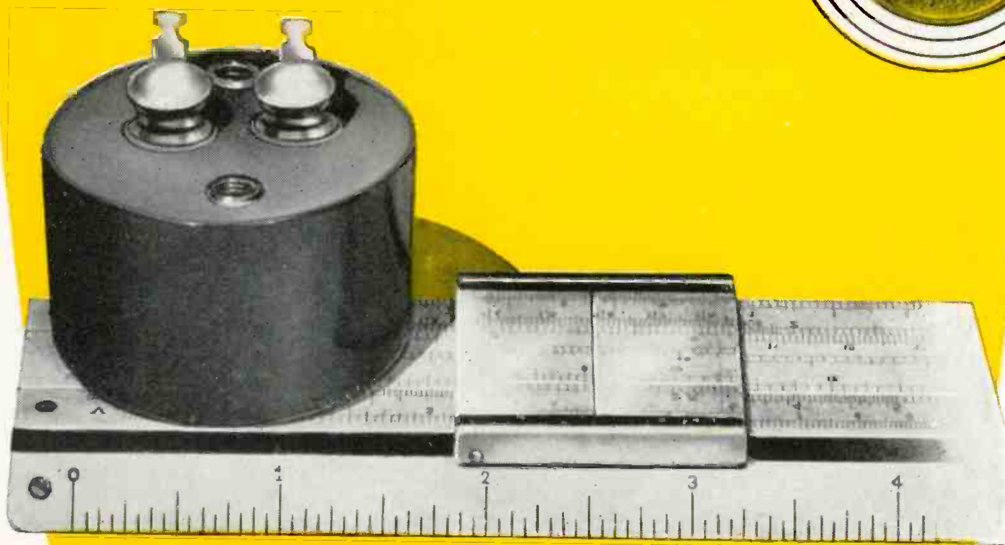
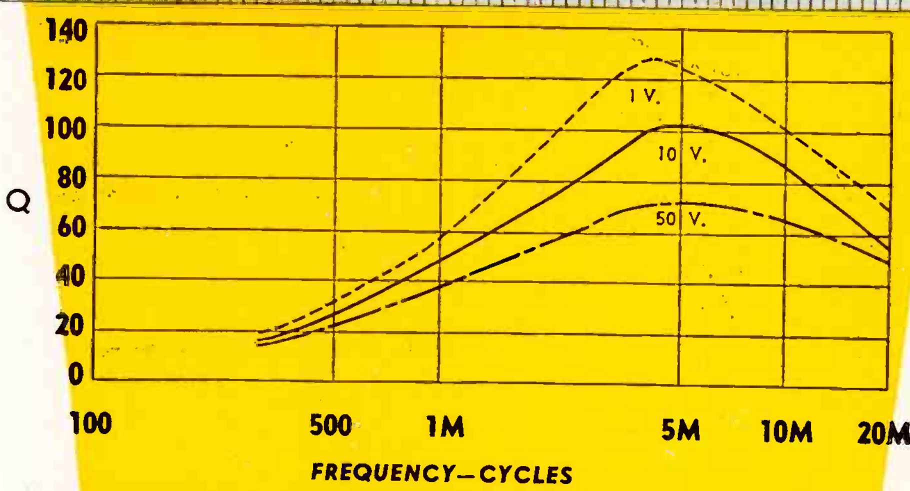
JANUARY · 1945

electronics

A McGRAW-HILL PUBLICATION

HIGH Q COILS *by* UTC





There are many applications in the audio field requiring coils of high Q and good stability. UTC coils of the type HQA series are ideal in this respect.

Q CHARACTERISTICS of a typical .14 Hy. coil at three voltages are illustrated.

VOLTAGE STABILITY is high. At 1,000 cycles, for applied voltages from .1 to 25 volts, the change in inductance is less than 1%. DC current change in inductance is approximately 1% per 10 Ma. linearly.

HUM PICKUP is low due to a self shielding structure: . . . 70 microvolts per gauss at 60 cycles.

TEMPERATURE effects are negligible. From —60 degrees C. to plus 85 degrees C., inductance variation is less than 1/3%.

MECHANICALLY, these units are hermetically sealed in a drawn steel case 1-13/16" diameter by 1-3/16" high. Weight . . . 5 ounces.

VIBRATION effects are not evident over entire range of normal aircraft tests.

HQA UNITS are available in any inductance value from 5 Mhy. to 2 Hy., and are ordered as: HQA followed by value in Mhy. Typical semi-standard values are:

HQA—12.5 . . . .$5.00 net	HQA—200. . . . .$8.00 net
HQA—30. . . . .$6.00 net	HQA—500. . . . .$9.00 net
HQA—80 . . . .$7.00 net	HQA—1250. . . . .$10.00 net

United Transformer Co.

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EXPORT DIVISION: 13 EAST 40th STREET, NEW YORK 16, N. Y., CABLES: "ARLAB"

electronics

JANUARY • 1945

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To ....

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Signed ....

Still Young at 99 . .

Who wants a tracing paper that's still good—and we mean *good*—still white, transparent, flexible—99 years later? Well, you can never tell. Maybe more tragic things have happened than having a drawing go to ruin in its sleep, but nevertheless, that can be awfully serious. That's only one reason why we developed ALBANENE white tracing paper. It's permanent, because it's made of 100% long-fibre pure white rags, treated with Albanite. In drafting rooms today there are drawings on ALBANENE that are years old and still in perfect condition.

What's Albanite? It's a crystal-clear, unaltering synthetic developed by the K&E Laboratories, and is simply tops as an impregnating medium for long-fibre paper stock. That gives ALBANENE extra transparency. And because ALBANENE stays white, it gives strong, contrasting prints. It's fine to work on too, with pencil or ink—keeps clean and takes erasures well. That's not the whole story; to get it all, write us on your letterhead for a sample sheet. Made in rolls, sheets, and pads.

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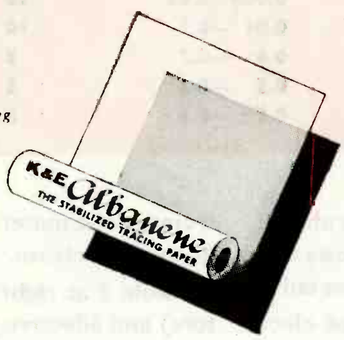

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What are Carbonyl Iron Powders?

ABOVE you see the fundamental characteristics found only in G.A.F. Carbonyl Iron Powders. The text below outlines kinds of powders, chemical and physical analysis, including "Q" value, and suggested uses.

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.

The particles making up the powders "E," "TH," and "SF" are spherical with a characteristic structure of increasingly larger 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," and the apparent density as determined in a Scott Volumeter are given in the following table for the five different grades:

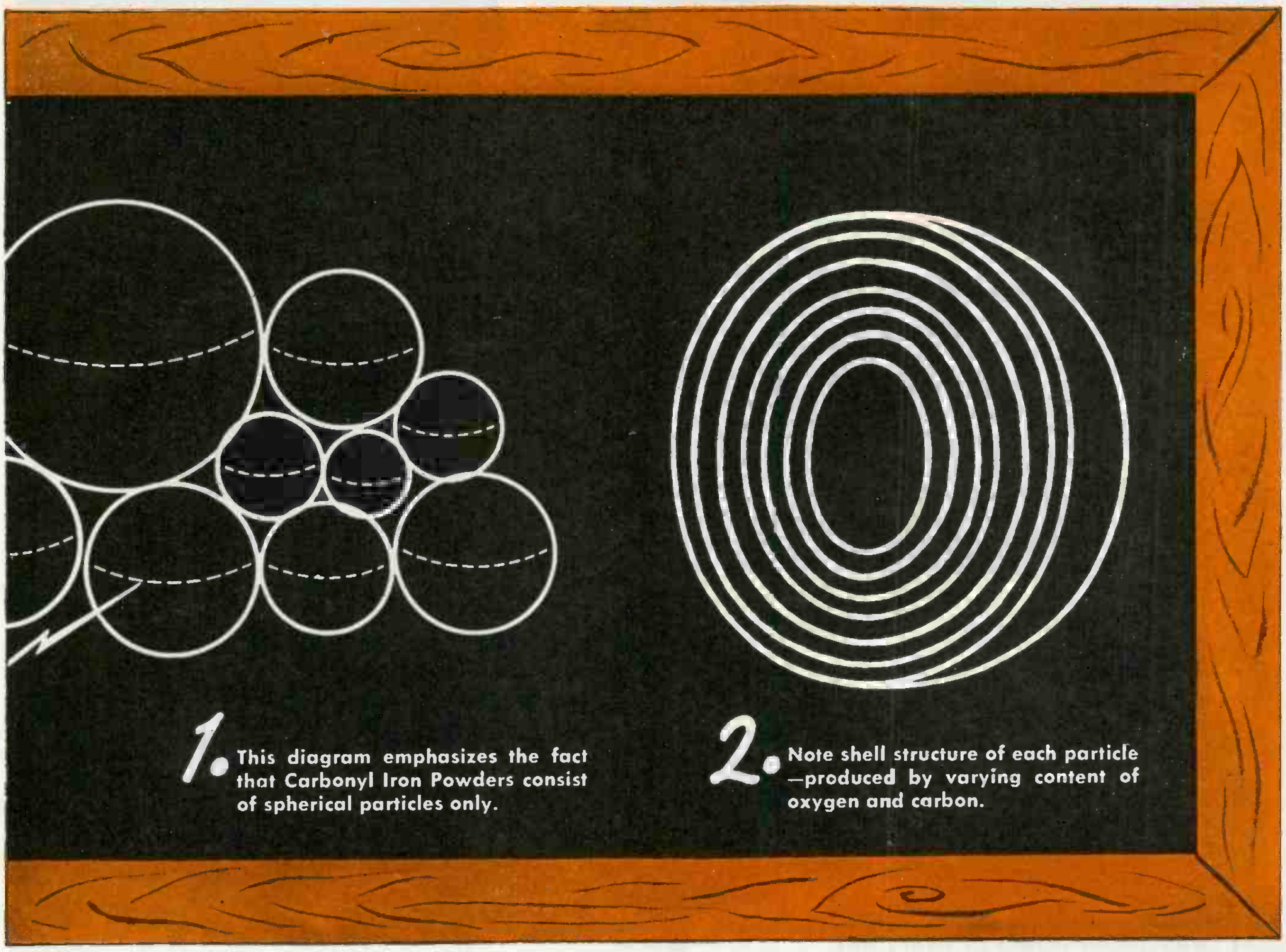
TABLE 1

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	8	4.4—4.7	2.5—3.5
TH	[illegible]	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

With reference to the chemical analysis shown above, it should be noted that spectroscopic analysis shows the rest to be iron with other elements present in traces only.

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

Table 2 at right 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.

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	98	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.)

"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.)

Further information can be obtained from the Special Products Sales Dept., General Aniline and Film Corporation, 437 Hudson Street, New York 14, N. Y.

G.A.F. CARBONYL IRON POWDERS


'ROUND THE CLOCK
WITH SUPER-PRO
For twenty-four hours of every day "Super-Pro" receivers are assisting the "Round the Clock" bombing of the enemy.... In war and in peace "Super-Pro" leads the field.
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THE HAMMARLUND MFG. CO., INC., 460 W. 34TH ST., N.Y.C.
MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT

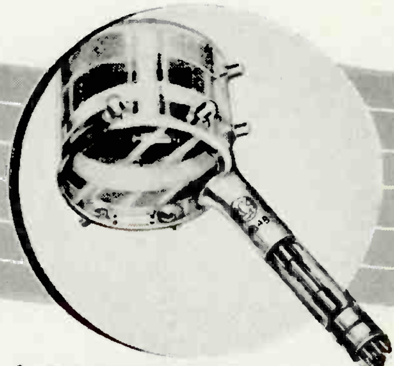
Electronic Television is

This is a story of leadership—as clean-cut, unassailable and complete as any industry can show.

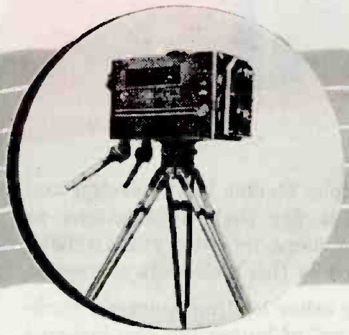
It's the story of RCA's development, in all of its basic essentials, of the electronic television system in use today. For RCA engineers contributed ALL of the essential elements of this system—including *tubes and circuits.*

RCA factories built the first transmitters and the first receivers of the type now almost universally used. The Radio Corporation of America through its broadcasting service—the National Broadcasting Company—installed the *first commercial television station*—a station whose operating and programming technique has set a standard of performance in the television broadcasting field.

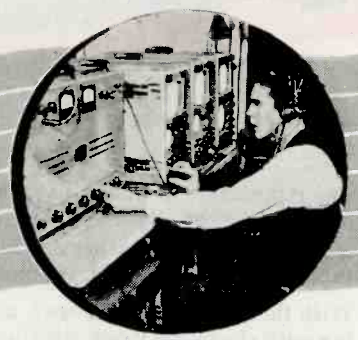
ELEMENTS OF THE TELEVISION SYSTEM



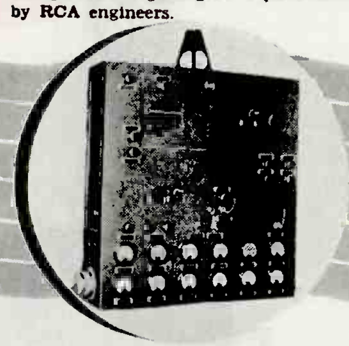
1. THE ICONOSCOPE—The "electric eye" of the television camera. Developed by Dr. V. K. Zworykin, RCA scientist, and brought to a high degree of perfection by RCA engineers.



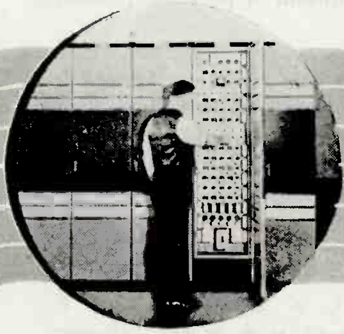
5. THE FIELD CAMERA — The RCA field pickup camera shown here is the first camera to use the "orthicon" pickup tube—by far the most satisfactory for "outside" pickups.



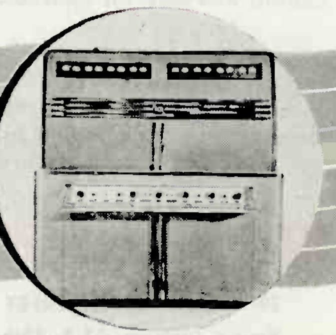
6. REMOTE PICKUP EQUIPMENT — RCA engineers built the first television equipment for field pickups—and the first such equipment (shown here) for use with the "orthicon" camera.



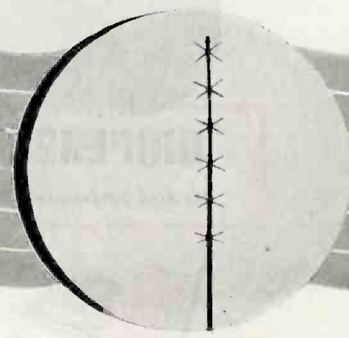
7. THE RELAY TRANSMITTER — The first transmitters to be used for television relaying were built by RCA engineers—the one shown here is for relaying from a remote pickup point.



11. THE SYNCHRONIZING GENERATOR—Furnishes the signals that key transmitter and receiver together. This type of synchronizing, now almost universally used, was developed by RCA.



12. THE VIDEO TRANSMITTER — The first commercially produced video transmitter, the 4 KW model shown here, was designed and manufactured before the war by RCA.



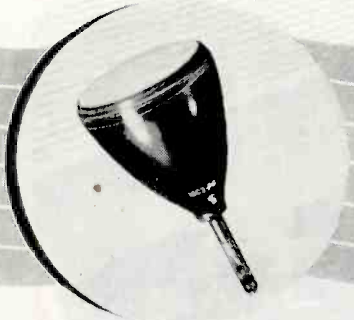
13. THE TELEVISION ANTENNA—RCA engineers have designed a large number of antennas for television. The turnstile antenna, shown here, was developed by Dr. G. H. Brown of RCA Laboratories.

an RCA Development

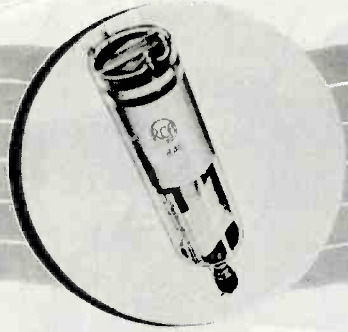
RCA and NBC engineers, working together, established the *first television relay system*, put on the first outdoor program, the first "theatre" television, the first Broadway play, the first baseball game, the first television from an airplane.

Consider, for instance, the elements of the television system as presented on these pages. Note that RCA engineers played a big part in developing *every one of them*. Add to this the fact that these same engineers have been working *100% of their time* on radio, radar and other electronic equipment of the *most advanced types* for the Army and Navy, and you can well understand the basis for RCA television leadership.

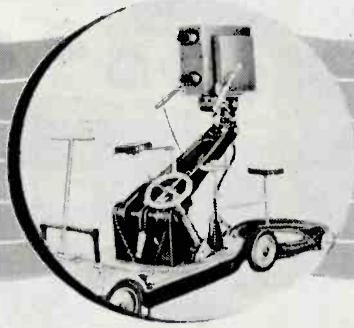
You can expect the best of all kinds of television transmitting and receiving equipment from RCA—the leader from start to finish.



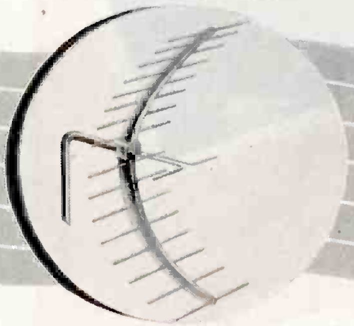
2. THE KINESCOPE — The reproducing tube used in all present-day receivers. Developed by Dr. V. K. Zworykin of RCA Laboratories as part of his "all-electronic" television system.



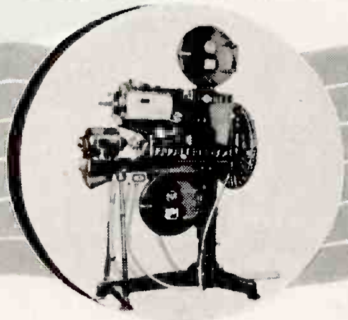
3. THE "ORTHICON" — The high-sensitivity pickup tube, which requires much less light and hence makes outside pick-ups practical. Developed by Dr. Rose and Dr. Iams of RCA Laboratories.



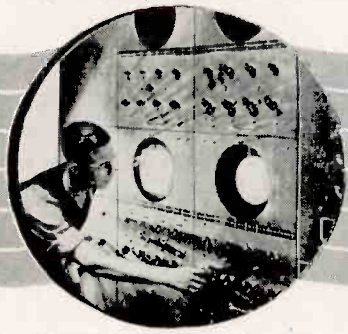
4. THE STUDIO CAMERA — Deluxe-type studio cameras shown here were first designed and built by RCA. Cameras of generally similar design are now used in nearly every television studio.



8. BEAM ANTENNAS — Beam antennas such as the one shown here, which may be used with the relay transmitter shown at left, are largely based on original RCA research.

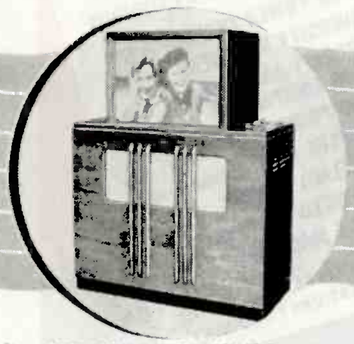


9. THE FILM SCANNER — The arrangement which allows standard motion picture films (24 frames) to be televised over a 30-frame, interlaced system was devised by RCA engineers.



10. THE MONITOR EQUIPMENT—The system of monitoring several video channels by means of a picture tube and an oscilloscope for each channel was first used by RCA engineers.

BUY MORE WAR BONDS



14. "BIG SCREEN" RECEIVERS — RCA engineers designed and RCA factories built the first home television receivers. Their newest contribution, shown here, is the home receiver with a built-in, large-size screen for comfortable viewing from any point in an average-sized living room. Picture is unretouched.

RCA

For Everything in Television

RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION · CAMDEN, N. J.

Champion

OF THE VERY HIGH FREQUENCY BAND

Transmitting Tube GL-8002-R, full input up to 120 megacycles, for FM and Television service. Price $125.

Broadcast needs for high-frequency tube performance are superbly met by this modern vacuum triode, station-tested over a substantial period.

Engineered to combine high-frequency operation with high output, the GL-8002-R offers you unusual qualities of durability and top-grade performance. Construction is very rugged. For example, the substantial thimble seal of fernico metal and glass with equal coefficients of expansion, minimizes breakage during installation or service, and typifies the strength built into every part of the tube. Also, the careful selection of component materials contributes to the high power output delivered within a compact structure.

There are three grid-leads which can be used for neutralization or excitation, or can be connected in parallel, and this feature, as well as the multiple filament leads, greatly reduces inductance to these electrodes. Throughout, Type 8002-R is engineered for high performing characteristics, and for the long-term economy that results from sturdiness and efficiency.

Ratings are given at the right, along with comparative figures for Types 889-R and 8009, which are similar in purpose and general design. The range in capacity between these types enables you to select a tube suited to your particular transmitter requirements. Additional G-E transmitting tubes also are available in the high-frequency classification, and the data on these will gladly be supplied. Consult your nearest General Electric office or distributor, or write *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.

GL-8002-R. $125.

Maximum frequency for full ratings, 120 megacycles. For reduced ratings, 200 megacycles. As a Class C radio-frequency power amplifier, plate voltage is 3,500; current, 1.0 amp; input, 3.0 kw; dissipation, 1.2 kw. Cooled by forced air.

GL-889-R. $325.

Maximum frequency for full ratings, 25 megacycles. For reduced ratings, 100 megacycles. As a Class C radio-frequency power amplifier, plate voltage is 8,500; current, 2.0 amp; input, 16 kw; dissipation, 5.0 kw. Cooled by forced air.

GL-8009. $450.

Maximum frequency for full ratings, 25 megacycles. For reduced ratings, 100 megacycles. Special introverted anode helps to minimize inductance, thus increasing suitability for high-frequency applications. As a Class C radio-frequency power amplifier, plate voltage is 10,500; current, 6 amp; input, 60 kw; dissipation, 20 kw. Cooled by water and forced air.

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FM does it —

THROUGH STORM AND NOISE

with clear reception that will build and hold greater audiences

Over a period of a year, more radio receivers are turned off during programs because of man-made and natural electrical disturbances than for any other cause. If your station serves areas where electrical devices produce high noise-levels, if you are geographically located where static is a problem, consider FM. Frequency Modulation will give your listeners vastly improved reception, virtually free from noise — and do it with less transmitter power and reductions in operating costs. Or, with the same power and the same cost, it will enlarge your primary service area.

In order to provide radio reception with low background noise level, the signal strength of an AM broadcast station should be about 100 times stronger than that of the interfering noise or signal. By comparison, an FM broadcast station can provide reception with the same low background noise level but with a signal strength only about twice that of the noise level itself.

Consider, for example, the case of the 1-kw AM station on 1200 kc. With a 400-ft half-wave antenna overlooking flat country and where conditions of ground conductivity are average (3×10^{-14} EMU) this station can generally provide its radio audience with satisfactory noise-free service over the following approximate effective areas:

AM Service	*Range*	*Coverage*
Day	22 miles	1520 square miles
Night	10.5 miles	346 square miles

Compare this performance with the virtually interference-free reception that a 1-kw FM station can provide over the same terrain, using a 2-bay circular antenna 400 feet high:

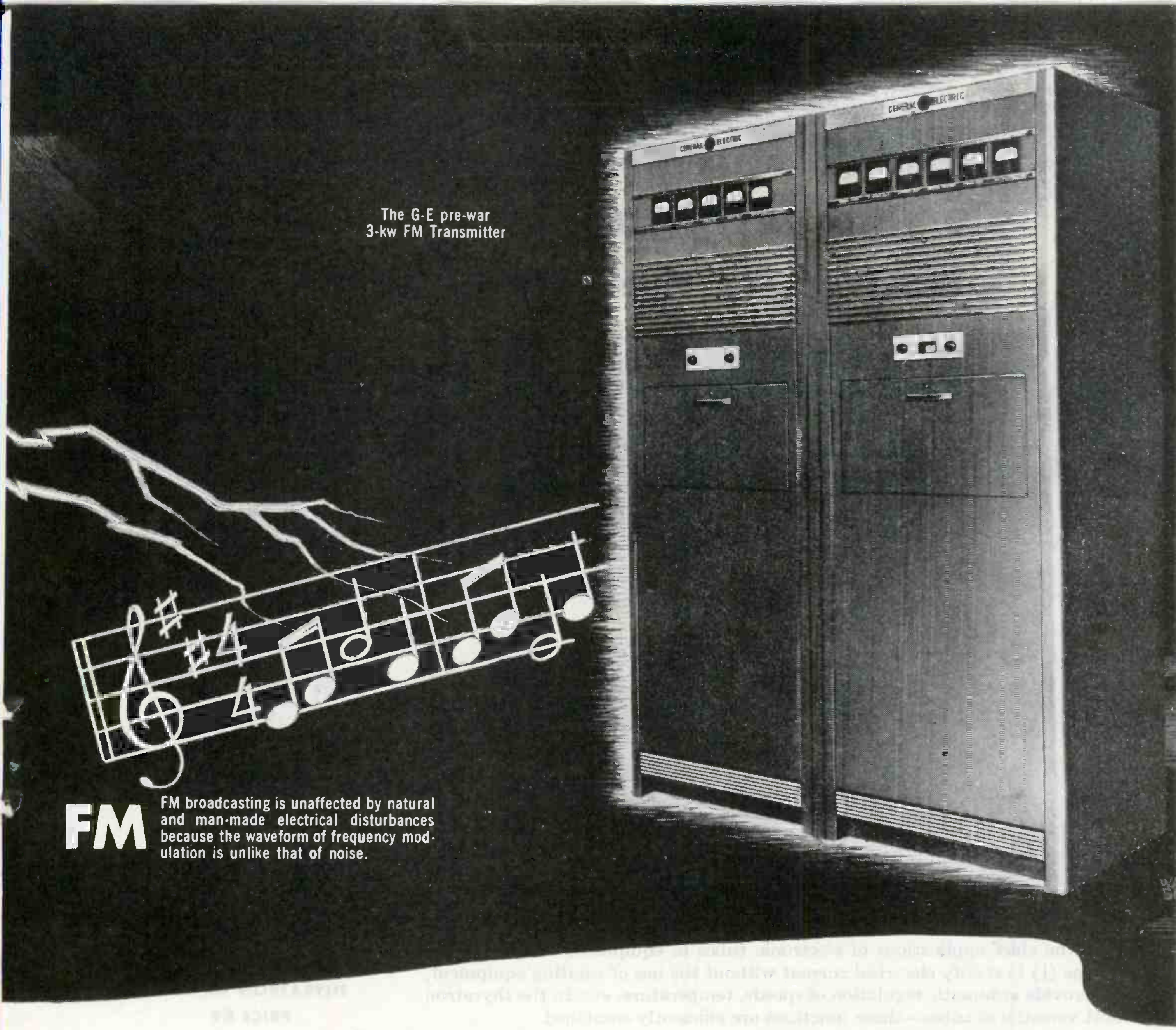
FM Service	*Range*	*Coverage*
Day and Night	43 miles	5800 square miles

Performance like this provides better service. Service like this builds larger audience and greater advertiser interest.

STUDIO AND STATION EQUIPMENT • TRANSMITTERS

GENERAL ELECTRIC

160-B1-6910



Look to General Electric when you plan your FM station. G.E. is the one radio manufacturer with experience in designing and building complete FM 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 today's 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 record. G.E. operates its own FM proving-ground, station WGFM, at Schenectady. 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 tells you about General Electric's plan to help you obtain early delivery of transmitters and associated equipment.

50 FM BROADCAST STATIONS ON THE AIR
OVER 300 APPLICATIONS PENDING

FM DOES IT—

FM multiplies your effective coverage day and night.
FM gives your audience programs with lower background noise.
FM minimizes station interference on your frequency.
FM contributes to the economy of your broadcasting system.

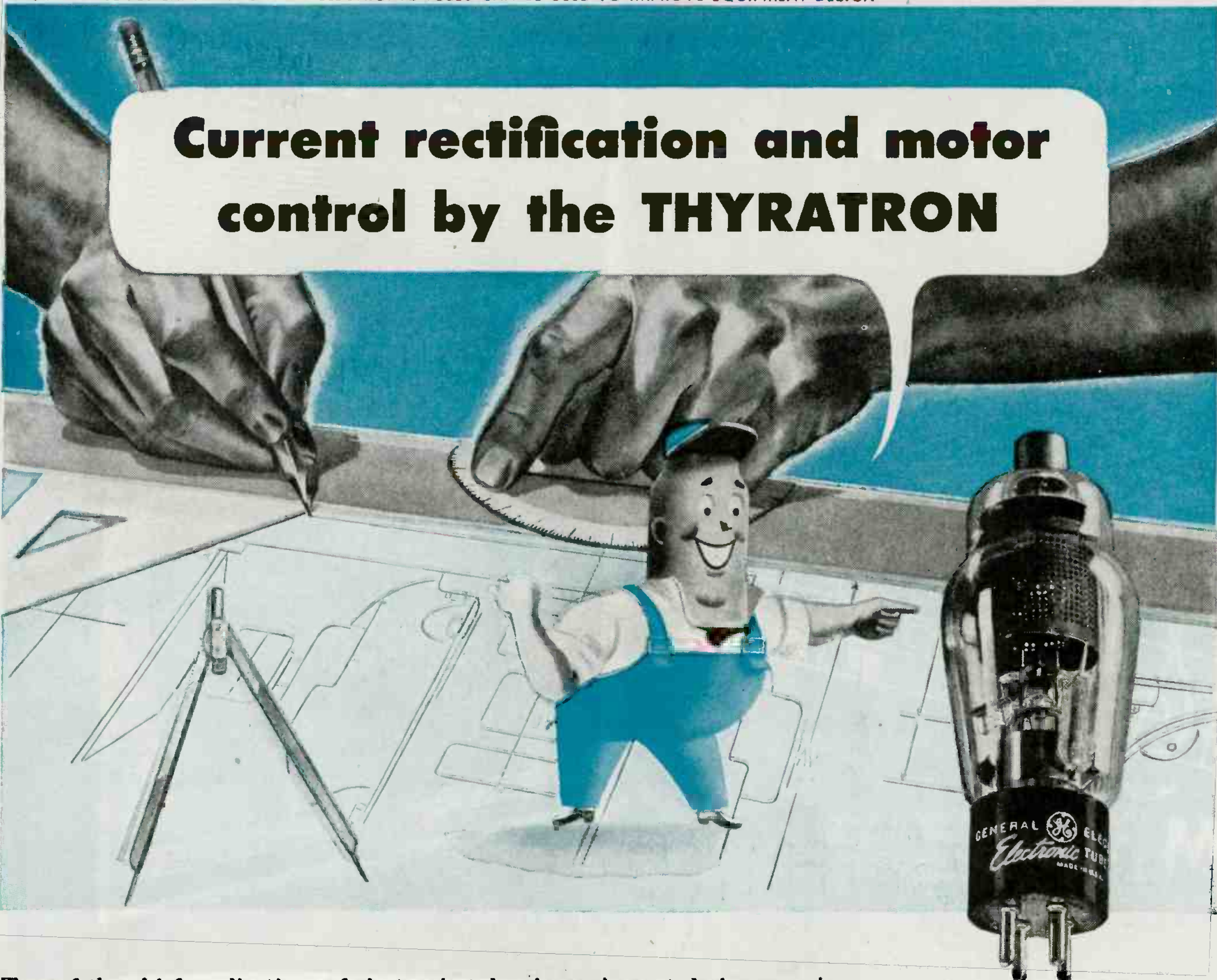
General Electric's FM equipment will include revolutionary circuit developments, new component designs, and improved layout features that will contribute directly to the quality and economy of your broadcasting system.

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.

ANTENNAS • ELECTRONIC TUBES • HOME RECEIVERS

FM • TELEVISION • AM *See G.E. for all three!*

NO. 1 IN 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.*

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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

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PACIFICO

Excellence of Performance

Chicago Telephone Supply Company is a scientific manufacturing organization devoted to craftsmanship in mass production. The excellence of performance of CTS variable resistors reflects the exacting care that goes into every detail of construction.

Soon the advanced techniques of intensive war manufacturing experience will be utilized for civilian production. For the highest standards in variable resistors, both wire wound and carbon types, look to Chicago Telephone Supply Company.

Manufacturers of Quality Electro-Mechanical Components Since 1896

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A 25-Watt General Purpose Radio-Telephone Transmitter—Available for operation between 1.5 M.C. and 30 M.C.

HARVEY "AMPLI-STRIP"

For I-F and AUDIO Amplification.

HARVEY
OF CAMBRIDGE

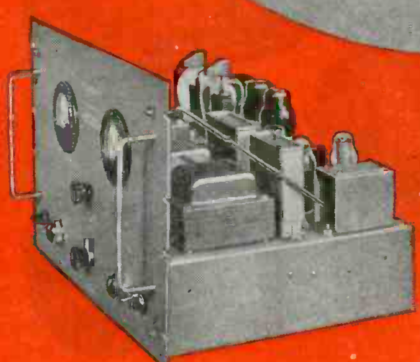
RADIO AND ELECTRONIC EQUIPMENT

The units illustrated are representative of HARVEY OF CAMBRIDGE design and construction "know-how" as well as precision of manufacture and testing. Each is a precision product designed and developed by HARVEY OF CAMBRIDGE to fill specific needs in the radio-electronic fields.

Some, like the 206 PA Power Supply and the "Ampli-Strip" are new developments resulting from HARVEY'S one-hundred per cent war work.

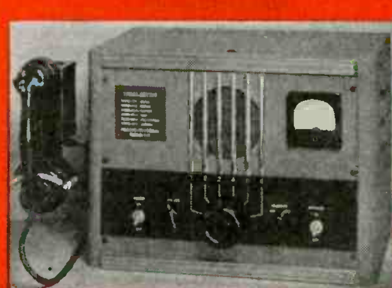
Others, like the UHX-25 Transmitter and Marine 25 Radio Telephone are typical of HARVEY OF CAMBRIDGE products which have long been recognized as standards of quality and dependability.

Years of exclusive specialization in the manufacture and development of this type of equipment are your guarantee of complete satisfaction from all HARVEY OF CAMBRIDGE products and of competent, intelligent assistance in bringing to a successful solution any of your present or projected radio-electronic problems.



HARVEY Regulated Power Supply 206 PA

For labaratory D.C. Source—Range 500 to 1000 volts.



HARVEY MARINE 25

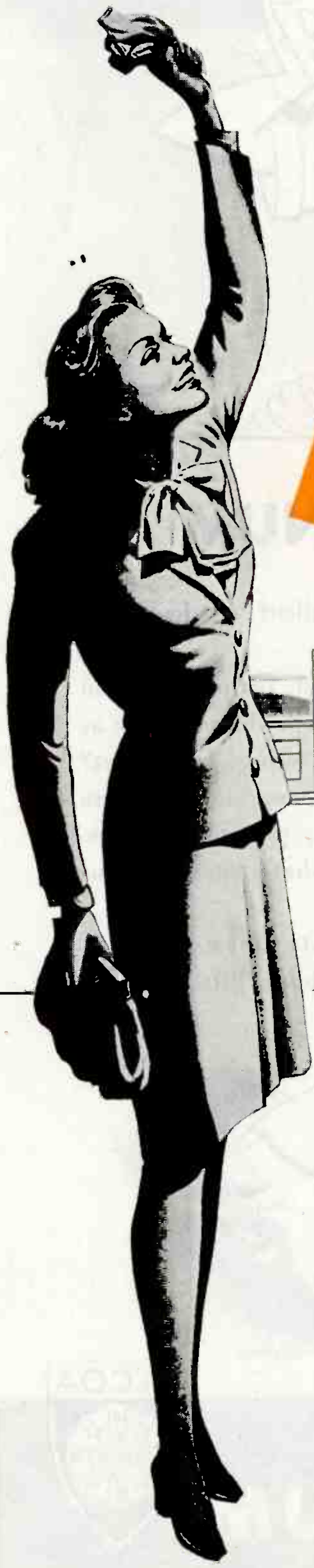
A 6-Channel Marine-Radio Telephone.

HARVEY
OF CAMBRIDGE

HARVEY RADIO LABORATORIES, INC.

439 CONCORD AVENUE • CAMBRIDGE 38, MASSACHUSETTS


The TINYMITE
SMALLEST PAPER CAPACITOR - - - yet 100% MOISTUREPROOF
TYPE P5N
TYPE P4N
FEATURES
1. Bakelite Resinoid Ends. Lead wire cannot pull out, even under hot conditions.
2. Non-Inductive.
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
BUY EXTRA WAR BONDS . . . 'TIL THE WAR IS OVER.
Pat. Pend.
DUMONT
ELECTRIC CO.
MFR'S OF
CAPACITORS FOR EVERY REQUIREMENT
34 HUBERT STREET NEW YORK, N. Y.



★ *Structural member of Bullet-Sealing Fuel Tank used on the B-29 Super-Fortress. It is made entirely of National Vulcanized Fibre.*

Is there an Idea for your New Products in this War-time Use of National Vulcanized Fibre?

National Vulcanized Fibre, because of its remarkable combination of properties—resilience, formability, lightness in weight and exceptional strength—was found to be exactly the right material for this structural member of the bullet-sealing fuel tank of the B-29 Super-Fortress. Its superior resiliency and shock-absorbing qualities protect the tanks from the sudden and great impacts of landing. The same properties that make National Vulcanized Fibre the best material for this and thousands of other war-time applications make it equally practical for countless peace-time uses. National Vulcanized Fibre may be the means of developing new, profitable products for you—of enabling you to get the lead on your post-war competition.

• • •

National engineers are available today to assist you in your current design and research work. Write, phone or wire us.

Electrical Applications—National Vulcanized Fibre, in combination with its exceptional physical and mechanical properties, has high dielectric strength which makes it 'the one best material for numberless electrical and electronic uses.

NATIONAL VULCANIZED FIBRE CO.

Wilmington, Delaware *Offices in Principal Cities*

IN READINESS TO START POST-WAR DELIVERIES

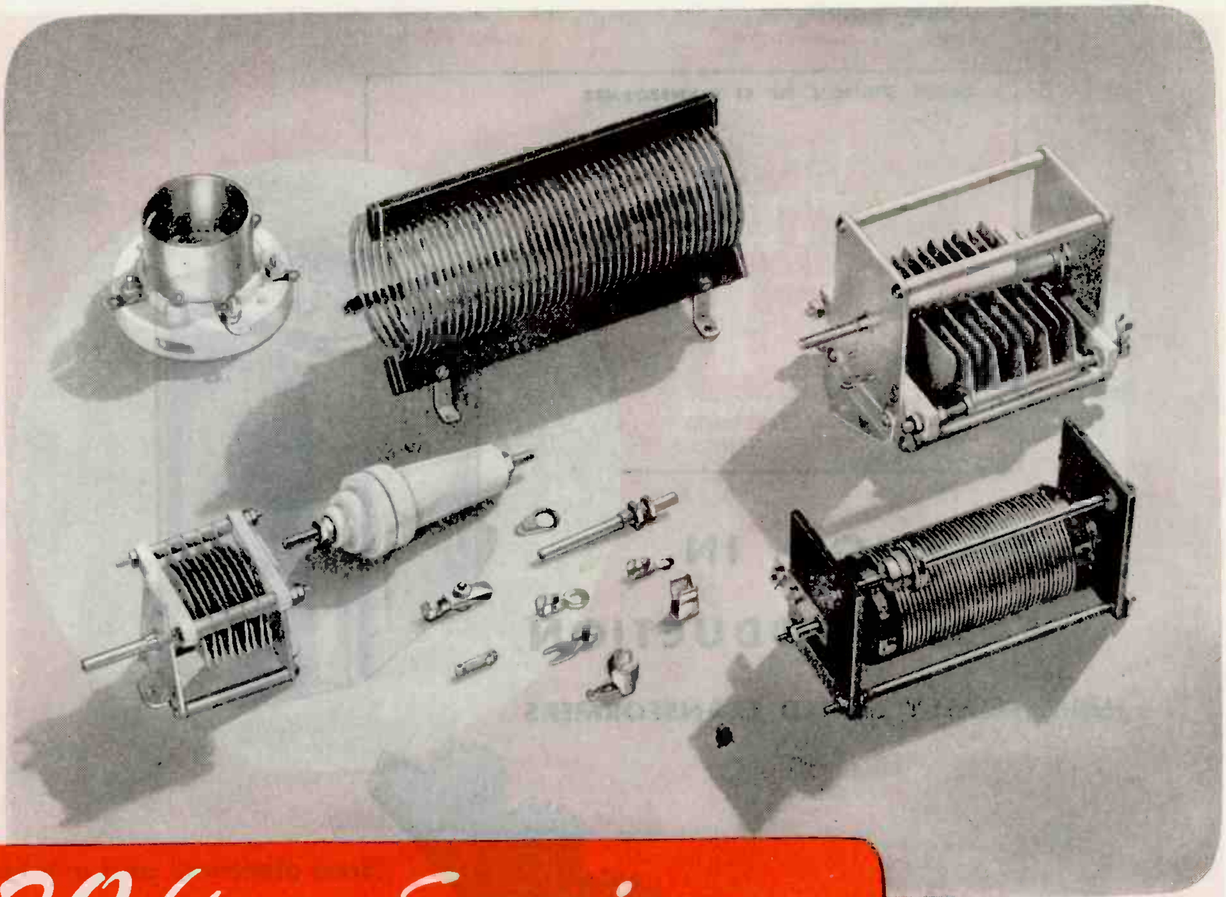
The art of Transformer design, manufacturing technique and the ample production capacity that made possible meeting tremendous War requirements, will be in readiness to serve you post-war as they have in the past.

You are assured of traditional quality and reliability of Jefferson Transformers, and the full cooperation of our engineering staff when civilian needs can again be filled. JEFFERSON ELECTRIC COMPANY, Bellwood (Suburb of Chicago), Illinois. *In Canada:* Canadian Jefferson Electric Co., Ltd., 384 Pape Avenue, Toronto, Ontario.

JEFFERSON ELECTRIC

TRANSFORMERS


CROSS SECTION OF SE TRANSFORMER
SUPER ELECTRIC PROD. CORP. JERSEY CITY, N.J.
PRECISION IN
MASS PRODUCTION
HERMETICALLY SEALED TRANSFORMERS
Close electrical and mechanical tolerances are maintained by gauging and testing every component part carefully. One or one hundred thousand transformers —all are alike. . . . Our complete facilities, including laboratory, design, development and manufacturing, are available to interested makers of electronic equipment.
Your Inquiry is Invited
SUPER ELECTRIC PRODUCTS CORP.
1057 Summit Avenue, Jersey City, N. J.
Manufacturers of Transformers for: Power • Audio Frequency • Luminous Tubes



20 Years Experience
In Parts Manufacture

- CONDENSERS—Variable, Fixed, Gas Filled Pressure, Neutralizing—a type for every transmitter need.
- INDUCTORS—Wire-wound, edgewise wound copper strip, copper tubing —fixed, tapped, or continuously variable—50 watt to 100 KW.
- INSULATORS—Stand-off, Thru-Panel, Cones, Bushings, Antenna Strain or Compression—a type for every requirement.
- TUBE SOCKETS—Steatite or Porcelain—Wafer, Bayonet, Miniature, Acorn or Special Types—a socket for almost any transmitting tube.
- HARDWARE—Tube Caps, Inductor Clips, Solder Terminals, Fuse Clips, Panel Bearings, Flexible Shafts—those hard-to-find constructional parts.

Ask for Catalog 968D

OTHER FAMOUS JOHNSON PRODUCTS

- Plugs and Jacks
- Couplings
- Concentric Line
- Chokes
- Antennas
- Antenna Phasing Equipment
- Antenna Coupling Units
- Heavy Duty R. F. Relays
- Make Before Break Switches
- Sampling Transformers

ARMY NAVY

JOHNSON
a famous name in Radio

E. F. JOHNSON COMPANY • WASECA • MINNESOTA

NEW, HIGH-STRENGTH ZIRCON PORCELAIN...

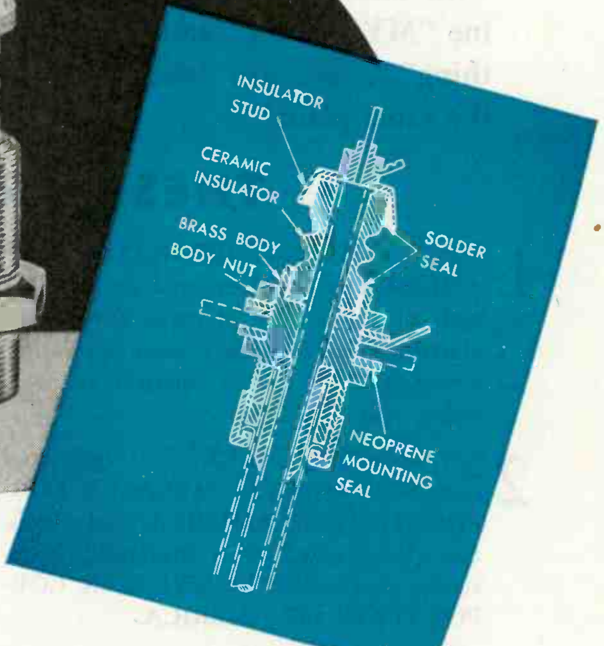
Solder-sealed

TO METAL

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	4.9×10^{-6}	5.3×10^{-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 characteristic gives Zircon Prestite its remarkable thermal shock properties and warrants comparison with other low-loss, high-frequency ceramic materials.



...a stronger, simpler way to seal coaxial cables

Laborious mechanical assemblies can be eliminated . . . gas-tight, shock-resisting hermetic seals assured . . . with this new Zircon Prestite coaxial cable seal.

Especially designed to meet extreme conditions encountered in wartime communications applications, this development offers many advantages for similar uses.

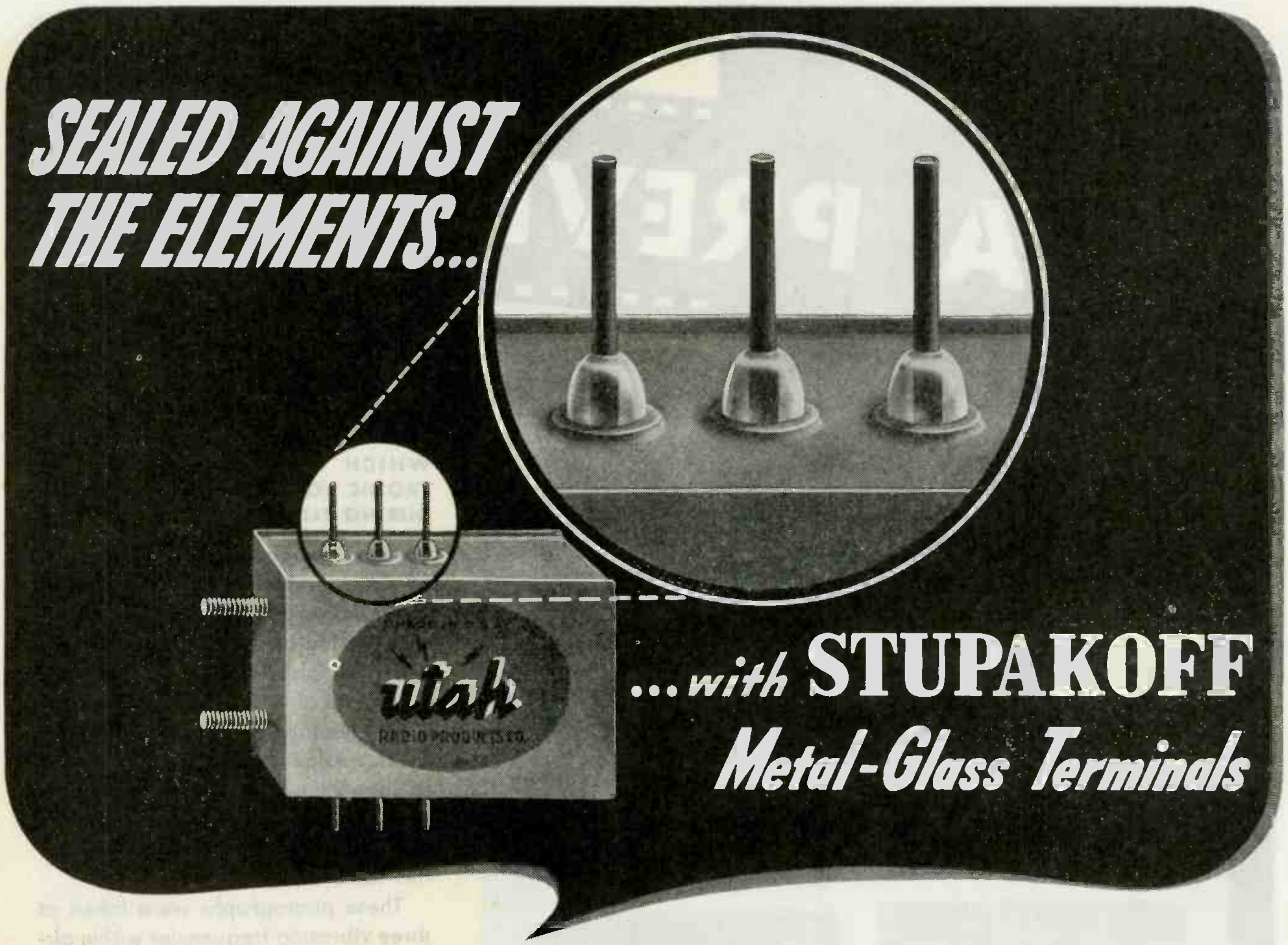
Zircon-base Prestite—a special form of Westinghouse Prestite—provides extreme low-loss factor and high resistance to heat shock, as well as extremely high mechanical strength (see table). Solder-sealed directly to the metal cap and base by the Westinghouse solder-sealing process, this assembly makes possible a high-strength hermetic seal.

The resulting seal offers an important aid to designers in the growing field of pressurized coaxial cable and wave guide developments. Moisture, dirt and corrosive atmospheres are permanently sealed out. Dielectric characteristics of enclosed gases—even under pressure—can be maintained at constant values regardless of outside variations in temperature, humidity or barometric pressure.

Investigate the advantages that Westinghouse solder-sealed assemblies can offer in your design developments. Write Westinghouse Electric & Manufacturing Company, P. O. Box 868, Pittsburgh 30, Pa. J-05156

Westinghouse *Solder-sealed Prestite*

FOR COMMUNICATIONS EQUIPMENT



The hermetically sealed transformer illustrated functions properly under the most adverse conditions. Stupakoff metal-glass terminals, soldered, welded or brazed to the container, protect against humidity, fungi and other elemental hazards. Ideal working conditions are sealed in—detrimental conditions are sealed out.

Stupakoff metal-to-glass sealed terminals are made possible by the metal, Kovar—a cobalt, nickel iron alloy which forms a chemical bond with glass through a heating process, in which the oxide of Kovar is dissolved into the glass. Kovar matches the expansion of thermal shock resistant glass and forms a permanently vacuum and pressure tight seal.

Stupakoff manufactures Kovar-glass terminals with single or multiple, solid or hollow electrodes. For those equipped to do their own glass working, Kovar is supplied as sheet, rod, wire, or tubing; or fabricated into cups, eyelets or special shapes.

Write Stupakoff today for assistance in engineering Kovar-glass terminals to your product.

KOVAR*-Glass Seals for

- ELECTRONIC TUBES
- TRANSFORMERS
- RESISTORS
- CAPACITORS
- CONDENSERS
- VIBRATORS
- SWITCHES
- RELAYS
- INSTRUMENTS
- GAUGES
- METERS
- RECEIVERS
- TRANSMITTERS

DO MORE THAN BEFORE—BUY EXTRA WAR BONDS

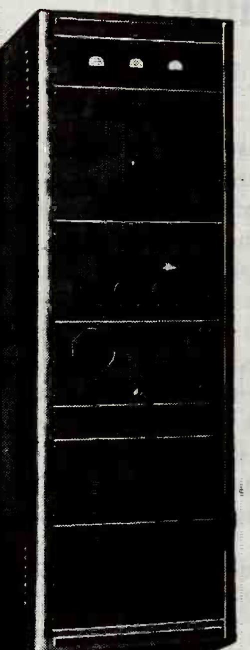
*TRADE MARK 337962 REGISTERED IN U. S. PATENT OFFICE

ARMY (E) NAVY
"FOR GREAT ACHIEVEMENT"

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Products for the World of Electronics

Orders Filled Within
30 to 60 DAYS

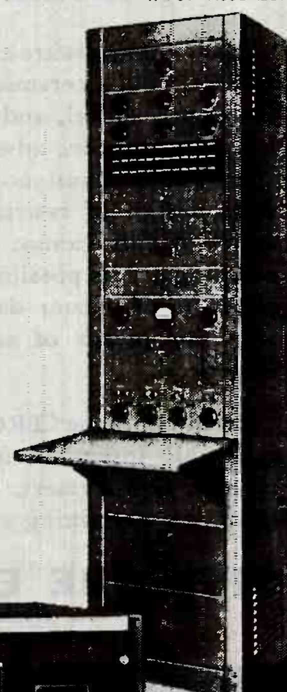


TEMCO can assure delivery of 250 Watt to 10 KW Transmitters for Broadcast and other services within 30 to 60 days after hostilities cease and restrictions are lifted.

