic of rectifier and amplifier

In an ideal filter on an amplitude modulated carrier, the amplitude of the two sidebands relative to that of the carrier may be altered by the same amount. In this case the only result is a change in the modulation index or degree of modulation; or the phase of one sideband may be linearly advanced and the other linearly retarded by the same amount relative to the carrier in which case the signal as a whole is advanced or delayed. In either case, the presence of the filter makes no contribution to the non-linear distortion. In a non-ideal filter, if the change in amplitude of one sideband through the filter is different from that of the other, or if the phase advance of one sideband differs from the phase retardation of the other, intermodulation products will be produced. The result may be pictured by considering the wave

PREVIEW OF A STARTLING NEW FARM TYPE BATTERY

OLD

The present No. 748 1½-volt "A," 90-volt "B" A-B Pack
Dimensions, 15 13/16" x 6 15/16" x 4 15/32"
Weight, 23 lbs., 11 oz.

NEW

The New No. 758 1½-volt "A," 90-volt "B" A-B Pack
Dimensions, 10 11/16" x 6 13/16" x 4 1/8"
Weight, 16 lbs., 13 oz.

30% SMALLER, LIGHTER —BUT SAME CAPACITY!

THIS GIVES YOU an advance look at the latest "farm-type" radio battery to be developed by National Carbon Company. A revolutionary construction makes this smaller, lighter "Eveready" "Mini-Max" battery a reality. Actually it is a good 30% more compact than the present No. 748 A-B Pack. Yet not one bit of capacity has been sacrificed in achieving a valuable reduction in size and weight.

The advantages of this more compact battery will be obvious to you. The way is paved for smaller, less expensive battery-operated radio sets. And these sets will have the advantage of being far easier to move about from room to room. The way is likewise paved for sets of the present size utilizing the space saved by the new battery to use larger speakers giving improved receptivity and tonal qualities. Both add up to a greater demand for farm-type radios and an important increase in business for you.

This newcomer, known as the "Eveready" No. 758 A-B Pack, is only one of many improved types of "Eveready" batteries which will appear after the war. Look to National Carbon's exclusive construction, used in the "Mini-Max" battery, for more and equally important news to the trade.

"EVEREADY"

MINI-MAX

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RADIO "B" BATTERIES

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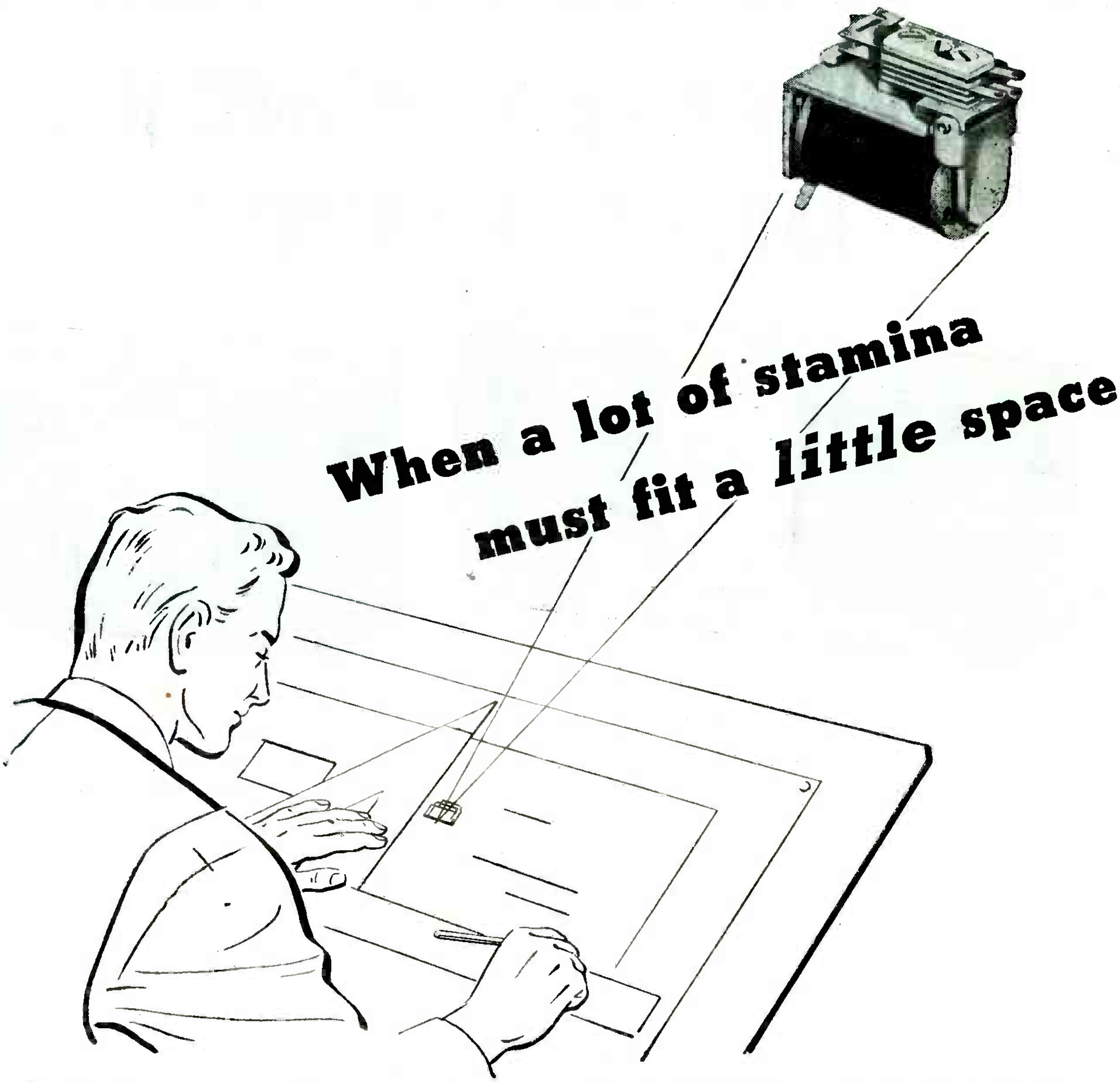

If space requirements dictate a small relay—and service conditions a powerful one . . . here's the relay to fit your needs. It's the Automatic Electric Class "S" Relay—tiny in size, light in weight, but dependable and packed with power.

Class "S" Relays have been designed especially to meet the exacting conditions of service on fast, modern aircraft. They offer a combination of features never before found on any relay, large or small. For example:

1. **Vibration-resistance is not just "added on"—it's designed right into Class "S" Relays. And they withstand with a large margin of safety the most rigorous operating tests of the Signal Corps and the Air Forces.**
2. **A unique spring design provides high contact pressure within small space limits.**
3. **An added assurance of reliability is provided by twin contacts.**
4. **The new type of pin-pivoted armature with full length bearing provides the Class "S" Relay with exceptionally long life even under the toughest conditions.**

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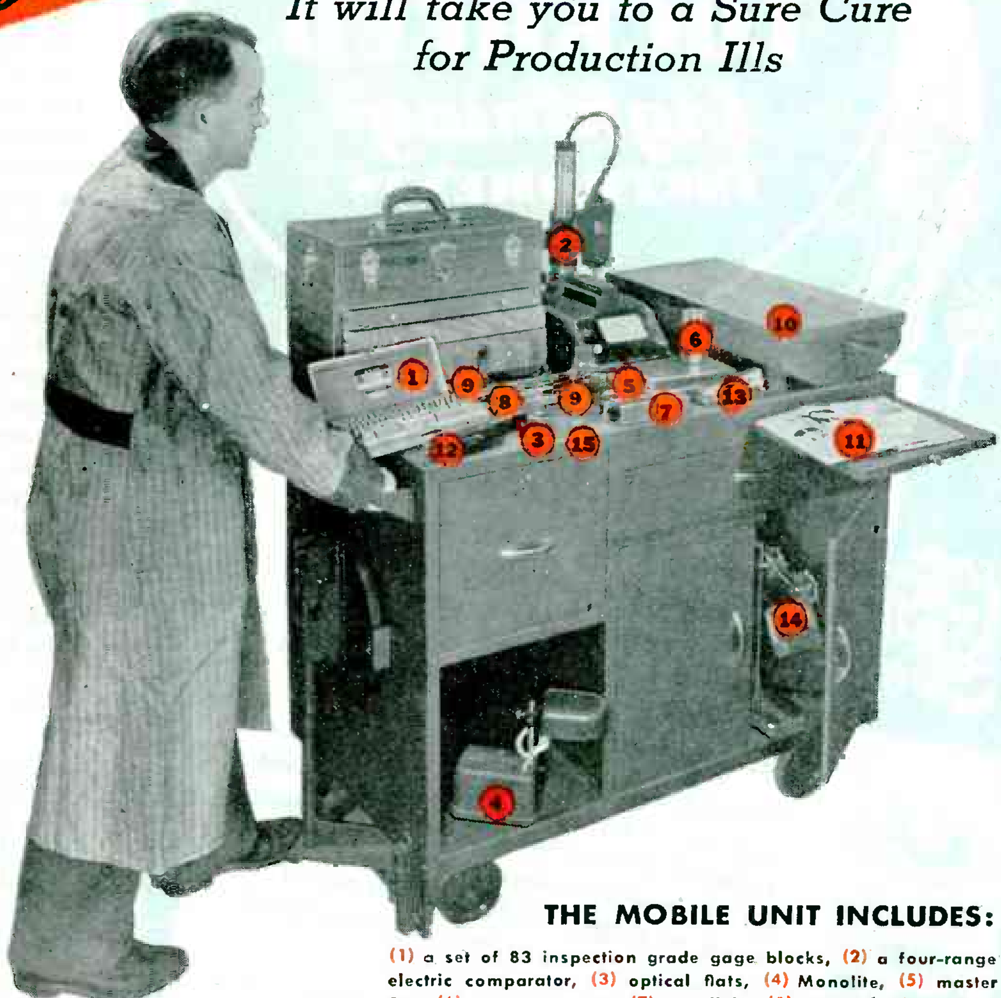

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A complete inspection laboratory on wheels for **ONLY**

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THE MOBILE UNIT INCLUDES:

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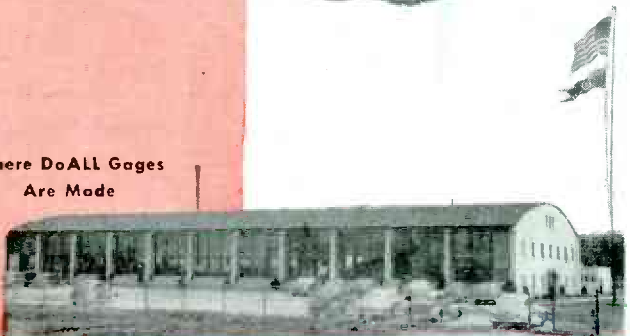

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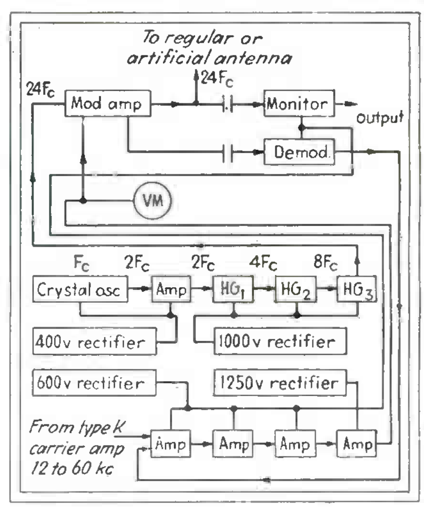
at the output of the filter as being made up of two components, one formed by the carrier with symmetrical sidebands, and the other being a single component at the frequency of one sideband and of such amplitude and phase as to represent the difference between the sideband transmitted through the filter of this frequency and the symmetrical sideband component of the same frequency. The symmetrical components form an undistorted amplitude modulated wave, the modulation on which may be recovered without distortion. The excess or difference component will be demodulated against the perfectly modulated carrier as a single sideband signal, with all of the distortion resulting from such demodulation by a linear detector.

More exact analysis confirms the conclusion of this very rough descriptive analysis. In order that the non-linear distortion be kept within satisfactory limits for this multiplex system, the phase shift through the filters must be linear to within a few degrees and the amplitude distortion over the pass band of the filter must be less than a decibel. The measured band-pass



Circuit of transmitter, power supplies and monitoring unit

characteristics of the receiver designed to these specifications are shown.

Unattended Transmitter

The transmitter developed for the multichannel radio link is illustrated in the block schematic diagram. The last stage, which is the modulator stage, is a bridge capacity-neutralized, plate-modulated,

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TV

Whether Amplitude Modulation . . . Frequency Modulation . . . or Television – dependability is a *must* for all broadcast equipment.

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For more than thirty-five achievement-studded years . . . from the Poulsen Arc to the new CBS Television Station . . . Federal has served the broadcast industry with superior equipment.

Federal's background includes such milestones of electronic progress as the 1000 Kw Bordeaux Transmitter; Micro-ray, the forerunner of modern television technique; and the first UHF multi-channel telephone and telegraph circuits, part of a world-wide communications system . . .

All this, plus the war-sharpened techniques that are the result of ability *and* experience, combine to give you craftsmanship . . . the kind of craftsmanship that builds dependability into all Federal equipment.

In AM . . . FM . . . TV . . .

. . . your prime need in broadcast equipment is dependability – *look to Federal for it.*

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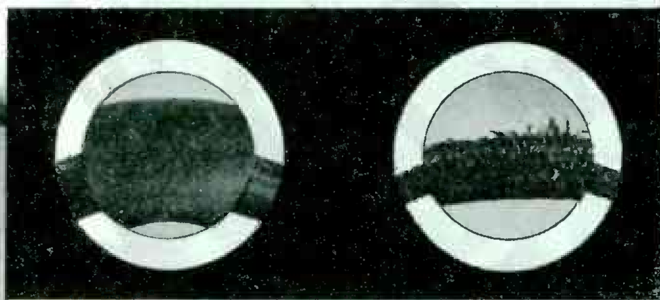
Selecting PROPER CABLES PROTECTS ELECTRONIC EQUIPMENT



Relative deterioration after six years exposure: *Left;* Okoprene sheath smooth and unchanged by elements. *Right;* Saturated braid with compound eroded and braid destroyed.

• The right wire or cable is vital to the electronic equipment you make. Without it your product cannot stand squarely on its performance merits — cannot do the failure-free job for which you made it.

Okonite makes a wide range of wires and cables to meet the end-uses of your electronic product. In process industries, for example, where heat, oils, or chemicals are encountered, Okoprene sheathed cables are particularly valuable.

FACTS TO REMEMBER ABOUT OKOPRENE

● Okoprene, compounded with neoprene, is an exceptionally durable covering for cables developed in the Okonite Research Laboratories. Applied over the wire insulation or used as a sheath or jacket over assembled conductors, Okoprene can be used to protect practically any type or design of cable.

MOISTURE AND HEAT RESISTANCE — Okoprene sheaths will not rot or deteriorate when subjected to moisture. The protective covering is flexible at temperatures even lower than minus 18°C. (0°F.).

CHEMICAL RESISTANCE — The Okoprene jacket has excellent resistance to most acids, alkalies and other corrosive chemicals.

OIL RESISTANCE — When exposed to the solvent action of petroleum products, Okoprene sheaths retain their full mechanical strength.

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Single conductor Okolite insulated and Okoprene protected wire.

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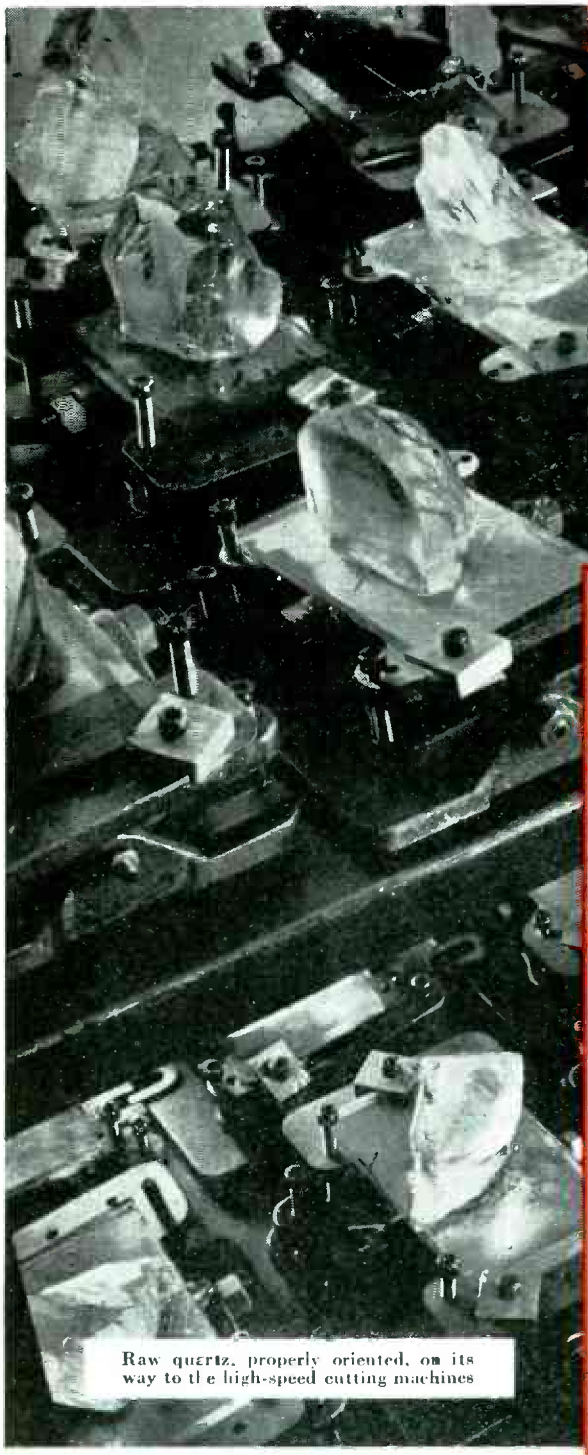

Raw quartz, properly oriented, on its way to the high-speed cutting machines

NORTH AMERICAN PHILIPS research and engineering have contributed to four developments that have advanced the art of crystal processing. Each has solved at least one problem in the mass production of quartz oscillator plates to meet the rigid demands of war equipment.

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- ***X-Ray Quartz Analysis Apparatus:*** First practical, commercial device specifically designed for accurate mass production of quartz crystals. It provides the best known method of measuring the precise angles required.
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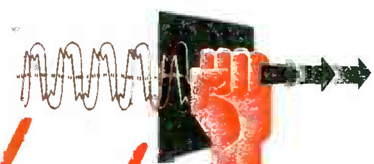

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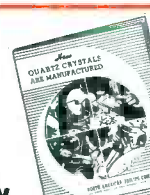

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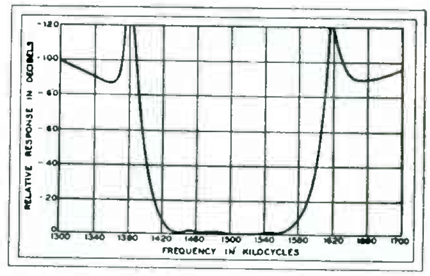
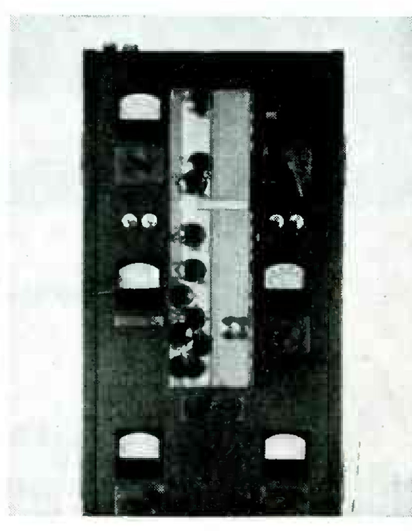
Class C amplifier which delivers approximately fifty watts of radio frequency power. The signal modulating power is developed through a chain of four Class A amplifier stages. Loosely coupled to the modulator is the demodulator unit from which the signal envelope voltage of correct phase is obtained which is returned to the input of the signal amplifying stages to effect the negative feedback correction on the transmitter. A monitor unit designed to check the operation of the transmitter is connected at the junction of the output circuit of the modulator and the balanced coaxial transmission line.



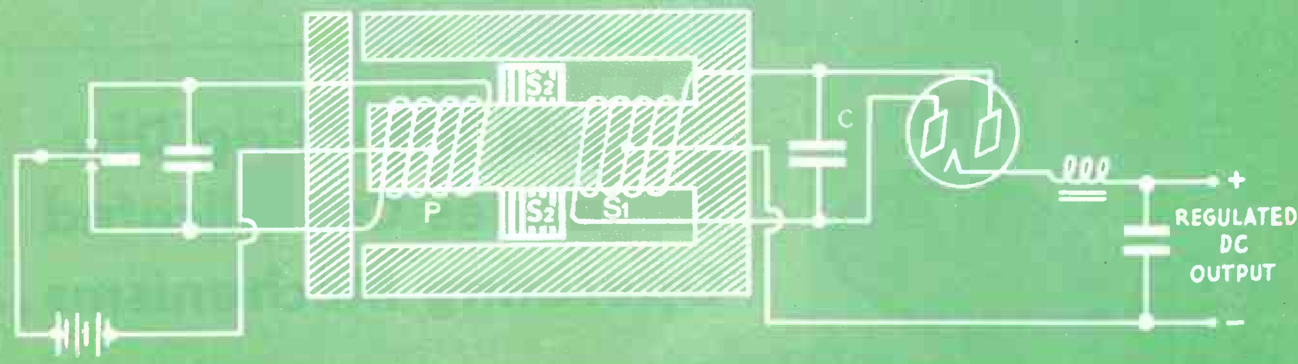
Overall amplitude-frequency characteristic of the multiplex receiver

As shown in the block diagram, a voltmeter is provided in the plate circuit of stage four to indicate the peak a-c signal voltage applied to the modulator. The gain of the four stages in tandem with 40 db of negative feedback is such that a single tone input at 28 db below 1 milliwatt will modulate the transmitter 80 percent. To protect the signal amplifiers from excessive input signal voltage in case the feed-



Front panel of transmitter showing recessed tuning controls

E-L DEVELOPS HIGH DEGREE OF VOLTAGE REGULATION IN VIBRATOR POWER SUPPLIES



● One of the most serious and annoying problems faced by radio and electrical engineers has been fluctuating output voltages due to varying input voltages. Now, Electronic Laboratories has solved this problem by using a high-efficiency, regulated type transformer system applied to vibrator operation for DC systems.

This type of transformer, as shown above, consists of primary and secondary windings having a linear magnetic leakage path between them. The tank condenser, C, is connected across the secsecondary winding.

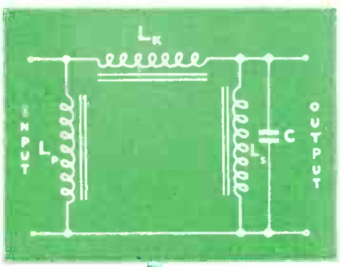


Fig. 1

The equivalent circuit diagram is shown at the right (see fig. 1). L_k represents the leakage inductance provided by the magnetic shunts. L_p and L_s are primary and secondary inductances respectively, L_s working at the saturated portion of its curve.

The net voltage across the output terminals is the vectorial sum of the equivalent voltage input and the drop across the reactance L_k. This drop is due to the condenser current (addative) and the inductive current drawn by the saturable reactor L_s (subtractive). In operation, when the input voltage rises, there is a proportional increase in condenser current. Also, due to the non-linear characteristics of L_s, there is a more than proportional increase in the inductive current. The next effect is an increase in the inductive (subtractive) drop in the reactor L_k. Thus, the voltage across the output terminals tends to remain substantially the same. When the input voltage goes down, the inductive drop on L_k will fall at a faster rate than the capacative drop due to C, for reasons explained above. This results in a net gain in capacitance or addative drop which prevents the output voltage from decreasing with the input voltage.

To insure absolutely flat regulation, coils wound on the primary are connected to buck a small percentage of the voltage of the secondary as shown by the accompanying schematic (see fig. 2). The bucking voltage, being a linear quantity, can be made to compensate exactly for the small rise in voltage across L_s as it swings through its saturation curve.

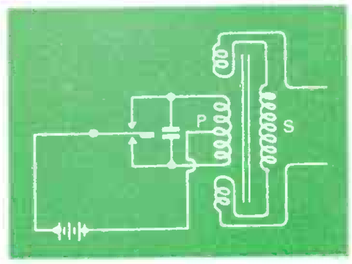


Fig. 2

An important feature of this system is its excellent load regulation. The output will tend to remain constant with load, since the reactive energy stored in the secondary circuit can be made large compared to the actual energy delivered at the output. This method of regulation is particularly suited to battery-operated power supplies, because it is a *high-efficiency* regulator and not a losser, as available heretofore. In addition, the output wave form approaches a sine wave, which is especially desirable in certain applications. Also, any number of output voltages and currents, both AC and DC, can be obtained from the secondary circuit of a single transformer.

* * * * *

E-L Vibrator Power Supplies have wide application in many fields: radio, electrical, electronic, marine, aviation and railroad. Their high efficiency and versatility with multiple inputs and outputs, enable them to meet many power supply needs. They may be designed to provide any wave form required for specific equipment. . . . Economy is assured because of long, efficient service with minimum maintenance. E-L Engineering Service is available to discuss your power supply problem and to design a vibrator power supply to meet specific voltage, power, size and weight requirements.

E-L STANDARD POWER SUPPLY
Model 1566

This typical E-L unit, with voltage regulation, is used to supply the necessary voltages for the Signal Corps Model BC-100 Walkie Talkie Transmitter-Receiver, from a 6, 12, or 24 volt storage battery.

Input Voltages: 6, 12 and 24 volts DC

Output Voltages: 140 volts DC at 0—55 ma . . . 90 volts DC at 30 ma. . . 45 volts DC at 250—550 ma.

Regulation: Output voltages are held constant within 5% over the entire range of load changes listed above, as well as over input voltage variations, as for example, 5.7 volts to 7.5 volts.

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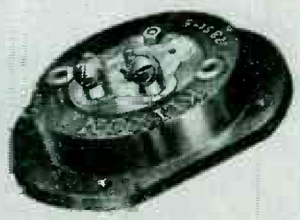
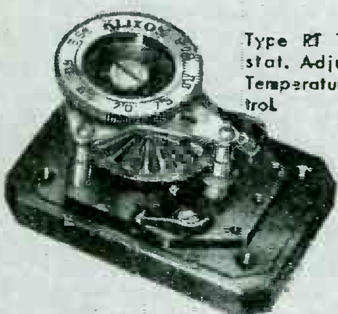
Type C-7220 Precision Snap Switch. 12 amps. 30 Volts D. C., 125 Volts A. C.



Type C-2851 Thermostat. For such use as Roughing Controls on Outer Crystal Ovens.

Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.

Type PM (NAF-1131) Circuit Breaker.



Type RT Thermostat. Adjustable Temperature Control.

Type ER Series. Ambient Compensated Time Delay Relays.

Type B-3120 Thermostat and Heater, Crystal Dew Point Control.

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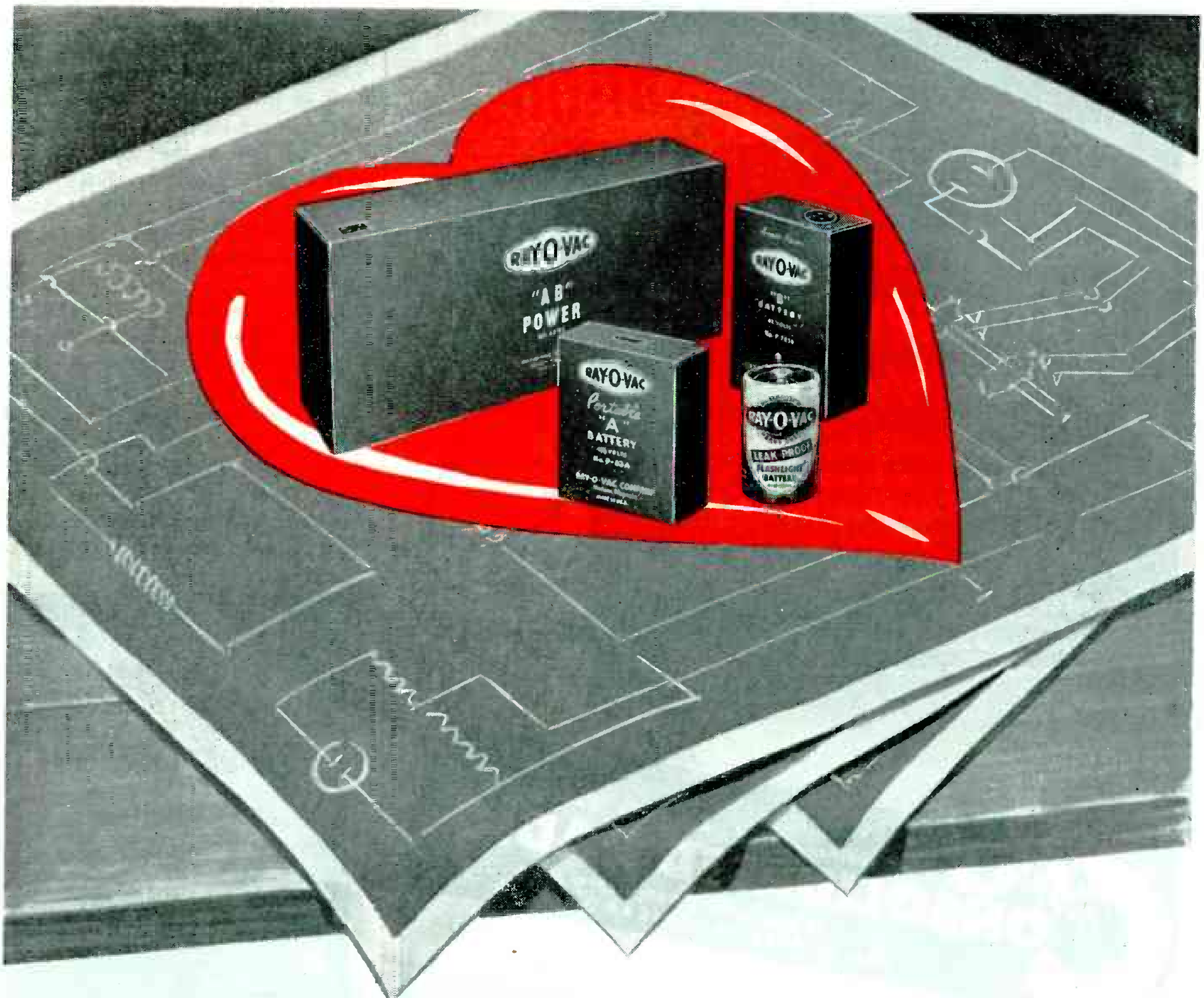

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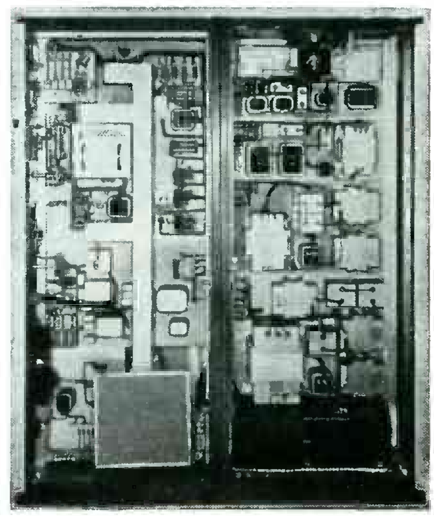
back voltage is interrupted through failure of the radio frequency carrier, a relay is used in the grid circuit of the modulator which opens the primary circuit of the 600-volt rectifier when the grid current drops below a given value.

Tests jacks enable maintenance personnel to introduce a test signal from a signal generator on the grid of any stage. Provision is also made for the insertion of a shielded vacuum-tube voltmeter on the grid and on the plate of the stage under test. The grid of the following stage is disconnected and grounded, and the plate voltmeter capacity made equal to the grid capacity. This measuring technique allows the gain frequency characteristic of each signal frequency amplifier, or



Right-hand side of transmitter. Air passing through the filter at bottom is forced by a blower through a ventilating duct for distribution to the tubes

of the four in cascade, to be readily obtained.

With respect to neutralization, an excellent condition was obtained with the simultaneous minimizing of the modulator plate currents and maximizing of the grid currents. It was found that a suitably linear relationship between the plate voltage and load current was realized for a load impedance permitting a carrier output power of approximately 50 watts. For this condition the total plate-circuit bandwidth, for a 3 db reduction in amplitude, is approximately 1.8 megacycles.

Klystron Characteristics

Characteristics of Klystrons as well as conventional tubes are conveniently measured by dynamic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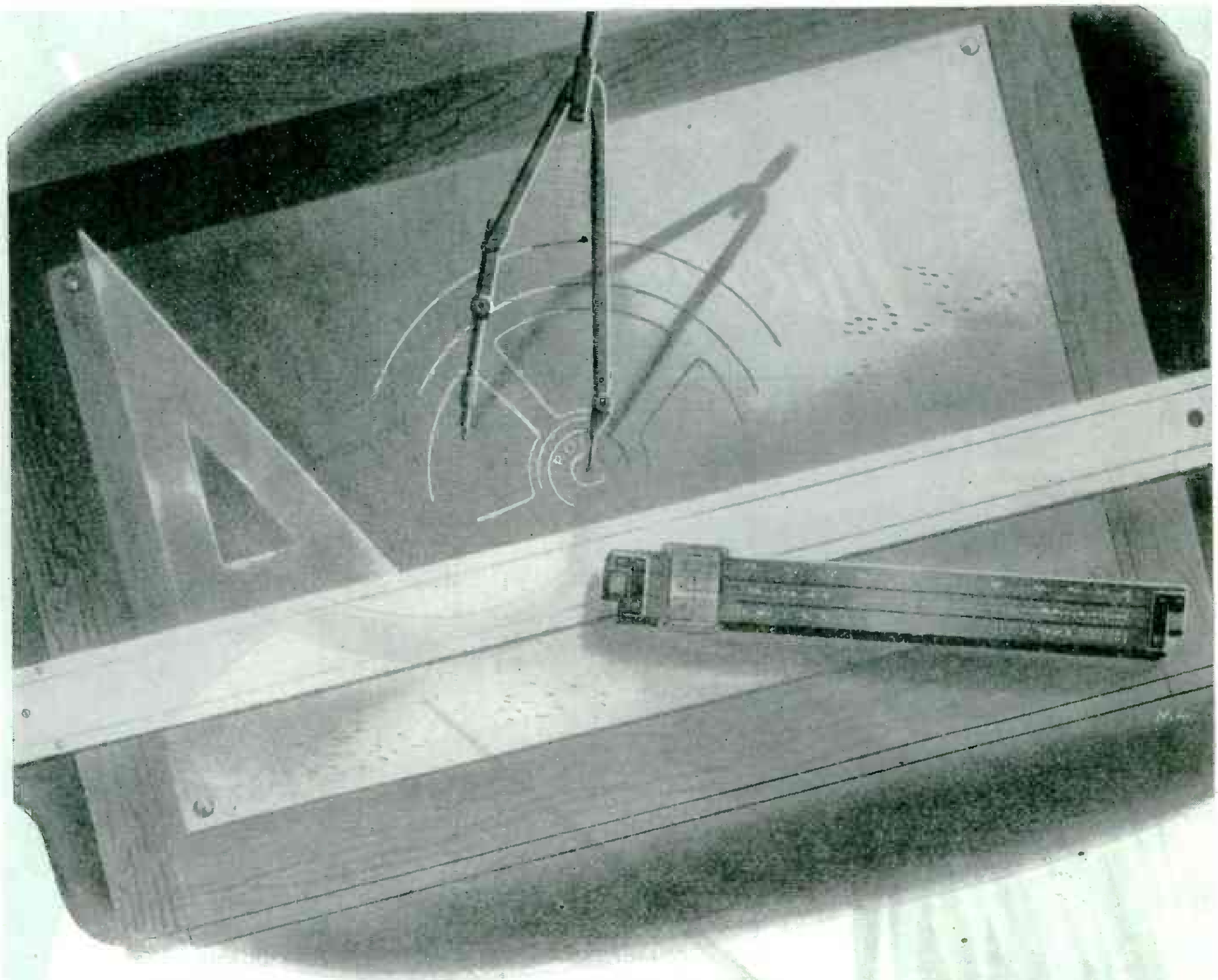

This Blueprint Must Wait

In April, 1942 . . . nearly 3 years ago . . . Rola girded itself for War work and since has confined its Speaker manufacturing to authorized experimental models and needed repairs. From that time, and to meet rising demands for intricate military communications equipment, Rola's facilities have been expanded until now, nearly three times as many people are employed. New machinery has been designed and built and new manufacturing processes have been developed and perfected.

Until wartime obligations are completed all needed manpower and equipment must continue in the production of vital communications components, but after that, Rola firmly intends to keep *all* its employees and *all* its equipment busy. This is a reasonable expectation. The latest developments and discoveries . . . by-products of Rola's wartime activities . . . are finding application in new Speaker designs, that set new standards of Speaker performance. And beyond this, other things are projected that will enable Rola to serve *more customers,* in *more ways* than ever before.

Specific announcements must wait, but this, in short, is Rola's declaration of policy to its Employees, to former Customers and to the Electronic Industry . . . Rola's blueprint for the future.

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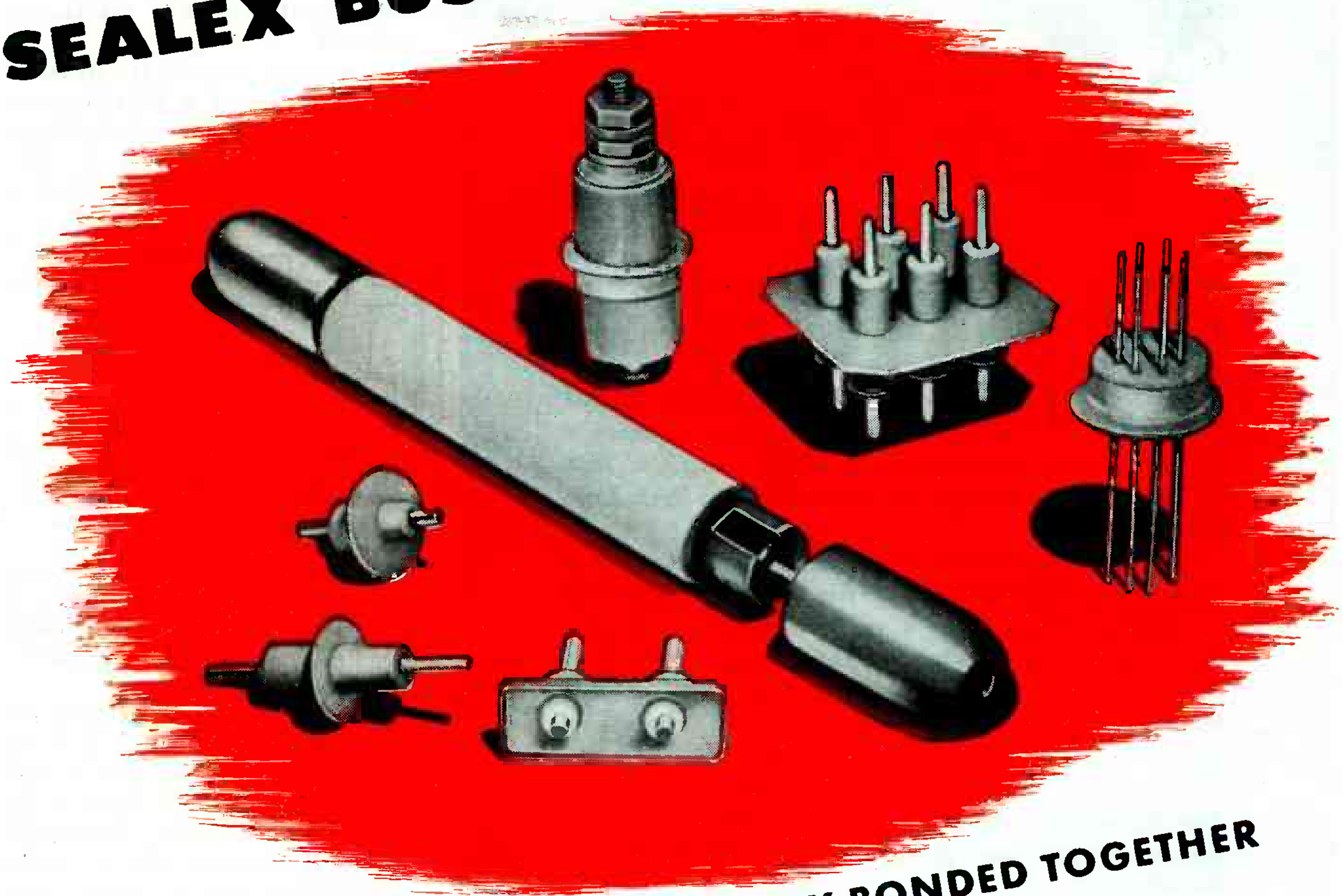

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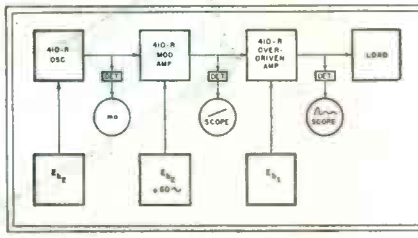
methods. Coleman Dodd of Sperry Gyroscope Co. showed how the method was applied to Klystrons and presented some of the results obtained.

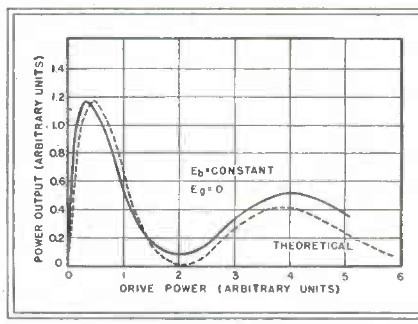
To observe some of the dynamic characteristics of a Klystron amplifier, the arrangement shown in the diagram was used. A type 410-R Klystron oscillator is used as



Block diagram showing the method used to measure dynamically the characteristics of Klystron amplifiers

an excitation source for a Klystron amplifier whose beam voltage is modulated at 60 cps. The oscillator supplies constant drive power to this first amplifier.