Although our skills, at present, are devoted exclusively to producing Radar and special Electronic Equipment for the armed services involving mechanical and electrical complexities of the highest standards, TEMCO *engineering versatility and production flexibility* are geared for a quick changeover to fill post-war orders rapidly.

Ours is a long standing reputation for designing and building high quality communication and electronic devices. By placing your order now with TEMCO you will be assured of prompt delivery of perfected Transmitting equipment. TEMCO advancements in design, materials and construction are ready to serve you as an aid in the success of your post-war plans.

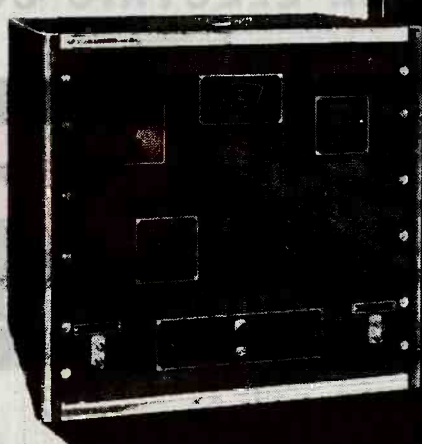
Consult with us at your earliest convenience regarding your requirements.



TEMCO

RADIO COMMUNICATION EQUIPMENT

TRANSMITTER EQUIPMENT MFG. CO., INC.
345 Hudson Street, New York 14, N. Y.



TELEVISION

Quiz

FOR PROSPECTIVE STATION OWNERS

1. What firm's pioneering development of the Cathode-ray Tube (the heart of a television set) gave television its first *clear* pictures...and made television commercially possible?

2. What manufacturer's national advertising—for more than a year—has been devoted to answering the public's eager questions about television?

3. What company designed and built 3 of the 9 television stations on the air today (more than any other company)?

4. What firm's extensive experience in television station design, construction and operation has set a pattern for profitable management of an average-size station?

5. What manufacturer's experimental station telecasting equipment provided a week-in-week-out demonstration of low operating cost and rugged dependability since the summer of 1940?

6. What firm's strong patent position assures clients of exclusive and important features not matched by other companies' television station equipment?

7. What company's experimental television station was the first to offer the use of its facilities during wartime to advertisers and advertising agencies to develop commercial techniques...and to provide experienced directors, writers and talent for television's inevitably-swift postwar expansion?

8. What manufacturer has provided a plan to instruct operating executives and technical crews, which will insure the efficient commercial operation of your postwar station?

9. What firm's telecasting equipment is rated "tops" in signal transmitting efficiency and effectiveness...and in installation and operating economies?

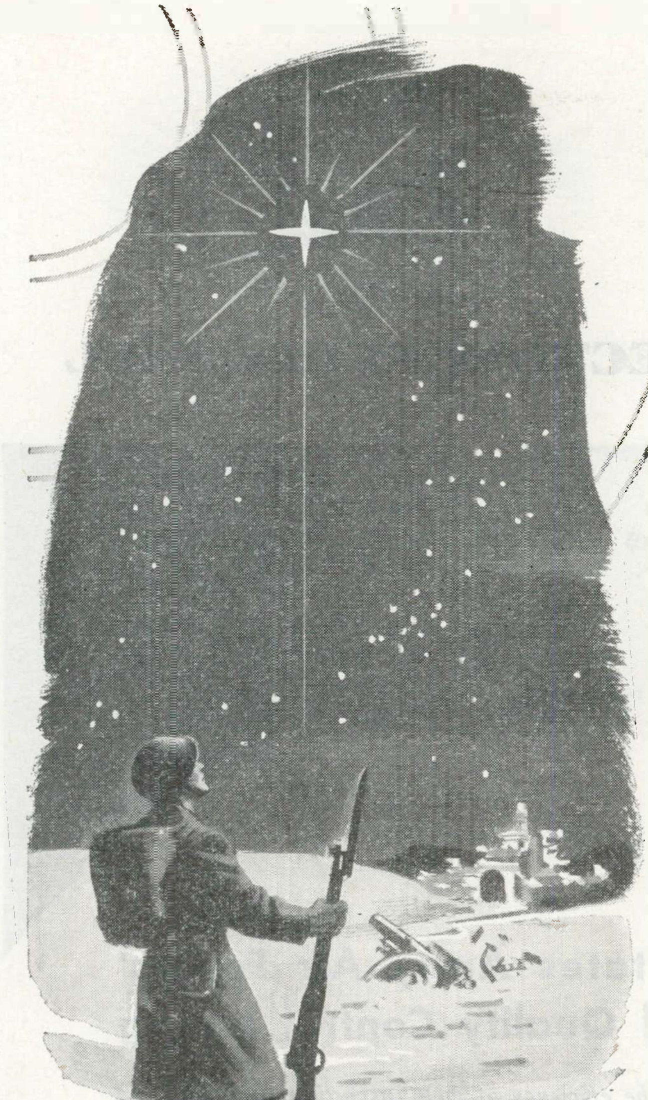
The one-word answer to all these questions is: DUMONT

A copy of "Planning Your Television Station" is yours for the asking. This booklet outlines equipment requirements for a complete, low-cost telecast operation...and suggests plans for expediting postwar delivery of equipment and training of personnel.

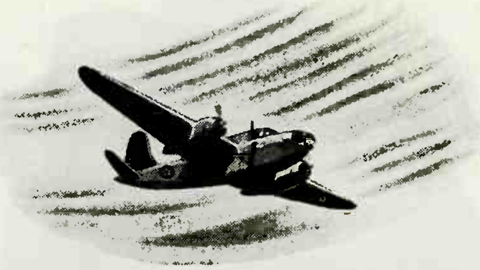
DUMONT *Precision Electronics and Television*

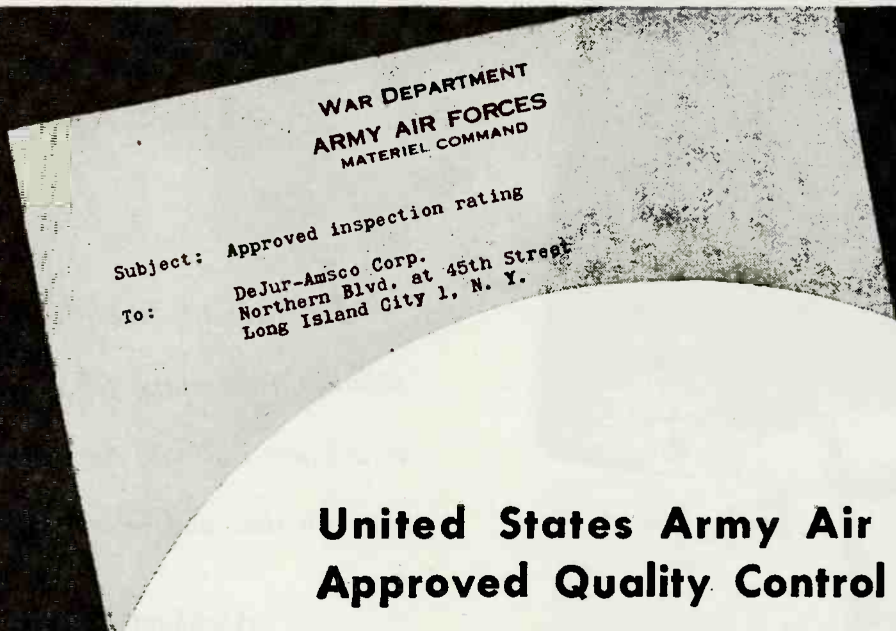
ALLEN B. DUMONT LABORATORIES, INC., OFFICES AND PLANT, 2 MAIN AVE., PASSAIC, N. J.
TELEVISION STUDIOS AND STATION WABD, 515 MADISON AVENUE, NEW YORK 22, N. Y.


In meeting
the challenge of the future,
Western Electric
equipment leads the way
War's end will bring a challenge to everyone. To those identified with communications and transportation, faster, better interchange of ideas and goods will be the order of the day.
We at Western Electric—with our 75-years heritage of leadership in communications equipment—believe we are peculiarly qualified to accept this challenge.
In world-wide telephony, broadcasting, aviation, marine and mobile radio—in every field where sound-transmission apparatus plays a part—Western Electric has led and will continue to lead the way. In these fields as well as in television, Western Electric will play a dominant part in the future.
To speed Victory, buy more War Bonds—and keep them!
Western Electric
ARSENAL OF COMMUNICATIONS EQUIPMENT
Distributed by GraybaR
ELECTRIC COMPANY



A HIGH HONOR FOR THE DeJUR INSPECTION PERSONNEL





United States Army Air Forces' Approved Quality Control Rating

"As a result of the efficiency of your inspection personnel and procedures in production of equipment for the Army Air Forces, your company has been given an 'approved' quality control rating"—this is a direct quotation from the letter received by the DeJur-Amsco Corporation from the District Supervisor, Eastern Procurement District, AAF Technical Service Command.

This rating is the Army Air Forces' official recognition of the ability of the DeJur inspection personnel to meet all AAF inspection requirements. And it means that in future fabrication of DeJur products, Air Corps inspectors will not function in the same capacity as heretofore but will stand by merely for supervisory purposes. The men and women inspectors of the DeJur-Amsco Corporation are extremely pleased with this new honor, and pledge unrelenting care in the performance of their duties.

BUY MORE WAR BONDS . . : HOLD ON TO THEM

DeJur-Amsco Corporation

NORTHERN BOULEVARD AT 45th STREET
Long Island City 1 New York

Basic Design makes the difference!

Smudge-voice

While these two columns read identically, word for word, the smudged column is a visual representation of an acoustical condition when background noise interferes with transmitted speech.

The words may be readable, but effort and concentration are required for accuracy. And so with reproduced sound: with general purpose microphones, articulation is lowered even though ambient noises do not completely override speech. The Electro-Voice Differential is specifically designed to erase interfering background noise. Speech is clean, clear, crisp . . . unadulterated by stray pickup or distracting background.

Electro-Voice

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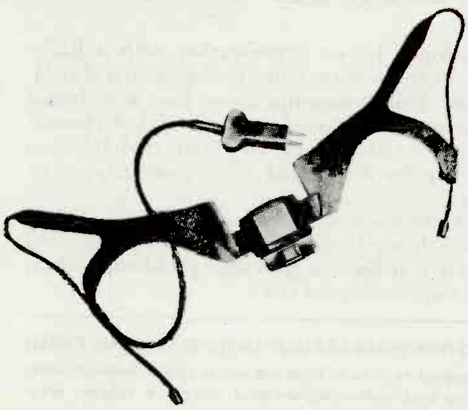
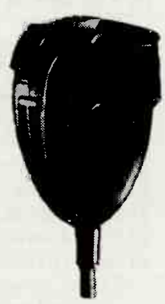


Electro-Voice DIFFERENTIAL MICROPHONES

Electro-Voice engineers have years of experience in the elimination of ambient noise. We designed and developed the now-famous "Lip-Mike," the first successful Differential microphone. Our new Model 205-S for aircraft, railroad, industrial and police applications is another Differential achievement. Soon there will be Electro-Voice Differential microphones for all communication services. Watch for them.

If any of your limited quantity needs can be met by standard model Electro-Voice microphones, with or without minor modifications, contact your local radio parts distributor.



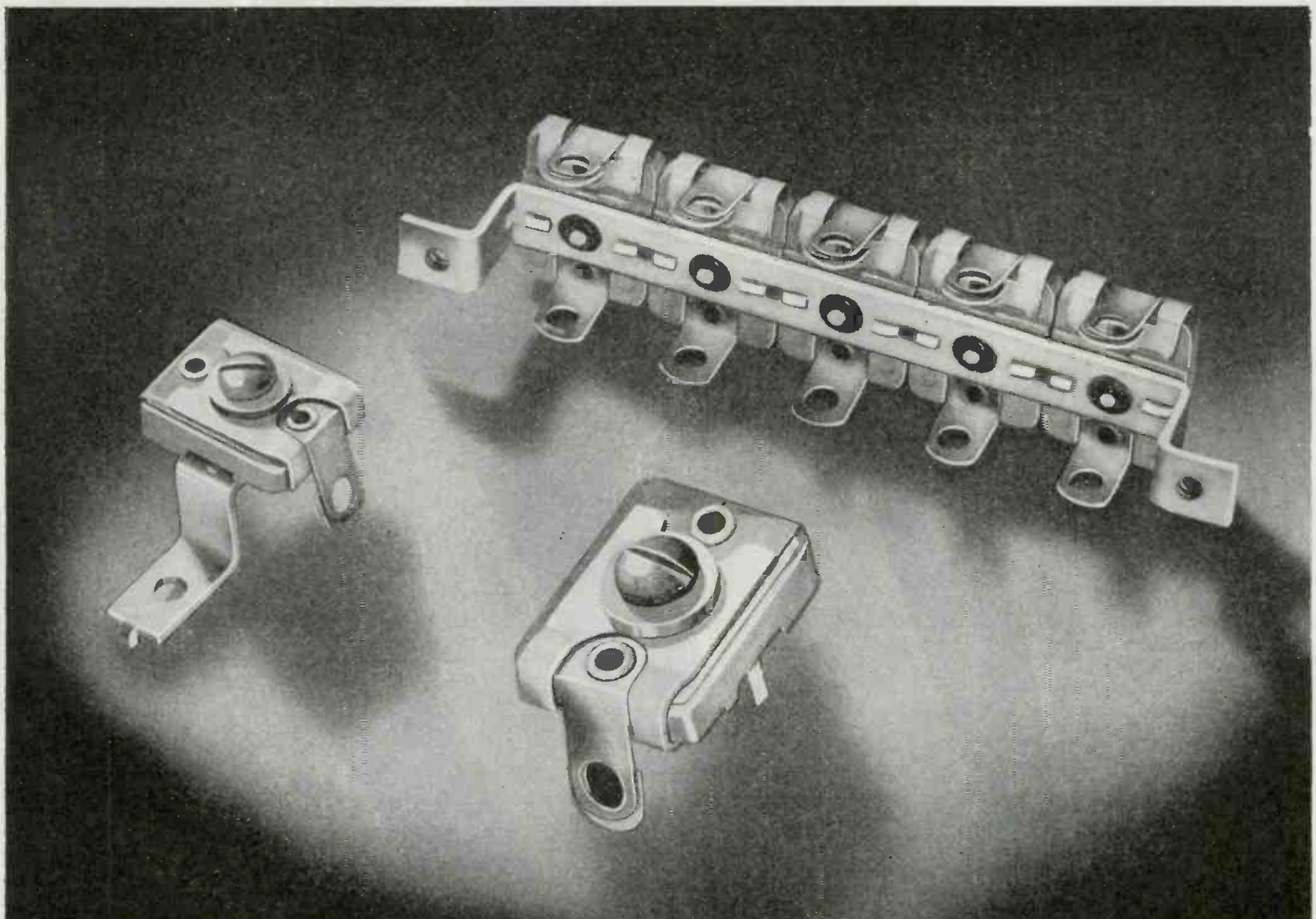
BLOOD DONORS ARE URGENTLY NEEDED . . . SEE YOUR LOCAL RED CROSS

Electro-Voice MICROPHONES

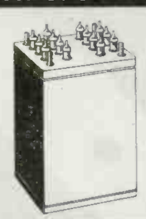
ARMY E NAVY

ELECTRO-VOICE CORPORATION • 1239 SOUTH BEND AVENUE • SOUTH BEND 24, INDIANA

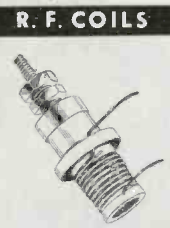
Export Division: 13 East 40th Street, New York 16, N. Y., U. S. A. Cables: Arlab



TRANSFORMERS



R. F. COILS



I. F. COILS

CHOKE COILS

STANDARDS

AUTOMATIC Mica Compression Trimmers have for many years been the Radio Industries' time-tested standard of quality and design.

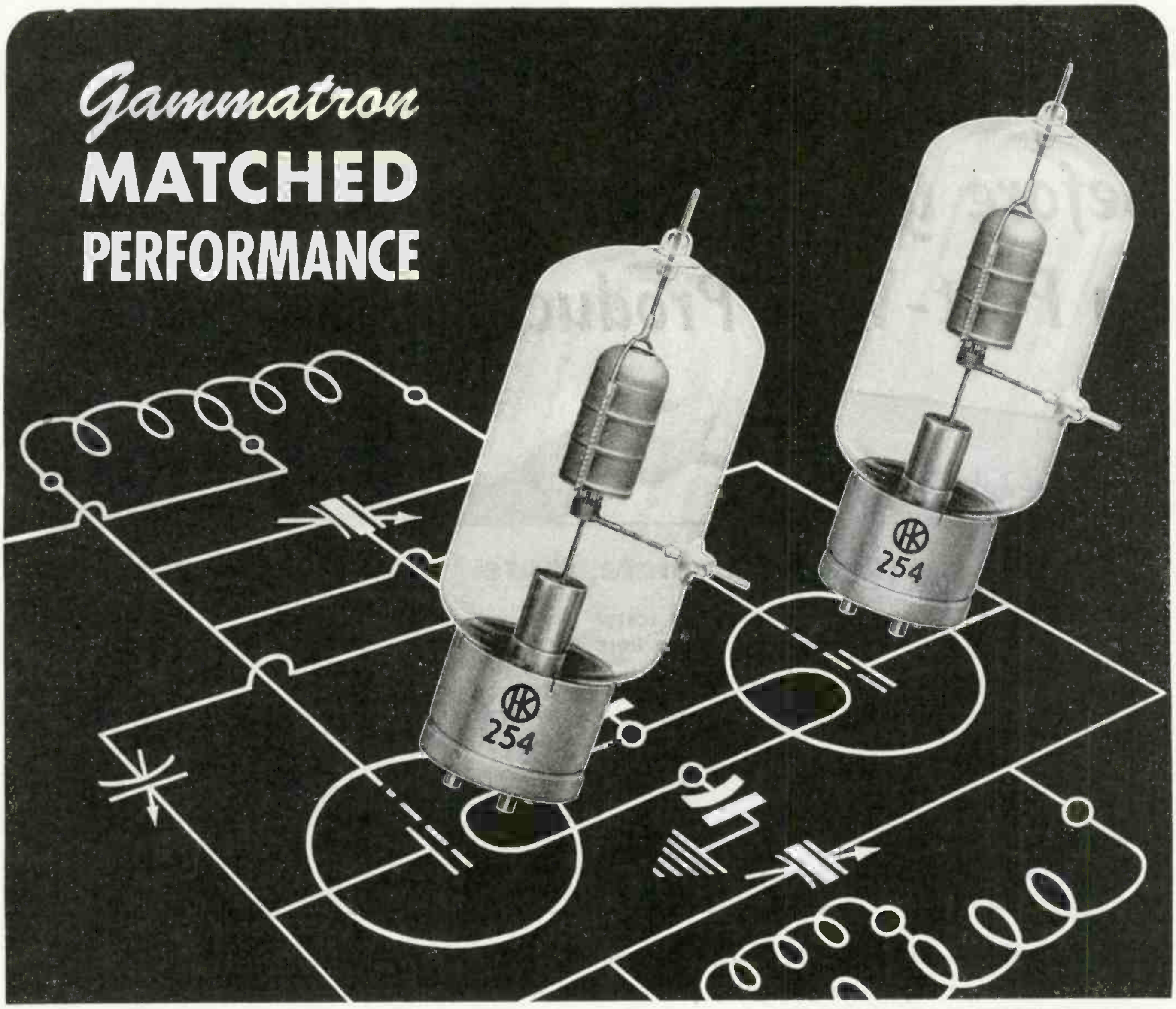
To assist you in your post-war receiver designs, we have prepared a Trimmer Catalog showing dimensions and capacitances of the many types which will be available immediately. Why not gain the advantage of quick delivery and maximum economy by incorporating standard type trimmers in your design considerations. A copy of the *AUTOMATIC* Trimmer Catalog will be mailed to you free on request.

ARMY E NAVY

AUTOMATIC MANUFACTURING CORPORATION

COMPLETE ELECTRONIC ASSEMBLIES & COMPONENT PARTS

900 PASSAIC AVE. EAST NEWARK, N. J.



Gammatron UNIFORMITY MEANS LONGER TUBE LIFE

Heintz and Kaufman engineers have continually developed closer electrical and physical tolerances for Gammatron tubes over the past 16 years, knowing that matched characteristics result in better operation and longer tube life.

Today the importance of tube uniformity, especially in the very high frequencies, is widely recognized; and many of the peacetime standards we have established for Gammatrons are now contained in the wartime specifications for all tubes of the Gammatron type . . . When you design a transmitter around a pair—or even a dozen—Gammatrons, you will get the full benefit of our years of experience in pioneering constantly higher standards of transmitting tube performance.

HEINTZ AND KAUFMAN LTD.
SOUTH SAN FRANCISCO · CALIFORNIA

Gammatron Tubes

HK-254 *Matched* CHARACTERISTICS

MAXIMUM RATINGS

Power Output	500 Watts
Plate Dissipation	100 Watts
Amplification Factor	25
DC Plate Voltage	4000 Volts
DC Plate Current	225 M. A.
DC Grid Current	40 M. A
Max. Frequency	175 Mc
INTER-ELECTRODE CAP.:	
C grid-plate	3.6 uuf
C grid-filament	3.3 uuf
C plate-filament	1.0 uuf
Filament Voltage	5 Volts
Filament Current	7.5 Amps.

KEEP IT UP . . . . BUY WAR BONDS

Before you get going on Post-War Production

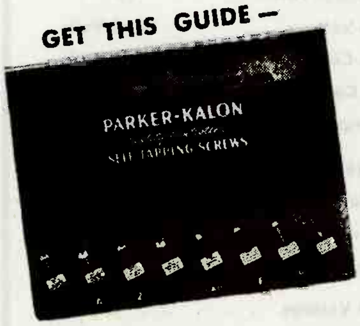
Now is the time to talk to a P-K Assembly Engineer. Before your post-war assembly practices are set-up, have him check all fastenings and point out where you can use the *short-cut method* – P-K Self-tapping Screws – to make savings in time, labor and materials.

One operation makes a fastening with a P-K Self-tapping Screw. You just drive it into a plain untapped hole. You eliminate tapping for machine screws, and tap expense . . . fumbling with bolts and nuts . . . troublesome inserts in plastics . . . riveting in hard-to-reach places. Truly a short-cut to assembly economy!

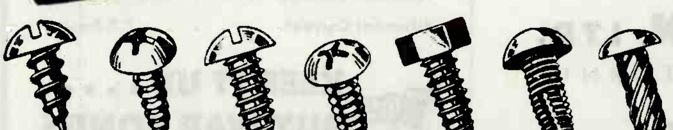
You'll find the P-K Assembly Engineer's advice unbiased. He'll recommend P-K Screws only when they will save time, lower costs, provide stronger fastenings. And he'll recommend only the best type of Self-tapping Screw for the job, because Parker-Kalon makes *all* types.

No matter what kind of plastic, or metal, you are working with, there's a P-K Self-tapping Screw designed for the job, and you'll find you can adopt it to advantage in 7 out of 10 cases.

GET THIS GUIDE –

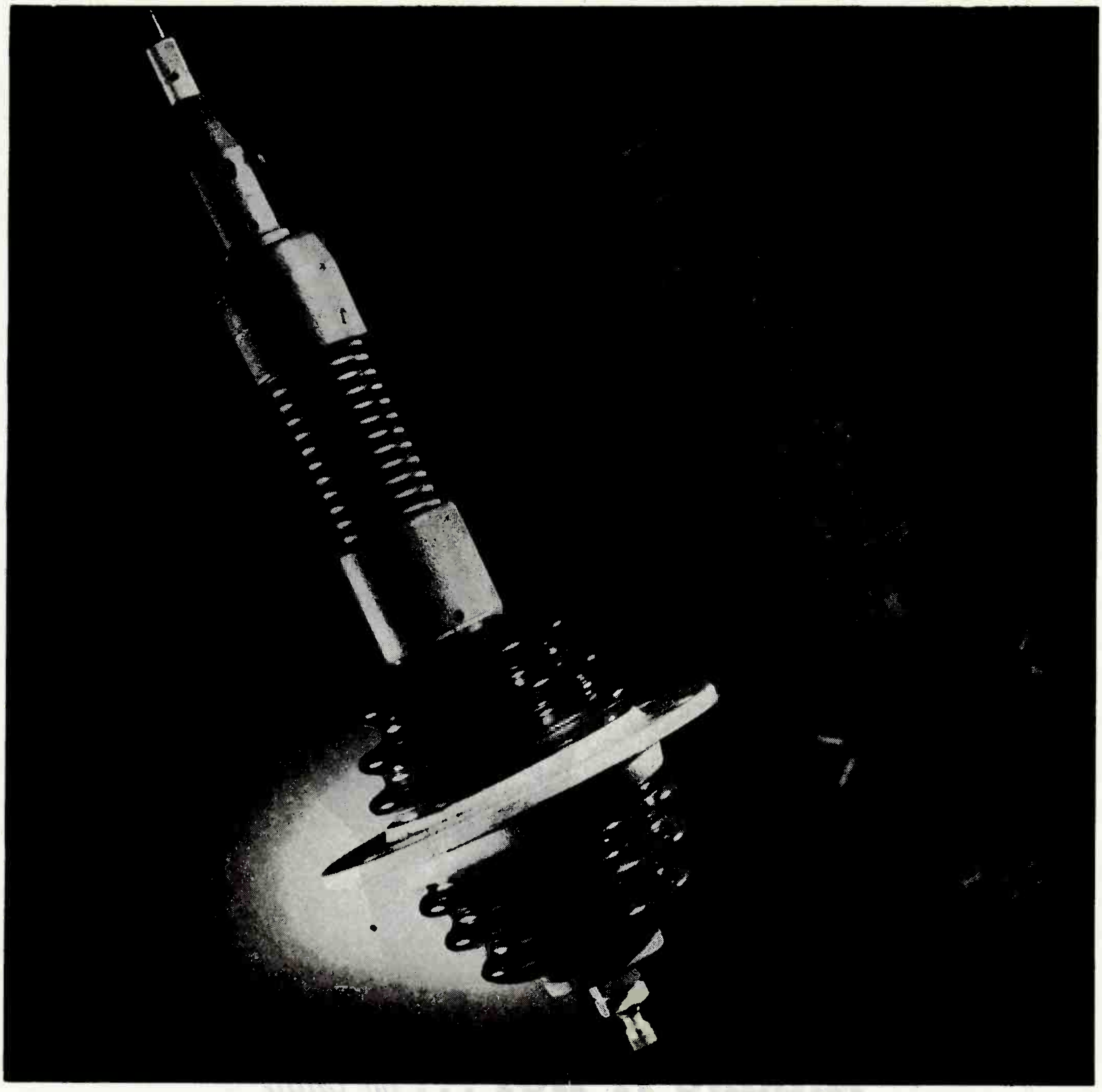


This new "User's Guide" is full of information on where and how to use all types of P-K Self-tapping Screws. File size – fitted with wall hanger. Write for your copy, and invite a P-K Assembly Engineer to call. (Or, send details of fastening jobs and we'll mail recommendations to you.) Parker-Kalon Corp., 208 Varick Street, New York 14.



SELF TAPPING SCREWS FOR EVERY METAL AND PLASTIC ASSEMBLY

PARKER-KALON
Quality-Controlled
SELF-TAPPING SCREWS



MAKING IT HOT . . . *for callite tube components*

For the extreme temperatures of high frequency heating, or in powerful short wave transmitters, oscillator tubes must be extra rugged. The Ken-Rad Type 810 is such a tube. Contributing to its sturdy efficiency are ***Callite tungsten filaments, stem lead assemblies and molybdenum grid wires.***

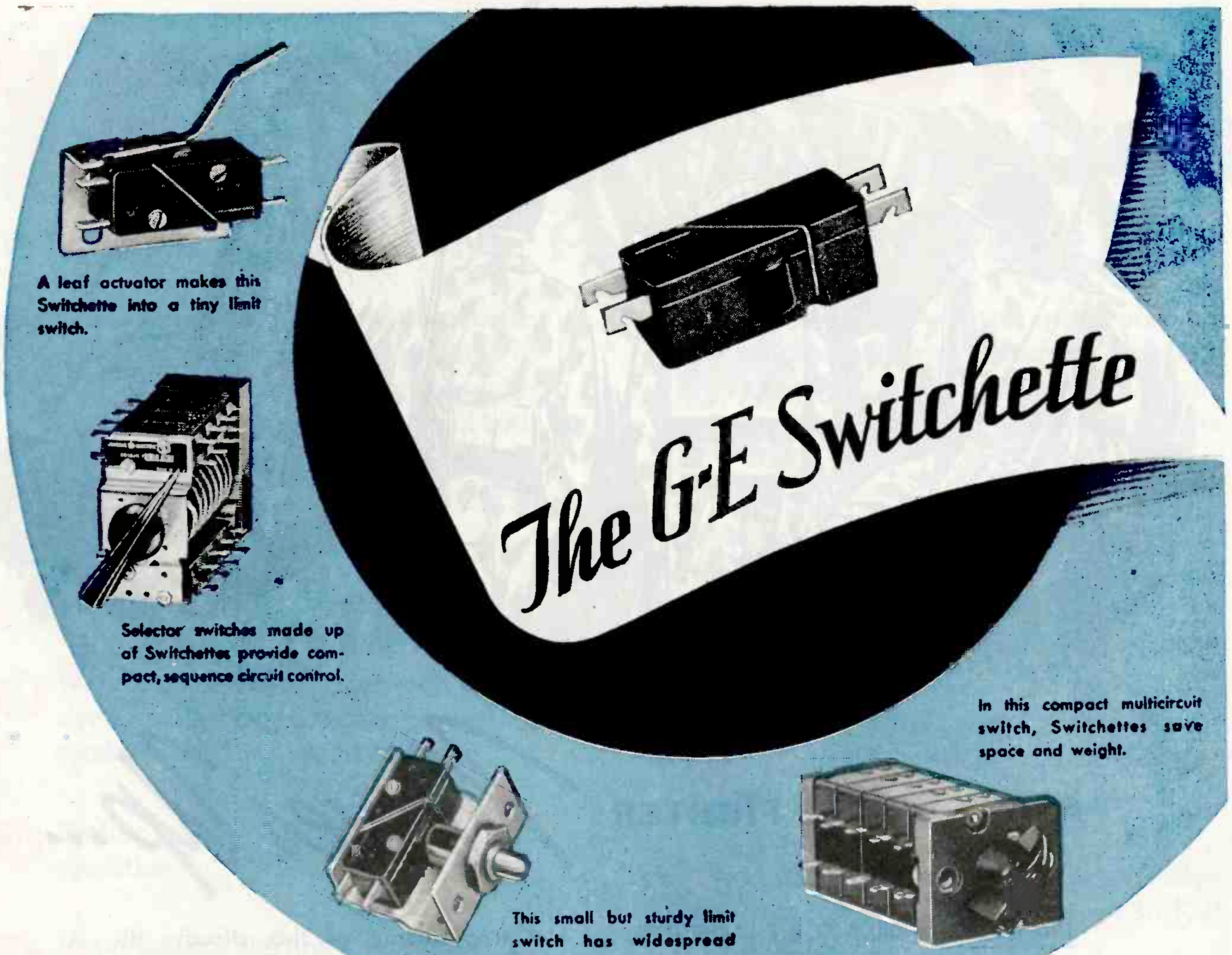
Leading tube manufacturers recognize the superiority of *Callite tube components,* the result of Callite research in tungsten, molybdenum and special alloys. For instance, one Callite development which facilitates tube-making is "**KULGRID**,"* a stranded composite wire which does not oxidize readily at the high temperatures required for beading, stem-making, sealing-in and exhaust.

*Covered by U.S.A. and Foreign Patents

Callite Tungsten Corporation,
544 Thirty-ninth Street, Union City, New Jersey
Branch Offices: Chicago, Cleveland

Callite
CALLITE TUNGSTEN CT
tube components

HARD GLASS LEADS, TUNGSTEN AND MOLYBDENUM WIRE, ROD AND SHEET, FORMED PARTS AND OTHER COMPONENTS FOR ELECTRONIC TUBES AND INCANDESCENT LAMPS.



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

YOU can use Switchettes to control several circuits from a single location. They can be actuated by cams in selector switches, or by a bellows or lever in limit switches. Whichever way you use them, G-E Switchettes help you save space and make your equipment more compact.

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.

Don't handicap your *important designs*

Your plans for a smaller, lighter, or more compact equipment need not be stymied by the lack of a suitable make-and-break contact mechanism. More than 200 modifications of the Switchette are ready to meet your needs. In addition, we have a variety of limit switches, transfer and selector switches, push-button stations, thermostats and timers built around the Switchette. Perhaps you can use some of these ready-made devices to advantage.

Send for a catalog

If you don't already have a copy of our Switchette catalog, mail the coupon below. If none of the forms listed in the catalog meet your needs, our engineers will be glad to work with you to adapt them. *General Electric Co., Schenectady 5, New York.*

General Electric Company, Section 676-142
Schenectady 5, New York

Please send me Bulletin GEA-3818, which gives detailed information on Switchettes.

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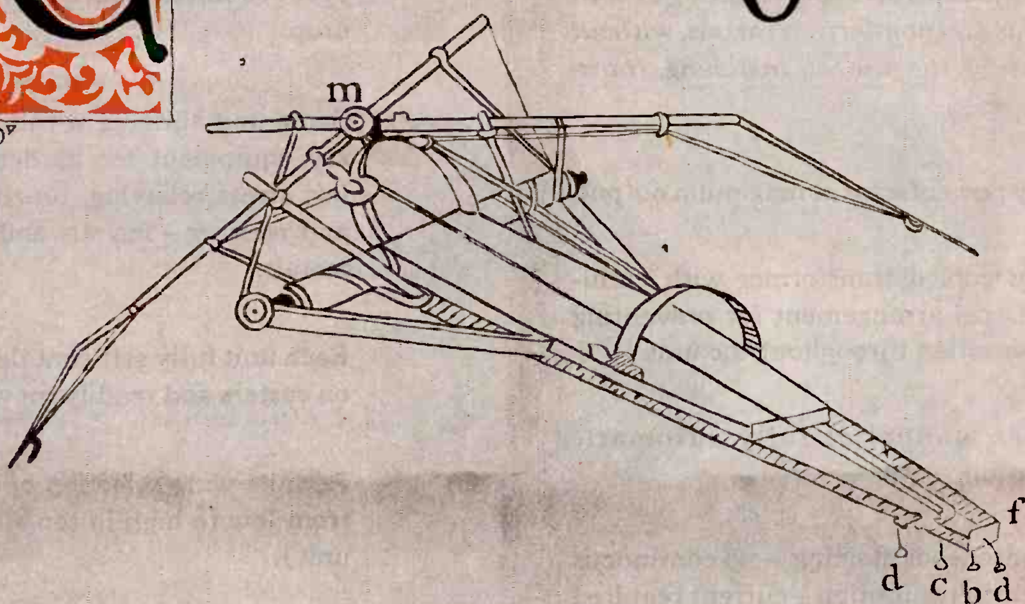
Experience Counts



In 1500, Leonardo da Vinci had a fine idea — a flying machine!

His 16th Century Flying Fortress had a dandy arrangement of stirrups and pulleys which operated oars supposed to propel the craft through the air. Leonardo's machine didn't work and it didn't work for one simple basic reason . . . There wasn't enough knowledge and experience to develop a flying machine. Had da Vinci the benefits of our experience he could have built a *flying* flying machine.

There is a very significant moral to that story — **Experience Counts!**

For years, WARD PRODUCTS CORPORATION has been the leader in the design and manufacture of sectional and one-piece antennas. This position was established and maintained because WARD has the *Experience* that *Counts*. WARD has pioneered many of the design changes that have become accepted standards in the industry . . . For the finest sectional and one-piece antennas for automobile and home applications — Look to WARD!

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WARD *Antennas*

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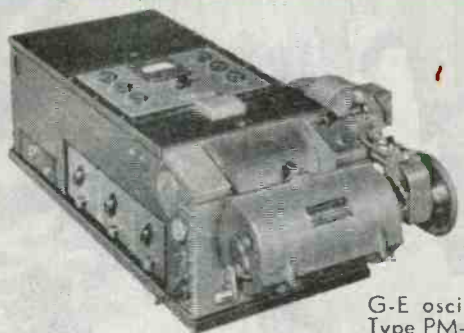
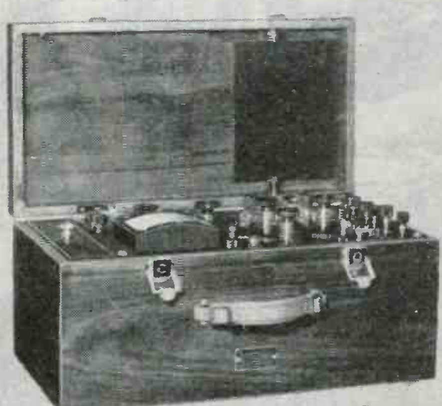
A MINIATURE OSCILLOGRAPH

WEIGHS 10 POUNDS

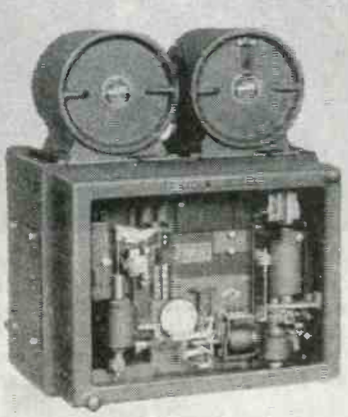
SIZE: $4\frac{1}{2}$ by $4\frac{1}{2}$ by 14 inches



G-E oscillograph, Type PM-10, set up for tests with magazine film holder, driving head, and a-c motor unit



Portable oscillograph, Type PM-12, for general use where only two elements are required



Automatic oscillograph, Type PM-13. Starts recording one-quarter cycle after disturbance occurs

THIS **6-ELEMENT OSCILLOGRAPH** was developed for use where light weight and small size are essential. It's easily portable, to obtain "on the spot" photographic records of the characteristics or the performance of many machines and devices. Records simultaneous variations of six rapidly changing phenomena. Type PM-17; net price, $850 up. Write today for leaflet GEA-4331.

IF SMALL SIZE IS NOT ESSENTIAL, HERE ARE OTHER G-E OSCILLOGRAPHS

TYPE PM-10—Records 6 to 12 phenomena simultaneously. A large, multi-element, general-purpose oscillograph for a wide field of application. Includes simultaneous viewing with recording. Net price, $3160 up.

TYPE PM-12—Anyone can operate it. For work in the field, in the laboratory, or in the classroom. For either visual indications or taking oscillograms of current and voltage waves. Originally developed for school use, industry has found this 2-element portable especially valuable for observing or recording welding current. Net price, $665.

TYPE PM-13—Entirely automatic. Can take as many as 100 oscillograms of transients and surges without attention. Particularly useful for determining the sequence of relay and breaker operation and the effect on system stability. Net price, $2125.

Our nearest office will be glad to help you select the right oscillograph for your specific requirements. *General Electric Company, Schenectady 5, N. Y.*

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GENERAL ELECTRIC

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Sangamo MICA CAPACITORS

Because of the precise and accurate operations involved in the manufacture of mica capacitors, too much emphasis can not be placed upon the importance of modern equipment and adequate working facilities. The facilities used by Sangamo for gauging mica are shown in the attached picture. Other departments, utilizing equally accurate, modern, and efficient methods, for MICA SPLITTING, MICA PUNCHING, INSPECTION, and STACKING, are all vital factors in maintaining Sangamo excellence.

Mica Gauging

The preparation of mica to be used as the dielectric in a mica capacitor requires many steps. Splitting the laminations from the mica block is the first step, but it is only the beginning in a long and carefully controlled series of operations in the final preparation of the mica. As the electrical capacitance of a mica capacitor depends upon the dielectric constant of the mica, its thickness, and the active area of the electrodes used in the unit, these factors must be accurately controlled. In some cases several thousand or more individual mica films are used in the construction of a capacitor and the dielectric failure of any one of these pieces would result in the destruction of the entire unit. Consequently, it is readily apparent that extreme care in selecting and gauging of the individual mica laminations is of extreme importance. The dielectric constant of mica is determined by precise electrical measurements, but usually this constant is fairly uniform for any group or batch of mica of equal quality when obtained from a single source or mine.

While proficient splitting operators can split mica so that approximately 80% or more of their production will come within limits of one-half thousandth of an inch in thickness, this is not sufficiently accurate to accomplish the results desired in obtaining uniformity of characteristics. Consequently, it is necessary to gauge each mica lamination on special beam gauges, as shown in the accompanying picture. Here, trained operators select mica to thickness limits of one-fourth of a thousandth of an inch or less. This gauged mica is separated into groups according to the thickness of the lamination, and each group is then ready to be punched to the special size and shape required for the particular capacitor in which it is to be used.

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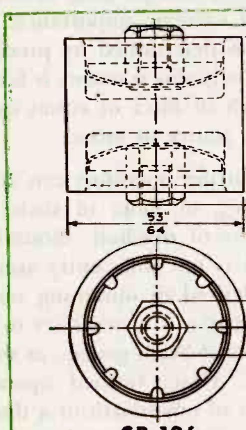
HIGH VOLTAGE Ceramic Condensers

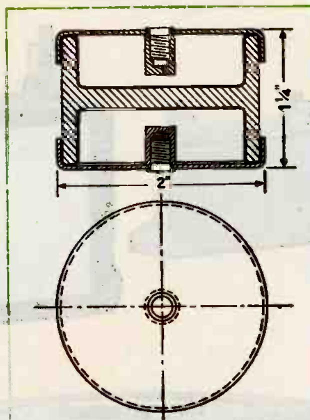
ERIE DOUBLE CUP CERAMICONS
REG. U. S. PAT. OFF.

These compact, high voltage condensers are designed to carry appreciable amounts of current at high voltage without danger of corona or excessive internal heat. The silvered ceramic construction provides choice of temperature coefficient, excellent stability and retrace characteristics. Two sizes are illustrated above.

Type SP-106 is rated at 5 KVA. Peak working voltages at sea level for types SP-106 and SP-172 are as follows:


SP-106

Capacity	Temperature Coefficient	Peak Working Volts at Sea Level
SP-106		
20 MMF	NPO	10,000
30 MMF	NPO	6,500
39 MMF	NPO	5,000
51 MMF	N-750	10,000
75 MMF	N-750	7,500
100 MMF	N-750	5,500
SP-172		
51 MMF	NPO	10,000
75 MMF	NPO	10,000
100 MMF	NPO	10,000
200 MMF	N-750	10,000
300 MMF	N-750	10,000
390 MMF	N-750	8,000


SP-172

If you have applications for condensers of this style for either military or peacetime equipment, our engineers will be glad to discuss them with you.

Note: Test voltage, SP-106 and SP-172—60 cycle RMS equal to peak working voltage.

Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

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Turner pioneers the communications field with scientific engineering that reproduces only those vibrations received by the diaphram without adding any of the harmonics. The full meanings of sound are delivered with their delicate gradations of tone and volume. A soft whisper or a shrill fortissimo come clear and crisp in the full focus of intelligibility.

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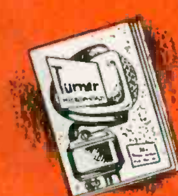
Crystals Licensed Under Patents of the Brush Development Company

The TURNER Company CEDAR RAPIDS, IOWA



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4. Sturdy, rigid construction.
5. We make adapters to fit any type chassis.

Send us your specifications, or a sample chassis, for quotations. We are ready to meet your delivery schedules.

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High precision machined (not die cast). Stainless steel pins. Used to hold socket clips in correct alignment during wiring.

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*MEETS REQUIREMENTS OF WPB SUBCOMMITTEE ON MINIATURE TUBES

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The dielectric constant of the nonvolatile DC Fluids (those above 20 centistokes) is 2.7 to 2.8 and their dielectric loss is exceptionally low, remaining at less than 0.0001 over a wide frequency range. Inquiries for detailed information are invited.

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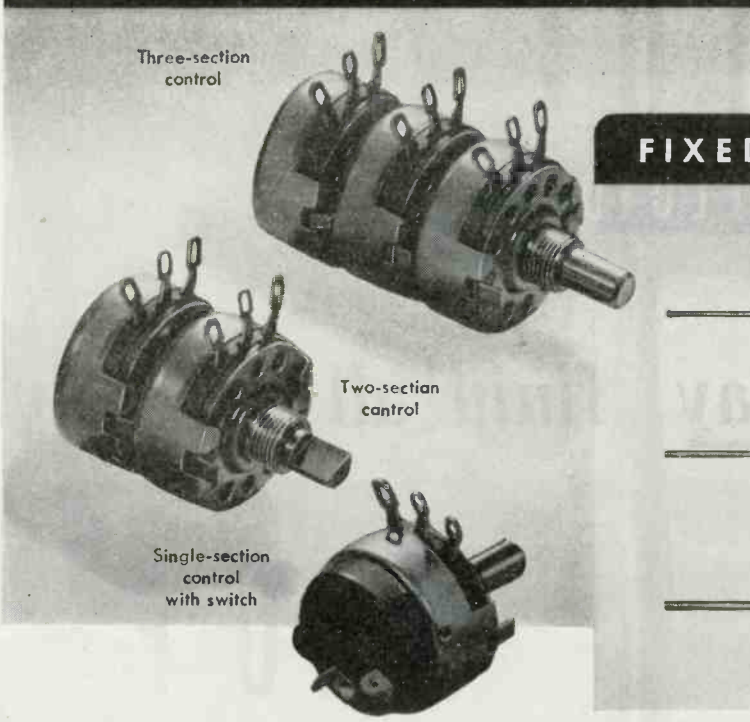
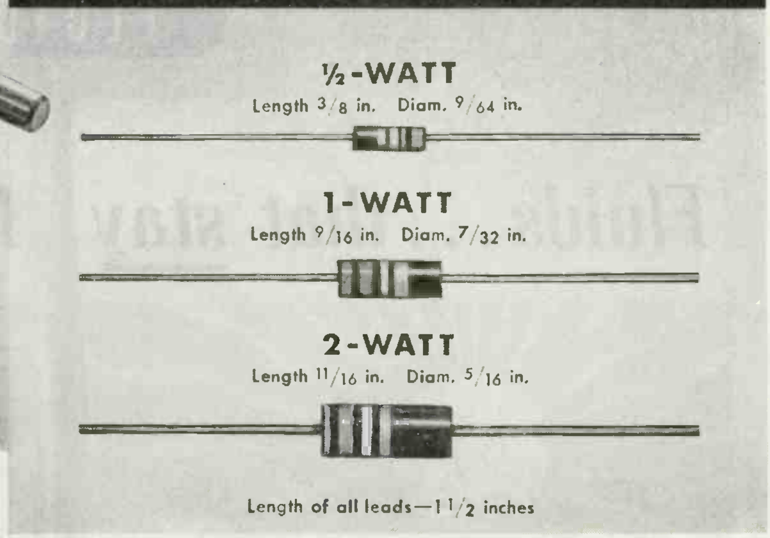
Dow Corning

ADJUSTABLE RESISTORS

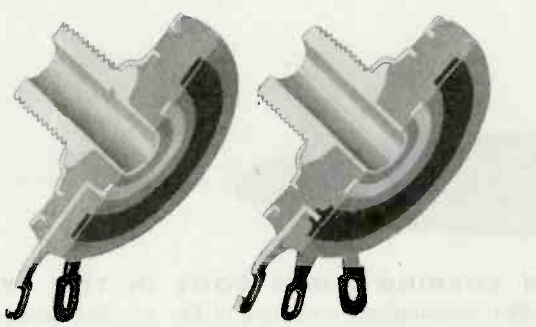


FIXED INSULATED RESISTORS



The Only Continuously Adjustable Composition Resistor of 2-Watt Rating with Substantial Safety Factor

The resistor material in the Type J Bradleyometer is molded with the insulation, terminals, face plate, and threaded bushing into a one-piece unit. It is not a film or paint type resistor. During manufacture, the resistor material is varied throughout its length to provide the desired resistance-rotation curve. Once molded, the resistance curve does not change. Heat, cold, or moisture cannot affect the Type J Bradleyometer, and long, dependable life is guaranteed. Supplied for rheostat or potentiometer uses, with or without a switch.



Cross-sectional view of Type J Bradleyometer showing how the terminals are molded into the solid-molded resistor element.

All Experts say–

Allen-Bradley Resistors are *"Tops" in Quality*

WAR SERVICE . . . far more grueling than laboratory tests or civilian service . . . has proved beyond a doubt that Allen-Bradley resistor engineers know how to design and produce fixed and adjustable composition resistors that satisfy all service conditions. Allen-Bradley resistors are the choice of the experts because they are "tops" in quality.

The latest Allen-Bradley achievement is the new 2-watt insulated Bradleyunit . . . 11/16-inch long and 5/16-inch diameter . . . yet it passes all load and endurance tests and requires no derating for even the toughest service. Like the well-known 1/2-watt and 1-watt Bradleyunits, it is available from 10 ohms to 0.47 megohms in all R. M. A. standard values in tolerances of 5, 10, and 20 per cent. Send for technical data sheet, today.