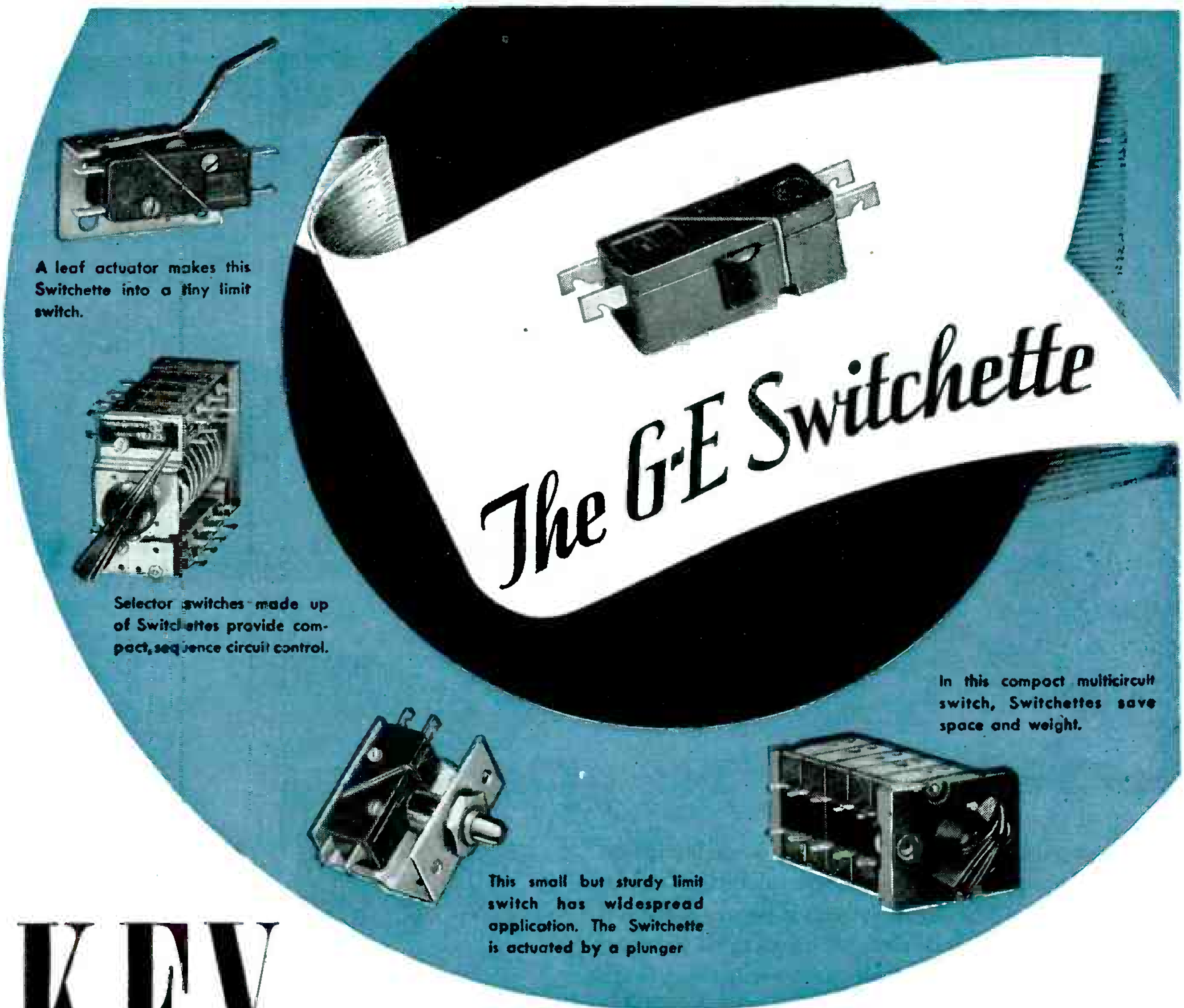
A crystal detector coupled to the amplifier output supplies an oscilloscope with a signal that is proportional to the power output of the first Klystron amplifier. This oscilloscope is operated with its sweep synchronized with the beam modulating voltage, giving a pattern on the screen of power output vs beam voltage characteristic for constant drive power. Beam voltage, modulation voltage, and drive power are



A comparison of theoretical and dynamically measured Klystron amplifier characteristics reduced to common ordinates shows the usefulness of the method

varied so that a variety of operating conditions can be investigated.

The variable power output of the first amplifier is used to drive a second Klystron amplifier. An oscilloscope, monitoring the output of this amplifier, traces the power output vs drive power characteristic for the Klystron amplifier operated



A leaf actuator makes this Switchette into a tiny limit switch.

Selector switches made up of Switchettes provide compact, sequence circuit control.

In this compact multicircuit switch, Switchettes save space and weight.

This small but sturdy limit switch has widespread application. The Switchette is actuated by a plunger

KEY TO COMPACT DESIGN

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Note the dimensions: 1¼ by ½ by ½ inch. Yet the Switchette handles up to 10 amperes at 24 volts d-c (230 volts a-c), and is sturdy enough to withstand millions of mechanical operations.

Its small size, its lightning-fast snap action, and its ability to resist high physical shock and vibration make it ideal for built-in applications on electric control equipment that has to "take it." Best of all, because of its unusual double-break contact structure, it simplifies the solution of many tricky circuit-control problems.

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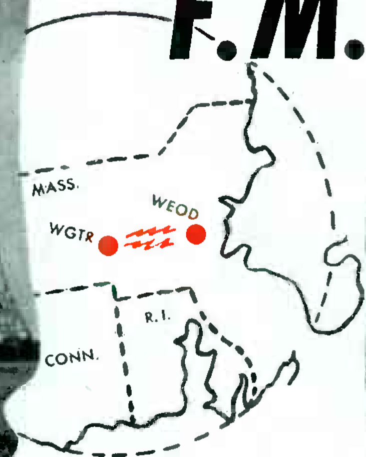

BOSTON

F. M. relay operation...offered by others as a postwar possibility...is already an REL accomplishment of proven reliability.

● For five years, the first studio-to-transmitter F. M. relay ever to be installed has been in continuous practical operation by the Yankee Network *without wire connections* between studio and transmitter. Programs originating in Station WEOD, located atop the Buckminster Hotel, Boston, are relayed to Station WGTR 50 kw, also an REL installation in Paxton 43 miles distant, over two hill-ranges and beyond line of sight.

Yes, REL has in back of its organization five years of practical operation—in F. M. relaying, a field generally regarded as one for future development. REL has again established a scientific precedent . . . and continues to energetically and successfully lead the field in radio pioneering!

REL equipment in this installation consists of 250 w., S-T link transmitter operating on 156.75 mc.

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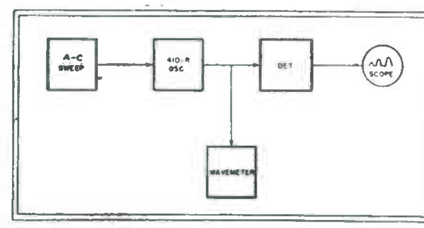
at a constant beam voltage. Dynamic characteristics obtained in this way and those predicted by the theory compare quite well.

This power output vs drive power characteristic illustrates several practical conclusions. They are: (1) power output does not reach a saturation value as the drive power is increased, but reaches an optimum and then decreases, (2) with excessive drive, power output will pass through several maxima and minima, (3) power gain is about 2.5 times as great at low drive powers as it is at maximum power output, and (4) operation beyond the first maximum is undesirable.

Dynamic methods of observing Klystron characteristics can be applied equally well to Klystron oscillators. A Klystron oscillator is shown in the accompanying block



Frequency characteristics of Klystron oscillators as well as their power characteristics can be measured dynamically

diagram which obtains its variable beam voltage from a standard plate supply transformer. The output of the oscillator is monitored by a crystal detector and oscilloscope. The pattern on the oscilloscope indicates how power output of the oscillator varies with changes in the beam voltage.

The wavemeter connected to the output circuit of the Klystron oscillator provides a way of checking variation in oscillator frequency as the beam voltage is changed. A notch will appear in the oscilloscope trace at the point corresponding to the frequency at which the wavemeter is absorbing power.

Over page is a typical Klystron oscillator characteristic which was obtained by this method. Frequency deviation curves at the top of the figure were obtained by the absorption type wave-meter method. Tuning of the resonant cavities and changing the length of the feedback line can also be investigated by this method.

Minor trimming adjustments are

The Greeks gave us a word for it . . . now we give it to *you*

WHEN Sperry first developed its velocity-modulated, ultra-high-frequency tube, the word "KLYSTRON" was registered as the name of the new device.

This name — from the Greek, as coined by scientists of Stanford University — is an apt description of the bunching of electrons between spaced grids within the tube.

"Klystron" is a good name. So good, that it has come into widespread use as the handy way to designate *any* tube of its general type, whether a Sperry product or not.

This is perfectly understandable. For the technical description of a Klystron-type tube is unwieldy, whether in written specifications, in conversation, or in instructing members of the Armed Forces in the operation of devices employing such tubes.

These conditions have prompted many requests from standardization agencies—including those of the Army and Navy—for unrestricted use of the name Klystron. In the public interest, Sperry has been glad to comply with these requests . . .

From now on, the name KLYSTRON belongs to the public, and may be used by anyone as the designation for velocity-modulated tubes of any manufacture.

Sperry will, of course, continue to make the many types of Klystrons it now produces, and to develop new ones.

On request, information about Klystrons will be sent, subject to military restrictions.

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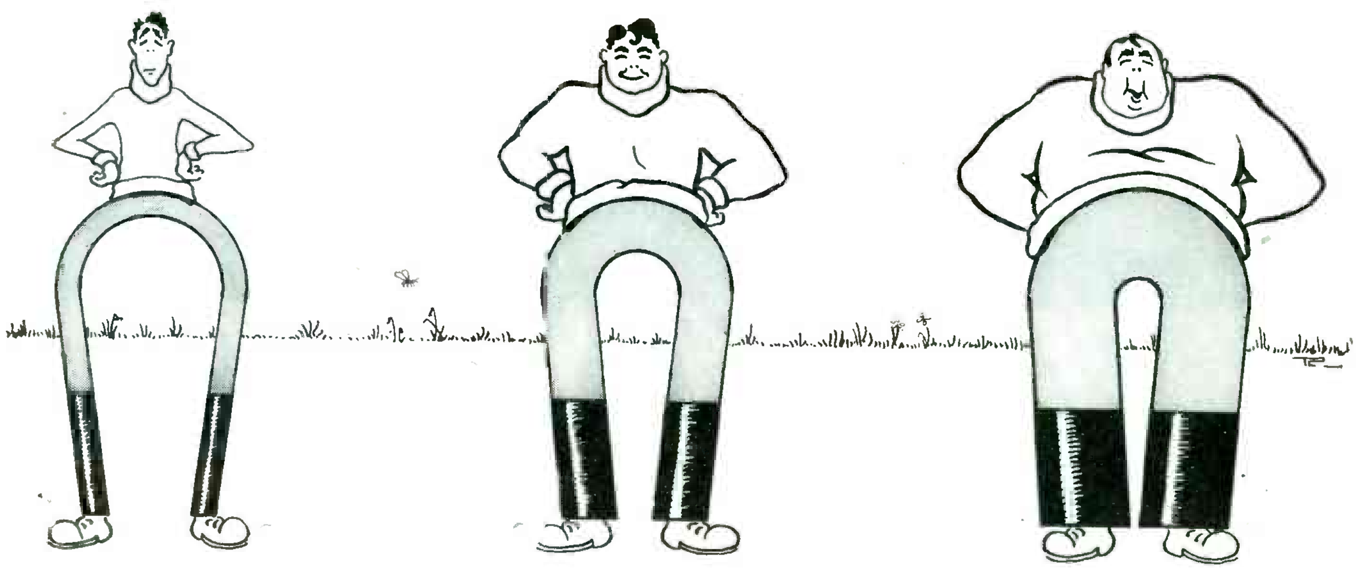
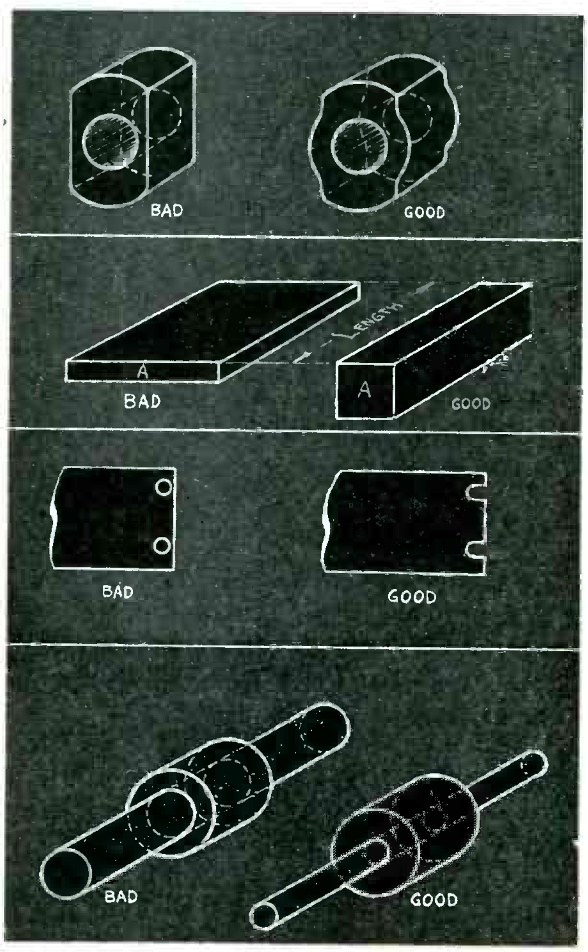


NEITHER TOO FAT NOR TOO THIN



That skinny chap at the left could do with some setting up exercises. An extended course at some accredited physical culture school would put some flesh on his bones, where it belongs. And as for that rather portly gentlemen on the right, he's no Superman. He's too fat.

Magnets, like people, should be well proportioned. Just the right amounts of metal at the right places give them the mechanical strength to withstand the necessary grinding down and subsequent annealing operations. The shape as well as size has a bearing on the energy content desired. A few simple rules on proper proportioning which will help in designing magnets are discussed in our pamphlet "PERMANENT MAGNET DESIGN." We'll be glad to send you a copy.

3-CC-1

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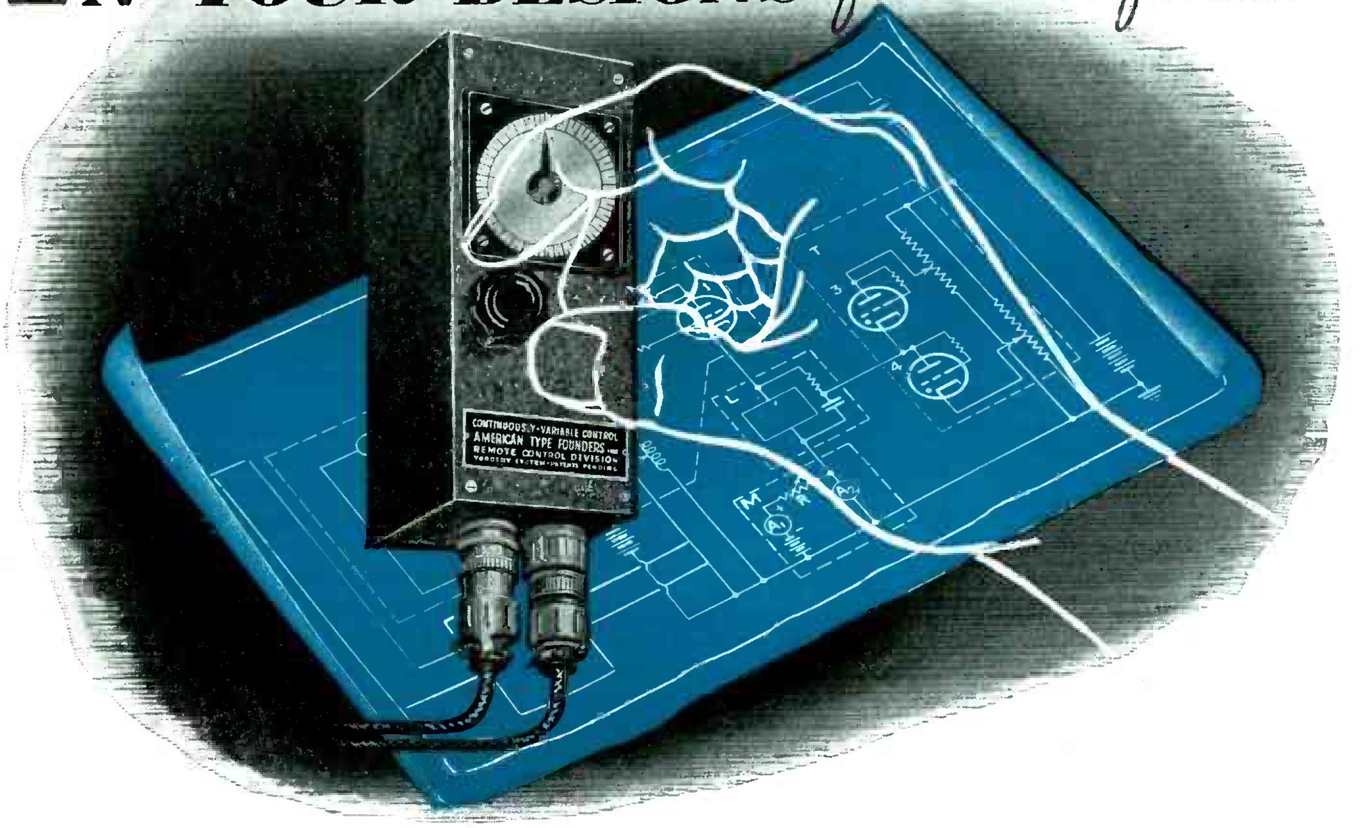

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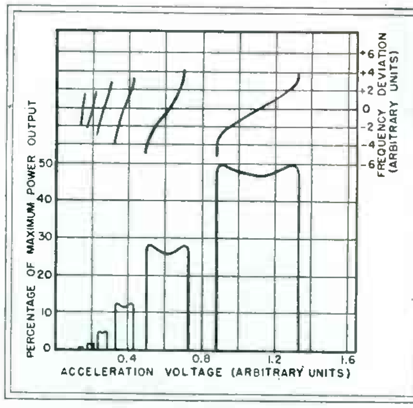


Using the wavemeter and oscilloscope, these Klystron oscillator characteristics were obtained (see ELECTRONICS November 1944, p 106)

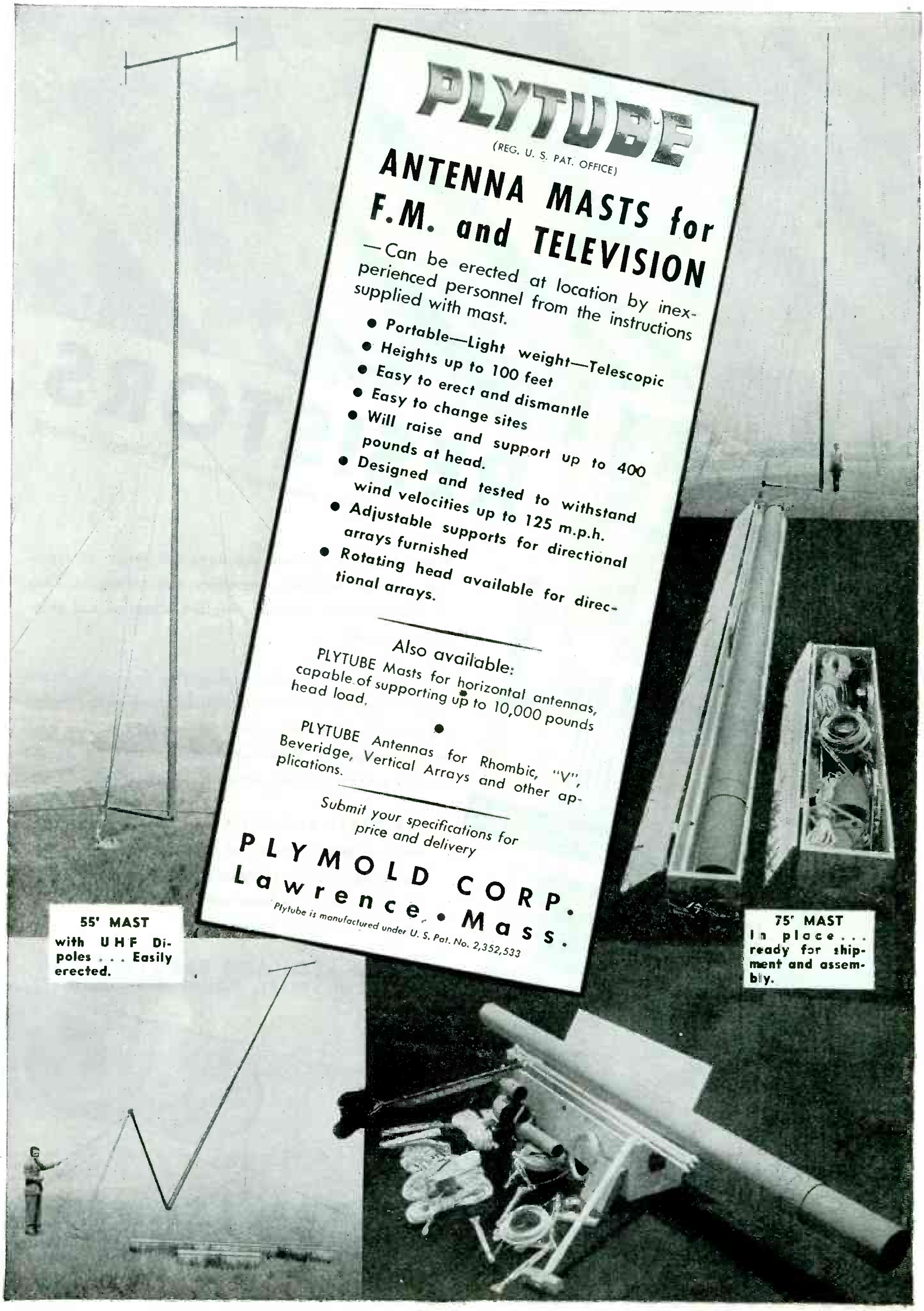
usually all that are required to get the tube to work at a static operating condition after it has been adjusted using this dynamic method. The equipment was demonstrated and those present had an opportunity to make adjustments on 410-R Klystrons and observe the effects on oscilloscopes.

Two-Resonator Klystron Oscillator

Dependence of power output and frequency of Klystron oscillators on beam transconductance was explained by D. R. Hamilton of Sperry Gyroscope Co.

By representing the Klystron oscillator as an ideal pentode with associated coupled resonant circuit, phase delay network and feedback loop; conventional circuit analysis can be used to predict the behavior of the Klystron oscillator. The theoretical results are amply verified by measurements made by the dynamic technique described and demonstrated previously.

Representing the Klystron by an equivalent oscillator of conventional components indicates that the difference between the Klystron and the more conventional arrangement lies in a distinction between the basic nature of the electronic transconductance in the Klystron and in a conventional vacuum tube. In a triode, transconductance arises from the control which the static grid voltage exerts on the static plate current. In a Klystron, the r-f current arises from grid control of the electron velocity in an already accelerated electron beam, followed by the resulting bunching action in a field-free drift space. A static plate-current vs. grid-voltage characteristic whose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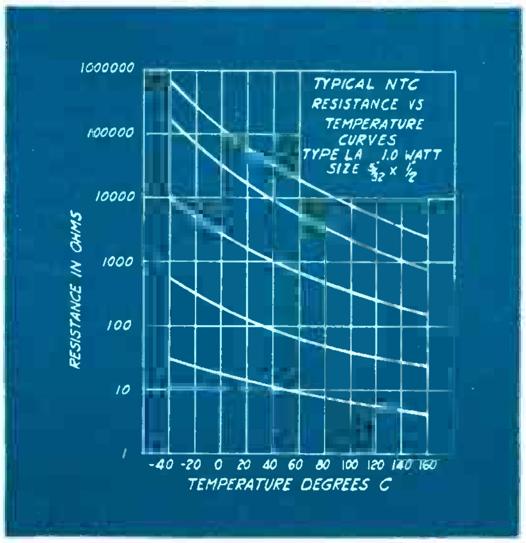
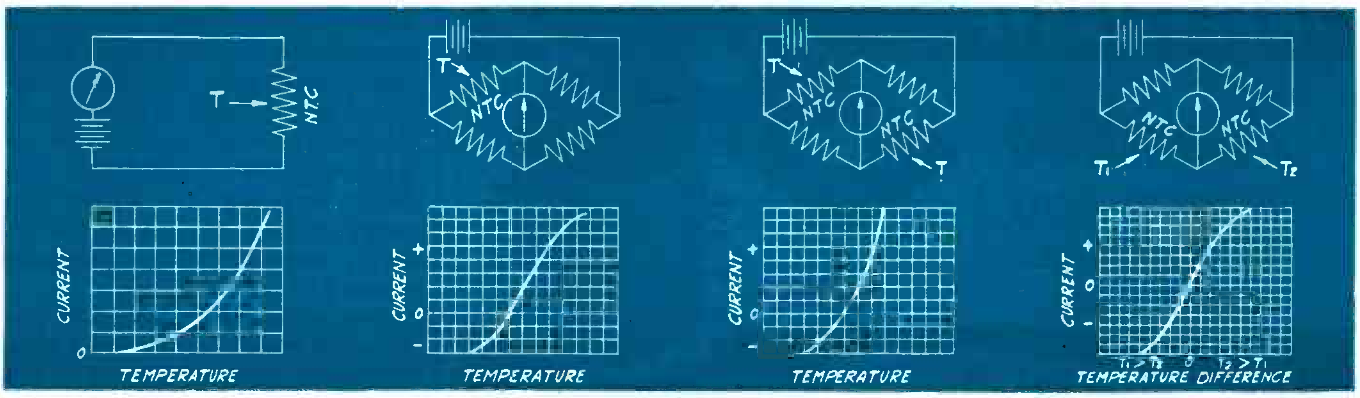


CHECK THESE ADVANTAGES OF KEYSTONE NTC UNITS FOR YOUR APPLICATION

Keystone NTC units are electrical resistors especially developed to have an unusually high negative temperature coefficient of resistivity. The slopes are much greater than those observed with pure metals or their alloys. The result is an element with very high thermal sensitivity, useful on AC or DC, inherently suitable for remote indication, which has gained wide acceptance for temperature measurement and control purposes. NTC units are made in wide range of shapes, resistance values, temperature coefficients and wattage ratings, of which the characteristics at the left are typical. The circuits below suggest basic means for translating resistance changes into current or voltage variations. Modifications and extensions of these principles are many, especially in conjunction with electronic apparatus.



This simple series circuit of voltage source, instrument and NTC unit has been utilized to indicate engine coolant temperature, etc. It provides sufficient accuracy for many applications despite scale crowding at the bottom.

Basic bridge circuit straightens and steepens the characteristic. Zero-center meter may be used or balance point may be placed near the lowest temperature. Electronic balance indication provides enhanced sensitivity.

Adding a second NTC unit, and exposing both to the temperature to be indicated, gives a double unbalancing effect and increases sensitivity under certain conditions over part of the temperature range.

Two NTC units in adjacent arms is a method of indicating equality of two temperatures, or temperature difference or rise. Temperature of either source can be obtained by substitution of standard resistance for other NTC unit.

Keystone NTC resistors are also valuable for neutralizing the change in resistance with temperature of electrical indicating instruments and control devices, for introducing time delays and many other applications. Write and tell us about your problem—we'll be glad to analyze it for the applicability of NTC units.

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slope gives the transconductance of a triode, is therefore meaningless; nevertheless, one may still speak of a dynamic transconductance which is the ratio of peak r-f current passing through the output resonator to the peak r-f gap voltage across the input resonator. One may thus proceed along conventional lines to analyze the behaviour of the Klystron oscillator bearing in mind this distinction in the physical origin in graphical portrayal of the electronic transconductance.

Curves obtained from this theory also show the way in which a Klystron oscillator may be adjusted to give a linear frequency modulation characteristic with nearly constant amplitude, and imply the known fact that detuning of the resonators may be utilized to obtain a higher output over a narrower range of frequency. (For curves of the type referred to by Mr. Hamilton and the method of their derivation see ELECTRONICS for November 1944.)

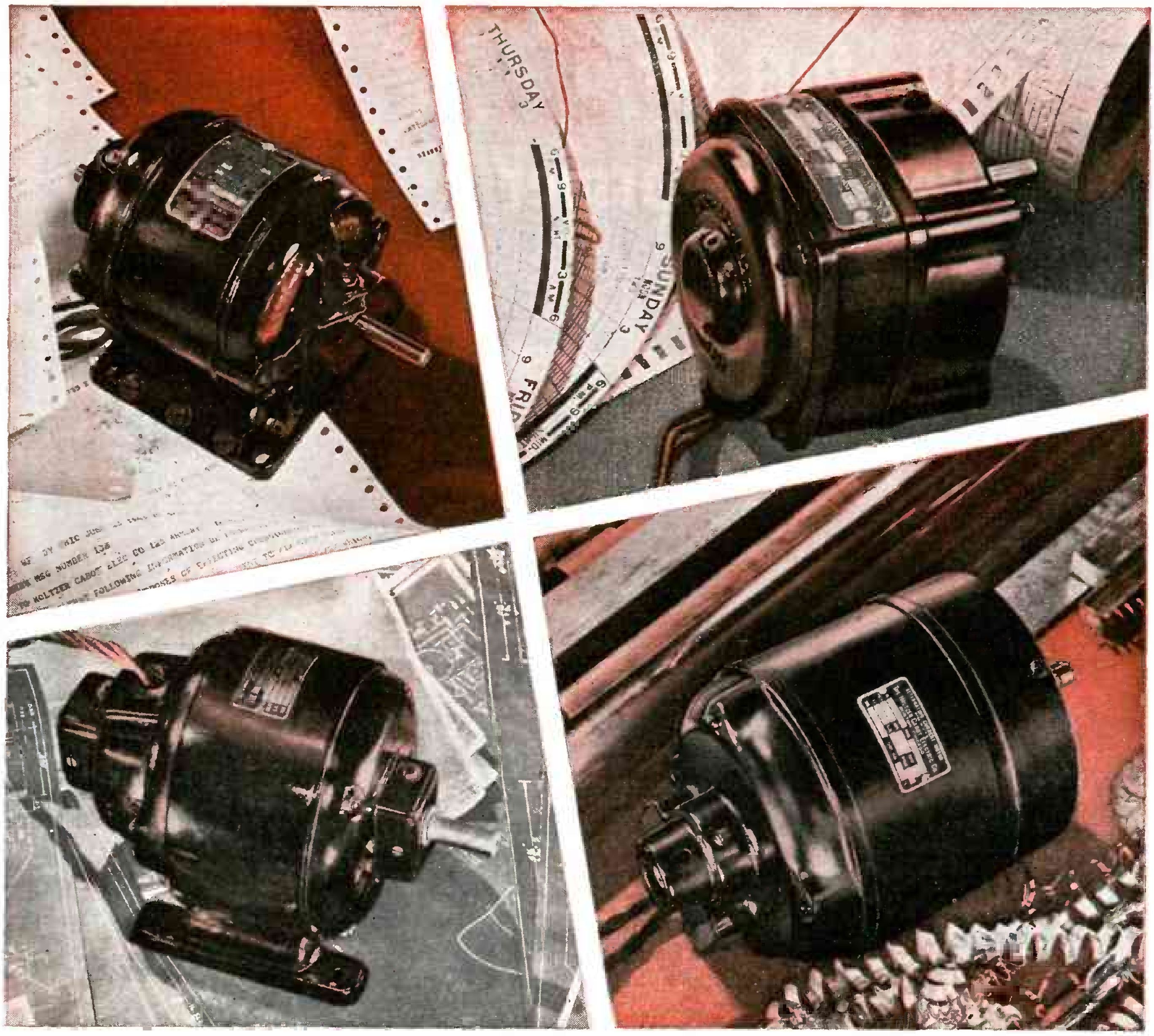
Impulse Noise

Measurements of the susceptibility to impulse noise, such as ignition interference in receivers, were presented by Jerry B. Minter of Measurements Corp. To obtain reproducible results, a noise source consisting of a d-c pulse plus a carrier pulse was used to simulate the frequency-energy distribution of ignition wave trains. The synthetic pulse and the signal were simultaneously applied to the receiver input through a balancing network.

Test equipment required to perform the measurements are a pulse generator, a signal generator and an output meter. For the latter, a polarized peak-reading vtvm is preferred although an oscilloscope can be used.

The noise interference is a function of the noise intensity and therefore measurements should be made at several noise levels. The technique consisted of determining what signal level was required to adequately over-ride the noise for various receiver conditions.

Results from the measurements on f-m receivers show that a balanced type of discriminator of short time-constant gives the best noise rejection. In television, afc of the horizontal synchronizing



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For over 50 years Holtzer-Cabot has concentrated its facilities in the design and application of special motors, such as those illustrated above, to meet specific design and performance requirements of such products as machine tools, instruments, business machines and aircraft. And although today, military requirements get first call on all of Holtzer-Cabot's motor production, our motor development engineers will gladly discuss your postwar fractional H.P. motor requirements with you. There is no obligation, of course.

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ALLIS-CHALMERS Power Transformers are designed and built for continuity of operation with minimum of maintenance.

In spite of increased industrial loads demanded by the war effort, these transformers have operated far beyond their rated capacity for extended periods without interruption, without other than routine maintenance. *That's performance!*

It is a source of considerable satisfaction to us that Natvar insulating materials, because of their high uniformity, were selected for this important application.

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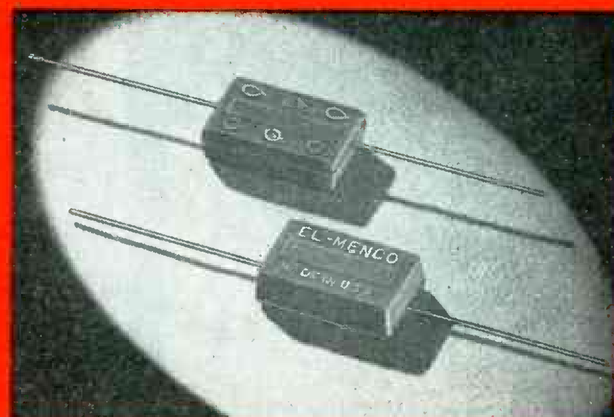
So little



but they mean so much to so many

Small, unseen, Electro Motive Capacitors — in countless numbers — are contributing to the certainty of our battle communications systems.

Upon the continuously reliable performance of these systems the lives of our fighting men depend. They *must not* fail.

Electro Motive is proud of the part its products are playing now — looks forward to the day when the same products will be helping to bring comfort and entertainment to the men they are now helping to protect.

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CAPACITORS

generator has a decided advantage. Because of the serious effects on noise susceptibility of detuning, Mr. Minter recommended afc for the local oscillator.

X-Ray Irradiation of Quartz Crystals

The various effects produced by subjecting quartz plates to x-ray radiations were described by Clifford Frondel, Department of Mineralogy, Harvard University. In general, the frequency of oscillation decreases continuously during irradiation to a limiting value, and types of plates dependent on different elastic constants are affected unequally. For example, high-frequency BT plates decrease with irradiation between 0.006 and 0.12 percent of the initial fundamental frequency. (See ELECTRONICS for Dec., 1944, p. 227.)

The technique is now being used in production of quartz plates and rates of frequency change now being accomplished average about 40 cycles per minute of exposure to the rays. The frequency change brought about by the x-rays can be reversed and the plate restored to its original frequency and color by baking at temperatures over about 175 deg C. The plates can also be sensitized to irradiation by prior baking.

Equipment for X-Raying Quartz Plates

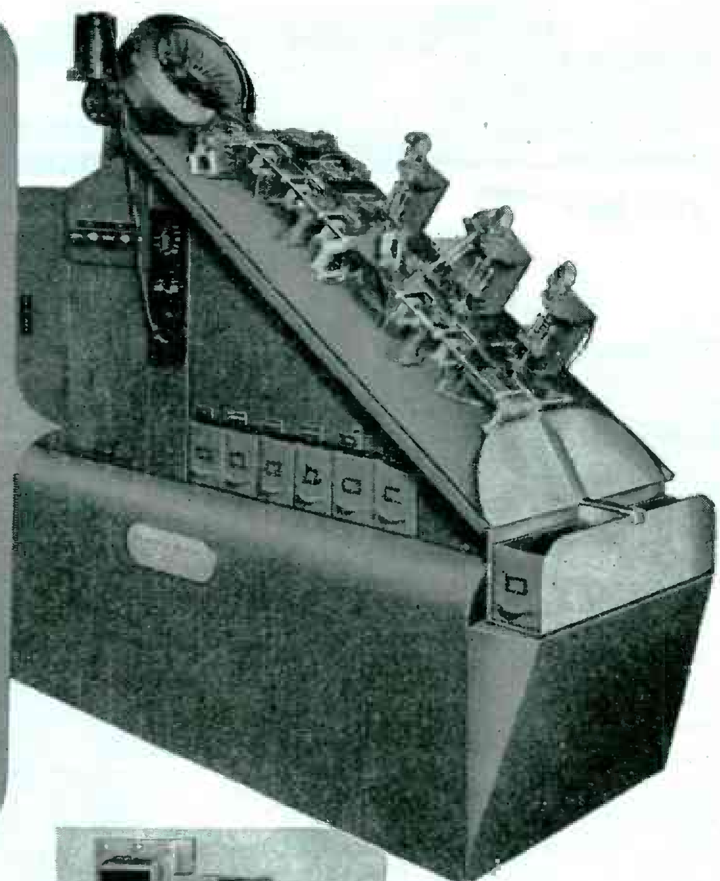
Description of preliminary experiments which consisted mainly of radiating many crystals with various types of x-ray tubes com-

X-ray irradiation unit developed by North American Philips in collaboration with Dr. Frondel and the U. S. Army Signal Corps for lowering the frequency of quartz plates

86 Pieces Gaged Per Minute

EACH CHECKED FOR 7 DIMENSIONS

Thanks to MICRO SWITCH

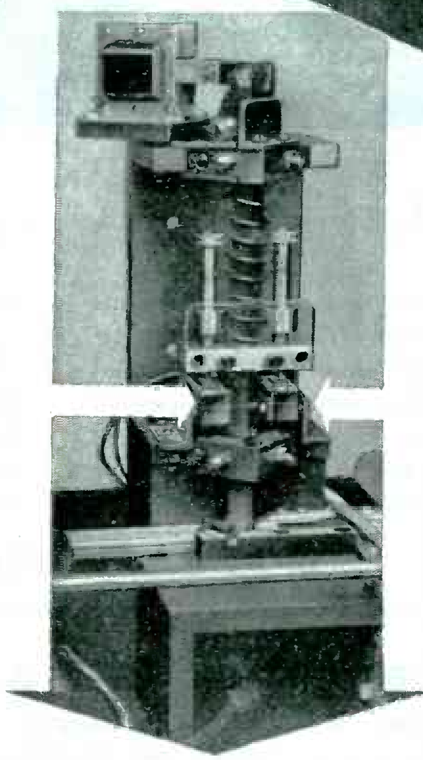


Automatic checking of small parts to assure that they are within allowable tolerances is accomplished by this "Gage-O-Matic" precision gaging machine through the use of Micro Switch products.

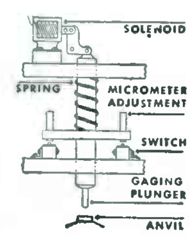
Built by the General Control Company for the use of Hamilton Standard Propellers, the "Gage-O-Matic" permits high speed checking of seven accurate dimensions at the rate of 85 pieces per minute.

This is accomplished by pairs of plastic enclosed switches which monitor each gaging operation. They are actuated by micrometer heads mounted on a sliding bar. If the part being tested is in tolerance, *one* switch is actuated . . . if under tolerance, *both* are actuated . . . if over tolerance, neither is actuated.

If the part is over or under tolerance, it drops through a tube into the proper rejection drawer, automatically segregating rejected parts for their particular defect.



Here's How it Works



The small parts are fed through a chute by a rotating hopper. As the part slides down the chute, it is stopped at different intervals by solenoid controlled levers. The part is positioned between the gaging plunger and anvil, then the solenoid on the gaging head is released. The spring drives the gaging plunger assembly down and in contact with the part.

The gaging assembly is then pulled up by the solenoid and the part, if acceptable, is permitted to move to the next state.

1,001 Jobs For Micro Switch Products

In wartime production and after victory, there are 1,001 important jobs for Micro Switch products in every branch of industry. They control temperature, help package products, limit machine operations and serve as sensitive and efficient controls for a limitless number of electrical and electronic devices.

Production and design engineers, planning new products or seeking ways to improve present products, should be thoroughly familiar with the many advantages of these rugged, compact, sensitive snap-action switches. Write today for Handbook-Catalog No. 60 which gives complete details on electrical characteristics, housings and actuators.

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TRADE MARK
A DIVISION OF FIRST INDUSTRIAL CORPORATION
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This is the basic switch—a thumb-size, feather-light, plastic enclosed, precision, snap-action switch, Underwriters' listed and rated at 1200 V. A., at 125 to 460 volts a-c. Capacity on d-c depends on load characteristics. Accurate reproducibility of performance is maintained over millions of operations. Basic switches of different characteristics are combined with various actuators and metal housings to meet a wide range of requirements.

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FERRANTI equipment is foremost in our fight for Victory in '45. The new tanks, the latest form of underwater sound equipment and America's newest bombers with their improved detecting devices, utilize Electronic Equipment dependent on transformers and inductors for their efficient and reliable operations.

With a capacity now *ten* times that of recent years, and still growing, Ferranti Research, Engineering and Production facilities have kept ahead of military needs, and thereby offer unexcelled Service and prompt deliveries on Transformers, Chokes, Filters, and other allied *QUALITY* products for commercial use.

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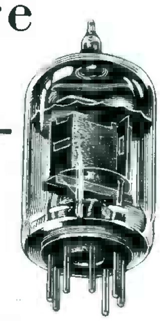
more efficient ... in miniature



The modern hearing aid is a fine example of greater efficiency . . . in miniature. No longer does the awkward ear trumpet or an apologetic "a little louder please" embarrass the hard of hearing. The compact hearing aid of today with its inconspicuous ear button, now admits these people to a world from which partial deafness had formerly isolated them. This has been made possible by smaller tubes.

In countless applications, TUNG-SOL Miniature Tubes do everything the large old style tubes did and in most cases are doing it better.

To manufacturers of radio sets and electronic devices, size and weight reduction is so important that TUNG-SOL is now producing many of the new miniature types. The development of other miniature types to function where larger tubes are now used is also foreseen.

Designers of electronic equipment are invited to work with TUNG-SOL engineers in the planning of circuits and in the selection of tubes. Consultation work of this character is held in strictest confidence.

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

ARMY E NAVY

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors mercially available in order to determine empirically the most appropriate conditions of radiation was made in a paper by Charles Roddy of North American Philips. Features of equipment specifically engineered for irradiating quartz plates in production were also given.

From the experiments, it was decided that the following conditions might be stated as an approximate specification for a suitable tube.

1. Tubes must have high current capacity and be capable of continuous operation.

2. Voltage necessary, not in excess of 60 kv. (Limit of voltage on anode ground tube). Higher voltages, in addition to providing radiation which is not easily absorbed in the small thicknesses of quartz, requires larger tube diameter. This in turn reduces the field intensity at the irradiated surface, under present limitations of the mechanics of tube construction.

3. The window material should be as thin as possible, and of a material with extremely low absorption such as Lindemann glass or beryllium.

4. The tube should be of the grounded anode type in order to facilitate cooling by water at ground potential.

5. Tube should have as many windows as possible in order to utilize as much of the hemisphere of radiation as possible.

A tube of this general description had been designed for diffraction purposes and had a capacity of 25 ma and 60 kv for continuous operation. This tube was provided with a redesigned chrome-iron envelope and larger portals arranged at a higher anode angle, in order to cover the area necessary. The number of windows was reduced to two.

To protect the thin Lindemann glass windows from secondary electronic bombardment, the cathode assembly was shielded so that the X-ray beam from the anode passed through a small hole in the shield. Enlarging this hole provided a beam of greater cross-section, but failure of the window became a problem due to charges built up by secondary electron bombardment which puncture the window. This was overcome by welding two crossed wires over the aperture to

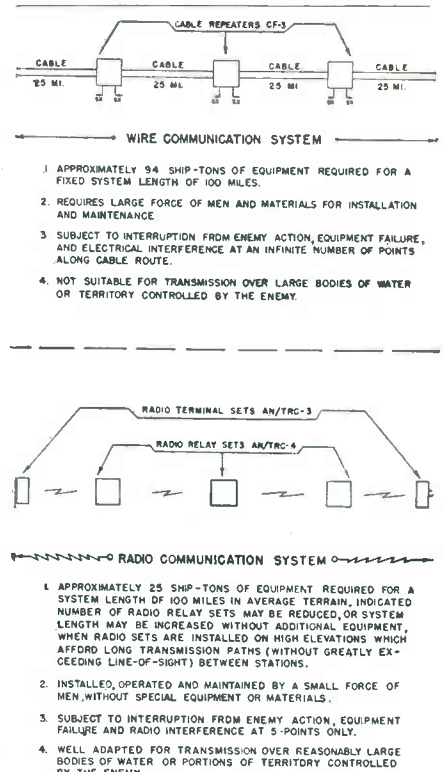
form an electrostatic barrier to electron emission. This tube, operated at 25 ma and 50-60 kv with two windows, gave results which apparently approach practical speeds. The problem of feeding crystals into the x-ray beam on each side of the tube with absolute safety to the operator was solved by designing drum shaped fixtures. (See page 166, ELECTRONICS, Nov., 1944.)

Army Radio Relay

A description of radio-relay communication systems in the U. S. Army was presented by Lieutenant-Colonel William S. Marks, Jr., Captain O. D. Perkins, and W. R. Clark, Signal Corps Ground Signal Agency, Asbury Park, N. J.

The Army's vhf radio relay system may be used either to integrate wire and radio circuits or as a separate system in much the same manner as wire circuits.