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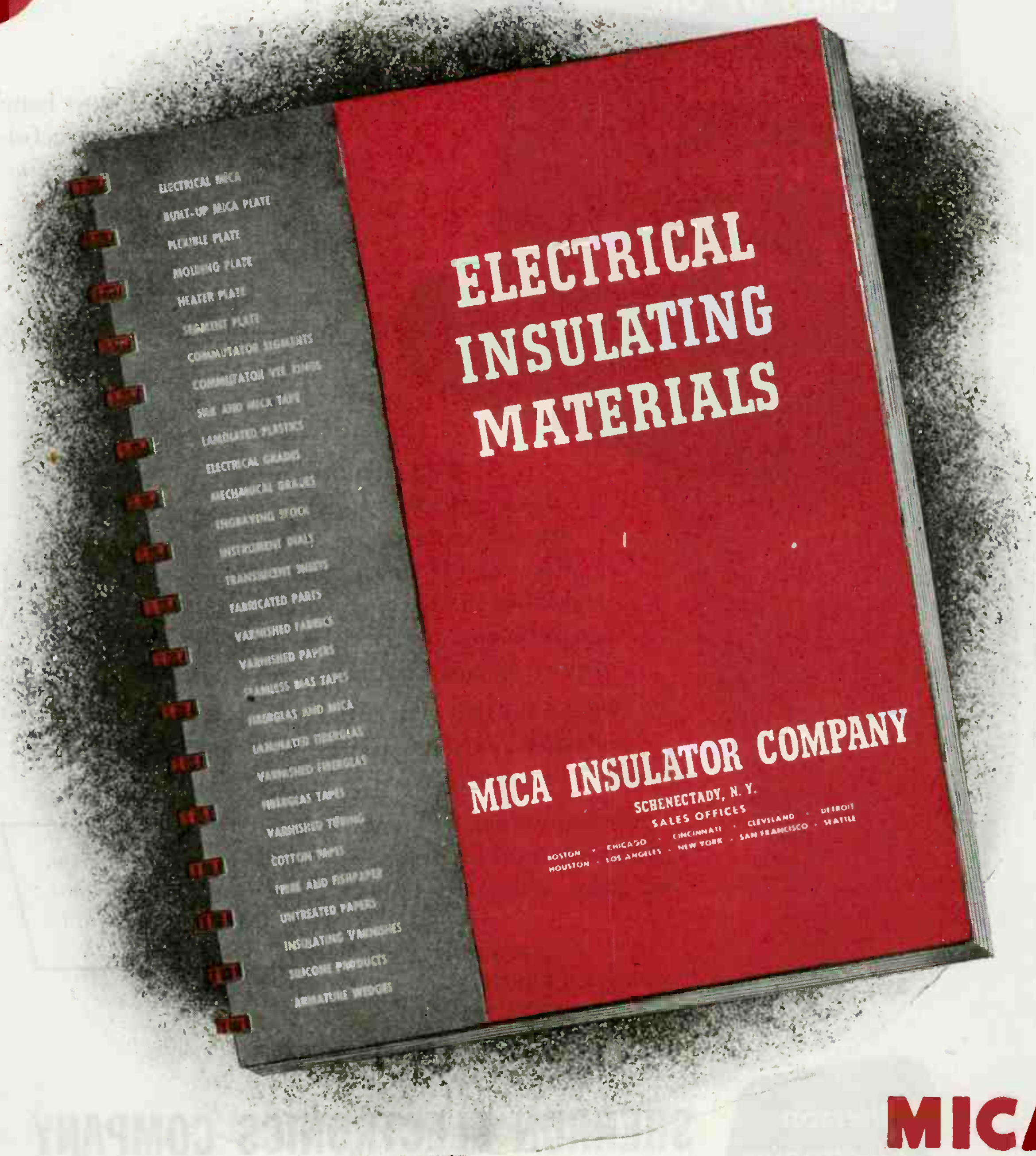

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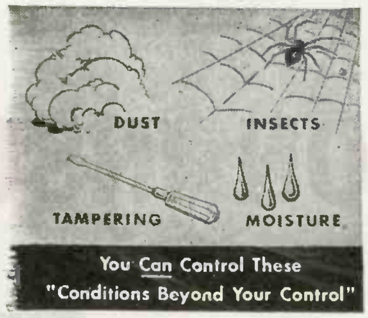

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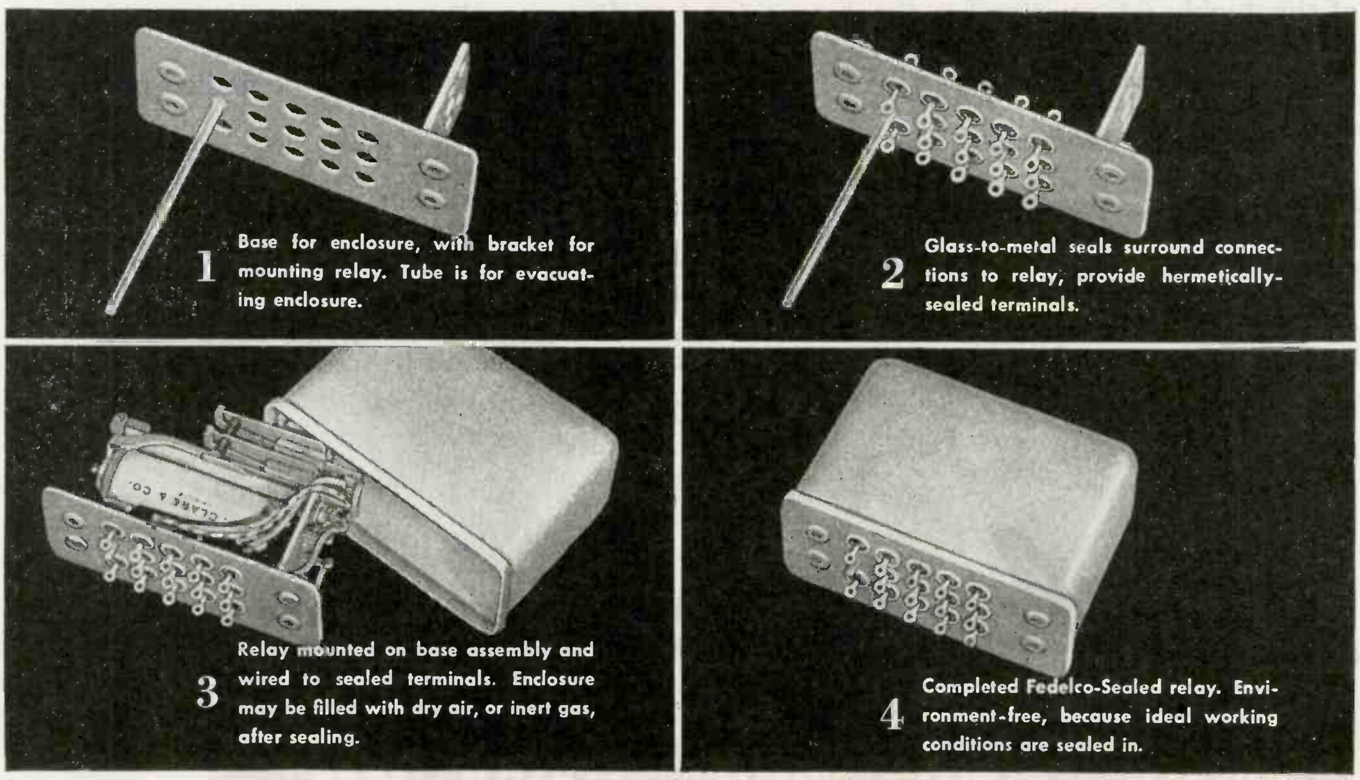
Here's how we Fedelco-Seal a Clare Type "C" Relay



1 Base for enclosure, with bracket for mounting relay. Tube is for evacuating enclosure.

2 Glass-to-metal seals surround connections to relay, provide hermetically-sealed terminals.

3 Relay mounted on base assembly and wired to sealed terminals. Enclosure may be filled with dry air, or inert gas, after sealing.

4 Completed Fedelco-Sealed relay. Environment-free, because ideal working conditions are sealed in.

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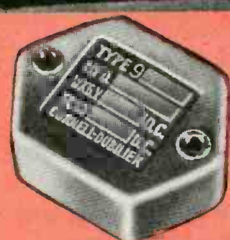
Every operation in their processing is subject to careful checking and re-checking. Specialists in capacitor manufacture dictate the proper tests, the value of the tests and their sequence in the manufacturing process.

Such precise attention to detail brings its reward in the reputation C-D capacitors have for quality and performance. We are maintaining that reputation . . .

***PROOF:* More engineers choose C-D than any other make.**

Today our special skills are focussed on the capacitor problems of the nation and of industry. Our enormously enlarged facilities may be able to help you. Cornell-Dubilier Electric Corporation, South Plainfield, N. J. Other plants: New Bedford, Brookline, Worcester, Mass., and Providence, R. I.

*This reliable bridge balancing test for checking capacity and power factor is one of the many, many tests used at C-D during the course of production. If the bridge is not in balance, capacity of unit being checked is off, and a hum is heard by tester. When capacity is correct she hears no signal.



HERE'S A FAMOUS C-D MICA CAPACITOR — THE TYPE 9 FOR R. F., BY-PASS, GRID AND PLATE BLOCKING IN LOW POWER TRANSMITTERS AND AMPLIFIERS.

Special impregnation resists changes in capacity with high insulation resistance.

No magnetic material reduces losses at all frequencies.

Moulded in Bakelite for greater mechanical strength and better insulation.

Short, heavy terminals for minimum r.f. and contact resistance. Typical of C-D's precision engineering.

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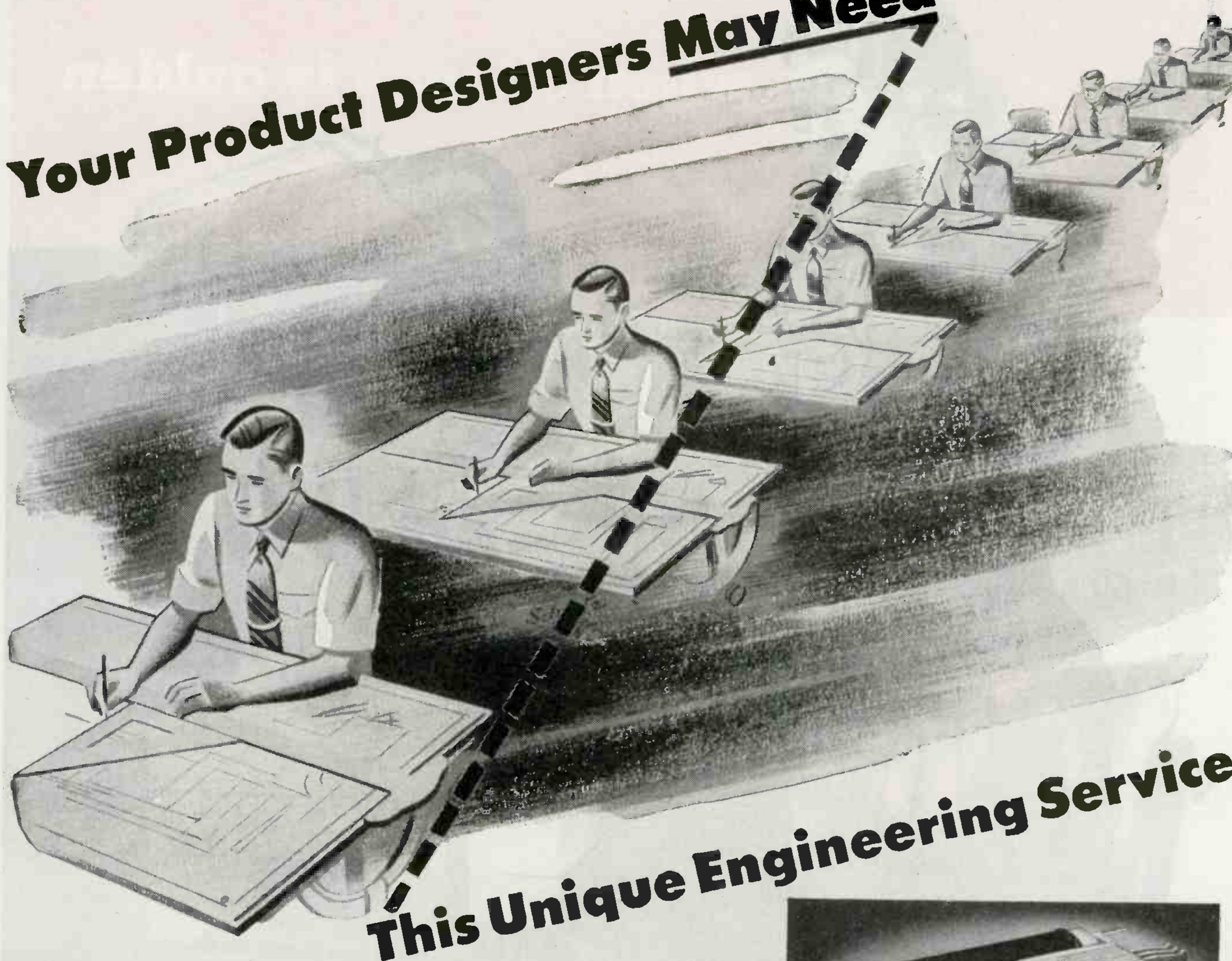

There are hundreds of products on drawing boards today that will do a better job at lower cost with the *right* electrical control apparatus. The problem is: precisely what apparatus?

That is where the Automatic Electric field engineer can help. He is a specialist in electrical control, backed by an organization that offers this three-point service:

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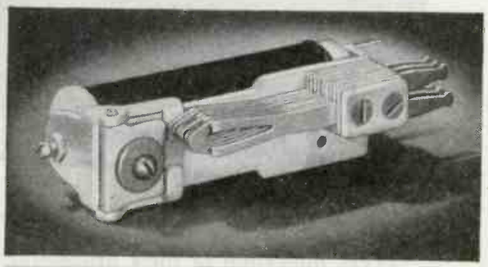
2. A complete range of relays, stepping switches and other control units—time-proved products readily adapted to your needs.
3. A design and manufacturing service for complete engineered assemblies.

Ask our field engineer for a copy of our catalog of control devices. He will be glad to show you how they can serve you.



Here are jobs that can be done easier and better with Automatic Electric control devices:

Automatic Selection and Switching of Circuits • Time, Temperature and Sequence Control • Counting and Totalizing • Inspection and Sorting Operations • All Types of Electrical and Electronic Control.

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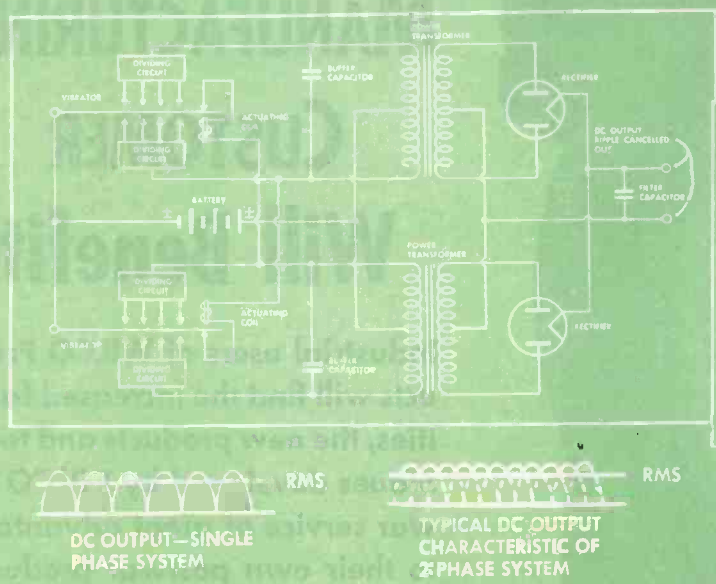
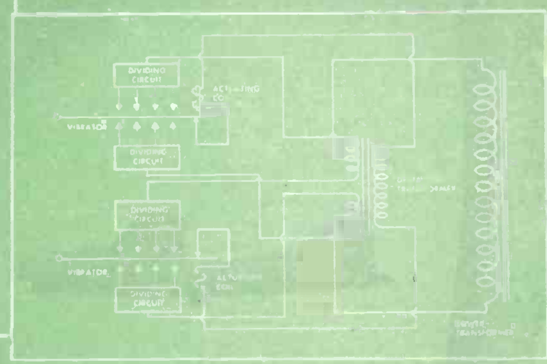
SYNCHRONIZATION OF VIBRATORS FOR PARALLEL OPERATION





Typical E-L single-phase and two-phase circuits of dual vibrators which permit power outputs in excess of 1,000 watts.

While improvements in circuit technique developed by Electronic Laboratories have allowed commutation of currents up to 25 to 30 amperes, recent requirements for increased power have necessitated introduction of dual vibrator circuits thereby doubling the output of E-L Power Supplies. Both in-phase and two-phase systems are available permitting output powers in excess of 1000 watts.

Parallel Operation — Single-Phase — A.C. Output

In units furnishing A.C. power as output, the vibrators must operate in phase. This operation is secured by means of modulating voltage obtained from a secondary placed on a current dividing reactor, which insures the division of the current between the two vibrators. The primary is center-tapped with the center tap feeding the power transformer, while the ends connect to power contacts on the same side of the respective vibrators. If one vibrator makes contact before the other there will be a voltage induced in the secondary of the transformer. This induced voltage is applied to the actuating coil of the other vibrator in such a way as to be in phase and thereby cause it to increase its frequency and decrease that of the higher frequency vibrator. When the vibrators reach the same frequency it is obvious there will be no modulating voltage. The time constant of the current division network is such as to take care of small time differentials. The circuit has the further advantage of allowing the use of one large power transformer which gives higher efficiency than can be secured by using two smaller ones.

Parallel Operation — Two-Phase — D.C. Output

In vibrator power units which have a filtered D.C. output, the advantages of a two-phase system are obvious in the reduction of the filter network required to secure a given A.C. ripple on the output.

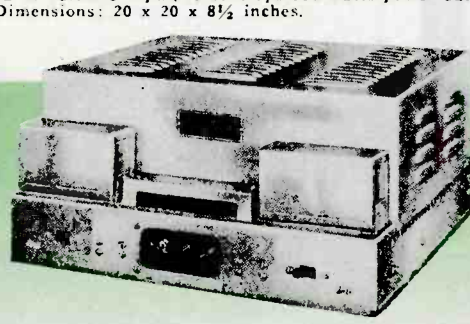
To correct any possible frequency deviations, Electronic Laboratories' engineers have cross-modulated the D.C. voltage applied to the respective actuating coils with an A.C. voltage secured from the opposite transformer primary. The A.C. voltage is of such a value that the alternate in- and out-of-phase relationship effectively forces the vibrators to assume the same frequency. The 90° phase relationship essential to insure low ripple outputs from associated rectifiers is secured by the action of the modulating voltage, inasmuch as the vibrator having the higher natural frequency will make contact first upon the application of the input voltages. This causes the effective voltage on the actuating coil of the lower frequency vibrator to be $E_{dc} + E_{ac}$ (E_{ac} is the modulating voltage received from the transformer winding associated with the higher frequency vibrator). When the lower frequency vibrator actually makes contact, the phase of the A.C. modulation is such that the effective voltage applied to the higher frequency vibrator is $E_{dc} - E_{ac}$, thus causing a reduction in its frequency until synchronism is obtained with the lower frequency vibrator and contact is broken. It then functions in the normal manner. The cycle then repeats itself and maintains the 90° phase shift.

The E-L unit, shown below is a typical Vibrator Power Supply used in the operation of communication equipment. With a 12 volt DC input, it develops 500 watts power output. Dimensions: 20 x 20 x 8½ inches.

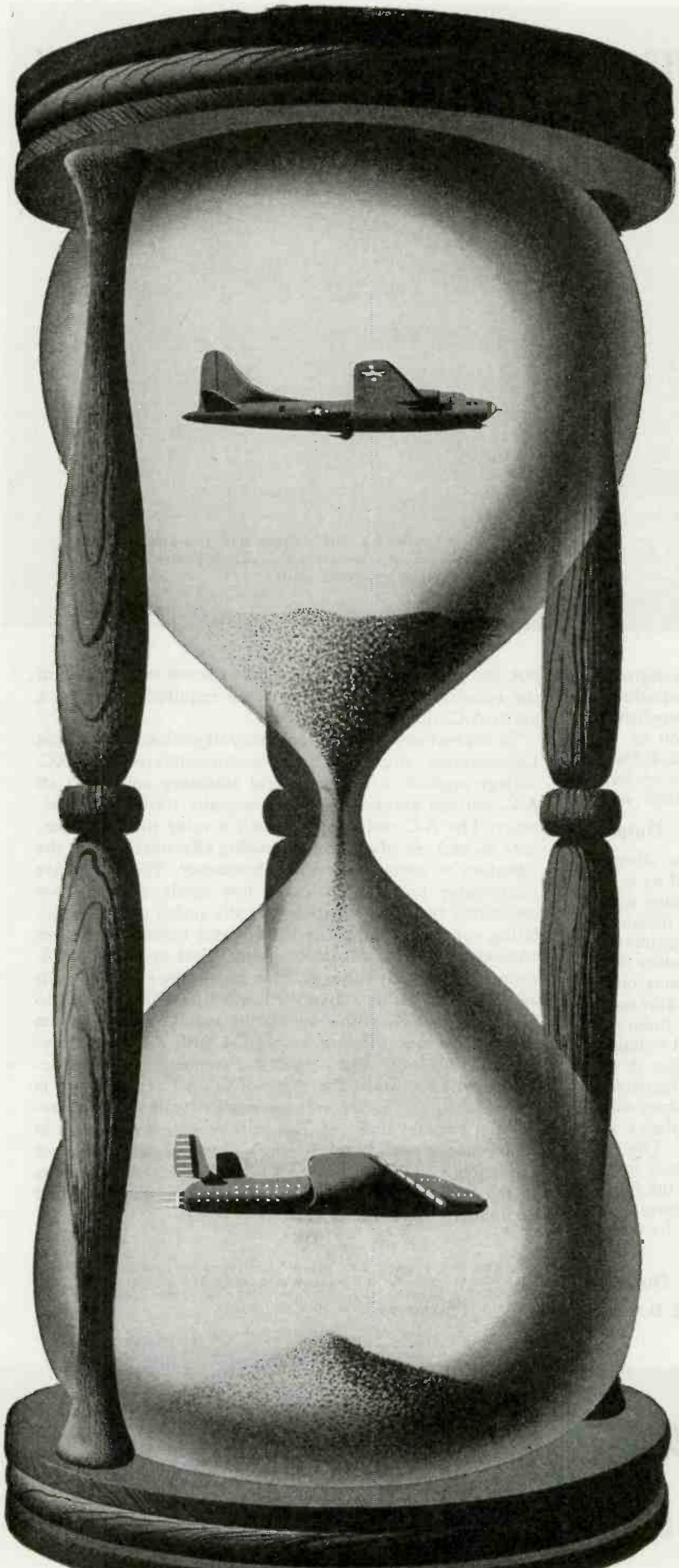
Electronic

LABORATORIES INC.

INDIANAPOLIS



VIBRATOR POWER SUPPLIES FOR LIGHTING, COMMUNICATIONS, AND ELECTRIC MOTOR OPERATION · ELECTRIC, ELECTRONIC AND OTHER EQUIPMENT



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.

THE H. A. WILSON COMPANY
105 Chestnut Street, Newark 5, New Jersey

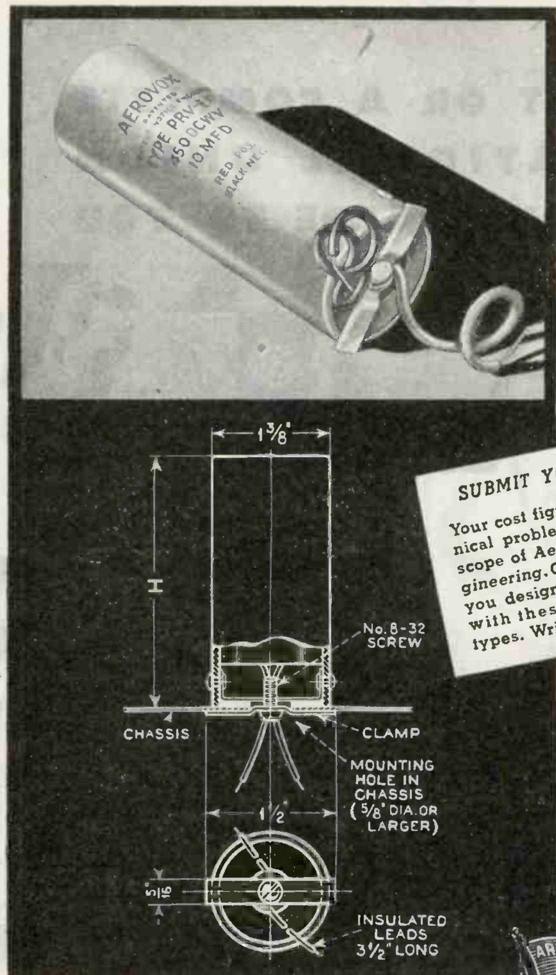
Branches: Detroit • Chicago

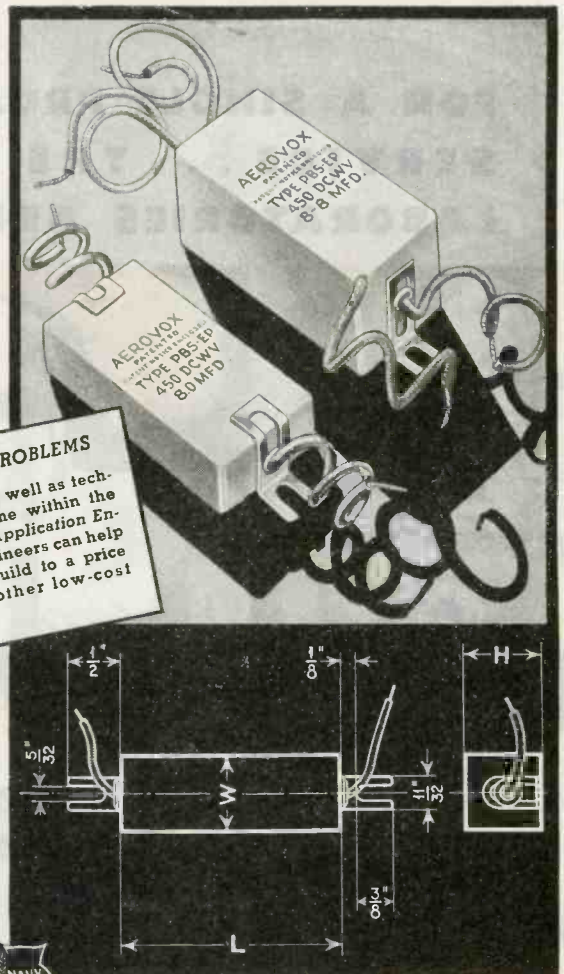
WILCO

Thermometals—Electrical Contacts
Precious Metal Bimetallic Products

MAXIMUM CAPACITANCE

at minimum cost...





SUBMIT YOUR PROBLEMS

Your cost figures, as well as technical problems, come within the scope of Aerovox Application Engineering. Our engineers can help you design and build to a price with these and other low-cost types. Write us.

CLAMP-MOUNTING ELECTROLYTICS

● **PRICE** with inbuilt *Aerovox Quality*—that's the prime objective of the ingenious Type PRV one-hole-mounting paper-cased electrolytic. • Wax sealed. Impregnated cardboard-tube container. Suitable for commercial and other applications where extreme operating conditions are not encountered and metal-can types are not essential. • Note ingenious clamp and center-screw mounting means. This type can take the place of various other vertical-mounting electrolytics such as twist-prong, spade-lug, screw-base, etc. • Normally with etched foil. Also available in plain foil. High-purity aluminum elements throughout. Positive and negative lead for each section. 450 and 600 v. D.C.W. 4 to 40 mfd.; 8-8 to 20-20 mfd. 1-3/8" dia.; 3 to 4-3/4" high.

CARDBOARD-CASE ELECTROLYTICS

● **PRICE** with inbuilt *Aerovox Quality*—that's the prime objective of this popular Type PBS rectangular cardboard-case dry electrolytic. • Sections housed in sturdy cardboard containers. Patented Aerovox Adjustimount or swivel metal flange permits mounting flatwise or on narrow side according to space limitations. Also, PBS units may be stacked and held together by overlapping metal flange and soldering securely. • Normally with etched foil. Plain foil also available. High-purity aluminum elements throughout. Made in single and multiple sections. Separate sections with positive and negative leads for each section. • 450 and 600 v. D.C.W. 4 to 16 mfd.; 8-8, 8-16 and 8-8-8 mfd. Dimensions: *L*, 2-7/16 to 3-3/16"; *W*, 3/4 to 1-1/2"; *H*, 1/2 to 1-7/16". A good general-purpose electrolytic for normal service.

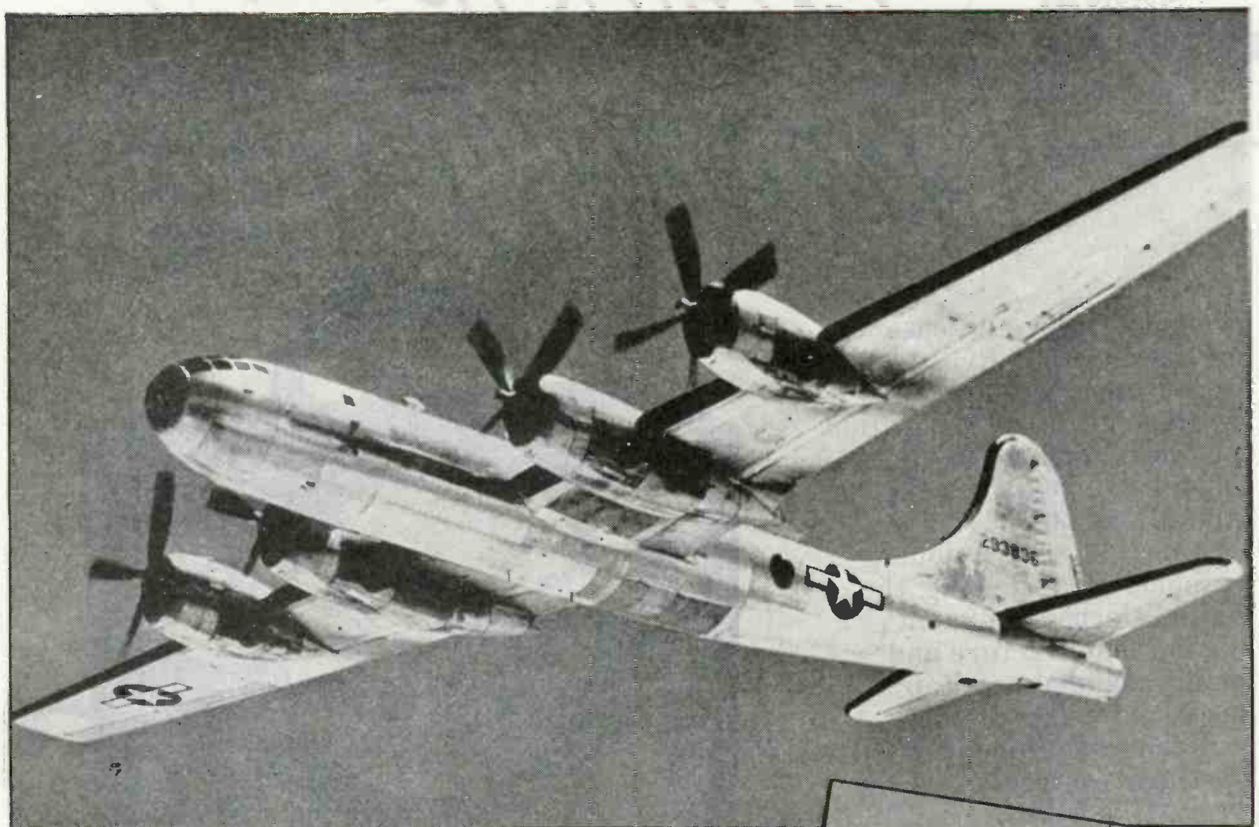
AEROVOX *Capacitors*

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.

Whitaker Can Wire It



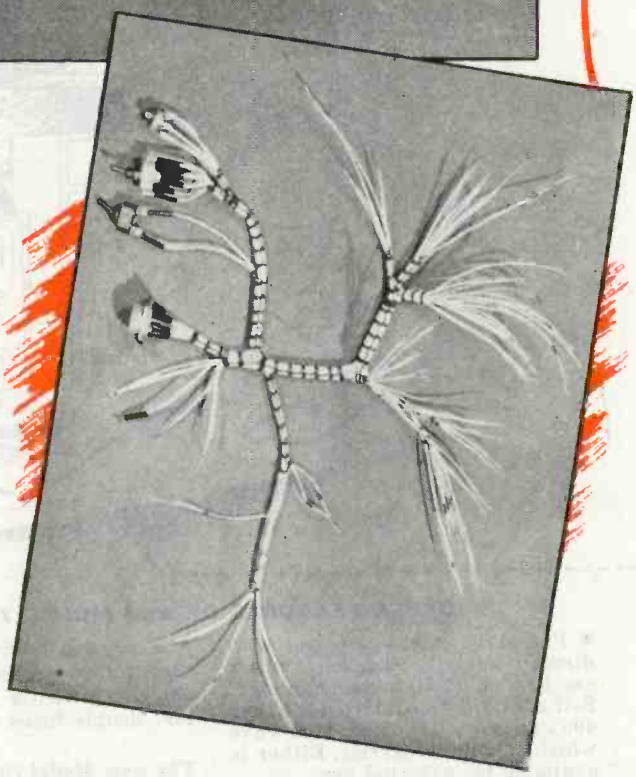
IF YOUR PRODUCTION NEEDS include:

★ **WIRING HARNESSES**
★ **BONDING JUMPERS**
★ **CABLE ASSEMBLIES**
★ **CABLE or TERMINALS**

--you'll find WHITAKER is a dependable source

Whitaker has complete facilities for engineering and producing cable and wiring assemblies, harnesses, or any type of flexible leads for power and lighting.

In addition to an engineered wiring service, Whitaker also offers a quality line of standard cable products . . . Catalog on request . . . Your inquiries are solicited.



Wiring Harness Assemblies made by Whitaker vary from the simplest type of sub-assembly to others that are a major portion of the complete product.

WHITAKER CABLE CORPORATION

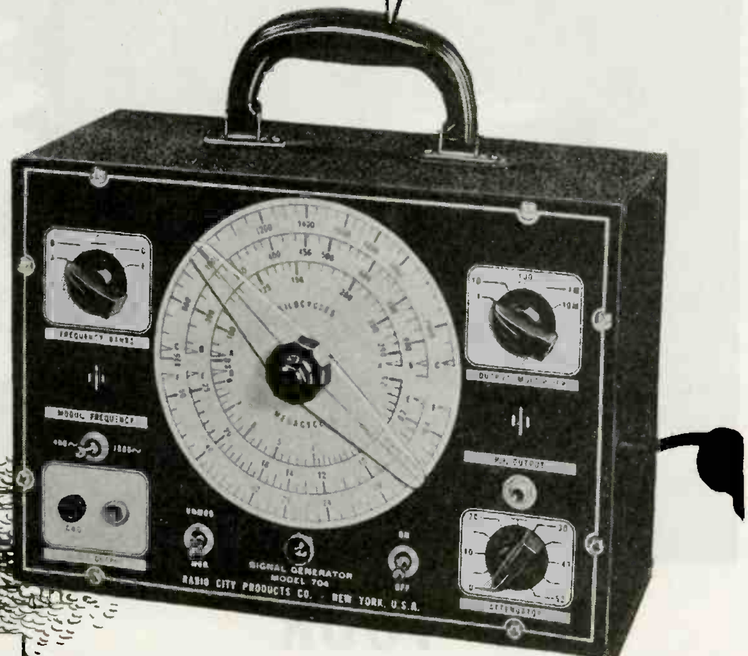
General Offices: 1307 Burlington Avenue, Kansas City 16, Missouri
Factories: Kansas City, Mo. • St. Joseph, Mo. • Philadelphia • Oakland

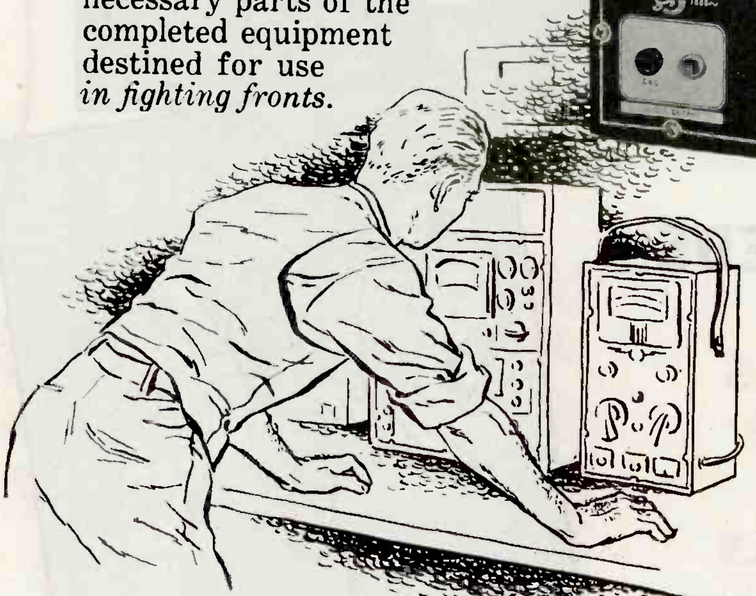
NEW RCP SIGNAL GENERATOR
model 704

GREATER ACCURACY AND STABILITY

plus new high frequencies for FM and television

The simplicity and ease of operation of RCP testers speeds production testing at the Van Roe Corporation of New York. Here RCP Model 804 Dual-Testers and Model 664 V.T. Voltmeters have a double responsibility—testing the Signal Corps equipment during manufacture and being included as vital, necessary parts of the completed equipment destined for use *in fighting fronts.*





GET THIS NEW RCP MODEL 704. It's a complete wide range Signal Generator, meeting the broad requirements of today's testing with great accuracy and stability. Model 704's range is from 95 kilocycles to 100 megacycles. Fundamental frequencies are continuously variable from 95 KC to 25 MC in 5 bands. Calibration is accurate to 2% for high frequency bands. See other special features described here. *Complete, ready for use* **$46.50**

OTHER FEATURES OF RCP MODEL 704

★ Planetary drive condenser with direct reading calibration. Output can be modulated or unmodulated. Self-contained modulation is either 400 cycles or 1000 cycles sine wave which modulates carrier. Either is available for external use.

★ Protective features are: Automatic shorting of all coils not in use; individual shielding of R. F. circuits, coil assembly and attenuator, overall steel case, chassis and panel.

★ Five step ladder attenuator is used for controlling output. Convenient pilot-lite "on-off" indicator; double-fused line cord.

The new Model 704 Signal Generator is only one of the complete line of RCP Test Instruments. Send for our Catalog No. 128. Our engineers will be glad to confer with you on your test problems or to design special instruments.

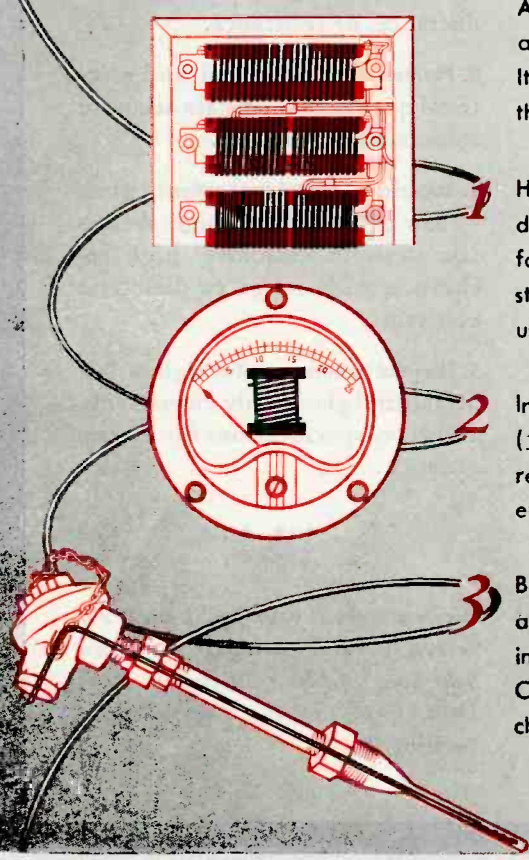
FOR EVERY PURPOSE
RCP
TEST INSTRUMENTS

MANUFACTURERS OF PRECISION ELECTRONIC LIMIT BRIDGES — VACUUM TUBE VOLTMETERS — VOLT-OHM-MILLIAMMETERS — SIGNAL GENERATORS — ANALYZER UNITS — TUBE TESTERS — MULTITESTERS — OSCILLOSCOPES — AND SPECIAL INSTRUMENTS BUILT TO SPECIFICATIONS.

RADIO CITY PRODUCTS COMPANY, INC.
127 WEST 26th ST., NEW YORK 1, N. Y.

Another Famous D-H Alloy Advance

...does 3 JOBS EFFICIENTLY



Advance* is a Driver-Harris alloy made from electrolytic Nickel and Copper under close control of exclusive Driver-Harris methods. It possesses a number of remarkable properties ideally suited for these 3 distinctly different applications.

1. High electrical resistance (294 ohms per Circular Mil-foot), great ductility and non-corroding properties make it particularly good for winding heavy duty industrial resistors employed in motor starting and controlling equipment. Both wire and ribbon are used in this application.

2. In finer sizes *negligible* temperature co-efficient of resistance ($\pm.00002$) combined with high resistivity makes it the most desired resistance alloy for winding precision resistors of the type used in electric meters and laboratory testing devices.

3. Because Advance* develops high and uniform thermal e m f against Platinum, Copper or Iron, it is used extensively by all instrument manufacturers in the well-known Iron-Advance and Copper-Advance (Constantan) Thermocouples. Small temperature changes are clearly indicated through larger scale deflections.

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

Advance is only one of a large, famous family of versatile Driver-Harris resistance alloys that can be relied upon to make your post-war products more dependable. For important information about improved resistance alloys write for a free copy of Data Book R-42 . . . a complete text on Advance and other D-H alloys.*

Driver-Harris COMPANY

HARRISON, NEW JERSEY

BRANCHES: CHICAGO · DETROIT · CLEVELAND
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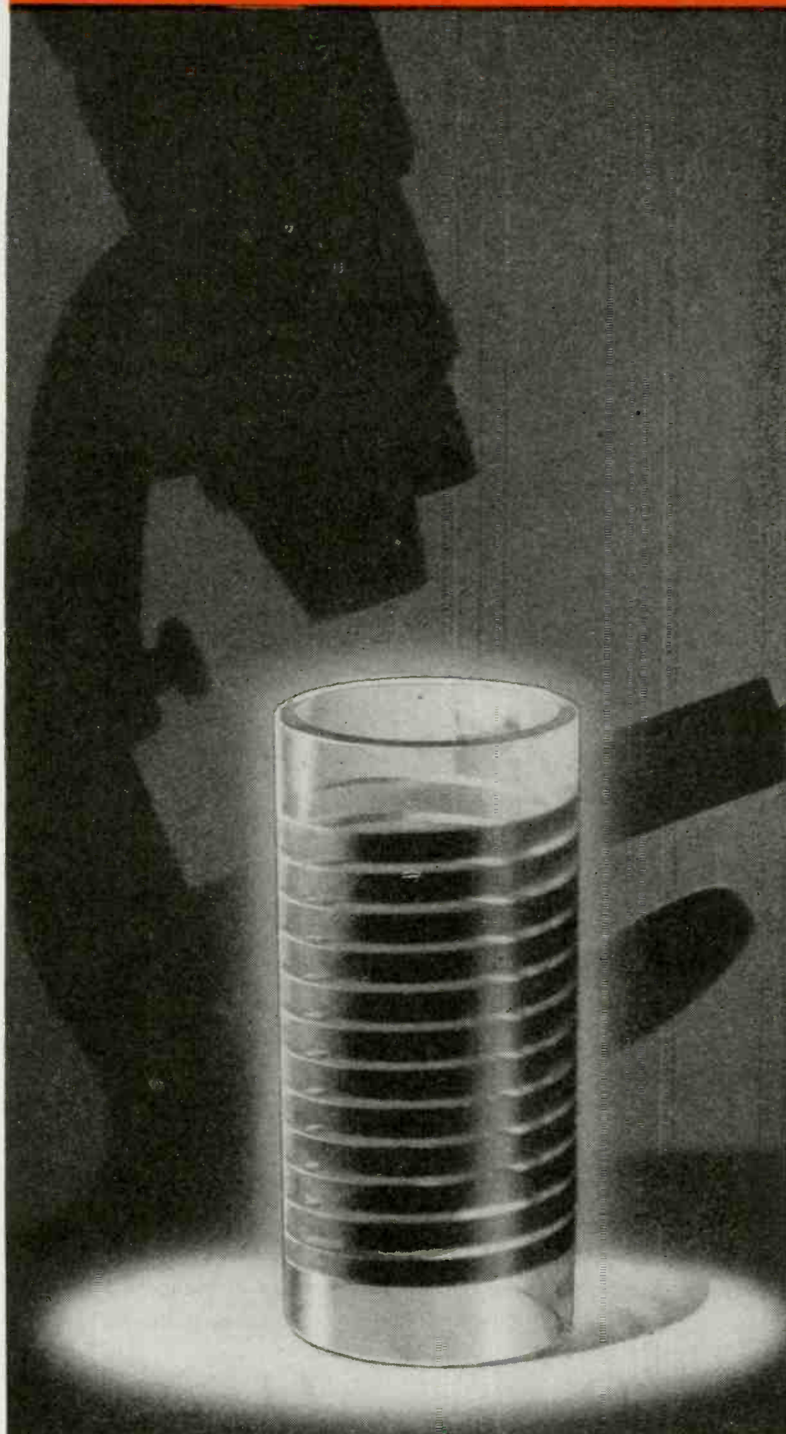
Special Purpose Alloys Since 1899

Have you looked into METALLIZED GLASS?



YOUR electronic problems may find an answer in Corning's process for permanently bonding metal to glass.

Which of the following qualities will help you?

1. **Hermetic** bond between glass and metal — assures positive and permanent seal against oil, water, and gas.

2. **Precision** metallizing — allows accurate control of capacitance, inductance, or resistance.

3. **Permanent** mechanical and electrical qualities—maintain accurate tolerances indefinitely.

4. **Superior electrical properties** of glass — low power factor, high dielectric strength, extremely high resistance, wide range of dielectric constants.

5. **Thermal endurance** of a high order. Metallized glass easily meets Army and Navy specifications for thermal shock.

• • •

Write us about your problems. We'd be interested in seeing if glass can help you. Address Electronic Sales Dept. E-1, Corning Glass Works, Corning, N. Y.

CORNING *means* Research in Glass

Electronic Glassware

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THE FACTS ABOUT SMALL METAL TUBING UP TO 5/8" OD

Superior facilities are devoted exclusively to the production of small metal tubing. Long before the war we set our maximum size at ⅝" OD because experience has shown that only by so doing could we maintain high quality in the smaller diameters. As a result, we have a mill, operating at top speed, equipped to produce in a routine manner what formerly was known as "specialty" tubing. So, if you need cold drawn tubing in any metal, and the OD does not exceed ⅝"—then the inherent benefits of our specialization are yours for the using.

SUPERIOR

THE BIG NAME IN SMALL TUBING

SUPERIOR TUBE COMPANY, NORRISTOWN, PENNSYLVANIA

ARMY NAVY

FOR EVERY SMALL TUBING APPLICATION FROM ⅝" OD DOWN

SUPERIOR Seamless in various analyses. **WELDRAWN** Welded and drawn Stainless, "Monel" and "Inconel"

SEAMLESS and Patented LOCKSEAM Cathode Sleeves

This generator armature has been "Harvelized" by Hanson-Van Winkle-Munning Company. They use Harvel varnish because — (1) bakes quicker — (2) bakes harder — (3) does not become brittle — (4) lasts longer.

THE SECRET OF BETTER INSULATION in a NUTSHELL

FROM the shell structure of the familiar Cashew nut comes a natural phenol which is the basic component of Harvel Insulating Varnishes. The discovery of this unique insulating ingredient which has been utilized by Irvington in the manufacture of a superior insulating varnish is the result of exhaustive research and an experience of over thirty-six years in making all types of insulating varnishes.

Harvel varnishes have many excellent insulating properties which add years to the life of motors, generators, transformers and other electrical equipment. They possess the highest safety factors even when operating under excessive heat, heavy over-loads and in atmospheres where acid or alkali fumes and abrasive materials are present. For example:

Motor failures in a large chemical plant occurred every three months until Harvel varnish was used. Now, three years of uninterrupted service on these same motors is not unusual. This is typical of Harvel performance under extreme conditions.

Harvel reduces the time necessary to produce a unit of electrical equipment by cutting the average baking time in half on applications involving multiple coats. It polymerizes to a solid infusible state and will not soften or "throw-out" at high peripheral speeds.

Harvel varnishes have excellent dip-tank stability—exceptional penetrating power—and contain no objectionable solvents.

Because the unusual features of Harvel varnishes are not all disclosed by ordinary laboratory methods of testing, why not get these facts first-hand? We will gladly send you a generous sample for testing. See for yourself how Harvel varnishes are superior for use with any type of insulation — for application on equipment wound with Formex and Formvar coated wire, Fiberglas, cotton, asbestos, and paper or enameled wire of all classes.

For catalog, samples, or for technical assistance on unusual problems, write Dept 106.

Irvington

VARNISH & INSULATOR CO.

IRVINGTON, NEW JERSEY, U. S. A.

4176

PLANTS AT IRVINGTON, N. J. & HAMILTON, ONT., CAN. • *Representatives in 20 Principal Cities*

A Word About Reconversion

RECONVERSION already is getting started in a few plants. For others, it may be just "around the corner", but Radio still is completely absorbed in its wartime job.

That's the situation at Rola today. The things made here . . . transformers, coils and other intricate parts for Military Communications . . . still are being required in gigantic quantities, and since Rola is one of the few plants of its kind equipped to make those things, the obligation to produce *in maximum amounts* cannot be slighted.

This means we may not be able, now, to give our old customers the kind of service they have learned to expect from Rola . . . *all* the experimental models, *all* the technical assistance and *all* the other things we used to provide. This we should regret, for we are proud of our quarter-century reputation for Service, but there is no alternative and we hope our friends in the Radio Industry will understand our present position.

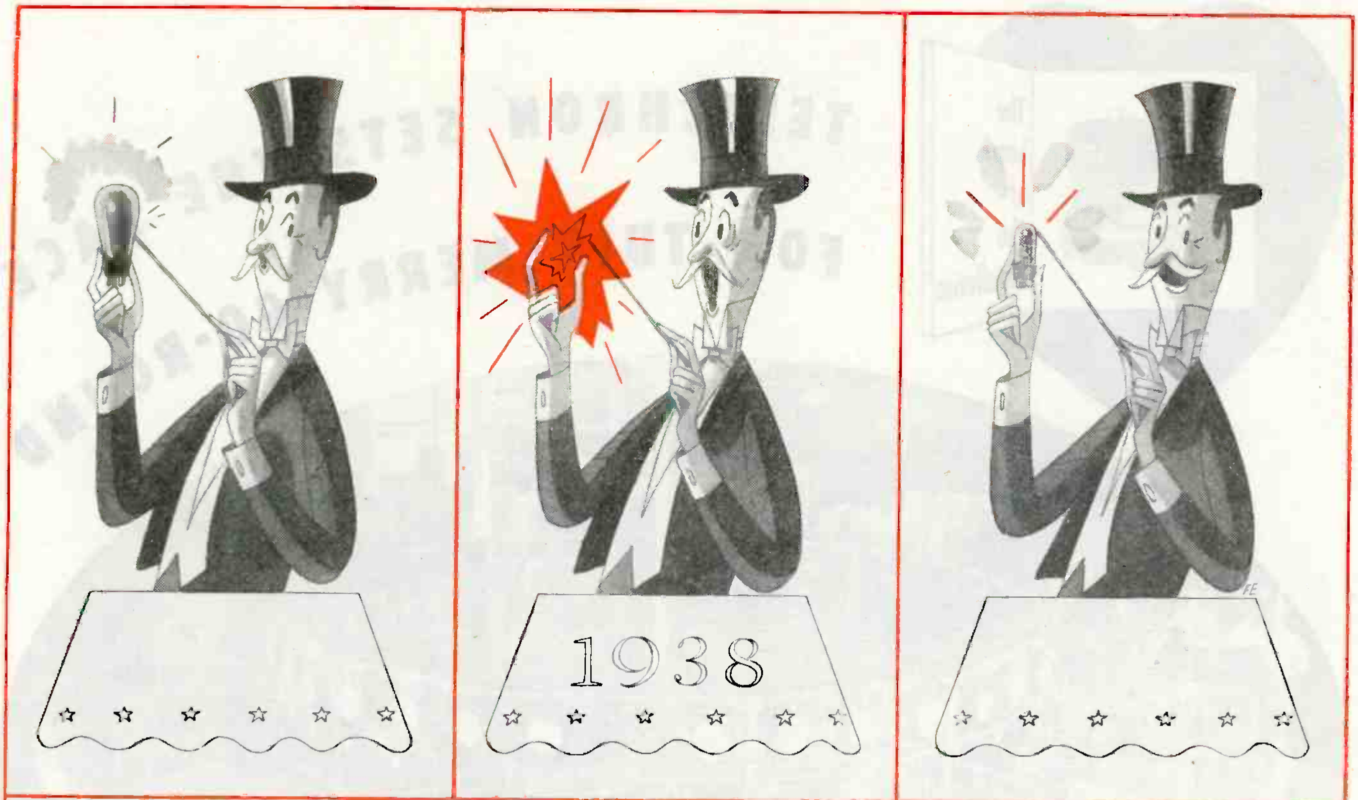
No one can predict how long this intervening period may be, but Rola's reconversion . . . when it comes . . . will be speedy, and at that time set makers again can look to Rola for the "Finest in Sound Reproducing Equipment."

THE ROLA COMPANY, INC. • 2530 SUPERIOR AVENUE, CLEVELAND 14, OHIO

ROLA

ARMY E NAVY

MAKERS OF THE FINEST IN SOUND REPRODUCING AND ELECTRONIC EQUIPMENT



THEY SAID IT COULDN'T BE DONE!

Back in 1938, Hytron began designing new dies and converting production machinery for the first BANTAM GT tubes. The industry said in effect: "You're crazy; it won't work. You can't telescope standard glass tubes to BANTAM size and get the same results." Beam tetrodes, such as the 50L6GT, particularly were considered impossibilities. The intense heat developed during normal operation would warp the elements and crack the small glass bulb.

But Bruce A. Coffin, originator of the BANTAM GT, stuck to his guns. In a few short years, Hytron developed over fifty GT types. The GT became the most popular receiving tube.* Short leads, low capacitances, advantages of shorter bombardment at lower temperatures, ruggedness of compact construction plus both top and bottom mica supports, smaller size, standardized envelopes and bases — all contributed to that popularity.

The BANTAM GT permitted new space economies in pre-war receivers. Only its universal acceptance as standard by all manufacturers makes possible fulfillment of the Services' demands for receiving tubes. In increasing numbers, as this war draws to its ultimate conclusion, Hytron will continue to supply you with the popular BANTAM GT tubes which everyone said just couldn't be made.

**1941 industry production figures: GT—32,000,000; metal—27,000,000; standard glass, G, and loctal—56,000,000.*

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON CORPORATION ELECTRONIC AND RADIO TUBES

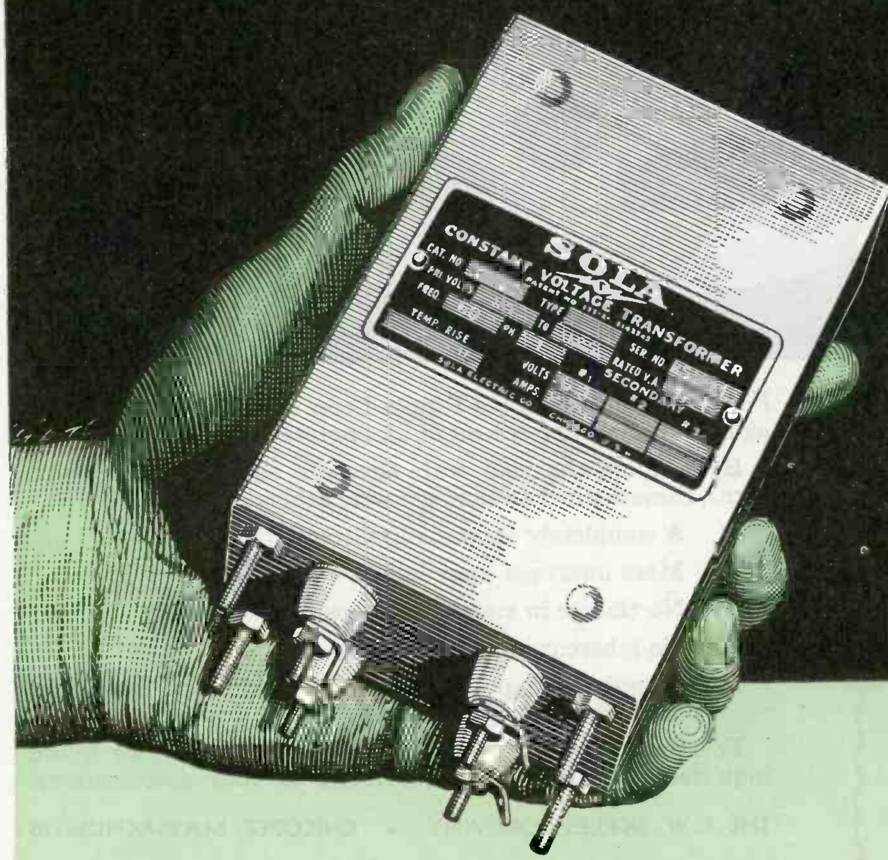
SALEM AND NEWBURYPORT, MASS.

BUY ANOTHER WAR BOND

This SOLA CONSTANT VOLTAGE TRANSFORMER

has an important postwar future in

YOUR



HEATING CONTROLS • REFRIGERATION CONTROLS • TELEVISION SETS • F-M RADIO • VACUUM TUBE VOLTMETERS • ELECTRONIC GAUGING AND INSPECTION EQUIPMENT • PHOTO-METRIC INSTRUMENTS . . . ***there are other applications of course***

Here is a SOLA Constant Voltage Transformer that should be a built-in part of your equipment—

First: because it will stabilize output voltage at your rated requirements regardless of line voltage fluctuations as great as ±12 to 15%.

Second: because its small, compact size is ideal for chassis mounting.

Third: because of its low, economical cost.

Fourth: because of the saving that can be made through the elimination of other components.

Fifth: because a majority of anticipated service calls can be eliminated from your cost calculations.

Sixth: because the users of your product will get greater satisfaction from trouble-free service.

This particular transformer is rated at 6.3 volts, 17VA output and is designed primarily for the stabilization of vacuum tube filament and heater voltages. Other voltages and capacities for chassis mounting can be supplied on the same low cost, economical basis to meet your exact requirements.

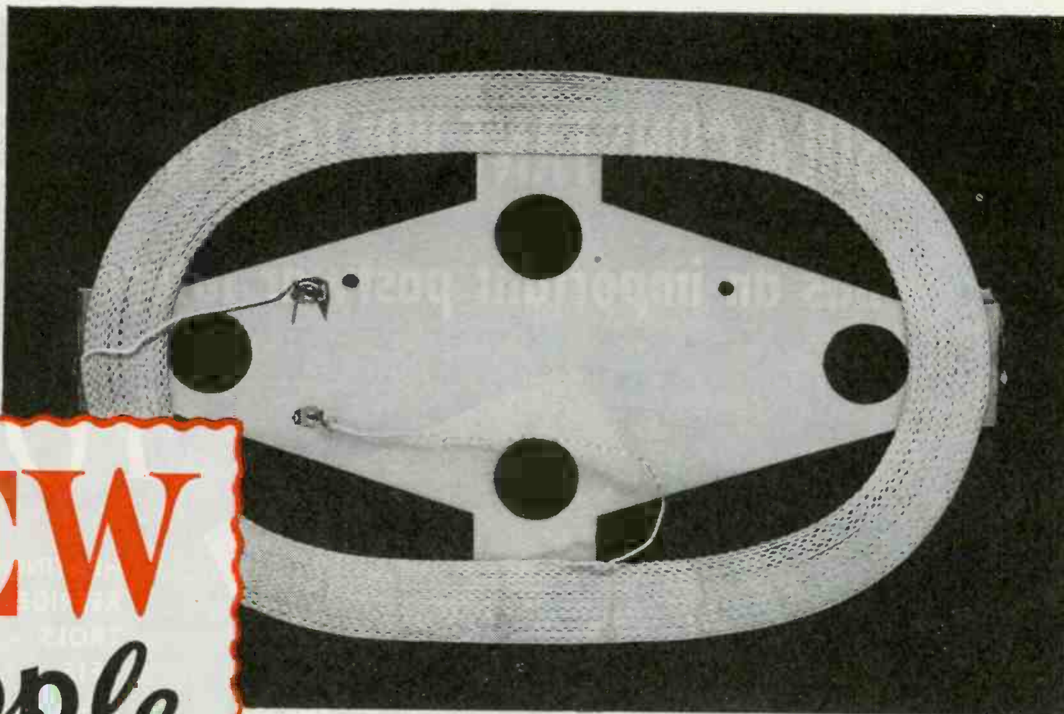
SOLA Constant Voltage Transformers

To Manufacturers:

Complete specification details covering this new Constant Voltage Transformer will be furnished at your request.

Ask for Spec. No. DCV-103

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.**



NEW Ripple Loop

Combines Alternating Straight and Rippled Turns to Produce More Input Per Loop Dollar

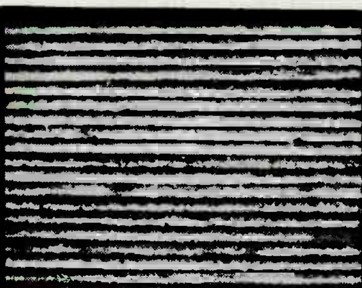
First with the Low-Loss Ripple Loop in 1940, Sickles scores again with an *improvement* of an *improvement*.

By winding the loop with alternate straight and rippled turns, these distinct advantages were achieved:

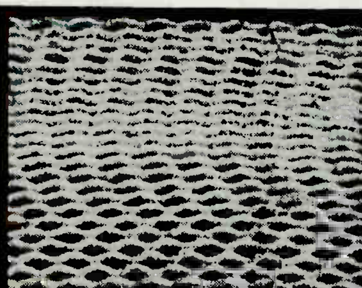
1. A completely open mesh pattern.
2. More input per loop dollar.
3. No change in size or cost of wire.
4. No inherent increase in cost.
5. Complete adaptability of size, shape and mounting method, to your needs.

For your wartime production or postwar plans, we invite inquiries. Write for a sample made to your specifications.

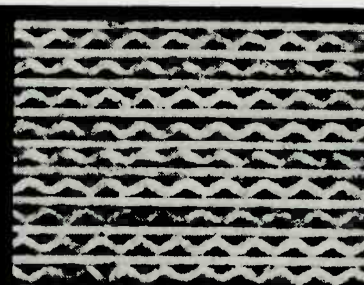
THE F. W. SICKLES COMPANY • CHICOPEE, MASSACHUSETTS



FAIR The original straight-wire loop was only fair. An enlarged section shows how wires were in contact at all points; a decided obstacle to efficiency.



GOOD The patented (1940) Sickles Ripple Loop was a vast improvement. It offered a more open mesh pattern and higher efficiency.

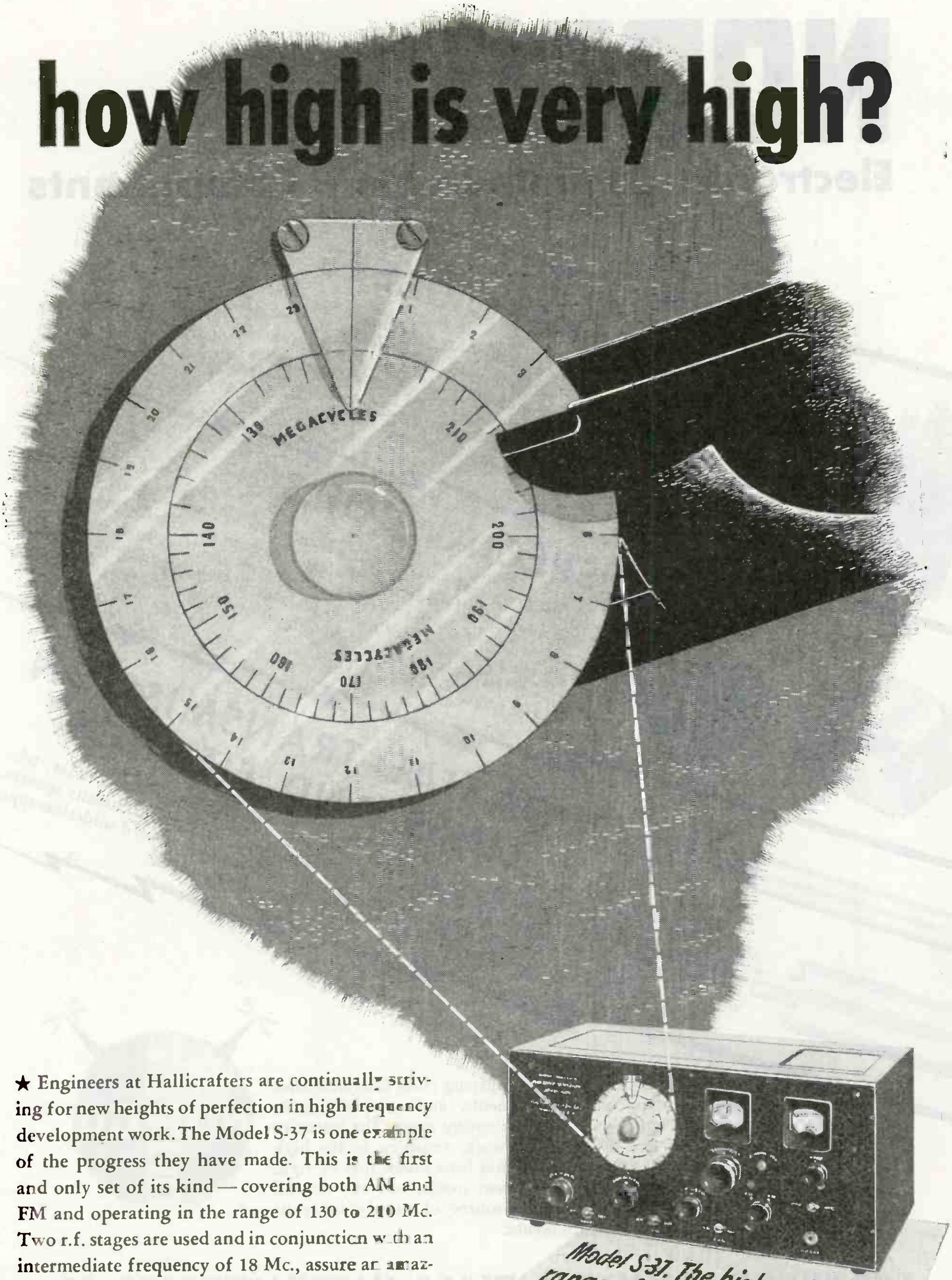


EXCELLENT This enlarged cross-section of the new Sickles Ripple Loop (Patent Applied For) shows how alternate straight and rippled turns produce the completely open mesh pattern that means higher in-put per loop dollar.

SICKLES

Radio and Electronic Specialties for Today and Tomorrow

how high is very high?



★ Engineers at Hallicrafters are continually striving for new heights of perfection in high frequency development work. The Model S-37 is one example of the progress they have made. This is the first and only set of its kind — covering both AM and FM and operating in the range of 130 to 210 Mc. Two r.f. stages are used and in conjunction with an intermediate frequency of 18 Mc., assure an amazingly high ratio of image rejection. It is becoming a valuable instrument in the hands of all exploring the upper reaches of the high frequency ranges.

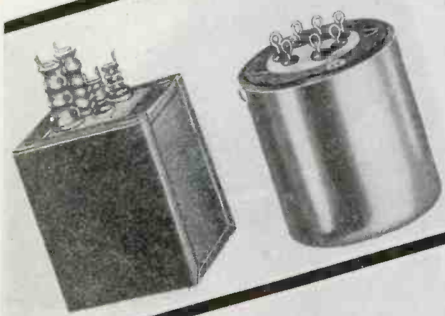
hallicrafters RADIO

Buy a War Bond Today!

THE HALLICRAFTERS CO., MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT, CHICAGO 15, U. S. A.

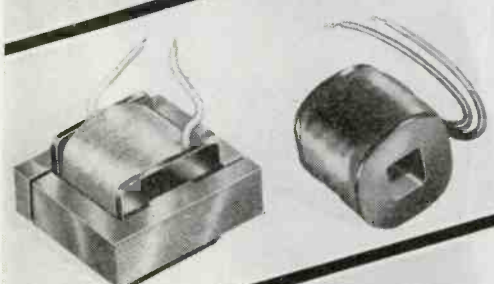
NORCO

Electronic Communication Components



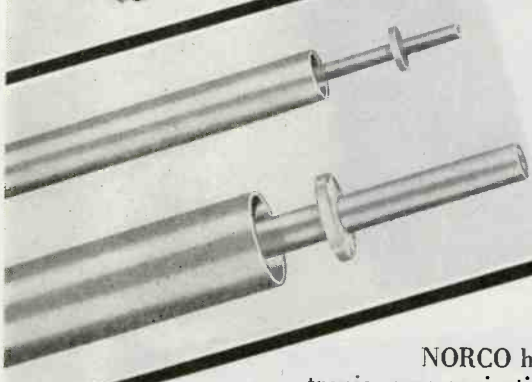
TRANSFORMERS

NORCO Transformers are designed to keep pace with electronic progress. Precision-built to assure the highest standards of performance. Manufactured to your specification or furnished for varied applications such as: audio, small power, 400-cycle aviation instrument, test equipment, television, high fidelity broadcast and recording amplifiers, etc.



SPECIAL COILS

NORCO special coils are of advanced design and embody only the finest quality materials. Painstaking care by skilled craftsmen assure precise, uniform construction with resultant high operating efficiency. Used for high Q reactors, 400-cycle aviation instrument, test equipment, special relays, or other devices requiring better quality coils.



COAXIAL TRANSMISSION LINES AND FITTINGS

NORCO coaxial cables, used for radio communication, radar, television, and FM are available with Dupont Poly-F, or Steatite spacers. A complete line of fittings, both solder, and improved solderless types can be supplied for NORCO Transmission Lines.

NORCO has been supplying close tolerance electronic communication components, and complete audio frequency amplifiers to discriminating users. The intensive engineering and development work, resulting in the high standard of NORCO products, has been intensified by rigid wartime demands. Whatever your needs, you can depend on NORCO as a dependable source of supply for your present or future requirements.

NORTHERN COMMUNICATIONS MANUFACTURING CO.

210 EAST 40th STREET **NEW YORK 16, N. Y.**

Manufacturers of Transformers • Reactors • Sound Systems • Recorders Equalizers • The Norco Full Range Phonograph • Also Coaxial Transmission Lines

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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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107 Monroe Street, Garfield, N. J.
Please rush my complimentary copy of *The ABC of Electronic Heating* today to:

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He's TWICE the Man He Used to Be...

when you start him driving AMERICAN PHILLIPS SCREWS

Take him off the slow, dangerous, *high-cost* drudgery of driving slotted screws. Put him on the trigger-end of a 4-winged Phillips driver and start him driving American Phillips Screws.

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Here's another difficult hardening job, done simply and quickly with Megatherm.

Exact contour hardening of the inner gear of these supercharger clutch discs was done in less than ⅔ of a second each.

These gears were hardened to a depth of .050", with the hardening closely following the tooth and root contour of the gear surface, without affecting the strength or ductility of the remaining metal. The unretouched photograph above tells the story.

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The Megatherm automatic timer limits the heat period to exactly ⅔ of a second, then operates a solenoid which trips the disc into an oil-quench bath.

Here is another example of Megatherm's adaptability to many hardening problems involving irregular and "hard-to-get-at" surfaces.

If you have a surface hardening problem . . . whether for wartime or peacetime application . . . consult Federal's Megatherm engineers for the answer or write for complete data.

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Federal Telephone and Radio Corporation

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. INDUSTRIAL ELECTRONICS DIVISION

AN IT&T ASSOCIATE

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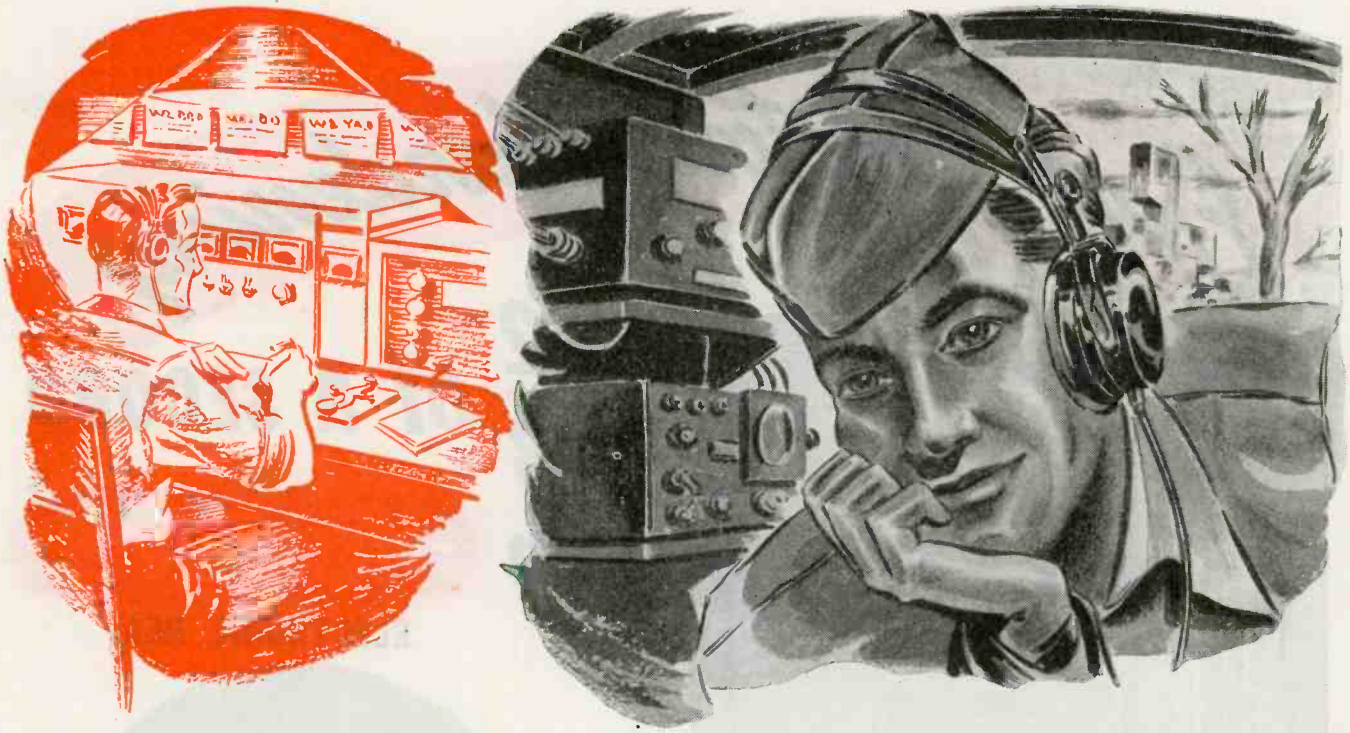

After ADOLPH and TOJO are Q·R·T

The rig he left behind is due for a big change when GI Joe comes home. War experience has been an "eye opener" for him. From chassis to sky wire many pre-war Ham outfits will undergo a major alteration and amazing technical advances will be put into practice. Stimulated by training and experience gained in the armed services thousands of new enthusiasts will swell the ranks of amateur radio.

When the gang goes back on the air again, CQ'ing, SS or DX; UNITED will be ready to serve the Amateur with war-perfected Transmitting Tubes.

Since 1934 UNITED has specialized in engineering, designing and building Transmitting Tubes that set the Quality Standard for the entire Radio Industry. When performance counts UNITED Tubes provide a maximum of electronic efficiency—plus a long and dependable life. Accept nothing less than UNITED quality for your own tube requirements.

Order direct or from your electronic parts jobber.

MASTERPIECE OF SKILLED HANDS

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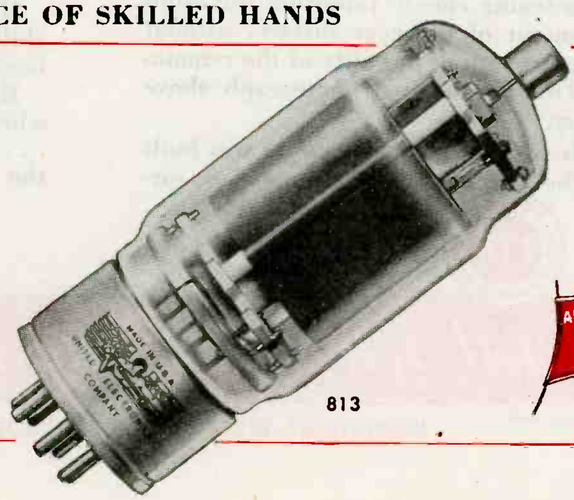

813

ARMY E NAVY

WHAT DOES AMERICA WANT?

IT IS THE PURPOSE of this editorial, the thirty-first of a series, to state the urgent need for a clear declaration of American policy in world affairs.

Within the past few weeks there has been a wakening conviction in this country that the determination of international arrangements cannot safely be put aside until victory has been won. For we have seen actions taken in Europe seemingly without full consultation and agreement of the Allied powers, which may profoundly affect the design of the post-war world.

A declaration of American policy is needed, and it should be accompanied by a statement of our firm intention to exert full effort to procure its acceptance and furtherance. Emphatically, this does not mean that an American platform should be put forth as an ultimatum, which other nations must accept totally, or reject at the cost of having the United States withdraw from collaborative participation in world agreements and organization. On the contrary, the first plank in such an American platform should be a firm commitment on our part to participate with our associate nations in building a general system of world security and order. By definition, this requires that each participant be willing to accommodate its purely national interests to a program that can be accepted as fairly representing the interests of all. But equally, there is imposed on each participant an obligation to state honestly and openly what it conceives its individual interest to be, as well as its concept of what measures will best serve the general interest.

☆ ☆ ☆

Americans have displayed a singular diffidence in the matter of formulating a bill of American objectives — singular, in that it contrasts so sharply with our power to exercise as broad a leadership as we are able to define. This reluctance stems partly from the inherent difficulty of arriving at a coherent statement of national aims in a country like the United States — so vast in area, so multiple in its sectional and group interests, and so soundly committed to the free expression of individual thought. But it stems also, in part, from a tradition of national isolation which, however understandable in historic perspective, now stands clearly discredited by two world wars which were not of our making, but from which we were unable to hold aloof.

That the economic wellbeing and political security of the rest of the world is closely bound to the decision and performance of the United States is questioned nowhere but in America. Political boundaries and restrictions cannot build effective fences against the interplay of economic forces, and the sheer weight of American economic influence is of crucial import to all the other nations of this globe. In large measure their decisions will be shaped either in response to the opportunities that our procedures offer them, or in defense of interests that our procedures may jeopardize.

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The United States contains only about 6 percent of the world's population. But — our national income, before the war, amounted to almost 25 percent of world income; our industrial output as a whole approximates 45 percent of world totals, and we now are producing a like percentage of the world's munitions; we have 35 percent of the world's railroad mileage; 25 percent of merchant fleet tonnage; 50 percent of the world's telephones; 45 percent of steel production; 40 percent of aluminum production; 33 percent of coal output; we are refining (though part of the production comes from imports) 55 percent of the world's copper, and 70 percent of its petroleum; we now are producing 50 percent of the world's rubber (though post-war resumption of natural rubber production will sharply reduce this balance); our shares of agricultural production are, of course, much smaller, but just before the war we accounted for 35 percent of world cotton production, 15 percent of wheat, and 10 percent of wool.

Whether we like it or not, we must exercise political responsibilities commensurate with the weight of our economic power in an inter-dependent world. But before responsibilities can be assumed, they must be defined. Can the United States arrive at a clear agreement and statement of aims for which it is willing to stand sponsor?

The recent campaigns of both political parties have helped to provide an encouraging answer. In general, election mandates are glaringly deficient as indicators of a unified national purpose. A majority of voters declare themselves for the winning candidate. But even among the majority there are varying degrees of enthusiasm for the platform principles espoused by their candidate; and the substantial minorities of the defeated parties may have had no enthusiasm whatsoever for particular planks in the winning platform, or for the platform in its entirety. A sportsmanlike deference to the will of the majority is a feeble substitute for unified national conviction.

But this Presidential campaign was noteworthy for certain basic principles upon which both the platforms and the candidates of the major political parties were united. Surely, upon such areas of agreement there may be said to have been an American mandate; the more so, because upon certain of them, we have evidence that no party or candidate could have declared opposition with any hope of victory. What then were these agreed-upon principles? The following is an attempt at a fair summary:

1. That America, in collaboration with its Allies, is committed to seeing the war through to the unconditional surrender of our declared enemies.

2. That America is committed to a responsible role in a world security system after the war, including a commitment to lend the support of our armed forces to repel aggressions that may violate such security.

3. That America is committed to the post-war goal of substantially maintaining in this country an economy that will provide jobs for those who are able and willing to work.

4. That America is committed to the principle of achieving this goal of sustained, high-level employment of manpower and economic resources under a system primarily activated by competitive enterprise.

These are American mandates. They can be made the nucleus of a coherent national policy, for they define aims upon which the great majority of our people are emphatically agreed. But no one can pretend that in this generalized form they serve as more than directional guides for either internal legislation or international negotiation. This skeleton of aims must be clothed with the living flesh of agreed-upon means. Here we have no national mandates of comparable clarity, but it is patently clear that it is our compelling task to achieve them.

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On our elected representatives in government rests the primary responsibility for formulating the specific programs required to implement national policies. Under our system of government, those representatives need continuous nourishment in the form of mandates as to what the people want. Particularly during a period when so many urgent problems are being thrashed out upon an international basis, this imposes a grave responsibility upon all sectors of our citizens; for it requires them to think in terms of the welfare of our nation as a whole, to focus upon those points which offer possibilities for substantial agreement among Americans, rather than upon matters of individual, group, or sectional advantage.

In earlier editorials I have tried to define a basis for national policy in keeping with that broad purpose. They have dealt with problems that are basic to the healthy functioning of free enterprise under the competitive system, with the mobilization of our resources for war and for reconversion to peace-time production, with labor and management responsibilities and relations, with national debt and taxation, with foreign trade and our economic relationships abroad, with the industrial development of backward areas. Since they have been presented in the McGraw-Hill publications, which reach a group broadly representative of all American industry, they have centered upon problems that have an economic rather than a strictly political import.

Future editorials, to appear during 1945, will deal with comparable subjects selected in recognition of the urgent importance for arriving at concerted definitions of national policy. I am fully aware that no individual or group can speak authoritatively for the American Nation. But I hope that an honest attempt to formulate sound concepts of national interest in crucial economic matters will help to crystallize American policy both by focusing agreement and by eliciting dissent.

☆ ☆ ☆

Here there is space only to indicate in broadest outline what I conceive to be desirable foundations for an economic policy for the United States:

1. The attainment of a high and sustained level of business activity and employment in the United States and in the world.

2. Active and expanding markets for world trade based upon fair competition rather than upon bloc agreements, discriminatory preferences, and cartel arrangements.

3. The encouragement of industrial development in nations that have been backward in that respect.

4. A recognition that hospitality to imports, rather than constituting a threat to national standards of living, offers in fact the most potent instrument for international bargaining that any nation can command.

5. A willingness to assume a responsible national role in international arrangements designed to provide such financial stability as may be needed to support mutually advantageous world exchange of goods and services.

We must see to it that the end of military warfare does not merely open the door to an era of economic warfare.

The fact is that America has no choice but to assume leadership in world affairs. For the weight of our influence will be felt by other nations no less whether our attitude be positive or negative. And the cost to us of any international obligation which we might undertake must in all fairness be weighed against the equally real cost to us of dealing with measures that others may take to protect themselves against the results of our non-participation.

We have tended in the past to approach international commitments timidly, fearful that we might be outwitted in a world battle of wits. And in so doing, we have too often ceded to others the initiative of suggestion, leaving to ourselves the thankless task of accepting or rejecting what they demand of us.

Our one bargaining weakness stems from the fact that other nations, by contrast feeble in potential power, know what they want and are able to mobilize all their strength to achieve it.

America can be the most effective nation on earth — if only it knows what it wants.

James H. McGraw, Jr.

President McGraw-Hill Publishing Co., Inc.

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MALLORY SWITCHES
Assures Precision Performance

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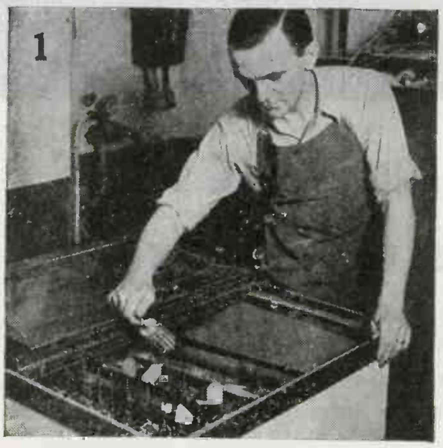
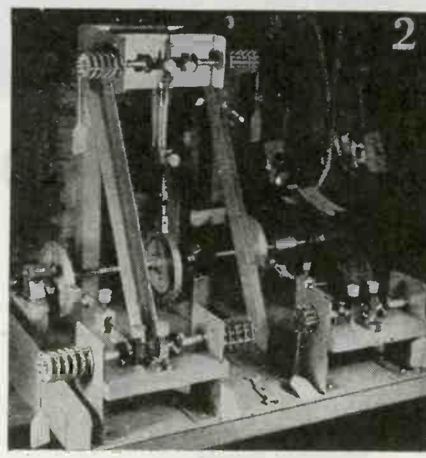
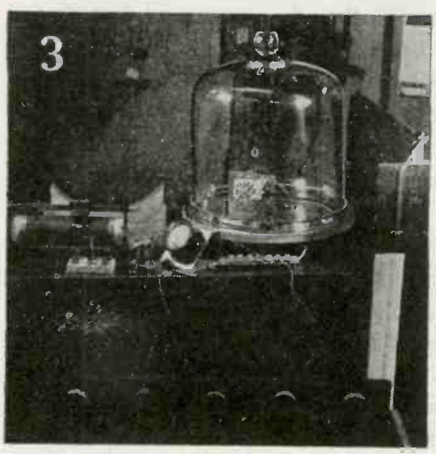


1 SALT SPRAY TEST: In a few short hours, switches are subjected in this salt spray chamber to conditions that equal years of marine service.



2 SWITCH LIFE TEST: Hour after hour, this machine continues to operate the switch until it is destroyed. Results enable Mallory to develop switches with operating life exceeding normal requirements.



3 LOW ATMOSPHERIC PRESSURE TEST: The rarified air of the substratosphere is reproduced inside this large bell jar. Data from this test has aided Mallory in developing better switch construction for aircraft application.

4 FUNGUS CONTROL: In this laboratory, fungus cultures from the tropics are used in testing the fungicidal properties of new impregnating materials for the insulation in Mallory Switches.

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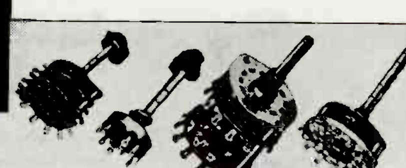
MALLORY



Industrial and Electronic Switches

CROSS TALK

▶**OPTIMISM** . . . In a questionnaire submitted to executives of radio receiver manufacturers by a large parts manufacturer to determine the industry thinking so far as receivers are concerned, considerable optimism was displayed. The concensus was that only 83 days would be required after government restrictions were removed before the industry would be going into production; that in the first six months the industry would produce some 5,200,000 receivers; that by the end of the first year 13,650,000 sets would be ready for sale.

Of these 35 percent would have 8 tubes or over and 65 percent would use 7 tubes or less. During the first year, manufacturers estimate that 96,560 television receivers would be made.

And now, boys, hold your hats, for here we go again! The manufacturers who made the above estimates, also planned to make in the aggregate 8,077,000 receivers during the first six months and 21,518,000 during the first yearly period. This is not quite up to the good old days when industry produced about twice as many sets as could be sold over the counter so that year-end dumping made headaches for creditors and good buys for the listener.

▶**RESEARCH** . . . Rumors that the National Defense Research Committee (NDRC) is to be liquidated soon come as a great shock. We hope it is not true. No one of us will ever know or could ever appreciate the value or the volume of the work done by Harvard, California, MIT, Columbia, Johns Hopkins and other universities and by industry under grants from NDRC. So much has been accomplished by so many hundreds of the nation's best scientists and engineers working behind NDRC's closed doors that the mere vastness of the electronic, chemical, electrical or mechanical research makes it virtually impossible to comprehend the effort even if the books were thrown open for all of us to see.

The secrecy under which this work must be done keeps people from knowing the benefits derived. To most people and perhaps even to Congressmen NDRC is just another alphabetical government agency that should be lopped off. The truth is that nearly all research into weapons of war stopped at the conclusion of the last war. The truth is that we were caught flat-footed at the beginning of this war; that many of our lost ships and their lost crews would still be at sea had aggressive research into such an obvious subject as anti-submarine warfare been carried out. It is the truth that much of the materiel now going into service could have been ready at the beginning of the war—and not, as is the fact—almost at the end. Research would have made it possible.

It is poor business, bragging how we compressed into a few months all the research that ordinarily would take years. It is no way to win wars or save lives. Research into defensive and offensive methods and machinery is less expensive, even in terms of dollars, before a war starts than after it is almost lost.

Surely, the kind of work accomplished under NDRC will not be stopped. A way must be found to continue wartime research so that we never get caught again.

▶**COLLEGE** . . . Ask the average high-school boy what he thinks of when you mention the word "research" and it is ten to one he will say "chemistry." For years there was a great deal of planned whoopla about the glamor of chemistry, the forefront of the future. The result was obvious; a student who had an urge to get into research went in for chemistry.

Perhaps the present glamor surrounding the word "electronics" will serve one good end, at least; that of attracting young men into fields of electronic or physical research. Up to the present there has been little urge for a youngster to consider the broad field of electronics or any of its parts as a lifetime study. The radio industry has had a bad record in its dealings with scientists or engineers. Only a few companies felt the need for or would spend money for research. Many engineers were kicked out at the end of the season; and hired only when a new series of models was to be developed. Only the large companies were stable, and the number of electronic men they could employ was distinctly limited.

Happily, electronics is now in the situation in which chemistry found itself at the close of the last war. It is booming; new blood is needed; and the sky is still the limit as to what may come of it.

Young men should be taught that there is a future for them as electronic experts.

Broadcasting's POST-WAR

Standard a-m stations indicate what gear they will need for modernization of existing plants. and replacement. Proposed increases in power are reported. Intentions relative to other services such as f-m and television are revealed. ELECTRONICS' survey emphasizes importance of market offered by one branch of the communications field

WHEN the war ends and transmitting equipment once more becomes readily available there will be a substantial backlog of demand for it among standard a-m broadcast stations. Fully 34.2 percent of the stations now in operation hope to increase power and 26.1 percent of this group proposing to crack on more kilowatts have already filed application with the FCC for permission to do so.

These and other facts indicative of the post-war market for electronic gear in one of the most important branches of the communications field are revealed in a survey just completed by ELECTRONICS. The editors contacted chief engineers of 64.8 percent of all the standard a-m broadcast stations in the country. Only 8.9 percent said they have no plans.

Complete New Transmitters

In addition to the need for new equipment where power increases are proposed, there are many reasons why stations want to purchase new gear. Chief among these, in order of importance, are:

Obsolescence of equipment
Worn-out equipment
General inadequacy
Poor quality
Desire to standardize

Thus 7.4 percent of all the stations contacted plan to buy complete new a-m transmitters soon after V-E (Victory-in-Europe) day or after Japan collapses. Architects, builders and suppliers of materials such as sound-proofing and lighting in particular will be interested to know that 3.9 percent of all the standard a-m broadcast stations contacted hope to have new studios, and 1.3 percent say they are already dickering for new transmitter building sites.

Component Parts and Accessories

Partial replacement of existing equipment, or addition of duplicate equipment, is contemplated by 69.4 percent of all stations. Reasons given are the same as those noted in connection with complete new transmitters. The following list indicates the number of stations apparently waiting to buy or build specific items:

Transcription equipment	44.0%
Recording devices	43.4
Microphones	40.8
Studio audio systems	29.9
Field amplifiers	29.7
Audio and modulation monitors	25.8
Antenna systems	12.6
Transmission lines	12.3
Frequency monitors	4.3
R-F units	1.9
Power supplies	1.9
Modulators	1.3

PLANS FOR PEOPLE

Technical Personnel per Station

	Pre-War	Today	Post-War
Men	7.4	6.7	11.7
Women	0.4	1.6	0.8
	7.8	8.3	12.5

Other indicated items include mobile units, auxiliary transmitters, emergency power systems, ground systems, master controls, attenuation panels, miscellaneous amplifiers, level indicators, overload equipment, phasing and coupling devices.

Post-war plans are not yet sufficiently far along to permit determination of the number of individual items the average station proposes to acquire. However, in the case of microphones, sufficient information is at hand to indicate that purchases should average better than one per station.

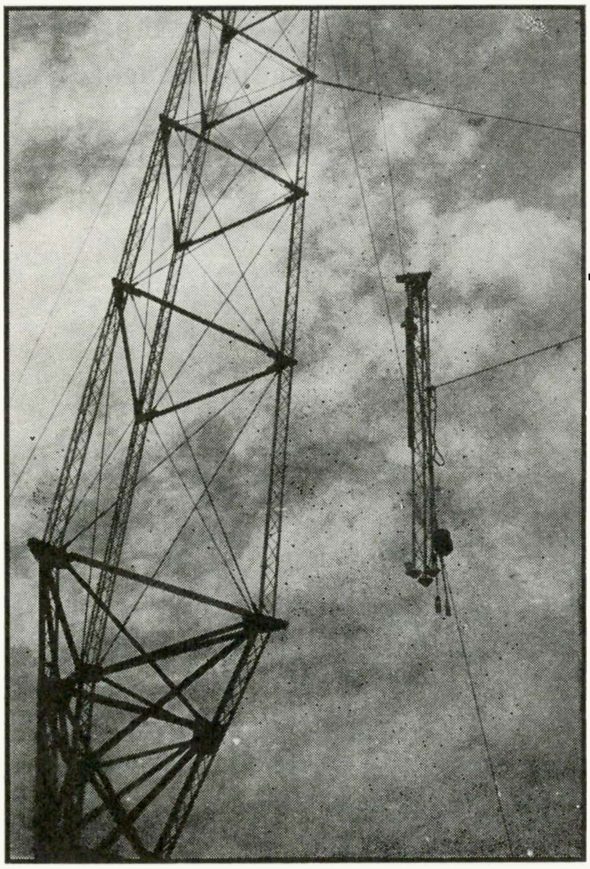
Tubes and Test Equipment

Regarding replacement tubes, 1.9 percent of the stations surveyed say they use more or less standard types readily available even in wartime and have ample stocks on hand, while 62.3 percent are apparently obtaining a sufficient number of harder-to-get types of tubes to keep things going and perhaps avoid the need to place abnormally heavy orders when the dam breaks. The remaining 35.8 percent are, to some extent, tube starved. It looks as though a-m broadcast stations will lay an average of $315 on the line for replacement tubes the instant these become available.

Purchase of new test and measurement equipment is planned by 51.6 percent of all stations con-

EQUIPMENT PLANS

There will be much new construction among standard a-m broadcast stations, aside from their plans for other services



tacted. Specifically, the items rank in this order of interest:

Signal generators	17.4%
Field strength meters	15.1
Noise and distortion meters	14.7
R-F bridges	9.1
Oscilloscopes	8.0
Tube testers	4.5
Vacuum-tube voltmeters	3.2
Phase monitors	2.6
Square-wave generators	2.2
Multimeters	1.5
Capacitance bridges	1.3
Circuit analyzers	1.1

Interest was also exhibited in impedance bridges, Q meters, and miscellaneous instruments. Dollar value of proposed purchases cannot be estimated owing to the probable duplication of individual items and to the unknown factor of price on post-war gear.

Other Services, S-T Links

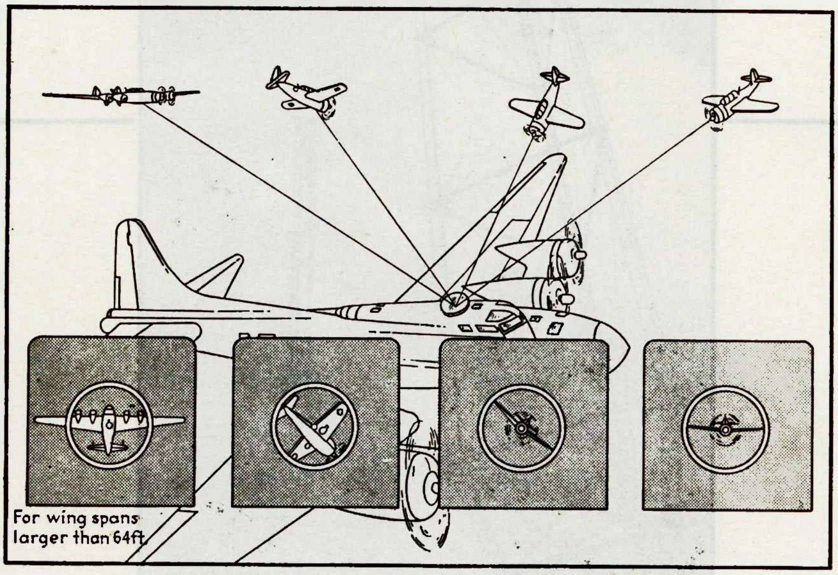
Immediate post-war operation of frequency-modulation stations, in addition to present a-m facilities, is planned by 66.8 percent of the stations contacted. Of those planning such additional services 40.6 percent say they have already filed applications with the FCC. Average power requested appears to be in the neighborhood of 10 kw. Eventual operation of television transmitters is planned by 17.8 percent and 38.5 percent of this group have filed applications in Washington. Average power requested is 6 kw.

Plans for studio-transmitter links among standard a-m stations proposing to operate f-m and television stations after the war are highly speculative and dependent upon some factors over which the stations themselves have little control. Of the stations surveyed, however, 67.8 percent presented some tentative plans. Of this group 2.7 percent will need no s-t links at all, since studios and stations are to be at the same location. Among stations proposing f-m service, 40.3 percent hope to use radio links, 35.4 percent plan wire links, and 12.9 percent would like to use coaxial cables. In the television picture, 11.2 percent plump for radio links, 4.4 percent expect to use coaxial cables, and 1.1 percent hope wire lines suitable for the job can be devised. These percentages total more than 100 percent because alternate proposals were given in a number of cases.

Considering the fact that all of the above figures deal with the proposed post-war plans of just one communication group . . . the existing standard a-m stations of the country . . . it is apparent that the potential market for transmitting equipment in the United States itself is indeed bright, without even considering export possibilities. For there are many f-m stations already operated by people not having a-m licenses, and therefore not covered in this survey, and several such television stations. More stations, operated by people not yet in the field, are obviously to come. There is also much additional business among present and potential operators of point-to-point commercial communications services, police, fire, forestry and other public-welfare services, and industrial services such as aviation and railroads that are clamoring for space on the airlanes.—W. MacD.

The K-8 Computing

Aircraft turret gunsight and electronic servo system automatically provide correct deflection to compensate accurately for speed of enemy plane and all other factors affecting time of flight of bullet, extending range of machine guns on bombers to 1000 yards



Target properly encircled by reticle image

THE gunsight known by the U. S. Army as the Model K-8 is an electrical brain used in bomber gun turrets to automatically insure hits on enemy aircraft.

With this system it is only necessary for a gunner to keep a reticle in the sight lined up with the target to compensate for all the factors which affect the course of the bullet in flight and to provide the necessary lead to compensate for the relative velocity of the enemy aircraft. All of the computation is done electrically. The final voltage, representing the desired offset between the line of sight and the gun, is then sent to an electronic servo system to provide the desired offset.

Development of the K-8 was begun in 1938 in the laboratories of the Fairchild Camera & Instrument Corporation, and the sight has been in production and in combat use many months.

Advantages of Electronic System

Use of an electrical computing system has many advantages over previously used mechanical systems. With an electrical system it is possible to include all of the factors which should enter into the computation. With the mechanical systems used prior to the development of the K-8 it was necessary to eliminate some of the factors entirely and to provide only partial compensation for some of the remaining factors.

Another obvious advantage is that electrical computation is instantaneous, which is of great importance when dealing with target speeds of 300 or 400 miles per hour and bullet velocities of 2,700 feet per second. Electrical computation also eliminates backlash and the consequent necessity of adjustment and effects of wear. Furthermore, when dealing with the very limited space available in aircraft turrets, an electrical computing system permits the distribution of various components of the system wherever convenient in a turret, since only electrical wiring is required between components. This also permits the reduction in size of the equipment in front of the gunner's face, thus giving the gunner much greater visibility.

An aircraft gunsight requires two major compensations. One is the lead to compensate for relative velocity between the target and the bomber in which the gunsight is used; the other is the correction for windage and gravity, known as ballistic deflection.

Lead is determined from the product of angular velocity and time of flight of the projectile. Time of flight in turn depends upon the following five factors:

(1) Azimuth position of gun
(2) Gun elevation
(3) Range of the target
(4) Indicated air speed of the bomber
(5) Altitude of the bomber

The ballistic deflection also depends upon the same five factors but there is no exact relationship between the two, so it is necessary to compute them separately. Previous mechanical computers have had to neglect the effect of indicated air speed and altitude; to further simplify the problem, it has been necessary for them to use only two of the remaining factors at a time for a given computation. For instance, in computing the vertical deflection, it was possible to include only azimuth position of the gun and gun elevation in a mechanical computer, the effect of range being neglected entirely.

With the K-8 computing system all factors have been included in all computations. Consequently, instead of producing an approximation to the correct deflection, the sight produces an almost exact solution under all conditions. As a result, scores three or four times greater than any previously re-

Gunsight

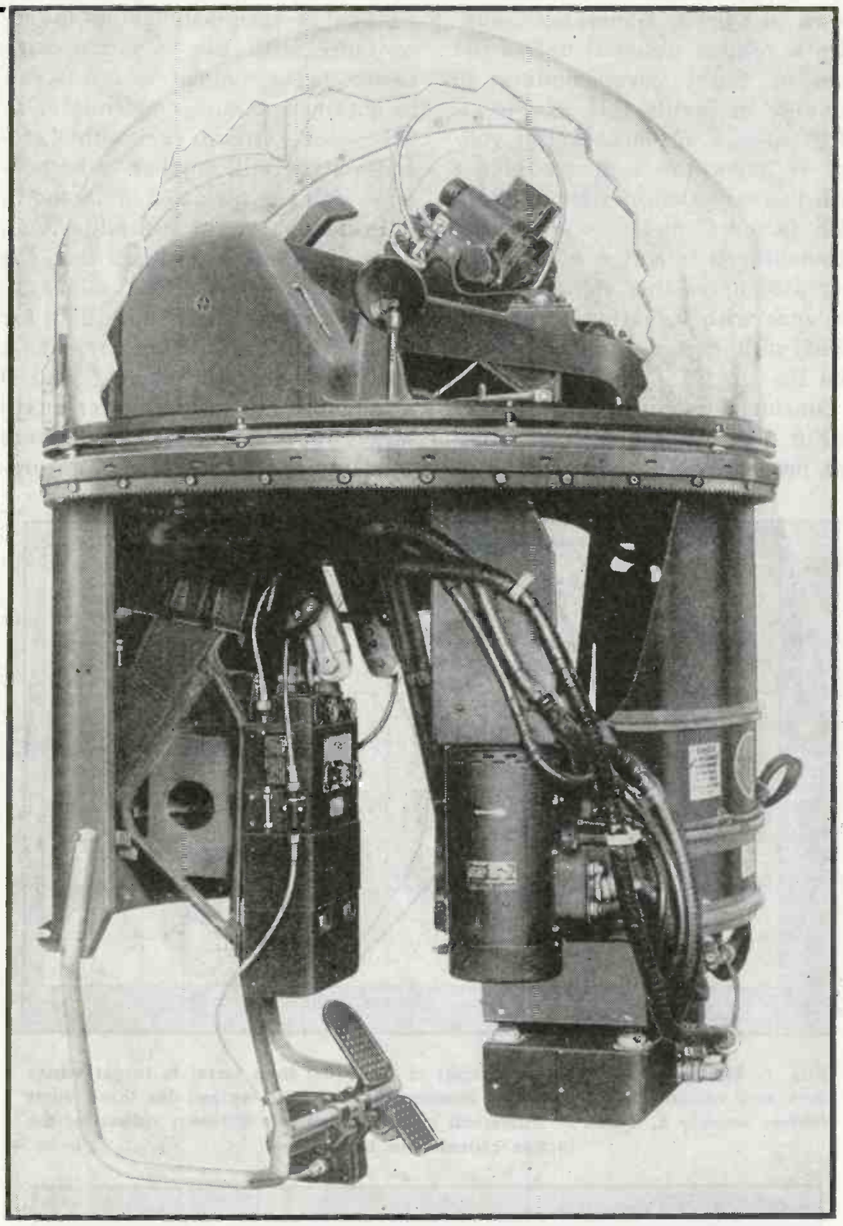
By H. ERWIN HALE
Engineer in Charge
Computer Section
Fairchild Camera & Instrument Corp.
New York, N. Y.

corded for mechanical computers were obtained with this equipment.

Method of Computation

The angular velocity of the target is obtained by means of specially designed d-c generators connected to the turret and gun elevation drive. These generators are in effect electrical tachometers but they have wound fields in place of the usual permanent-magnet fields used in such devices. The purpose of the wound field is to provide for multiplication of the angular velocity (indicated by the speed of the generator) by the time of flight (indicated by the strength of the current in the fields of these generators). Thus it was necessary to develop generators with extremely low residual magnetism in order to maintain the linear relationship of this product. The residual magnetism in these generators is kept under one percent.

The time-of-flight current is obtained from an electrical attenuator network especially developed for this purpose. The attenuators themselves are essentially the same as those which have been used in the radio industry for a number of years. However, the accuracy requirements are far greater than previous applications have demanded. The problem of obtaining this accuracy and the special tapers required for the various attenuators was worked out in conjunction with another concern of long experience in this field. Attenuators or T-pads, as they are known, are used in the computing network in order to maintain constant circuit impedance while the attenuation, corresponding to the various factors entering into the computation, is altered. The various attenuator networks are supplied with current by specially designed permanent-magnet d-c generators.



Cutaway illustration of Martin upper turret for heavy bombers, showing the Fairchild K-8 gunsight installation. The sight itself is at the top. Foot pedal for range control is at the bottom, with the computer directly above and fitting between the gunner's legs. Power unit is under gunner's bucket seat at right

Design of Computing Network

The approach to the problem of designing an electrical computing network is, in the case of the gunsight computer, purely empirical because the relationship between the various factors is so complex that they cannot be represented easily by mathematical formulas. It should be noted, however, that electrical computing networks which follow exact mathematical formulas can just as easily be built and, in fact, have been built.

Three families of curves are shown in Fig. 1, representing the variation of time of flight with four factors, namely A, B, C and D; a fifth factor, E, is omitted for reasons of clarity. Each family gives the variation of A with time for five different values of B and for fixed values of C and D as indicated. Inspection of these curves shows that time of flight does not vary with A under the condition B_3. Only factors C and D affect time of flight under this condition of operation.

The electrical computing network used to produce the required shape of compensating curve for any given combat situation is shown in Fig. 2. Generator 1 supplies a voltage proportional to the time of flight corresponding to curve B_3 in family C_1D_1 of Fig. 1. Attenuator C attenuates the voltage of generator 1 in accordance with the variation of time of flight with factor C under condition B_3. Attenuator D in series with C further attenuates this voltage in accordance with variation of time of flight with factor D under condition B_3.

Considering only condition C_1D_1 in Fig. 1 for the moment, if a voltage proportional to the maximum difference between curves B_1 and B_3 is produced by generator 2 in Fig. 2 and is subtracted from the voltage corresponding to B_3, point X on B_1 will be obtained. If this second voltage is then attenuated in accordance with the variation with factor A, the complete curve B_1 can be obtained. Another attenuator in this second circuit varies this second voltage still further in accordance with the variation of factor B.

Inspection of curve families C_2D_1 and C_1D_2 in Fig. 1 shows that the differences between the values B_1 and B_3 are less in each case than for family C_1D_1. Consequently, it is also necessary to provide C and D attenuators in this second or auxiliary circuit. With the attenuators thus far mentioned, a voltage proportional to time of flight for all conditions between B_1 and B_3 for all values of A, B and C is obtained.

To obtain a voltage proportional to time of flight for conditions between B_3 and B_5 it is necessary to add a voltage to that corresponding to B_3 under condition C_1D_1. It was found that by extending curve B_5 as indicated by the dotted line, some of the attenuators already mentioned as being used in the first auxiliary circuit could be used for these conditions also. To do this, reversing switches are provided in the auxiliary circuit to cause the voltage from generator 2 to be added to rather than subtracted from that of generator 1. The same A and B attenuators can be used, but different C and D attenuators must be provided. This is easily accomplished by switching different C and D attenuators into the circuit, as shown in Fig. 2.

Since the distance from X to B_3 is less than that from B_3 to Y, a greater voltage is required in the latter case. This is accomplished by providing a voltage from generator 2 corresponding to the distance B_3Y. A fixed amount of attenuation is then switched into the circuit for conditions between B_1 and B_3.