The heart of this system is the broad band fm radio set developed by the Camp Coles Signal Laboratory of the Signal Corps Ground Signal Agency with the collaboration of Link Radio Corporation. This set is capable of operation either as a terminal of a radio cir-



Tactical comparison of wire and vhf radio transmission for army use. Terminal equipment is identical for both systems

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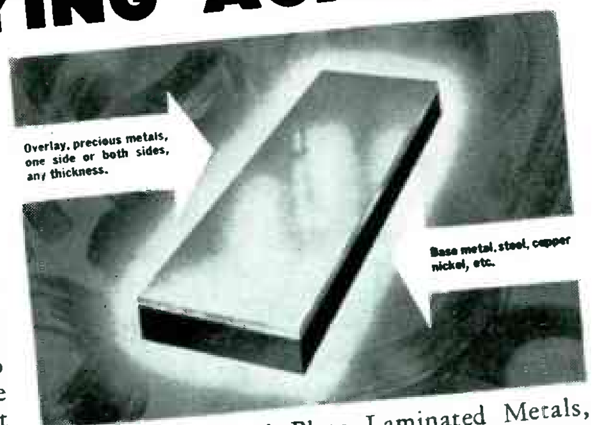

Some day *soon* . . . buying will be done on a selective basis. Then you will have to have every improvement . . . economy of operation, performance such as long life, and price in your favor. General Plate Laminated Metals can help put your product out in front in the competitive stages. Here's how . . . in electrical equipment, it gives you better electrical performance at a fraction of the cost of solid silver . . . in chemical apparatus, it gives you corrosion resistance, inside, outside or both . . . in other applications, ease of fabrication, low cost, plus long life.

No matter what your contemplated postwar products . . . peanut tubes or giant turbines . . . General Plate Laminated Metals can do a better, more economical job for you.

Investigate General Plate Laminated Metals, today. They are available in raw stock or wholly fabricated parts of precious metals laminated to base metals or base metals laminated to base metals. . . . Each and every combination is designed to do a specific job for you better and more economically. Write, specifying your particular problems and our engineers will gladly make their recommendations.

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ATTLEBORO, MASSACHUSETTS

cuit or as an automatic radio relay. It is used in conjunction with the Army's telephone spiral-four carrier-cable system which provides the practicable terminal equipment whereby a radio circuit can be integrated with the wire circuit, or substituted therefor, in whole or in part, as necessity dictates.

The accompanying table shows a tactical comparison of wire and vhf radio transmission facilities. Telephone and telegraph terminal equipment is common to both the radio system and the spiral-four wire system.

Duplex operation is achieved by the use of separate receiving and transmitting frequencies at each radio set. Four telephone channels, each approximately 2800 cycles wide, within an audio frequency band of 200 to 12000 cycles are obtained from the telephone terminal. Channel 1, operating at voice frequencies, is normally used as an order channel for intercommunication between terminals and relay sets for supervision and line-up purposes within the system. Each radio set is equipped with filters to confine the order channel to the band 200 to 3000 cycles and prevent mutual interference with the carrier frequency channels.

Ringing over the individual telephone channels is accomplished from field telephones or switch-

Components of radio communication field terminal equipment. Transmitter and receiver are at center

boards by the use of voice frequency ringers which provide a 1000 cycle tone modulated by the 20 cycle telephone ringer. Tone teletype channels may be provided over any one telephone channel by the connection of the telegraph terminal. Facsimile service may be obtained by the use of facsimile terminal equipment.

The field components of a typical radio set included are a horizontal three-element antenna array comprising a driven dipole fed by a 50

ohm flexible solid dielectric coaxial transmission line and parasitically excited reflector and director dipoles, all adjustable in length to the operating frequency and supported on a mast head by a 40-foot sectional steel tube mast, and a 2500-w, 115-v, 60-cycle, gasoline engine driven generator.

A 250-w radio-frequency amplifier is available as auxiliary equipment for use with the 50-w radio transmitter to increase signal strength over unusually long or noisy transmission paths.

Commercial vhf fm police radio sets were used in the North African Theater of Operations in conjunction with two-tone telegraph terminal apparatus to provide the first

A radio relay station in North Africa

employment of radio relay systems and of radio teletype in tactical operations by Allied Military Forces.

Additional radio teletype facilities were provided during the Sicilian campaign by a duplex system from Tunis to Malta with relays on Cape Bon and Pantelleria.

Radio relay was the link between American VI Corps at Anzio beachhead and its commanding Fifth Army whereby primary means of communication for this vital operation was provided across enemy territory in a manner impossible with wire lines.

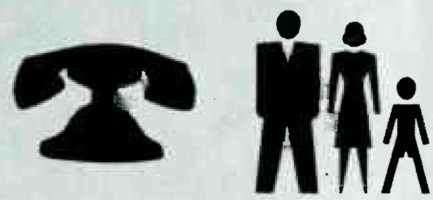
Early in 1944, plans for the invasion of Europe across the English channel included the use of the newly developed vhf fm multichannel equipment. Preliminary tests along the coast of Maine (over comparable topography to the tentative cross-channel route performed with the new equipment) solved technical problems of propagation anticipated in the coming operation. Facilities were installed in England prior to D-day.

On the second day after the initial landing on the Normandy coast,

A MODERN SYLLOGISM

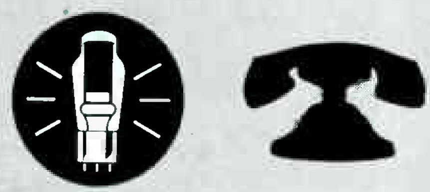
MAJOR PREMISE:

Bell Telephone System serves the American Public.



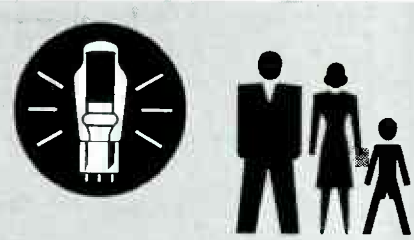
MINOR PREMISE:

Bell Telephone Laboratories develop the facilities of the Bell System.



CONCLUSION:

Therefore, Bell Laboratories serve the American Public.



And that is the *raison d'être* of the Laboratories. For the Bell Telephone System, the Laboratories carry on research studies in all the sciences and development work in all the engineering arts that relate to electrical communication.

For the Western Electric Company, the manufacturing unit of the System, the Laboratories develop equipment, prepare specifications for its construction, and engage in various engineering activities.

For the Armed Forces of the United States, under contracts of the Western Electric, the Laboratories have undertaken more than a thousand development projects — many with spectacular effect upon our enemies.

BELL TELEPHONE LABORATORIES ***explore and invent, devise and perfect for our Armed Forces at war and for continued improvements and economies in telephone service.***

the cross-channel circuit began operation, providing facsimile transmission of air reconnaissance information on military objectives from Tactical Air Command Headquarters in England to the invasion forces in Normandy. Shortly thereafter, full multichannel telephone and teletype facilities were provided from Central Headquarters in England to the field commanders of the First US Army in France. The Air Forces linked their base command establishments by means of similar radio circuits

As the Armed Forces progressed across France, additional radio relay facilities were established for

Radio relay terminal equipment as set up in the field

both tactical requirements in the forward areas, and for administrative purposes in the rear communication zone. With the installation of additional cross-channel facilities, and of wire lines and other radio circuits on the continent, the radio relay systems became part of a completely integrated and comprehensive network of telephone, teletype and telegraph circuits.

Electrometer Tube

Minute measurements with an electrometer tube having the functions of the grid and plate reversed were described by W. A. Hayes of Westinghouse. The sensitivity of the tube is made possible by an extremely low grid current and a high grid-to-cathode resistance (ELECTRONICS, December, 1944, page 176).

It was pointed out that special regulated power supplies, although useful, are not generally required for operation of an instrument of this type. Experience in the laboratory has indicated that ordinary radio-type batteries, when properly seasoned, are entirely satisfactory for the majority of applications. The amount of measurable drift de-

pends upon the sensitivity of the indicating galvanometer used in measurement.

One method of partial compensation for drift is to obtain both filament and bias potentials from a common source and by suitable adjustment of components the variation is made proportional for both elements. This method and several others may be used where extreme sensitivity and accuracy is required. To measure to 0.1 mv, a 4.5-9.0-volt dry battery on the anode and a 6-volt storage battery for filament and bias supply will provide ample stability to make the measurement. Readings more accurate than that require compensation. A change of 0.01 mv can be detected under these conditions using a galvanometer having a sensitivity of 0.0005 μa.

Selectivity of Superregenerative Receivers

Selectivity design parameters of superregenerative receivers were given by Allan Easton of Emerson Radio, who stated that, contrary to popular opinion, the selectivity of a very high-frequency superregenerative detector is better than can be obtained with tuned circuits. Study of the effect of circuit elements on the selectivity of a production receiver showed a total bandwith of 5 percent for a double-tuned antenna transformer alone, while it was 1.75 percent for the superregenerative detector alone.

The receiver examined contained a selective antenna transformer, buffer amplifier, superregenerative detector, quench oscillator and audio amplifier.

After measurement of the contribution of the antenna and detector stage transformers to the total selectivity characteristic, it was found inadvisable to depend upon antenna transformer selectivity because of leakage of strong signals which bypass the transformer. Modification of the superregenerative detector was made to meet the selectivity requirements.

Data on the effects of quench frequency and amplitude over a wide range of values showed a dependence of selectivity on these factors. The total bandwidth is roughly proportional to quench frequency and amplitude. Although no simple correlation between sensitivity and

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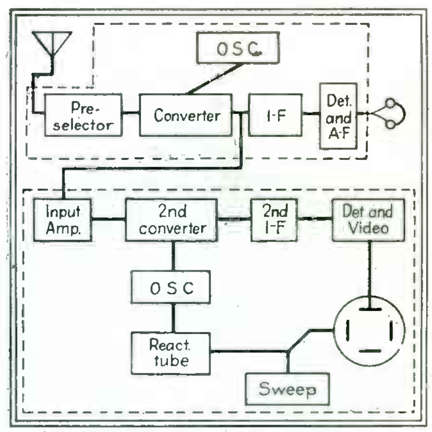
R. F. AND TRANSMITTING COILS AND CHOKES; I. F. TRANSFORMERS quench constants exists, the signal-to-noise ratio is greatly improved as quench frequency and amplitude are reduced. For 100-Mc operation, optimum values were 50 kc and 3 volts rms amplitude.

It was found that bandwidth in selectivity decreased by a ratio of 2:1 as the size of the detector grid capacitor was reduced from 50 $\mu\mu$f to 10 $\mu\mu$f. Detuning on strong signals was reduced by a larger ratio.

R-F Spectrum Analyzers

A mathematical discussion of the properties of tuned circuits in terms of the relations between bandwidth, resolving power and repetition rate was presented by Everard Williams of Air Technical Service Command, Wright Field,

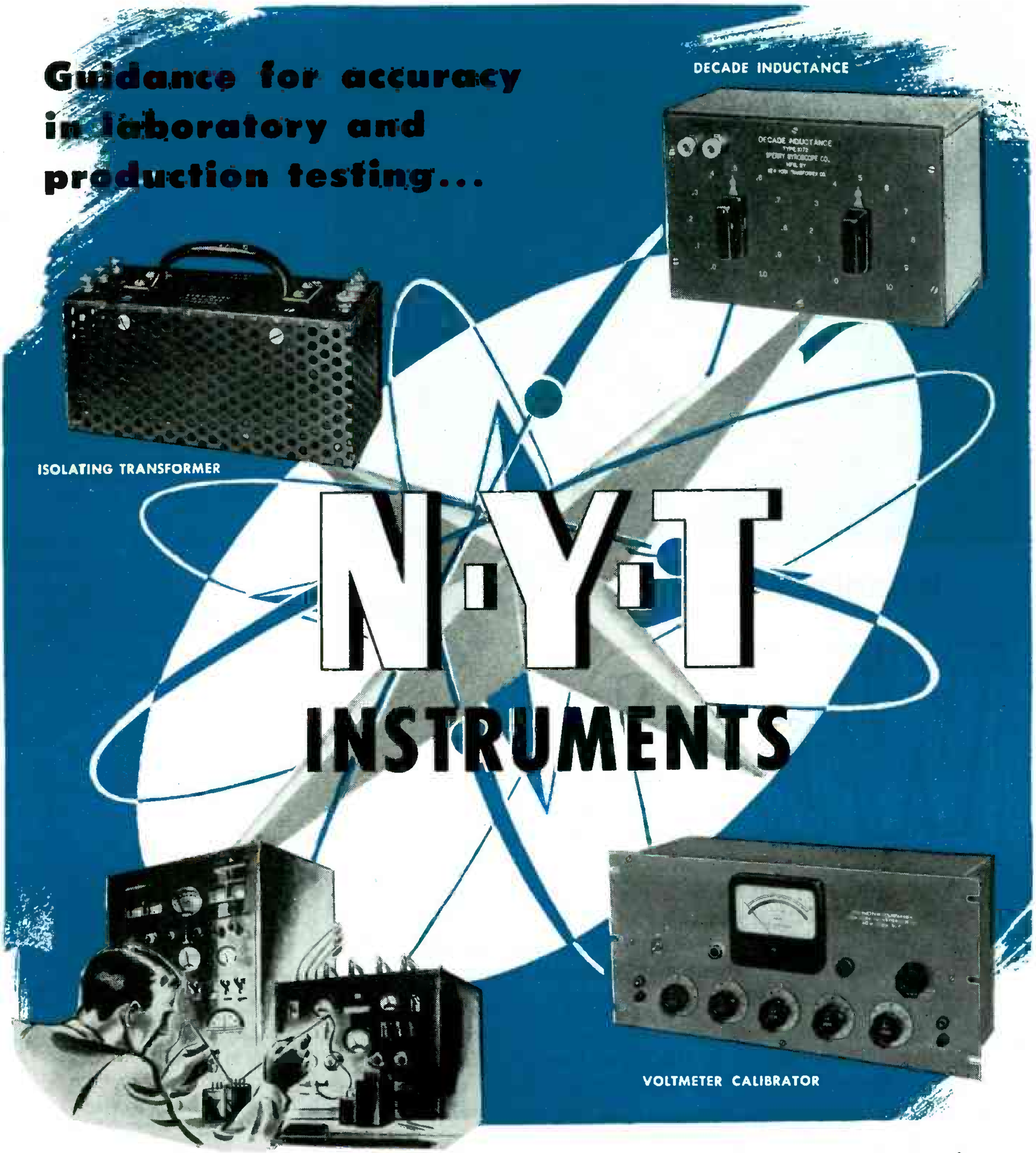


Block diagram of the essential elements of the spectrum analyzer

and Dale Pollack of Templetone Radio Co. The authors discussed two types of radio-frequency analyzers—the generalized continuously tuned spectrum analyzer for radio-frequency analysis, and one in which the analyzer is an adjunct to a conventional radio receiver, designed to show a band on either side of the frequency to which the receiver is tuned. Application of the theory to the design of a special-purpose analyzer, the air-borne AN/APA-10, was shown. A complete chassis and several sub-assemblies were shown.

Direct Current from Oscillator

Design and construction of a fractional-mu triode and its use in an oscillator circuit for supplying direct current to a cathode-ray tube was described in a paper by R. C. Hergenrother and R. L. Freeman of Hazeltine Corp. If the tube has



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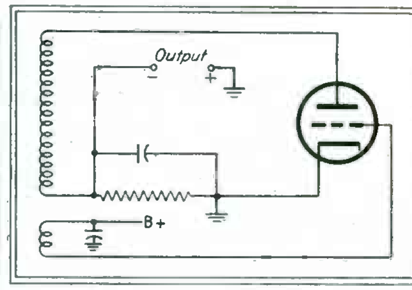
an amplification factor less than unity, it was shown that the direct voltage developed across the grid leak greatly exceeds the magnitude of the anode supply voltage.

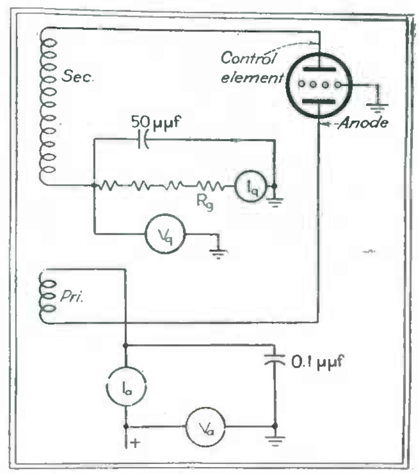
Conventional triodes were first employed as inverted tubes, with



Circuit of conventional triode arranged with plate and grid reversed to operate as a fractional-mu tube for high-voltage output across the grid leak

the grid functioning as the anode and the plate as the control element. With this connection, the mu of the tube becomes the reciprocal of the conventional value. Large grid conductance and small allowable grid dissipation of most tubes limits the anode supply voltage for the oscillator to less than 100 volts. It was also found that conventional tubes are not capable of withstanding high voltage between elements.

It was found that a fractional-mu



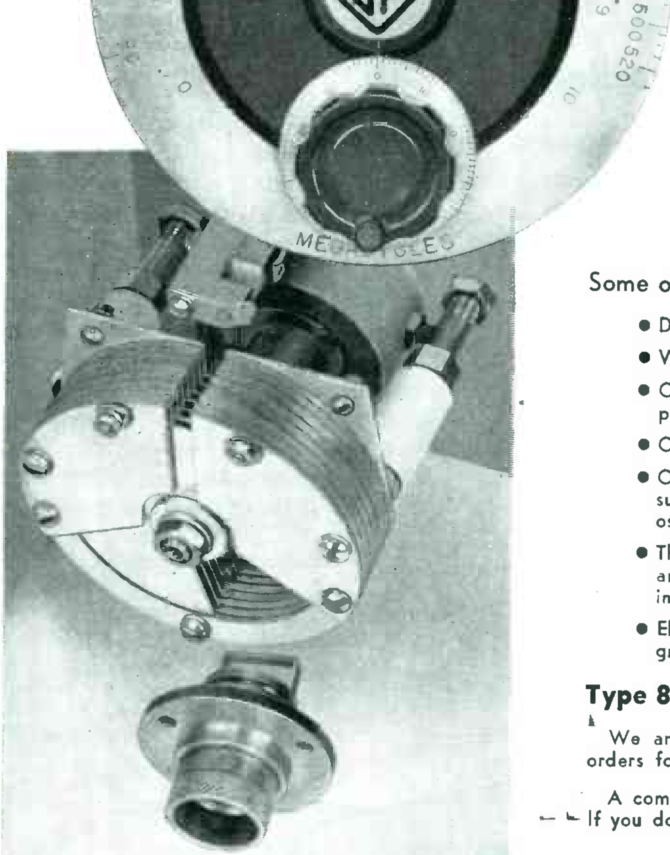
Oscillating at a frequency of 125 kc, this circuit develops a potential across the grid leak of 16 times the anode supply voltage. Special construction of the tube provided a mu less than unity

oscillator tube to be used as a generator of d-c voltage of the order of 6000 volts from anode-supply voltages of 300 volts must conform to these requirements:

(1) The mu should be about 0.1.

(2) The control element should

NEW OSCILLATOR



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- The Type 857-P1 Power Supply furnishes a plate voltage of 350 volts and filament supply of 2.5 volts for the W. E. Type 316-A tube used in the oscillator
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We are in limited production now for high priority war orders; reservation orders for later deliveries are being accepted.

A complete description appears in the G-R Experimenter for November, 1944. If you do not have a copy, write for Bulletin 930.

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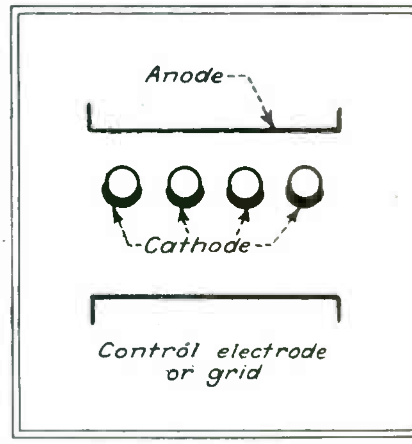
safely withstand a negative voltage of 12,000 volts with respect to all other elements and supports.

(3) The transconductance at small or zero bias on the control element should exceed the total circuit conductance.

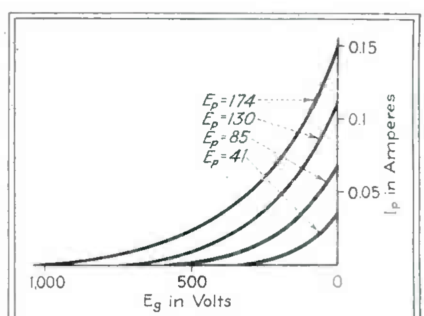
Several experimental tubes were made and from these the construction shown in the diagram was evolved. The central element is a cathode composed of a directly-heated, w-shaped filament or a parallel array of indirectly heated



Practical construction of fractional-mu tube for obtaining several thousand volts across an oscillator grid leak. The cathode strips were coated on the side toward the control electrode

cathodes. The anode consists of a plate mounted on one side of the cathode, while the control element consists of a plate on the other side. The mu becomes less than unity when the control element is more distant from the cathode than the anode. The anode conductance and the transconductance is increased by decreasing the cathode-anode distance. Coating the cathode on one side greatly reduces the value of the uncontrolled anode current.

Tests of this tube in an oscillator



Characteristic curves for the fractional-mu tube show that 1000 volts can be obtained at an anode potential of 174 volts

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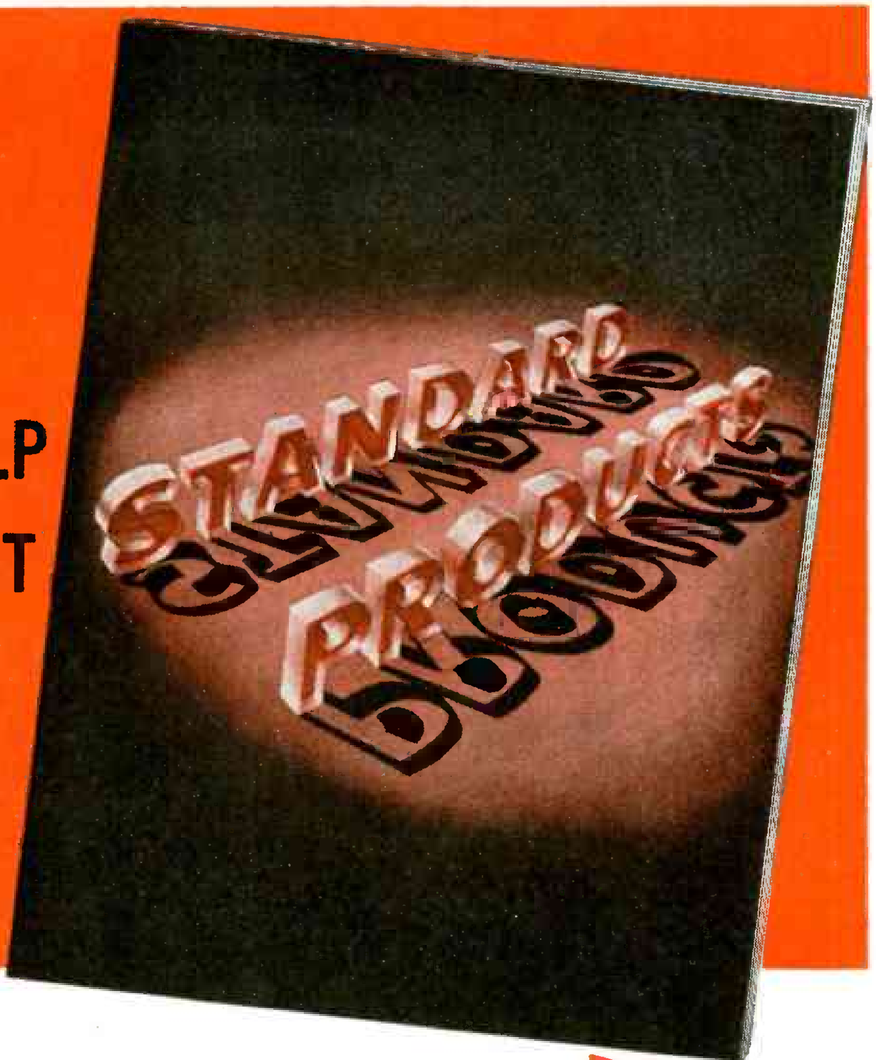

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circuit were made using a tuned circuit with a bypassed grid leak connected in series between the control element and the cathode, with a feedback coil in the anode circuit. The voltage across the grid-leak was 16 times the anode-supply voltage. The efficiency, or ratio of power developed in the grid leak to the power input, was 23 percent. The circuit was designed to operate at a frequency of 125 kilocycles. Current of several hundred μa was available for the load circuit.

Crystal Quality

The quality of coils and capacitors is defined as the ratio of reactance to resistance and expressed as the Q of the unit. Need for a similar expression for the quality of crystals was pointed out in a paper by I. E. Fair of Bell Laboratories. Factors which determine the performance of crystals were discussed and a figure of merit, M, for expressing quality, and a performance index, PI, were suggested.

The measure of quality, M, is expressed by the equation $M = Q/r = 1/(\omega_1 C_0 R_1)$ where ω_1 = the angular frequency of resonance; C_0 = the static or parallel capacitance of the crystal; R_1 = the series-resonant resistance of the crystal.

Thus, M provides a ratio of the Q of the motional arm to the ratio of capacitance of the crystal.

The quality factor M has no dimensions and is purely an expression of circuital quality.

The performance of a crystal is determined by M and the frequency of operation relative to its resonant frequency. The relative frequency is determined primarily by the magnitude of the circuit capacitance placed across the crystal by the oscillator. The performance Index PI is, therefore, an expression of performance. It is an expression of activity in terms of the crystal constants and the capacitance of the rest of the oscillator. It is given by the approximate equation $PI = 1/[R_1\omega_1 (C_0 + C_t)^2]$ or $PI = M/[\omega_1 C_0 (1 + C_t/C_0)^2]$ where C_t is the circuit capacitance. It is found that PI is the antiresonant resistance of crystal and circuit capacitance in parallel at the oscillating frequency.

The grid current produced in an

oscillator by a crystal of particular *PI* should be considered a characteristic of the oscillator circuit and not of the crystal. By thus separating the crystal from the oscillator circuit and viewing each on its own merits, there is provided a standard of quality which can be measured readily and accurately. It also leads to simple formula for the theoretical study of crystal quality and facilitates better design of crystals and oscillator circuits.

The performance index is therefore a term to express crystal performance not in terms of the grid current of some particular oscillator, but in a fundamental circuital unit-impedance. It is a term that may be used to compare performance of crystals at different frequencies. Its value is independent of plate voltage, grid leak resistance or of the plate impedance of the vacuum tube oscillator. It provides a measuring stick that should replace the "activity" figures of grid current insofar as the crystal is concerned.

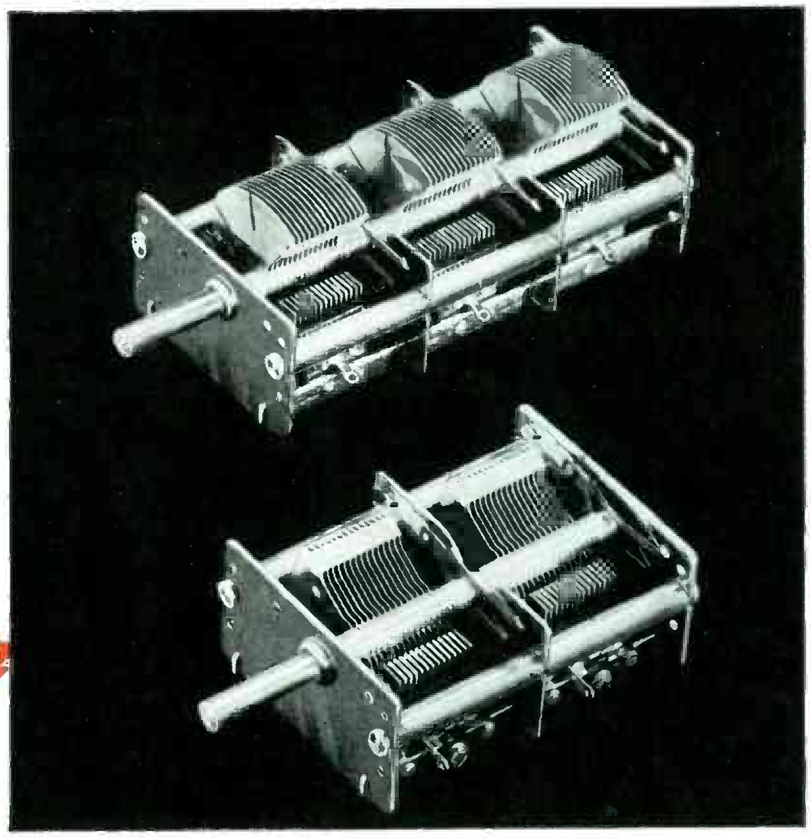
Performance Index Meter

A means of measuring the anti-resonant resistance of a crystal to provide a value of PI was described in a paper by C. W. Harrison of Bell Laboratories.

The measurement of anti-resonant impedance directly is very difficult. However, this impedance is readily computed from the expression Q_1X_t, where Q_1 represents the effective inductance divided by the effective resistance of the crystal at the operating frequency and X_t represents the reactance of the capacitance introduced by the oscillator.

The basic circuit used for the measurement of PI is essentially a *Q*-meter circuit with the exception of an additional circuit to permit measurements proportional to QX rather than to just Q. The additional circuit is an attenuator which varies with frequency in the same manner as does the reactance, X_t. The output of this network is measured by a vacuum tube voltmeter and provides readings that are proportional to PI.

The generator differs from the Q meter in two ways; (1) the source of energy has to be controlled by the crystal under test and (2) con-



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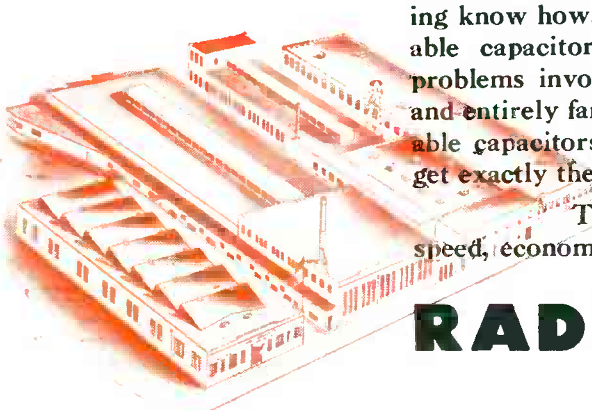

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siderable power is required to oscillate the crystals with the amplitude at which they are to be used. The zero generator impedance is simulated by an automatic amplitude-controlled oscillator, that is, the output of the generator is essentially independent of the load impedance of the crystal circuit.

The crystal circuit consists of the crystal under test in series with a variable capacitance and measurements are made at the frequency where these two are series resonant. The frequency is adjusted to that exact frequency by a phase shifting network in the oscillator. The series capacitor is split into two parts, one which is variable and the other which is fixed and large compared to the variable capacitor. The fixed capacitor provides an impedance element across which the voltmeter is connected. The input capacitance of the voltmeter is incorporated in the magnitude of the fixed capacitor. A calibrated capacitor attenuator interposed on the input of the voltmeter enables the voltmeter to be used to indicate voltage ratios in terms of the attenuator calibration. The output of the attenuator provides the input to the network whose attenuation is inversely proportional to frequency.

From circuit equations, it can be shown that, (1) the ratio of the generator voltage to the voltage appearing across the capacitive load impedance is a function of the performance index of the crystal and (2) that the calibration permits an evaluation of its magnitude at resonance.

The PI meter enables the measurement of crystal activity in absolute terms and is not relative to some arbitrary standard. It also makes possible the measurement of the effective capacitance that the oscillator circuit shunts across the crystal terminals and it permits the measurement of all electrical equivalent circuit constants of a crystal when used in conjunction with a capacitance bridge and a frequency measuring means.

Exalted Carrier Reception

Systems of receiving amplitude and phase-modulated waves were described by Murray G. Crosby of Press Wireless. In these systems,

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A new series of KAAR radiotelephones, offering improved performance and greater convenience, is now available to police and fire departments, public utilities, sheriffs' offices, railroads, the forestry service, and similar users of radiotelephone communication. Designed with the needs of these services in mind, this series provides instant heating tubes, single channel or five channel operation, and crystal controlled or tunable receivers. Notice how compact this equipment is, and how it is immediately accessible for tuning or servicing, although the cabinet itself may be permanently secured to a shelf, wall, vehicle, or vessel.

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A five channel transmitter with power output of 50 watts. All five channels are independently tuned, and any one may be instantly selected by turning a knob on the front panel. Standard frequency range is from 1600 to 6000 Kc. Furnished with companion tunable or fixed tuned crystal-controlled receiver as desired. Power supply (8"x8"x17") is a separate unit, interconnected by a 12-foot cable. Available for operation on 117 volts 60 cycle A. C., 12, 32 and 110 volts D. C.

SERIES 96 • 100 WATT KAAR RADIOTELEPHONE

(NOT ILLUSTRATED)

Five channel instant-heating transmitter, with an output of 100 watts and having a standard frequency range from 1600 to 6000 Kc. The companion receiver may be of the tunable or fixed tuned crystal-controlled type as desired. R. F. ammeter and plate milliammeter are mounted on front panel. This 100 watt radiotelephone, including transmitter and receiver, is only 19½" high, 22" wide, 14¾" deep. Furnished with separate power supply (8" high, 16" wide, and 17" deep). Available for operation on 117 volt 60 cycle A.C., 32 or 110 volt D.C. circuits.

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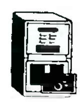
★ **FIVE CHANNEL TRANSMISSION...** Any one of five channels from 1600 to 6000 Kc can be instantly selected by turning the large knob on the panel.

★ **CARRY ONLY 1 SPARE TUBE...** For simplicity of replacement there is only one type of tube used in these Kaar transmitters. (For 117 volt AC operation, 5R4GY rectifier tubes are also employed.)



★ **REMOVABLE PANEL...** By removing six finger-tight lugs, the front panel of the transmitter may be lifted away, exposing all tuning controls. This allows complete tune-up to be made in a short time without moving the set.

★ **SIMPLE TO SERVICE...** When four screws are released, transmitter slides out like a letter file to simplify tube replacement.

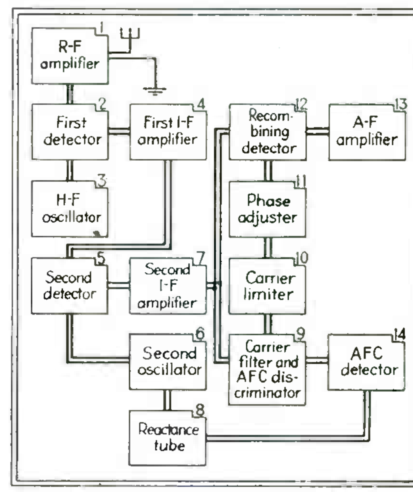
★ **FITS MOST ANYWHERE...** Transmitter may be placed above or below the receiver, or on either side of it. Transmitter and receiver units are each 10" high, 13" wide, 13" deep. This equipment is easy to install.

★ **REASONABLY PRICED...** Although Kaar instant-heating radiotelephones offer all these features for convenience and simplicity, they are competitively priced. Your inquiries are cordially invited.

elimination of the distortion is accomplished by filtering the carrier and recombining it with the signal at a raised or exalted level, or by recombining in a type of detector which inherently eliminates the carrier-fading distortion.

This type of fading is common in receiving broadcasts at medium frequencies in the area where the sky wave and ground wave are nearly equal in strength. This occurs at night in the region from 50 to 150 miles from the transmitter. Where the ionosphere is depended on for transmission, as in high-frequency transmission, carrier fading is practically always present.

The essential elements of an exalted-carrier receiver are shown in the block diagram. In this, the



Block diagram of an exalted-carrier receiving system

blocks numbered from 1 to 7 form a double-superheterodyne receiver whose i-f output divides into two branches. One branch feeds a recombining detector, 12, and the other branch feeds into carrier filter 9 which separates the carrier filter from the side bands. After filtering, the carrier is fed to limiter 10 which holds the carrier amplitude at a constant value. The limited and filtered carrier is recombined with the unfiltered signal at a phase determined by phase adjuster 11. The combination signal that results is detected in 12 and supplied to the audio-frequency amplifier.

The system includes an afc discriminator which employs the same crystal filter for both the carrier filter and the frequency discrimin-

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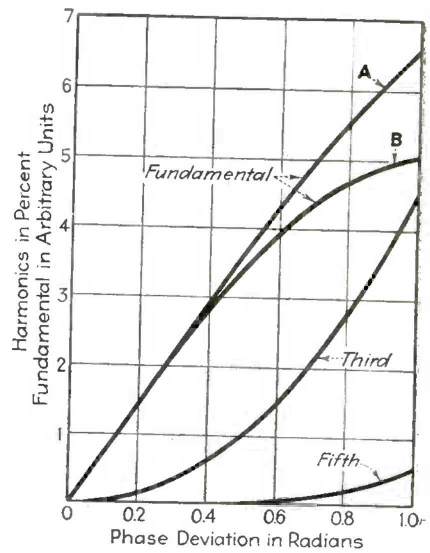
ator. If separate crystals or afc circuits were used, careful synchronization would be necessary.

Since the objective is elimination of distortion caused by overmodulation that results from carrier fading, this may be done by feeding the carrier to a single diode detector with the amplitude of the carrier exalted with respect to the unfiltered signal. The carrier may



Fundamental and harmonic output for phase-modulation detection. Curve *A* shows fundamental output for exalted-carrier diode detection with or without carrier limiting. Curve *B* gives fundamental output for multi-grid detection without carrier limiting

then fade to a greater depth before overmodulation occurs because the effective percentage of modulation fed to the detector is reduced.

Other types of detectors and their advantages and disadvantages were discussed by Mr. Crosby, as was the effect of limiting the carrier.

In testing the system, the number of faults marring program reception were counted to determine the relative number of faults per minute. Each time fading distortion occurred, a fault was counted. The observations showed that with two different antennas the number of faults with the exalted-carrier system was about one-third that for unexalted carrier equipment.

With the exalted-carrier system, it was found that operation of the avc system when the carrier faded produced a burst of volume in the receiver output. This burst effect takes place with unexalted-carrier detection as well

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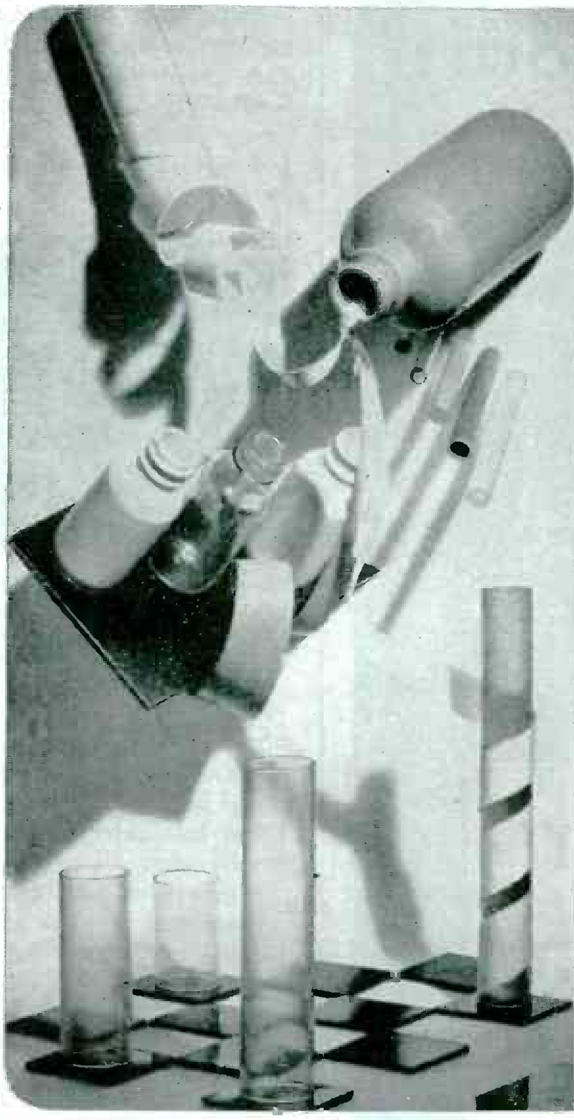

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Rockwell Hardness	M25-M69
Impact Strength, ft. lbs. per in. of notch; ½" x ½" notched bar Izod test	0.8-7.9
Water Absorption, 24 hrs., %	1.6-2.1

ELECTRICAL

Volume Resistivity, ohm. cms. (50% rel. hum. at 25°C)	10^{10}-10^{12}
Dielectric Strength Short Time, Volts per mil, ⅛" thick	250-400

THERMAL

Distortion Temperature, °F	115-215
Transition Temperature, °F	117-160
Softening Point, °F	140-250
Specific Heat, cal. per °C per gram	0.3-0.4
Burning Rate	Slow
Thermal Expansion, 10^{-5} per °C	11-16
Thermal Conductivity, 10^{-4} cal. per sec. per sq. cm/1°C per cm.	4.5-7.8
Resistance to Heat (continuous) °F	140-220

CHEMICAL EFFECTS

Weak Acids	Slight
Strong Acids	Decomposes
Weak Alkalis	Slight
Strong Alkalis	Decomposes
Alcohols	Softens
Esters	Dissolves
Ketones	Dissolves
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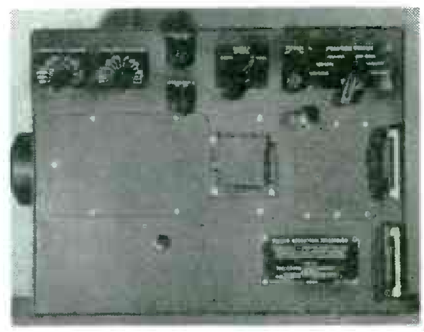
but the volume burst usually contains the distortion which is produced when the carrier fades. An audio volume-limiter circuit was used to remove these volume bursts.

Small Two-Channel Oscilloscope

A portable two-channel recording oscilloscope for battery operation was described in a paper by R. F. Wild and D. C. Culver of Brown Instrument Co. The unit was developed as a flight vibration recorder for and in cooperation



Batteries of the hearing-aid type supply 540 volts to a 2-inch c-r tube in this portable two-channel recording oscilloscope. Made by Brown Instrument, it uses conventional film packs

with the Technical Development Division of the Civil Aeronautics Administration.

The instrument is designed for simultaneous recording of two input signals of any frequency between 5 and 300 cps and between 0.5 millivolts to 2 volts amplitude, derived from vibration pickup devices or strain gauges located at various points about a plane. Marking signals are also recorded to establish a time base on the records. A 2-inch cathode-ray tube operated at about 540 volts is used, and an electronic switch operating at about 20 kilocycles is provided for mixing the signals.

Records are made on 12-exposure film pack $2\frac{1}{4} \times 3\frac{1}{4}$ inches. An $f/2$ lens is used in the camera. Signal traces on the screen of the cathode-ray tube can also be viewed directly by using a port on the side of the cabinet. Recurrent and single sweep is provided at three different fixed speeds.

The instrument includes batteries of the hearing-aid type, weighs 27 pounds, has a size of $6 \times 12\frac{1}{2} \times 16\frac{1}{2}$ inches, and is completely self contained. Its principal use is the study of flutter in air-

This "big gun of electronics" is a symbol of Machlett's ability as a tube manufacturer.

In this unique tube is found the highest development of the basic requirements common to all electron tubes for whatever purposes. These are:

The tube must be structurally sturdy, compact, and completely vacuum-tight.

It must embody means for the accurate, effective and stable control of an electron stream.

It must have adequate heat-dissipating properties.

The difficulties of meeting these requirements are multiplied many times by each increase in size, design-complexity, and voltage. They reach an all-time high in this 2,000,000-volt d-c X-ray tube.

When buying electron tubes, whether X-ray, oscillators, amplifiers or rectifiers, look for the Machlett name as evidence of high technical achievement protecting your purchase. For information about available types of Machlett tubes write Machlett Laboratories, Inc., Springdale, Conn.

The ML 880 is a radio oscillator tube for use in transmitters, and has a maximum output of 60KW.

MACHLETT

APPLIES TO RADIO ITS 46 YEARS OF X RAY TUBE EXPERIENCE craft, supplementing equipment weighing several hundred pounds, and particularly in small aircraft where bulky test equipment cannot be carried.

High-Frequency Heating

Although the principles of dielectric heating were well understood by the opening of this century, it is only recently that sufficient power at high enough frequencies has been available to make this method industrially feasible.

In bringing out these points, Paul D. Zottu of Thermex Division, Girdler Corporation, retraced the historic development of our knowledge of high-frequency heating.

Electric field heating is readily controlled, clean and compact. Of the applications so far of industrial importance are wood assembly, plastic heating, molding, bonding, vulcanizing, sterilizing, drying. A great deal has yet to be learned of the use and control of electric field heating. Dielectric factor, power factor, a-c and d-c resistance, breakdown due to electric field, nature of dielectric, heating requirements and voltage and frequency must still be studied. The experience gained so far in applying dielectric heating has indicated the extent and importance of these factors which must be studied. As yet too little information about them is known to make possible full utilization of the technique.

Equivalent Triode Networks

Four-terminal networks which are equivalent to various triode connections were shown by Harold A. Wheeler of Hazeltine Corporation.

There are three simple ways of connecting a triode in a four-terminal network, because the common or grounded electrode may be the cathode, anode or grid. The grounded-cathode circuit, shown at (a) in the figure, is the original phase-reversing one-way repeater, amplifying both voltage and current. The grounded-anode (cathode-follower) circuit shown at (b) is a non-phase-reversing one-way repeater but amplifies only current.

The grounded-grid circuit shown at (c) has degenerative feedback by conductive coupling, in such a manner that it amplifies only voltage. It may be treated as a hypo-

6 blades hardened every 10 seconds

10 KW RADIO-FREQUENCY GENERATOR

This unit has many applications. Its "table top" work surface eliminates the need for small tables, and all controls are centralized on the sloping panel. Large sturdy casters provide speedy mobility.

The job is to harden only the teeth of hand hack saw blades —with 6 blades completed every 10 seconds, or 36 blades per minute.

The amazing speed . . . accuracy . . . uniformity, all come with radio-frequency heating at 8500 Btu's per square inch per minute. Compare this with the old method, at 5 Btu's per square inch per minute.

Similar high speeds are possible in every metal heating job—annealing, hardening, brazing, sintering, forging and soldering. And the heating is so simple that it's a "push button" job for unskilled help.

Another great advantage comes with Westinghouse design . . . a single shielded cabinet contains generating equipment and controls, easy to install and maintain . . . requiring a minimum of space.

Westinghouse Radio-Frequency Generators for induction or dielectric heating are available in eight different standard sizes up to 200 kw, with a range of frequencies for all but the most unusual needs. For added information, write for Descriptive Data 85-800. Or, for aid on any specific application, ask a Westinghouse engineer to call. Write Westinghouse Electric & Manufacturing Co., P.O. Box 868, Pittsburgh 30, Pa. J-08098

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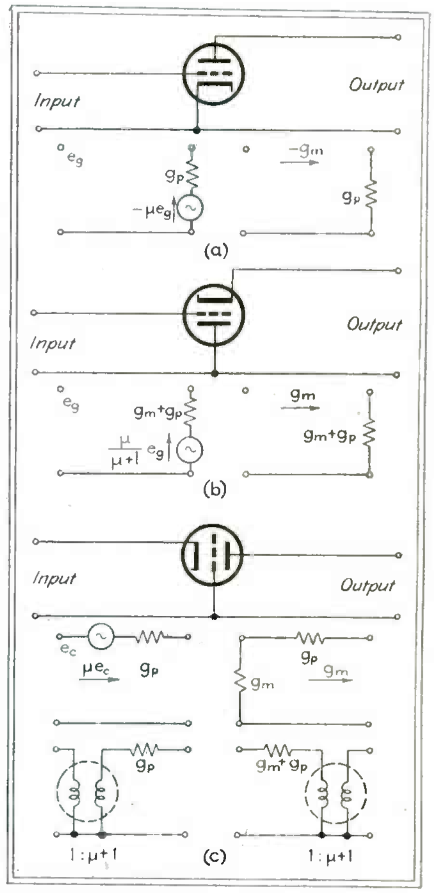
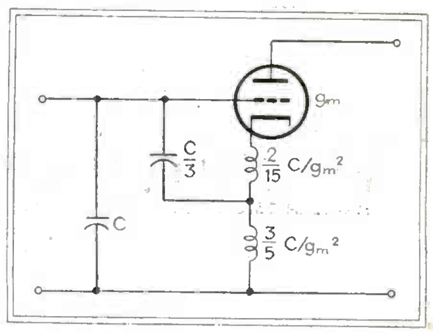
Electronics at Work



The three ways in which a triode can be connected and the equivalent circuit for each

thetical repeater-transformer with an impedance ratio of $\mu + 1$, which also multiplies the power in the same ratio. It has some advantages at high frequencies because the grid shields against capacitive feedback coupling. However, the plate conductance becomes a feedback element and the mutual conductance becomes an input load limiting the amplification. Also the output load is reflected into the input through the hypothetical transformer.

Input conductance may be simulated by cathode-lead inductance to represent tube phase lag and

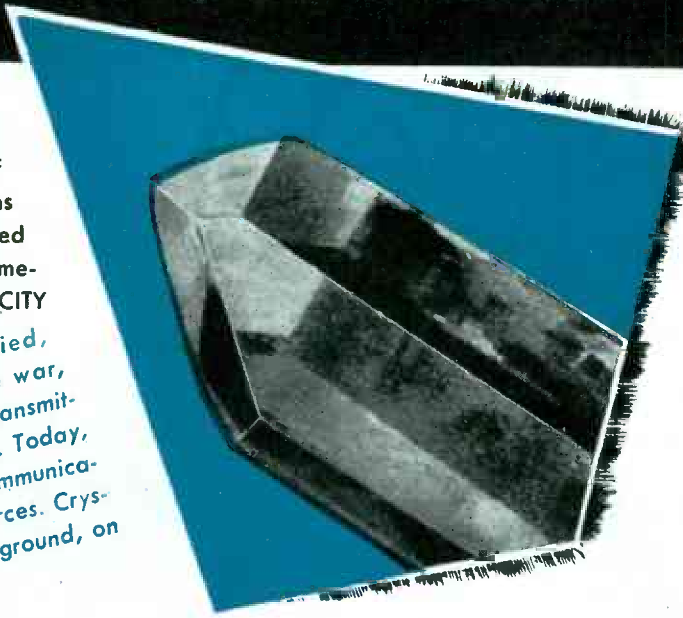


Equivalent high-frequency circuit which approximates effect of electron stream on triode behavior

TELICON

CRYSTALS

The raw product comes from Brazil. As a result of interplay of elements — over possibly millions of years—Mother Nature endowed the raw quartz with the phenomenon of PIEZO-ELECTRICITY



Crystals were applied, before the war, on a small scale mainly in transmitters and in supersonic television. Today, the crystal is the **heart** of all communications equipment of the armed forces. Crystals are used in the air, on the ground, on the sea and under water.

American inventive ingenuity made possible a mass production technique which enabled this probably youngest of all industries . . . to produce tens of millions of this critical component.

Crystals of all types . . . for frequency control or for supersonic applications . . . plated or pressure mounted . . . in hermetically sealed or in plain holders . . . are manufactured — in two most up-to-date plants — by TELICON Corporation.

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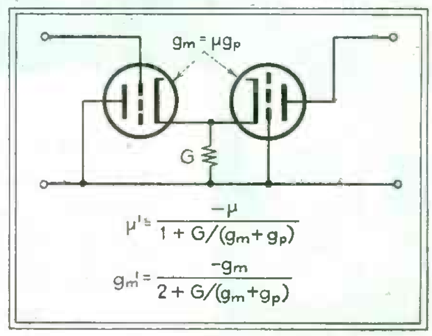
shunt capacitance to simulate input loading. In this way electron-inertia effects and transit time are approximated. The equivalent circuit is also shown.

The double-triode circuit with cathode intercoupling is interesting



Non-phase reversing cathode-coupled amplifier

as a non-phase-reversing one-way voltage and current amplifier with less than half the transconductance and much less capacitive feedback coupling than single-tube circuits.

Radio-Frequency Dehydration

Pharmaceuticals which are unstable at high temperatures can be dehydrated by radio-frequency fields. For example, penicillin loses activity in a few days upon standing in water even at room temperature, at high temperatures its activity is lost faster. If dried, however, the penicillin retains its activity and is therefore dried and stored in this state and redissolved in distilled water when required for use.

To prevent destruction of the penicillin, it has been dried at 50 degrees below zero in a vacuum of 0.1 mm. This technique required several complicated and special pieces of equipment such as a refrigerated condenser necessary to keep the vapor out of the high vac-

Final drying of penicillin is done in these plastic bottles which are rotated to hold the penicillin inside by centrifugal force. The vacuum chamber travels in a continuous-process cycle in which it is loaded, evacuated, subjected to an r-f field and finally unloaded

uum pump used in the process.

To speed up the dehydration process, a technique described by George H. Brown and developed by R. A. Bierwirth and Cyril N. Hoyler and himself, all of RCA Laboratories, was used. It was impossible to apply a dielectric field to the equipment in its original condition, chiefly because at the high vacuum used, air ionizes most readily. Because of the solvent used, it was impossible to dehydrate penicillin at a high vacuum without freezing the solution.

After several attempts in which special bottle designs were used, a technique in which the penicillin was placed in plastic bottles and the bottles rotated at high velocity in to an electric field was found satisfactory. The rotation created sufficient centrifugal force to spread the solution in a thin layer on the inside of the bottle, holding it there at a force 100 times gravity so that the pencillin was not lost by foaming.

Dr. Brown adjusts the r-f energy being delivered to the penicillin solution during the preliminary evaporation stage in which the dilute solution is concentrated by evaporation at room temperature under reduced pressure

Using a 2 kilowatt oscillator operating at 28 megacycles, a continuous-processing 3-minute drying

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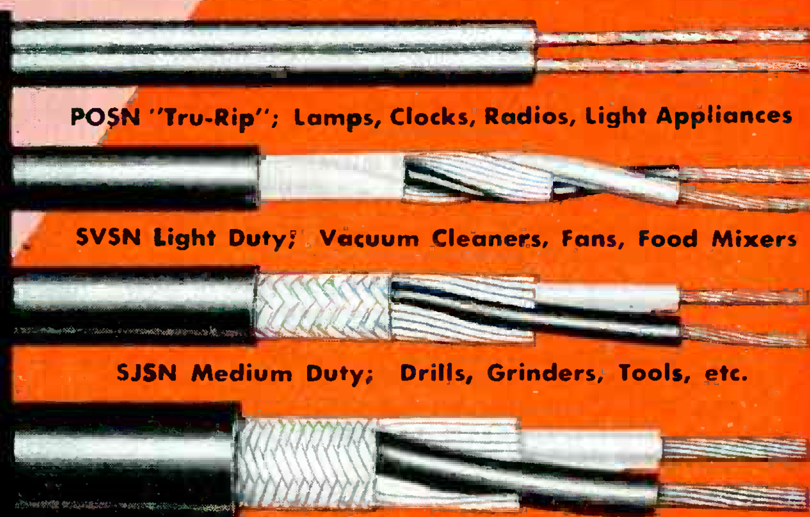

POSN "Tru-Rip"; Lamps, Clocks, Radios, Light Appliances

SVSN Light Duty; Vacuum Cleaners, Fans, Food Mixers

SJSN Medium Duty; Drills, Grinders, Tools, etc.

SSN Heavy Duty; Portable Tools, Bus Heaters, etc.

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cycle is now possible. This great improvement in dehydration suggests that radio frequency can be applied to other pharmaceuticals. However, because of an inherent mistrust of radio-frequency dehydration, it is not likely that pharmacists will apply the technique. It is up to the electronic engineer to find and apply this technique where it is possible. At the close of the lecture moving pictures of the process in action were shown.

New Types of Radiators

Some new antenna types were described by A. G. Kandoian of Federal Tel. & Radio Corp. These have a radiation pattern which is essentially equivalent to that of a dipole.

One type is intended primarily for vertical polarization and gives an omnidirectional pattern in the horizontal plane. It operates over several octaves of frequency without a substantial change of either input impedance or radiation pattern.

The second type discussed is a loop antenna with an omnidirectional radiation pattern in its own plane. The radiators forming the loop are metallically supported from the mast or other supporting structure and both supports and radiators form part of the coaxial feeding circuit. A large number of these antennas may be stacked for a high degree of directivity in the vertical plane.

The third antenna described also consists of a loop and perpendicular to it is mounted a vertical dipole. The radiation pattern of this antenna is similar to the other types but the free space field at all points has both horizontal and vertical components in equal amounts. Any desired ratio of amplitude as well as phase relationship between the horizontally and vertically polarized fields may be obtained.

Quartz Crystals for War

A review of the prewar quartz crystal manufacturing facilities and the tremendous changes made necessary by war needs was presented by Major Edward W. Johnson of the Signal Corps. Before the war, the then existing industry was only capable of producing about 100,000 units per year. Lab-


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oratory methods were used and no standard techniques or production machinery were available. To further complicate matters, it was thought that only the best grades of quartz were suitable for manufacture of oscillating plates.

As a result of the concerted efforts of the Signal Corps and the industry, the latter was expanded from some 15 prewar firms to approximately 115, and the capacity to the point where it is now producing at a rate of approximately 30,000,000 units a year. This expansion resulted from the adoption of standardized equipment, improved techniques, and a continued search for improvements. At the same time, quality has been vastly improved.

As an example of the wide use of crystals in the Army, he said that 1200 crystals and 396 coils are required by the 536 pieces of radio equipment used by one regiment. The need was met by production of 9 million plates in 1942, 21 million in 1943 and 30 million in 1944. Speaking of the changes in size, he stated that 92 percent of the crystals produced in 1944 were less than 0.3 sq in. in area; less than 1 percent were 1 in. square, the popular prewar size.

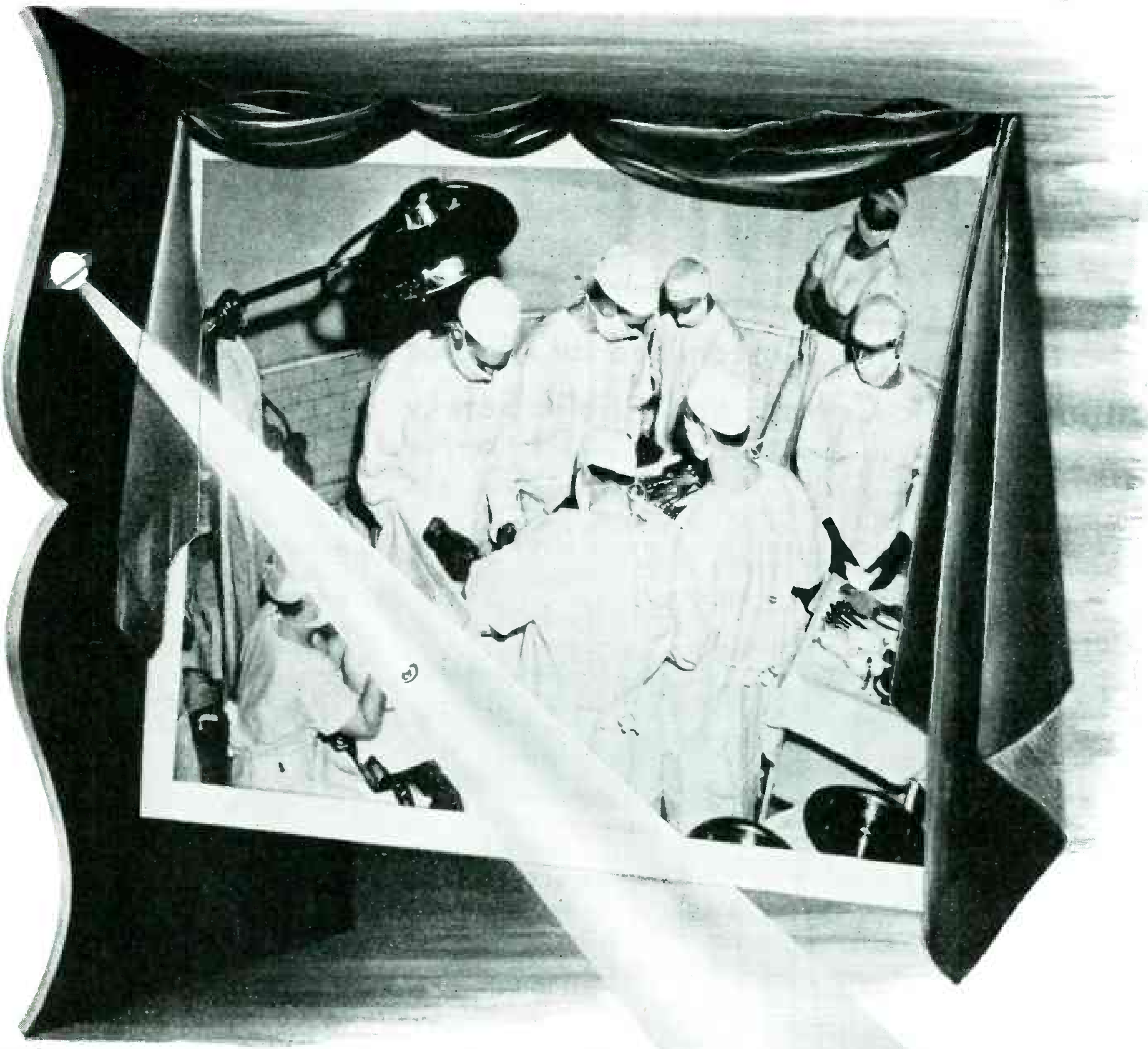
To meet emergency demands for special frequencies, several field units for crystal grinding have been set up in all active theaters. These are manned by specially trained personnel.

Induction Heating

From experience with many large industrial high-frequency heating installations, Wallace C. Rudd of Induction Heating Corporation told what can be expected in the plant.

The industrialist is not accustomed to equipment requiring the careful technical handling of electronic assemblies, nor is he receptive to acquiring such habits. It therefore becomes necessary for the electronic engineer to design his equipment to stand up under the conditions of the factory.

Production equipment is not moved with the care necessary in handling vacuum tubes. Instructions for tube placement and care are not followed. It therefore becomes necessary for the electronic engineer to supervise installation. In fact, the industrialist is more



Light through an earlobe works an electric meter!

Any light source can be made to operate meters and meter relays without costly, bulky amplifiers. Luxtron* photocells, developed and manufactured by Bradley Laboratories, do this today for many purposes . . . such as looking at a patient's earlobe and instantaneously telling you the oxygen content of his blood . . . at a warehouse and warning of fire . . . or at a furnace to gauge its temperature.

New chapters in the story of the simplest way to transform light into electric energy are daily written by Bradley's Luxtron photocells. For information on how they can help you, write Bradley Laboratories.

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Copper Oxide Rectifier Advances

Bradley applies knowledge of electrical circuits to the development and manufacture of a unique line of "Coprox" rectifiers. Write for illustrated bulletin giving ratings and special advantages.

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likely to demand service for electronic equipment than with other types.

Some of the problems must be licked in design to make the unit not just automatic, nor fool proof, but operator proof. The operator does not want gadgets, just buttons to push. If safety devices stop operation, there is either a service call or the safety device is blocked from operating with a service call later as a consequence. The solution of these problems is in the province of the electronic design engineer.

VHF Tetrode

Operation well into vhf is made possible by design features of a medium-power transmitting tetrode, the Eimac 4-125A, developed by the Eitel-McCullough Laboratory design group and described by Clayton E. Murdock of Eitel-McCullough.

A pair of the new Eimac 4-125A's in a conventional push-pull arrangement is shown in the photograph. A total driving power of less than 5 watts will satisfy the requirements for full rated power output which is over 300 watts per tube.

Interelectrode capacitances of the 4-125A have been kept to low values for a tube having such power capabilities. The plate-to-grid

Driven directly from a signal generator, these Eimac 4-125A's deliver 750 watts at 14 Mc

capacitance is 0.03 $\mu\mu$f, and the input and output capacitances measure 10.5 $\mu\mu$f and 3.0 $\mu\mu$f respectively. The tube is 2-½ inches in diameter and has a seated height of 4-⅜ inches.

A disk-type stem and short heavy electrode connections keep lead inductance to a minimum. To aid in holding the screen grid at

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MF-66 Glass base material is readyl Material, facilities and techniques are at last available for the production in quantity of the new Formica grade which is superior to all other grades in low losses at high frequencies. This material, created to extend the useful working range of laminated plastics, is ready for prompt shipment to high priority customers.

THESE ARE ITS CHARACTERISTICS:

MECHANICAL STRENGTH *(average values)*			WATER ABSORPTION *(average values)*
TENSILE (non-directional)	FLEXURAL (flatwise)	COMPRESSIVE (flatwise)	24 HRS. IMMERSION AT 25°C SAMPLE: 3" x 1" x 1/8"
10,000 P.S.I.	14,000 P.S.I.	42,000 P.S.I.	0.15%

DIELECTRIC STRENGTH *(average values)*	DIELECTRIC PROPERTIES *(average values)*					
	POWER FACTOR			DIELECTRIC CONSTANT		
SHORT TIME METHOD 1/16" SHEET	1 kc.	1 mc.	30 mc.	1 kc.	1 mc.	30 mc.
450 V.P.M.	.015	.011	.018	4.9	4.7	4.6

Grade MF-66 is recommended for radio and radar coil forms, antenna bases, terminal strips and molded parts.

Fungus resistance of MF-66 is outstanding due to the absence of cellulose. The material is readily machinable to close tolerances into strong, shock-resisting insulating parts. Its low water absorption insures high electrical and dimensional stability in humid climates. Ask for quotations!

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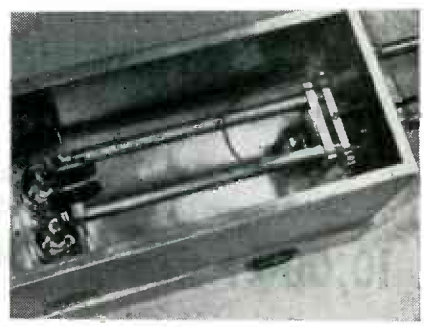
r-f ground potential, two screen leads have been provided.

Full output without neutralization at frequencies as high as 100 Mc is possible because of the combination of low interelectrode capacitance and small physical size. Above this frequency, a slight amount of neutralization is required, but full power output can be obtained at 120 Mc. Even at 160 Mc, an output of 250 watts per tube is possible. Preliminary tests have shown an output of 175 watts per tube at 215 Mc.

Internal insulators are eliminated. The 32-watt thoriated-tungsten filament, tantalum control grid and tantalum screen grid are supported by their own leads from the dish-type stem. The tantalum plate is supported by a single lead from the top of the envelope. A shield which extends from the



Parallel line test amplifier at 100 Mc delivers 750 watts with less than 5 watts driving power

screen grid and an outside metallic base shield isolate the input and output circuits.

Two typical test r-f amplifier units constructed in connection with the development of this tube illustrate its applicability to vhf. One amplifier unit for low-frequency tests handled an input power of one kw at a plate efficiency of 75 percent, and was driven from a single 6L6 doubler.

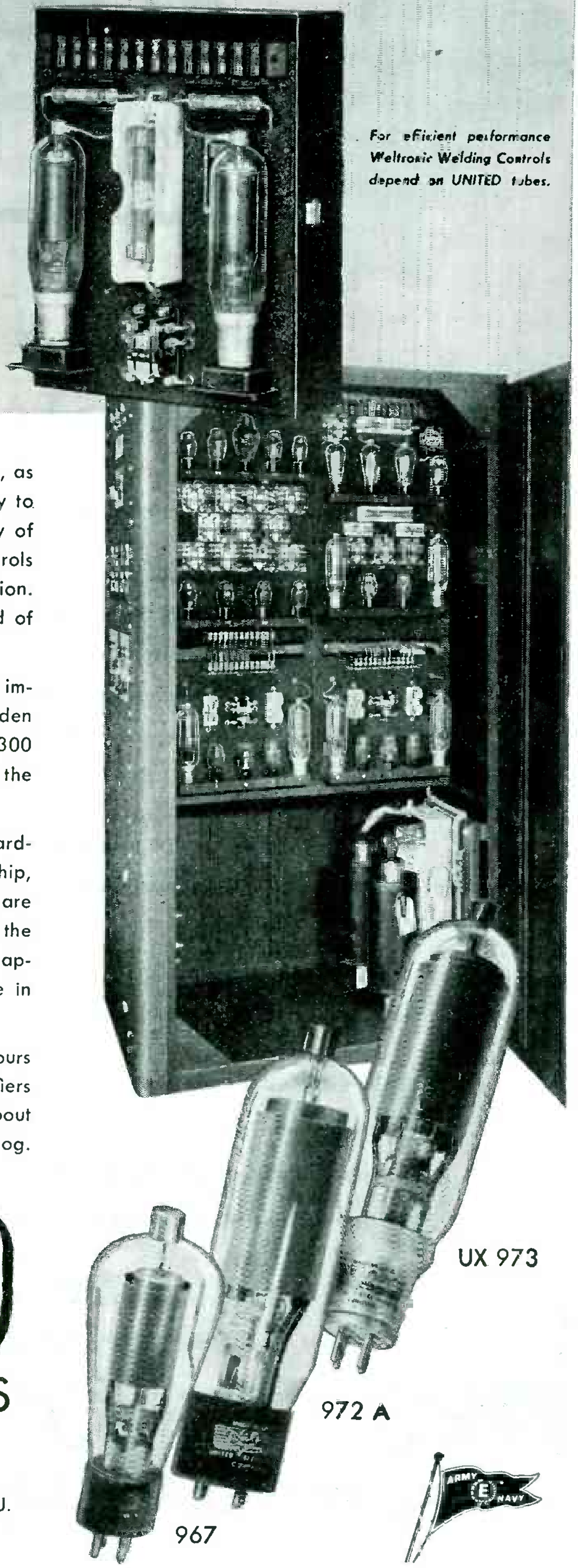
For tests at 100 Mc and above, the unit illustrated (in metal cabinet) was used. There were no significant differences between the operation of the tubes at 14 Mc and 100 Mc. The driving power at 100 Mc was less than 5 watts per pair of tubes and plate efficiencies of 75 percent were obtained.

Pushbutton Double-Superheterodyne

The design of a double superheterodyne receiver which is tuned solely by push buttons was de-

300 WALLOPS a minute

but still these tubes keep going



For efficient performance Weltronic Welding Controls depend on UNITED tubes.

For better and more precise control of stop-and-go currents, as in resistance welding, mechanical methods have given way to electronics. For this application the WELTRONIC Company of Detroit, Michigan, builds Electronic Timers and Welding Controls distinguished for their fine construction and efficient operation. In the heart of these units lies the toughest proving ground of tube stamina.

The rapid and instantaneous changes in load conditions imposed on the power tubes in this function would bring sudden death to tubes built to ordinary standards. Impulses up to 300 per minute are commonplace and put the best tubes to the severest test.

For this gruelling job WELTRONIC Engineers have standardized on United Mercury Rectifiers. Their sterling workmanship, unusual physical ruggedness and excellent electrical design are the reasons underlying this preference. Built to withstand the continuous, severe conditions of these and other industrial applications, tubes by United are appearing more and more in important places.

Where the going is extra tough and several thousand hours of dependable service are essential . . . United Mercury Rectifiers are demonstrating their superior qualities. Get the facts about these better tubes today. Write for a copy of our latest catalog.

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tailed in a paper by John D. Reid of Crosley. He described an experimental model made before the war that has no dial or tuning knob but has two vertical rows of push-buttons. The left-hand row of eleven buttons allows selection of the hundreds figure from 5 to 15—the right-hand row of ten buttons allows selection of the tens figure from 00 to 90. Thus, any frequency from 500 to 1590 kc may be selected by pushing two buttons. To receive WLW on 700 kc, the 7 button in the first row is pushed and the 00 button in the second row.

The first i-f value is approximately 4 megacycles and gives freedom from spurious responses. The second i-f value is 200 kc and enables adjacent-channel selectivity to be obtained. The "100" buttons switch-tune the first oscillator and input circuit in steps of 100 kc. The "10" buttons switch-tune the second oscillator and input circuit in steps of 10 kc.

By choice of a first i-f value at least twice the highest frequency it is desired to receive, and a second i-f value at least half the lowest frequency it is desired to receive, spurious responses are made negligible.

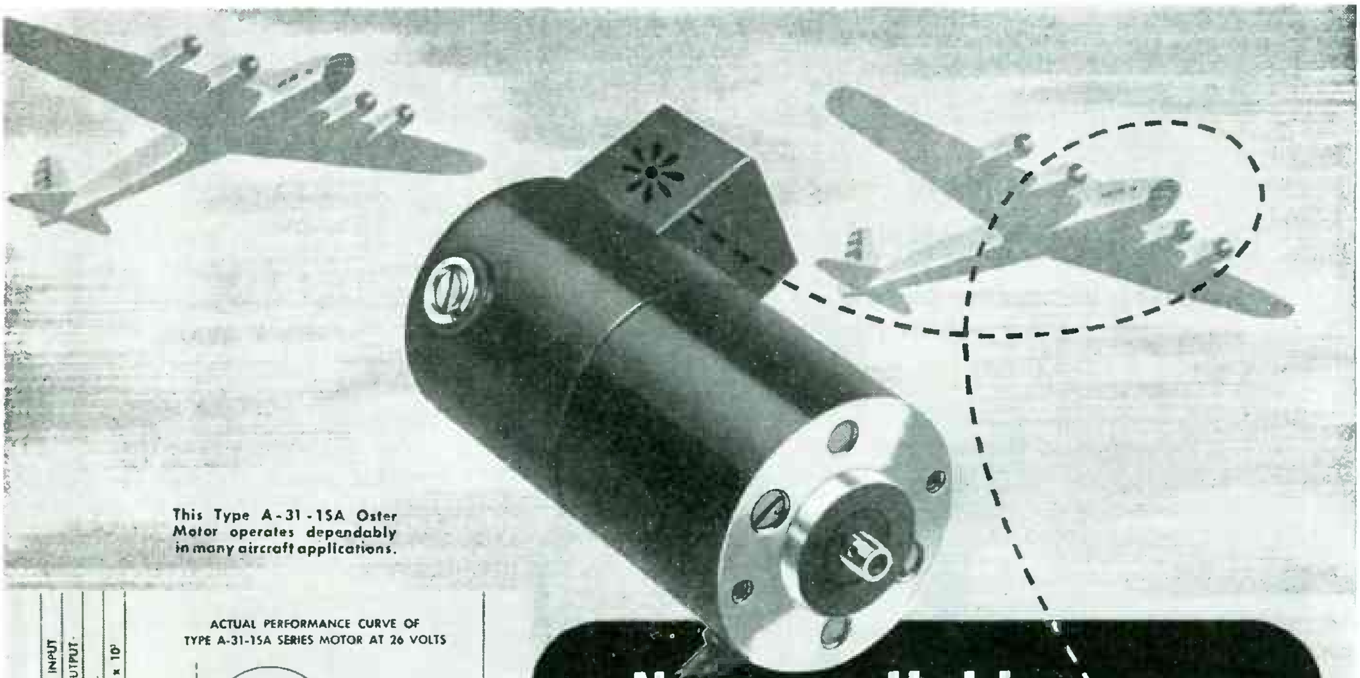
Since the input and output circuits are all tuned to different frequencies, a high overall gain can be obtained without using shielded coils or a metal chassis.

A sample receiver was demonstrated which was constructed on a pressed wood chassis and contained no shields. Although stored away for several years until it was recently resurrected, the tuning was within 5 kc over the broadcast band. It was suggested that postwar push-button models of similar design might advantageously make use of crystals.

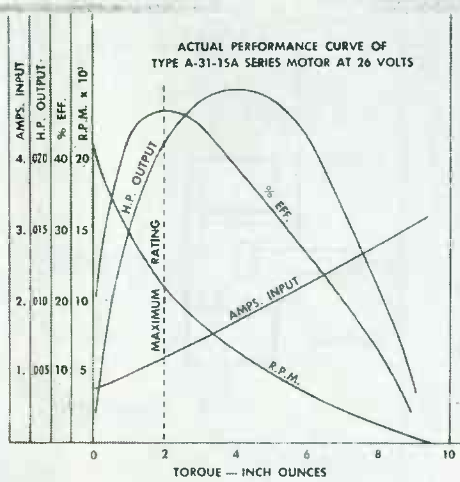
The performance of the six-tube set was superior to the conventional 6-tube superheterodyne with a tuned r-f stage. Listening tests in suburban Cincinnati showed that it was possible to receive interference-free signals on 40 of the 106 standard broadcast channels.

Reflex Oscillators

The transit-time reflex oscillator has distinct advantages as a low power source in such applica-



This Type A-31-1SA Oster Motor operates dependably in many aircraft applications.



Rating of type A-31-1SA Motor

Horsepower — 1/50 intermittent.
Speed — 10,000 rpm.
Voltage — 26 D.C.
Winding — series.
Rotation — clockwise viewing rabbet end.
Duty Cycle — 15 min. on — 30 min. off.

Features of type A-31-1SA Motor

Housing — die cast aluminum, totally enclosed.
Finish — black anodized.
Weight — 11 ounces.
Bearings — High quality single shielded ball bearings, lubricated with grease suited for any specific application. Bearing housings fitted with steel inserts.
Brushes — High grade metal graphite of ample size to assure unusually long brush life.
Thermostatic Protector — Prevents motor burnouts, adjusted to open motor circuit in approximately one minute under locked rotor conditions at rated voltage.
Temperature Rise — 55° C. maximum frame temperature rise at rated load.
Mounting—Standard ¾" dia. Air Corps rabbet.
Modifications—Special shaft extensions, mounting arrangements, leads, etc. Information regarding motors for specific applications furnished upon request.

Suitable for various aircraft applications.

All ratings and data are approximate.

Now available . . . an Oster Motor

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thermostatically protected *

to prevent motor burnouts, and adjusted to open motor circuit in approximately one minute under locked rotor conditions at rated voltage . . .

Here is another Oster motor with features that make it ideal for many applications in aircraft. The thermostatic control prolongs the life of the motor by preventing burnouts. Its weight (11 ounces) and body size (1½ x 3") are reduced to a minimum without impairing efficiency. The performance record is backed by 16 years of engineering experience in the fractional-horsepower field.

You can depend on it to deliver creditable results that add to your own reputation for selecting sources wisely. Let us help you fit this or other Oster motors to your requirements. Write for further details.

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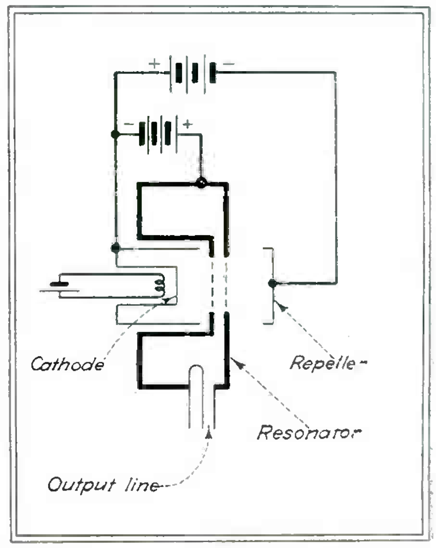
M-23

John Oster Manufacturing Co.

DEPARTMENT E-23 • RACINE, WISCONSIN

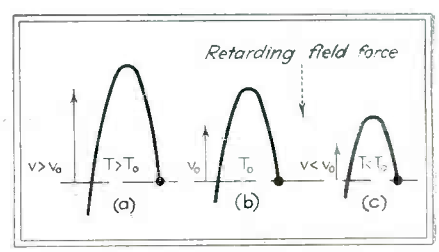
tions as a beating oscillator in double-detection receivers or as a frequency-modulated oscillator in low-power transmitters. So far the efficiencies which have been attained are quite low, as J. R. Pierce of Bell Telephone Laboratories pointed out in presenting the paper, but, that need not be a handicap in some applications. It may be light in weight, need have no magnetic focusing field, and may be made to operate at comparatively low voltages.

An electron stream from the cathode passes through the longitudinal radio frequency field between two resonator grids where the stream is velocity-modulated, then into a retarding field produced by a repeller electrode where the beam becomes bunched. Finally the bunched stream returns across the r-f field, exciting the resonant circuit.



Elements of a reflex oscillator that illustrate the principle of operation

Bunching in a retarding field is also shown. The retarding field in this case is the electrostatic potential gradient between resonator grids and repellers. The drift time is the time an electron projected into the field takes to return



Principle of drift-space bunching

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Wide Range • High Fidelity • Moving-Coil

← Three types of response for all purposes

The circuit combines two dynamic generators, each with a specific frequency response. Its ideal quality is produced by coupling the outputs electrically and acoustically. Total band 25 to above 10,000 cps. Broad crossover from 150 to 5,000 cps. Crossover band in the D220 has been designed to eliminate peaks in the middle frequency range.

D220 - Dynamic .... (30 - 50 ohms)

D220T - Dynamic (Available in 200 - 250 ohms, 500 ohms or High Impedance)

LOW
For pickup systems requiring embellished lows and good intermediate range.
(25 to 5000 cps.).

FULL
For high fidelity requirements where smooth, flat response and broad range are necessary.
(30 to above 10,000 cps.).

HIGH
For all purposes requiring richness in the higher frequencies. Slightly rising characteristic.
(From 150 to 10,000 cps.).

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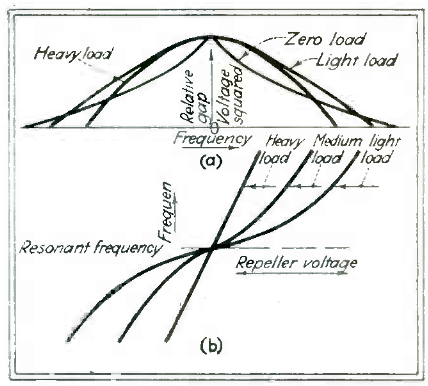
SEND FOR BULLETINS ON OTHER MODELS IN PRODUCTION to the resonator-grid region. The medium projection velocity is V_0 and the time to return to the plane of projection is T_0.

Electrons projected faster will return later; those projected slower will return sooner. In this way a velocity-modulated beam is converted into a density-modulated beam.

Reflex oscillators can be tuned electronically by varying the voltage-gradient between resonator grids and repeller electrode. For moderate loads, the total electronic-tuning frequency range between half-power points is not greatly affected by loading; for very heavy loads it is decreased. The rate of change of frequency with voltage is faster the heavier the load. Theoretical curves of relative power vs frequency and of frequency vs repeller voltage, which illustrate this phenomena, are shown. Measured curves are very similar.



Effect of load on electronic tuning (a) output vs frequency characteristic and (b) frequency vs repeller-voltage curves of a reflex oscillator

If, as above for instance, the oscillator is operating off circuit resonance by means of electronic tuning and if the repeller voltage is kept constant, when the load is changed in a purely resistive sense, not changing the resonant frequency of the resonant circuit, the frequency of oscillation will change because of the shifting to a new frequency-vs-repeller voltage curve.

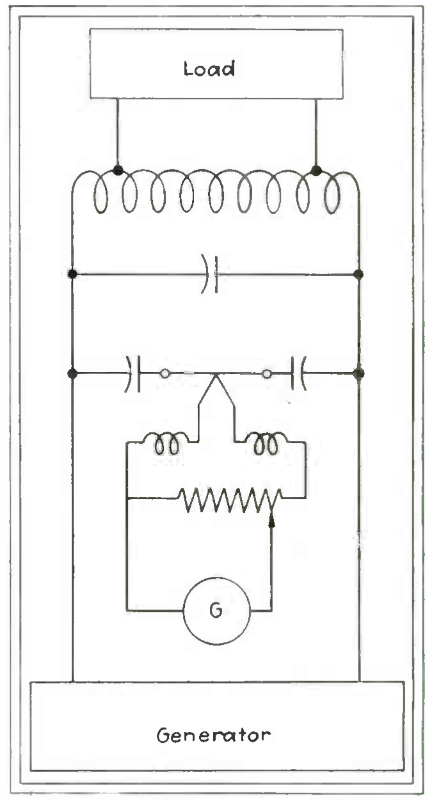
High-Frequency Wattmeter

The power dissipated in a high-frequency load is that power in which interest lies. A wattmeter which measures this power was described by Eugene Mittel-

mann of the Illinois Tool Works.

Because of the wide discrepency observed between the rated power output and that actually obtainable from industrial heating equipment, the wattmeter was designed to measure dissipated power by the method illustrated in the circuit diagram.

Because of the current drawn from the generator by the load, the voltage across the load will be a function of the load and the internal impedance of the generator. The thermocouple-galvanometer instrument is made square law and



Connection of wattmeter to h-f generator to read the voltage across the load. By means of the resistor, the meter reading is made proportional to watts. If the thermo-couple-galvanometer combination is square-law, the wattage scale is linear

therefore its indication is proportional to the power being dissipated in the load. The meter is calibrated at no load using the equivalent no-load loss conductance of the generator as a standard of comparison. Although the generator contains vacuum tubes whose impedances vary with load, measurements on diathermy and industrial dielectric and induction heating equipment over a variety of loads showed the maximum error to be within five percent.

Besides measuring power, this

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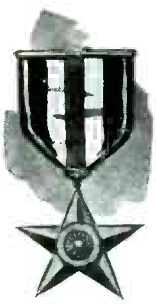

Little or no introduction is needed by the welcoming committee. The Sergeant has been through many hells. As a crew member he's been over Berlin in giant bombers. Over a lot of other German cities, too. More recently, he's been over Tokyo...time and time again!

Before long, thousands of fighters like Sergeant Adams will be back on their jobs in American industry. They know from experience what American equipment can do. Many will have first-hand knowledge of the war job performed by Eastern-built equipment—not only earlier types of amplifiers related to sound systems but also the newer types of Eastern units related to wartime and industrial instruments. As civilians, these men are going to say, "If it's built by Eastern, it's okay!"

To aid the war effort, our engineers are available for consultation on any amplification or electronics problem. Eastern will continue to apply its resources to designing and manufacturing war equipment until the day of Victory. Meanwhile, on request, we will send you the next of a series of articles on peacetime sound and electronic equipment, prepared by our engineering staff. Ask for Brochure 3-F.

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wattmeter can be used to indicate proper loading of the generator. For a given generator there is only one value of equivalent loss resistance referred back by the external load for which maximum power dissipation is obtained. It is possible, therefore, to provide a marking on the meter dial indicative of this value. To obtain proper matching the coupling is adjusted until the meter deflection reaches this mark.

In an industrial installation, the wattmeter and its calibrating resistor can be mounted with the other meters. The calibrating resistor, used to adjust the sensitivity of the meter so that it is reading true watts, is calibrated as a multiplier in the case illustrated in the accompanying photograph.

Commercial application in which the wattmeter is mounted at the center with the other generator meters; the calibrating resistor is to the right of the wattmeter

The Servo Problem

That the purpose of a servo system is to reproduce a signal at a place or a power level or in a form that is different from the original signal but is under its control was explained in a paper by Enoch B. Ferrell of Bell Laboratories. The same can be said for a public-address amplifier, a telephone repeater or an i-f amplifier. The servo uses negative feedback as do some of the others and its circuit elements include motors, gears or thermostats. Noise and distortion

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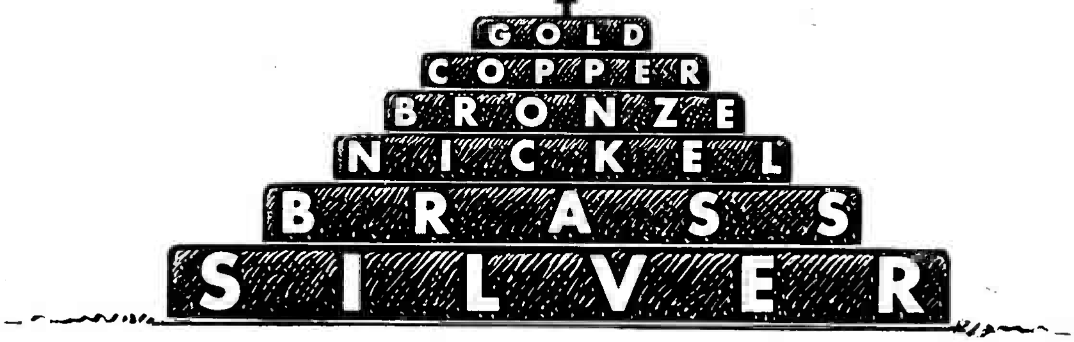

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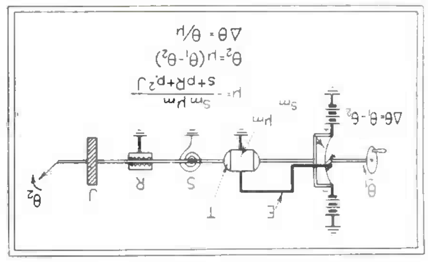
are called error in servos but the basic problems of stability, bandwidth and linearity are the same.