A second auxiliary circuit is used to provide a voltage corresponding to the distance LY. This voltage is subtracted from the sum of the other two voltages and is attenuated much more rapidly with factors A and B, as can be seen from inspection of the curves. A different value of attenuation for factor C is also necessary in this second auxiliary circuit. However, it is found that attenuation for factor D is the same as in the case of the first auxiliary circuit. Consequently, the second auxiliary circuit is connected into the first auxiliary circuit prior to factor D, which thus modifies the output of both circuits.

In a similar manner, it was found that factor E affected all circuits equally. Consequently, the first auxiliary circuit is connected to the main circuit prior to the attenuator for factor E. The current or voltage out of attenuator E is proportional to the time of flight under all conditions of all five factors illustrated.

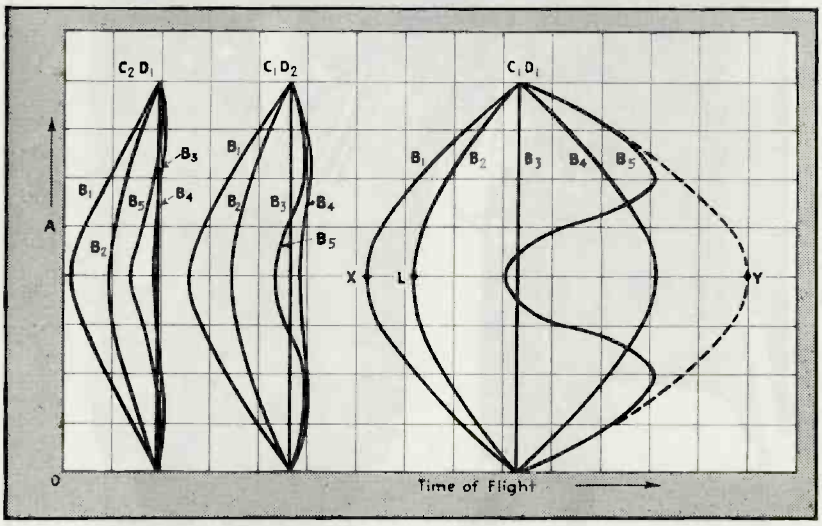


FIG. 1—Manner in which time of flight of the bullet from turret to target varies with one variable, A, for various combinations of fixed values for three other factors, namely B, C and D. Numerical subscripts indicate different values for the factors represented by letters

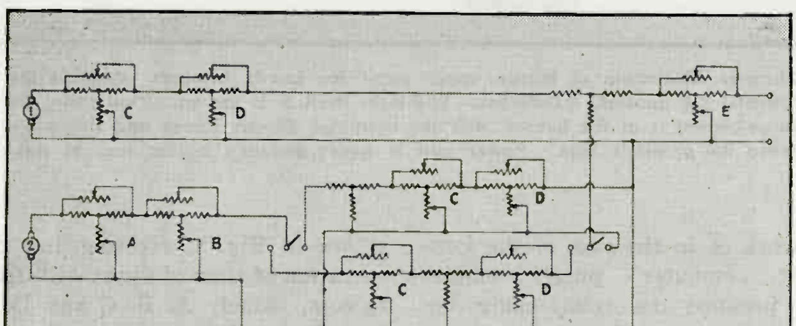
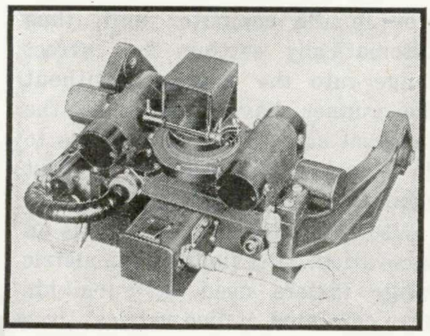
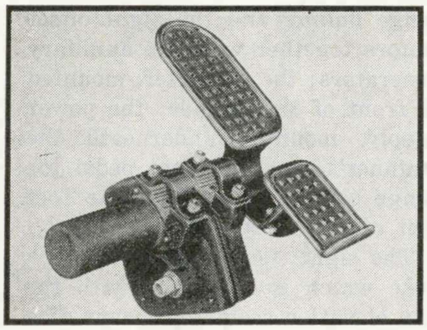


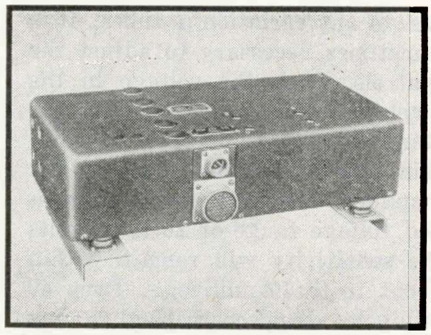
FIG. 2—Electrical computing network, made up of three permanent-magnet d-c generators and a number of different specially tapered attenuators



Complete sight assembly, including range-finding system and sight offset motors



Mechanical foot-control assembly for range adjustment



Power unit assembly, operating directly from plane's storage battery

If necessary, still further refinement could have been added by the addition of further auxiliary circuits. The circuit as shown will, however, give values of time of flight which are accurate within 0.01 second, which would result in errors of less than 1 yard at 1,000 yards for a relative speed of 200 miles an hour.

Lateral and vertical ballistic deflections are computed with circuits very similar to that just illustrated for time of flight. The voltage from the vertical ballistic deflection circuit is added to that from the vertical relative velocity generator and this voltage is then delivered to the electronic servo system. The same is true of the lateral ballistic voltage except that it is added to the voltage from the lateral relative velocity generator modified by a gun elevation attenuator. This is necessary since the azimuth relative velocity generator is driven by turret rotation in the horizontal plane while the sight is offset in a plane making a variable angle with the horizontal plane.

Gun Offsetting Problem

One other compensation must be added to those heretofore mentioned. Because of space and weight limitations it is not practicable in an aircraft turret to offset the guns, and consequently the sight itself must be offset in order to, in effect, offset the guns. However, this leads to a complication, since any offset of the sight tends to move it off of the target. The gunner then has to rotate his turret to bring the sight back on the target. But since relative velocity is obtained from rotation of the turret, any rotation to compensate for the offset of the sight will result in a false velocity being put into the system. Furthermore, it will be found that any rotation to compensate for the offset of the sight will cause a still greater offset, etc. This would result in an unstable system and it would be impossible for a gunner to keep his sight on the target.

To overcome this difficulty with a mechanical computer, a fixed amount of damping is introduced. In effect, a time lag is introduced into the system. This lag varies with range and all other conditions affecting the time of flight. The practical effect is to limit the useful range over which the compensating sight is effective in mechanical types of computers. At very short ranges the sight is much too sluggish to be of any benefit, and at long ranges the damping is insufficient so the gunner has difficulty staying on the target. Strictly speaking, a fixed amount of damping provides a satisfactory correction for only one range and one set of all other conditions of altitude, air speed, azimuth and gun elevation position.

With the K-8 electrical system it is possible to provide an exact solution of this gun offsetting problem. A small generator is provided on the same shaft as the motor which offsets the sight. The velocity of this generator is then proportional to the rate at which the sight is offset. The same time-of-flight current supplied to the field of the velocity generators is also supplied to the fields of the auxiliary generators on the sight. The output of the auxiliary generators is subtracted from the corresponding output of the relative velocity generator. In this way the velocity of offset of the line of sight is subtracted from the turret velocity to give true target velocity. All velocities are, of course, multiplied by time of flight. With this K-8 system the performance of the sight is the same at all ranges and a true solution is obtained.

Servo System

The servo system of the K-8 gunsight converts the voltages from the computing network into mechanical motion to offset the sight laterally and vertically. Without the great development in the art of electronics within the past few years the electrical computing system would have been impossible. True, the computer would still compute, but electronics is required to make this computation available as a mechanical motion, which is the ultimate result required in any gunsight-compensating system.

The servo system of the K-8 sight is unique in that it involves a balanced d-c amplifier which is precise enough for an accurate computer and yet rugged enough for use in an aircraft turret with attendant airplane vibration and gun shock. This amplifier was developed especially for this application. It has a sensitivity of 20 millivolts and performs throughout a temperature range from 65 degrees below zero to 160 degrees above, and a humidity range of 0 to 95 percent (actually it has performed satisfactorily while dripping wet).

The circuit of the servo amplifier is shown in Fig. 3. In the complete unit two such amplifiers are used, one for lateral deflection and the other for vertical deflection. A pair of matched 6SF5 triodes is used to control a pair of 2050 thyratrons which supply a split-field series motor as shown. Balance and bias adjustments are provided to take care of any variation in tubes. It is sometimes necessary to adjust the controls, when the voltage in the airplane varies radically from the standard voltages, in order to maintain maximum sensitivity of the amplifier. However, over the specified voltage range of 26 to 32 volts the sensitivity will remain within about 10 to 40 millivolts. Even 40 millivolts would correspond to only a 2-yard error at 1,000 yards, well within the accuracy of the gun itself.

The thyratron plate supply is obtained from a specially designed four-phase alternator. One phase is used for each of the four thyratrons (two for each amplifier). The direction of rotation of the motor which offsets the sight is determined by which field is energized. This depends on which thyratron fires, which in turn is determined by the polarity of the d-c signal applied to the input of the 6SF5 tubes.

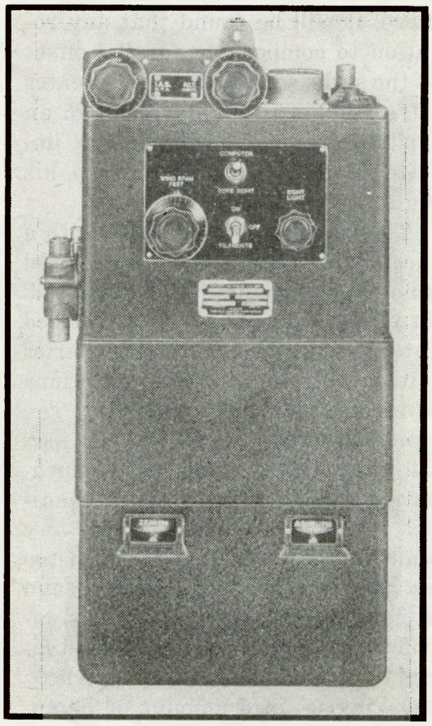
The motor continues to drive until the voltage from the so-called bucking potentiometer, which is also driven by the motor at the same time the sight is offset, equals the voltage from the computing network. When this occurs the input to the amplifier is reduced below the amplifier threshold sensitivity of 10 or 20 millivolts, and the thyratrons stop firing.

The bucking potentiometers are supplied from a permanent-magnet generator driven by the same motor which drives the permanent-magnet generators used for supplying the computing network. In this way all the voltages of both the network and the bucking potentiometers vary together so that a null system is obtained. Any variations in the speed of the motor driving the generators do not effect the computation in any way. Since the bucking potentiometers are driven from the same shaft which offsets the sight, the mechanical backlash is held to an absolute minimum. Any backlash in the gear train of the motor has no effect on the ultimate accuracy of the offset of the sight.

Mechanical Construction

The K-8 sight consists of four main units: the sight itself, which includes the optical system for range finding and the sight offset motors together with the auxiliary generators; the computer, mounted in front of the gunner; the power supply, mounted underneath the gunner's seat; the foot pedal for range control, located on the foot rest of the turret.

The sight itself is mounted in a yoke which is connected with the gun elevation sector by means of a linkage system so that the entire unit elevates as the guns are elevated. The sight mount is pivoted in the yoke to provide for vertical deflection, and the sight itself rotates in the sight mount to provide for lateral deflection.



Computer unit with control panel. This faces the gunner and fits between his legs, so that controls are readily accessible during combat

Optical System

The optical system of the sight provides a reticle consisting of a solid ring of light with a dot in the center. This ring of light is variable in size to provide a means of determining the range of the target. The size of this reticle ring is controlled by means of the foot pedal through a flexible shaft. At the same time that the foot pedal varies the size of the reticle ring it also positions the range attenuator in the computer unit, thus automatically setting the correct range into the computer without the gunner having to know the range at all. All the gunner has to do is to keep the reticle ring just encircling the target.

Use of a solid ring of light is an innovation. Previous stadiometric range finders used in gunsights have consisted of two vertical lines which are adjustable in spacing, or in some cases a variable-size ring of 7 or 9 dots has been used. A solid circle of light is highly advantageous because planes may assume almost any attitude during attack. With only two vertical lines as a guide it is difficult to determine the proper range unless the target is horizontal. With a circle of dots, which because of mechanical reasons must consist of an odd number of dots, it is difficult to range under any conditions because there are never at any time two dots opposite each other.

Computer Unit

One other factor which enters into the range computation is the wing span of the target airplane. To eliminate mechanical linkages this factor is put into the K-8 computer electrically by means of potentiometers in the lateral and vertical deflection circuits.

The computer unit is mounted between the gunner's knees where it is out of the way and yet where all of the controls are readily accessible. The computer unit contains the attenuators used in the computing network, the velocity generators, the reversing switches, the gearing to drive velocity generators and attenuators, and the necessary controls for the system.

As previously mentioned, the velocity generators and azimuth gun elevation attenuators are driven by means of flexible shafts connected to turret gearing, and range is put into the computer automatically by operation of the foot pedal. Indicated air speed and altitude are set in manually by means of controls located on the computer unit. It is not necessary to have these factors put in automatically since they do not vary appreciably during combat. Wing span of the target is also set in manually by means of a control located on the front of the computer unit. All controls are provided with indirect illumination. This illumination together with the sight light is variable in brilliancy by means of a rheostat located on the computer unit. This permits use of the unit under any lighting conditions or even at night, when visual activity must be maintained by reducing artificial lighting to an absolute minimum.

Power Supply Unit

The power supply contains the amplifier previously described, and the four-phase alternator for supplying the thyratrons. It also contains the permanent-magnet network generators and a motor for driving them. This motor also drives the four-phase alternator.

The network generators are especially designed units. Each has two windings and a commutator on each end of the shaft to provide two direct voltage outputs per generator. Four generators supply the computing network and a fifth generator supplies the bucking potentiometer. A sixth dual output generator supplies the B and C voltages for the amplifier. A single casting provides the common end bell for all six generators, thus providing automatic alignment for each gear of the gear train driving the generator. All six generators are magnetized simultaneously in a special magnetizing jig especially developed for this particular unit. Each generator is magnetized to give exactly the right voltage output required for each of the networks.

All connections between the various units are electrical with the exception of the connection to the foot control, which is a flexible shaft. This gives a large amount of leeway in the adaptation of this sight to various turrets.

Performance Data

The electrical computing system described above has provided a material advance in the art of aircraft gunsighting, by extending the effective range of .50 cal. machine guns to more than 1,000 yards. Without it the maximum range at which hits might be expected has been only 400 to 600 yards, and even then the probability of obtaining a hit has not been very high. With this sight the number of hits approaches that obtained when firing at a stationary target from a stationary platform. When it is realized that a pursuit ship must come within 200 to 400 yards in order to score effective hits, it is readily apparent that the K-8 sight provides a really deadly defense against pursuit attack. In order to press home an attack a pursuit ship must fly through six or eight hundred yards of deadly accurate .50 cal. machine gun fire from the bomber.

Conclusions

Although the electrical computing system described above was developed primarily for use in an aircraft gun sight, it will have many other applications in post-war developments. It is particularly adaptable for complex problems involving several variables which are difficult or impossible to handle by mechanical means. In fact, the more complex the problem and the more variables involved, the greater the necessity for use of an electrical system to obtain an accurate solution without time lag and with a minimum of equipment and expense.

Since many of the parts are standard radio equipment and a large part of the assembly work consists of wiring the various components, it is obvious that considerably less skilled help is required in the manufacture of electrical computers than for equivalent mechanical systems, resulting in lower first cost and cheaper maintenance.

The K-8 sight is designed for operation from a 26 to 32-volt d-c power supply. However, an a-c computer has been developed for commercial use. This eliminates much of the rotating equipment required for the d-c system, with consequent further reduction of mechanical parts. Many other improvements in methods of computation, component parts and production methods have recently been developed, all of which will result in even greater accuracy.

The K-8 electrical computing gunsight was conceived by Irving W. Doyle, a Fairchild engineer, and the problem was worked out in cooperation with the author.

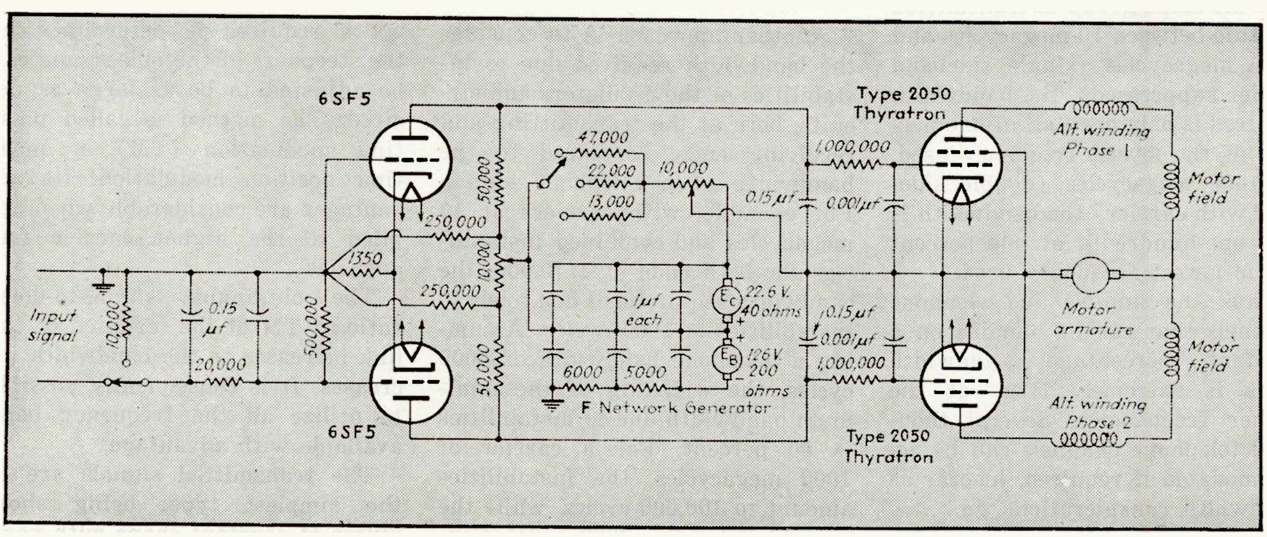


FIG. 3—Servo amplifier circuit used in the K-8 gunsight

PULSE-TIME

A new type of radio transmission, in which the carrier consists of pulses, and the time interval between the pulses is varied in accordance with modulation. The system takes advantage of inherently wide bands available at uhf, and improves signal-to-noise ratio

TRANSMISSION utilizing the higher frequencies poses a problem not involved with the lower frequencies: how to take advantage, from a transmission viewpoint, of the much wider bandwidths per channel which are available. The elements of such signals as telegraph, telephone, and facsimile, when transmitted by amplitude modulation, do not require the electrically available bandwidths.

An approach to the problem is to estimate the bandwidth required by the signal as a percentage of the carrier frequencies, and to decide whether, in view of the number of channels required, one can justify intensive packing of the channels.

A group of twelve telephone channels properly segregated, on a single sideband and an amplitude modulation basis, occupies a bandwidth of approximately 50 kilocycles. In the transmission of this group over a pair of wires between 10 and 60 kilocycles, the bandwidth is five times as large as the lowest frequency used.

If the same group is transmitted by radio between 10 megacycles and 10.05 megacycles (single sideband carrier suppressed), the bandwidth required is only one-half of one percent of the lowest frequency used. At 1000 megacycles (double sideband with carrier) the bandwidth is only one-hundredth of one percent of the lowest frequency used.

Thus the number of telephone channels that can be handled on a constant percentage bandwidth basis is extremely large at the higher frequencies. Several thousand telephone channels can be accommodated if required, insofar as bandwidth considerations go.

Present-day telephony, telegraphy, and facsimile requirements, in most regions of the world, would not justify any such large numbers of channels. Hence, practical consideration of how best to utilize the available bandwidth presents a fundamental problem to communication engineers.

> **HISTORY**
>
> Pulse-time modulation was announced in France and England by A. H. Reeves and E. M. Deloraine, in 1937. In that same year experiments directed by E. H. Ullrich at the Paris laboratory of International Telephone and Telegraph Corp. indicated that TM had a signal-to-noise ratio 20 to 40 db better than AM. Experiments over a one-mile range in England in 1938 between a mobile transmitter and a fixed receiver confirmed these measurements. C. E. Brigham, technical head of Kolster-Brandes, Ltd., English IT&T affiliate, and W. A. Beatty studied practical applications in 1938 and 1939.

Circuit Instabilities

Another approach is to consider the bandwidth required due to instabilities of the oscillators and circuits, both at the transmitting and receiving ends, compared to the bandwidth of a telephone signal. For example, with carriers at 10 megacycles and combined instabilities for both ends of 1/10,000, the bandwidth requirement due solely to instabilities is 1000 cycles. Assuming a telephone bandwidth of 3000 cycles, the widening of the minimum bandwidth due to instabilities is 30 percent. For a carrier of 1000 megacycles, the instabilities amount to 100,000 cycles, while the signal band still is 3000 cycles. Consequently, the widening due to instabilities is equal to 30 times the telephone bandwidth.

To determine how to transform the telephone signal in such a way as to employ usefully a greater bandwidth than the original signal is evidently of considerable interest. The value of such a transformation is dependent on improvements in transmission and equipment.

One solution is the transformation of the speech signals into frequency-modulated signals. An improved signal-to-noise ratio can be obtained; the improvement, within limits, is proportional to the band-width used.

Pulse-Time Modulation

Another method of transmission applicable to telephony consists essentially of transmitting intelligence by pulses of constant amplitude and duration, the instantaneous amplitude of the voice being translated into variation of time intervals between successive pulses, the rate of this variation corresponding to the instantaneous frequency of the signal. The bandwidth required is determined by the steepness of the pulses, and can be adjusted to be as large as desired. The method is called pulse time modulation (TM) or pulse time position modulation. Its advantages are considerable when applied to the higher carrier frequencies.

The obtainable signal-to-noise ratio of TM at the terminal of the link increases as the bandwidth increases. It is consequently possible to utilize all the frequency band available with advantage.

The transmitted signals are of the simplest type, being short pulses of constant shape with variable timing. The system introduces

MODULATION

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New York, New York

the possibility of reducing considerably the influence of parasites of artificial origin, and the possibility of increasing considerably the signal-to-noise ratio of the link on the sole condition that the maximum potential due to noise is lower by a certain quantity than the maximum amplitude of the received pulses. If the noise amplitude is greater than the signal pulse amplitude, then there is the possibility of time modulating during part of the pulse interval only, and of eliminating the majority of the interference by blocking the receiver except during the extremely short interval when the pulses are actually transmitted. Also, the impulses can be given additional characteristics which permit them to be separated from the noise.

Of the various types of time modulation considered one presents the possibility of using one series of pulses in fixed time position and another series that is time modulated, the interval carrying the intelligence. It is possible to suppress the fixed pulses, giving an economy in power and the possibility of providing more channels in a multiplex distributor system. These fixed pulses are reproduced locally at the receiver and synchronized by suitable synchronizing pulses transmitted at comparatively large time intervals. Also, by use of rugged repeaters capable of operating on trigger action, the usual requirements for stability, distortion, and noise are reduced.

Tests were carried out in England over an experimental link about one mile long. The measured signal-to-noise ratio improvement at the receiver output was 20 db. Signal-to-noise ratio of 30 db on amplitude modulation was converted into a 50 db signal-to-noise ratio on double pulses. The 20 db separation was maintained down to a ratio of 15 db on amplitude modulation; below this figure the separation decreased.

Theory of Pulse Time Modulation

After the following general exposition, it seems useful to explain more in detail why pulse modulation improves the signal-to-noise ratio and to give some theoretical results showing quantitively how this improvement depends upon the frequency band used.

Generally speaking, a receiver for any type of modulation can be divided into the following sections:

a. A linear amplifier and detector;

b. A series of limiters introducing a fixed or adjustable amplitude gate;

c. A converter or demodulator restoring the audio characteristics of the original signal;

d. A series of audio filters eliminating all frequencies not used in the desired signal, followed by audio amplifiers which bring the signal to the desired level.

In an AM system, b does not ex-

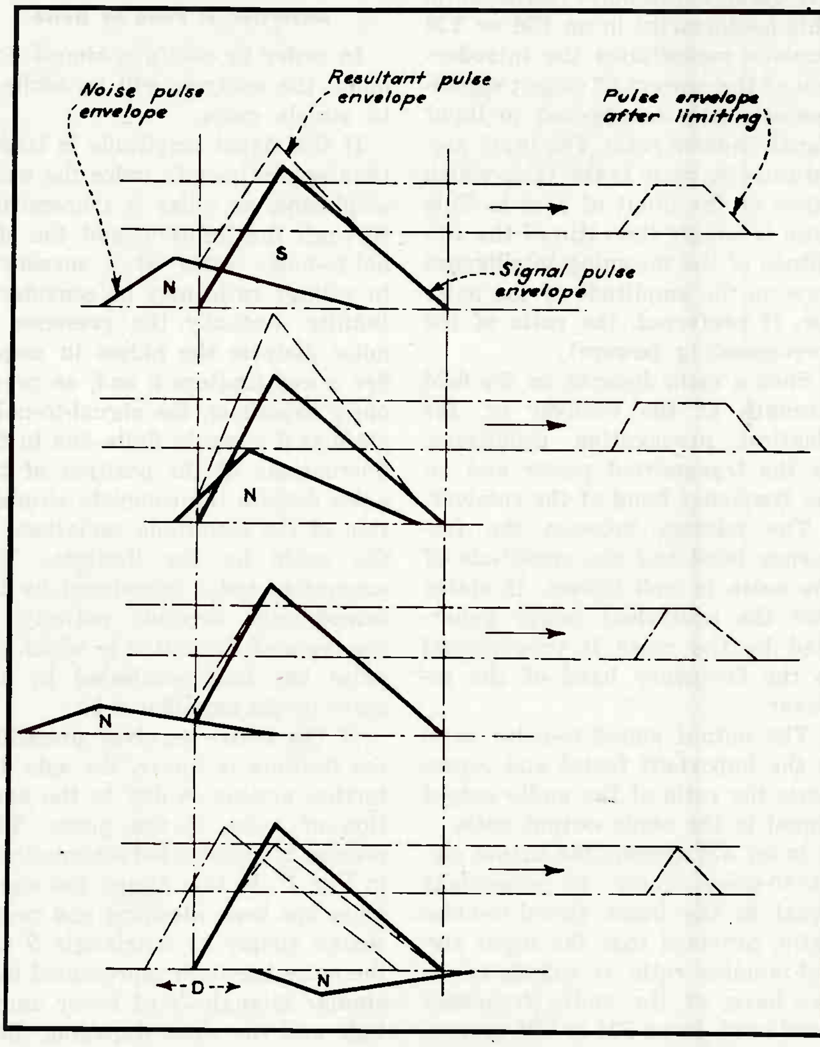


FIG. 1—The effect of noise on the final pulse shape and time position is shown in this illustration. Signal and noise are both shown as triangular pulses

ist and c is a linear detector which is usually included in a. In other words, in an AM system, the whole receiver can be considered as a linear system not only as regards the relationship between the output audio signal and the original audio signal at the transmitter, but also as regards the output and input signals.

In an FM system, part b generally precedes the linear detector of a, and part c is a discriminator.

In pulse modulation, b may procede or follow the linear detector and c is a special type of demodulator circuit not herein described.

The essential difference of TM and FM compared to AM is that the receiver is no longer a linear system. The relation between the audio output signal of the receiver and the audio input signal at the transmitter obviously must be linear but, in the receiver itself, non-linear devices considerably distort the signal-to-noise relationship. This nonlinearity in an FM or TM receiver necessitates the introduction of the concept of output signal-to-noise ratio as opposed to input signal-to-noise ratio. The input signal-to-noise ratio is the ratio which exists at the input of a or b. This ratio is simply the ratio of the amplitude of the incoming intelligence wave to the amplitude of the noise (or, if preferred, the ratio of the corresponding powers).

Such a ratio depends on the field strength at the receiver or, for identical propagation conditions, on the transmitted power and on the frequency band of the receiver.

The relation between the frequency band and the amplitude of the noise is well known. It states that the equivalent power generated by the noise is proportional to the frequency band of the receiver.

The output signal-to-noise ratio is the important factor and represents the ratio of the audio output signal to the audio output noise.

In an AM system, the output signal-to-noise ratio is essentially equal to the input signal-to-noise ratio, provided that the input signal-to-noise ratio is calculated on the basis of the audio frequency band used. In an FM or TM system, there is no such simple relationship between the output signal-to-noise ratio and the input signal-to-noise ratio.

The noise present in the receiver ahead of c does not, as such, generate any audio noise at the output of d. In an FM system the noise, in order to be audible, must affect the frequency of the signal applied to the discriminator. In the same manner in a pulse system, the noise in order to be audible must affect the positioning in time of the pulses. In other words, the noise is introduced in the system only through the fluctuations of the characteristic factor of the signal: amplitude fluctuation in AM; frequency fluctuation in FM; time displacement fluctuation in TM.

It is therefore clear that the output signal-to-noise ratio may be quite different from the input signal-to-noise ratio, depending on the way this transformation has taken place after the signals have travelled through b, c, and d.

Distortion of Pulse by Noise

In order to obtain a simple formula, the analysis will be confined to simple cases.

If the signal amplitude is larger than approximately twice the noise amplitude, no noise is transmitted through the limiters, and the signal-to-noise ratio at c measured in voltage ratio may be considered infinite. Actually the presence of noise distorts the pulses in amplifier a and limiters b and, as previously explained, the signal-to-noise ratio at d is again finite due to the fluctuations of the position of the pulse despite the complete elimination of the amplitude variations of the noise by the limiters. The amount of noise introduced by the demodulator depends entirely on the types of distortion to which the pulse has been subjected by the noise in the amplifier a-b.

If the entire receiver preceding the limiters is linear, the sole distortion arising is due to the addition of noise to the pulse. This process is represented schematically in Fig. 1. In this figure, the signal pulse has been idealized and represented simply by a triangle S and the noise has been represented by a similar triangle N of lower amplitude and the same duration. Representation of noise and pulses by triangles of the same shape is justifiable because the shape is actually determined by the frequency band of the receiver. Distortion introduced in the desired pulses by different noise pulses is indicated in this figure.

As a first approximation, disregarding the change in slope, the distorted pulse may be regarded as an additional pulse whose leading edge is advanced or retarded in time by an amount varying with the position of the noise pulse, but the maximum value of this displacement is proportional to the ratio of noise amplitude to pulse amplitude. This time displacement of the leading edge is converted in the demodulator into audible noise. In other words, any noise small enough in amplitude to be eliminated by the limiters will nevertheless generate an audible noise at the output of the demodulator through time displacement of the pulse front.

The amount of noise reintroduced at the output of the demodulator can be calculated in the simple case represented in Fig. 1. The noise amplitude after demodulation is proportional to the time displacement of the pulse front, while the desired maximum signal amplitude is proportional to the maximum time displacement D allowed in the system.

Calculation of Signal-to-Noise Ratio

Maximum time fluctuation of the pulse front is obtained for a relative position of the noise pulse and the desired pulse as represented in Fig. 2. Input signal-to-noise ratio as indicated in Fig. 2 is the ratio of the amplitude of the two pulses. The output signal is proportional to the maximum time displacement D; the output noise amplitude is proportional to the displacement of the pulse front.

In Fig. 2 this displacement caused by the noise is reprsented by the line $a'b'$, and can be calculated as a function of the input signal amplitude, the input noise amplitude, and the build-up time G of the signal pulse. From similar triangles $a'bb'$ and bcd,

$$cd/a'b = bd/a'b'$$

But

$$cd/a'b = (S/N)_{input} = G/a'b'$$

Solving for $a'b'$

$$a'b' = G(N/S)_{input}$$

The signal-to-noise ratio in the output is the ratio of the maximum pulse displacement D to the displacement of the pulse by the noise $a'b'$, hence

$$(S/N)_{output} = D/a'b'$$

Substituting the above expression for $a'b'$ in this last equation,

$$(S/N)_{output} = (D/G)\ (S/N)_{input} \quad (1)$$

Maximum time displacement D and the build-up time G can vary within relatively large limits and Eq. (1) therefore shows that, for the same input signal-to-noise ratio, the output signal-to-noise ratio may be quite different depending on the choice of D and G.

The above elementary calculations are presented as a simple demonstration of Eq. (1). The reasoning might not be considered entirely convincing since the output signal-to-noise ratio should actually be expressed in rms value while the calculations involving Fig. 2 are based on peak values. The peak value of the signal is quite clear; however, suitable selection of peak values of the noise is not so obvious. It has been found that the noise amplitude requiring consideration in Fig. 2, in order to approximate experimental values, corresponds to the mean square noise amplitude. The mean square noise amplitude is also the most probable one for normal noise voltage distribution.

The maximum possible time displacement D depends on the system used, but it is always a fraction of the time interval between two successive pulses. This time interval itself is determined by the maximum number of pulses required to reproduce correctly the highest signal frequency.

Effect of Signal Frequency

In a single-channel system, if f is the highest audio signal frequency to be reproduced correctly, the number of pulses is equal to $2f$ or $3f$ and, therefore, D is a certain fraction of $1/2f$ or $1/3f$. In a multi-channel system with n channels, the total number of pulses is $3nf$ and D is a fraction of $1/3nf$.

The time G in Eq. (1) is equal to the build-up time of the pulse and is directly related to the frequency band of the receiver if it is assumed that the transmitted pulse is steeper than that finally applied to the detector in the receiver. If the frequency band of the receiver is $\pm F$, the build-up time G is approximately related to the frequency band F by

$$G = 1/3F \quad (2)$$

For a single-channel system we can, as an example, assume that $D = 20$ percent of the period between successive pulses or

$$D = 1/10f \quad (3)$$

Expressing D and G in Eq. (1) with the values of Eq. (2) and (3), there results the equation

$$(S/N)_{out} = (S/N)_{in} \times 0.3F/f \quad (4)$$

Equation (4) shows that, for a given input signal-to-noise ratio

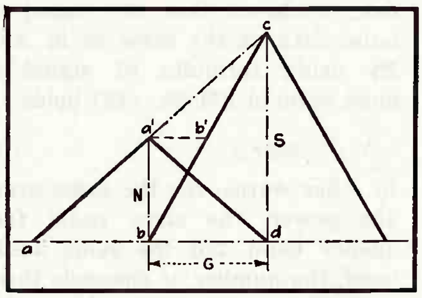


FIG. 2—By representing the signal and noise pulses as isosceles triangles, the relation between input and output signal-to-noise ratios can be determined by geometry

and for a given audio signal spectrum, the useful output signal-to-noise ratio is proportional to the frequency band F used by the system.

In order to compare these results to the signal-to-noise ratio obtainable in an AM system, it seems proper to assume the same average power in both cases. It then becomes relatively simple to calculate the input signal-to-noise ratio for the pulse system as a function of the input signal-to-noise ratio for the AM system. For the complete computation, certain assumptions concerning the pulse shape and its rms value are necessary.

Regardless of these assumptions, an equation of type (5) applies. In this equation K is a numerical factor dependent on the pulse shape and also on the crest factor of the noise.

$$(S/N)_{input\ TM} = K(S/N)_{input\ AM} \quad (5)$$

This equation merely expresses the fact that, when the pulses become narrower and the average power is maintained constant, the peak power is increased in the same proportion as the frequency band and the input noise power so that the input signal-to-noise ratio remains constant. The input signal-to-noise ratio for a pulse system with a given average power is therefore roughly equal to the signal-to-noise ratio for the same average power with an AM system.

When the pulses approach the ideal case of a triangle with a decay time and build-up time equal, the factor K is close to 1.5. With this value of K, by comparing Eq. (5) with Eq. (1) and remembering that in an AM system the output signal-to-noise ratio is the same as the input signal-to-noise ratio, the ratio of the TM signal-to-noise ratio to that of AM is obtained:

$$(S/N)_{output\ TM} = (S/N)_{AM} \times 1.5D/G \quad (6)$$

In Eq. (6), D and G could in turn be expressed as functions of F and f in order to derive

$$(S/N)_{output\ TM} = (S/N)_{AM} \times 0.45F/f \quad (7)$$

Equation (7) applies only for the special choice of time displacement D made in conformation with Eq. (3). For a different value of D as a function of f, the numerical factor of Eq. (7) would be different but the form of the equation would not change. Although from Eq. (7) it appears possible to use TM with a frequency band F only twice the frequency f, practical consideration limit F to a lower limit several times higher. Nevertheless this relation expresses in a quantitative manner the fact that the signal-to-noise ratio obtained in a pulse modulation system is proportional to the ratio F/f of the total frequency band used to the frequency band of the signal. This relation is similar to that for FM.

One of the interesting aspects of pulse modulation is expressed by Eq. (6) and (7): the use of a wide frequency band gives a gain in signal-to-noise ratio.

Furthermore, with pulse modulation, especially at very high carrier frequencies, problems of modulation at the transmitter are greatly simplified and, in such cases, the use of a large frequency band is in itself justified by normal operating conditions.

Pulse modulation has been proposed mainly for multi-channel operation. For such operation pulse modulation allows time selection as opposed to frequency selection, and it is expected that time selection may have merits when compared with frequency selection.

Multi-Channel Operation

It might be expected that multichannel operation with pulses would necessitate a very large frequency band since the frequency used for a single channel is large. Contrary to usual multi-channel operation based on frequency selection, it should be emphasized that the total bandwidth in pulse modulation is essentially independent of the number of channels. The bandwidth is determined by the build-up time of the pulses and not by the number of pulses. In principle, the number of potential channels can be calculated as a function of the total frequency band and the spectrum of the signal.

Assuming an ideal case where the pulse width can be kept as small as twice the build-up time G, also that the guard time between extreme positions of two successive pulses of different channels can be reduced to three times the build-up time G, then the maximum time displacement D possible for each channel is such that the unmodulated time interval T between two successive pulses is determined by

$$T = 2D + 2G + 3G \quad (8)$$

If now it is assumed that the signal-to-noise ratio per channel is the same as in a corresponding AM system of the same average power per channel, then Eq. (6) gives a relation between D and G, i.e., $D = 2G/3$. Using this value in Eq. (8),

$$T/G = 19/3 \quad (9)$$

But T is related to the number of channels N and to the frequency band of the signal f by

$$T = 1/3f(N + 1)$$

The factor $N + 1$ has been introduced rather than N to take into account the marker pulse. The build-up time G is related to the total signal band-widths by Eq. (2) and therefore Eq. (9) yields

$$N + 1 = 3F/19f$$

For N large with respect to 1,

$$N_{TM} = 0.158F/f, \quad (10)$$

where N_{TM} is the number of channels for time modulation.

It is interesting to compare Eq. (10) with similar equations for AM or FM transmissions. For AM, assume that each channel is transmitted by single sideband amplitude modulation of a subcarrier, that a guard band of $1/3f$ is allowed between channels and that transmission is effected by double sideband amplitude modulation of the main carrier. Under these conditions, Eq. (11) holds.

$$N_{AM} = 0.75F/f \quad (11)$$

For FM assume that transmission of separate single-sideband amplitude modulated channels is accomplished by frequency modulation of the main carrier with an index so chosen that the signal-to-noise ratio is the same as in AM. By using formulas of signal-to-noise ratio in FM Eq. (12) holds:

$$N_{FM} = 0.35F/f \quad (12)$$

In other words, for the same average power, the same radio frequency band and the same audio band, the number of channels theorectically possible with pulse modulation is only $\frac{1}{5}$ of what is can be with AM and $\frac{1}{2}$ of what it can be with FM transmissions.

As an example, if the maximum modulating signal is 3 kilocycles, and the total radio frequency band is ±3 megacycles, the possible number of channels for each modulation method is: $N_{AM} = 750$, $N_{FM} = 350$, $N_{TM} = 150$.

At first sight these figures appear very favorable to AM. However, a number of channels as large as 750 could hardly be handled in an AM system because the non-linear distortions introduced by the repeaters would be in excess of acceptable values.

FM transmission would facilitate the problem of distortion in the repeaters but would not entirely eliminate it. The non-linearities of tube characteristics are the main difficulties in AM transmission and a similar difficulty exists in FM due to the non-linearity of the phase response of the circuits.

Improved Repeater Performance

For pulse modulation, there is no source of distortion due either to tubes or to circuit characteristics as long as the frequency band is large enough to reproduce correctly the build-up time. Even from this viewpoint, repeater requirements necessary for pulse modulation are not very severe inasmuch as it is not essential in pulse modulation to produce faithfully the shape of the pulse. In other words, for multichannel transmissions operating with a large number of relays, pulse modulation, in principle, has a fundamental advantage: distortions introduced in the different repeaters are not cumulative. The only effect of additional repeaters is to increase the noise if the frequency band of the repeater is not sufficiently large.

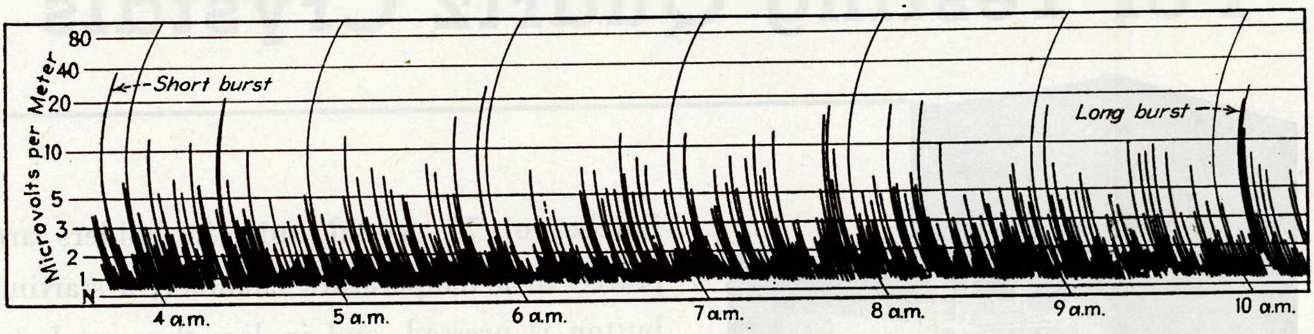
It should be stressed that the above formulas, especially Eq. (10), are only approximate and are based on certain assumptions that may or may not be practically obtainable under actual operating conditions. Nevertheless, only the numerical factor of Eq. (10) could be different. The fundamentally important aspect of this equation is that of number of channels is proportional to the ratio F/f.

The numerical coefficient in Eq. (10) assumes specifically that the signal-to-noise ratio for each channel is the same as in AM. If it is desired to increase the signal-to-noise ratio, it can be done either by increasing the time displacement allowed for each channel and keeping the steepness of the pulse the same (which means that the total frequency F is left unchanged), or by maintaining the displacement the same and increasing the steepness of the pulse (which means that the total frequency band F is increased).

In the first case, the number of channels possible with the same frequency band F would be smaller. In the second case, the number of channels would be the same but the frequency band needed would be larger. This flexibility of the pulse modulation system is of great practical advantage.

While the foregoing outline covers only the broadest aspects of pulse time modulation technique, it will be appreciated from the discussion that this type of modulation opens far-reaching possibilities in the field of transmission using very high frequencies.

Typical signal strength recording, showing two distinct examples of bursts. This record was obtained at Laurel, Md. for f-m station WGTR 337 miles away at Paxton, Mass., operating on 44.3 Mc with power of 83 kw, during the early morning hours of Nov. 11, 1943 while Leonid meteor showers were near a peak. Signal strength at this distance is normally insufficient to give good aural reception. The accompanying account is abstracted from Exhibit 4 of the Frequency Allocation Hearings in Washington and is published with the approval of the FCC Engineering Department



Measurement of V-H-F Bursts

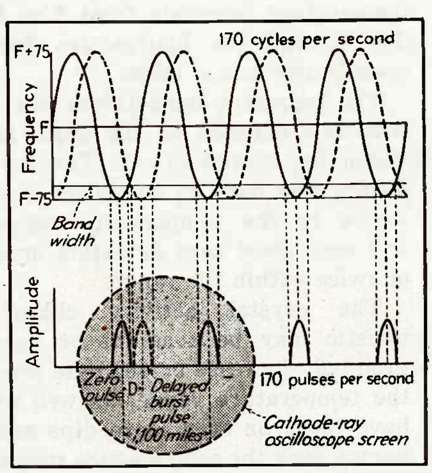
Sudden increases in strength of signals received beyond line-of-sight range are believed due to meteors passing through upper atmosphere. Pulse techniques gave path lengths

Continuous recordings of signal strength of selected f-m and television stations, made at distance ranging from 100 to 1400 miles, have at times revealed unexpectedly strong signals that could not be attributed to reflections from aircraft or to undulating tropospheric discontinuities. These signals, which have been designated as bursts, usually involve a sharp rise in signal strength over a period of a few tenths of a second, but occasionally the burst may be sustained for several seconds or more.

Measuring Path-Length of Bursts

In order to determine the propagation path-lengths of the burst pulses, a series of tests was made by transmitting a steady signal having evenly spaced reference pulses. When the path length for the momentarily strengthened signals or bursts is longer than for ground wave signals, these burst pulses appear between the reference pulses, and the measured path differences are a clue to the origin of the bursts.

The method of pulsing involved frequency-modulating the transmitter ±75 kc by a continuous 170-cycle tone. The f-m signal was received on a Hallicrafters S-27 receiver, the i-f output of which was fed to a Hammarlund Super-Pro receiver tuned to a narrow pass band at the lower end of the swing. The resulting sharp pulses were fed to the vertical plates of a cathode-ray oscilloscope. The horizontal sweep was set at one-half the tone frequency so that two reference pulses appeared simultaneously on the screen, as shown on the accompanying diagram. Any difference in path length D causes the burst signal to be delayed by a time interval D/c where c is the velocity of propagation, so that the pulse of the delayed burst occurs between the ground wave pulses.



Method used for measuring path lengths of v-h-f bursts

During the tests the path differences ranged from about 150 to 900 miles, corresponding to total path lengths of from 350 to 1100 miles.

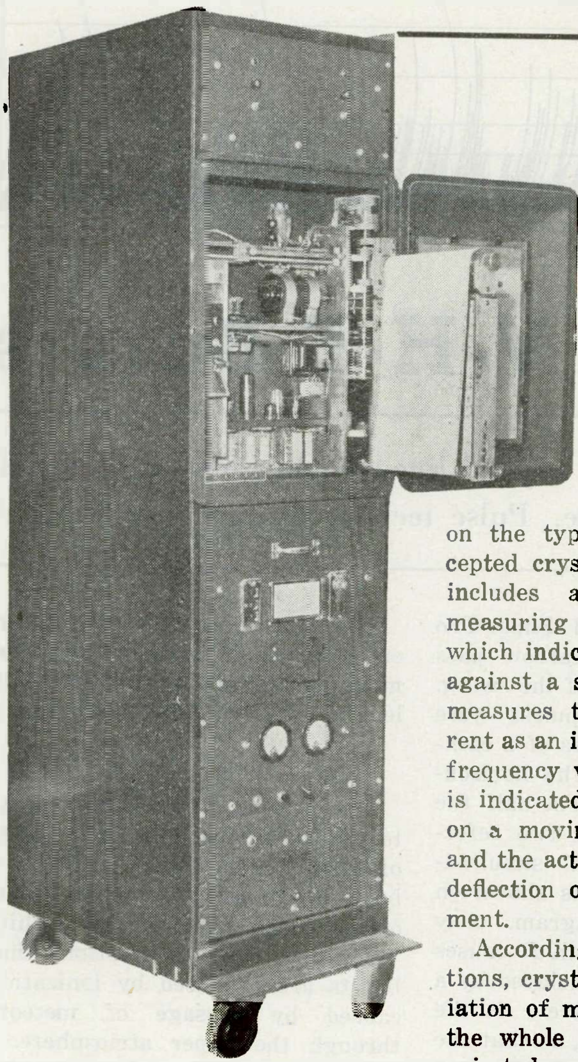
Cause of Bursts

The greater distances can be interpreted as reflections from media of height comparable to the E layer but lying to each side of the great-circle plane. This correlates quite well with the assumption that bursts are produced by ionization caused by passage of meteors through the upper atmosphere.

Visual correlation of bursts and meteors was obtained by engineers on several nights. In one instance a brilliant meteor with a persistent visible train was observed along the plane of the signal path, with sufficient inclination of the track to reflect the signal back at an acute angle, and the increase in signal strength was sustained for about ten seconds.

Bursts have also been recorded at Laurel, Md. on 71.75 Mc from television station WRGB. They are less frequent than at 44.3 Mc, and have a shorter average duration. Engineers have concluded, however that bursts are not sufficiently prevalent to impair the usefulness of that portion of the v-h-f spectrum in which they occur.

Multiple X-Y Recorder For Testing Quartz Crystals



View of complete crystal test equipment, with the recorder at the top (with door open), the temperature chamber directly below, and the electronic equipment at the bottom

Batches of 71 crystal units in holders are placed in a temperature chamber, a starting button is pressed, and in less than an hour this new electronic crystal recorder delivers 71 sets of curves, each showing frequency-deviation and activity plotted vs temperature

QUARTZ crystals have to pass specified production tests regarding activity and frequency variation over a wide range of temperature. To make these tests a large number of crystals, 60 or more, is arranged on a rotary table and placed in a cold chamber, which is cooled with dry ice to −40 or −50 deg C. By passing warm air into the chamber, the temperature is slowly increased, at a specified rate not exceeding 3 or 5 deg C per minute, to a maximum temperature of 50 or 90 deg C, depending on the type. The universally accepted crystal testing apparatus[1,2] includes a frequency deviation measuring circuit (cycle counter) which indicates the beat frequency against a standard frequency and measures the oscillator grid current as an index of activity. Thus a frequency variation of 2000 cycles is indicated by a current of 2 ma on a moving coil d-c instrument, and the activity is indicated as the deflection of a 0–1 ma d-c instrument.

According to one set of specifications, crystals with frequency variation of more than 1840 cps over the whole temperature range are rejected, as well as crystals with an activity below 0.260 ma at any temperature. Readings are made at temperature intervals from 2 to 5 deg C, and the figures are frequently put into a table.

The frequency-temperature characteristic depends on the angle at which the crystal is cut. The frequency may have its maximum anywhere in the temperature range and may show zero deviation once or twice within the range.

The crystal activity characteristic may be constant or may gradually increase or decrease over the temperature range, as well as have three or even more dips and humps over the temperature range.

To trace a diagram which gives an accurate picture of a crystal's characteristics, such as that in Fig. 1, 10 or even 20 points are not sufficient; at least twice as many are necessary. Automatic plotting of the two curves appears highly desirable, and simultaneous plotting of both curves automatically for each crystal in a large batch during a single run of a cold chamber constitutes a goal long sought in the crystal industry. With the development of the electronic X-Y recorder to be described, this goal has been achieved.

Function of an X-Y Recorder

An X-Y recorder traces on a chart the relation of two variables, neither of which is time. A typical X-Y recorder is the old steam engine indicator or the modern cathode-ray oscilloscope.

There are true X-Y recorders, such as the one to be described and the given examples, and there are pseudo X-Y recorders, in which the chart is moved in proportion to

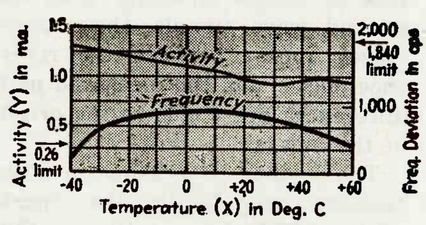


FIG. 1—Example of type of graph desired in production testing of quartz crystals, showing both activity and frequency deviation plotted against temperature

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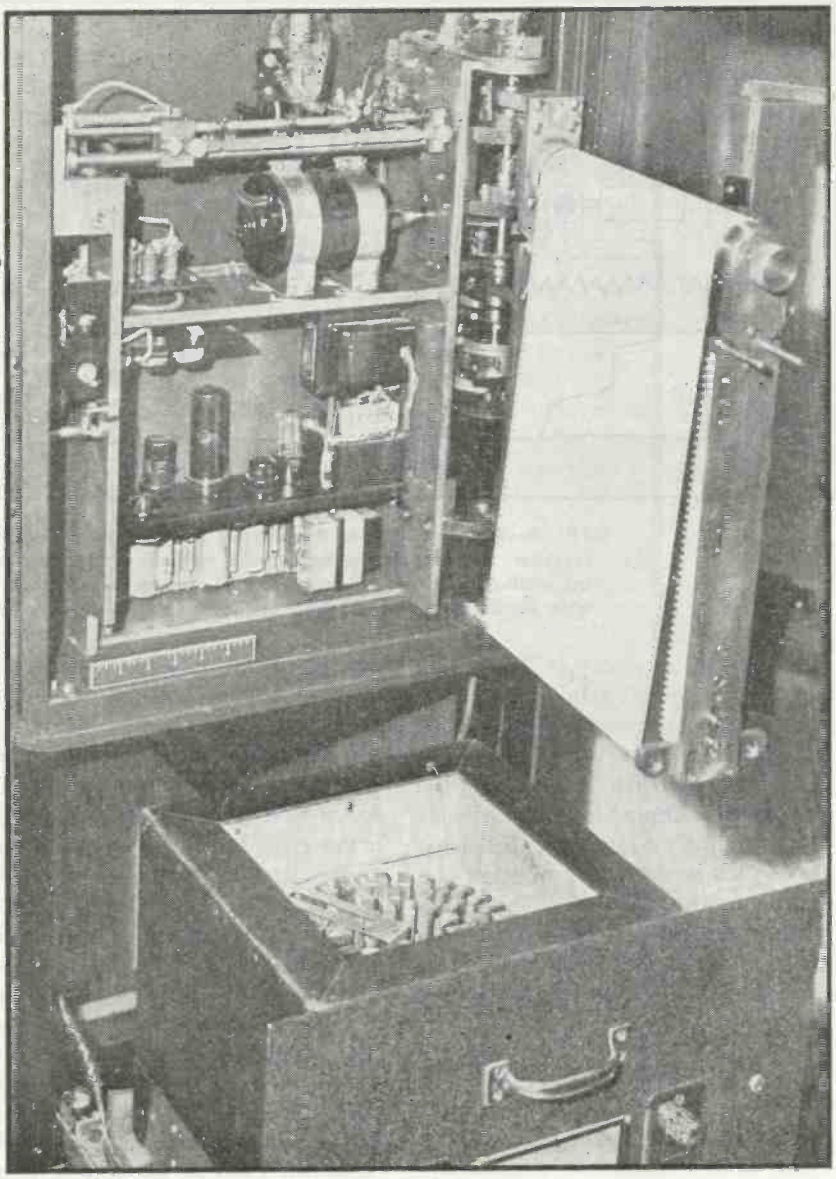
time and one of the variables is so controlled that it too increases in proportion with time. An example of this type is a viscosity-temperature recorder equipped with a temperature controller, raising the temperature of the liquid under test in exact proportion to time.

No X-Y recorder has been known so far which traces two curves simultaneously, two different magnitudes versus a third one, and especially not tracing a large number of diagrams for the same number of samples under test.

X-Y recorders would be useful for many industrial problems,[3] but the design was considered difficult because the moving of the paper surface (generally a drum) required high controlling forces. These forces may be available in such X-Y recorders as stress-strain recorders for tensile testing machines, but not generally, especially not in electrical instruments.

By using what can be called sweep-balance principle,[4] this difficulty is easily overcome. In one of the various designs, a continuously rotating drum is covered with voltage-sensitive paper, known as Teledeltos paper and used for facsimile recorders. A black mark is produced on this paper when an electric discharge is passed through the paper at the moment of balance corresponding alternately to the frequency or activity value to be recorded, while the position of the stylus along the axis of the drum is adjusted by the second magnitude, which in this case is the temperature.



Closeup of recorder, with chart carriage swung out and the crystal-holding drawer pulled out from the temperature chamber

Automatic Wheatstone Bridge Recorders

The sweep-balance system of recording applies a measuring principle which can be best explained by going back to the elements of design and the existing types of recorders, as used for recording on strip charts.

In the ordinary Wheatstone bridge, with one resistor arm used as a resistance thermometer, the slide wire contact is adjusted by hand until the null galvanometer (generally of the moving-coil type) goes to zero. The position of the contact is then read on a scale alongside the slide wire. As long as 30 years ago this adjustment was done automatically in regular time intervals by means of a step-by-step motor-controlled movement. Recorders of this type are widely used for temperature measurements with thermocouples and resistance thermometers. In a multiple recorder the time between two recordings is between 10 and 20 seconds.

The next step in recorder development (as far as potentiometric recorders are concerned) was the continuous balance recorder with an amplifier and null motor in the diagonal of the bridge for the adjustment of the slide contact, as indicated in Fig. 2(a). The motor is only moving when there is a change of the magnitude to be measured, and the motor is running to bring the contact to the balance point with variable speed, slowing down when coming near the balance point. Recorders of this type have also been known for many years. A twin recorder for power factor and capacitance of high-voltage dielectrics, based on this principle, has been described.[5]

The highest speed obtained with

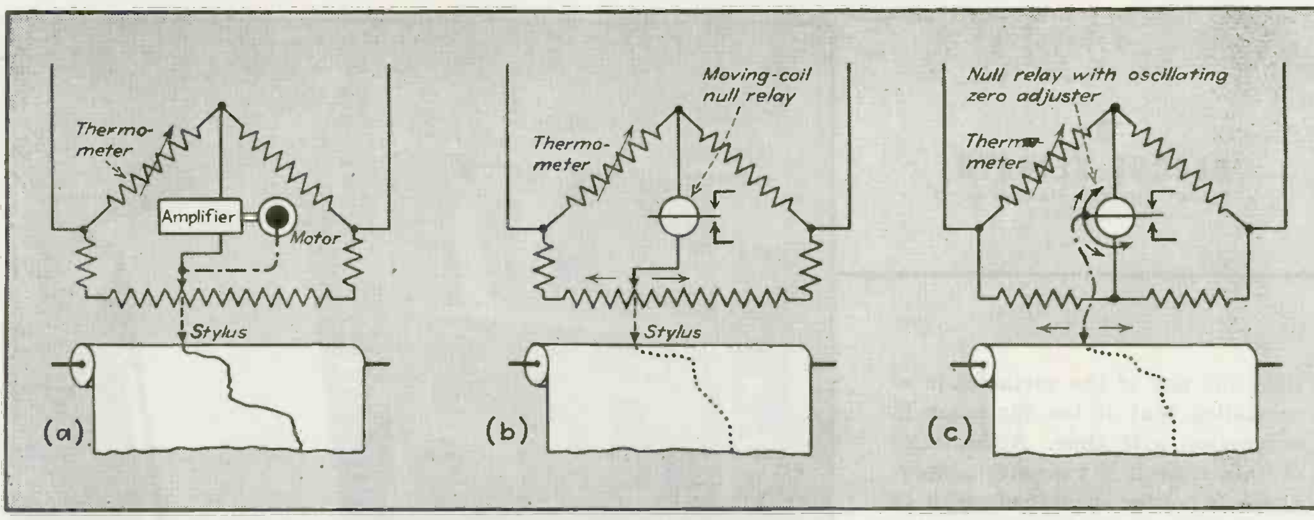


FIG. 2—Basic circuits for three types of Wheatstone bridge recorders. Null motor recorder with reversible motor and continuous balance is at (a); (b) represents an oscillating sweep-balance recorder, while (c) shows a sweep-balance recorder with oscillating relay as used in the multiple X-Y recorder for quartz crystal units

this type of recorder is about one second between two recordings from different transmitters. Damping problems and hunting problems increase with the speed. The design is simple for low speeds (ten seconds or more for full-scale travel) irrespective of whether d-c or a-c power is used. This null-motor principle is applied for the positioning of the stylus of the new crystal recorder according to temperature.

Sweep Balance Recorder

With the sweep-balance recorder shown in Fig. 2(b), the balance point of the bridge is neither approached step by step nor by a continuous motor movement stopping at the balance point. Instead, the motor-driven contact is swept with high speed along the full length of the slide wire. The slide wire contact moves a stylus over the recorder paper, with the stylus always representing the position of the slide wire contact. In the diagonal of the bridge is a moving-coil null relay, with contacts close together symmetrically to the null position. For greater sensitivity, the relay may be connected to the bridge through an amplifier, which need not have constant amplification factor.

During the first part of the sweep, up to the balance point, the upper contact of the relay is closed and a capacitor is charged from a d-c source of 200 to 300 volts. Within a short time (for the highest recording speed, within less than 1/1000th second upon approaching the balance point, and for low recording speeds within less than 0.1 percent of the time for one recording cycle) the contact arm moves to the lower contact and closes the discharge circuit. The resulting discharge from the stylus to the electrolytic paper takes place in less than 1/1000th second.

Because the time of charge and discharge is very small in comparison to the period of the sweep and some time is left at both ends of the slide wire, there is always enough time to complete the charge of the capacitor even at the lowest points of the scale. After the charge is completed, the relay contacts separate with no voltage difference and no current flowing, and close again for the discharge over a high resistance. It is a perfect null method of recording, wherein the sensitivity of the relay and its amplifier (if used) in the diagonal is without influence.

Oscillating Spring-Relay Recorders

The sweep balance principle can also be applied in another way, simplifying the recorder to some extent but sacrificing the null method feature. The slide wire and the sliding contact of the bridge circuit are replaced by two fixed resistors, as in Fig. 2(c). The relay in the diagonal is the same moving-coil relay with zero center and two contacts. But the zero adjuster is movable—by means of a motor—from the position where the coil, without current in it, is in the middle between the two contacts, to a position where only an electromagnetic countertorque to the mechanical spring torque (equal to the unbalance current in the diagonal for the full desired range) brings the needle again to the zero position between the contacts. The zero adjuster is oscillating with a maximum angle of about 60 degrees through the one angular position of the zero adjuster where the needle is free between the contacts. A stylus is mechanically connected to the zero adjuster, and produces a mark on the recording paper each time the adjuster passes through the balance position, much as in Fig. 2(b).

The oscillating spring recorder is not operating with a null method, but is using a deflection method with the possible errors of all deflection methods. Its accuracy is determined by the mechanical torque of the spring and the absolutely linear torque characteristics of a moving-coil ammeter, both of which have very small temperature errors. The scale characteristic is given by the spring and, if properly designed, is fully proportional. This is better than with a deflection ammeter, where the scale divisions depend on the uniformity of the flux along the airgap.

When the full angular movement of the zero adjuster is completed, it has to snap back to the null position. To save inactive recording time, this back move is made in a much shorter time than the forward move (about 15 percent of that time).

Adaptation for Current Recording

Instead of using the oscillating spring system in a bridge circuit for recording a resistance change such as that occurring in the resistance thermometers of Fig. 2, this system may just as well be used for recording a current. If the current to be measured is not a continuous direct current, but consists of short impulses with zero current between them, a null method could not be employed anyhow, at least not with a high-speed zero indicator. The current output of the frequency counter in the present testing equipment is of this intermittent nature.

The position of the oscillating zero adjuster at which the mechanical torque balances the electromagnetic torque developed by the coil is marked by the capacitor discharge through the stylus. Oscillating spring recorders can work with a maximum current of one milliampere or less if necessary. The mechanical oscillation, however, limits the speed. So far, three sweeps per second have been made successfully with the oscillating relay. In the present crystal recorder the sweep takes 0.833 second, including the return to the starting position.

The sweep-balance recording system can be adapted to any electrical or mechanical measuring problem, as long as both or at least one of the magnitudes can be transformed into electrical currents or voltages. Since they operate without ink, all sweep-balance recorders can be used at extremely high or low temperatures without any difficulty. The mechanism is simple and, except for the electromagnetic relay, there are no delicate parts. In some sweep-balance recorders an electronic relay can be used, eliminating all motion except that between stylus and paper and the movement of the balancing mechanism.

Design of the Crystal Recorder

In designing the crystal recorder for industrial use, it was decided to use a temperature chamber for 72 crystals and trace 72 diagrams at the same time. A net height of one inch per diagram was considered sufficient and the total height of one diagram was chosen to be 1.25 inches. The diagrams had to be traced on an endless strip of Teledeltos paper with a total length of $72 \times 1.25 = 90$ inches. The length of one diagram, representing the temperature range, had to be in a reasonable ratio to the height, and not much over 2 inches.

In order to get full freedom for the design of other recorders, a standard-size recording paper with 10-inch net width was selected and the instrument was designed so that four groups of 72 diagrams each were traced side by side, one group after the other on the 10-in. chart, as shown in Fig. 3. The long endless loop of paper had to be folded back and forth several times on idler rolls to fit into a recorder case of normal size. A large number of sprocket pins are in constant engagement with the paper, so it is possible to move the same sheet of paper several hundred times around without tearing the holes in the paper.

One complete paper cycle is made in 60 seconds, leaving 0.833 second time per crystal to mark zero line, frequency and activity with three points, each by the discharge of a capacitor. For frequency, a larger capacitor is used than for activity, to make the frequency curve heavy and the activity curve light.

In the arrangement of Fig. 2(c), both stylus and zero adjuster are

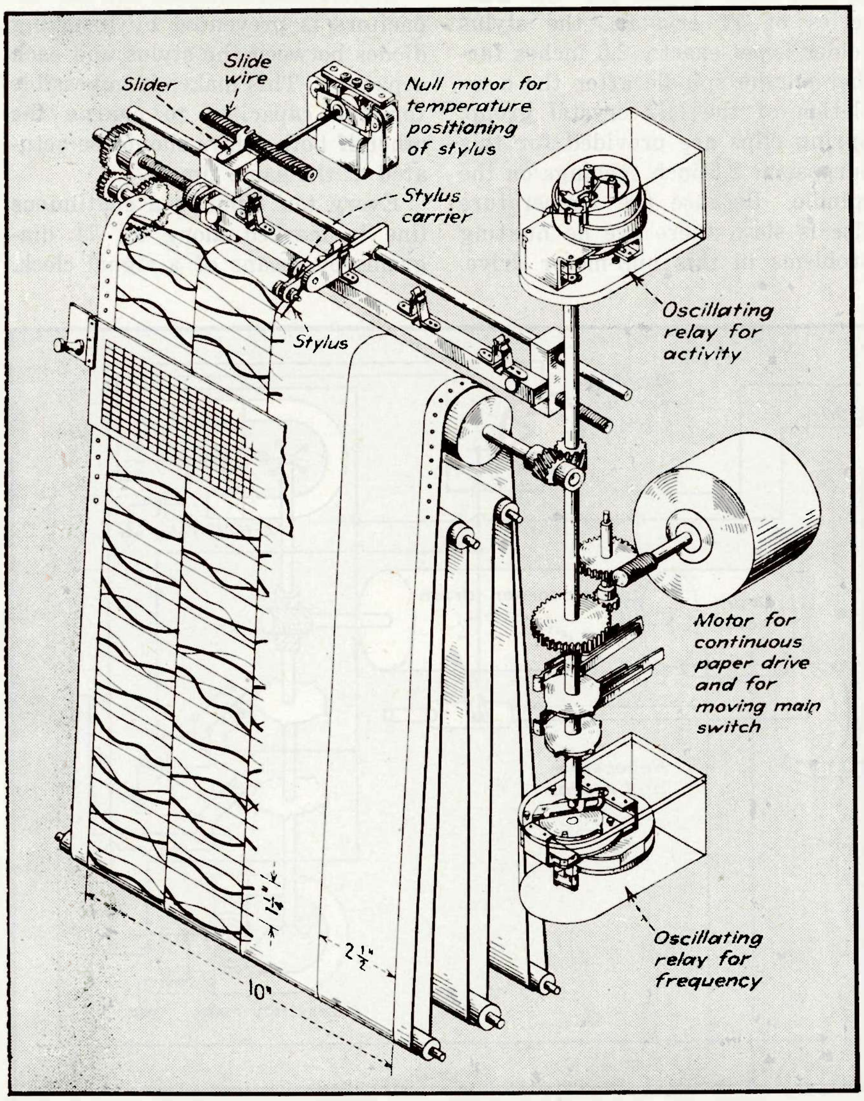


FIG. 3—Isometric drawing of the chart section of the crystal recorder. During each complete cycle of travel of the endless-loop chart, the stylus burns black dots at correct positions on the frequency, activity and reference curves for each of the 71 diagrams occupying one vertical row on the chart

oscillating, and the recording is made on a line at right angles to the direction of the paper movement. In the crystal recorder, however, frequency and activity have to be recorded in the direction of the paper movement and only the zero adjuster has to oscillate while the paper moves under the stylus with a constant speed of 1.5 inches per second.

Circuits Employed

This problem was solved as shown in Fig. 3. There are two oscillating relays, both operating in synchronism with the paper movement, with one cycle of each corresponding to 1.25 inches of paper travel. A relatively strong motor moves the paper with constant speed. The motor also moves the zero adjusters, and gives the signals (by means of cam-actuated contacts) to operate a solenoid ratchet mechanism that connects the next crystal on the turntable in the temperature chamber into measuring position during the time the oscillating relays move back to zero position.

One of the 72 crystals was replaced by a resistance thermometer consisting of 500 ohms of fine nickel wire, arranged in the same case used for the crystals, so that its thermal time constant would be the same as that of a crystal. (This explains why the industrial version of the recorder makes 71 rather than 72 diagrams at a time.) The resistance thermometer, connected in a 60-cycle bridge circuit as indicated in Fig. 4, was the transmitter for the null-motor drive of the stylus across the paper. The three-stage amplifier in the diagonal of the Wheatstone bridge has an output of about 5 watts maximum and is connected to the rotor of the reversible null motor. The travel of the stylus for the full temperature range is 2.5 inches.

To use the next section of the 10-inch wide paper for the next series of 71 crystals, the stylus holder is set exactly 2.5 inches farther on the spindle after the completion of the last crystal group. Spring clips are provided for this purpose at 2.5-inch spacings on the spindle. Because the temperature rise is slow, there are no hunting problems in this null-motor drive.

The motor for the paper drive also serves to wind the springs of both moving-coil relays by means of a crank which rotates a five-star wheel, so that synchronism of a relay movement over 72 degrees and paper movement over 1.25 inches is obtained. The paper moves from the zero line (marked by a capacitor discharge) to the maximum relay deflection, and from there to the next zero line.

Somewhere on this travel, according to the currents in the two moving coils, the discharge from each of the corresponding capacitors is passed through the one stylus. This marks the paper with two points, frequency and activity, at the temperature measured and placed on the diagram by the null-motor drive.

Interference between the two capacitors is prevented by inserting diodes between the stylus and each capacitor. This makes it impossible for one capacitor to charge the other if both relays should be actuated at the same time.

Every ten minutes a continuous line is marked along all 71 diagrams by means of a signal clock.

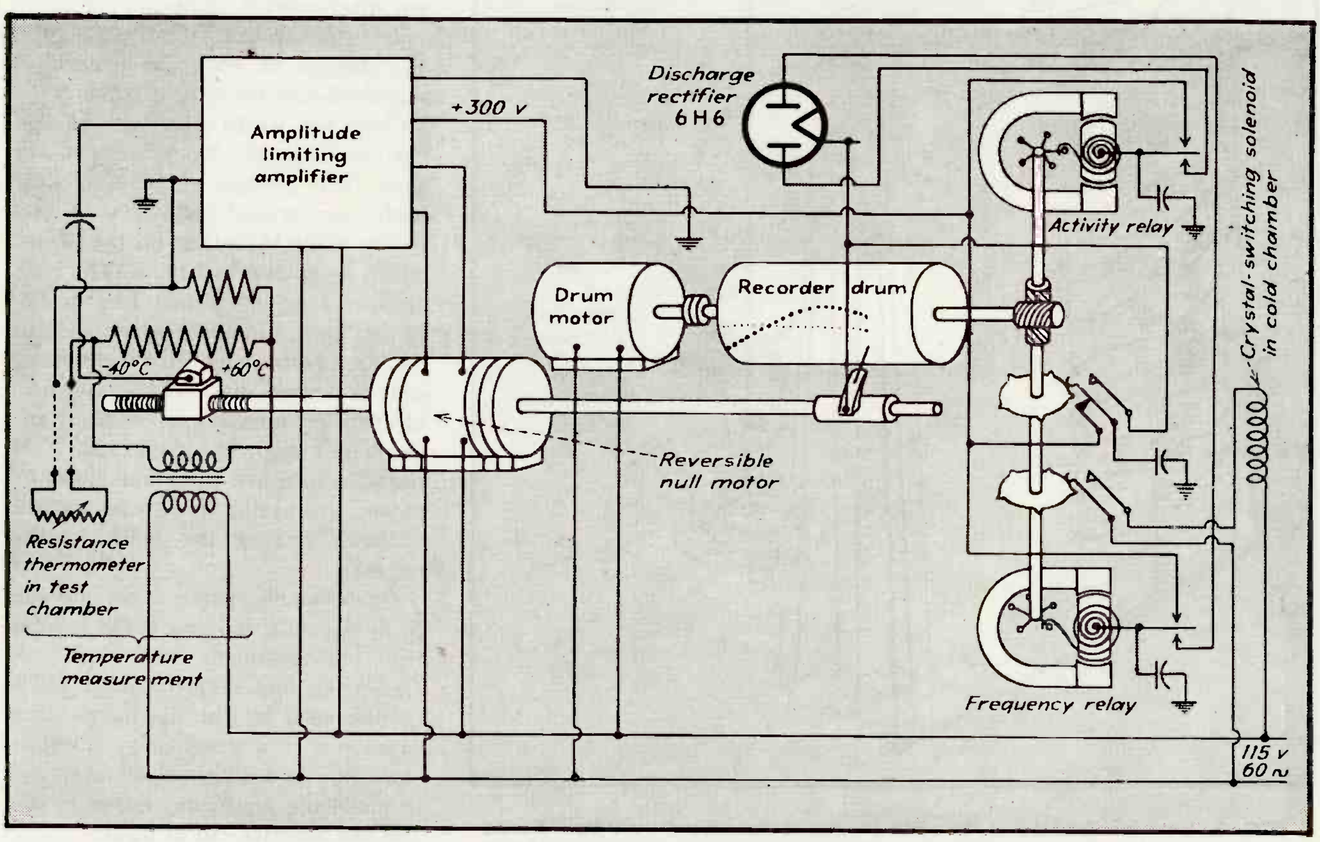
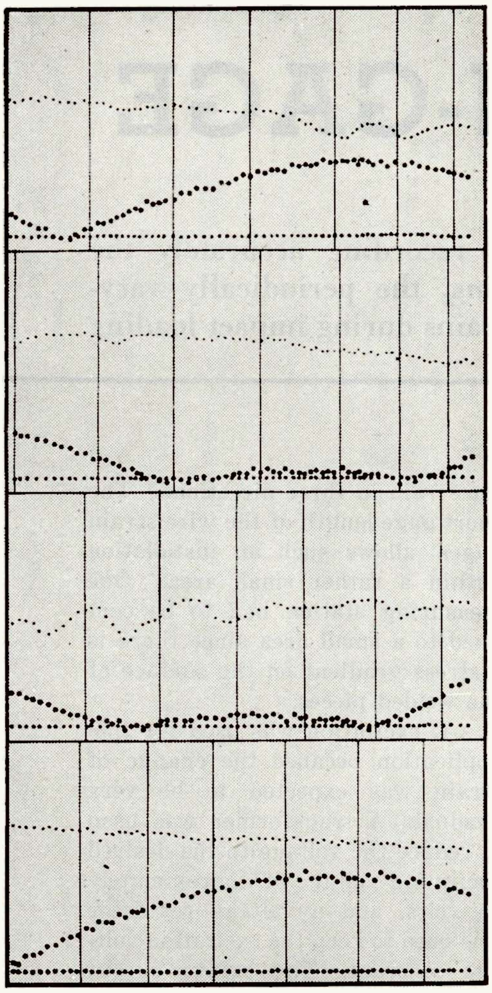


FIG. 4—Circuit arrangement of the recorder. The two oscillating relays close the capacitor discharge circuits at correct instants to plot activity and frequency values for each crystal in turn



Full-size reproductions of four of the diagrams plotted by the recorder. These diagrams were taken at random from different columns of the strip chart, hence the vertical 10-minute traces do not line up

This interrupts each diagram recording every ten minutes for 0.833 second. In this way the diagrams also include a record of the rate of temperature increase, to show whether the rate of rise was within the specification limits.

The frequency deviation diagrams are plotted without regard for the sign of the deviation. Instead of crossing the zero line, the curve therefore seems to be reflected at the zero axis. The general shape of the curve (whether convex or concave towards the zero line) therefore indicates whether the crystal is above or below the reference standard.

The shape of the activity curve is affected by a number of factors. Carelessness in the edging (beveling) operation may produce dips at certain temperatures. Reworking may eliminate such dips and permit salvaging of such crystals.

Generally low activity curves, especially towards the high-temperature end, can in many cases be traced to insufficient cleaning of the crystals after final lapping, the embedded dirt particles restricting free oscillatory movement. Activity curves that show a general drop below freezing temperature are usually indicative of moisture in the sealed holder. In such cases crystals can be salvaged by more careful drying after opening the holder.

Quality Control Applications

The crystal recorder was originally built to meet unusual requirements. Probably never before has a recorder been built to trace 71 two-curve X-Y diagrams at the same time by plotting automatically more than 4000 measurements, immediately visible, in less than one hour. No fundamental difficulties arose, although some improvements of a mechanical nature had to be made.

From the standpoint of crystal production supervision the result was also highly satisfactory. One set of 71 crystals was tested a number of times over a considerable period of time. The curves were all fully identical in all their details, giving proof of the satisfactory accuracy of all measurements.

Over and above its originally intended application, the recorder was found useful as an aid to quality control in production. The temperature at which the frequency maximum occurs indicates the angle at which the wafer was cut, the influence for a B-T cut crystal being approximately 30 deg C per angular degree variation around the freezing point.[1] A series of 71 diagrams shows at a glance what care has been taken in production to maintain the orientation angle within given limits.

In mass production of crystals the effect of certain changes in manufacturing procedure can be verified only by running a comparatively large batch of test units, so that observed results can be averaged. The recording method described lends itself particularly to this purpose owing to the wealth of information obtained in each picture.

Since a temperature run, if made in 45 minutes for instance, provides frequency and activity curves each made up from 45 measuring oints, such curves can be considered to be equivalent to continuously recorded curves in which a single crystal is observed while subjected to a steadily changing temperature. Due to this almost ideal continuity, undesirable dips or humps can hardly escape detection as sometimes happens during manual testing at a necessarily limited number of temperatures.

It has been the practice to open up tolerances if the spacing of the temperatures at which measurements are made is decreased. It appears, therefore, that it might be safe to increase inspection tolerances further if, through the use of an automatic recorder like the one described, the ideal condition of continuous testing can be approached more closely. Opening up tolerances would increase the efficiency of crystal manufacturing as expressed in the number of acceptable finished crystals per pound of raw material, thereby helping to conserve a commodity the procurement of which has been under heavy strain in the past.

Acknowledgement

In December 1942 Mr. R. K. Hellmann suggested that for the solution of this crystal testing problem an adaptation of the sweep balance recorder described in this paper be used. With his assistance and under his supervision such a recorder was designed and built at the Connecticut Telephone & Electric Division and its workability proved in collaboration with the crystal manufacturing department of the same company. Mr. Hellmann assisted in evaluating the tests which were performed and in compiling other data used in the preparation of this article.

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Practical STRAIN-GAGE

Electronic techniques speed material and design testing, by recording accurately the slowly varying strains due to temperature changes in welding, the periodically varying strains in turbine bucket metal and the rapidly changing strains during impact loading

THE demands of the war have forced engineers to create new designs with higher and higher efficiencies. This has meant, in many cases, an increase in the speed of rotating machines, an increase of temperature in thermal machines, and a better utilization of materials in almost any kind of apparatus. Better utilization of materials was achieved by an increase of the stresses to values approaching the safe limit. Much apparatus used in combat is subjected to impact loads, and engineers were forced to build apparatus which continued to function despite severe mechanical impacts.

With time at a premium, new methods had to be developed for testing sample designs speedily.

These tests involve, in a large number of cases, measurements of static and dynamic strains for the determination of the breakage strength of a material, for the determination of the damping factor, for the determination of the modulus of elasticity, etc.

Advantages of Strain Gage

The wire strain gage[1, 2] was found to be a suitable tool for many of these measurements due to its small size, its low cost, and the ease with which it can be attached to the test pieces. These gages are either attached to the sample under test or are made an integral part of the test equipment.

Three typical strain gage applications will be described. One deals with slowly varying strains due to temperature changes encountered in welding operations; another involves the periodically varying strains occurring in an oscillating tuning fork; the third deals with rapidly changing strains encountered in impact loading.

Stresses During Welding Operation

To study the proper sequence in the welding of complex structures, welding engineers were interested in obtaining a record which showed the magnitude of the stresses within the welded structure during the welding operation. For establishing a suitable measuring technique two plates were joined by an arc-weld as shown in Fig. 1.

Wire strain gages were selected for the measurement since the surface was not to be defaced to install the gages. It was also desirable to measure the stress in at least two dimensions; this requires the use of three strain gages for measuring the strain in three directions.[3] The short gage length of the wire strain gages[4] allows such an installation within a rather small area. One measuring station had to be confined to a small area since there is a stress gradient on the surface of the welded pieces.

A-C excitation was used for this application because the change of strain was expected to be very gradual. A transformer was used to reduce the voltage to the desired excitation voltage of approximately 25 volts, and a voltage regulator was used to keep the excitation voltage constant. The bridge output voltage was amplified, rectified, and fed to a photoelectric recorder[5] that was able to follow frequencies up to approximately 5 cps.

One problem encountered was the temperature change to which the gages were subjected due to the heating of the metal. Gage resistance varies during welding due to

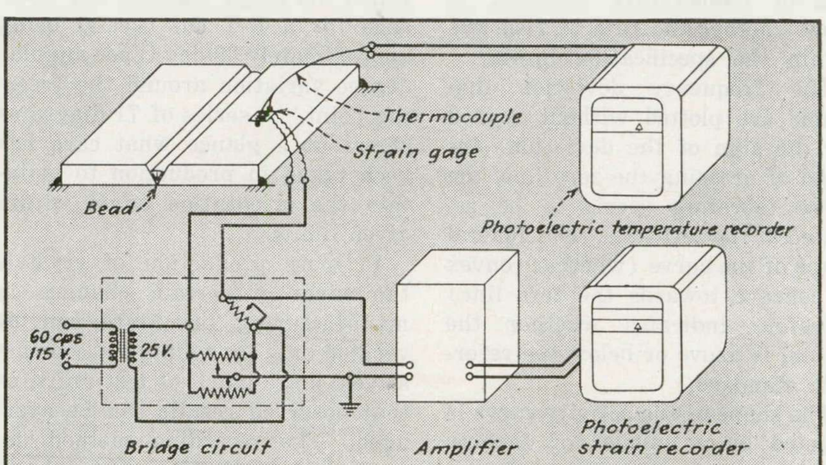

FIG. 1—Setup used for measuring stresses occurring during welding operations

From a paper presented before the National Electronics Conference, Chicago, 1944.

APPLICATIONS

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the difference in the coefficient of thermal expansion of the base material and the gage wire and due to the change in resistance of the gage wire with temperature. The temperature limit of commercially available gages was found to be approximately 400 deg F.

For many applications where the forces are in only one direction, such as strain measurements in bars subjected to compression, the effect of those temperature changes can be cancelled by using two gages to measure the strain in two directions perpendicular to each other.[2] These two gages are connected into the two arms of a bridge circuit in such a way that the resistance changes due to the applied load add up, while the resistance changes due to temperature changes cancel.

The arrangement just described could not be used for this application since the forces acted in various directions. Tests made on steel specimens showed, however, that the resistance change of the gage was a function of the temperature, and this function was found to be the same for a large number of gages. A calibration curve based on this function showed that the resistance change was caused exclusively by the difference in the coefficients of thermal expansion of the steel and the filament material.

A temperature record was drawn for any instant of the welding operation, by a second photoelectric recorder connected to a thermocouple which was imbedded close to the center of the gage. The resistance change due to the temperature change was determined for any instant by means of the above-mentioned calibration. This resistance change was deducted from the recorded resistance change. The resulting curve corresponds to the actual strain and stress in the welded specimen.

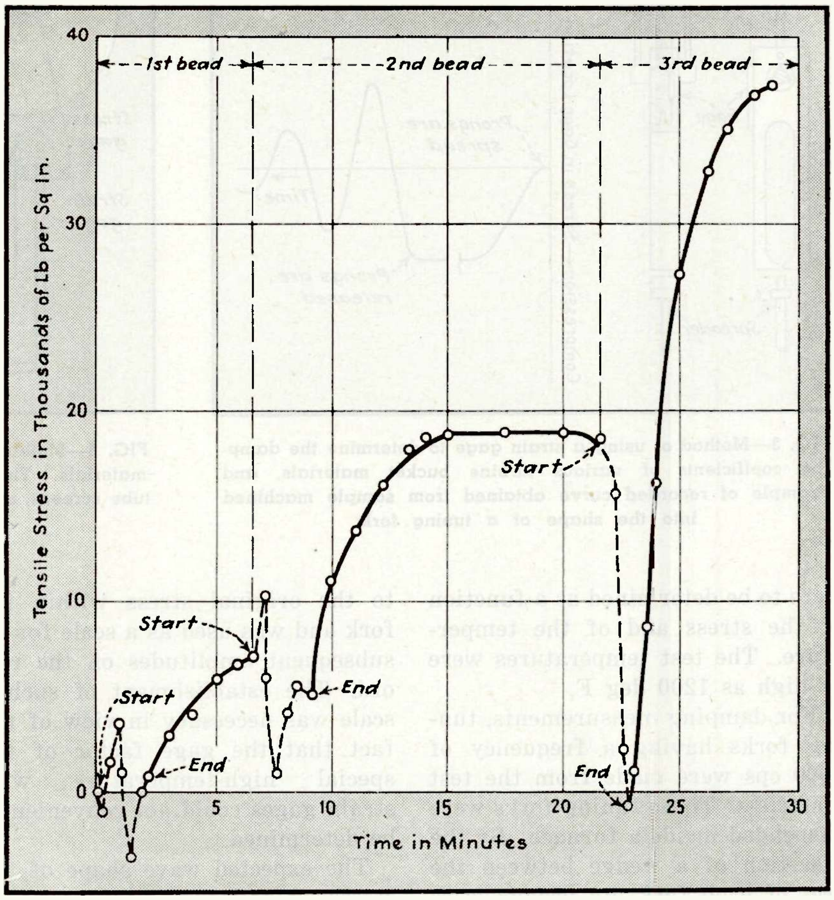

FIG. 2—Variation of stress with time in a sheet of 3/8 in. low-carbon steel as obtained with the equipment shown in Fig. 1, using a model SR4-AB5 bonded type strain gage developed by Baldwin Locomotive Works

An example of such a time-stress curve for a welding operation is shown in Fig. 2. After the first bead was completed, the stress increased until the second bead was begun. When the metal was heated again, the strain was reduced to approximately zero. After completion of the second bead and subsequent cooling of the material, the stress increased again, this time to a higher value. This was expected, since the second bead covered a larger section of the welding groove. During the next heating period, due to drawing of a third bead, the strain again decreased to approximately zero, and then increased to a still higher value during the subsequent cooling period. (This time it reached a value even above the yield point of the material.)

Damping Coefficient Measurements

Turbine designers desired to know the damping coefficients of various bucket materials. In general, the higher the damping coefficient of a material, the lower are the stresses which may occur in a structure due to resonant vibrations excited by the same periodic forces. The damping coefficients

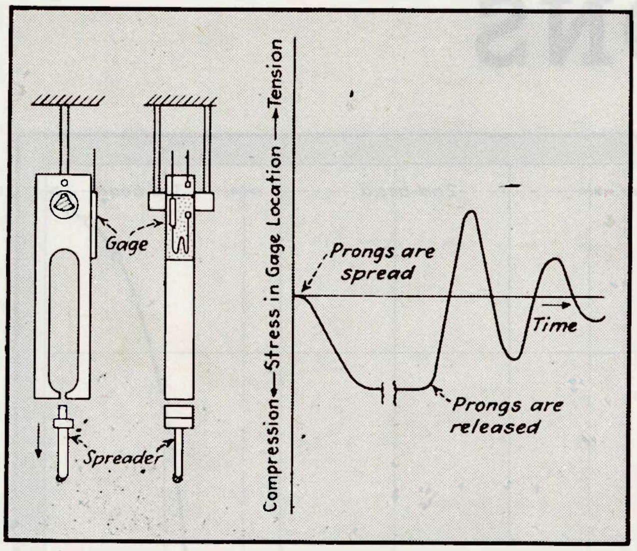

FIG. 3—Method of using a strain gage to determine the damping coefficients of various turbine bucket materials, and example of recorded curve obtained from sample machined into the shape of a tuning fork

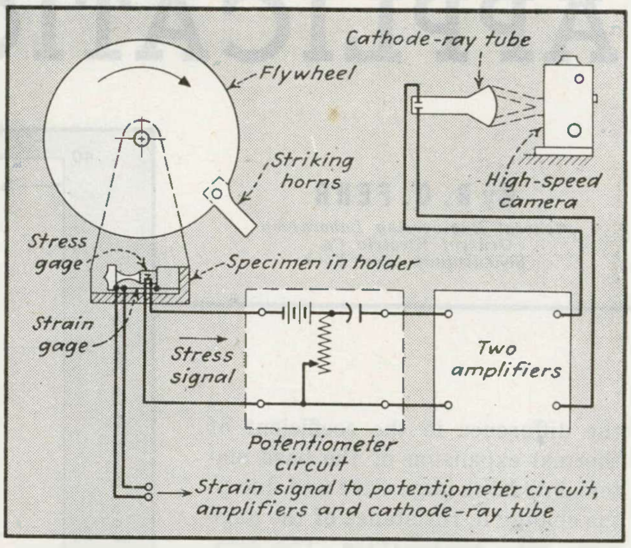

FIG. 4—Method of determining dynamic breakage strength of materials. The camera simultaneously photographs three c-r tube screens, one of which has a timing wave. Total duration of each test is half a millisecond

were to be determined as a function of the stress and of the temperature. The test temperatures were as high as 1200 deg F.

For damping measurements, tuning forks having a frequency of 1000 cps were made from the test materials. These tuning forks were suspended inside a furnace. By the insertion of a wedge between the feet of each fork, its prongs were stressed to a pre-determined value. This stress was then suddenly released, and the decrease of the vibration amplitude was measured by special high-temperature wire strain gages[6] attached to the prongs of the fork as shown in Fig. 3. The rate of decrease of vibration amplitude was a measure of the damping coefficient.

The vibration frequency was within the frequency range of the commonly used voltage amplifiers, and hence d-c excitation of the strain gages was used. The output voltage of the strain gage circuit was amplified and recorded by a magnetic oscillograph[7].

The associated equipment had to be designed for a true recording of the first amplitude of the oscillation which followed the transient caused by the sudden release of the stress within the tuning fork, because this amplitude corresponded to the original stress within the fork and was used as a scale for all subsequent amplitudes on the record. The establishment of such a scale was necessary in view of the fact that the gage factor of the special high-temperature wire strain gages could not conveniently be determined.

The expected wave shape of the stress which was to be recorded is shown in Fig. 3. The stress is increased when the prongs of the tuning fork are spread apart, and when this stress is suddenly released, the prongs begin to oscillate around their normal position.

For an analysis, the stress or the output signal of the gage could be segregated into a square wave and a damped oscillation. The signal due to the damped oscillation was desirable for recording, while the signal due to the square wave did not contribute to the determination of the damping co-efficient. The time constant of the circuit, therefore, was made very low so that the signal due to the square wave disappeared after a very short time and thus did not interfere with the desired record of the damped oscillation.

A convenient check of the circuit response to square waves was obtained by connecting a square-wave generator[8] to the input terminals of the circuit and recording the signal.

The results obtained with the equipment described above have been recently published elsewhere.[4] It was found that for steels, such as SAE-1020 and SAE-4140, the damping coefficient increased many times with increasing temperature, and that the damping coefficient also increased with increasing stress.

A by-product of those measurements was the determination of the modulus of elasticity, which was determined from the resonant frequency of the fork for various temperatures. For the materials mentioned above, the modulus at 1000 deg F was approximately 80 percent of the modulus at room temperatures.

Measurements of Impact Strength

For rational design of apparatus subjected to impact, the dynamic impact strength of the materials used for the design should be known. At the present time, designs of apparatus are mostly based upon the static characteristics, even when the apparatus is to be subjected to impacts. When the dynamic breakage strength is lower than the static breakage strength, the apparatus may not withstand the impact, and when the dynamic breakage strength is above the static value, the weight of the apparatus may be unnecessarily high.

To help answer this question, stress versus strain measurements were made on test bars which were torn apart at high velocities. The machine[9] used is diagrammed in Fig. 4. The flywheel was brought up to the desired impact speed, and the striking horns were released. The tup at the end of the test specimen was struck by the striking horns, and the specimen was torn apart.

To obtain the dynamic stress versus strain curves, two quantities were measured. These quantities were the stress and the strain.

For the measurement of the stress, a wire strain gage was cemented to the specimen in a larger-diameter section in which the elastic limit was not exceeded. The stress in the smaller test section, in which breakage occurred, was then obtained by calculations using the value of the strain measured in the larger section.

For the measurement of the strain, a single Nichrome wire of 2-mil diameter was stretched parallel to the specimen. The two ends of this wire were attached to the two ends of the test bar. The resistance change of such a wire due to elongation[10] is linear up to its point of breakage.

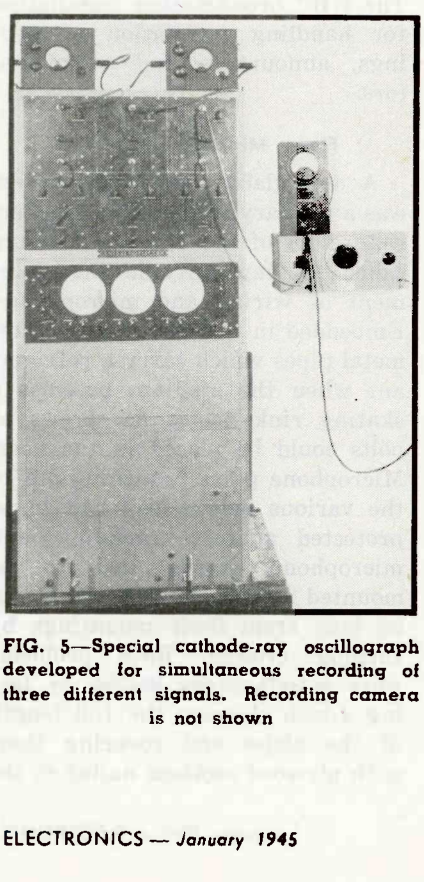

FIG. 5—Special cathode-ray oscillograph developed for simultaneous recording of three different signals. Recording camera is not shown

The stress in the test bars increased to its maximum value in approximately 40 microseconds, and the complete time for the breakage did not exceed half a millisecond. The true recording of this fast signal demanded amplifying and recording equipment which could follow a rapid rate of change in voltage.

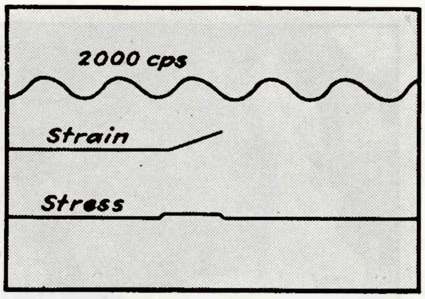

FIG. 6—Typical oscillogram of dynamic stress and strain measurements. Striking velocity here is 50 ft per sec, and sample is Dural 17ST

D-C excitation was applied to the strain gages, and voltage amplifiers with frequency response at least up to 50,000 cps were used. It also had to be made certain that a square-wave signal did not excite any oscillations of the circuit elements.

For the interpretation of the records, it was necessary to have three traces on the film: the stress signal, the strain signal, and the timing wave. The encountered frequencies were beyond the range of available magnetic oscillographs, and hence the cathode-ray oscillograph shown in Fig. 5 was used for simultaneous recording of three signals. The amplifiers were part of the oscillograph, and had a total gain of 120 db. There were two amplifiers for each channel, and each amplifier had its own attenuator. Cabinets on top of the oscillograph contained the potentiometer circuits and the batteries for d-c excitation of the gages.

The screens of the cathode-ray tubes were photographed with a high-speed camera of the continuous drive type, such as is used for filming with stroboscopic lights. This camera was loaded with spools holding from 50 to 100 feet of film, and the film was run with a maximum speed of 100 feet per second. This gave a running time between 1 and 1½ seconds.

The timing of the high-speed camera was done with good success by the operator. Later a contact-making device was installed which saved film. A short section of unexposed film was inserted in a 100-foot roll of old, exposed film.[11] The camera motor was then synchronized in such a way that the unexposed film passed behind the lens just when the breakage of the specimen occurred. A typical record is shown in Fig. 6.

To mention some of the results obtained by this test,[12] the dynamic strength and the dynamic breakage energy of Dural (17ST) and Steel (SAE-X-1112) increased approximately 30 percent when the striking velocity was increased from 0 to 100 feet per second.

The author is indebted to Miss H. M. Morris and Mr. R. M. Rood of the General Electric Company for their assistance with the measurement of stresses due to welding.

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Broadcasting POLITICAL

Technical report on radio facilities installed at Chicago Stadium for use by the four major networks that covered the Republican and Democratic conventions, with details of equipment and operating procedures. A guide for planning future convention coverage

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Now that the full cycle of routine has been completed for the 1944 conventions of both political parties, a technical report can be rendered that tells of a job well done and also serves as a pattern for 1948.

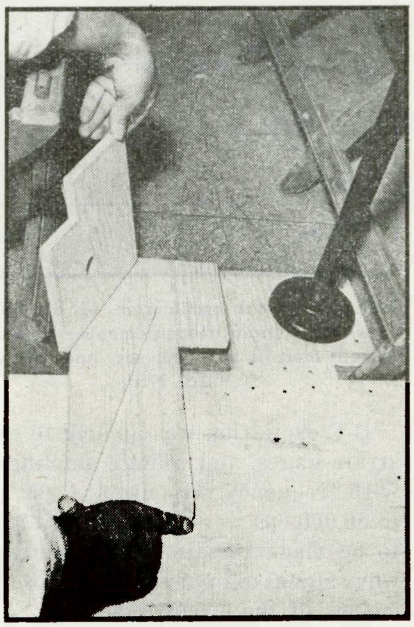
Use of the same auditorium in Chicago for both Republican and Democratic conventions simplified the over-all radio arrangements. By common consent, it was agreed that physical plans approved by the Republican committee would be acceptable to the Democratic party leaders.

Equipment Procuring Problems

The group assigned to the 1944 convention project by the National Broadcasting Company began serious consideration of engineering plans early in January 1944. At a meeting of technical representatives of the four major networks, it was decided that NBC would install and operate the extensive delegation floor microphone system, apply to WPB for priorities, and place orders for all necessary materials, the total cost to be divided between the networks.

No time was lost. To the WPB a few days later went applications for 64 RCA 88-A microphones, 2,000 feet of DT-10 cable and 20,000 feet of No. 19 lead-covered twisted pairs. An order was placed with the Illinois Bell Telephone Co. for the network's convention communication system in Chicago, comprising four 5-trunk, 12-station boards in the Chicago Stadium and the Stevens Hotel, interconnected by local wire lines.

The network's owned and operated stations and its division headquarters were combed for vital control units. NBC offices in Hollywood, San Francisco, Denver and Cleveland supplied amplifiers and short-wave equipment. Fortunately, 5,000 feet of No. 19 twisted rubber-covered lead-covered cable for microphone circuits and 2,000 feet of DT-10 cable for the floor microphone system were available from vendors when needed.



Two-part wood base for microphone stand, with grooved channel for shielded microphone wires

What appeared at first to be one of the most difficult problems was solved when the WPB granted a priority on the 64 microphones, on condition that they be returned to the manufacturer after the conventions had ended and reconditioned for use by the military forces.

General Arrangements

To obtain sufficient space for radio booths of equal size was the first construction problem. Investigation showed that only 37 feet were available for this purpose between two stair wells in the mezzanine, directly behind the speaker's stand on the south side of the stadium. However, by moving the front of the booths to the rear of the stair wells, 49 feet of space was obtained between the aisles. This location restricted the headroom, but this difficulty was solved by building the booth floor on three different levels and by using the plaster underside of the mezzanine as the booth ceiling.

As can be seen from Fig. 1, the convention radio installation comprised two separate sections: (1) The delegation floor microphone system, feeding all networks, the public address system, local broadcasting stations, recording firms and the sound film companies; (2) The NBC broadcasting installation for handling convention proceedings, announcers and commentators.

Floor Microphone System

A dependable, safe floor system was a primary essential but the terrazzo floor of the Chicago Stadium called for ingenuity in the placement of wiring and microphones. Embedded in this floor were hollow metal pipes which carry a refrigerant when the stadium becomes a skating rink, hence no screws or bolts could be placed in the floor. Microphone pairs branching out to the various delegations had to be protected against trampling, and microphone stands had to be mounted rigidly so they would not be torn from their mountings by surging crowds. Both problems were satisfactorily solved by laying ⅞-inch sleepers the full length of the aisles and covering them with plywood sections nailed to the

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sleepers to form raised aisle walks.

The method of running the wire circuits between the sleepers is shown in Fig. 2. Spare pairs of cable were run along the edges of the aisles where they could be fished out when needed.

Each microphone stand was secured to a chair with a 1-inch pipe strap and the base of the stand wired to the bottom seat rail, as shown in Fig. 3. Details of the microphone stand and mountings are shown on the opposite page. The two wood pieces, one with a groove, protect the microphone cable running between the aisle wireway and the pipe stand.

While rearranging the floor microphones for the Democratic convention it was learned that Texas had designated two delegations, both of which had to be seated while committees decided which group should be recognized. Fortunately the flexible system of microphone circuits made it possible to provide the extra microphone where it was needed.

All lines from the floor microphones terminated at the microphone control panel located on the rostrum near the post of the convention chairman. On this panel were 64 buttons and their accompanying tally lights—one set for each delegation—and a master release button. Sixty-five wire pairs ran from the 64 relay windings to a battery supply in the NBC booth. When the chairman recognized the spokesman of a delegation, the engineer on the switching panel pressed the button corresponding to that delegation, thus connecting the proper floor microphone through the amplifying system to all networks and the several other

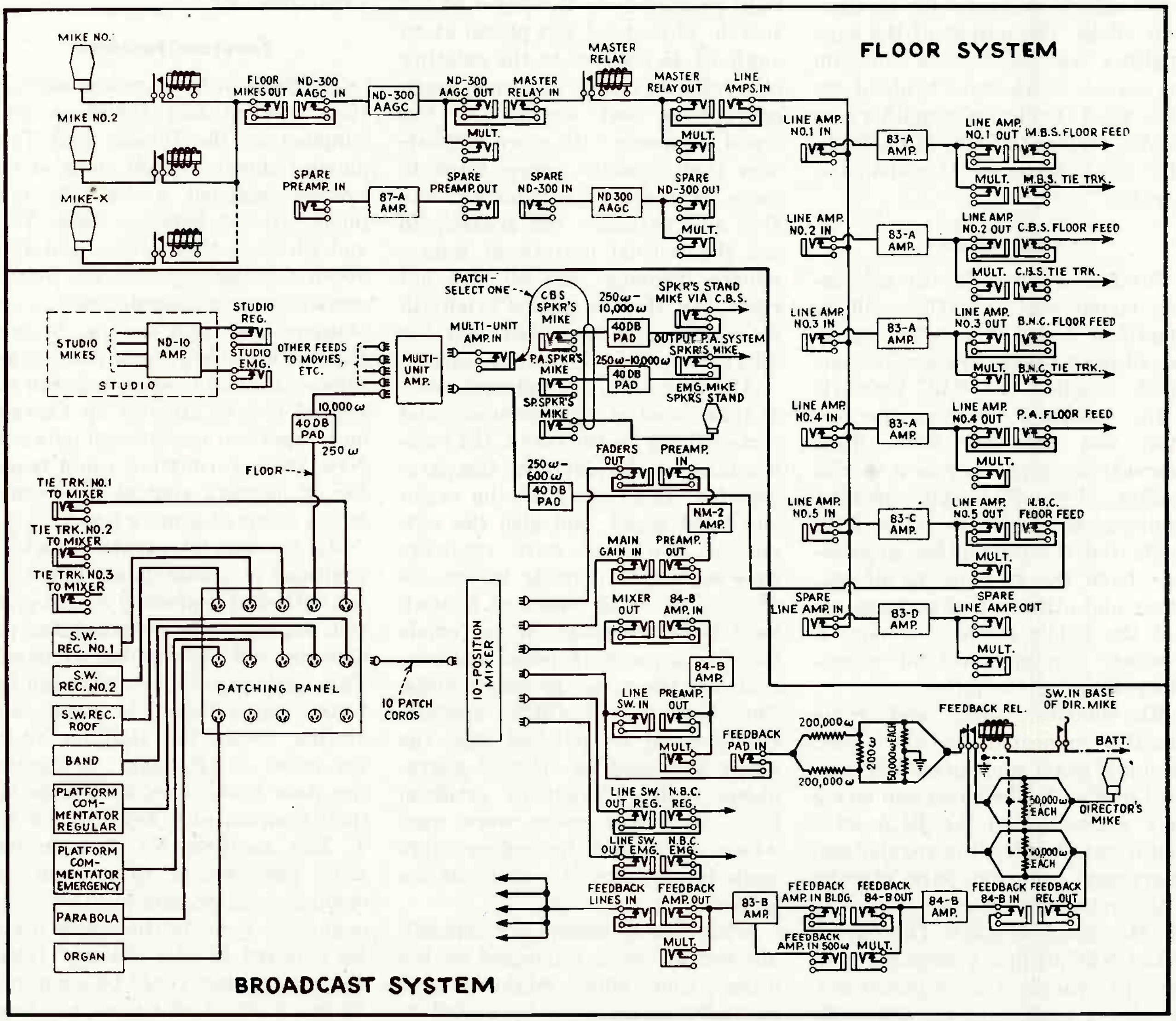


FIG. 1—Speech schematic of floor and broadcast systems installed at Chicago stadium for the two national political conventions in 1944

sound services. By pressing the release button, this microphone was disconnected and the circuits made ready for the next delegation. Four or five microphones could be paralleled, as was done on several occasions when delegations were being polled member by member.