The drawing shows a simple servo system in which a low-power input shaft controls a high-power output shaft. The difference in the two shaft positions is converted to a voltage by means of the potentiometer. The voltage is applied to a motor which drives the output shaft into agreement with the input shaft. The potentiometer and motor can be considered as amplifying elements similar to vacuum tubes.

Negative feedback is introduced through the drive of the potentiom-



Simple servo system which incorporates negative feedback

eter body by the motor shaft. Thus, unwanted effects of frequency discrimination and non-linearity are reduced by an amount dependent upon the signal transmission gain around the feedback loop.

This transmission characteristic is designed to give a phase reversal at low frequencies. If an error exists it is propagated around the loop and because of this reversal annuls itself, but at some higher frequency the reactances introduce an additional phase reversal and when the error gets around the loop it tries to reinforce itself. If the return signal is larger than the original error, the error grows until it is limited by overloading in the system and the system oscillates. We say it sings around the loop.

Two margins of safety needed to avoid this singing have been described by Bode. At gain crossover, which is the frequency for which the amplification is unity and the gain is zero, a phase margin is needed. At phase crossover, which is the frequency for which the returned signal is in phase with the error, a gain margin is needed. Good design practice provides a gain margin of 10 to 20 db and a phase margin of 40 to 60 degrees.

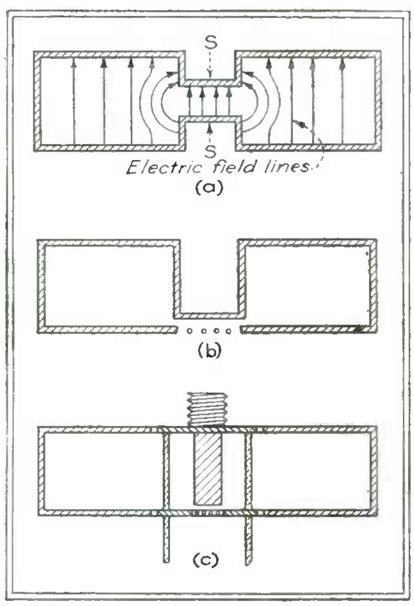
To permit the use of more gain, a

phase-correcting network can be used to improve the phase margin. To obtain proper phase margin, the loop transmission characteristic must have a slope of about 9 db per octave in the region of gain cross-over. With proper phase equalization, the low frequency gain can be made large and hence the errors in following can be made small.

Disk-Seal Tubes

Union of electronic and electromagnetic circuits is accomplished by the disk-seal tubes introduced publicly by E. D. McArthur, Research Laboratory of General Electric.

To obtain usable characteristics at vhf, it becomes necessary to combine the functions of the circuit inside the envelope and that customarily outside the tube bulb. By making the tube electrodes a part of a cavity resonator as illustrated, the electron stream is brought directly into the electromagnetic circuit, thereby eliminating tube-lead inductance. Inter-electrode capacities are an integral part of the circuit, and radiation which is the greatest single factor limiting the impedances that can be obtained without shielding at vhf is completely eliminated by using cavities.



The center of a cavity, being the best place at which to current-excite it, is the ideal position for the electron stream

Because of skin effect, the electromagnetic field is confined to the cavity but heat is conducted to the outside where its efficient radiation

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Sheets of Acadia Polystyrene—compression-molded—have properties superior to those fabricated by other methods—no shrinkage at normal temperatures—better heat resistance.

Complete details are available on request. For quick reference a few of Polystyrene's outstanding points are summarized here:

Dielectric Constant	2.5 to 2.6 at frequencies 10^6
Power Factor, 60 cycles	.0001 to .0003
10^3 cycles	.0001 to .0003
10^6 cycles	.0001 to .0003
Dielectric Strength, Volts/Mil ⅛" thickness	
Short time	500 to 700
Step by Step	450 to 600
Volume Resistivity, ohms-cms	10^{17} to 10^{19}
Heat Resistance	150° F to 250° F
Softening Point	190° F to 250° F
Specific Gravity	1.05

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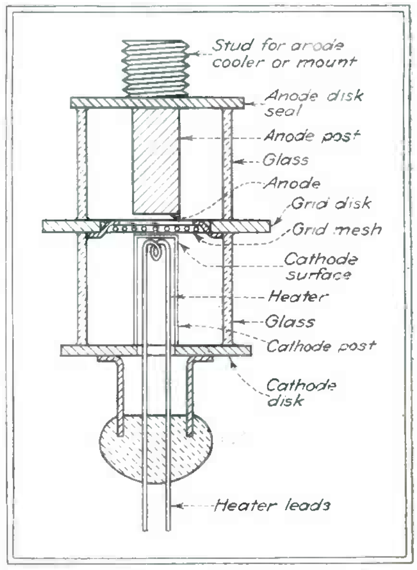
4035-4117 Ogden Avenue, Chicago 23, Illinois • • *Branch Offices in All Principal Cities* will not interfere with the high-frequency circuit. Likewise, the application of direct voltages to the tube electrodes can be done through the cavity walls, the skin effect confining the r-f field more effectively than would chokes in the feeder leads.

Although the use of parallel plane electrodes required to give uniform transit angle throughout the electron stream reduces the locating of the electrodes to a single dimensional problem instead of a two-dimensional problem, as it is in cylindrical electrode construction, the severe requirements for exact parallelism and the extremely close spacing of the electrodes requires far greater machining tolerances than heretofore. Mechanical construction of a disk-seal tube is shown. (The complete paper appeared in ELECTRONICS for February 1945.)



Basic constructional details show how the electronic elements are shaped to be a part of the electromagnetic circuit

Shielding Dielectric Heating Installations

Increased industrial use of electronic heating requires that the high-frequency generators used be properly shielded to prevent interference with other radio services. In a paper prepared by G. W. Klingaman and G. H. Williams of RCA, the results of field measurements made on a typical dielectric heating installation were presented.

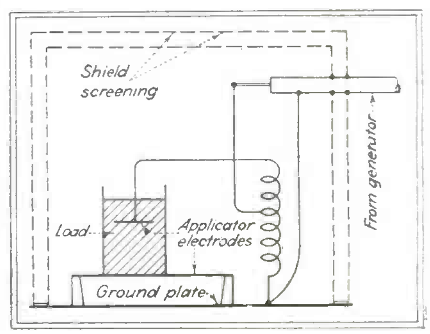
The applicator electrode and

worktable were set up about 12 ft from the generator and connected with a concentric transmission line. The incoming power line and remote control station wires were led through metal conduits. The usual safety ground was connected directly to a ground pipe. The power input to the generator was held constant at 6 kw; the frequency was 9 Mc.

The initial field strength and field strength measurements made after the application of various types of shielding are given in the table below. Various types of shielding both of the applicator

Conditions	Field strength μ/meter converted to 1 mile
As installed—no load shielding	316.
Single screen cage over load	1.3
Generator cabinet shielded	0.12
Double screen cage over load	0.007
Double screen door on cage	0.0036
Slot 30-in. with 8-in. extension	0.04

worktable and the generator tester were applied and field measurements made. The results of cut-and-try shielding indicated that all holes and cracks in the generator must be shielded. Continuously bonded bronze screening extending all the way around the cabinet door and wire screening over meter holes and ventilator grill were required. A filter in the power line placed inside the generator cabinet was necessary and the leads to the remote control station were also shielded.



Shielding of worktable was most effective using this double wire screen connected to the worktable ground plate

Of several methods of shielding the worktable, the one shown proved the most satisfactory. The two shields consisted of bronze screening fastened to a wooden

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From users of PRESTO equipment all over the country comes the same story: "It's rugged, it's dependable, it stands the gaff!" The increased use of transcribed material in wartime broadcasting has placed a heavy burden on all recording and playback equipment. PRESTO users—including many of the major broadcasting stations—have found that their equipment is handling the job with ease. That's because PRESTO devices are products of integrity—built to do *more* than will ever be expected of them.

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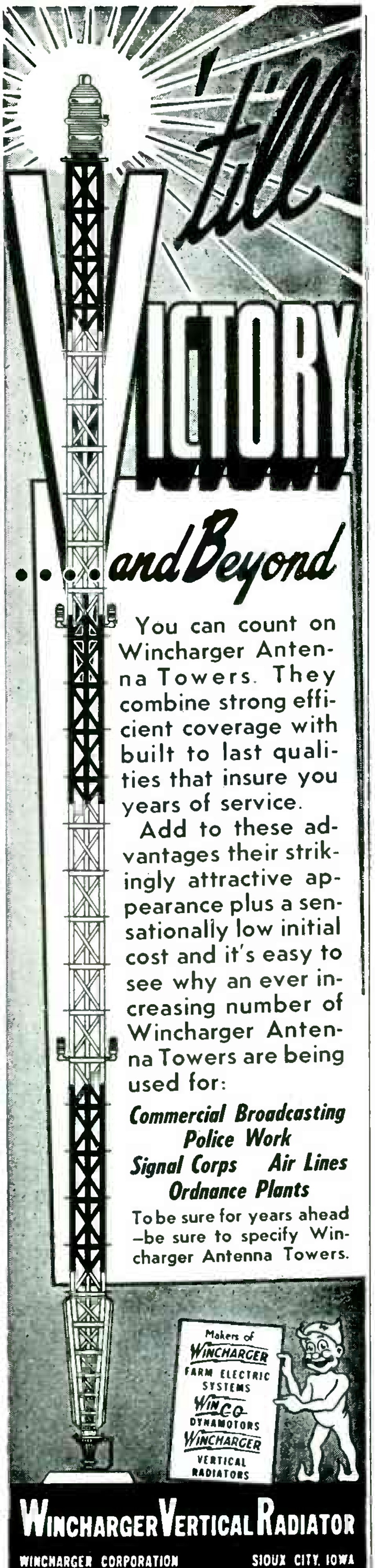

frame. The screening makes contact with the lower or ground-potential applicator electrode.

An opening was cut in the worktable screening to facilitate placing the load between the applicator plates. A simple door provided for this opening was used and also an extension around the opening so that the opening itself could remain free for continuous feeding of the worktable.

Miniature Tubes

Advances in vhf receiving tube design were described by R. L. Kelly in a paper prepared by N. H. Green and himself, both of RCA Victor.

The 1.4-volt filament tubes, although not useful at vhf, did nevertheless demonstrate the utility of small, strong tubes for portable equipment such as is now in demand by the armed forces. Acorn tubes, although inconvenient because of their peripheral pins which require a large-area ring-type mounting, indicated the advantages to be attained at vhf by using heater type tubes with small electrodes.

The 9000 series was therefore developed to replace acorn tubes by a more useful mechanical design but of identical static electrical properties. Recently additional tube types have been developed in this miniature series of 6.3-volt, 150-ma, heater-type tubes.

These miniature tubes combine the advantages of small size, excellent v-h-f performance and adequate mechanical strength yet are light in weight.

Although the glass envelope is so small as to limit heat radiation, this is not as serious as had been anticipated and is offset by the short leads which efficiently conduct heat to the pins for radiation. The all-glass base and low-inductance leads account for the excellent vhf performance.

Some of the characteristics of the miniature tubes are listed below.

6C4-a vhf triode which has about one-third the interelectrode capacities of the 6J5, gives 2.5 watts at 150 Mc.

6J6-a twin-triode of parallel-plane electrode construction to provide uniform transit time, delivers 1.5

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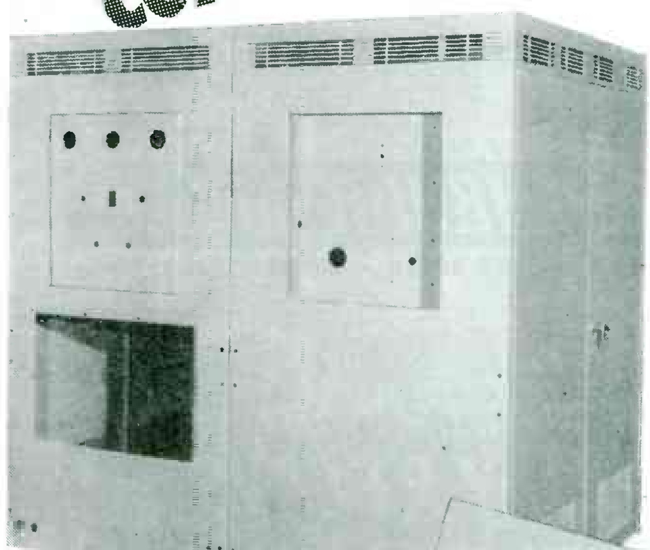

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watts at 250 Mc as a push-pull oscillator and can be used as a push-push mixer or local oscillator up to 600 Mc and is well suited for multivibrator and blocking oscillator applications.

6AG5-an r-f pentode for operation up to 200 Mc and is recommended for use in video amplifiers. It has a figure of merit (figure of merit is $g_m/(C_{in} + C_{out})$) of 2120; for comparison, the figure of merit of the familiar 6AC7 is only 470.

6AL5-supplants the 6H6 which, because of its wide cathode-anode spacing, has an internal drop of 26 volts at 60 ma. The 6AL5 has closer cathode-anode spacing giving it an internal drop of only 10 volts at 60 ma and a resonant frequency of 700 Mc. The high perveance of the 6AL5 makes it useful in broad-band detectors.

6J4-designed for use as a grounded-grid oscillator, has the smallest grid wires wound with the greatest turns per inch of any tube so far built commercially and therefore has the most uniform grid-plane potential. Three grid-pin connections reduce grid-to-ground impedance. Plate-to-cathode capacitance is 0.2 $\mu\mu$f.

6AQ-6- a triode plus a duo-diode.

6AK6-audio power amplifier having about one watt output with ten percent harmonic distortion.

2D21-miniature edition of the 2050 has a peak inverse potential rating of 1300 volts. Cathode-current rate of rise should not exceed 100 amperes per microsecond, and the average anode current over a 30-second period should be limited to 100 ma.

Is Industrial Technique Different?

That industrial electronics differs from communication work, especially in the emphasis on costs and the type of personnel available for operation and routine servicing, was pointed out in a paper by W. D. Cockrell of General Electric.

Because of the emphasis on reliability in radio, the operating personnel as well as the station itself must meet minimum standards and be licensed. Furthermore, it has been found necessary to have an operator on duty at all times when the station is operating.

On the other hand, industrial electronic equipment must be so

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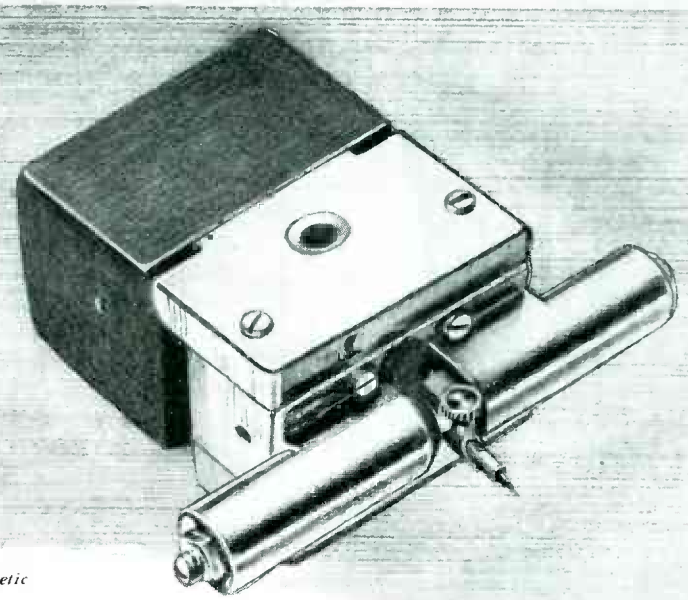

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Freedom from Distortion . . . *less than 1% at 400 cycles*

Laboratory tests measure a distortion freedom of less than 1% when a 400-cycle note is recorded . . . with a Fairchild No. 541 Magnetic Cutterhead . . . at a level of + 18db (reference .006 watts) to produce a stylus velocity of 2.5 inches per second.

Exceptional design and precision skill has produced a magnetic cutterhead that successfully damps the moving armature — through the use of unusually long cushion blocks and a positive means of adjusting and maintaining the armature in correct balance.

The result is the long sought *correct bass response* that remains free from distortion while producing the finest possible full volume recordings up to 8,000 cycles.

When mounted in a Fairchild adapter, the No. 541 Magnetic Cutterhead also provides a sapphire advance ball on a swivel mount that permits instant change from "in-out" to "out-in" cut direction . . . a micrometer-threaded screw control of cut depth . . . and an easily accessible screw adjustment of the cutting stylus angle.

Standard with the No. 539 Fairchild Recorder, the outstanding performance and operating qualities of the No. 541 Magnetic Cutterhead are now available to all owners of earlier Fairchild portable models and many other types of recorders.

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SOUND EQUIPMENT

built that it can be installed by the average electrician as easily as a typical motor or magnetic control panel. It must usually be so designed that it can operate satisfactorily in whatever factory atmosphere it must be used.

The typical manufacturing system utilizes two types of personnel on machines. The highly skilled set-up man "sets up" or adjusts the machines to perform the desired function so that the unskilled or semi-skilled machine operator may perform the simple operation necessary for each cycle of operation.

Since the average operator at the machine generally knows little or nothing about the operation of the electronic equipment, the equipment must be so designed that no incorrect operation on

Maintenance of the multitude of electronic tubes and circuits at Radio City Music Hall, New York, cannot be done by the average theater electrician

the operator's part can damage it and it must also contain safety devices so that the operator cannot be harmed. Other devices such as photoelectric door openers or smoke detectors or precipitators must operate for weeks or months at a time without any supervision.

Servicing is perhaps the most difficult problem which we face today in the acceptance of electronic control. There are, of course, no licensed operators who have passed an examination in the theory of their equipment. There is rarely anyone in the plant from the chief electrician or plant engineer on down who had studied any electronic theory or knew anything about electronics beyond twisting

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Here's a line of home radios thoroughly postwar — with no prewar entanglements of leftover ideas or equipment. They're built by the company whose name is a byword in aviation radio — a tough and exacting field.

These instruments are designed with an eye and ear on all the advances made in radio during the war. And their construction has the precision you'd expect from hands that fashion aircraft radios.

Sets like these will attract the cream of the market. Our distributors must be the cream of radio merchants. So for that reason our franchise has been made particularly attractive.

Lear policy aims to avoid the pitfalls of prewar radio merchandising. Dealers will have a line they can count on to be stable in models, in prices and in discounts. It will be supported by substantial advertising and sales helps.

We have purposely prepared the Lear wholesale distributor franchise to be one of the most advantageous dealership opportunities in the industry. If you are interested and feel that you can meet the qualifications, address LEAR, Incorporated, Home Radio Division, Sales, 230 E. Ohio St., Chicago 11, Illinois.

LEAR RADIO

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the dial of his home radio until a year or so ago.

Division of industrial electronic equipment into four classes was made by Mr. Cockrell. In the first classification, he included interphone systems, public address systems, and carrier current operation, both for communication and for relaying.

Another class of industrial electronic equipment comprises industrial amplifiers and oscillator units in which the frequencies involved are within the ranges with which the radio man has worked previously and the precautions to be observed are typical.

However, included with the familiar circuits will be found some new and unfamiliar circuits which must be studied carefully both for themselves and for the unusual effects which they may create in the more familiar circuits. In this field, the radio engineer who has kept up to date with the circuits used in television and radar will find himself much better prepared than his less wide-awake friend. Engineers who understand the operation of clipping, discriminating, scanning and pulsing circuits will find themselves much more at home in this class of equipment. In this class, he included such things as oscillators for high-frequency induction and dielectric heating, elevator leveling equipment, diathermy equipment, metal detection, etc.; amplifiers used for spectrophotometers, biological experiments, frequency and time standards, sound meters, etc.

Typical of the small control devices mentioned is this general-purpose photoelectric relay

Further removed from communi-

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Investigate the Unique Characteristics of G-E Neon Glow Lamps

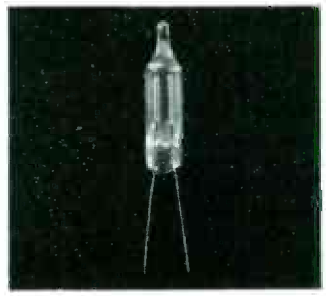
● The unique characteristics of General Electric Neon Glow Lamps recommend them for a variety of uses in radios and electronic devices . . . as indicators, voltage regulators, pilot lights and test lamps.

The uses described at right are typical. If you think G-E Neon Glow Lamps can be useful to you, write or phone the address below. Experienced General Electric Lamp Engineers will be glad to discuss your problems with you.

CONSIDER THESE ADVANTAGES

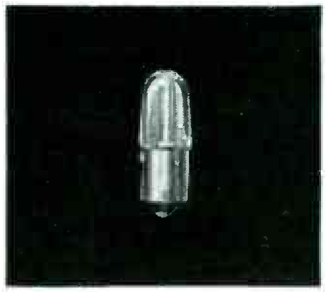
1. Distinctive orange-red glow—no colored cover glass needed.
2. Dependable performance and long life—rated at 3,000 hours.
3. Very low current consumption—less than ½ milliampere for smallest lamp.
4. Variety of sizes and wattages.
5. High resistance to vibration, shock.
6. Normally usable on a-c or d-c.
7. Screw base lamps for 105-125 v. circuits; similar lamps with bayonet bases available without resistors.
8. Produce practically no heat.
9. Nearly flat volt-ampere characteristics.
10. Insensitive to voltage variations above critical value.

NE-48 (also NE-16). Indicator lamps. Special volt-ampere characteristics of these lamps indicate use as voltage regulators. Screw base lamp available as NE-45.*



NE-2 One of the most widely used indicator and test lamps—popular because of compactness and small size. Nominal wattage is only 1/25 watt. This lamp is unbased—has wire terminals.

*NE—16 meets JAN-1A specifications for 991. Special marking JCG-991 supplied for small extra charge.



NE-51 For general indication, such as showing existence of potential across various parts of electrical circuits.

NE-17 Indicator and pilot light lamp that flashes to show condition of B-battery in portable radios. Frequency of flashes decreases as battery runs down.

ORDER NO.	NE-2	NE-51	NE-17	NE-48	NE-16 (4)	NE-45	NE-30	NE-32	NE-34	NE-36	NE-40	NE-42
Watts, Nominal	1/25	1/25	(3)	¼	¼	¼	1	1	2	2	3	3
Volts (Circuit)	105-125	105-125	(3)	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125
Starting Voltage (1) AC / DC	65 / 90	65 / 90	(3)	65 / 90	— / (5)	65 / 90	60 / 85	60 / 85	60 / 85	60 / 85	60 / 85	60 / 85
Base	Unbased (Wire Terminals)	S. C. Bay. Min.	D. C. Bay. Cand.	D. C. Bay. Cand.	D. C. Bay. Cand.	Cand. Screw	Medium Screw	D. C. Bay. Cand.	Medium Screw	Sk. D. C. Bay. Cand.	Medium Screw	Sk. D. C. Bay. Cand.
Maximum Overall Length	(2) 1 1/16″	1 3/16″	1½″	1½″	1½″	1⅝″	2 1/16″	2″	3 5/16″	3¾″	3 5/16″	3¾″
List Price (plus tax)	$.08	$.10	$.45	$.35	$.42	$.40	$.40	$.45	$.50	$.55	$.60	$.65

(1) Applies to lamp when new.
(2) Glass part; wire terminals extend additional 13/16″.
(3) Designed for DC flashing operation in RC circuit.
(4) Meets JAN-1A specifications for 991. Special marking JCG-991 supplied at small extra charge.
(5) Designed for 67-87 Volts D.C. (D.C. operating voltage at 1.5 milliamperes, 53-65 volts).

For further information, write address below for Bulletin 7100.

NELA SPECIALTY DIVISION LAMP DEPARTMENT

GENERAL ELECTRIC

1 Newark Street, Hoboken, N. J.

cation electronics is the class of industrial electronic equipment consisting mostly of the small control devices such as photoelectric relays, timers, and contact amplifiers employing only one or two tubes. These devices usually operate from raw a-c on the tube plate or anode and, although the devices are simple, they require a new concept on the part of the engineer, who must think in terms of a single cycle rather than in wave trains.

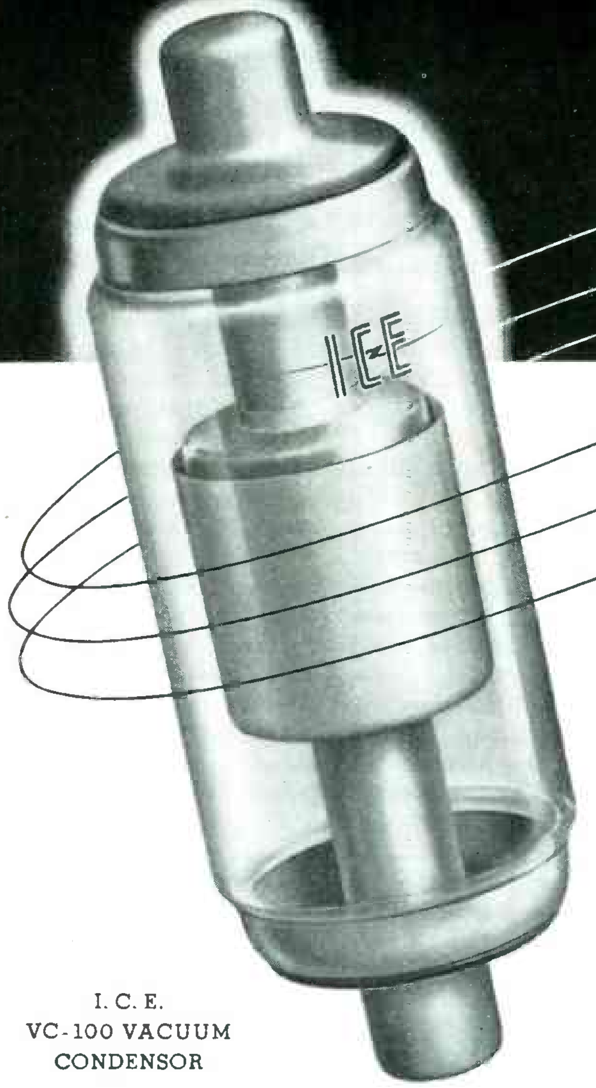
Control of grid-controlled gas-filled tubes by shifting the phase of the grid brings to light a whole host of grid-shifting circuits. Again, amplifiers which must respond to zero frequency or d-c bring a whole new set of problems.

Regulating circuits in which hunting of motors may occur, require new concepts of oscillation in which mechanical devices form a part of the oscillating circuit.

In another class of industrial electronic equipment we become almost completely divorced from radio theory and practice. This is large power-conversion equipment such as the ignitron and tank-type mercury-arc power rectifiers, inverters, and frequency changers. The fundamental theory of operation of these devices is usually simple but, because of the sizes of these equipments and the amount of power involved, great emphasis must be placed on such things as maximum tube capacity, efficiency of operation, long life and reliability with minimum maintenance and the effect of harmonics.

A very important consideration also is the proper circuit breaker protection for the rectifier, the transformer, and the a-c and d-c connected equipment. Since a power rectifier capable of supplying 5000 amperes at 600 volts d-c is a fairly common piece of equipment it may be seen that the power involved in a short circuit fault on the d-c system or failure of a tube to rectify can become tremendous.

Since design and installation of this type of equipment would seem to be more in the field of the electrical power engineer than that of the radio or control engineer, he suggested that the radio man interested in this type of equipment would do best to obtain his training through central station or power utility sources.



I. C. E.
VC-100 VACUUM
CONDENSOR

I-C-E

HAS THE ANSWER TO YOUR MICROMICROFARAD PROBLEM

You don't have to build equipment to suit the capacity of any particular condensor. I. C. E.'s advanced research now makes available to you reliable vacuum condensors in capacities ranging from 10 to 110 micromicrofarads . . . in steps of one micromicrofarad. I. C. E. precision assures accuracy of one micromicrofarad, plus or minus. Standard condensors available in sizes VC-12 . . . VC-25 . . . VC-50 and VC-100.

Order your requirements today

Send for this Complete Catalog

A new catalog, fully illustrated, describes in detail I. C. E. vacuum condensors as well as other high precision vacuum equipment. Write for your free copy today.

Research on Your Other Problems

The I. C. E. research laboratory is ready to serve you in the development and designing of tubes and other vacuum units required by electronic equipment you are now designing. Write Engineering Department today.

I-C-E

ELECTRONIC TUBES

RESEARCH • DESIGN • PRODUCTION

INDUSTRIAL & COMMERCIAL ELECTRONICS

BELMONT, CALIFORNIA

NEWS OF THE INDUSTRY

Inventions wanted; national and regional meetings; Central America's market possibilities; new OWI transmitters; industrial tube potentialities; meetings ahead; Washington News on licenses, manpower, network recordings, production, and standardization

Radio and Electrical Engineers Hold Technical Meetings

A FEW MORE THAN three thousand members of IRE crowded the halls of New York's Commodore Hotel for the thirty-third annual Winter Technical Meeting. Last year's attendance was about 1900. At the opening morning session, incoming president Everitt spoke of the things to come for the Institute.

He acknowledged the need for wider geographical representation on the board and for greater autonomy in the local sections but put the winning of the war, as it should be, first. Other policies which will be prosecuted throughout the coming year involve the establishment of a professional staff including a technical secretary and a technical editor.

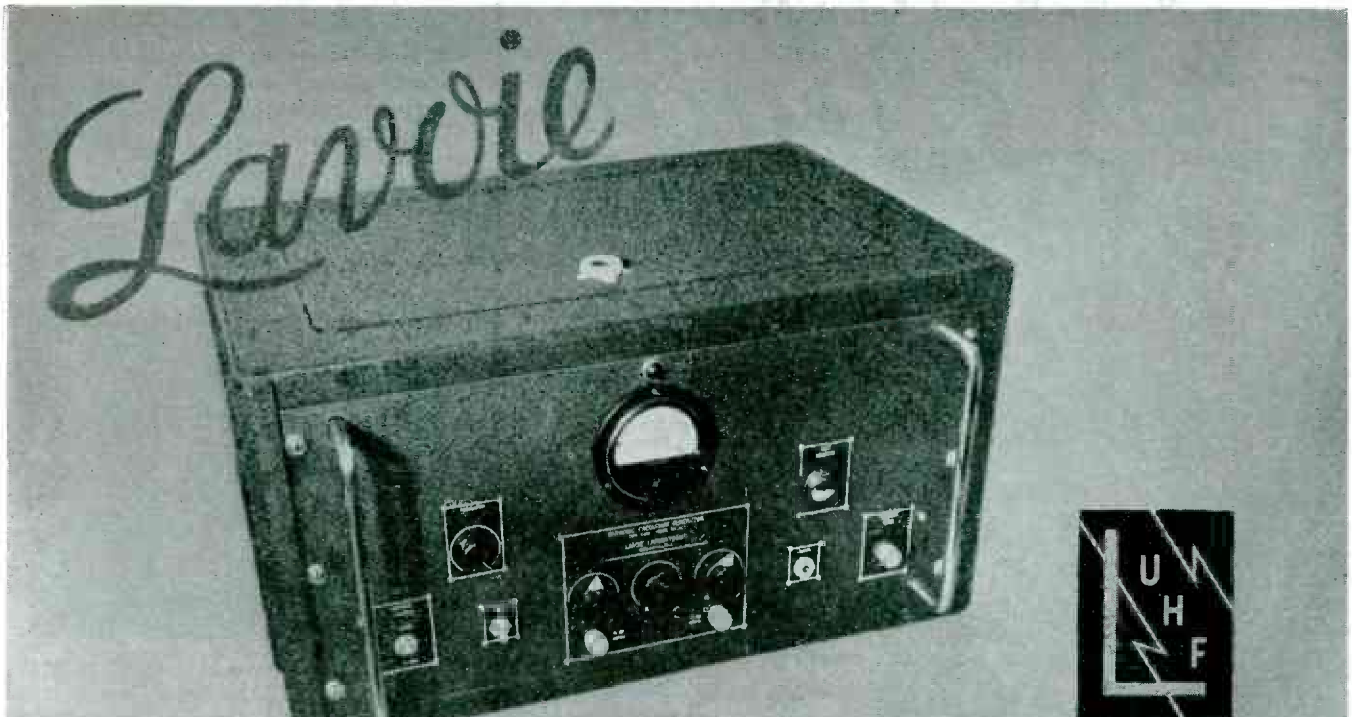
Fearing no shrinkage in membership after the war, he exhorted the members to take over the field of electronics to which, by conquest, they are entitled. He suggested that this might eventually involve changing the name of the organization—a move requiring careful thought. As for the problems of headquarters space, they are to be solved by new facilities which will grow out of a building fund to be handled by a committee headed by B. E. Shackleford and I. S. Coggeshall. The objective is to be prepared for participation in a combined engineering building or a separate one as seems most advantageous later on.

Other business of the Institute took place at the jammed banquet where the Medal of Honor, the Morris Liebmann Memorial Prize, and twelve honorary fellowships were awarded as reported in ELECTRONICS for February. Other features included participation by exhibitors to the extent of 60 or more and 42 technical papers. (See The Electron Art, this issue.)

On the evening before the start of the technical sessions, IRE and AIEE jointly presented Capt. Jennings B. Dow, USN, director of the electronics division of the Bureau of Ships (recently retitled from the radio division) as the featured speaker of the Edison Medal presentation to Dr. E. F. W. Alexanderson.

Dr. Alexanderson, himself famous for amplifiers and other electronic developments, suggested in his acceptance that the world should exchange the blue glasses of the economist for the rosy ones of the inventor after the war and that electronic engineers working in the spirit of Edison might be looked to

Part of the crowd of 1250 who attended the annual banquet of IRE. Seated at the speakers' table from left to right are: Austin Bailey, R. A. Heising, C. A. Powel, G. P. Adair, Capt. E. M. Webster, Col. V. B. Bagnall, W. W. Hansen, H. M. Turner, F. C. de Wolf, H. B. Richmond, W. L. Everitt, H. H. Beverage, O. H. Caldwell, Capt. A. H. Addoms, R. A. Hackbush, E. F. W. Alexanderson, G. W. Bailey, G. B. Hoadley, and J. E. Shepherd

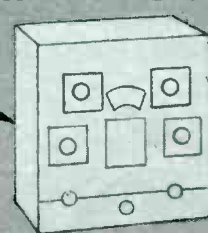


HARMONIC FREQUENCY GENERATOR

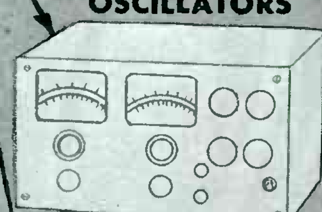
for
- FAST
- EASY
- ACCURATE

CALIBRATION of

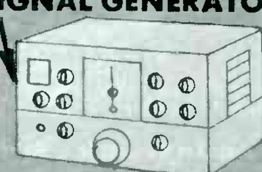
WAVEMETERS



OSCILLATORS



SIGNAL GENERATORS



RECEIVERS

NOW you can obtain precision calibration up to and beyond 2000 megacycles of receivers and wavemeters at a fraction of the time previously required. Also, by means of a Beat Detector built into the instrument, you can cclibrate oscillators and signal generators with equal ease. Output voltages in multiples of 10 or 40 megacycles are provided with crystal-controlled accuracy. It not only selects 10 or 40 megacycle series by mecns of a front panel switch, but identifies any ONE of these harmonics by means of a Frequency Identifier*, (supplied separately) providing high attenuation of all voltages except that of the frequency to be identified.

* In writing for full details, please specify the frequency of Identifier wanted.

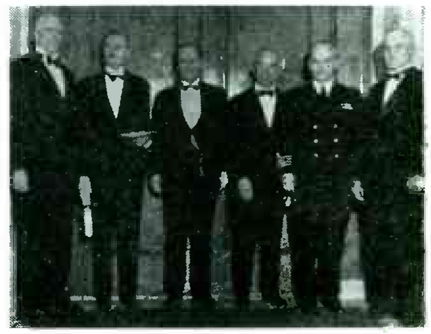
Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS

MORGANVILLE, N. J.

Specialists in The Development of UHF Equipment *and in* The Manufacture of UHF Antennas to revitalize the electrical industry by starting new enterprises.

Captain Dow spoke about the Navy electronics program and pointed out that the expenditure for research and development in 1945 is approximately $80 million as contrasted with roughly $3,800,000 before 1942, drawing the ob-

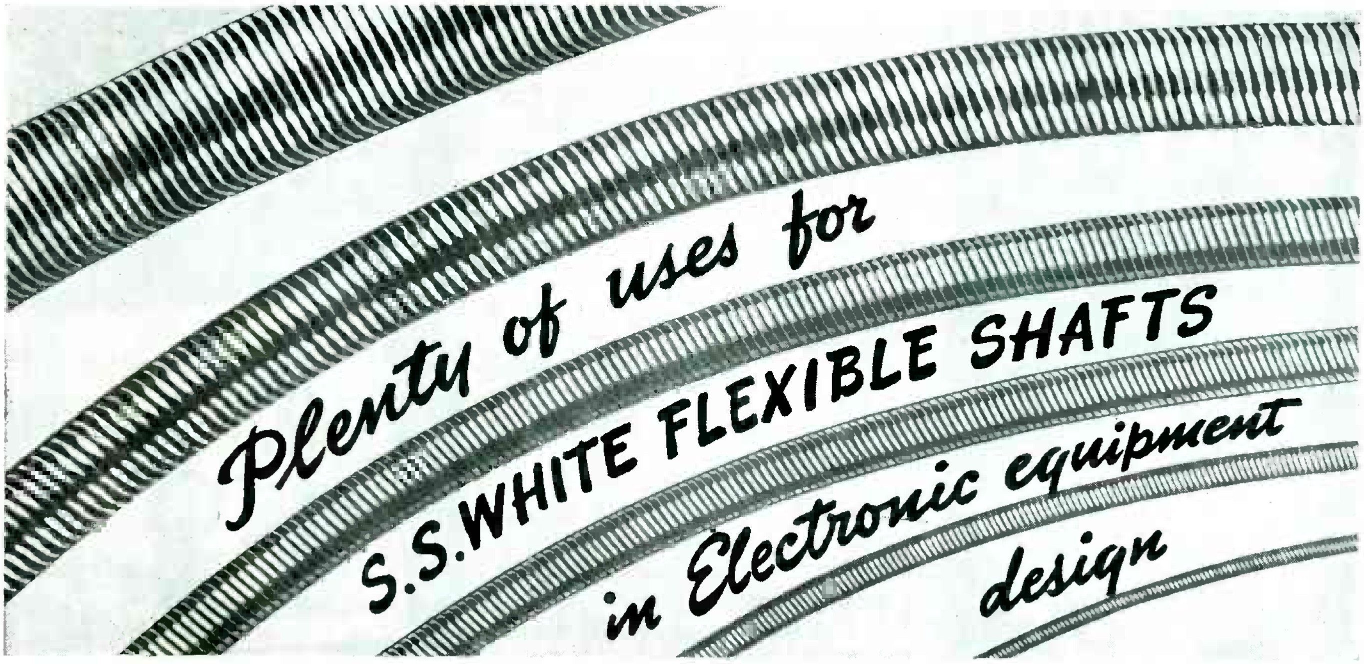


H. M. Turner, C. A. Powel, E. F. W. Alexanderson, R. C. Muir, Capt. J. B. Dow, and Karl T. Compton pose on the occasion of the joint IRE-AIEE session at which Dr. Alexanderson was presented with the Edison Medal

vious conclusion that our peacetime program has let war catch us with our guard down. He suggested a postwar minimum of $25 million a year.

He continued with a statement to the effect that the outcome of the war is largely contingent upon the relative electronic standings of the various belligerents. In scope, he showed that electronic equipment for the Navy has expanded from the end of 1941, when there were 2082 vessels and landing craft (in which were installed at least one transmitter and two receivers) to 1944 when there were 37,981 such vessels. In a large carrier there are 101 complete pieces of equipment. A battleship has 78, a small motor-torpedo boat 7, and some of the smaller landing craft as many as 13. For the 38,000 vessels, the total number of pieces of equipment comes to about 300,000. In dollar value, the Naval aircraft electronics program is almost identical. The year 1944 saw delivery of more than $1,300,000,000 worth of radio, radar, and sonar apparatus in addition to a large amount purchased directly from the Army.

Another subject touched upon by the Captain was the matter of radar patents and the official position of the Navy with regard to their disposition and handling



As basic mechanical elements for power transmission and for remote control, S. S. White flexible shafts advantageously serve the following purposes in electronic equipment:

POWER TRANSMISSION

- As a drive from small motors to operating mechanisms over short or long distances.
- For "coupling" power driven elements inside a piece of equipment.
- For mechanical power drive from one piece of equipment to another.
- For power take-off from any power source for driving auxiliaries.

REMOTE CONTROL

- For connecting control knobs and dials to adjustable elements and for "coupling" such elements inside a piece of equipment.
- For remote control of elements requiring rotary or "push-pull" manipulation from more or less remote points.
- For indicating the position of a moving part located where it can't be seen.

BASIC ADVANTAGES

of S. S. White Flexible Shafts for these jobs

- With a single flexible shaft you can direct-connect practically any two points, regardless of their relative locations. This means fewer parts to make and to assemble—lower costs. The large selection of S. S. White shafts meets a wide range of power drive and remote control requirements.
- Flexible shafts make possible improved designs because they give you a free hand in placing driving and driven or controlled elements wherever they should be for best efficiency, easy assembly, space saving, convenient operation and servicing.

256-PAGE FLEXIBILE SHAFT HANDBOOK FREE TO ENGINEERS—Gives complete information and data about flexible shafts and how to select and apply them. A free copy will be sent to any engineer who writes for it direct to us on his business letterhead and indicates his position.

S.S.WHITE INDUSTRIAL DIVISION

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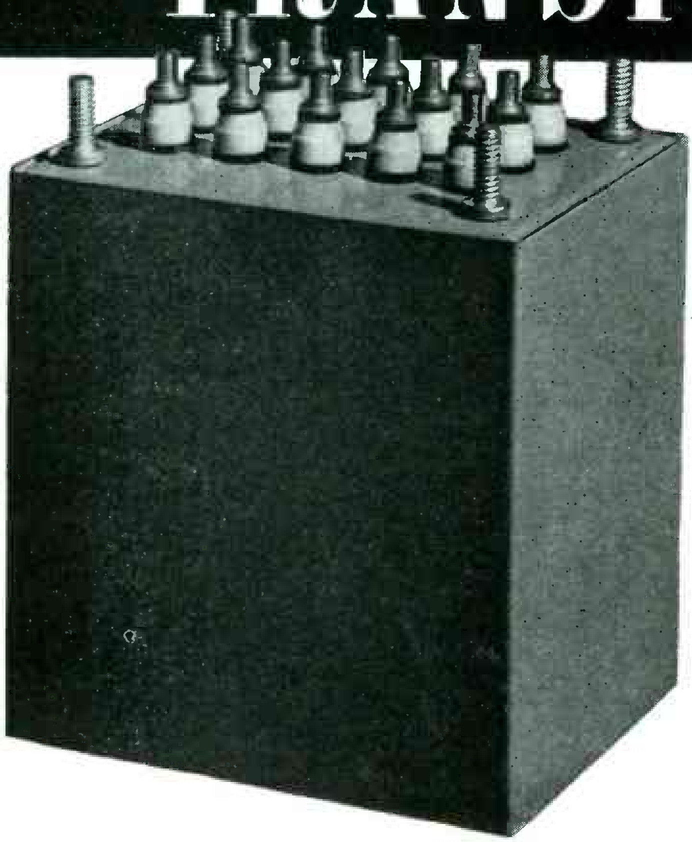
FLEXIBLE SHAFTS · AIRCRAFT ACCESSORIES · MOLDED PLASTICS · MOLDED RESISTORS · FLEXIBLE SHAFT TOOLS

One of America's AAAA Industrial Enterprises postwar. Because radar patents will be widely held in industry, by foreign interests, among individuals, and by Government, the program he outlined is looked to as a means of avoiding a situation where contractors will be unable to supply the best designs because of adversely-held patents, where excessive costs will result from pyramiding of royalties, or where a great amount of litigation will follow the issuance of patents. Essentially, the scheme involves a patent pool. He foresaw an average yearly radar business of $75 million.