Audio Circuits

The first amplifier in the floor system was an automatic audio gain control amplifier. Its purpose was to increase automatically the gain of the amplifying system for weak voices to a point just below the sing-back setting of the public address system. It also automatically decreased the gain of the system for strong voices, thus preventing overloading.

After the aagc amplifier came the master relay. Floor microphone relays were adjusted to operate prior to the master control relay to eliminate clicks. The output of the aagc amplifier was fed into a 600-ohm bus across which were bridged six RCA 83-A bridging amplifiers to provide service to CBS, MBS, BNC, NBC, the public-address system and a spare.

NBC System

Further analysis of the convention layout and operation will be simplified from this point on by describing a single system, the one which supplied the NBC network.

The speaker's stand on the rostrum was provided with three microphones supported on a special bracket. Two 77-B microphones, connected to amplifiers in the CBS booth, fed the convention proceedings from the rostrum to all networks and other sound services except the public address system. A Western Electric cardioid microphone supplied the latter.

Microphones, audio and radio circuits connected to the NBC patching panel and mixer are outlined in Fig. 1. The panel and mixer were connected to the RCA 84-B studio amplifier feeding regular and emergency program wire circuits to the network's Chicago studios in the Merchandise Mart. The output of the NBC bridging amplifier connected to the floor microphone system fed a multi-unit amplifier. By this means, either the microphone circuit from the speaker's stand via the CBS booth or that from the public address system or the NBC emergency microphone installed at the rear of the speaker's stand, could be selected depending on which circuit had normal level and highest quality. The three feeds were either on patch cords or faders and under the immediate control of the mixing engineer, permitting him to switch from one circuit to another as conditions dictated. Through this multi-unit amplifier, therefore, it was possible to feed the microphone output to all interested services while requiring the presence of only three microphones on the speaker's stand.

This microphone set-up proved its soundness on all occasions save one, the platform appearance of Herbert Hoover. Whenever the ex-president speaks he provides his own short metal stand carrying a light to illuminate the pages of his speech. This stand was placed at an angle of 45 degrees to the existing microphones, and an emergency microphone was spotted on the stand. Someone with more enthusiasm than common sense tried to move the special microphone to one side and persuade the speaker to use the normal battery of microphones. Sensing that all was not right, Mr. Hoover paused briefly in his speech and requested that the microphones be left as they were.

All remaining microphones, such as those used by the announcer and commentator in the booth, the commentator on the platform, the parabola for crowd noise, at the organ and band stand, and also the output of two short-wave receivers were connected directly to the 10-position mixer by means of Hubbell male twistlock plugs, or to female plugs in a patching panel and connected to the mixer by patch cords. The output of NBC's stadium studio could be patched into the mixer and used as another microphone position. Pads or artificial lines of proper value were used where necessary to reduce high audio levels down to —60 vu at the mixer.

Microphones needed for immediate service were connected to the mixer; those which might be used on short notice were connected to the patching panel. The mixing engineer had to be on his toes every moment to have the right microphones properly connected and to fade in and fade out microphones as dictated by program requirements.

The feedback amplifier was fed with a double input, from the output of the mixer and from the output of the special events director's microphone. During normal operations the program transmitted to the network was fed to jacks installed at the various announcer, commentator, and engineer positions. Staff members could be thus kept advised of what had been said in order to eliminate repetition. Whenever the special events director had general instructions to pass on to the staff, he merely pressed the button in the base of his microphone, cut off the program, connected his microphone to the feedback circuit and talked to all points simultaneously.

Telephone Facilities

The behind-the-scene communications system and facilities were supplied by the Illinois Bell Telephone Company. High spots of the system included a full-talk telephone circuit between New York and Chicago NBC offices and four 506-B cordless type private branch exchange switchboards, two at the stadium and two in the Stevens Hotel. This circuit provided instantaneous communication between the special events director in Chicago and important operational points in New York, permitting rapid transfer of network control to Chicago in the event of a news break.

At the special events director's position, a cradle hand telephone set with dial connected to a 4-position key box was provided for the director and one for his assistant. This enabled both men, through the booth switchboard, to reach any station inside the stadium or on the other 506-B board, or contact the New York office, by connecting their instrument to key position No. 1. Key position No. 2 connected both instruments to a local exchange operator, and position No. 4 connected them to the traffic director's board in the Stevens Hotel. From here they could be connected to trunk No. 1 which routed them through to NBC, New York, via the full talk circuit. Key position No. 3

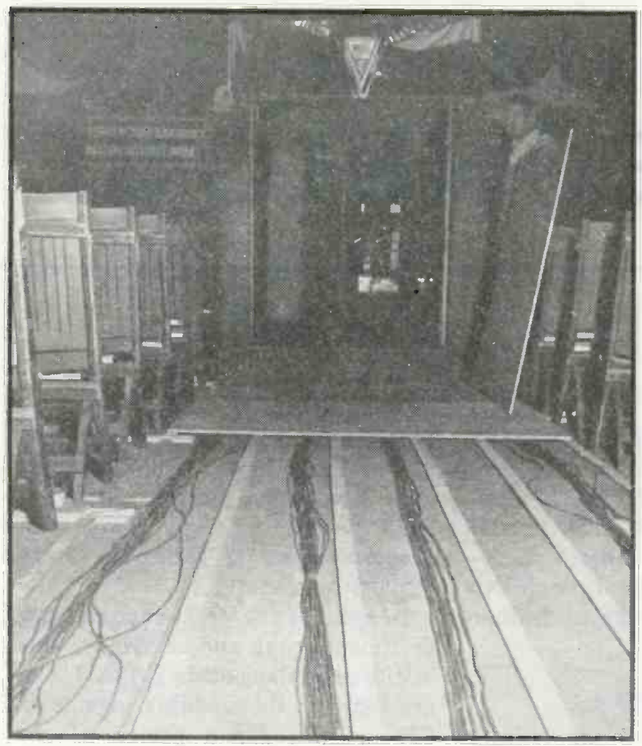


FIG. 2—Construction of wireway in aisles of stadium, and method of running and protecting the wire pairs going to the delegation microphones

FIG. 3—Method of anchoring delegation microphone stands to backs of seats and to temporary flooring laid in aisles over ⅞-inch wood sleepers

was isolated on each box. The director could be connected with a long-distance telephone operator on this position, whereas the assistant could talk to all the operational points within the stadium through the booth switchboard. This latter feature enabled the director and his assistant to talk jointly to a given location through the booth switchboard or carry on separate conversations if the occasion required.

Cue Circuits

Engineers on duty at the floor microphone switching panel on the rostrum, at the duplicate panel in the NBC booth, and the technician in general charge of service on the convention floor were connected to the same station on the 506-B board. By connecting the news desk telephone in the stadium office with the booth switchboard, the director was able to make rapid contact with any one of the locations without going through the office board. Continuous visual light signals replaced bell ringers on all telephones in the booth, stadium and Stevens Hotel studios, and also at locations near the speakers' stand in the stadium where a ringing bell would interfere with the broadcast or convention proceedings.

Each commentator and announcer had a microphone and earphones, which could be connected to the combined program and cue feedback circuit or to the convention proceedings circuit. Two loudspeakers were suspended on the wall of the NBC booth, one connected to the NBC network for cues, and the other to the booth amplifier handling convention proceedings. Also in this booth were short-wave program receivers and frequency-measuring equipment covering the 30-40 Mc pack cue transmitter. The whip antenna of this transmitter extended through a hole in the top of the booth, while vertical and horizontal dipole antennas for program reception were located atop the booth.

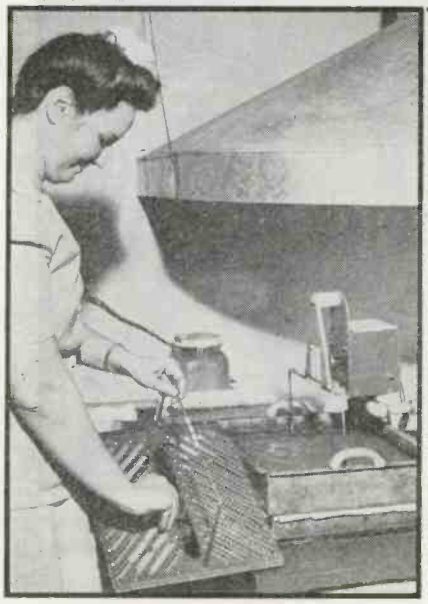
Preventative Maintenance

In an undertaking of this nature, which at its best must be considered a temporary one from an engineering viewpoint, special precautions must be taken to keep service failures at a minimum.

Constant supervision of the Chicago stadium and Stevens Hotel installations paid off with a record of no major failures and few minor troubles. The engineer assigned to the duplicate switching panel in the NBC booth was constantly checking each microphone on the floor system to determine if any had been disconnected from the circuit or damaged in any way. On the convention floor another engineer was in constant communication with the booth. If a particular delegation microphone showed upon test that it was functioning abnormally, a man was dispatched to make immediate repairs. Such emergencies, it was foreseen, were most likely to arise during the unrestrained parades of jubilant delegates. At such times, the repairman would have found it difficult to buck the crowds in order to reach his objective.

For thoroughness in basic planning, installation and technical assistance, the writer wishes to give credit to members of NBC's engineering staff, particularly Gerald Hastings, Al Poppele and J. A. Weis from the New York office, and Frank Schnepper, H. C. Luttgens, Carl Cabasin and others from Central Division headquarters in Chicago.

Quartz ETCHING TECHNIQUE



In the first etch, the disoriented layer is removed from a group of quartz blanks by a temperature-controlled solution of ammonium di-fluoride

By L. A. ELBL *Engineering Department Crystal Products Company Kansas City, Mo.*

Many quartz crystal units deteriorate with time, both in the field and in storage depots, the cause being attributed to the phenomenon of "aging." At frequencies above 5 or 6 megacycles, this effect is particularly noticeable. An increase in crystal frequency is often accompanied by decreasing activity.

As a result of extensive experimentation on the matter, it is now generally agreed that aging is caused by the progressive accumulation of submicroscopic particles of quartz on the surfaces of the crystal blank and their eventual loss. These particles appear to be the result of abrasive action during various stages of manufacture and form what is often referred to as the "disoriented layer."

Aging is accelerated by high temperature and humidity. These two factors make aging a particularly serious problem in the tropical climate of the South Pacific.

Etching crystal plates to final frequency rather than grinding them in with abrasive has proven an effective cure for aging. After etching, there is very little change in either the activity or the frequency of the unit. To insure quality crystals, the U. S. Army Signal Corps requires that almost all future crystal units be brought to final frequency by etching rather than by grinding.

Etching Process

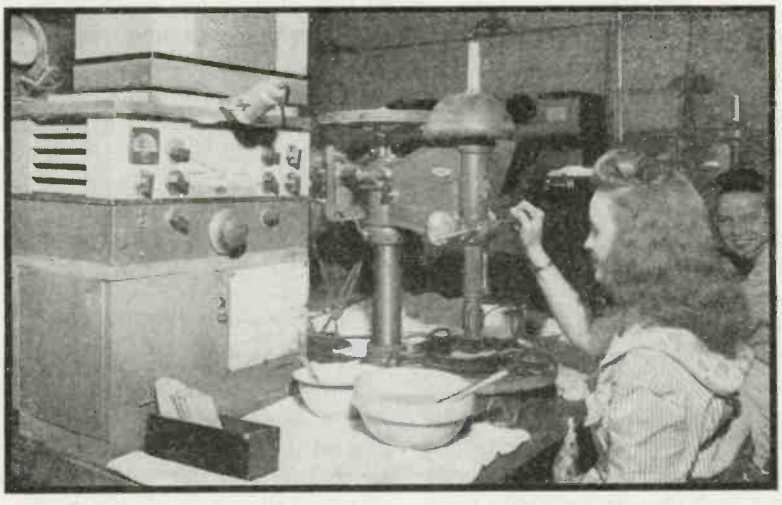
We have developed an etching procedure which is very satisfactory. The various steps and processes are described.

To develop a surface suitable for etching, a minimum of ten mils is removed from the surface of each crystal with 600-grit silicon carbide and then a minimum of two mils is removed with 145 aluminum oxide. Final lapping before etching is done with the aid of a radio receiver. The mean or average frequency of the crystals can be followed on the receiver and the lapping operation stopped at the correct frequency.

Between lapping stages, the blanks are brought to exact dimensions with respect to length and width. For best activity, plates for each frequency must be made a slightly different size. To insure proper edges, crystals are next beveled by machine.

In spite of the great care exerted in dimensioning and beveling, some of the crystals contain chips. These are removed by tumbling groups of 600 crystals for a period of six hours in jars containing a water mix of 600-grit carborundum and garnet. The plates are then thoroughly washed.

After final lapping, the blanks are dipped in a concentrated solution of chromic acid and rinsed in water. Next, each crystal is given a thorough scrubbing with soap and water. Crystals are then loaded into specially constructed baskets holding six hundred crystals. The baskets are swished first in ammonia water and then in clear running water. The design of the basket is such that the crystals are held at an angle of 45 degrees to



At Crystal Products Co., the mean frequency of the quartz blanks is followed on a radio receiver during lapping. The plates then go through several cleaning operations to prepare them for the mass etch in ammonium di-fluoride

Signal Corps contracting officers are now requiring that etching be used in bringing most quartz crystal plates to final frequency, to eliminate aging effects due to flaking. The equipment and procedures employed at one midwestern plant are described

the motion of the basket to insure that every crystal is properly rinsed.

First Etch

The plates are now ready for the first etching stage, called the "mass etch" or "deep etch." This is done in a temperature-controlled solution of ammonium di-fluoride. The purpose of this etch is to remove in one step the minimum amount of quartz necessary to eliminate the disoriented layer. If this layer is not removed, the units will not be etched evenly in subsequent operations. This mass etch requires from 3 to 6 minutes, depending upon the strength of the etch solution.

The plates are next washed in hot water, dried, and examined for bevels, chips, and flaws. All plates needing attention are worked on diamond wheels.

The crystals are next classified according to frequency on a unit built from a Hallicrafter SX-28 Receiver. A neon light in the circuit flashes when the crystal frequency is registered on the dial. With this classifier, crystals are sorted into groups having frequencies 10 kilocycles apart. The groups are filed away in a storage cabinet to provide a bank of crystals for any order of frequencies desired.

Close Etching

Plates are taken out of the storage bank according to the daily needs. They are given a degreasing wash in boiling tri-sodium phosphate and are then rinsed and suspended from wheels for close etching. This etch is done on a time basis in an etch tank whose temperature is held constant to within ½ degree.

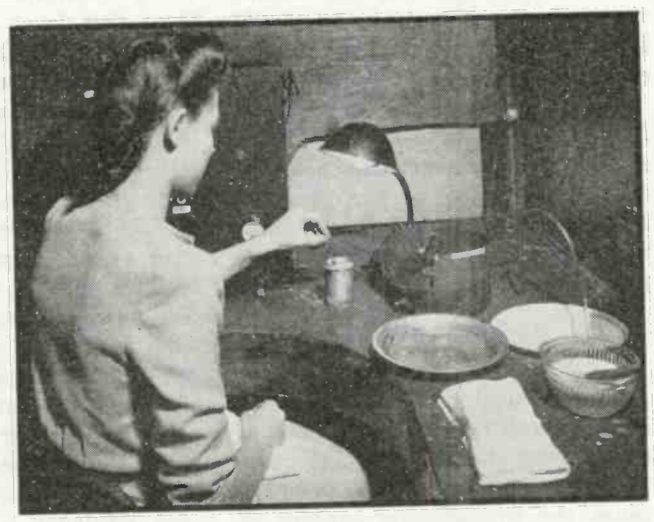
The crystals are placed in plastic baskets which are hung in tracks under the wheel according to the number of kilocycles to be removed. The baskets drop off into the etch at periodic intervals (according to the track used) and move around in the etch. When they reach a point to the left of the operator, they fall into a hot water bath and then into a drier. All crystals come off within five kc of the desired frequency.

Crystals removed from the first etch wheel are classified into groups every 500 cycles of frequency. They then go to a second close-etch wheel which moves more rapidly. The plates leave this wheel approximately 1500 cycles from final frequency.

In the final etching stage, each crystal is given individual treatment. If activity is low, it is brought to maximum by slight edge working on a wet-bonded abrasive stone. The final few cycles of frequency are taken off in the small temperature-controlled etch pot shown. Crystals are then washed thoroughly with soap and water, rinsed in running warm water, and dried in a mechanical drier. No towels are used on account of lint. Crystals are assembled between electrodes and sent to the inspection room for final mounting.

While the procedures given above are not new, the proper sequence of steps is very essential. Conversion from hand lapping to etching was accomplished smoothly.

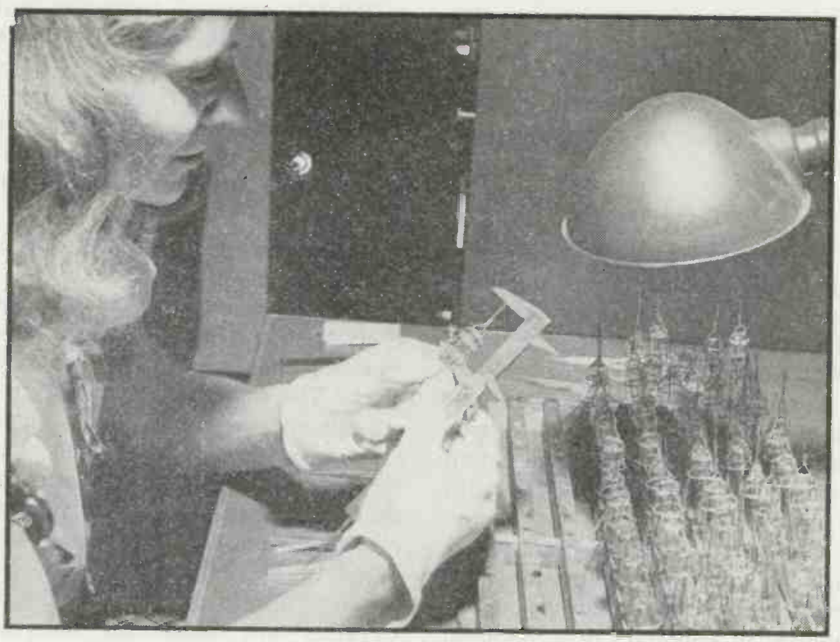
Plastic baskets containing quartz plates are dropped into the etch solution by this rotating wheel. Time in the bath is determined by having the basket follow the proper track



At the final etch position shown above, each plate is brought to maximum activity and final frequency by means of an abrasive stone and a small temperature-controlled etch pot

QUALITY CONTROL IN

Discussion of problems involved in setting up a statistical method of controlling quality of tubes and component parts during manufacture, with instructions for using process control charts in connection with random sampling techniques to detect promptly when a process is out of control and causing excessive shrinkage



Go no-go inspection for dimensional accuracy of tube parts is performed on a sample quantity taken from the grand lot

THE chief objective of a quality control system is to assure quality on an economic basis. Such a system should exercise its effect during manufacturing operations, through process control, and should insure the quality of the finished article by means of product control.

Effectiveness of the control can be determined in two ways: 1. By studying the presence or absence of critical attributes of the product; 2. By studying the variation of some mensurable characteristic of the product.

Sample Size

A statistical method of quality control requires consideration of the problem of sample size. Usually, this presents a difficult problem because the fundamental concept of the statistical approach is not clearly understood. When this difficulty is analyzed, the question of sample size resolves itself into a statement (on the part of management) concerning quality level to be maintained in the product. Once this level is established for interdepartmental or external shipments the percentage limits for defectives can be established and an intelligent solution to the sample-size question can be obtained.

As an example, management may decide to ship a finished product with a 9 to 10 probability that defectives will not exceed 30 per 10,000. Once management decides what risk it is willing to take to get a specific quality, the question of sample size can be rationally approached. If every unit shipped must be absolutely perfect, then 100 percent inspection and 100 percent efficiency are necessary. In mass production 100 percent inspection efficiency cannot be assured because of 1. Human judgment; 2. Prolonged work periods;[1] 3. Worker's skill; 4. Worker's concept of how the job should be done; and 5. Worker's attitude toward the work.

Because of these human factors controlling inspector efficiency, 100 percent inspection is not the practical solution for the problem.

Of course, most manufacturers desire to ship a product that is 100 percent perfect. How can it be done? In most cases (certainly in mass production), perfection in inspection is impractical and unattainable. Hence, the existence of merchandise returns from customers. It is a rare organization indeed which never has a product returned. However, though the manufacturer cannot achieve a 100 percent perfect product, he can certainly approach that condition. The essence of the technique is to obtain a random sample of good size and inspect it carefully. In this way, 100 percent inspection efficiency is obtained on the sample rather than partial inspection efficiency on 100 percent of the product.

Suppose management agrees it is permissible to have 100 defects in 10,000 parts; in other words, the fraction defective is 0.01 on the average. If this condition existed, a sample of 250 units would probably disclose two rejects.

If the lot had 200 defects per

Other articles on
QUALITY ENGINEERING

Quality Engineering in Tube Manufacture
ELECTRONICS, November 1944

Shrinkage Analysis in Tube Manufacture
ELECTRONICS, December 1944

TUBE MANUFACTURE

By EUGENE GODDESS
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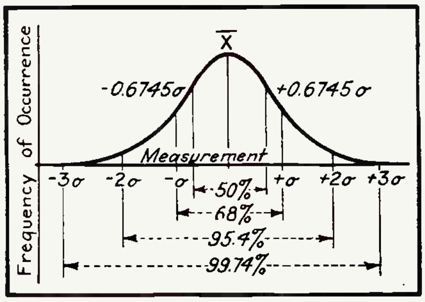
Dobbs Ferry, N. Y.

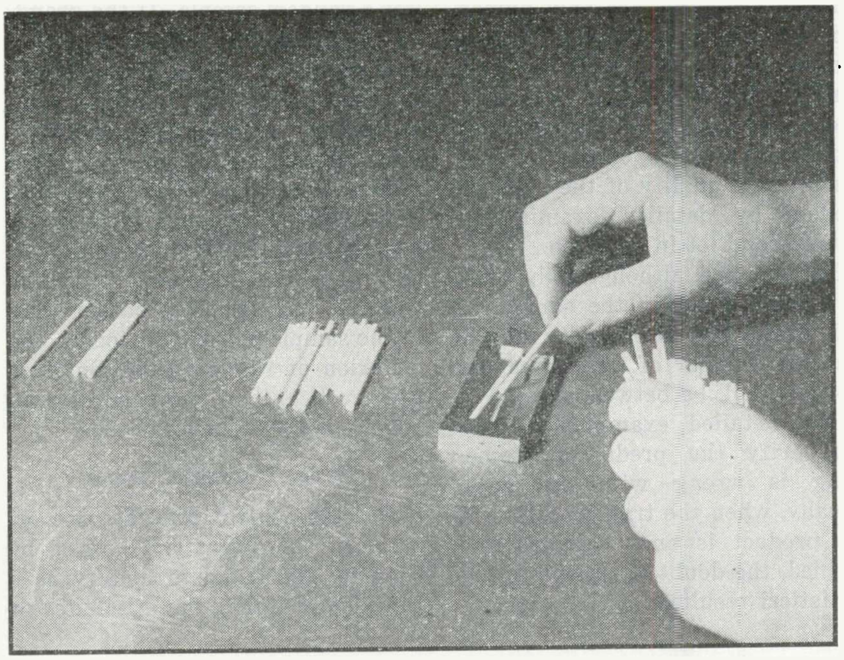
10,000 on the average, then a sample of 250 could have four rejects and a sample of 500 could have nine rejects. This example shows that as the sample size increases, the fraction defective in the sample approaches the fraction defective in the lot. The answer to the question of sample size rests then with management, which must declare that the observed fraction defective in the sample must be accurate, $\pm X$ percent. The actual technique for selecting samples and interpreting the results can be found in suitable texts on statistics.[2] These methods should be diligently applied in order to protect the manufacturer.

Once the theoretical sample size has been computed, it becomes necessary to select the practical sample size, depending on the availability of the product. If the theoretical sample size is 189 and the product comes packed in groups of 25, it is convenient to take a sample which is a multiple of 25. In this case, either 175 or 200 would be suitable but it is good practice to use the larger sample.

Sample size does not depend on percentage. For example, if percentage were a criterion in selecting a sample, then 1 out of 5 would be as typical as 200 out of 1000, since both are 20 percent samples. Likewise, if sampling information were on a percentage basis, a sample of 1 from a lot of 10 would be more typical than a sample of 50 from a lot of 1000. Of course, these extreme cases reduce the percentage basis of sample selection to an absurdity but they were selected to make the argument more poignant.

FIG. 1—Normal or Gaussian distribution curve relates frequency of occurrence with different values of deviation from the arithmetical mean $\overline{X}$ for a given measurement





Ceramic insulating rods for cathode-ray tube assemblies are checked for go and no-go in this jig. Deviations and frequency of their occurrence are shown in Fig. 1

The object in taking a sample from a grand lot is to obtain information about the quality of the grand lot, the assumption being that the sample has the same distribution of defects (or variables) as the grand lot. To be properly selected, a sample must be: 1. Taken at random so as to be typical; 2. Large enough that its distribution curve is not materially affected by sample size; 3. Composed of normal products and not containing engineering freaks.

In substance, sampling is safe if production on a product is running normally. When production becomes abnormal, units should be subjected to a manufacturing culling operation. The good product is then inspected on a sampling basis —actually, this amounts to inspecting a previous inspector's work.

Product Control

One of the problems which confronts quality control engineers is that of passing judgment on the grand lot. The lot can have one of three sources: (1) An outside supplier supplying a raw product; (2) A company department supplying a part to another company department; or (3) The company itself, offering its completed product for final inspection.

Regardless of where a grand lot comes from, judgment should be made in the same way. In evaluating the grand lot, the quality control department will feel pressure exerted upon it by: (1) The outside supplier, who feels his *good* product has been rejected; (2) The department head, who resents having a grand lot rejected because "a few bad ones showed up in the sample"; or (3) Over-anxious production men, who are trying to meet shipping schedules and contracts.

These pressures are only human and will always exist as long as humans play a part in the production picture. One of the best ways to overcome this situation is to sit with the persons involved and demonstrate the quality of the rejected product by detailed examination of the grand lot in question.

For example, although only 3 defects showed up in the sample of 250, there is a probability of 0.9 that the number of defectives per thousand will be between 21 and 7. If the detailed examination does not verify the prediction, something is wrong with the data. Usually, when the true condition of the product is once revealed and verified, the doubters accept future statistical results.

There is one other possibility of serious friction which cannot be ignored. Should the outside supplier insist that his product is *good* despite the rejection, it will probably be necessary to review the specification against which the examination was made.

The subject of product control is extensive indeed and will not be discussed further except for one additional warning. Be sure to select a *random* sample. If the grandlot is thoroughly mixed, the random nature of the sampling is not critical. But if the grand lot is not thoroughly mixed, it is imperative that the sample be selected by a random operation. It is interesting to note that a random sample means a sample selected in a random manner; thus the reference is to the technique of sampling rather than to the sample per se. Obviously, the criterion of random selection is to give each unit of the grand lot an equal chance of being chosen.

Process Control Charts

Process control prevents the occurrence of industrial losses by showing the trend in quality as a function of either the attributes or the variables. This is best illustrated by an example. Several constants from the American Standards Association War Standard Z 1.3-1942 are used, and it is well to point out that if the sample size changes, the constants also change. The ASA has issued three excellent publications covering this entire problem,[3] which are valuable in setting up a quality control system.

Suppose it is desired to control the depth of a grid assembly for a cathode ray tube. In such a case, quality is to be measured by observing the trend in a variable, and one way to proceed is given here:

1. Each hour, determine and record the depth of a sample of five grid assemblies.
2. Compute average depth by adding the depths and dividing by 5. Call this value $\bar{X}$.
3. Determine the range, R, of the sample by subtracting the smallest value from the largest.
4. After n values of $\bar{X}$ have been computed, determine the average of the averages, $\bar{\bar{X}}$, which is found by the equation $\bar{\bar{X}} = \Sigma\bar{X}/n$ where $10 < n < 25$.

CONTROL CHART DATA SHEET

PRODUCT GRID SUBASSEMBLY
CHARACTERISTIC DEPTH GRID CYLINDER
UNIT OF MEASUREMENT .001"
SPECIFIED LIMITS .260" MIN. .2655" MAX.
SPECIFICATION NO. X9943
PRODUCTION ORDER NO. XXX
PRODUCTION DEPT. NO. 2
NORMAL DAILY OUTPUT 3000
SAMPLE 5 PER HOUR
TEST SET NO. MICRO-CHECK
DATE AUG. 3, 1944
INSPECTOR'S CLOCK NO. 38
SIGNED: Helen Kay INSPECTOR

IDENTIFICATION	OBS. VALUE	IDENT.	OBS. VALUE	IDENT.	OBS. VALUE	IDENT.	OBS. VALUE	IDENT.	OBS. VALUE	IDENT.	OBS. VALUE
SAMPLE NO. 25	.263	26	.264	27	.263	28	.262	29	.262	30	.263
TIME 9 AM	.263	10 AM	.261	11 AM	.261	NOON	.263	1 PM	.262	2 PM	.263
OPERATOR NO. 105	.262	105	.263	105	.262	105	.263	105	.263	105	.263
MACHINE NO. 06	.263	1	.262	1	.264	1	.262	1	.264	1	.263
---- NO.	.263		.261		.261		.263		.263		.263
TOTAL 5)	1.314	5)	1.311	5)	1.311	5)	1.313	5)	1.314	5)	1.315
AVERAGE, $\bar{X}$	.263		.262		.262		.263		.263		.263
LARGEST VALUE	.263		.264		.264		.263		.264		.263
SMALLEST VALUE	.262		.261		.261		.262		.262		.263
DIFFERENCE: RANGE, R	.001		.003		.003		.001		.002		—
SAMPLE NO. 31	.263	32	.268	33	.263	34	.264	35	.261	36	.263
TIME 3 PM	.268	4 PM	.268	5 PM	.264	6 PM	.265	8 AM	.262	9 AM	.264
OPERATOR NO. 10	.268	10	.268	150	.262	150	.263	150	.261	150	.263
MACHINE NO. 1	.268	1	.265	1	.263	1	.262	1	.263	1	.263
---- NO.	.264		.268		.263		.262		.265		.264
TOTAL 5)	1.331	5)	1.337	5)	1.315	5)	1.316	5)	1.312	5)	1.317
AVERAGE, $\bar{X}$	.266		.267		.263		.263		.263		.263
LARGEST VALUE	.268		.268		.264		.265		.265		.264
SMALLEST VALUE	.262		.265		.262		.262		.261		.263
DIFFERENCE: RANGE, R	.006		.003		.002		.003		.004		.001

NOTES: (1) FOREMAN NOTIFIED. SAMPLE NO. 31 EXCEEDS MAX. LIMIT. 40 ADDITIONAL GRID ASSEMBLIES (SUB) TESTED. DATA RECORDED ON SUPPLEMENTARY DATA SHEET. ALL OK.
(2) FOREMAN REPORTS DEFECTIVE ARBOR REPLACED.

FIG. 2—Depth measurements on grid cylinder are recorded in this manner on a typical control-chart data sheet. Computed average values X and range R provide points for plotting on control chart

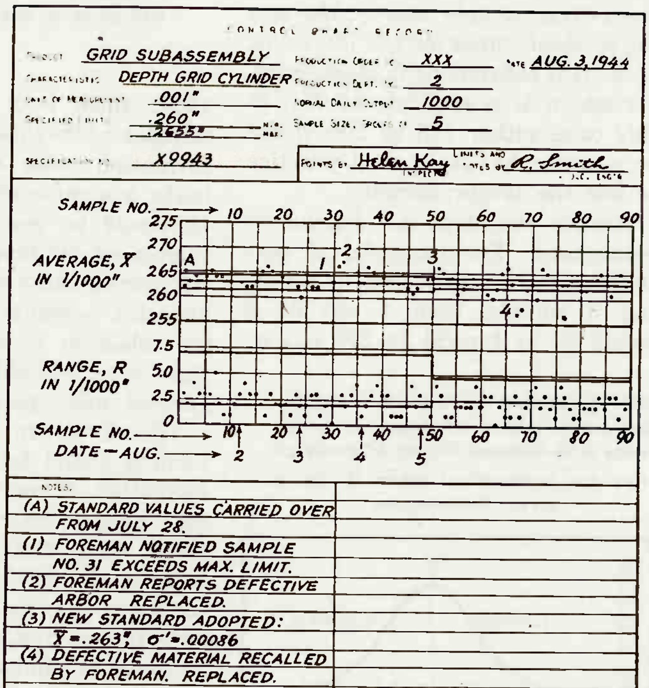


FIG. 3—Control chart record carries a plot of calculated values X and R from data sheet of Fig. 2. Points 25 to 36 are thus derived. Note point 31, which exceeds maximum limit established for this grid subassembly

5. From the same data, compute $\bar{R}$, the average of the ranges using the equation $\bar{R} = \Sigma R/n$ where $10<n<25$.

6. Compute control limit values for $\bar{X}$ as

$$X_{L\,upper} = \bar{\bar{X}} + 0.577\bar{R}$$
$$X_{L\,lower} = \bar{\bar{X}} - 0.577\bar{R}$$

7. Compute control limit values for $\bar{R}$ as

$$R_{L\,upper} = 2.114\bar{R}$$
$$R_{L\,lower} = 0(\bar{R}) = 0$$

8. Prepare two charts, one for $\bar{X}$ and one for R. Show $\bar{\bar{X}}$, $X_{L\,upper}$, and $X_{L\,lower}$ on one chart. Show $\bar{R}$, $R_{L\,upper}$ and $R_{L\,lower}$ on the second chart.

9. Plot the values of $\bar{X}$ and R on the respective charts.

10. If 25 consecutive values of $\bar{X}$ and R fall between the upper and lower limits, we can say that control exists. If not more than 1 out of 35 successive values of $\bar{X}$ and R (or 2 out of 100) fall outside the limits, it may be safely concluded that excellent control exists.

11. If good control exists (as described in step 10 above), $\bar{\bar{X}}$ and $\bar{R}$ may be adopted as standard values, i.e. $\bar{\bar{X}} = \bar{X}'$ and $\bar{R} = R$.

12. If good control does not exist, use only that portion of the data which can be considered as representative to recompute $\bar{\bar{X}}$ and $\bar{R}$.

13. Compute sigma prime, the standard deviation, as $\sigma' = \bar{R}/2.326$. This is an index to the dispersion or spread of the individual measurements about their average.

14. Let the maximum specified limit be X_{max}. Then, if

$$(X_{max} - \bar{X}')/3\sigma' > 1$$

$\bar{X}'$ and σ' may be used for ensuing calculations.

15. On the basis of $\bar{X}'$ and σ' (from step 14) determine the central line for $\bar{X}$, which is the average of the (representative) averages $\bar{\bar{X}}$ (see step 12) and is equal to $\bar{X}'$.

16. Compute the limits for $\bar{X}$ as

$$X_{L\,upper} = \bar{\bar{X}} + 1.342\sigma$$
$$X_{L\,lower} = \bar{\bar{X}} - 1.342\sigma'$$

17. The central control line for R is

$$R_{control\ line} = 2.326\sigma$$

18. The control limits for R are

$$R_{L\,upper} = 4.918\sigma$$
$$R_{L\,lower} = 0(\sigma) = 0$$

19. Use the values of $\bar{X}$, $X_{L\,upper}$, $X_{L\,lower}$, $R_{control\ line}$, $R_{L\,upper}$, and $R_{L\,lower}$, as determined in steps 15 to 18, as control lines on their respective charts for the next 100 samples unless a major cause of failure is eliminated.

20. If a major cause of failure is eliminated, use the last 25 representative values to compute new control lines as indicated in steps 12 to 19.

21. If no major failure is eliminated in the next 100 values, then use the last 25 values to compute new control lines as indicated in steps 12 to 19.

22. Completed control charts should be filed.

An interesting observation can

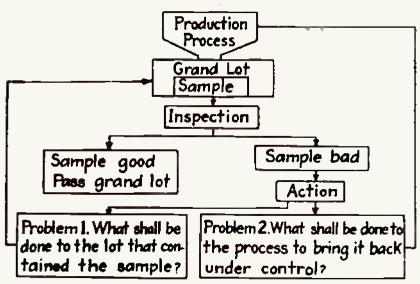


FIG. 4—Functional breakdown of situations resulting from a good sample lot and a bad sample lot under quality control

be made about step 14. The denominator of the fraction contains $3\sigma'$ because σ' is the standard deviation of the observed values from their average, and $3\sigma'$ includes 99.74 percent of the articles examined. Of course, this theory is based on a normal or Gaussian distribution curve, as shown in Fig 1. Thus,

$$\sigma = \frac{\sqrt{(X_1 - \bar{X})^2 + (X_2 - \bar{X})^2 + \cdots + (X_n - \bar{X})^2}}{n}$$

where X_1, X_2, ——— X_n are the observed averages and

$\bar{X} = (X_1 + X_2 + X_3 + \cdots + X_n/n$.

Use of the Control Chart

A typical control chart data sheet is shown in Fig. 2. Values of the constants given in the example are correct so long as the sample size is 5. Should the sample size vary, the new constants should be determined as explained in ASA publication Z 1.3-1942.

A quality control chart as shown in Fig. 3 should not be kept secret. It should be posted where the factory engineers, quality control engineers, foremen, factory production heads and division managers can observe it at will. New data should be plotted as soon as it is obtained and verified. If newly-plotted points are inside the limits, the manufacturing process continues uninterrupted.

But suppose a point occurs outside the 3-sigma limits as determined in step 16. Since a normal distribution is assumed (based on the 25 consecutive satisfactory samples), the point outside the 3-sigma limits is due to an assignable cause —in other words, it was not a chance variation.

As shown in Fig. 4, an out-of-control condition presents two problems: 1. What should be done with the lot that contained the sample; 2. What should be done to the process to bring it back under control?

The lot can be judged as explained under sections covering sample size and product control. With respect to the process, the best procedure is to request foremen and factory engineers to investigate the cause for lack of control. Until control is re-established, sampling should be done at an accelerated rate, say once every 5 or 10 minutes. Once control is re-established (25 consecutive samples within limits), the sampling rate may be reduced to its original value.

Quality control is a broad and involved subject, as is evidenced by the extensive literature that is available. Several aspects have not been mentioned in this article. Operator bonus for quality, control charts for fraction and number defective, relationship between control and specifications, sample size as a function of past quality history, Poisson distribution, rational sub-groups, and probability are a few that are important. The references provide much additional data.

References

(1) Dutton, H. P., Quality Control, *Factory Management and Maintenance*, 93, No. 9, Sept. 1935.

(2) "Engineers' Manual of Statistical Methods," John Wiley & Sons, New York, N. Y., 1941, p. 84.

(3) Z1.3-1942, Z1.1-1941, and Z1.2-1941, American Standards Association, 70 W. 45th St., New York, N. Y.

Audible AUDIO DISTORTION

By H. H. SCOTT
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DISAGREEMENT between the average non-technical listener and the engineer regarding the excellence of reproduced sound has become almost traditional. The listener's judgment is based upon whether or not he finds the reproduction faithful, or at least pleasing. The engineer, on the other hand, tends to have preconceived ideas based upon various technical characteristics, which may or may not be the factors governing the listener's preference.

Laboratory instruments and techniques represent a means and not an end. It is necessary occasionally to reconsider the results obtained through laboratory measurements, to decide whether or not they are indicative of the actual important performance characteristics of the equipment under test. This is particularly true in cases involving human judgment and psychological or physiological factors.

Quest for Perfect Reproduction

The characteristics of systems for the electrical reproduction of sound can be measured in physical terms to a high degree of precision, and such reproducing systems can be designed to perform with any given degree of excellence. A close approach to perfection will be found in certain types of transmitting and recording equipment, which is necessarily expensive. However, in the design of most audio-frequency equipment, and, in particular, radio receivers, phonographs, and sound picture projectors of the types manufactured in large quantities for home use, economic considerations must frequently take precedence over artistic ideals. In such a design perfection is not expected, and the problem is to provide the best possible results, as judged by the listener, within predetermined price limits.

Perfect reproduction of sound is the will-o'-the-wisp that has been chased through half a century by the phonograph, radio, and motion picture industries. Thirty years ago Edison attempted to demonstrate that there was no noticeable difference between the reproduction of his phonograph and the voice of the living artist. Radio advertisements through the years have acclaimed the tinny squeaks or muffled rumblings which were in vogue at the moment as absolute perfection. Actually, early phonographs and radios were so far from perfection that each successive change seemed like a tremendous improvement. Engineers and scientists, however, have never overlooked the shortcomings of what currently passed for perfect tone, and have anticipated the day when the reproduced sound would be indistinguishable from the original. Today this is a technical possibility, limited only by practical and economic factors.

Practical Considerations

In planning for the post-war period the matter of distortion in sound-reproducing systems should be reviewed carefully, to take best advantage of the existing state of the art and provide the public with the best possible tone quality per dollar expended. A hint as to some of the past difficulties and disagreements lies in the word quality. Our laboratory measurements so far are quantitative only. What the listener hears is qualitative, and the relationship between the two is extremely complex and little understood. About all we can rely upon is the fact that, if the commonly recognized types of distortion are reduced below certain measurable levels, the ear will be satisfied with the result. This procedure can be followed in the design of high-priced studio and transmitting equipment, but in the case of sound-reproducing systems for the home it is not yet commercially practical and may never be, because of price competition.

Distortion is of Three Types

It is unfortunate that no single measurement will define the excellence of sound reproduction. Audio distortion is generally classified into three types—namely, frequency discrimination, harmonic (also called amplitude or non-linear) distortion, and phase distortion. In the past the most advantageous balance among these three characteristics has not been maintained. This is the reason for the almost traditional disagreement among engineers, sales departments, and customers.

Frequency discrimination is easily measured with even a relatively simple oscillator. It met early acceptance in engineering circles as a criterion of quality. Actually it is only one of several important characteristics. The terms harmonic distortion and amplitude distortion are misleading and do not convey an impression of the real seriousness of this type of distortion. Phase distortion is important mainly in long transmission lines and other circuits where time delay occurs. The amount present in the usual home amplifier and loudspeaker system is considerably less important than the other types of distortion, but cannot, of course, be neglected entirely if these others are reduced.

Wide Frequency Response is Not Enough

These are the three types of distortion which the engineer considers and attempts to correlate. How do his measurements correspond with the judgment of the average listener, unprejudiced by

From a paper presented at the National Electronics Conference, Chicago, 1944.

Wide frequency response alone is not enough for perfect reproduction of sound. Generation of intermodulation frequencies must be suppressed in order to secure favorable listener reaction. A double-beat oscillator for intermodulation measurements is described

technical knowledge? The poor public acceptance of many so-called high-fidelity systems proves that, even when it is really attained, wide frequency response alone is not the answer. In fact, wide frequency response may be a disadvantage if noise or other forms of distortion are present. Considerable research is needed on the correlation between the various forms of distortion. The only information available is incomplete and often contradictory. In the meantime the engineer can attempt to base his measurements and conclusions on factors at least logically related to the average listener's reactions.

The alterations in music caused by variations from a flat frequency response or by moderate phase shifts in the reproducing equipment are not fundamentally different in character from variations which may exist under actual listening conditions with no electrical reproduction interposed. For instance, an orchestra will sound different when playing in different halls, and still differently again when playing outdoors. The acoustic conditions under which the listener hears the music will cause wide variations from what a microphone placed near the orchestra might pick up. When one hears music outdoors, or through a doorway, or from the back seat in a top balcony, it does not sound distorted in the popular sense of the term, and yet the effective transmission of different frequencies between the orchestra and one's ear may vary tremendously in both amplitude and phase. The ear will accept a large amount of this variation without considering the music as unnatural, even though many of the high or low frequencies may be missing entirely. This is probably one reason why the public has been able to tolerate radio receivers with poor frequency-response characteristics.

Intermodulation Products

What the average listener defines as tone is mainly governed by the frequency-response characteristic. A radio has a high tone, a mellow tone, or a deep tone, depending upon the frequency range and the balance between high and low frequencies. The non-technical person does not consider these variations in tone as distortion.

Electrical or mechanical reproducing systems, however, subject the music to another form of distortion which is unnatural because it is never encountered under conditions where the music is heard without reproduction or reinforcement. This is the poorly named amplitude or harmonic distortion. It is not the actual deviation from the original amplitude relationships which in itself is objectionable. Neither is it in most cases the increase in harmonics which were present in the original music at appreciable amplitudes. Associated with this form of distortion is the generation of many intermodulation products of an amplitude equal to or higher than the generated harmonics and bearing no harmonic or musical relationship to the components of the original sound. The importance of this form of distortion has been generally overlooked because of difficulties of exact measurement and interpretation. Actually this form of distortion is probably the most annoying of all types and warrants considerable further investigation.

It has long been noted that correlation between harmonic measurements and actual listening tests is inconsistent. The production of

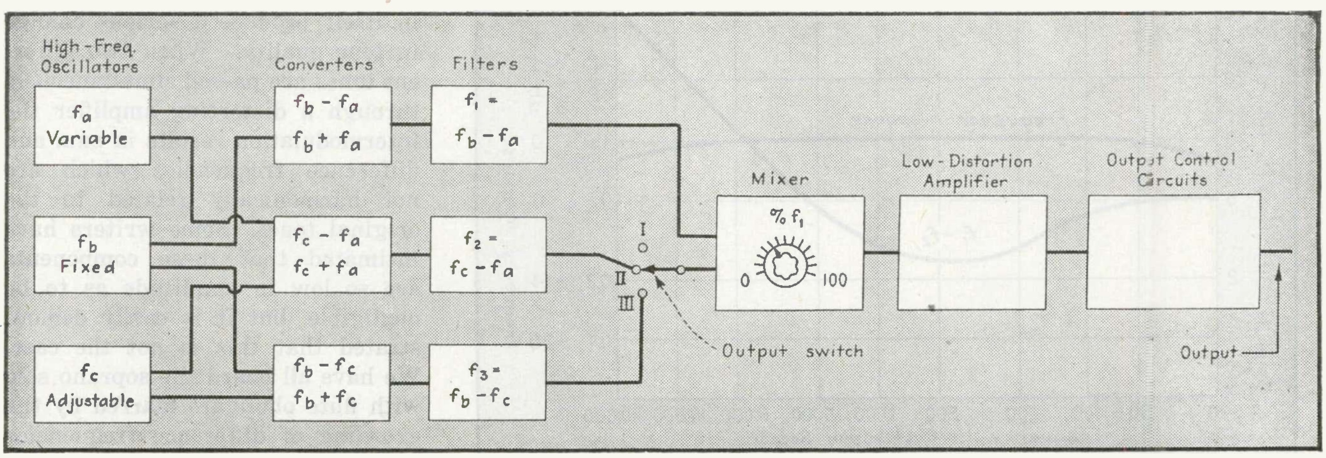

FIG. 1—Principle of operation of double-beat oscillator. At output switch position I the output frequency is f_1 and is variable. At II, both f_1 and f_2 appear at the output, and are so related that $f_1 - f_2 = K$ or $f_1 + f_2 = K$. At III, f_1 and f_3 are the output frequencies, with f_1 variable and f_3 equal to K

intermodulation products is not necessarily proportional to the production of harmonics excepting under certain carefully defined conditions. Hence the conventional methods of measuring harmonic distortion with a harmonic analyzer or distortion meter, which measures the amount of harmonics added to a single input frequency, is safe only when these harmonics can be kept to a very low level, of the order of a few tenths of a percent. In the design of sound-reproducing systems for the home this is never feasible, and limits of 10 or 20 percent are frequently met in practice. Furthermore, on systems of limited frequency range, high-frequency distortion may be audible and annoying, although the actual harmonics may be above the cut-off frequency. This type of distortion has more than nullified the advantages of many a good frequency-response characteristic.

Distortion in Power Output Stages

The procedure for rating harmonic distortion has been greatly oversimplified. For instance, when circuits were simpler, class A triodes were the general rule for power output stages. Such tubes produced relatively little distortion until actually overloaded, and the power output was conveniently rated at the level where 5 percent distortion occurred. Furthermore, such tubes had a low plate impedance, which tended to reduce the effects of a changing load impedance such as a loudspeaker.

In the quest for higher power efficiency, various successive stages of development have included the pentode, the class B amplifier, and the beam tube. Some of these tend to produce appreciable distortion, even at levels well below the maximum power output. Also, some have a high plate impedance, which exaggerates the effects of changing load impedance, thus accentuating the distortion caused by output transformers, shunting capacitance, and the normal changes in loudspeaker impedance. Many of these disadvantages can be overcome by the use of inverse feedback at the expense of gain and simplicity.

Many designers have seriously wondered whether these more elaborate output circuits offer any appreciable advantage, economic or otherwise, over the simpler triode systems. Under commonly encountered operating conditions amplifiers with identical distortion ratings may sound entirely different with degrees of actual audible distortion ranging from practically unnoticeable to practically unbearable.

There are many reasons for this. It is desirable, so far as possible, that the amplifier be operated below its overload point. Under these conditions the actual distortion produced bears little relation to the distortion at some particular degree of overloading. In class B systems, as an extreme, the distortion increases rapidly at low levels. Furthermore, in many systems push-pull and feedback circuits are used, which cause the distortion to vary with frequency. Push-pull amplifiers, for example, are often unbalanced at the extreme ends of the audio-frequency range.

Some Overloading May be Tolerable

Unfortunately, in equipment designed for home sound reproduction economic considerations limit the power-handling ability of the output stage and the efficiency of the loudspeaker. Consequently the systems are often operated just below the overload point, so that overloading occurs on volume peaks in the music. With good design an amplifier will overload gracefully. The result will be a certain unnatural brightness in the reproduction which may, however, be tolerable for short periods of time, particularly when heard at a high acoustic level, where the ear itself is distorting. The same degree of overloading in a poorly designed amplifier provides a muddy and coarse quality which is infinitely worse to the ear. Harmonic measurements made with single tones give little clue to this difference.

Many writers have pointed out that the intermodulation products and not the harmonics are responsible for the annoying quality when a sound-reproducing system is overloaded. Musical tones contain harmonics at various percentages, sometimes stronger than the fundamental. Adding a small percentage to these harmonics does not in itself produce a serious change in tone quality. When two different tones are passed simultaneously through a distorting amplifier the intermodulation results in sum and difference frequencies which are not harmonically related to the original tones. Some writers have intimated that these components are so low in amplitude as to be negligible, but it is easily demonstrated that this is not the case. We have all heard the soprano solo with flute obbligato marred by the growling of difference frequencies and the symphony orchestra which produces only a confused jumble of sound. Frayne and Scoville[1] showed

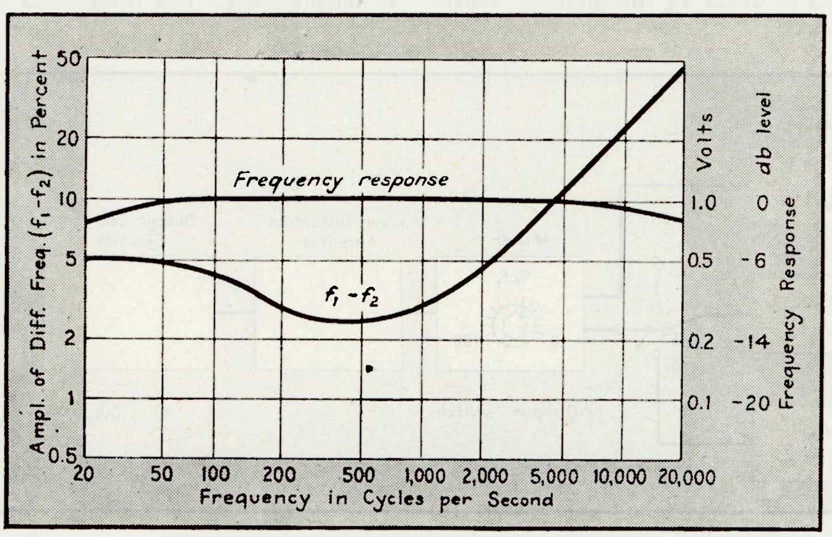

FIG. 2—Frequency-response and intermodulation curves on wide-range amplifier having rough high-frequency reproduction

in a simple mathematical analysis that it is quite possible for such components to be several times the amplitude of the harmonics. They calculated an average ratio of the order of 3.5, which, however, does not hold for conditions more complicated than those which they were considering.

How Intermodulation Occurs

The intermodulation products consist not only of the first-order sum and difference frequencies f_1+f_2 and f_1-f_2 (where f_1 and f_2 are the two fundamentals) but also the second-order terms $2f_1+f_2$, $2f_1-f_2$, f_1+2f_2, f_1-2f_2, and higher-order beats. None of these are harmonically related to the original components in the signal except by accident, hence the harsh discordance characteristic of certain types of so-called harmonic distortion. When the large number of tones involved in the reproduction of a symphony orchestra is considered and it is realized that every tone will intermodulate with every other tone, causing a series of sum and difference frequencies, there is little reason to wonder what causes the blurred effect characteristic of some amplifiers and loud speakers. These effects are what the average listener means by the word distortion.