Awards were made of the Alfred Noble prize to W. R. Wilson, GE, Pittsfield, for a paper on corona in aircraft at altitude and of the 36th honorary membership since 1884 to Dr. Dugald C. Jackson, professor emeritus of electrical engineering at MIT. During a joint Eta Kappa Nu-Tau Beta Pi dinner, V. Karapetoff, professor emeritus of Cornell University, spoke on concepts of relativity. Registration at the AIEE meeting ran over 1700, a figure which was last exceeded in 1941. Following are the technical papers and sessions bearing possible electronic implications:

Frequency Changers — Characteristics, Applications, and Economics, by S. B. Crary and R. M. Easley, GE.
Transient Response of Controlled Rectifier Circuits, by P. T. Chin and G. E. Walter, GE.
* A Method for Demonstrating the Voltage and Current Wave Forms of Controlled Rectifiers, by P. T. Chin and E. E. Moyer, GE.
Arc Backs in Rectifier Circuits—Artificial Arc-Back Tests, by R. D. Evans and A. J. Maslin, Westinghouse.
Rectifier Fault Currents, by C. C. Herskind and H. L. Kellogg, GE.
Voltage and Current Relations for Controlled Rectification with Inductive and Generative Loads, by K. P. Puchlowski, Westinghouse.
Damping and Synchronizing Torques of Power Selsyns, by C. Concordia and Gabriel Kron, GE.
Principles of Grid Control for Thyratrons, by P. H. Chin and E. E. Moyer, GE.
An Interval Timer for Arc Duration, by J. S. Quill, GE.
A Modulated Frequency System of Telemetering, by H. E. Renfro and A. P. Peterson, Control Corp.
Dynamic Measurements on Electromagnetic Devices, by E. L. Norton, Bell Labs.
A Portable Instrument for Measuring Insulation Resistance at High Voltage, by F. W. Atkinson and R. B. Taylor, Takk Corp.
A Comparison of the A-M, F-M, and Single Sideband Systems for Power-Line Carrier Transmission, by R. C. Cheek, Westinghouse.
The Resistance-Coupled Amplifier, by L. G. Cowles, Texas Co.
The Tapered Transmission Line, by J. W. Milnor, consulting engineer.
Tracer Controlled Position Regulator for Propeller Milling Machine, by C. R. Hanna and W. O. Osbon, Westinghouse; and R. A. Hartley, Adel Precision Products.
Application of Electrical Equipment for Propeller Milling Machine, by H. E. Morton. Morton Mfg. Co.; and O. G. Rutemiller, Crosley Corp.
Design of Sealed Ignitron Rectifiers for Three-Wire Service, by M. M. Morack, GE.
The Combination of Supervisory Control

Hermetically Sealed TRANSFORMERS



Illustrated at left is a Langevin Hermi-Lock hermetically sealed transformer. Case must be destroyed before interior of unit can be reached. Hermi-Lock provides extensive safety factor for combat use.

−50°C AMBIENT

+65°C AMBIENT

The failure of a hermetically sealed transformer is largely due to the fact that solder is depended upon for a mechanical union as well as the hermetic seal. Solder having a low tensile strength is readily fractured by thermal action, vibration or shock, and the seal broken; with failure a probability.

LANGEVIN hermetically sealed transformers employ the unique *Hermi-Lock construction which provides a positive mechanical union between body, cover and bottom, the solder being simply the sealing agent. The result is a dependable unit with little chance of failure under simultaneously adverse conditions.

Your inquiry for transformers of all types up to 5 KVA are solicited.

* Trade Mark Registered

The Langevin Company

INCORPORATED

SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

NEW YORK	SAN FRANCISCO	LOS ANGELES
37 W. 65 St., 23	1050 Howard St., 3	1000 N. Seward St., 38

with Other Functions on Power-Line Carrier Channels, by H. C. Cheek and W. A. Derr, Westinghouse.
Supervisory Control for New Chicago Subway, by W. A. Derr, Westinghouse; C. J. Buck, Chicago Rapid Transit Co.; and J. A. Stoos, Dept. of Subways and Superhighways, City of Chicago.
Power-Line Carrier Channels, by M. J. Brown, Westinghouse.
Mercury-Arc Rectifiers for Railroads, by S. S. Watkins, Gibbs and Hill, Inc.
Induction Heating of Moving Strip, by R. M. Baker, Westinghouse.
Preferred Practices for Electrical Control Devices for Aircraft, by F. W. Hottenroth Jr., GE.
* Conference on High-Frequency Cables, Lt. Comm. John H. Neher, presiding.
* Conference on High-Frequency Dielectric Heating, J. J. Orr, presiding.

Items marked with an asterisk (*) are not intended for publication by the Institute, either in Transactions or in reprint form. Others are available from AIEE, 33 West 39 St., New York 18, N. Y.

In anticipation of its Spring elections, AIEE followed up the meeting with an announcement of nominations including Dr. W. E. Wickenden for president.

Attention Inventors!

SIGNED BY C. F. Kettering, a note from the National Inventors Council of the Department of Commerce indicates that the Navy Department has a number of problems on which it would like to turn the country's inventors loose.

Among these are: (1) A device for transmitting rotary motion through a moisture-proof barrier for such applications as radio control knobs and generator shafts; (2) Waterproof jacks for microphones, headphones and telephone keys; (3) A continuous-sampling combustion-gas indicator with automatic alarm and suitable for installation in gasoline-driven motor boats for continuous sampling of bilge vapors; (4) A small portable field strength meter about the size and weight of a walkie-talkie and with frequency range from 100 to 20,000 kc and capable of measuring intensities from 10 to 1,000 millivolts per meter; (5) Radio antennas up to 300 ft high which can be handled by unskilled crews; (6) A method of measuring elastic stresses locked up in metallic structures; (7) A method of welding light-gage aluminum; (8) A precision twin-triode vacuum tube with the general characteristics of the 6SN7 type but with several modifications; (9) An expendable, compact, lightweight, rugged, mechanical device to permit successive closures of up to eight electrical

circuits with a time interval between closures of about 0.2 to 0.3 sec, and (10) A small, fast-acting, double-action solenoid to operate on 28 volts dc with a 20 lb pull at maximum air gap. The plunger must seat at each end of the travel.

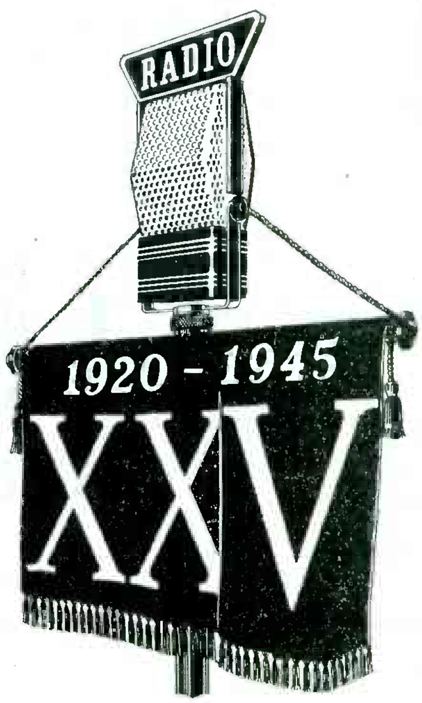
Suggested solutions should be prepared in sketch and description form and sent to the National Inventors Council, Department of Commerce, Washington, D. C., for consideration and report.

Circuit Theory for Servos

SERVO SYSTEMS were analyzed on the same basis as feedback amplifiers by Asst. Professor A. C. Hall of the MIT servo-mechanisms laboratory at a recent meeting of the New York section of IRE.

In the comparison of servos and amplifiers, the natural frequency of the servo was shown to correspond to a resonant rise in amplifier response and damping to correspond to amplifier gain. Conditions for instability and various degrees of damping were approached from the Nyquist diagrams for feedback stability.

Methods of controlling servo characteristics derived from this approach were demonstrated on a



This is the logotype adopted by National Association of Broadcasters to symbolize the twenty-fifth anniversary of KDKA's original operation and thus of the radio industry

. . . built for Long Life and Accuracy

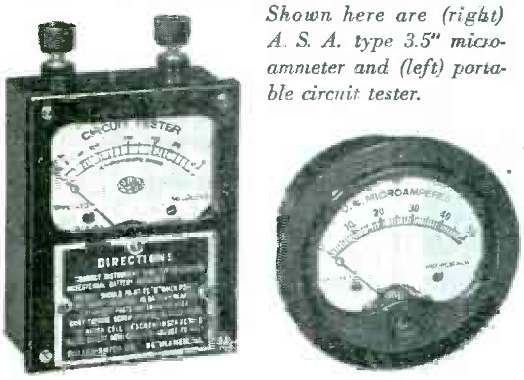
Made in d-c ammeters and voltmeters; a-c ammeters, voltmeters, triplex ammeters, single - and poly - phase wattmeters, frequency meters, power factor meters and synchroscopes.

BUY MORE
★ WAR BONDS

ROLLER-SMITH SWITCHBOARD INSTRUMENTS

OTHER R-S INSTRUMENTS

Panel and portable instruments of practically every standard size, shape, capacity, type and style are included in the R-S line of electrical instruments. Shown here are (right) A. S. A. type 3.5" microammeter and (left) portable circuit tester.



In both d-c and a-c switchboard instruments, Roller-Smith has concentrated on a moving system that will guarantee long-time accuracy and freedom from trouble. Fine grained hardened and polished steel pivots rotate in carefully selected jewel bearings. Springs are phosphor-bronze, well aged to minimize zero shifting. The rugged bridge construction assures permanent alignment of all parts and helps maintain calibration.

This careful construction of the mechanism, coupled with the best of materials and workmanship plus more than 40 years of experience in the design and manufacture of precision electrical instruments all add up to an assurance of accuracy and dependable performance. For complete information, with list of ranges commonly supplied, write for Catalog 4220.

ROLLER SMITH

Sales Representatives
In all Principal Cities

ROLLER-SMITH BETHLEHEM, PENNA.

Canadian Plant: ROLLER-SMITH MARSLAND LTD., Kitchener, Ontario

STANDARD AND PRECISION ELECTRICAL INSTRUMENTS OF EVERY TYPE laboratory model of a continuous-control servo. Damping was shown to be directly controlled by amplifier gain, and sensitivity to be governed by the natural frequency of the system.

Boat-to-Boat

RADIO-TELEPHONE communication between lifeboats at sea will be feasible with non-skilled men through the use of a new transceiver by cargo vessels of the U. S. Maritime Commission. Manual or automatic telegraph transmission can also be used. The unit operates entirely by power from a hand-operated generator which permits unlimited operation without the limitations of short-lived batteries. Units are entirely waterproof and attain, by the use of balloon and kite antennas, a range ten times that of present lifeboat transmitters on 500 kc. A range of over a thousand miles is obtained on the high frequency of the air/sea rescue program.

Synchronized Advertising

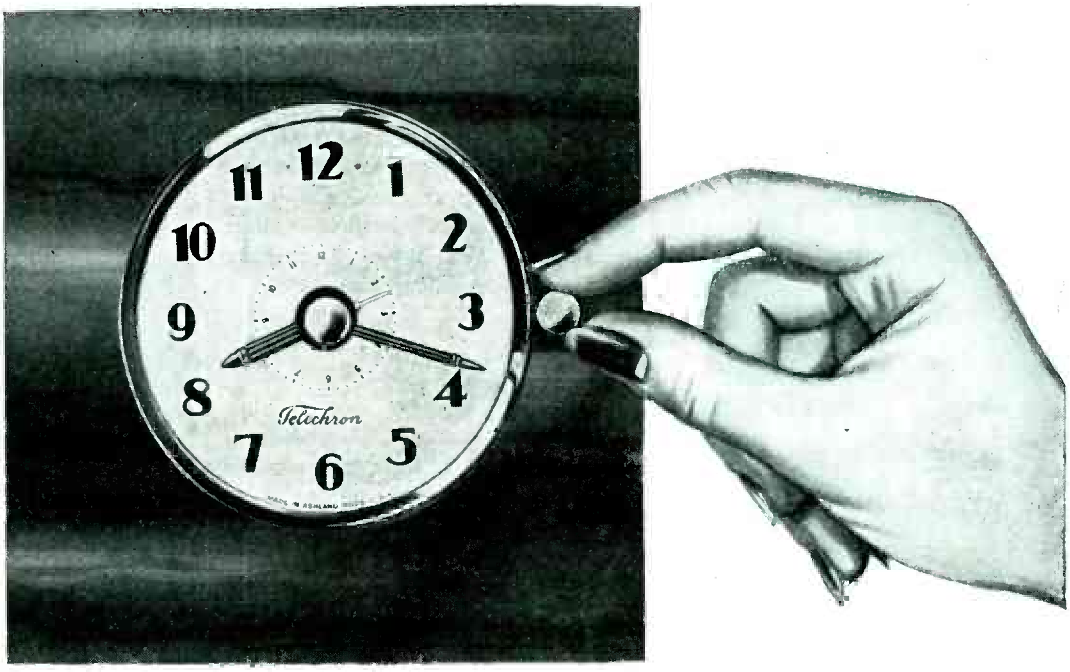
PEOPLE ALL OVER the world will be able to read the same advertisements at the same time according to a scheme worked up between Radio Corp. of America and one of the New York advertising agencies. Radiophoto transmission will be used to flash copy and layout for simultaneous release to publications throughout the globe. From these radiophoto centers, copy and layout would go by air mail to an additional network of cities. The scheme has already been used in a few cases and gives promise of practicality.

Central America—Receiver Market

THERE IS A GREAT vacuum in the home radio field in the Central American countries, according to Lazare Gelin of Lear Inc. who has just returned from a trip through Mexico, the Central Americas, Colombia, and Venezuela.

Having had a dozen years experience in export work in these countries, Mr. Gelin bases his predictions on commercial estimates and on comments given him by local businessmen. He adds to the com-

BUILD IT IN!



Telechron Electric Radio Switch Clock for quick-moving post-war receiver sales!

Telechron C40, electric radio switch clock, is a top-flight, A-1 sales booster for lower price receivers. The owner pre-sets the operating time—C40 turns on the station, *on the dot,* and also serves as an ideal alarm clock. Single control knob. A handsome time-saver that should be standard equipment on every radio designed for mass appeal. Low installation cost. Attractive pattern for panel mounting. Furnished in varying dial sizes, with dial and hand styles to meet your requirements. Famed Telechron accuracy, long life, dependability. Other styles and sizes for other radio requirements. Get the full, profitable facts now! Write or wire Automatic Control Division, Dept. K, Warren Telechron Co., Ashland, Mass.

COMPLETELY AUTOMATIC PRE-SELECTOR

Telechron Timer C32 offers complete automatic pre-selection of as many as 48 different 15-minute radio programs in sequence. Timer turns radio on for desired operating period, then turns it off. A flick of the finger sets the keys around the large and legible clock face. For panel mounting.

Telechron

REG. U. S. PAT. OFF.

WARREN TELECHRON COMPANY • ASHLAND, MASSACHUSETTS

ment that there are very few home receivers left, the admonition that prospective purchasers will expect their postwar radios to be considerably better than the prewar prototype.

The market for aircraft radio will also be huge, he thinks, basing his prediction on the fact that our southern neighbors have stepped directly from the ox-cart age into the air age, missing the rail and automotive transportation steps that we have gone through. They are so air-minded, he reported, that bricks have even been shipped by airplane in certain areas.

West Coast Speaks with 300 KW

INTENSIFICATION of psychological warfare against the Japanese is marked by the opening on our West Coast of six new 50,000-watt transmitters by OWI (Office of War Information).

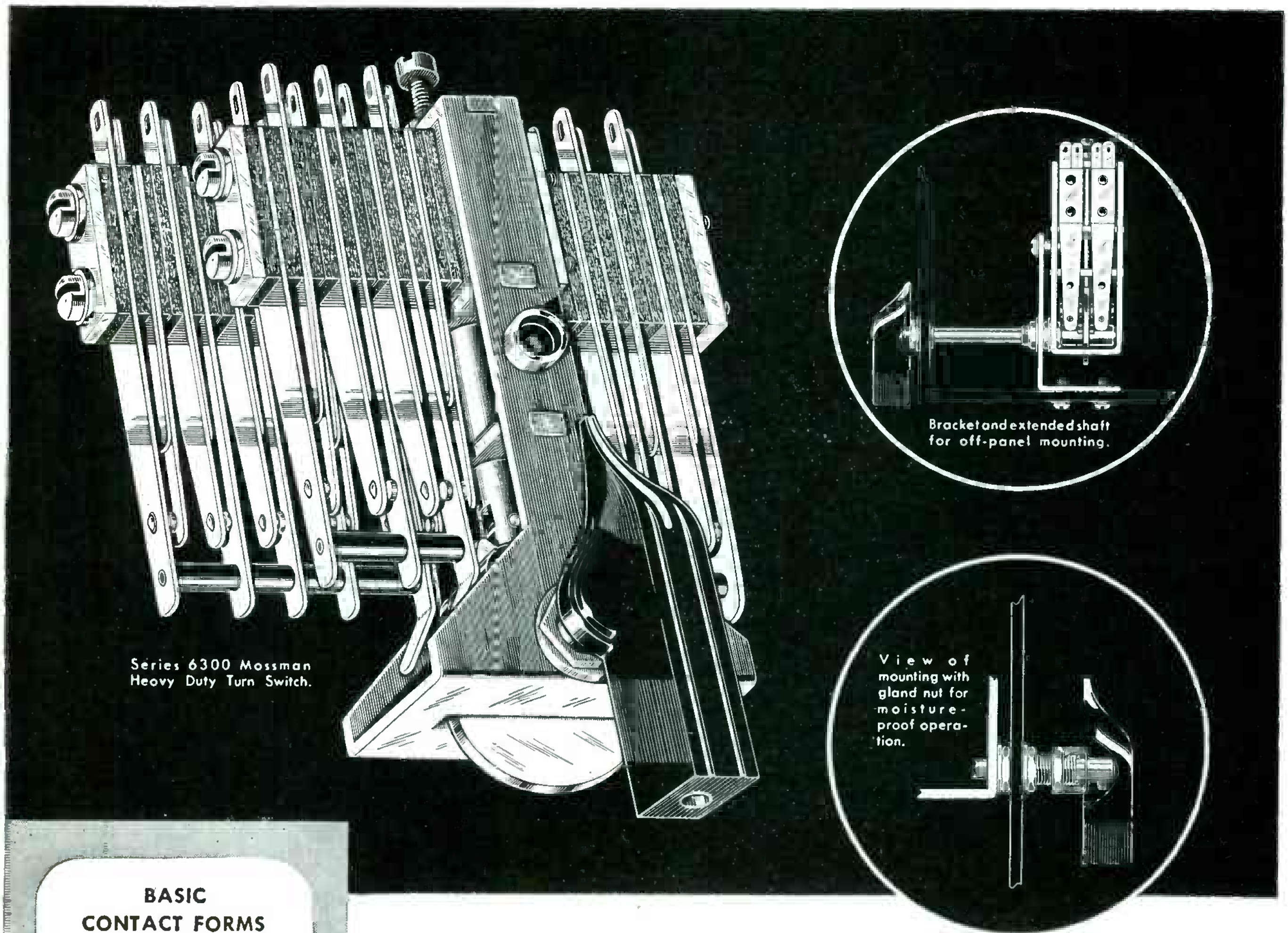
With these facilities, almost double the hours of broadcasting will be devoted to carrying the voice of America deeper and more completely into Japan, China, the Philippines, and the entire Far East.

One of the dual transmitters, KCBA-KCBF is operated by Columbia Broadcasting System at Delano, while the other two dual transmitters, KNBA-KNBC, and KNBI-KNBX are run by the National Broadcasting Co. at Dixon. Programs originate from OWI's new studios in San Francisco and include news, commentary, and specially designed radio features in many different languages and dialects.

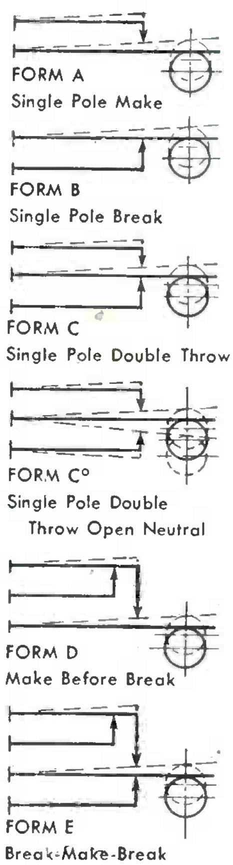
New Officers for Control Society

AT THE ANNUAL MEETING of the New York Society for Measurement and Control, held in New York recently, the following officers were elected for the forthcoming year:

President—Prof. Carl F. Kayan of Columbia University; vice president—C. H. Colvin of Guggenheim School of Aeronautics; secretary—H. L. Hildenbrand of The Esterline-Angus Co. Inc.; treasurer—E. E. Corbett of C. J. Tagliabue Mfg. Co.; Executive Committee—Irving H. Blatz and C. D. Corey of Bulova



BASIC CONTACT FORMS



MOSSMAN SERIES 6300 HEAVY DUTY TURN SWITCH

Permits Almost Unlimited Circuit Arrangements

Latest development in the Mossman line of precision heavy duty multiple circuit turn switches is the Series 6300 . . . a big, husky switch for panel mounting that permits a most versatile control set-up.

Electrical and production engineers will find this switch most useful in such applications as: Signal systems, alarm systems, controls for machine tools and welding equipment, lighting systems, annunciators and many other types of electronic devices and controls.

The Series 6300 Mossman Heavy Duty Turn Switches are available as either three position (Series 6303) or two position (Series 6302) switches. An almost unlimited series of combinations of contact assemblies may be built up by use of any combination of the six basic forms shown.

Standard heavy duty contacts are of 3/16" diameter fine silver, rated at 10 amperes, 110 volts A.C., non-inductive. Extra heavy duty contacts are of 5/16" silver alloy rated at 20 amperes, 110 volts A.C., non-inductive. Breakdown rating of springs to ground is 2000 volts, A.C.

Send for complete information on the new Series 6300 Mossman switches. Also ask for catalog which describes the full line of Mossman precision electrical components, including many types of heavy duty, multiple circuit lever switches, turn switches, push switches, plug jacks and other special switching components.

DONALD P. MOSSMAN, INC., 612 N. Michigan Ave., Chicago 11, Ill.

MOSSMAN

"Electrical" Components

Watch Co.; Harry E. Geddes of American Airlines Inc.; Robert K. Farnham of Instrument Publishing Co.; H. C. Roters of Fairchild Camera & Instrument Corp.

At the business meeting preceding the election, a report was given on the progress of plans to organize a national society for measurement and control.

Motion Picture Standards Under Way

AMERICAN STANDARDS Association has in the works a number of standards with possible electronic implications. These include: specifications for Class II Service Model 16-MM Sound Motion Picture Projection Equipment—Z52.13, Specification for Warble Test Film Used for Testing 16-MM Sound Motion Picture Equipment—Z52.32, Sound Records and Scanning Area for 35-MM Sound Motion Picture Prints—Z52.36, and Method of Determining Signal-to-Noise Ratio of 16-MM Sound Motion Picture Prints—Z52.38.

Phenomenal Tube Market

MAJOR POSTWAR MARKETS for electron tubes will be found in the manufacturing and processing industries rather than in communication, in the opinion of L. W. Teegarden, general manager of the tube and equipment department of the RCA Victor Division, Radio Corp. of America.

As an illustration, he pointed out that a single order recently received by the company for power oscillator tubes to be used in electronic power heating had a combined rated power equal to that of all radio stations in the United States.

Airways Radio Problems

RADIO RANGES along Federal airways will probably be kept in a constant state of change, according to Charles I. Stanton, Deputy Administrator of the CAA (Civil Aeronautics Administration), as he spoke before the Radio Technical Committee for Aeronautics recently. Although CAA expects to install a complete new v-h-f system of ranges with equipment which may be available before this summer and eventually replace all

...with SPEER GRAPHITE ANODES

Because Speer Graphite Anodes are high in thermal conductivity value, produce quicker diffusion and more uniform distribution of heat throughout the anode material, thus preventing "hot spots" which result in warping and fusing.

Speer Graphite Anodes have a very low expansion, and no softening point (graphic sublimes without melting at 3500° C.) and do not warp. Their non-warping quality permits tube manufacturers to produce closely matched tubes, the characteristics of which will remain constant throughout their entire life.

Speer Graphite Anodes are manufactured by a method which insures greater plate dissemination—not only of heat but also of power. This process also eliminates shrinkage generally brought about by high operating power as well as completely expelling all gases from the anodes.

. . . AND THEY ALSO

- Increase allowable plate power dissipation.
- Lower temperatures of associated tube parts.
- Withstand severe overloads.
- Prevent "hot spots" or fused holes.
- Minimize bulb darkening and insulator leakage.
- Improve degassing qualities.
- Decrease gas troubles.
- Enhance tube appearance.
- Provide precise anode dimensions.
- Produce uniform tube characteristics.
- Retain original dimensions in service.
- Maintain normal tube characteristics.
- Allow wide latitude of anode design.

SCC

SPEER
CARBON COMPANY
ST. MARYS, PA.
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MILWAUKEE · NEW YORK · PITTSBURGH

7869

low frequency ranges with v-h-f, Mr. Stanton suggests that continual research and development will make it necessary to install the best available equipment and study developments as they come.

Talking about language difficulties which will inevitably arise from inter-continental air traffic, he expressed the hope that a code system annd signals intelligible to all nationalities might be developed.

Association to Cultivate Good Labor Relations

RECENTLY ORGANIZED in New York and located in the Empire State Building is the Electronics Manufacturers Association Inc. formed to handle the labor relations of radio-radar and other electronic-product manufacturers in the greater New York area.

Officers and directors elected for an annual term include: I. Walter Wyckoff, Pilot Radio Corp., president; Leslie G. Thomas, Solar Mfg. Corp., vice-president; Arthur Freed, Freed Radio Corp., vice-president; J. J. Kuscher, DeJur Amsco Corp., secretary; Samuel J. Novick, Electronic Corp. of America, treasurer, and Erwin Feldman, general counsel.

MEETINGS TO COME

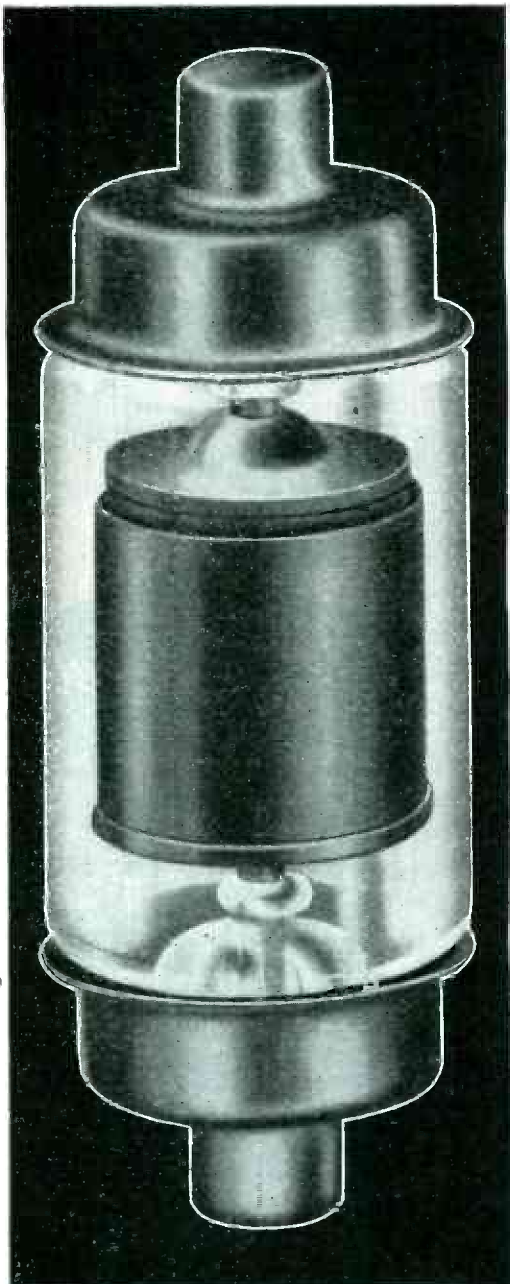
MARCH 21. AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, New York Section, Physical Limitations in Electron Ballistics. Mines Building, Columbia University, New York, N. Y. Prof. C. W. van der Merwe, symposium chairman, Dept. of Physics, Washington Square College, New York University, New York, N. Y.

APRIL 12-14. ELECTROCHEMICAL SOCIETY, 87th General Meeting, Hotel Claridge, Atlantic City, N. J. Colin G. Fink, secretary, Columbia University, New York 27, N. Y.

APRIL 12-14. OPTICAL SOCIETY OF AMERICA, Cleveland, Ohio. Arthur C. Hardy, secretary, Massachusetts Institute of Technology, Cambridge 39, Mass.

APRIL 16-20. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION, Spring Meeting, Palmer House, Chicago, Ill. . . . . . Cancelled.

APRIL 25-26. AMERICAN INSTITUTE



Jennings RADIO

NEW HIGH VACUUM

VC 50 TO 250 JENNINGS CAPACITORS

FOR FASTER, CLEANER AND MORE UNIFORM INDUCTION HEATING

Westinghouse

has incorporated the Jennings High Vacuum Capacitors in their standard radio frequency generating and control equipment, ranging in frequencies wide enough to meet all probable dielectric and induction heating needs.

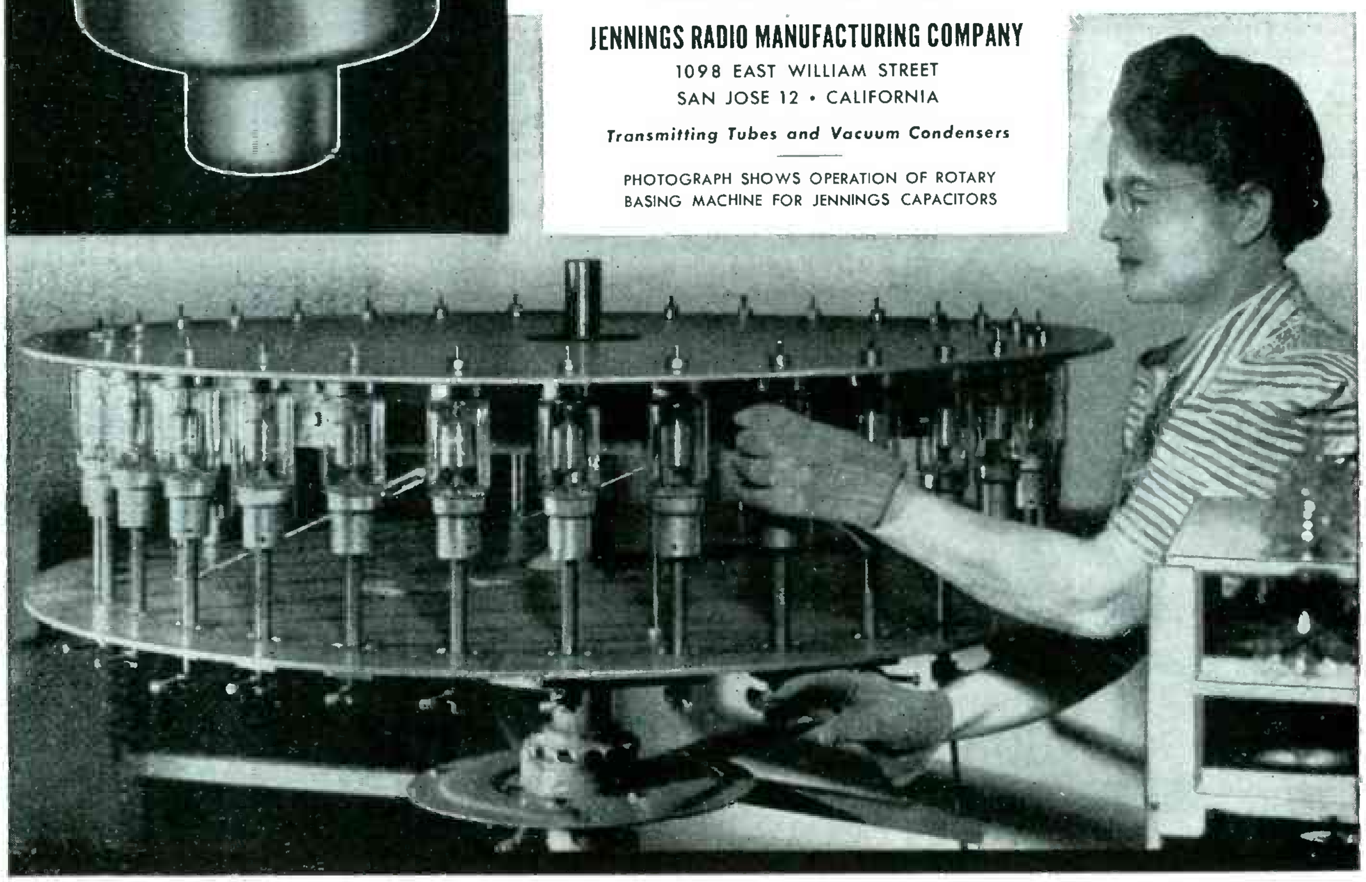
TROPICALIZE ***your equipment with Jennings Capacitors***

Literature will be mailed on request

JENNINGS RADIO MANUFACTURING COMPANY
1098 EAST WILLIAM STREET
SAN JOSE 12 • CALIFORNIA

Transmitting Tubes and Vacuum Condensers

PHOTOGRAPH SHOWS OPERATION OF ROTARY BASING MACHINE FOR JENNINGS CAPACITORS



OF ELECTRICAL ENGINEERS, North Eastern District Meeting, Buffalo, N. Y. H. H. Henline, secretary, 29 West 39th St., New York 18, N. Y.

APRIL 26-27. INSTITUTE OF THE AERONAUTICAL SCIENCES, National Light Aircraft Meeting, Detroit, Mich. Meetings Committee,—New York 20, N. Y. Subject to postponement or cancellation.

MAY ——. SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, 1945 Spring Meeting, Buffalo, N. Y. W. M. Murray, president, P. O. Box 168 Central Square Station, Cambridge 39, Mass.

WASHINGTON NEWS

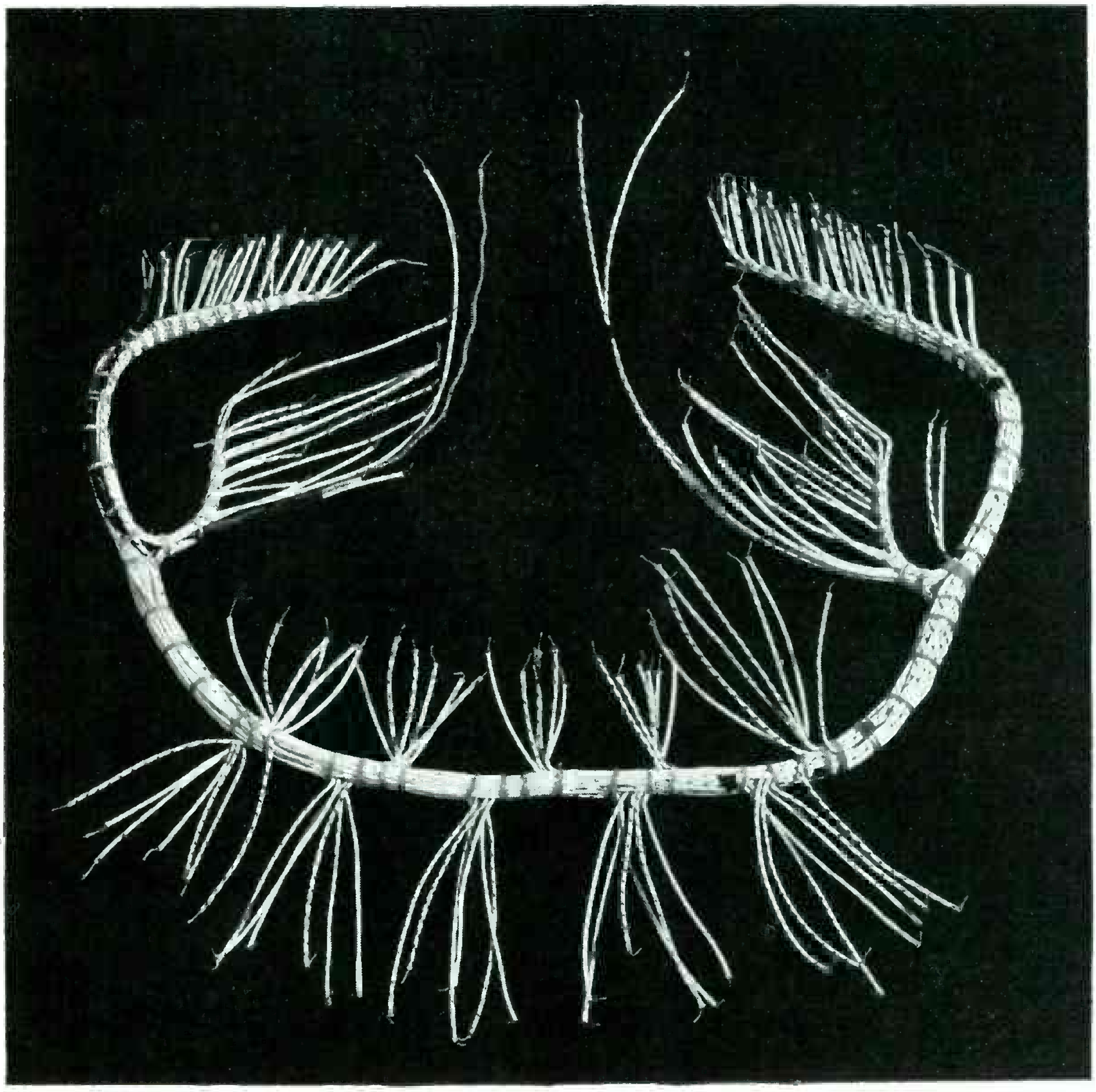
LICENSES. As a convenience to many licensed and formerly licensed commercial radio operators now in the military service or employed in war industries distant from their homes, a year's extension of license expiration has been granted by FCC. Many such operators do not have actual possession of their licenses at the present time, cannot ascertain their expiration dates, and therefore file timely applications for renewal. The new deadline is December 31, 1945.

MAN-POWER SURVEY RETURNS. Names of 1,050 licensed radiotelephone and radiotelegraph operators have been supplied by FCC to the War Manpower Commission (WMC). Operators are those having indicated their availability for full- or part-time employment in communications work. Fifth in a series of such lists, this one is the first to contain names of radio telegraph as well as radiotelephone licensees. So far some 20,000 of the nation's radio operators have been canvassed.

NETWORK RECORDINGS. Because of the scarcity of material and skilled personnel, FCC has postponed for an indefinite period consideration of an order which would have required that recordings be made of network programs. The Commission stresses its confidence in the ultimate desirability of such a rule and points out that many such recordings are currently being made and preserved.

TRANSCONTINENTAL COAXIAL. Recent approval by FCC of $3,684,000

A HEAVY WIRING HARNESS
by a Wire Manufacturer



helps solve your manpower problem

Use Lenz Laced Wiring Harnesses, constructed of approved types of color coded insulation to speed up your assembly operations, and release *manpower* for other work on the assembly line.

The Lenz organization, manufacturers of radio and instrument hookup, has the experienced personnel that can produce these harnesses with meticulous care and regard for precision, to meet your exact specifications.

Quotations will be gladly furnished on receipt of sketch and specifications.

LENZ

IN BUSINESS SINCE 1904

LENZ ELECTRIC MANUFACTURING CO.

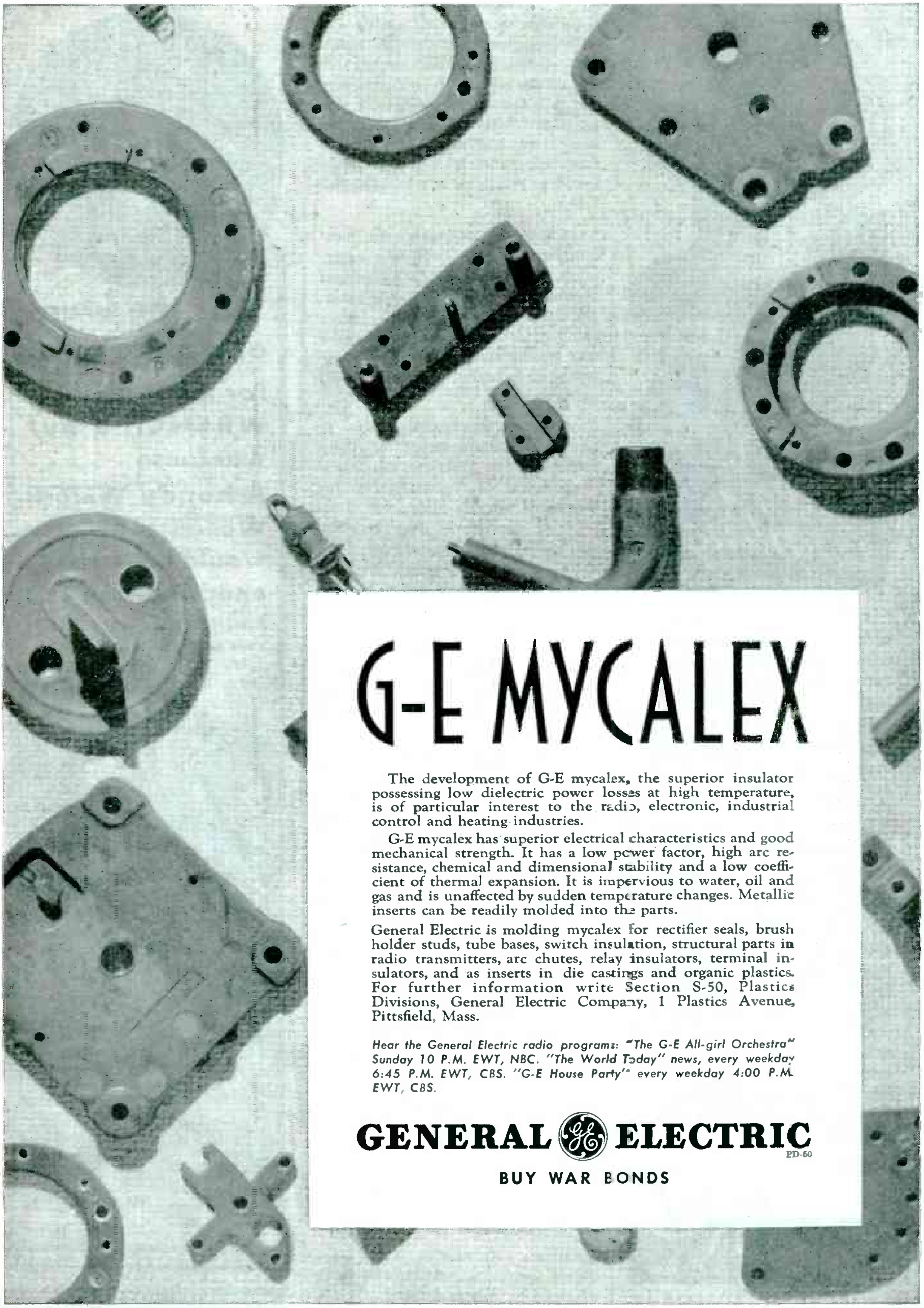
1751 North Western Avenue • Chicago 47, Illinois worth of projected coaxial cable between Shreveport, La. and Dallas, Tex. relates to another link in the proposed transcontinental coaxial route planned by AT&T. The new cable will run about 205 miles and contain eight coaxial units, seven pairs of 19-gage and three quads of 22-gage conductors with six pairs loaded for voice frequency operation.

SURPLUS DISPOSAL. Electrical machinery and apparatus disposed of by the Treasury Procurement Division in the month of December, 1944 came to $61,000 with $1,901,000 worth remaining on inventory. Communication equipment to the extent of $9,000 was disposed of in November by Reconstruction Finance Corporation. Still remaining on inventory with this agency is $17,806,000 worth of communication equipment.

INDUSTRIAL SOUND EQUIPMENT. One solution advanced in WPB for the insufficiency of industrial sound equipment is the possible use of commercial equipment not suitable for military, marine, and foreign use. Equipment rejected by the Army and Navy for lack of special sealing and weather-proofing may be made available for industry.

EQUIPMENT AVAILABLITY. Although the current policies of WPB and FCC will be toward a fairly deep freeze of installations in new broadcasting stations, such special radio services as airlines, public utilities, and fishing boats may expect to be allowed to acquire equipment from existing stock. Standard broadcast applications will require hearings unless the construction will result in service to a community which does not get primary service from an existing broadcast station while simultaneously all requirements of the January 26, 1944 statement of policy must be met. Changes in existing standard broadcast facilities which do not involve substantial construction work and which cost less than $500 will be allowed.

MANPOWER CLASSIFICATION. In a new listing by War Manpower Commission, all phases of communications operating services and all branches in the radio-electronic-communications manufacturing field were classified as critical war


G-E MYCALEX
The development of G-E mycalex, the superior insulator possessing low dielectric power losses at high temperature, is of particular interest to the radio, electronic, industrial control and heating industries.
G-E mycalex has superior electrical characteristics and good mechanical strength. It has a low power factor, high arc resistance, chemical and dimensional stability and a low coefficient of thermal expansion. It is impervious to water, oil and gas and is unaffected by sudden temperature changes. Metallic inserts can be readily molded into the parts.
General Electric is molding mycalex for rectifier seals, brush holder studs, tube bases, switch insulation, structural parts in radio transmitters, arc chutes, relay insulators, terminal insulators, and as inserts in die castings and organic plastics. For further information write Section S-50, Plastics Divisions, General Electric Company, 1 Plastics Avenue, Pittsfield, Mass.
Hear the General Electric radio programs: "The G-E All-girl Orchestra" Sunday 10 P.M. EWT, NBC. "The World Today" news, every weekday 6:45 P.M. EWT, CBS. "G-E House Party" every weekday 4:00 P.M. EWT, CBS.
GENERAL ELECTRIC
PD-50
BUY WAR BONDS

activities. Radio broadcasting and television were relisted as essential. Considering the workers in the 26-29 age group, industries in the essential classification will give up their male employees to the armed services first. Critical and essential industries will both be allowed to retain their men classified 4-F.

DECEMBER PRODUCTION. In communications and electronic equipment, WPB announces that output declined 1 percent from November, resulting in a 4 percent falling short of schedule. As to the total war production, there was an increase of 1 percent with a 2 percent deficiency.

COMMERCIAL STANDARDIZATION. To advise the Department of Commerce and the American Standards Association on future plans for standards work, a committee of industrial executives has been appointed by the Secretary of Commerce. Numbering eight, the committee is headed by Charles E. Wilson, president, General Electric Co., as chairman. Included among other members are Frederick M. Feiker, Dean of Engineering, George Washington University, and Frank B. Jewett, president, National Academy of Sciences.

NEW TELEVISION PERMITS. Five construction permits are issued by FCC for experimental television broadcast stations. Permitees include: Allen B. DuMont Laboratories (Washington, D. C.), Farnsworth Television & Radio Corp. (Fort Wayne, Ind.), Intermountain Broadcasting Corp. (Salt Lake City, Utah) P. R. Mallory & Co. (Indianapolis, Ind.) and Zenith Radio Corp (Chicago, Ill.).

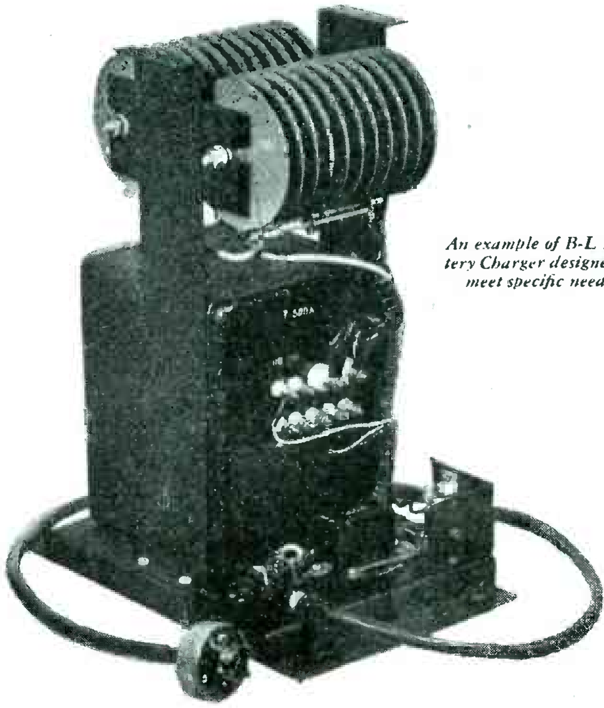
BUSINESS NEWS

FM BROADCASTERS INC., opens new offices at 1730 Eye St., N. W., Washington, D. C.

DIESEL ELECTRIC CO. has purchased an 11-story building at 105 East 106 St., New York, N. Y., for use as television facilities. The building contains 14 studios with ample ceiling height and clear areas suitable for the purpose.

COLUMBIA RECORDING CORP. acquires approximately 350,000 sq ft of space by purchase of the Kings

B-L Selenium Rectifier converts AC to DC.



An example of B-L Battery Charger designed to meet specific needs.

Specially designed B-L Transformer delivers 12 volts from the 115 volt output of the power supply.

This B-L Battery Charger meets special requirements of the Signal Corps

The problem of designing and manufacturing a charger for Signal Corps equipment which would meet the needs of increased loads was submitted to B-L engineers. The result is a Battery Charger producing *three times* the rate originally employed. It charges the batteries, and *keeps them charged*, in the Signal Corps equipment shown at the right.

The alternating current power supply is converted to direct current by sturdy, specially built B-L Selenium Rectifiers which meet the demands of this unit for charging the 6-cell 12-volt batteries. . . . The Charger itself is built to withstand rough usage and the severe moisture of the tropics.

A switch controls rate of delivery—5 amperes or 15 amperes . . . The built-in Thermal Circuit Breaker protects against overloads — the push button resets . . . The cut-out relay provides against any discharge of batteries in the event of power failure . . . Four fasteners permit handy removal from or installation to the base.

Mobile Unit, with Trailer, made for the U. S. Signal Corps by The Hallicrafters Co., Chicago.

Have You a Conversion Problem?

Twenty-five years of B-L specialized skill in AC-DC conversion problems is available to you. We are designers of Selenium and Copper Sulphide Rectifiers, Battery Chargers, and DC Power Supplies for practically every requirement. We invite your inquiries — without obligation.

SELENIUM — B L ELECTRICAL RECTIFIERS — **COPPER SULPHIDE**

THE BENWOOD LINZE COMPANY

1815 Locust Street • • • St. Louis 3, Mo.

DESIGNERS AND MANUFACTURERS OF COPPER SULPHIDE AND SELENIUM RECTIFIERS, BATTERY CHARGERS, AND D. C. POWER SUPPLIES FOR PRACTICALLY EVERY REQUIREMENT.

Mills plant of Remington Arms Co., Kings Mills, Ohio.

CANADIAN RADIO TECHNICAL PLANNING BOARD is the name given to an organization to devote its non-profit energies to frequency allocation and similar problems in Canada.

CAPACITRON CO. is now located in new and larger quarters at 849 North Kedzie Ave., Chicago 51, Ill. All Capacitron manufacturing facilities will eventually be housed here.

STROMBERG-CARLSON CO. launches an employee retirement and pension plan which provides for the creation of a cooperative retirement income fund made up of voluntary contributions from the current earnings of employees with five years or more of service, and larger contributions from the company.

RADIO CORP OF AMERICA points out that it has built since the beginning of the war more than 200 new electron tubes and 350 different types of apparatus never previously manufactured.

NATIONAL BROADCASTING CO. and GENERAL ELECTRIC CO. mark the fifth anniversary of the first television network to be operated as a service to the public. The occasion was the establishment of the relay station atop Helderberg mountain to connect WNBT and WRGB.

C. J. TAGLIABUE MFG. CO., Brooklyn, N. Y. has been taken over by Portable Products Corp., Pittsburgh, Pa., and will be operated as a separate division of the latter corporation.

INTERNATIONAL BUSINESS MACHINES CORP. and GENERAL ELECTRIC CO. plan to increase the scope of their proposed television and relay network. Following the first circuit which is to link New York and Schenectady, further facilities will connect New York and Washington via Philadelphia and Baltimore. Later extensions will take in Richmond, Atlanta, Utica, Syracuse, Rochester, Buffalo, Cleveland, Detroit, and Chicago.

PRESS WIRELESS, INC., New York, N. Y. organized and partially manned a shipboard communications unit which accompanied Gen-

"ONE multi-process automatic... and we can scrap FOUR slow....."

Standard machine tools, made in America by the world's leading industry of its type, are winning the wars. They are the envy of our enemies . . . the backbone of our future.

But there are products . . . many of them . . . which require specially designed high speed automatic machinery to put them economically within the reach of all. This is a peacetime problem soon to confront industry.

It is also a problem which many "name" companies are now entrusting to Atlas for solution. We have the personnel . . . 300 or more specialists . . . Engineers, Designers and Toolmakers, whose varied experience is pooled for the creating of products, tools, dies, jigs, special machinery and even complete production lines. A complete plant, equipped with the last word in precision machines and testing equipment, enables them to build and prove the means for making your products better, faster and at lower costs.

Atlas service is all-inclusive or partial, as your needs dictate. We work in cooperation with your staff or "on our own" . . . for large or small programs, an intricate multi-purpose machine or a single part . . . electronics, plastics, fine instruments, transportation, refrigeration . . .

If you are understaffed . . . too busy with war work . . . or need specialized aid . . . call Atlas for a consultation. Brochure on request.

ATLAS TOOL & DESIGNING COMPANY
METAL STAMPING COMPANY
Castor & Kensington Avenues, Philadelphia 24, Pa.

eral MacArthur's forces in the Lingayen Gulf invasion.

SYLVANIA ELECTRIC PRODUCTS opens its twenty-third plant, a unit located at Jamestown, N. Y., for production of parts for electron tubes and other electrical equipment.

CRONAME INC. is the new name of Crowe Name Plate & Manufacturing Co., Chicago, Ill.

NORTH AMERICAN PHILIPS CO. has delivered its millionth quartz crystal unit to the U. S. Army Signal Corps.

PERSONNEL

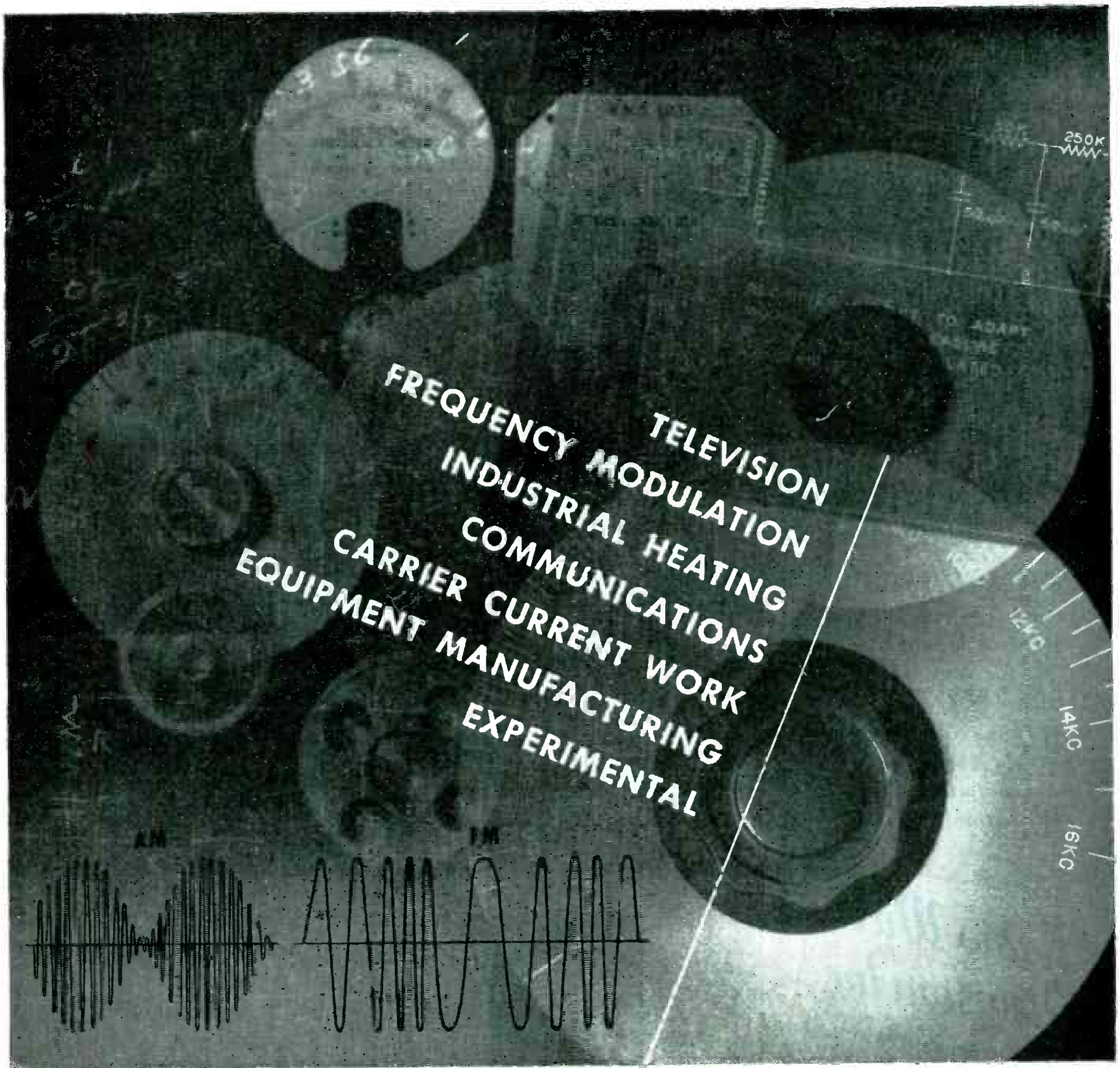
JOHN HUTCHINGS goes from chief engineer to vice president in charge of engineering at Continental Elec-

tric Co. Mr. Hutchings has been working on the development of industrial electron tubes.

FREDERICK E. TERMAN is dean of the Stanford University School of Engineering. He will assume his duties upon release from his present position as head of the Government Radio Research Laboratory at Cambridge, Mass.

F. J. BINGLEY, chief television engineer, Philco Radio & Television Corp., Philadelphia, Pa., succeeds Robert L. Gibson as vice president of Television Broadcasters Association. He also has been appointed to the post of engineering committee chairman for 1945.

CLINTON R. HANNA is appointed associate director of the Westinghouse Research Laboratories. Mr.



Post-war electronics demands new instruments

As the "era of electronics" approaches, it is increasingly evident that the need for more accurate, highly specialized instruments becomes greater. Many of the forerunners of such instruments are already perfected and in use today, but they are still under cover of strict military censorship. When these new developments and others now in the process of development are released — not all, but certainly a good many of the commonly known instruments will instantly become obsolete. In your plans for post-war activity you should make careful note of this fact, for it may save you valuable time in future plant or product conversion.

-hp- instruments are in the vanguard of these new developments. New *-hp-* oscillators, signal generators and vacuum tube voltmeters are setting new standards for rugged construction and split-hair accuracy. Technical data on these and others not yet perfected are, of course, not available today, but the time is not far off when they can be released.

In contemplating the improvement of your laboratory or the alteration of your production with post-war activities in mind, it will pay you to consult *-hp-* engineers. These new instruments may be the answer to your problem. Please give us full details so we can be of maximum assistance.

HEWLETT-PACKARD COMPANY

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CANADIAN OFFICE: 560 KING STREET WEST, TORONTO 2

931

Hanna is inventor of the tank-gun stabilizer which has been widely publicized.

WILLIAM E. CAIRNES, eight years with Galvin Manufacturing Corp.,

Chicago, Ill., becomes chief engineer for the home radio division.

PAUL A. PORTER is confirmed by the Senate in his appointment as FCC chairman. Mr. Porter was formerly general counsel for Columbia Broadcasting System.

O. B. HANSON, vice president and chief engineer, National Broadcasting Co., is appointed chairman of the Television Station Operations, Standards and Personnel Committee of Television Broadcasters Association for 1945.

GUS WALLIN becomes assistant chief engineer of the home radio division of Galvin Manufacturing

Corp., Chicago, Ill. Mr. Wallin has been with the company for five years.

D. W. RENTZEL, president, Aeronautical Radio Inc., becomes vice-chairman of the Radio Technical Commission for Aeronautics.

ROGER M. WISE becomes vice president in charge of engineering, Sylvania Electric Products Inc. He goes to the new post from the position of director of engineering.

FRANK B. JEWETT, chairman of the National Defense Research Committee, is an honorary member of the New York Electrical Society, New York, N. Y. Dr. Jewett has

just retired as vice president of AT&T.

WALTER S. SCHULTZ JR. is appointed plant manager of Madison Electrical Products Corp., Madison, N. J. He has been associated previously with Western Electric Co. and with Measurements Corp.

DUNFORD KELLEY goes from Littelfuse Inc. to Universal Microphone Co., Inglewood, Calif., as electromechanical engineer. His duties will be related to Army, Navy and postwar production of microphones.

J. H. DELLINGER, chief of the radio section of the Bureau of Standards is relected chairman of the Radio Technical Commission for Aeronautics.

JOSEPH W. CHAPLIN becomes director of communications for Press Wireless, Inc. to succeed D. K. deNeuf. Mr. Chaplin is former world champion telegrapher.

J. L. FIELDS is appointed to the staff of RCA Mexicana SA as technical consultant to RCA film sound recording licensees in Mexico. His headquarters will be in Mexico City.

REG M. BROPHY, Canadian Marconi Co., Montreal, becomes president of the newly organized Canadian Radio Technical Planning Board.

AWARDS

Workers of the following concerns in the electronic field have been awarded Army-Navy E burgees for excellence in production:

BARKER & WILLIAMSON
Upper Darby, Pa.

C. P. CLARE & CO.
Chicago, Illinois

COMMERCIAL CONTROLS CORP.
Plants A and B
Rochester, N. Y.

NATIONAL CARBON CO.
Cleveland, Ohio

PACIFIC SOUND EQUIPMENT CO.
Los Angeles, Calif.

SPARKS-WITHINGTON CO.
Jackson, Mich.

The Electric Eye Door Opener is already widely in use in restaurants and other public buildings . . . In hospitals, where sanitation is of even more importance, it is still comparatively new. Located between major operating rooms and the doctors' scrub room it makes possible the automatic opening and closing of doors without touch of hands. These controls are the result of the merging of Yale and Towne's extensive knowledge of mechanical door devices with the Electronic engineering of United Cinephone Corporation. They can be set to operate within whatever interval of time is required between the opening and closing of the door.

OTHER APPLICATIONS of United Cinephone Electronic controls are almost without limit. If you have a problem of measuring, gauging, counting, sorting, heating, or some other operation in your plant, which is costly and unreliable, you will want to investigate the possibility of solving the problem ELECTRONICALLY. That's where our extensive experience and facilities in Electronic design, engineering, and manufacturing can be of invaluable help. Your inquiry will be welcome.

Electronic fields we cover include:
1. Industrial Controls
2. Aircraft Communications
3. Test-Laboratory Equipment
4. Radio and Audio Equipment

UNITED CINEPHONE CORPORATION

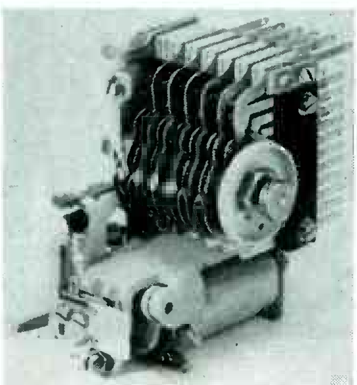
TORRINGTON, CONNECTICUT

NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

Automatic Selector

MODEL FTR-800 is a compact automatic selector which functions as a high speed multi-contact switch for use as an automatic timing or remote control device for railroad, radio, airport and other industrial applications. This unit will make a

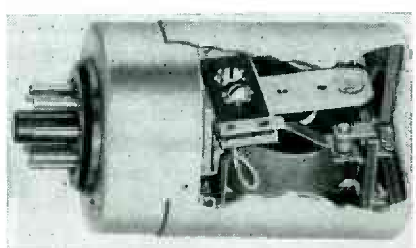


connection between a number of given circuits and a similar number of other circuits, each preselected from a group; control and perform various operations among a group of circuits by making consecutive individual connections; and act as a timing device or switch when it is used in connection with time-pulsing apparatus. It may also be used in telegraph or electronic equipment, remote control and signalling systems, testing and radio control. The rotor assembly of the unit is operated by a stepping mechanism which responds to impulses of current. The stepping mechanism can be controlled manually by a dial or by other means. Automatic control for the stepping magnet can be provided by interrupter springs, electronic circuits or relay circuits. Wipers are available in either double-ended or single-ended types and can be either bridging or non-bridging and the type of wiper determines the capacity of the selector. The unit is extremely rugged, measures 2½x3¼x3½ in., and has been designed for operating life of 4,000,000 revolutions at operating speeds up to 60 steps per sec.

Federal Telephone & Radio Corp., Newark, N. J.

Plug-In Relay

THE RELAY MECHANISM of this new plug-in type relay is encased in a cylindrical metal housing 2⅛ in. in diameter and 3⅛ in. high. It is rigidly supported against shock by means of a key in the center of an insulating disc which fits snugly in the top of the case. Relays are made to operate on standard voltages up to 115 v, ac or dc. These

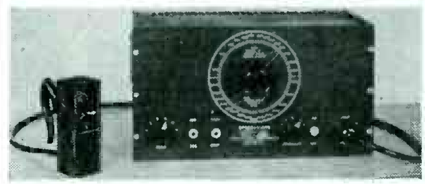


newer units are a modification of units used in small radio transmitters, aircraft control circuits, and similar applications where space is limited. DP, DT contacts are rated 4 amp at 115 v, 60 cycles ac, and at 24 v dc, ½ amp from 25 to 115 v dc.

Ward Leonard Electric Co., Mount Vernon, N. Y.

Stroboscope

MODEL NO. 1200 stroboscope is a newly developed instrument which increases the range through which moving objects can be examined. Rotary speeds from 600 to 600,000 rpm, or vibrations from 10 to 10,000 cps can be stopped and studied. A light source, mounted in a small probe at the end of a 5-ft flexible cord makes it possible to view small objects at close range. Motion of objects moving at irregular speeds can also be examined. Where extreme accuracy is desired, the unit can be operated from an external tuning fork or crystal standards. The necessity for constant readjustment of the repetitive rate is eliminated by the use of a stable



audio oscillator from which pulses are derived, and which insures clearly defined images at high speeds. The intensity of light and the duration of pulse length are controlled by a light-intensity control switch.

Communication Measurements Laboratory, 120 Greenwich St., New York, N. Y.

Tropical Dry Battery

THOUGH AT THE present time these batteries are being manufactured for the military only, readers will be interested in a new type of dry battery which is especially useful in the tropics and which is being used by the government in portable field communication and ordnance equipment which require a self-contained source of electrical energy.

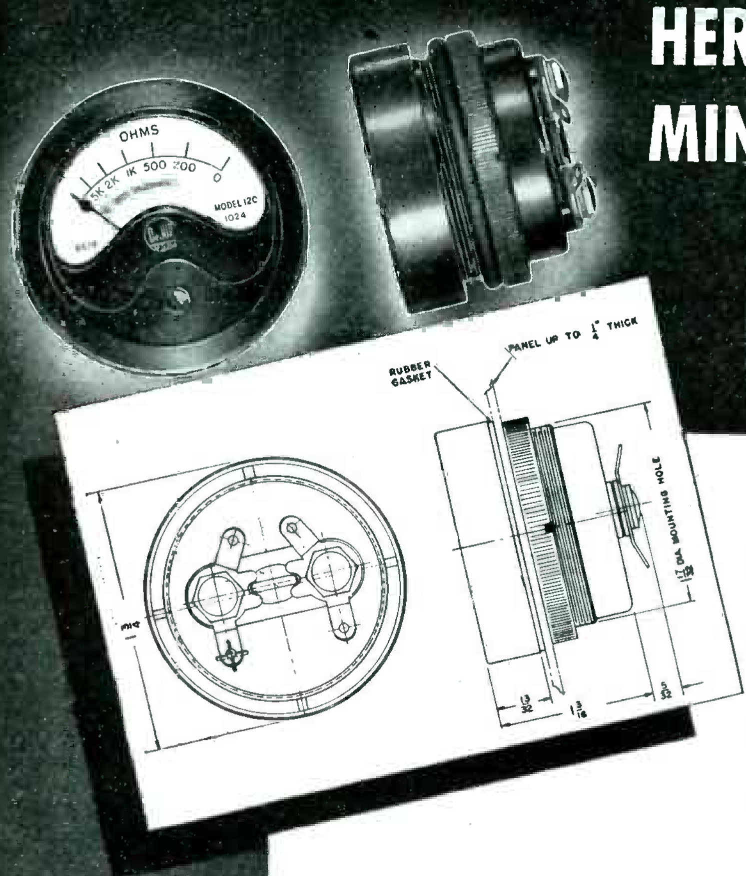
Samuel Rubin, associated with P. R. Mallory & Co., Inc., Indianapolis, Ind., and an inventor with achievements to his credit in the fields of electro-chemistry, invented the new type of battery cells which are made up of a combination of materials and construction not heretofore combined. The cells (comprising the battery) have what is called a flat discharge characteristic.

The new type battery has several advantages over ordinary dry cell batteries. It will withstand higher temperatures and provides from

DeJUR Presents to the Electrical Industry

HERMETICALLY SEALED MINIATURE 1½" METER

(MODEL 120)



Completely Immersion-proof Throughout

1 Hole Mounting for Easy Installation

Movement Built to A.S.A. Specifications

Ideal Component for All Small Equipment

- The smallest meter available, yet capable of performing a full-scale task in a variety of applications.
- Hermetically sealed, it can be immersed in water for as many as seven days without harm to its mechanism.
- The case, as well as the glass, is completely waterproof—thus, if the glass breaks, water still cannot penetrate.
- Since the equipment in which this meter is used must also sustain immersion, terminal studs are waterproof sealed.
- Supplied with the Model 120 is a waterproof gasket for mounting the instrument flange to the panel.
- Quickly and easily installed—only one hole—no drilling, no screws necessary—just tighten on with a ring.
- Ideal for all small equipment—present or postwar. Write for complete specifications and prices.

ARMY E NAVY

SUPPORT THE RED CROSS WAR FUND

DeJUR-AMSCO CORPORATION

GENERAL OFFICE: NORTHERN BLVD. AT 45th STREET, LONG ISLAND CITY 1, N. Y.

four to six times the operating life. Shelf life is greatly improved. The cells are hermetically sealed and possess the same ampere-hour service life (within rated current range) whether the battery is operated intermittently or continuously. Voltage (within practical limits) is maintained constant up to the end of the cell life. Under normal conditions no recovery time is required.

Licenses to manufacture these batteries have been granted by the Mallory Company to the following companies: Ray-O-Vac, Magnavox Corporation and Sprague Electric Company.

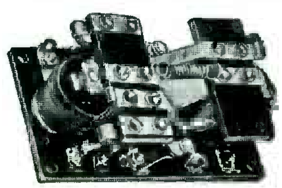
Speaker, Driver Unit

MODEL DR-12 PERMANENT MAGNET loudspeaker has a voice coil impedance of 16 ohms, and a power rating of 15 w. Its overall length measures $7\frac{1}{2}$ in. The bell diameter measures 7 in. All internal parts of the horn are die cast. The unit is waterproof and has universal mounting brackets for either surface or pipe mounting. The speaker is supplied with type PM-27 "dynaflux" driver unit which has a diameter of 3 in. and an over-all height of $2\frac{3}{4}$ in.

Atlas Sound Corp., 1443 39th St., Brooklyn 18, N. Y.

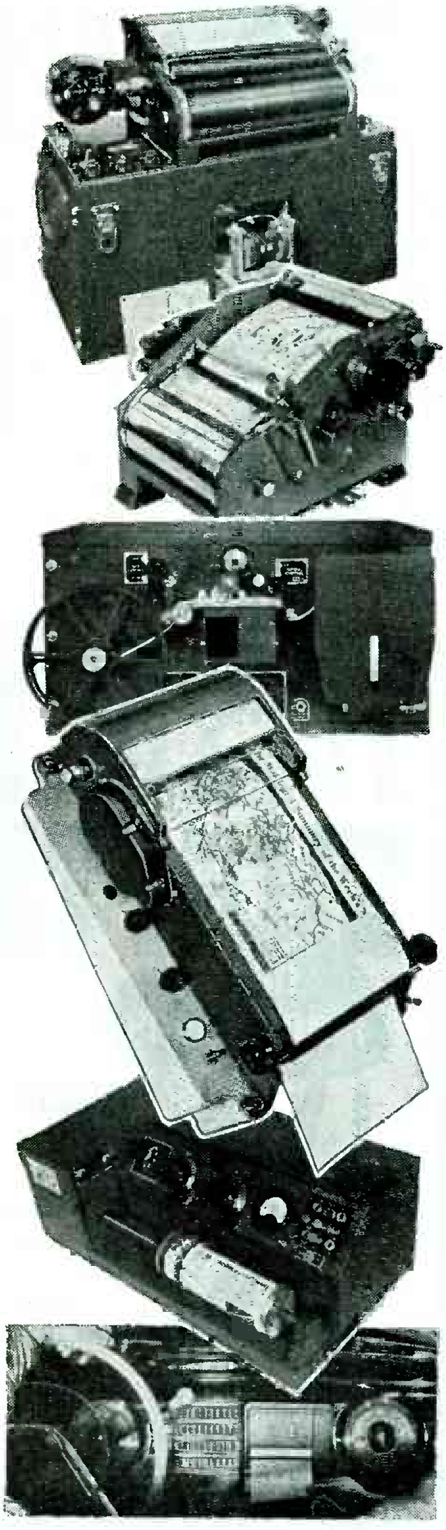
Relay Series

NO. 50XBX IS A NEW 2-coil, latch interlock relay series and is an addition to the manufacturer's "Memory" relay types. A new style positive interlock between the two symmetrical operating elements is utilized. This latch requires no extraneous parts other than integral extensions of the coil armatures



themselves. It operates positively from a momentary impulse. Application of power to one coil latches the contacts into one position. Power then applied to the other coil throws the contacts into a latched-in second position. A third unlatched position, useful for certain applications, can be obtained by

ALDEN



for Graphic Recording of any kind

OUR YEARS OF EXPERIENCE, and cumulative skills, in the designing and production of RADIO COMPONENTS, are now being used in making equipment which covers ***the entire field of FACSIMILE.***

Actual service, as found in war and communication work under all conditions, has given a PRACTICAL quality to our equipment which, under ordinary conditions, would not have been obtained in years of engineering with limited application.

ALDEN PRODUCTS COMPANY is manufacturing practically ALL TYPES AND SIZES of facsimile and impulse recording equipment—using all the varied recording mediums: Photographic Paper, Film, Electrolytic Paper, Teledeltos, and Ink.

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•

By* "COVERING THE ENTIRE FIELD," *we mean . . .

1. Some of our equipment has been used for the transmitting and receiving of photographic pictures of reasonably high resolution (such as the war pictures now appearing in the news).

2. Continuous Recorders—of the type whose value has been proven on National and International news service circuits—are now on their way to the Orient, to be used for the receiving of the so-called "picture" languages. They use ALFAX paper.

3. Also, through the use of ALFAX (the first high-speed black and white permanent recording paper), HIGH-SPEED Signal Analysis Equipment has been made possible for various laboratories and Government Departments. Other equipments have employed Teledeltos Paper for message work and other purposes.

4. For outlying posts, where servicing equipment is an impossibility, or, where radio or wire links are of poor quality and power, ALDEN Tape Recorders (recording medium, ink)—have been designed to operate with a minimum of trouble and adjustments, and have PROVED MOST SATISFACTORY.

5. The ability of ALFAX Paper and ALDEN Machines to record impulses as they occur, without the inertia problems of many previous methods, has made possible other recorders at various speeds (including slow). They will record a whole day's history of related phenomena, with time indicated, and often — with self-calibrated linear reference marks for ready interpretation.

ALDEN PRODUCTS COMPANY

117 North Main Street

BROCKTON (64E2), MASSACHUSETTS

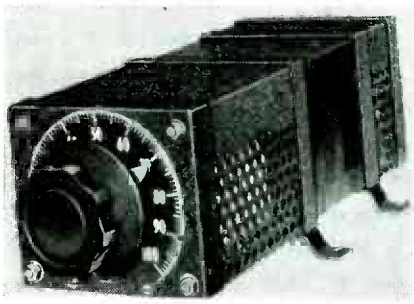
energizing both coils simultaneously. Make-before-break, or break-bfore-make contact combinations are readily obtained.

Relays are produced in ratings from 6 to 200 amp or more, and with practically any desired contact arrangement. Standard types provide for two auxiliary contacts (one in each coil) to obtain operation over a wide range of voltages, ac or dc. The units are small and compact. A typical unit, Type 50XBX103, has DP, DT main contacts, and is rated 6 amp at 24 v dc. It measures $3\frac{7}{16}$ x $1\frac{7}{8}$ x $1\frac{5}{8}$ in.

Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.

Variable Voltage Transformer

THESE TRANSFORMERS are designated as Vari-Former. They are available for one or three phase use. Voltage is continuously variable without circuit interruption from zero to maximum values. A self-aligning solid silver contact provides small increment voltage change throughout the range of the device. The contact is finger-tip controlled by a single knob. No carbon brushes are used. Incremented increase is in the order of 0.75 v or less. Standard units (auto-transformer types) are available wound for constant current, or taper wound for current proportional to voltage. Units are rugged, lightweight, drip-proof constructed and have high overload capacity, and low no-load loss. Mechanical damage and dust are minimized by a ventilated, heavy gage shell. Other features include minimum stray field, no radio interference, class A or B insulation, and auto-transformer winding or separate windings for isolation of circuits.



Gulow Corp., 26 Waverly Place, New York, N. Y.

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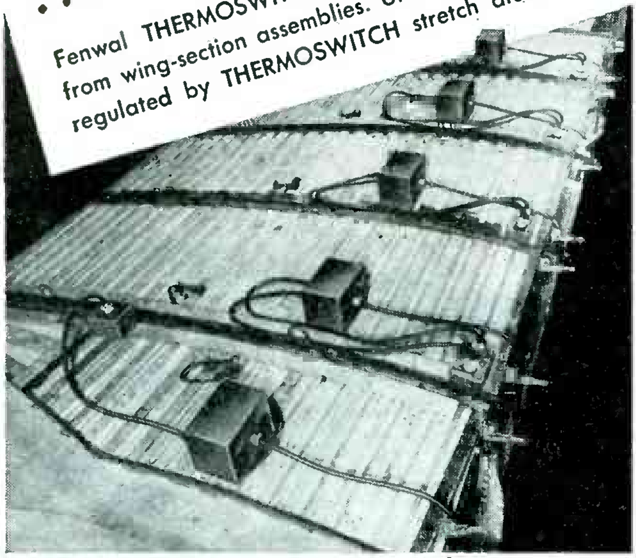

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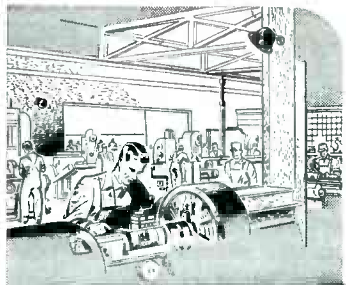

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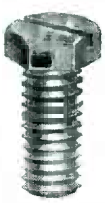

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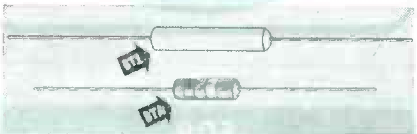
Insulated Resistors

TWO MANUFACTURERS announce insulated resistors. One of these is Type CM insulated resistors which have been specifically designed to meet recent Army-Navy specifications. They are integrally molded in one operation and are available in ⅓ (RC-10); ½ (RC-21); and 1-w (RC-30) sizes in all required ranges. The units meet salt-water immersion specifications and have good stability under load (the average change, according to the manufacturer, is less than 5 percent after 1000 hours under test at full load). These are available from Stackpole Carbon Co., St. Marys, Pa.

The second manufacturer is the International Resistance Company which announces a new addition to the BT line resistors. The new series is designated BTA and is designed particularly for applications requiring AWS RC30 Specifications. New units measure 0.718 in. long and 0.250 in. in diameter.



They are rated 1 w at 40-deg-C ambient temperature, and a voltage rating of 500 v. Minimum range is 330 ohms. Standard maximum range is 20 megohms. Higher ranges are available on special order. 401 N. Broad St., Philadelphia 48, Pa.

Fungus-Resisting Insulating Varnish

CLEAR BAKING varnish, No. PG-4-FC, protects each layer of wire and therefore if the surface of the winding is damaged in rough handling, the fungicidal protection of the varnish is still retained. The varnish (meets with Army Signal Corps specifications) can be used for all types of electrical windings. The degree of hardness can be controlled by altering the baking time and temperature and although the varnish solidifies completely in a relatively short period of time, a longer bake produces a finish which is extremely hard.

John C. Dolph Co., Dept. No. 22, 168 Emmett St., Newark 5, N. J.

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Many jobs can be done easier and better with Potter & Brumfield Standard Relays. We build a complete range of standard relays that will fit many applications. They are compact, sturdy, easily mounted.

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Full range of coil voltages. Ask for catalog giving specifications on all type of relays.

Potter & Brumfield Mfg. Co., Inc. **105 N. 10th St. Princeton, Ind.**

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Saves hours of work cutting clean, accurate holes in radio chassis—for connectors and other receptacles. Simply insert cap screw in hole to be enlarged (drill small hole if necessary), turn with ordinary wrench to force punch through the metal. No reaming or filing—hole is smooth and clean. No distortion—die supports metal. Ten sizes from ¾" to 2¼"; also up to 3½" for meters. Write for free catalog 33E to Greenlee Tool Co., 1923 Columbia Ave., Rockford, Ill.

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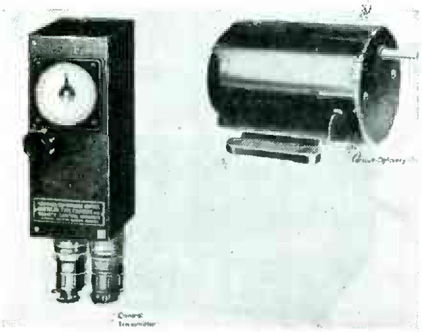
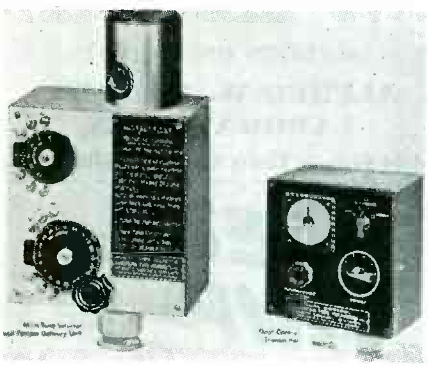
Precision Remote Controls

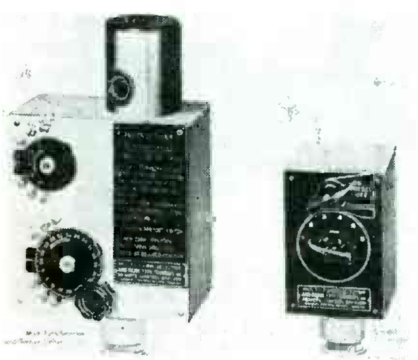
FOUR BASIC TYPES of precision remote controls which have been used exclusively by the Navy have been announced. These include a



continuously variable control which is a non-synchronous follow-up control provided with a repeat-back indicator for positioning the shaft of a reversible motor to any point of any revolution. The second type is a multi-turn selector, motor



driven so its connected load can be placed in any one of several (usually six) adjustable positions over one or a number of revolutions. The third type is a dual con-



trol which incorporates the features of both the continuously variable control and the multi-turn selector. This combination enables an operator to position the load to any one of the pre-set positions, or by turning a knob, to any point

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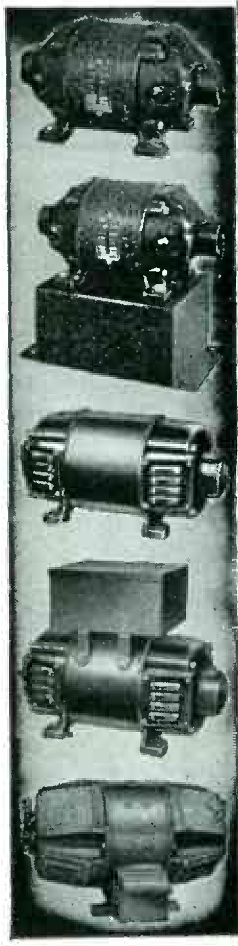

JANETTE CONVERTERS are specially designed for use with A.C. apparatus used in marine service. Electronic devices used on ships, shore stations, as well as for domestic applications, can be operated from a D.C. power supply, by using reliable Janette converters. Better deliveries can be made on 150, 300 and 500 voltampere, 115 volts D.C. to 1 phase, 60 cycle 110 volts A.C. rating, than for converters of other capacities or voltages.

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Wherever there are ships, you will find Janette converters.

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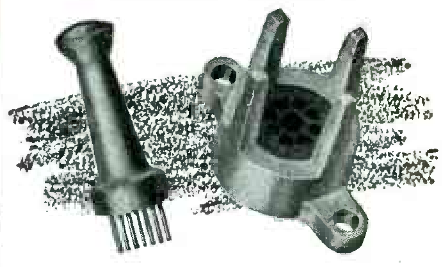

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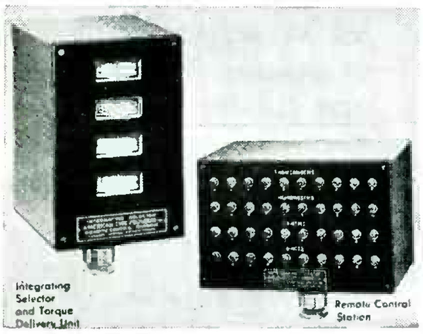
over the full range. The fourth control is an integrating selector which provides automatic setting of the load to a large number of



positions by means of a small number of push buttons. Normal accuracy of positioning can be as close as one one-hundredth of a degree of the output shaft. The devices are light in weight, small in size and depend entirely on electromechanical principles. They are built for any current characteristic, are rugged, and may be used in industrial, marine, aircraft and electronic applications.

American Type Founders, Inc., Remote Control Div., 11 W. 42nd St., New York 18, N. Y.

PA System

AN ALL-PURPOSE amplifying system which delivers a full 60 w of undistorted output is available on a minimum AA5 priority rating for industrial paging in plants and large offices or plant music. The amplifier has four individually controlled microphone channels, two individually controlled phono channels, universal output for matching any arrangement of speakers, individual controls for high and low frequencies. Amplifiers are available separately or with any combination of speakers and microphones.

Allied Radio Corp., 833 W. Jackson Blvd., Chicago, Ill.

Cloth Tape

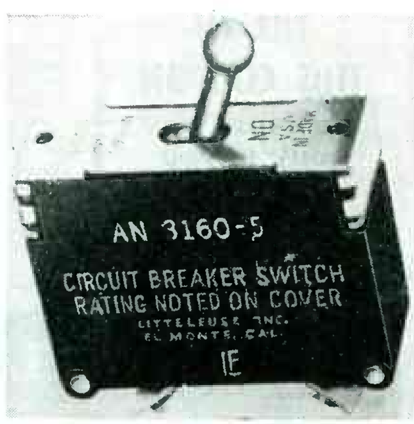
DESIGNATED AS Self-Stick these cloth tapes are manufactured with a new fungicide which protects them against water, moisture, salt spray, gases and other damaging elements. Mystik Adhesive Products, 2635 N. Kildare, Chicago 39, Ill.

Audio Chanalyst

THIS NEW AUDIO chanalyst, designated as Type 170-A, is a single unit, for audible or visual testing, which is comprised of several self-contained testing sections or channels. It can be used to test any point of any sound system from microphone to speaker, or it can be utilized in emergencies as a bridging unit to substitute for the defective section of an inoperative amplifier. A calibrated high gain amplifier is used for signal tracing, tube checking and gain measurements. The unit supplies its own test signal from a built-in beat frequency oscillator which can be operated by an internal auxiliary sweep circuit for checking multiple-speaker installations. A unit called VoltOhmyst has been modified for flat, linear measurement of audio frequencies, and is included as one of the channels. Other features include an impedance tester and a high-speed electronic indicator. Available on priority rating from RCA Victor Div., Radio Corp. of America, Camden, N. J.

Circuit Breaker

A NEW BI-METAL design is incorporated in No. 1560 switch breaker which takes 350 deg F and 60 deg F below zero without breaking. The bi-metal is used as the finger which pulls the trigger. No appreciable mechanical load is exerted on the bi-metal as it trips the breaker. The unit was designed primarily for military purposes but can be used to protect motors and other equipment having high starting surge currents. Its operating range is 5 to 50 amp at 32 v, dc or ac. It is capable of breaking 2500 amp on a



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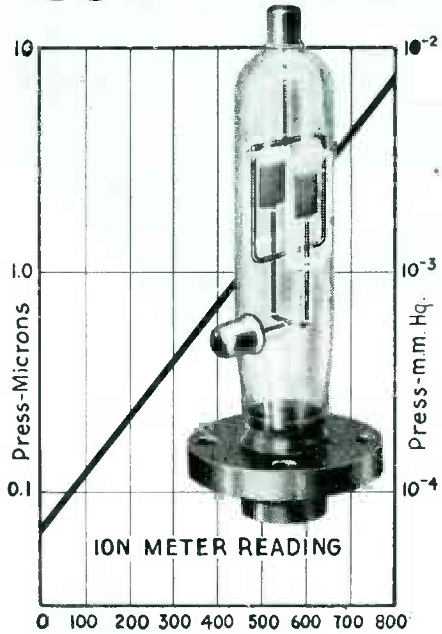

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Measures high vacuums with galvanometer down to 10^{-4} mm. Hg. in electron microscopes and other high vacuum apparatus. Utilizes discharge current between electrodes in magnetic field. Extremely sensitive and accurate.

The Universal line includes two types of vacuum gauges of special interest to users of electron microscopes—the Universal highly sensitive cold cathode ionization gauge and the rugged Universal thermocouple gauge.

Both gauges are standard equipment on R.C.A. electron microscopes—and can be supplied for other high vacuum work.

Universal offers a complete production service in special glass and tube work—including metal-to-glass seals of all types and sizes. Your problems will receive our immediate and courteous consideration.

THERMO-COUPLE GAUGE

Measures low pressure levels with millivoltmeter which indicates variation in thermocouple voltage due to changes in vacuum. Ideal for systems requiring rapid verification of high vacuums. Heater and instrument terminals fit standard 8-prong tube socket.

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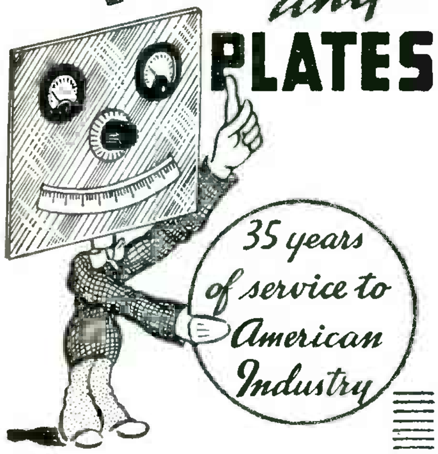

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short circuit. Tests made by the manufacturer indicate that it meets the requirements of holding 115 percent of the rated current for one hour; breaks within the hour on 138 percent of rated current; breaks at 200 percent of its load between 10 and 100 sec. These tests are all at ambient temperatures of 77 deg F ± 1.8 deg F. The breaker is enclosed in a sturdy moisture-proof Bakelite case. It is panel-mounted by two 6/32 screws, $\frac{1}{4}$ in. long, for $\frac{1}{16}$ in. thickness of panels. Overall size is $2\frac{1}{8}$ in. x 2 in. deep below panel, x $\frac{3}{4}$ in. wide.

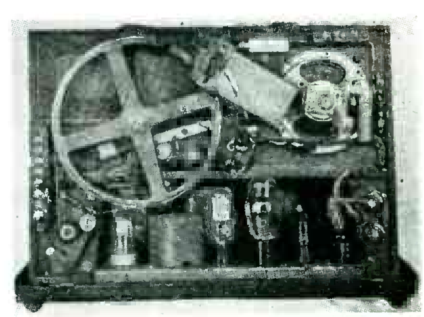
Littelfuse Inc., El Monte, Calif. and 4757 Ravenswood Ave., Chicago 40, Ill.

Midget Relays

WHERE SPACE AND weight are at a minimum there is available a new, lightweight, midget relay which weighs 1.2 oz and measures $1\frac{3}{32}$x$1\frac{3}{32}$ x$\frac{29}{32}$ in., SP, ST. The relay operates on dc only and has a switch capacity of DP, DT with 1.5 amp contacts. Power requirement is 1.75 w. The relay is described in bulletin No. 295 available from Guardian Electric Mfg. Co., Dept. M-R, 1625 W. Walnut Street, Chicago 12, Ill.

Recording Unit

AN EXTREMELY RUGGED, durable and practical film recorder, designated as The Recordgraph, is for use wherever a recording of sound, speech or code is desired. The unit is a compact, self-contained, portable machine weighing about 50 lb. Recordings can be made even though the machine may be upside down or subjected to vibration. Play-back is instantaneous. A standard Recordgraph (Amertype) film averages 50 ft in length and records a total of 115 tracks. Trav-



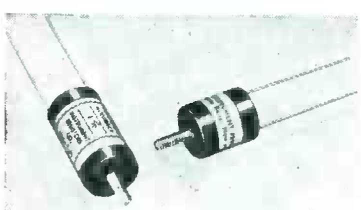
eling at an optional speed of either 40 or 60 ft per min, it provides several hours of continuous recording, and many more of intermittent recordings. The film used is a safety film which is permanent and non-inflammable, and requires no treatment or processing. Starting and stopping are controlled by either a manual switch, electrical impulse, voice or sound. Structural features include a built-in automatic volume control; built-in auditrol unit which automatically starts the recording upon receiving the impulse from voice or incoming signal; built-in speaker and internal connection; remote control operation; built-in transformer for telephone recordings; four separate input circuits; track location which permits the finding (in a few seconds) of any track out of the entire recording; monitoring facilities to check clarity and accuracy; volume indicator meter for recording; and easy access to all tubes, without removal of amplifier.

Several types of units available include special models for unusual requirements, rack or portable models. The Recordgraph is used by radio war correspondents, the Army, Navy and Marine Corps, four major radio networks, as well as police and Government departments and agencies.

Frederick Hart & Co., Inc., Recordgraph Div (formerly Amertype Recordgraph Corp) 333 West 52nd St., New York 19, N. Y.

Tropic Resistors

TROPI-PRUF RESISTORS designates a complete line of resistors which are especially made to withstand humidity and deterioration in tropical climates. Each component is en-



closed in a special Bakelite case. After complete dehydration the resistor is sealed in a special compound, and further made impervious to atmospheric surroundings

with Bakelite cap which is accurately machined to fit the Bakelite case. Leads are bare at the point of entrance through the case, and are permanently and hermetically sealed with special compound. No creepage of moisture or fungus growth can take place at any point. Corrosion, electrolysis or oxidation are effectively barred from the resistor unit by this method of enclosure. A No. 6-32 mounting screw is an integral part of the housing.

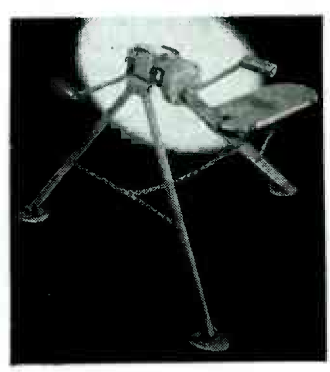
After completion of the unit, a special fungicidal coating is applied. This coating is non-toxic, meets all Signal Corps No. 71-2202-A specifications and is effective for about one year. These components provide complete protection from shorts, leakage or physical deterioration resulting from warm, damp, spore-bearing atmospheric absorption and adsorption. They are available in a diversity of resistance values and wattage ratings. Accuracy tolerances suitable for either general or precision applications are available.

Instrument Resistors Co., 25 Amity St., Little Falls, N. J.

Battery-Charging Hand Generator

A ONE-MAN HAND generator (delivers about 40 w) provides 8 v dc at 5 amp for charging batteries. The generator (developed around the original Magmotor types described in October ELECTRONICS) is a unit with permanent magnet fields which save about 10 w of primary power. The generator is moisture-proof, the shafts of the crank handles are sealed, and the unit is completely enclosed. Output is to two terminals to which the charging line is connected.

Carter Motor Co., 1608 Milwaukee Ave., Chicago, Ill.



"When Ordering Please Mention Electronics"

Panel-Type Measuring Instruments

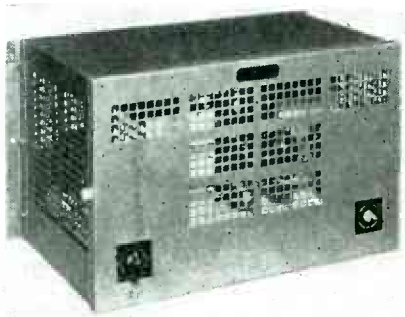
THESE PANEL-TYPE measuring instruments (dc ammeters, voltmeters, milliammeters and millivoltmeters) are U. S. Air Corps approved. They are water-proof and have flush square Bakelite cases which measure 1½ in. in body diameter; the front measures 1¾ in; weight is 10 oz. For use as dc ammeters the instruments are supplied with external shunts. Current utilized by the instrument is small so that any standard size and length of wire leads may be used without compensating the instrument for the resistance of the leads.

Similar 2-inch instruments are available in both dc and 400-cycles ac.

Roller-Smith Div., Realty and Industrial Corp., 11 Park Place, New York 7, N. Y.

Wall-Mounting Amplifier Cabinet

FOR UNIVERSAL installation of their No. 101 Series Amplifiers to any flat surface, this manufacturer has available Type 201-A wall mounting cabinets which are well ventilated and are designed for maximum accessibility for servicing and convenience of installation. The units come in an aluminum grey finish, and measure 12 x 20 x 20 in.



The Langevin Co., 37 West 65th St., New York, N. Y.

Cathode-ray Tube Shield

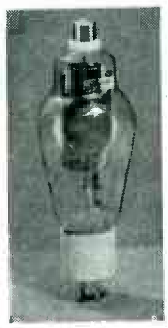
THERE IS AVAILABLE a cathode-ray tube shield (Maco Model M-996) for use with all three-inch cathode-ray tubes. The shield has a shock-absorbing cushion built into a clamp ring, and a gum rubber gasket around the tube face to mini-

mize shock and vibration. Shields are available for either panel or chassis mounting, or can be made to suit special requirements. Mechanical protection for the tube is provided by a transparent screen, available in either plain or colored Lucite. The shield body, formed of Mu-metal, is cadmium plated all over, with a black baked wrinkle outside finish.

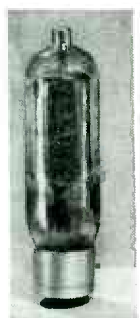
Metallic Arts Co., 243 Broadway, Cambridge 39, Mass.

Grid-Controlled Rectifier Tubes

A LICENSE TO manufacture grid-controlled rectifier tubes has been extended to Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago, Ill. They are the Taylor TT-17 and the Taylor 873. The former is comparable to the GE-FG17 and the latter is an 872A with an added grid control. The TT-17 specifications are: Filament 2.5-v ac at 5 amp; inverse peak plate volts—5,000-v dc at 2 amp; average plate current ½ amp; negative starting grid voltage; mercury-vapor type; size is 6¼ x 2$\frac{1}{16}$ in. with large plate connection at top, ceramic insulated; small 4-pin ceramic base with filament and grid connection to pins.



Left, the TT-17



Right, the 873

The 873 specifications are: Filament 5 v at 6.75 amp; inverse peak plate volts—7,500 v dc at 5 amp; average plate current 1.25 amp; size 8¼ x 2$\frac{1}{16}$ in. with large top plate connection ceramic insulated; negative starting grid voltage; jumbo 4-pin base ceramic insulated with metal shell; mercury vapor type.

Representation That Produces in New England for

NATIONAL
FABRICATED PRODUCTS

(See ad on Page 237)

One of the companies in the electronic field with a long and sound reputation for satisfaction . . . represented in New England by

HENRY P. SEGEL CO.

Manufacturers' Representatives
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Our 21st year of service to manufacturers, jobbers, schools and laboratories in New England

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Our Electronic Equipment For YOUR Post-War Use

We present a few items of equipment which our Post-War Plan proposes to release to you. These items are now being built for the U. S. Navy and other Armed Forces.

1. The original Portable Electric Megaphone*, now highly developed, for use by the Merchant Marine, yachts, airplanes, drydocks, shipyards, stadiums and outdoor arenas, construction companies, and Police and Fire Departments.

2. Our exclusive Divers Communication Equipment for use by marine salvage companies and manufacturers of diving suits.

3. Interior Communication Equipment and docking sets for all types of marine use.

Other equipment will be announced when released by the Armed Forces.

GUIDED RADIO
C O R P O R A T I O N

161 Sixth Avenue — New York 13, N. Y.

* Patent No. 2,301,459

After the War any infringement of this patent will be prosecuted.

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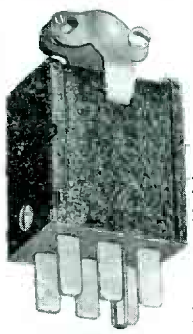
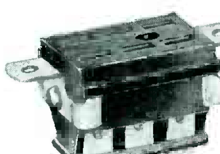
JONES 400 SERIES PLUGS and SOCKETS



P-406-CCT

A medium size Plug and Socket that fulfills practically every requirement in the public address, radio and kindred fields. Socket contacts are of phosphor bronze, cadmium plated.

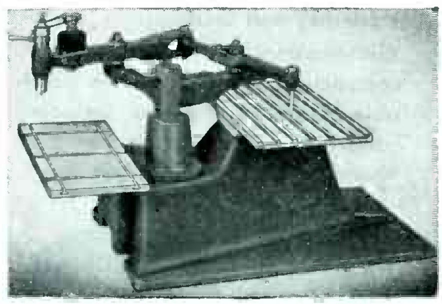


S-406-AB

Plug contacts are of hard brass, silver plated. Insulation is of molded Bakelite. All Plugs and Sockets are Polarized. Made in 2, 4, 6, 8, 10 and 12 contacts. Caps are of steel with baked black crackle enamel. A quality item at popular prices.

Send today for catalog No. 14 listing complete line of Jones Electrical Connecting Devices—Plugs, Sockets and Terminal Strips.

HOWARD B. JONES COMPANY
2460 W. GEORGE ST. CHICAGO 18



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Accurate Engraving with Unskilled Operators

Unskilled operators will profile or accurately reproduce in smooth lines any design, number, letter, emblem, signature; on iron, brass, copper, aluminum, soft steels and all plastics. Here are some of its other uses . . .

- Drills a series of holes, or profiles small parts.
- Cuts an even channel for wiring on panels. Increases accuracy and production.
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- Will not cause distortion.

For complete information on this and other models and prices write Dept. K

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1776 BROADWAY, NEW YORK 19

Literature

Industrial Electronics. "Fundamentals of Industrial Electronics" is the name of a 40-page booklet which is made up of a series of articles which appeared in Steel during 1944. The articles are by G. M. Chute, an application engineer with G. E. The book is intended to be a handy reference on industrial electronics as applied to the metal producing and metalworking industries. The author discusses electronics in motor controls, photoelectric relays, welding equipment, and electronic heating. Many circuit diagrams are given. General Electric Company, Schenectady, N. Y. Bulletin GEA-4309.

Electron Tubes. "Can the electron tube help you?" is the question posted on the inside front cover of a 21-page catalog which describes and illustrates the many types of electron tubes available from General Electronics Inc., 1819 Broadway, New York 23, N. Y. All the tubes are licensed under patents of RCA.

Vacuum Tubes—Packaging and Rating. The Industrial Edition of "Eimac News" contains an article on a new spring-packaging method for electron tubes which resists shock, mildew and corrosion. Also discussed in this edition is the why and wherefore of Eimac vacuum tube ratings. Eitel-McCullough, Inc., San Bruno, Calif.

Brazing Alloy. The use of a brazing alloy, called Easy-Flo, for carbide tipping is illustrated and described in Bulletin 11-A. The repair of broken cutting tools with Easy-Flo is described in Bulletin No. 14. Handy & Harmon, 82 Fulton St., New York 7, N. Y.

Vibration - Measuring Equipment. Bulletin GEA-4140 describes such vibration-measuring equipment as the dial-type indicator and light-beam type indicator for measuring displacement, and the velocity meter for measuring displacement or velocity of vibration. The range and accuracy of each instrument is

shown in a table. These instruments are useful for the improvement of the quality of products, reduction of damage to machinery and buildings, and reduction of noise. General Electric Co., Schenectady, N. Y.

Silver Solder Flux. A 4-page bulletin describes a new silver solder paste flux, designated as Superior No. 6, for use in brazing, hard soldering and silver soldering of both ferrous and non-ferrous metals. Characteristics and directions for use are given in the bulletin. Superior Flux Co., 1783 E. 21st St., Cleveland 3, Ohio.

Color Code Chart. A quick, easy means of identifying color codings and other features of resistors is contained in a resistor color code indicator which comes in a handy, vest pocket size and contains complete information on resistor color coding under the AWS specifications as well as joint Army-Navy specifications. Stackpole Carbon Co., St. Marys, Pa.

Electric-Welded Tubing. Better products through the correct fabrication and application of electric-welded tubing is the theme of a 32-page catalog prepared by Formed Steel Tube Institute of Cleveland, Ohio. The book is presented through the efforts of the Institute and fifteen welded tubing manufacturers. The book tells how tubing is made, how it can be bent, and assembled. Several types are illustrated and described.

U-H-F and Television Nomographs. The first of a series of nomographs to be published by Federal Telephone & Radio Corp., Newark, N. J. is available. The nomographs are designed to simplify and speed up calculations for u-h-f and television applications. Equations and limitations are given wherever there may be any doubt concerning the results. The set now being offered, twenty-five in number, represents the beginning of a projected series of more than one hundred graphic aids to the designer of radio, u-h-f and television equipment. Included in the set are six charts for use in the design of double-and tripled-

tuned band-pass circuits in the u-h-f and television ranges. Two of the charts cover series and shunt-peaking methods of range extension in wide-band amplifiers, while other charts relate to impedance characteristics in various types of transmission lines, including single wires in troughs and in square outer conductors; balanced two-wire and concentric lines, air-spaced, and with solid dielectric; quarter wave matching sections, and sending-end impedance in uniform lines. Other charts treat transmission line lengths, cut-off frequencies in circular wave-guides, u-h-f path lengths and optical line-of-sight distances. The remainder of the charts allow rapid calculation of deflection sensitivities of cathode-ray tubes, modulation percentages from oscillograms, reduction in gain caused by feedback, and dissipation of power in water-cooled devices.

Mica Ceramic Insulation. "Mykroy Molding Bulletin", No. 103, describes glass-bonded insulators designated as Mykroy. Specifications, design criteria and electrical, mechanical and physical properties of Mykroy are given. Also included is a list of recent applications of Mykroy molding of intricate parts. Electronic Mechanics Inc., 70 Clifton Blvd., Clifton, N. J.

Sems Fastener Units. "Fastening Applications Bulletin" designates the title of a leaflet which is designed to suggest to readers the practicability of Sems units which are pre-assembled lock washers and screws. The lock washer is made right on the screw so that it can't come off or get lost. Only a few of the hundreds of uses are illustrated in the bulletin. Several types of lock washers and screws are also illustrated. Shakeproof Inc., 2501 N. Keeler Ave., Chicago, Ill.

Electronic Heating. "The ABC of Electronic Heating" is the title of a 14-page catalog which includes specifications of standard generators available from this manufacturer, as well as illustration and descriptions which serve as introductory matter on the sub-

ject of electronic heating. Scientific Electric, Div. of "S" Corrugated Quenched Gap Co., 107 Monroe St., Garfield, N. J.

ASA Radio Symbols. Copies of booklet Z32.5-1944, "American Standard Graphical Symbols for Telephone, Telegraph and Radio Use", are available on request from Solar with a durable heavy paper cover. This booklet contains the final compromise schematic symbols now being used for both electronic and industrial circuit diagrams. Solar Mfg. Corp., 285 Madison Ave., New York 17, N. Y.

Pressed Ceramics. A second edition of the "Crolite Pressed Ceramic" catalog is available. It contains a listing and complete diagrams of many of the pieces the manufacturer is in a position to make immediately from existing dies, tools, jigs and fixtures. Some of the pieces in the catalog include antenna insulators, coil form bases, crystal holder parts, stand-off insulators, single r-f stage assembly plates, switch and stator parts, terminal blocks and boards, transmission line insulators, trimmer condenser bases, tube bases and tube socket parts and variable capacitor rotor parts. Henry Crowley & Co., Inc., West Orange, N. J.

Electrical Insulation. "Electrical Insulating Materials" is the title of an 86-page, spiral-bound catalog. It contains a history of the manufacturer. The catalog also presents in a simple, informative manner, the products manufactured and distributed by the five divisions of this company: Munsell (pure mica), Micanite (built-up mica), Lamicoid (laminated plastics), Empire (varnished fabrics and papers), and Mico (miscellaneous insulations). Characteristics and available forms of each product-group are described as a guide to selection for various applications. Information on proper handling and machining methods is included. The catalog is neatly indexed and contains many illustrations. Mica Insulator Co., 200 Varick St., New York 14, N. Y.

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MUST HAVE THOROUGH Pre-War Experience in Problems PRODUCTION CONTROL, ENGINEERING AND MANUFACTURING of Small Transformers

This is a $10,000-$15,000 year job

with a progressive, aggressive growing organization and requires a well qualified man

A Real Post-War opportunity

P-807, Electronics
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ELECTROCHEMIST OR Physicist: Capable of doing research and development work on electrolytic capacitors and primary cells. Experience in either field will be an asset but not required. Location middle west. Send complete personal history, summary of training and experience, photograph, availability and salary desired. Advertiser not committed to acknowledge any replies. P-808, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

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SALARIED POSITIONS — This advertising service of 35 years recognized standing negotiates for high salaried supervisory technical and executive positions. Procedure will be individualized to your personal requirements and will not conflict with Manpower Commission's. Retaining fee protected by refund provision. Identity covered and present position protected. Send for details. R. W. Bixby, Inc., 278 Delward Bldg., Buffalo 2, N. Y.

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WANTED—A good line of products upon a direct representative basis, throughout Canada. 28 years of selling experience. Good connection. Just completed 4½ years active service with Royal Canadian Air Force. Drawing account or salary and commission. Full particulars first letter please. C. Ferguson, P.O. Box 514, Winnipeg, Canada.

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Position desired with aggressive firm, $6000 minimum. Eight years engineering and sales experience with large electronic equipment manufacturer, in broadcast transmitting equipment, radar, and industrial heating. Welcome plenty of responsibility.

SA-797, Electronics
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Established Sales and Application Engineering organization in Chicago desires to represent an additional manufacturer. If you make products of merit used by Radio, Electronic and other manufacturers as part of their assemblies our efforts can secure substantial and permanent business for you. Write for details.

RA-782, Electronics
520 N. Michigan Ave., Chicago 11, Ill.

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WANT LINES FOR PACIFIC COAST!

Now is the time to get "set" in the rapidly expanding industrial Pacific Coast! We are thoroughly qualified to give manufacturers in electro-mechanical field a low-cost full sales-coverage of this important market. For details

Write or Wire

Sales Engineering Associates, Inc.
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Technical Sales Manager Available

Electrical engineer, twenty years unusual business and technical experience. Proven ability in organizing home office and field operations, policy formulation, sales training, advertising and sales promotion, sales research and post war planning. Aggressive, resourceful and tenacious. Especially qualified to coordinate sales and engineering departments. Age 43. $10,000.

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Additional Employment Ads on pages 376, 399, 407, 409, 413, 414 and 415.

If You are Doing War Work Now We are Ready to Work with You On Your Product of Tomorrow.

Our highly trained staff of experts can assist you in the design, engineering and sale of your product. We are equipped to help you create new, and improve old products; design informative labels; inject new ideas in your packaging and merchandising. We have had thirty years of experience in selling chain stores, department stores and jobbers —have an attractive showroom and office and experienced personnel skilled in checking competition. If you are interested in post-war sales volume and profits, write to:

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If you work with other industrial men, you can earn profits in spare time by recommending McGraw-Hill technical books to fellow workers. Write for details to

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VARIACS, RELAYS, ETC.

If you have, do not fail to send for a copy of our latest AVAILABILITY LIST!

ELECTRO-TECH
EQUIPMENT COMPANY
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Meters

BOUGHT AND SOLD

Stock of over 3000 new 2 and 3 inch panel meters

IMMEDIATE DELIVERY ON AA5 PRIORITY

Also 4000 used meters of all sizes in stock.

Maritime Switchboard
ELECTRICAL INSTRUMENTS
336 Canal St. N. Y. 13, N. Y.

SELLERS BUYERS TRADERS

More for your Dollar! **IRON & STEEL PRODUCTS, Inc.** 40 Years' Experience!

13422-A S. Brainard Ave., Chicago 33, Illinois
"ANYTHING Containing IRON or STEEL"

BEST QUALITY, USED ELECTRON TUBE MACHINERY

Equipment for the manufacture of all kinds of electron tubes, radio tubes, incandescent lamps, neon tubes, photo electric cells, X-ray tubes, etc.

AMERICAN ELECTRICAL SALES CO., INC.
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Universal Midget Tools

DANDY SIXTEEN PIECE SET

Midget Pliers, Diagonal Cutters, Four Midget End Wrenches, Needle-nose Pliers, Screwholder, Six Punches & Chisel, Round File, Midget Crescent Wrench. $14.85. IMMEDIATE DELIVERY. Remit Today. Catalogue Free With Order.

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ACOUSTIC EXPERIMENTAL ENGINEER

Graduate Engineer with Laboratory and design experience. To design microphones and other electro-acoustical devices.

ELECTRO-MECHANICAL DESIGN ENGINEER

Graduate Engineer to design Electro-Magnetic Devices; such as phonograph pickups, etc.

Write, giving phone number, education, experience and salary desired.

Well established West Coast concern.

P-804, Electronics
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JUNIOR RADIO ENGINEERS

Prefer: drafting, mechanical experience; six years or more practical design experience. Splendid opportunity with growing N. Y. radio manufacturer.

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DEVELOPMENT ENGINEERS

Mechanical and electrical. Graduate or equivalent training. Required for development work in the following branches:

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Statement of Availability Required.

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VACUUM TUBE DESIGNER

An Eastern manufacturer has an attractive opportunity for a graduate physicist or electrical engineer with several years of practical experience in vacuum tube design. It is necessary that applicants have sufficient production experience to develop designs which will improve quality and reduce cost through lowered shrinkage.
Furnish full details regarding experience, education, age, and salary requirements.

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Leading eastern manufacturer of electronic equipment requires graduate E. E. with project engineering experience to be responsible for administration of all engineering and research. Immediate and post-war opportunity.

P-788, Electronics
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ELECTRICAL ENGINEER POWER TUBES

Nationally known manufacturer of electronic devices has an opening for a junior electrical engineer with power transmission or general radio circuit experience. The work will be to supervise and design circuits for power tube tests and applications.
The work is not of a routine nature and offers a real opportunity for a young, capable and resourceful engineer. Location New York City.
Please send sufficient information relative to age, education, experience, and salary desired to warrant an early interview.

P-803, Electronics
330 W. 42nd St., New York 18, N. Y.

ENGINERS WANTED

by Large Radio Manufacturer for its Midwest Plant

1. R. F. and I. F. Coil design engineer with knowledge of powdered iron cores for turning. An important position involving coordination and supervision of other engineers. Man must be engineering graduate or have equivalent experience in permeability tuning systems.

2. Vibrator Power Supply engineer, thoroughly familiar with all types of vibrators, synchronous and non-synchronous, and associated transformer and filter circuits. Engineering graduate or equivalent experience.

Write details on education and background to Dept. 6E, Box 429, Grand Central Station, New York 17, N. Y.

ELECTRONIC PROJECT ENGINEER

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Man experienced in High Frequency, Ultra High Frequency and Television. Must have good theoretical background and experience in construction of equipment to meet specifications of Military Tactical Equipment. Practical experience gained in construction of equipment essential.

Firm established since 1888, heavy post-war future in Electronics. Excellent salary, advancement rapid. Address reply to —

LEWYT CORPORATION
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Engineer with good general radio knowledge and good knowledge of fundamentals of electricity for work as designing engineer on power and audio transformers.

Draftsman with good mechanical sense and as much radio knowledge as possible for work on transformer development and production.

DINION COIL CO., INC.
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A Central New England manufacturer employing over 1000 people needs Draftsman-Designer on telephone and signaling (mechanical) apparatus.

Knowledge of die-casting and plastic applications desirable.

WMC Regulations Prevail

P-805, Electronics
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RADIO ENGINEERS WANTED

Top radio design engineer wanted. Also juniors War Work-receivers etc. Post war-home radios radio phonos, television, electronic specialties, etc. Prosperous growing medium sized N. Y. radio mfr. Splendid opportunity. Our engineers know about this advertisement. Send complete background salary earned etc. We pay very highest salaries to good producers.

P-774, Electronics
330 W. 42nd St., New York 18, N. Y.

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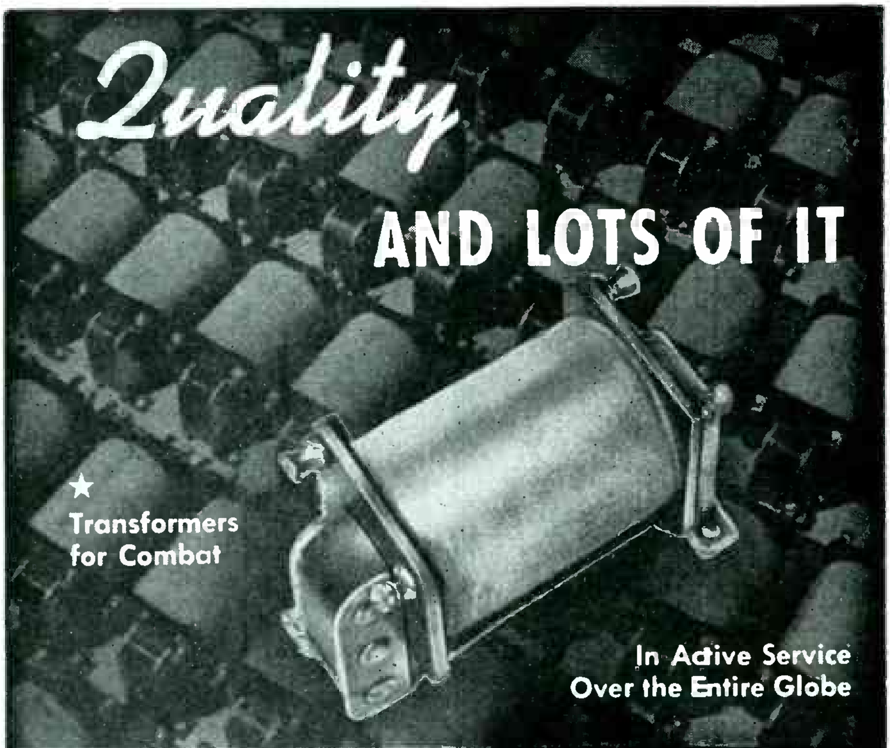
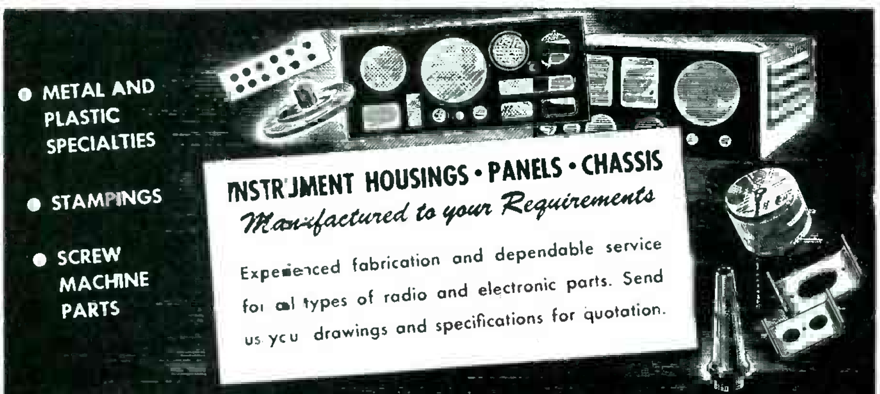
BOX NUMBER

When answering the classified advertisements in this magazine, don't forget to put the box number on your envelope. It's our only means of identifying the advertisement you are answering.



DINION COIL COMPANY

CALEDONIA, N. Y.

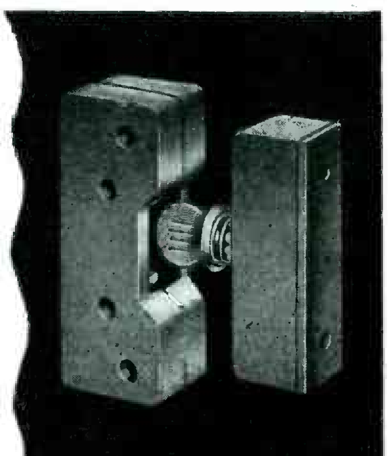


STAMFORD METAL SPECIALTY CO., 428 BROADWAY, N.Y. 13

Metal Work of Every Description

SAFETY DOOR INTERLOCK SWITCH

An inexpensive, dependable safety device that breaks power circuits when access doors are opened. Guards equipment, protects personnel. Particularly suitable for radio transmitters, X-ray and therapeutic machines, fire doors and burglar alarms. For details write — *Electronics Department, General Electric, Schenectady 5, New York.*



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177-DS-1

RAPID

METAL-COATING PROCESS

- FAST AND ECONOMICAL
- FOR HEAVIER COATINGS

REQUIRES ONLY RAPID ELECTROLYTE — RAPID METAL CLEANER — RAPID APPLICATOR

- Plating current is obtained from dry cells, storage battery, or any convenient source of direct current at 3 to 6 V., or use Rapid Plating Rectifier for heavy work.
- For silver surfacing bus bar connections, lugs, switch blades, etc. For plating or touching up miscellaneous surfaces with cadmium, nickel, zinc, copper and gold. Building up limited areas. Hard surfacing with nickel. Used in shop or field. Special applicators designed to speed up production line jobs.

Our laboratory is glad to cooperate. No obligation

Rapid Electroplating Process, Inc.

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Lavite STEATITE CERAMIC

Properties and Characteristics of Our LAVITE SI-5 Steatite Ceramic Body

Compressive Strength	96,000 lbs. per square inch
Tensile Strength	7,200 lbs. per square inch
Flexural Strength	10,500 lbs. per square inch
Modulus of Rupture	20,000 lbs. per square inch
Dielectric Strength	235 volts per mil
Dielectric Constant	6.42 } Frequency of 1 megacycle
Loss Factor	2.90 }
Power Factor	.446 }
Bulk Specific Gravity	2.664%
Density (from above gravity)	0.096 lbs. per cubic inch
Hardness (Mohr scale)	7.0
Softening Temperature	2, 350°F.
Linear Coefficient of Expansion	8.13×10^{-6}
Moisture Absorption (ASTM D-116-42-A)	0.009%

Makers of electrical and radio apparatus destined for war service are finding in LAVITE the precise qualities called for in their specifications . . . high compressive and dielectric strength, low moisture absorption and resistance to rot, fumes, acids, and high heat. The exceedingly low loss-factor of LAVITE plus its excellent workability makes it ideal for all high frequency applications.

We will gladly supply samples for testing.

D. M. STEWARD MFG. COMPANY

Main Office & Works, Chattanooga, Tenn.

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INDEX TO ADVERTISERS

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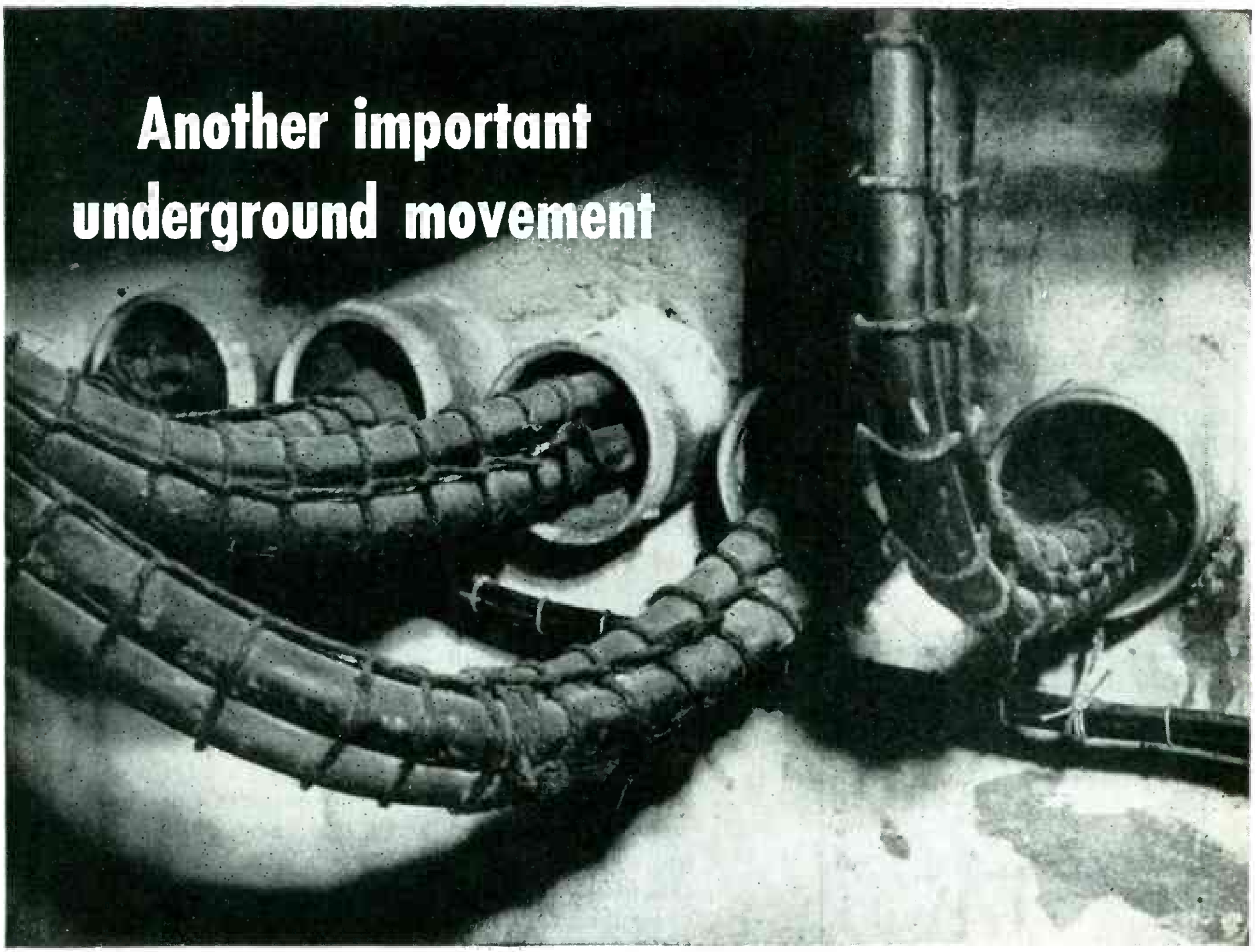

Unsheathed buried power cable insulated with Geon

THOSE large power cables represent an important development in the electrical industry. As they pass through the basement wall, they go directly into the earth. There the thinner-than-usual coating of GEON insulation will, without benefit of lead sheathing, resist the effects of the soil's acids and alkalies, will keep out moisture—*while its excellent electrical properties will be maintained.*

On the other extreme, GEON polyvinyl materials have been made into thousands of miles of fine "spaghetti" to slip on radio and switchboard wire. Through the entire range of wire and cable insulation GEON'S unusual properties have made possible a wide variety of applications. In addition to possessing fine electrical properties, GEON resists oils, acids, water, flame, heat, cold. It's practically wearproof. It's smooth—permits easy handling and installation. Thinner coatings of insulation mean more conductors per conduit. GEON can be brilliantly colored in the entire NEMA range for easy, positive identification.

Urgently needed for military uses, all the GEONS are subject to allocation by the War Production Board. Limited quantities are available for experiment, and our development staff and laboratory facilities will help you work out special problems or applications. For more complete information write Department FF-3, Chemical Division, The B. F. Goodrich Company, 324 Rose Building, Cleveland 15, Ohio.

CHEMICAL DIVISION
The B. F. Goodrich Company
ROSE BUILDING • CLEVELAND 15, OHIO

Geon
Polyvinyl Materials

DAVEN

30 to 60 DAY DELIVERY
ON ATTENUATORS

We've progressed a long way from those early war days when, regrettably, deliveries were too often a hope and a promise. While we're not yet back to the luxury of filling many orders from the shelf, present production schedules assure prompt Daven Attenuator deliveries. Some standard models are available in small quantities for almost immediate shipment. 30 to 60 day delivery may be had on average quantities of most standard type Attenuators and many special types not requiring new engineering. Write for details on your specific requirements.

THE **DAVEN** COMPANY
191 CENTRAL AVENUE
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NEW FEATURES OF DAVEN ATTENUATORS

NEW DETENT GEAR: Large gear and roller mounted in recessed front end of cover, separate from resistive network, gives accurate indexing.

CERTAIN STOP: Extrusions of detent gear and steel attenuator cover form sturdy stop to rotation, eliminating rotor-hub strain of previous method.

IMPROVED SHIELDING: Sturdy, snug-fitting steel cover affords superb electrical and dust shielding and greater all-around ruggedness.

CAPTIVE TERMINAL BOARD: Bakelite board held securely in position, readily released; new, heavy duty solder lugs.

ANTI-FUNGUS TREATED: On request.

SILVER ALLOY CONTACTS: Switch arm contacts and returns made of tarnish-resisting silver alloy lowers internal resistance. Other metals optional.

SEPARABLE COUPLINGS: (Feature of dual and multiple unit models) units easily separated for quick access to switch assemblies; simple, durable, foolproof.

SUPPORT THE RED CROSS ROLL CALL IN MARCH

136- zero phase shift amplifier

How to Lower Your Tube Costs

Simply base your designs on RCA Preferred-Type Tubes which, in a single year, dropped more than 13% in price.

Not only have prices been lowered by the Preferred-Type Program but the quality of the tubes has been improved, due to longer production runs and increased skill of workers.

How the preferred-type idea started

Long before Pearl Harbor, RCA found that despite the hundreds of different receiving-tube types being manufactured, almost every possible circuit requirement could be satisfied by a list of less than 50 tube types.

Moreover, by limiting the number of types being manufactured, it would be possible to realize tremendous savings in warehousing, distribution, test equipment, and other factors affecting cost.

The plan was promoted among equipment designers who, quick to see the advantages of fewer tube types, cooperated wholeheartedly to make the Preferred-Type Program a success.

When the war broke out, the Army and Navy adopted the Preferred-Type idea and established a list of their own, including many tubes already on RCA's Preferred-Type list. Military equipment was designed almost exclusively around Army-Navy Preferred-Type Tubes. This forward-looking policy simplified military tube stocks and insured speedy replacements on the fighting fronts.

Which RCA tubes are preferred types

By substantial indication of preference, designers themselves — not RCA — determine which tubes are Preferred Types.

Because the list of Preferred Types (metal, miniature and glass) is still rather fluid, it is advisable to check with us before your final decisions are made regarding any specific tube. Write to Department 62-28E, RCA, Harrison, N. J.

The fountain-head of modern Tube development is RCA.

62-6136-28

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