Previous Intermodulation Research

In certain branches of audio-frequency engineering the presence of intermodulation has produced such serious results as to necessitate more investigation than usual. Frayne and Scoville[1] described an intermodulation test for use in connection with variable-density film recording. Hilliard[2], working in the same field, pointed out the advantages of a similar technique for measuring the performance of amplifiers, radio transmitters, and other systems. He observed that, of two systems having the same total harmonic distortion as measured by conventional means, the one with the greater amount of intermodulation provided reproduction which was definitely more objectionable, and he recommended a means of measuring the intermodulation by applying to the amplifier simultaneously a low and a high audio frequency. In Hilliard's system the higher audio frequency is treated as a modulated carrier and its modulation by the lower frequency measured in much the same way as the modulation of a broadcast station. While the amount of equipment required for such measurements is not negligible, Hilliard reported, "by comparison other methods are inadequate and inconvenient, as well as more laborious." Hilliard considered that the intermodulation had to be less than 2 percent to be unnoticeable to the ear.

In discussing the Hilliard paper, B. F. Meissner[3] pointed out that he had used the two-sine-wave method of test in his development work on electronic musical instruments, analyzing the output with a General Radio wave analyzer, and considered this "the ideal distortion-measuring system, since it measures directly what the ear itself hears as the objectionable element in sound reproduction." Lewis and Hunt[4], in connection with their investigation of tracing distortion in phonograph recording, recognized the importance of the intermodulation components. Their analysis includes re-recording, which is customarily used in the production of vertically cut records in order to minimize tracing distortion, which on this type of record consists mostly of even harmonics and first-order intermodulation products.

At a somewhat earlier date Harries[5] in England used intermodulation measurements to demonstrate the advantages of the so-called Harries valve over the then-current pentodes. Earlier references will be found in European publications, particularly German.[6, 7, 8, 9] Of these Janovsky[9], as early as 1929, performed certain experiments to determine which of the various intermodulation products were most noticeable.

Conventional Distortion Measurements

Analyzers and distortion meters have been developed to a point where harmonic distortion can be measured to 0.1 percent. There are also numerous oscillators available which provide a sufficiently pure signal for these tests. However, intermodulation measurements have not been widely adopted, presumably because of the equipment required, the complexity of the measurements, and the large number of components to be measured and evaluated.

There are many applications where harmonic or distortion-meter measurements alone are inadequate. Home-type sound-reproducing equipment generally operates at distortion levels such that serious intermodulation may be present, and this intermodulation does not have, excepting under a specific set of conditions, a fixed relation to the harmonics. A sharp high-frequency cut-off characteristic will render harmonic measurements useless in the upper octave of the frequency range, yet

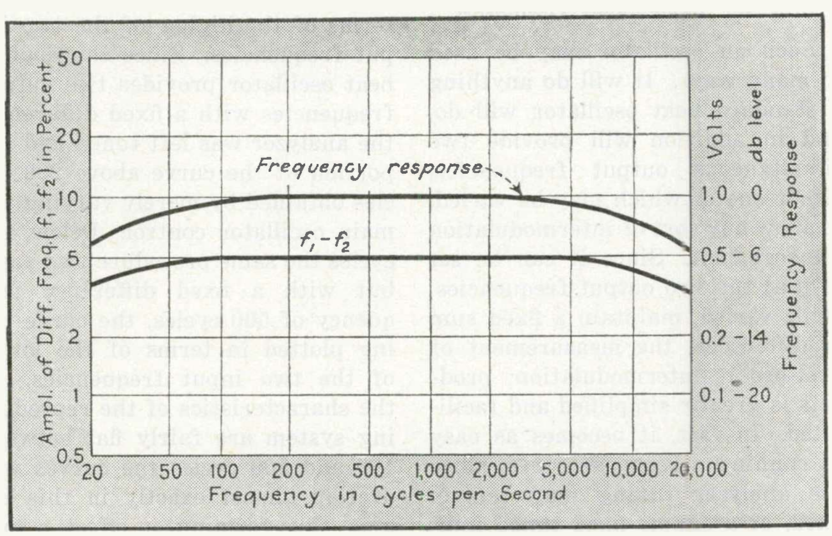

FIG. 3—Frequency-response and intermodulation curves on wide-range amplifier having clean high-frequency reproduction

intermodulation is frequently at its worst in this range. High noise levels, hum, etc., also encountered in low-priced equipment, affect distortion-meter measurements.

Double-Beat Oscillator

A development program had been planned covering complete methods for intermodulation measurements, with the hope of investigating also the relation of such measurements to distortion as judged by the average listener. Like many other programs, this has had to wait for the war, but one instrument has been developed which has proven unusually satisfactory in such applications. This is the fundamental instrument needed for convenient and accurate intermodulation measurements—namely, the source for producing two tones free from harmonics and intermodulation. The new instrument is called the double-beat oscillator and is shown diagrammatically in Fig. 1. Where a standard beat oscillator includes two high-frequency oscillators, this has three. The outputs may be heterodyned in various combinations so as to provide (I) a single variable output frequency, (II) two variable output frequencies having a constant sum or a constant difference, or (III) two independently variable output frequencies. The instrument also includes mixing controls for adjusting the relative amplitudes of the two output frequencies, as well as usual output circuits for varying the total output over wide ranges.

Uses for Double-Beat Oscillators

Such an oscillator may be used in many ways. It will do anything a standard beat oscillator will do, and in addition will provide two simultaneous output frequencies, either one of which may be varied, to allow any sort of intermodulation measurement. Since it can be set so that the two output frequencies, while varied, maintain a fixed sum or difference, the measurement of first-order intermodulation products is greatly simplified and facilitated. In fact, it becomes as easy as running a response curve, since the analyzer tuning may remain fixed, or a simple fixed tuned indicator may be used. This is a tremendous advantage when large

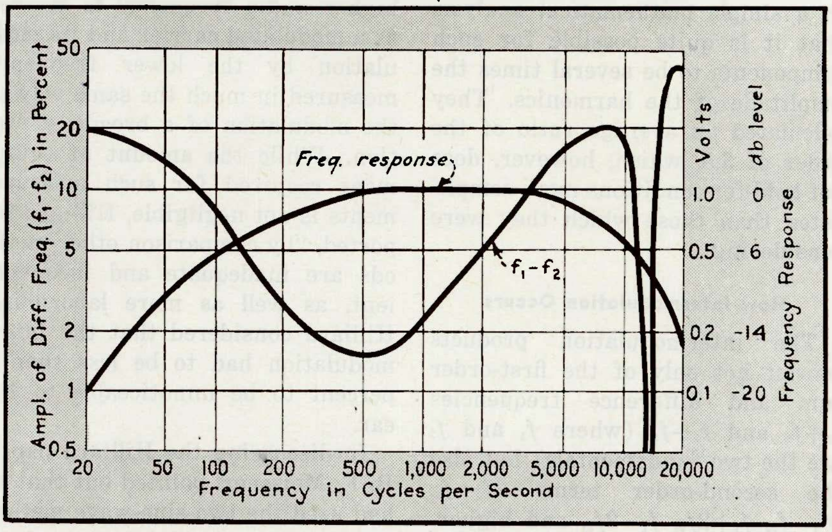

FIG. 4—Frequency-response and intermodulation curves on poor-quality amplifier

numbers of laboratory measurements must be made or for production or routine maintenance checking. The double-beat oscillator is less expensive than two beat-frequency oscillators and much simpler to use because of the constant sum or difference feature and the mixer circuits.

Measuring Procedure

Figures 2, 3, 4, and 5 show samples of results obtained with the double-beat oscillator in measuring the difference frequency generated in various types of amplifiers and sound-reproducing systems. The curves were taken as follows: Above 200 cycles a constant difference frequency of 100 cycles was used, the amplitude of the difference frequency being plotted in terms of the higher of the two input frequencies. Since the double-beat oscillator provides two output frequencies with a fixed difference, the analyzer was left tuned and the portion of the curve above 200 cycles obtained by merely varying the main oscillator control. Below 400 cycles the same procedure was used, but with a fixed difference frequency of 500 cycles, the curve being plotted in terms of the lower of the two input frequencies. If the characteristics of the reproducing system are fairly flat between 100 and 500 cycles the curves will overlap almost exactly in this region, thus forming, in effect, a continuous curve.

The main justification for this procedure is purely practical and arbitrary. It is a simple means of obtaining a continuous curve showing first-order intermodulation as a function of the controlling frequency (which is generally the lower of the two frequencies in the low-frequency region and the higher of the two frequencies in the high-frequency region). Such curves on amplifiers producing strong first-order intermodulation check far better with audible estimates than any other simple distortion curves that we have found to date. Janovsky considered the difference tone as the most serious component in this annoying type of distortion.

A similar curve can be obtained without shifting the difference frequency, but two peaks will appear when the fundamentals equal that frequency. This is no disadvantage for routine and production testing, since the difference frequency may be chosen so that it lies in a part of the range where distortion is ordinarily small—for instance, around 400 or 500 cycles.

Analysis of Sample Results

Figure 2 shows an amplifier characterized by a good frequency-response characteristic, but a rough and annoying quality in the high-frequency reproduction. The rise in the difference tone at high frequencies shows the reason. Judged by its frequency-response curve, this is an extremely fine amplifier. On actual listening tests it performed very poorly. The intermodulation characteristic shows at least one very good reason.

Figure 3 shows an amplifier with inferior frequency response to Fig. 2. If only the frequency-response curves were available, one might conclude that the cleaner reproduction of the amplifier shown in Fig. 3 was a result of greater attenuation of high frequencies. Actually, over the important region up to 10,000 cycles the difference between the two amplifiers in this respect would never be noticeable, and the amplifier of Fig. 3 is characterized by unusually clean, crisp, full-range reproduction. The intermodulation curve shows one reason for this. Although ordinary frequency-response and distortion measurements indicate that the amplifier of Fig. 2 is better than that of Fig. 3, listening tests definitely indicate the opposite.

Figure 4 shows another case involving an amplifier with rather poor frequency characteristics, also characterized by harsh reproduction which many designers have attempted to avoid by reducing the high-frequency response. This particular amplifier has bad intermodulation at both the low- and high-frequency ends. Also, in the high-frequency region there is one point where the intermodulation cancels out exactly, which indicates the risk in making intermodulation measurements at only a few frequencies.

Figure 5 shows the actual voltage across the voice coil in a loud speaker - amplifier combination. When operated into its rated load impedance the amplifier is satisfactory, providing less than 2 percent intermodulation. Because of the high output impedance of the amplifier and the variation in the loud speaker impedance with frequency, the intermodulation curve shows sharp rises at the low- and high-frequency regions. While either the amplifier or the loud speaker, when checked alone by conventional methods, seems satisfactory, the combination of the two is definitely not.

Second-Order Products

The foregoing curves show only first-order intermodulation, which may not always be the controlling factor. It is realized that under certain conditions, and particularly in highly balanced circuits, the first-order intermodulation products will tend to cancel and the second-order intermodulation products become the important factors in the audible distortion. It is, of course, possible to build an oscillator having an output such that one or more of the second-order intermodulation products can be kept constant, but this has not seemed warranted so far.

As a practical matter, many push-pull amplifiers do not seem to be as well balanced as might be assumed, particularly at the extremes of the frequency range, so that the first-order intermodulation products are as strong as or stronger than the higher-order products. (The amplifier shown in Fig. 4 is push-pull.) Harries[5] reported that on symmetrical overloading the first-order intermodulation products rose to a maximum as the overloading increased and then fell off as the second-order intermodulation products rose. His observations were on single output tubes having an S-shaped amplitude characteristic, but also seem to apply to many actual push-pull amplifiers. Under these conditions the distortion is generally serious before the first-order intermodulation has reached its maximum.

Conclusions

We have used this double-beat oscillator only on a few special applications, but it has proved so satisfactory and convenient that we feel that there may be a real demand for such instruments in the field. It is mentioned not as a cure-all, but as a further step in the design of audio-frequency measuring equipment in an effort to obtain results which correlate better with listening tests.

The writer will be very glad to receive comments and suggestions from other engineers who have used two-frequency measurements, or who have devised equipment for making such measurements.

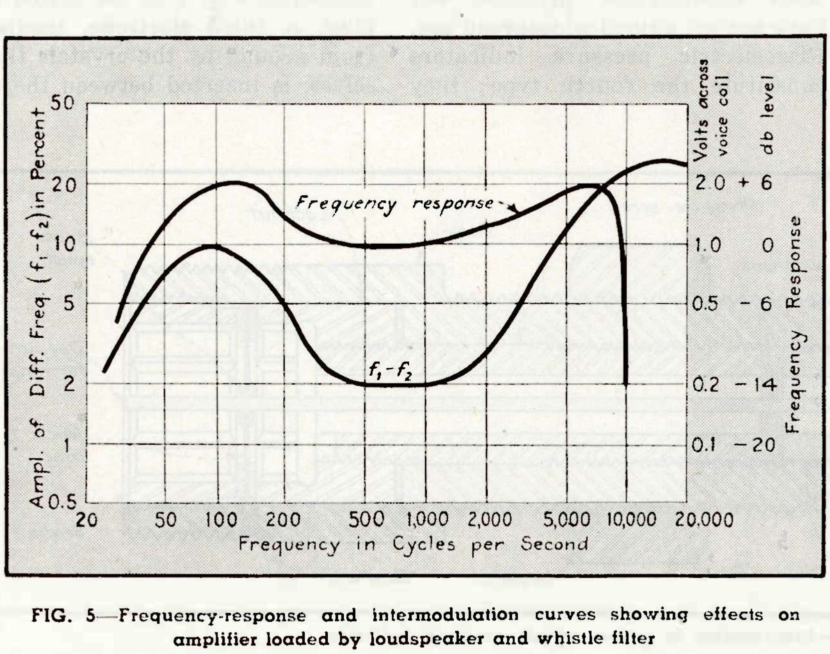

FIG. 5—Frequency-response and intermodulation curves showing effects on amplifier loaded by loudspeaker and whistle filter

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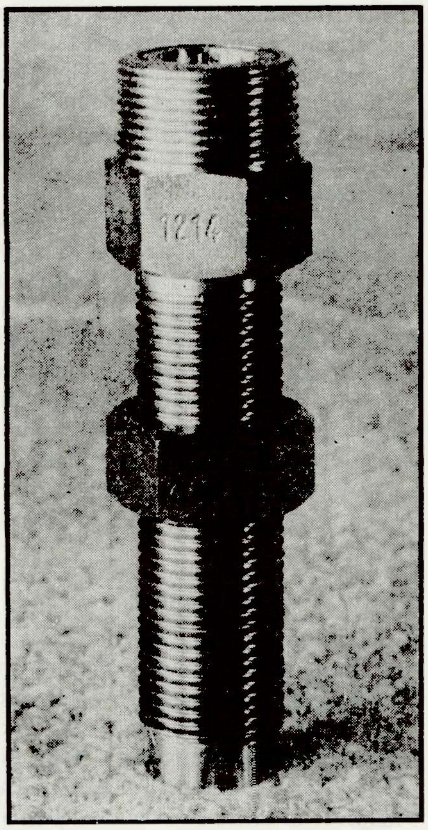
Electronic



Pressure-sensitive quartz crystal unit, shown actual size. Output terminal is at the top

Quartz crystal unit, inserted in an engine head like a spark plug, converts pressure variations into a pulse wave form requiring an amplifier having essentially flat response from 1 to 20,000 cps. A wide-band oscilloscope reproduces the pressure pattern

TO THOSE familiar with engine work, the need for an accurate means of recording pressure-time and rate-of-pressure-change curves is obvious. An engine pressure curve means as much to an automotive or aircraft engineer as the square-wave response of an amplifier means to an electronic engineer.

A good engine pressure indicator should record equally well either static or dynamic pressures, and have an accurate calibration that is not affected by time, fatigue, temperature, or shock. It should make a complete diagram recording for each explosion of the cylinder in which it is inserted, and should not respond to engine vibrations. Physical dimensions closely approaching those of an average size spark plug are most desirable. And since automotive engineers normally are not electronic engineers, simplicity of operation is essential.

Four different types of electrical or electronic pressure indicators have been developed. Those with carbon as the pressure-sensitive element have been virtually abandoned due to a high response to engine vibrations and inconsistency of calibration. Magnetic type pickups do not respond to the high-frequency components in pressure waves. Capacitance-variation types show considerable promise, but have not yet gained widespread use. Piezoelectric pressure indicators constitute the fourth type; they have had extensive industrial use, and have proved to be the most satisfactory for the instrument to be described.

With the quartz crystal type of pressure indicator, it is possible to study combustion balance under all conditions of operation and the effect of changes in carburetor adjustment, as well as carburetion and ignition characteristics, during successive cycles. The same equipment may be used on spark or compression-ignition types of internal combustion engines, air compressors, fuel-injection lines and in all other applications where pressure changes must be measured.

Construction of Piezoelectric Unit

The pressure-sensitive unit consists of two quartz crystals mounted in a small cylindrical casing between two grounded electrodes, indicated in Fig. 1 as the piston and plug. A third electrode, insulated from ground by the crystals themselves, is inserted between the two

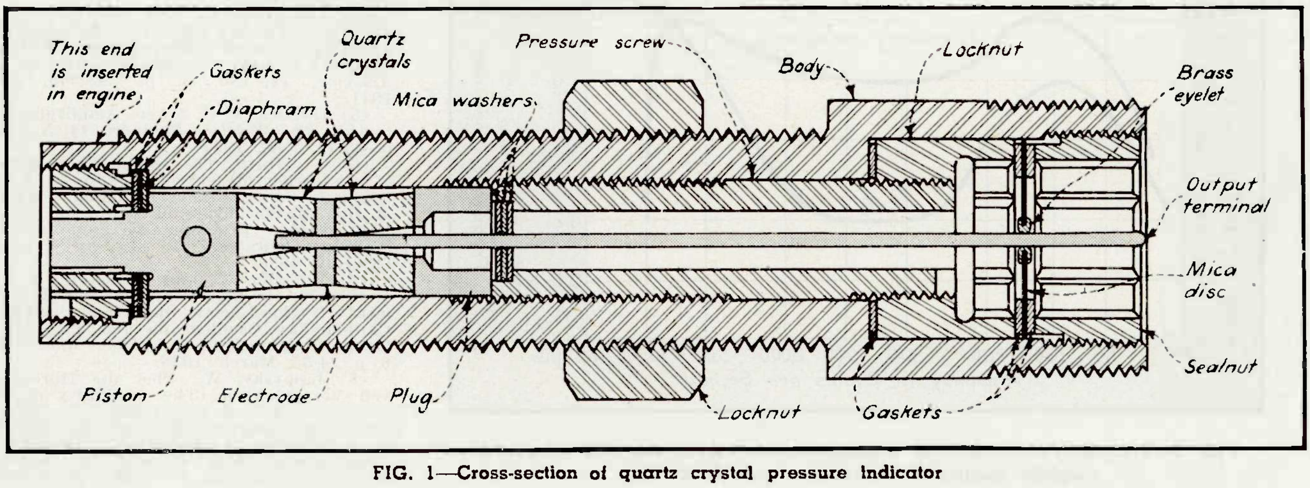
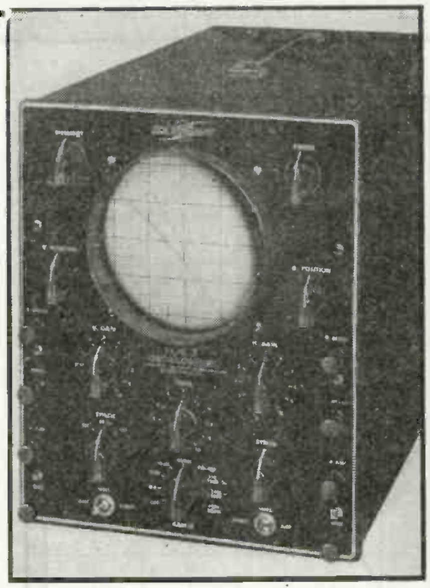


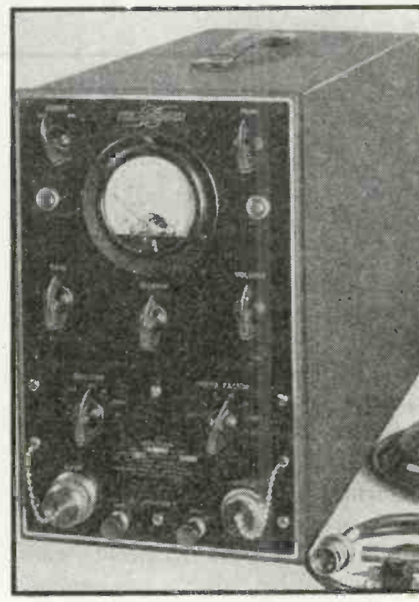
FIG. 1—Cross-section of quartz crystal pressure indicator

Engine-Pressure Indicator

By J. W. HEAD
President
Industrial Electronics, Inc.
Detroit, Michigan



Cathode-ray oscilloscope developed for engine-pressure studies, with built-in amplifiers capable of handling frequencies from 1 to 20,000 cps



Cox type II special amplifier made by Commercial Research Laboratories, Detroit, for use as part of the electronic engine-pressure indicator

crystals and connected to the output terminal of the unit. The end that is inserted into the engine has a pressure-tight seal which excludes all gasses.

The crystals are held under constant pressure by the two grounded electrodes. When an external pressure is exerted on the piston, thus further compressing the two crystals, electrical charges appear on each crystal. The quantity of this charge varies directly with pressure and is therefore a direct measure of the pressure exerted. The voltage between the center electrode and ground, when no current is drawn from the unit, is directly proportional to this charge and inversely proportional to the capacitance between the two electrodes. This voltage may be applied to the grid of an amplifier tube.

Amplifier Circuit Requirements

It is impossible to produce amplifier tubes with an infinite input resistance or with perfect insulation. For these reasons, some current is drawn from the pressure unit by an amplifier and errors are introduced. If, however, the time constant of the circuit connected across the crystals is large with respect to the rate of change of pressure, only a very small portion of the charge on the crystals can leak off between the pressure peaks, and thus crystal loading errors will be small.

In order to make the time constant such that the unit will be accurate over the speed ranges desired, it is necessary to connect a comparatively large capacitor across the output of the unit. This is provided for in the input circuit of the special amplifier developed for use with this unit. The values of capacitance and resistance in the input circuit of the amplifier are such that approximately five percent of leakage will occur in 0.05 second. Thus, a five-percent error would occur if a pressure were applied to the unit and this pressure held at a constant value for 0.05 second. However. due to the fact that the pressure wave in an explosion chamber is not constant, the error for engine speeds of 1000 rpm and greater is quite small.

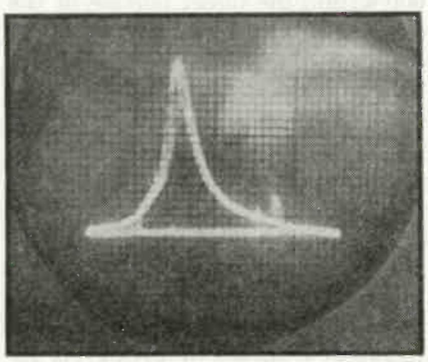


FIG. 2—Pressure diagram obtained from four-cylinder engine operating at 1200 rpm with peak pressure of 700 lb per sq in.

The sensitivity of the crystal unit is unaffected by temperatures up to 350 degrees Centigrade. Above this temperature the sensitivity drops rapidly, until at about 573 degrees Centigrade it is zero. At this temperature the quartz changes from what is known as alpha to beta quartz. However, as soon as cooled, the quartz returns to its previous form and the unit regains its normal characteristics.

Physical Characteristics of Quartz Unit

This pressure indicator has been used to record explosions in which the pressure rises in less than half a millisecond, with no evidence of resonance in the unit.

In the assembly of the unit, the crystals and mica insulating discs cannot be touched with the fingers. They are chemically cleaned, dried, and put in place with tweezers. This is necessary to keep the d-c resistance of the unit above 1000 megohms.

This same low leakage factor must be maintained in the cable connecting the pressure unit to the amplifier: the cable must also maintain a constant capacitance under the vibrations encountered in engine studies, since the voltage out-

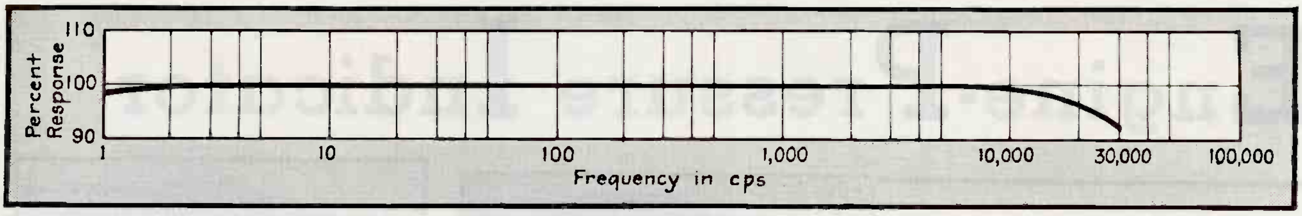


FIG. 3—Frequency response of the special Cox type II amplifier designed for engine-pressure studies

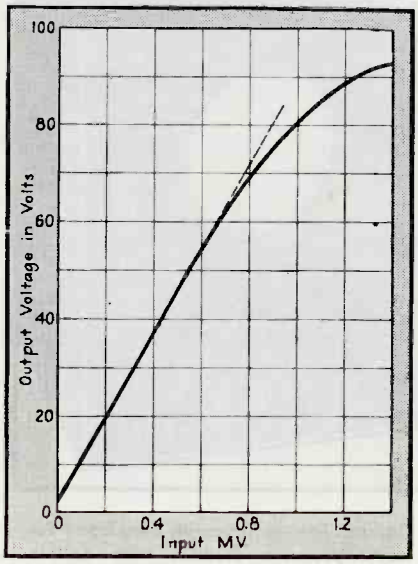


FIG. 4—Gain characteristic of amplifier, showing distortion-free gain of 90.000 at inputs up to 0.6 millivolts

put of the unit is inversely proportional to the shunt capacitance across the crystals. The normal capacitance of the unit together with its special 6-foot cable is about 30 $\mu\mu f$.

The maximum pressure for which the unit is recommended is 5000 lb per sq in., while the minimum pressure for which it is usable is somewhat below 50 lb per sq in. Lower pressures, such as those encountered in engine manifolds, can be measured by using a mechanical type of low-pressure multiplier, in which the pressure applied to a comparatively large diaphragm is transferred by direct contact to the much smaller diaphragm contained in the pressure pickup. Provision is made for either air or water cooling of this unit, which permits placing it directly in the exhaust system of an engine.

Amplifier Characteristics

A three-stage resistance-capacitance coupled amplifier has been designed for use with the quartz crystal pressure indicator. An amplifier that will function with this pressure indicator must handle a wave form that contains a wide range of frequencies and is practically of uni-polarity.

An idea of the requirements of the amplifier and oscilloscope used in this work may be obtained from Fig. 2, which shows the engine-pressure diagram obtained from a four-cycle engine operating at 1200 rpm. The oscilloscope sweep frequency is twice the frequency of the pressure curve. As may be seen, half the pressure wave has practically zero pressure change. To amplify this wave form properly, the amplifier must respond to almost zero-frequency square waves without distortion.

In the amplifier, 2 μf capacitors are used for coupling between stages and for isolating the d-c component from the output. A properly balanced means of low-frequency compensation is used in all stages of the amplifier. High-frequency response and minimum phase shift have been obtained by reduction of stray capacitance. Conventional methods of high-frequency compensation have not been used because of their tendency toward square-wave distortion.

The frequency response of the amplifier is given in Fig. 3, and is flat within two percent from 1 to 15,000 cps. The response is down only 8 percent at 30,000 cps, and is usable up to 100,000 cps. However, in engine pressure studies, frequencies above 20,000 cps are never encountered. Phase shift is linear with respect to frequency, and is negligible in this application.

The unusually good low-frequency response of the amplifier enables it to be used in many applications for which a d-c or direct-coupled amplifier would normally be used, without the objectional d-c amplifier instability.

Input Impedance

The grid resistance of a vacuum tube is usually considered as being infinite, but may drop to as low as 10 megohms due to heating of the grid by the filament and secondary emission from the grid as a result of electron bombardment. By proper choice of electrode potentials, however, the grid resistance of the first stage of this amplifier has been kept up to approximately 1,000 megohms. A 100-megohm grid leak resistor used in the input circuit gives the amplifier an input impedance of approximately 90 megohms. A 0.008-μf shunt capacitor is placed from grid to ground to provide for the output of the pressure indicator. Since the output of the indicator is inversely proportional to the value of this shunt capacitor, its value may be altered to meet the requirements of any unusual pressures that might be encountered.

To increase the over-all usefulness of the amplifier, a front-panel selector switch is provided to change the input impedance to 0.5 megohms with the shunt capacitance removed from the circuit. This enables the instrument to be used with strain gages, low-impedance vibration pickups, and other applications where high-gain voltage amplification is required.

Voltage Gain

As may be seen from the gain curve in Fig. 4, the over-all gain of the amplifier is approximately 90,000 within the linear portion of the curve and drops to 80,000, due to overload distortion, with an input of one millivolt. With input signals of 0.5 millivolt and over, the output of the amplifier may be coupled directly to the deflection plates of an oscilloscope and a 2-inch image produced without additional amplification. With input lower than 0.5 millivolt, the vertical amplifier in the oscilloscope must be used if an image of 2 inches or greater is required, and this amplifier must then be able to handle the pressure wave form without distortion.

The maximum input signal that

can be used without overload distortion in the first stage is 300 millivolts. Input signals greater than this are fed through the input selector switch and a 2-μf capacitor having an input impedance of 0.5 megohm. The same input receptacle is used for all input positions.

The input range of the second stage, in which the gain control is located, is from 5 to more than 1,000 millivolts. Choice between the first and second stage input positions is determined by the amplitude and impedance of the signal voltage and the desired phase relationship between the input and output signal.

The third stage has a binding post connection for feeding an external signal through a separate gain control into its grid. This connection is normally used for superimposing a marker signal onto the phenomena being studied on the oscilloscope screen, for purposes of establishing time or phase relationships. It also enables the third stage to be used as a single-stage amplifier.

Calibration

A 60-cycle calibrating voltage, read directly on the front-panel rms voltmeter and variable from 0 to 1,000 millivolts, can be connected through the input selector switch to the grid of either the first or second stage. Thus, when an oscilloscope is used in conjunction with the amplifier, it is always possible to calibrate the equipment in terms of volts-per-inch deflection.

Since the quartz crystal pressure indicator is factory calibrated in terms of millivolts per-pound-per-square-inch pressure, it is possible to calibrate the oscilloscope vertical deflection in terms of inches deflection per pound-per-square-inch of pressure. The same holds true when an output meter is used with the amplifier, provided, of course, the wave form under study is symmetrical.

Power Supply

Satisfactory electronic regulation was obtained by regulating in front of the voltage-regulator amplifier system. This method is so effective that the power supply can be overcompensated for line voltage fluctuations, and the instrument can be operated from the same power line used for arc welders, punch presses and other heavy factory equipment. With a 14-volt surge introduced into the line voltage and the amplifier at maximum gain, the image on the oscilloscope screen will not be deflected more than 1 inch. The hum level of the amplifier at maximum gain is less than 3 percent with an input signal of 0.5 millivolt.

Oscilloscope Requirements

For normal pressure studies, the voltage output of the amplifier is sufficient for cathode-ray recording without additional amplification. To take care of special cases, however, a cathode-ray oscilloscope was developed with the same general characteristics as the amplifier. The horizontal and vertical amplifiers are identical and provide a maximum deflection sensitivity of 25 millivolts per inch. The sweep frequency extends down to two cps, and provision is made for connecting onto the deflection plates of the cathode-ray tube directly from the front panel.

The multiple-contact synchronizer and timer unit shown in Fig. 5 provides a square-wave-front potential of sufficient amplitude for all applications in which it is necessary to lock the frequency of the sweep to the speed of the engine. Also, it provides a marker signal which may be superimposed on the image under study by connecting to the marker input terminals on the amplifier.

Timer

Mechanically, the contactor consists of two discs and a drive shaft. The drive shaft is attached to the crank shaft of the engine and geared to the two contactor discs. The gear ratio is such that the discs rotate at one-half crank shaft speed. The synchronizing or timing-axis disc contains four insulated segments which form a part of the electrical circuit. The marker or angle finder disc contains one segment.

Brushes which make contact with the disc segments are controlled through 360 degrees of rotation by front-panel tuning mechanisms. Rotating the position of the timing-axis brush varies the relative time between the initiation of the oscilloscope sweep and the drawing of the pressure diagram. Thus, the operator may synchronize to any desired portion of the oscilloscope image.

The control for the marker or angle-finder brush is calibrated in degrees. When this control is so positioned that zero degrees on the dial corresponds to top dead center position of the engine, an angular relationship between dead center and any part of the pressure curve can be established. When so adjusted, a mark will be superimposed on the pressure curve at the point of dead center. This is illustrated in Fig. 6. Rotating the angle finder dial will move the mark away from dead-center by the angular distance in degrees indicated on the dial. This enables the operator to study all parts of the pressure diagram in relation to the crank angle.

For sources of material in this article, the author wishes to give credit to the Commercial Research Laboratories, Inc., Detroit, and to RCA Victor Division, Camden.

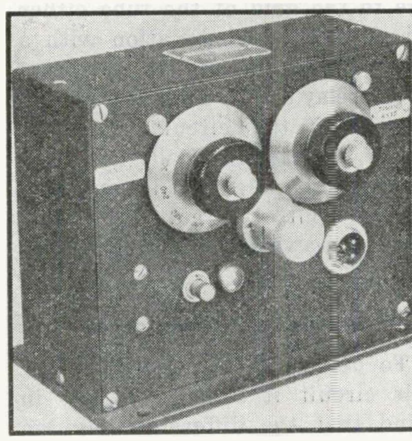


FIG. 5—Contactor unit used to provide synchronizing and marking signals

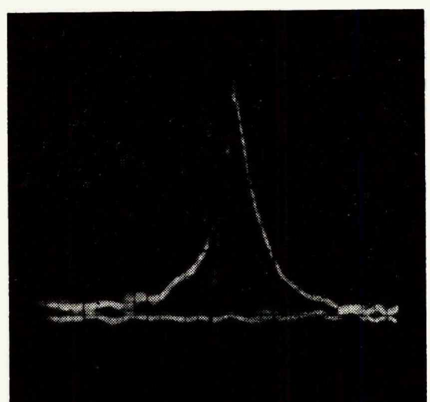


FIG. 6—Example of pressure pattern having vertical marker (produced by contactor unit) at top dead center

RELAYS IN Industrial Tube Circuits Part II

The choice of the most sensitive operating point for vacuum tube relay control is chiefly governed by the ratio of relay pull-in to drop-out currents. A graphic method is presented for determining average plate current for operation from variable voltage sources

By ULRICH R. FURST
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It is often desired to operate a relay when a certain variable voltage reaches a predetermined value, and to release it at another value of this variable voltage which may be higher or lower than the first. By connecting a relay in the plate circuit of a vacuum-tube and applying the variable control voltage to the grid of the tube either directly, or in combination with a bias voltage, the desired operation of the relay can be achieved. An advantage of this circuit, shown in Fig. 1, is that practically no power from the signal circuit is consumed in the control circuit; the only current drawn is the tube grid current.

Sensitivity of Tube Control

To determine the sensitivity of this circuit it should be kept in mind that the difference between the two critical grid voltages at which the relay in the plate circuit shall operate or release, multiplied by the dynamic transconductance G_m' of the tube, gives the difference between pull-in and drop-out current of the relay:

$$\Delta I_p = \Delta E_g G_m' \qquad (1)$$

To obtain high sensitivity it is therefore advisable to use a relay adjusted to operate with a small current differential (ΔI_p small) and a tube with a high transconductance (G_m' large).

At first glance one would think that it would be of advantage to operate the relay at a high plate current, because transconductance is greater at larger plate currents, but unfortunately the drop-out current of relays of a given type is the same fraction of the pull-in current, and therefore the current differential between these two values also increases with increasing current; in fact, as Fig. 2 plainly shows, the current differential increases much faster than the transconductance so that an increase of the plate current actually reduces the sensitivity by increasing the required differential of the control voltage. In Fig. 2, a shift of the pull-in current from point A to point B shows how the corresponding grid voltage differential decreases from ΔE_1 to ΔE_2. The greatest sensitivity can therefore be obtained by the use of a relay which requires the least current for its operation and at the same time has contacts large enough to handle the specified load. At the same time the resistance of its coil should be low enough, so that excessive supply voltages are not required.

Determination of Operating Values

It might be emphasized that relay coil resistance seldom matches the plate resistance of the tube, but this is of little importance because voltage sensitivity of the circuit is more important than most efficient power transfer into the relay coil.

To find the most suitable value of coil resistance, the plate-current vs. plate-voltage curves of the tube should be used as in the design of communication amplifiers. The correct load-line is made to intersect the abscissa axis at the supply voltage and the zero grid-voltage line at a current which is higher than the pull-in current of the relay by a suitable safety factor. Because the pull-in current depends on the relay coil resistance (the minimum power consumed in the coil is usually constant for a particular relay type), the best operating point for the tube has to be found by trial and error or by a method described by George.[1]

In the case of pentodes the trial and error method can be greatly simplified because the voltage drop within the tube can usually be neglected. Under this assumption the desired coil current is slightly larger than the rated power of the relay divided by the total supply voltage, and the desired coil resistance equals the supply voltage divided by the plate current. The screen voltage can be safely reduced until the load-line intersects the zero grid-voltage curve at its bend, or it can be increased to shift the operating point towards more negative grid voltages. This shift does not affect the sensitivity of the circuit.

Phototube Control

A typical application for a circuit designed in such a manner is a photoelectric relay where the variable control voltage in the grid circuit is developed across a high resistance in series with the phototube as in Fig. 3. A change of phototube current due to a change of il-

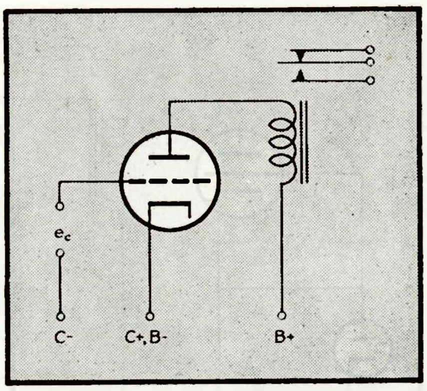

FIG. 1—The basic vacuum tube relay control circuit

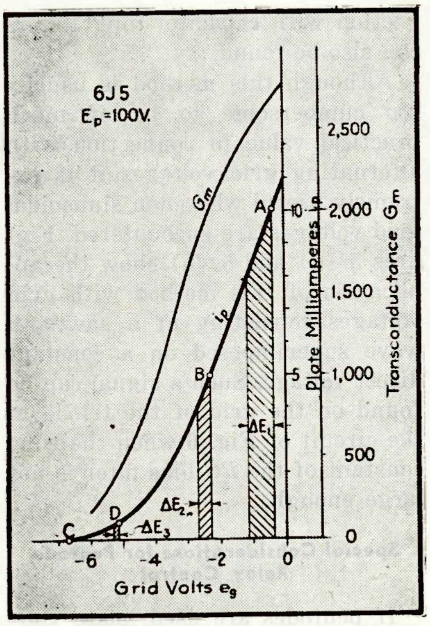

FIG. 2—(right) Current differential between pull-in and drop-out currents of relay type are proportional to pull-in current, therefore greatest sensitivity of tube control is obtained at low plate currents

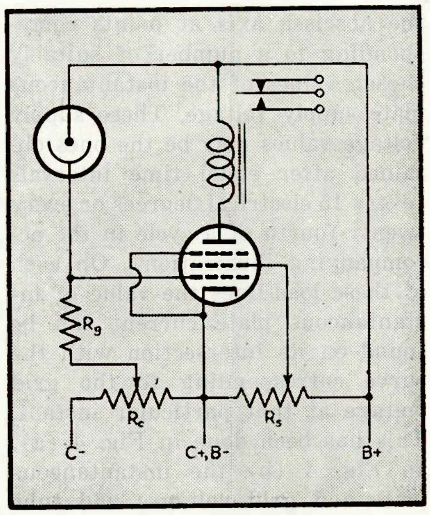

FIG. 3—An indirect phototube relay control circuit

lumination causes a change of grid voltage and operates the relay when a predetermined light intensity on the cathode of the phototube is reached. In this circuit, increasing illumination increases the voltage drop across the grid resistor R_g, thus making the control grid of the tube more positive and therefore increasing the plate current of the tube. The critical value of illumination can be adjusted by the voltage divider R_c or, if a pentode is used, by varying the setting of R_s to change the screen-voltage.

If the current differential of the relay is ΔI_p in μa, the dynamic transconductance of the tube is G'_m in μmho, the resistance in the grid circuit is R_g in megohms, the current through R_g caused by the phototube is I_g in μa, the sensitivity of the cell is S in μa/Lm, and the change in light-flux on the cathode of the phototube is ΔJ, then sensitivity is given by:

$$\Delta I_p = \Delta E_g G'_m = \Delta I_g R_g G_m' = \Delta J S R_g G_m' \qquad (2)$$

This equation also shows that in this circuit the relay is operated by a difference rather than by a percentage change of illumination.

It should be noted that this equation uses the load-dependent dynamic transconductance G_m' rather than the static transconductance G_m. It is well known that $G_m' = G_m r_p (r_p + R_l)$ where r_p and R_l are the tube plate resistance and load resistance respectively. The latter is the resistance of the relay coil in this case. Due to the high plate resistance of pentodes, there is practically no difference between G_m' and G_m and the latter value can be used in Eq. (2) when dealing with pentodes. No screen series resistors should be used with pentodes, to avoid screen degeneration which reduces the sensitivity of the circuit. The reason for this is that bypass capacitors of impractical size would be needed to make the time constant of the screen circuit sufficiently large. Bleeders or constant-voltage circuits should be used to obtain the screen voltage.

Operation With A-C Power Supply

Just as in the case of on-off control, operation of tubes directly from an a-c power supply may frequently be desired. In this case the control action of the grid circuit can also be obtained from a variable a-c or a variable d-c voltage. More complex signals such as variable saw-tooth or square-wave voltages may be used. Of course, the situation is more complicated because operation of the relay depends on a gradually changing plate current rather than on one which changes abruptly from zero to its highest value. More care must be given to the filter circuit necessary for fast-operating relays because the gradual increase or decrease of plate current increases the tendency of the relay to chatter.

The fastest way of finding the correct electrical properties of the relay is usually by trial and error. The rule-of-thumb (the average plate current with a-c operation is approximately half the current that would be obtained from a direct voltage which equals the rms value of the alternating voltage) furnishes a very suitable starting assumption, and in many cases might offer a satisfying solution by itself. If alternating control voltages are used, this rule may also be extended to the grid voltages, but this double approximation reduces the accuracy of the method especially when plate and grid voltages are not exactly 180 degrees out of phase.

It might also be of advantage to measure and plot tube characteristics for a-c operation. Average plate currents (measured with a moving-coil instrument) should be plotted against rms supply or plate-voltages, with the grid voltage (a-c or d-c, as the case may be) as the parameter. This method gives fairly good results. Special charts have also been published which might be used with advantage in those cases for which they have been calculated.[2]

If a more detailed analysis of the plate current is required, the plate-current vs plate-voltage diagram can be used. Unfortunately, because the plate supply voltage is not constant, more than one load-line has to be drawn. These load-lines are all parallel to each other and intersect the abscissa axis at points corresponding to a number of suitably chosen values of the instantaneous plate supply voltage. These supply voltage values may be the ones obtained after equal time intervals (every 15 electrical degrees or every twenty-fourth of a cycle in the accompanying illustration). On each of these load-lines the value of instantaneous plate current can be found on its intersection with the curve corresponding to the grid voltage at that particular instant. This has been done in Fig. 4 (a). In Fig. 4 (b) the instantaneous plate and grid voltages and tube current have been plotted against time from values obtained from Fig. 4 (a). The average plate current of 0.95 ma (the shaded area under the curve in Fig. 4 (b) divided by the length of one full cycle) compares favorably with the value found by rule-of-thumb of 1.05 ma.

From this curve the average current for resistor-input filter or no filter can easily be determined for different grid voltages. The peak current which is important in connection with capacitor-input filters can also be found.

Although this method is usually too cumbersome to be of much practical value in connection with alternating grid voltages it is extremely useful when non sinusoidal grid voltages are encountered. Figures 5 (a) and 5 (b) show the application of this method with grid voltages consisting of a sawtooth wave superimposed on a constant direct voltage. Such a signal can be found on the grid of the triode in the circuit of Fig. 6 when the time constant of the *RC* bias filter is not large enough.

Special Considerations for Pentode Relay Control

If pentodes are used, plate voltage has little influence on the plate current, and the load-lines should be plotted in a plate-current vs screen-voltage diagram. This diagram is never furnished by tube manufacturers, but the family of curves for the same tube connected as a triode is frequently available and is an excellent approximation, except for small plate voltages. The slant of the load-line must be obtained from the value of screen series resistance. The load-lines are vertical when the screen grid is connected to the tap of a bleeder potentiometer. The coil resistance does not influence the magnitude or wave shape of the plate current and can therefore be chosen afterwards. For the same reason, the average current through the relay remains the same regardless of the type of filter circuit used. Pentodes do not behave like half wave rectifiers and a current-limiting resistor is never needed because the screen grid already limits the current to a value determined by the tube characteristics.

Frequently the relay can be connected in the cathode circuit of the tube, the result being equivalent to a cathode follower. Such a circuit offers certain advantages, especially when a high impedance pilot circuit is used, and where stability is more important than voltage amplification and sensitivity, as in phototube work. The circuit behaves essentially like a cathode follower used in communication amplifiers and all considerations and methods described in this series can be modified to suit the special conditions with this in mind.[3,4]

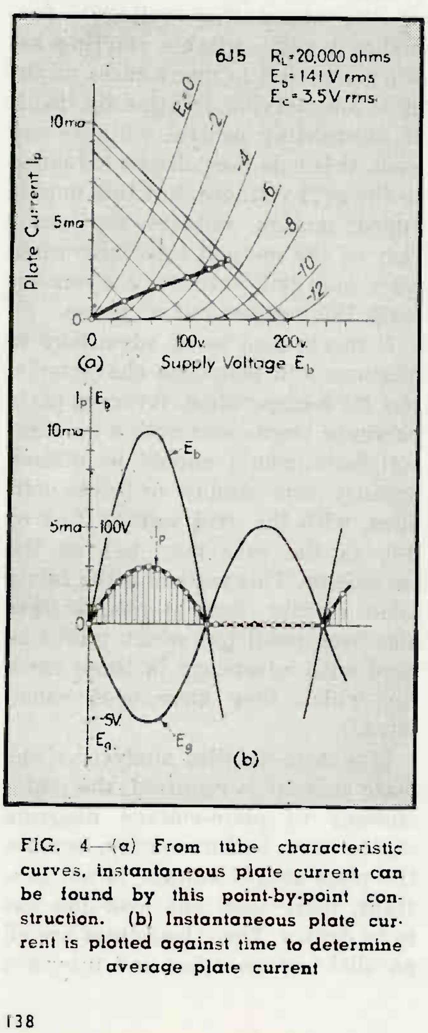

FIG. 4—(a) From tube characteristic curves, instantaneous plate current can be found by this point-by-point construction. (b) Instantaneous plate current is plotted against time to determine average plate current

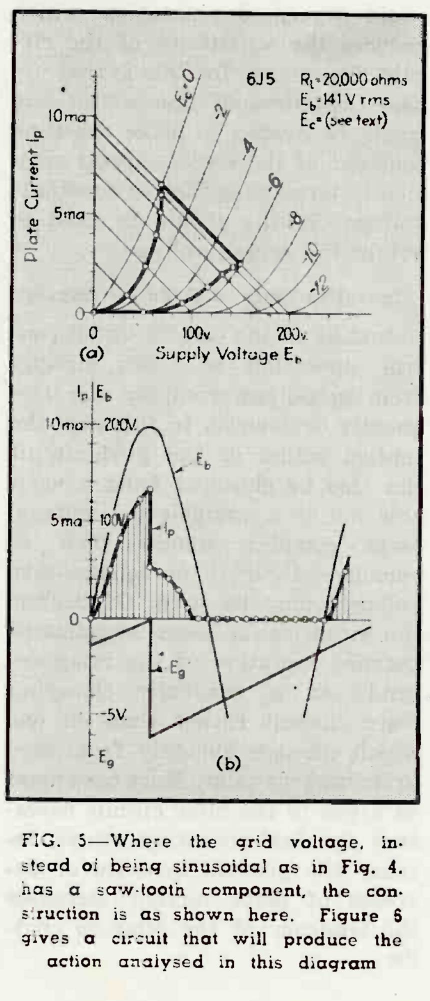

FIG. 5—Where the grid voltage, instead of being sinusoidal as in Fig. 4, has a saw-tooth component, the construction is as shown here. Figure 6 gives a circuit that will produce the action analysed in this diagram

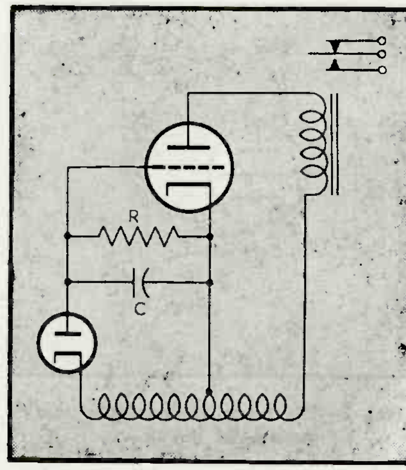

FIG. 6—If the time constant of *RC* is short the grid voltage will contain a saw-tooth component. For best operation *RC* should equal the period of the power-supply frequency

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(2) Schwarzman, W. A., ELECTRONICS, Aug. 1943, p. 94.
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The ENGINEER'S PLACE in DISTRIBUTION

Users and producers of electronic gear have equal stakes in post-war distribution efficiency. Buyers from a cross-section of industry were asked by ELECTRONICS how they think components and equipment should be sold to them. Here are the answers

ENGINEERING TRAINING for salesmen of electronic equipment assumes considerable importance in the light of a survey just completed by ELECTRONICS. Buying executives from a wide variety of industries were asked several questions about the way electronic components and devices should be sold. Nearly 100 different titles were represented among the individuals contacted in 110 different branches of industry.

Original Components

Relative to the purchase of parts for assembly into equipment, the buyers were asked whether they would want salesmen who offered such components to be trained engineers. Those saying yes totalled 88.1 percent—no, the remainder, or 11.9 percent.

Many of the yes answers were modified. Some stressed the necessity of engineering training but added that the salesman should also have practical experience.

In the next question, the respondees were asked their preference as to different channels of distribution. Those who wanted to do business with engineers said the engineers should be from the factory or branch office, by a plurality of 67.4 percent. Manufacturers' representatives with nearby supply connections came in for 24.6 percent of the votes.

Parts for Service and Repair

Considering replacement components, 39.0 percent of the buyers felt that engineering training for the salesmen was important. Of the entire group, however, 76.5 percent expected engineering recommendations to be provided by the manufacturer in the event replacements turned out to be too costly or frequent.

Among recommended sources of supply for replacement parts, the electrical wholesaler led with 23.3 percent against the 22.4 registered for the manufacturers' representative. Then followed the radio parts distributor with 21.9, the factory with 15.9, the radio dealer with 8.4, and the electrical dealer with 5.5.

Complete Assembled Products

Considering packaged electronic equipment—induction heaters, welding controls, phototube units, and the like—60.0 percent of the buyers questioned said they would need to be sold by sales engineers who could show how to apply their products. Only 23.5 think they can get by without any engineering guidance. The remaining 16.5 percent said they were capable of engineering their own applications but still want to deal with an engineering-trained salesman.

Most of the latter group believe that while they could if necessary, do their own application engineering, they would be relatively slow at it compared with a specialist and prefer to leave such engineering to specialists.

In the category of complete assembled electronic products the manufacturers' representative placed first as a supply source by 41.7 percent with the factory second—28.6.

Accessibility, Guarantees and Service

Are application sales engineers welcome to survey the plants where their products might prove to have value? Of the whole group of buyers 77 percent say yes. Only 16 percent register an unequivocal no.

The question of guarantees found 65.8 percent expecting a warranty on performance as well as workmanship and materials. However, 24.7 percent want no guarantees except for material and workmanship.

Installation and servicing can be performed by the existing staffs of 77 percent of the people contacted, with only the remaining 23 percent expecting to need outside help.

Crux of the Problem

One salient moral to be derived from the many general comments made on the subject of electronic merchandising concerns a dissatisfaction of the kind expressed in the following complaint by a research associate in a sound lab:

"If there's anything that burns me up it's to order some equipment direct from the XYZ Co., and six months later have somebody walk in and want to know if everything is going all right with those so-and-so's we got from XYZ on account of he's the local representative for same and he has a letter from the factory and he thought he ought to call. It turns out that he doesn't know ac from dc and made $12,000 commission on what business we gave XYZ last year."—F.H.

Amplifier Theory

Method of utilizing equations for negative-feedback amplifiers to design an analogous voltage-regulator system and determine when it will be subject to hunting and other faults

By JOHN M. CAGE

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MECHANICAL analogies are used extensively in the schools to clarify electrical concepts. However, in some instances mechanical problems are most conveniently solved by the mathematics developed originally in connection with electrical theory. A case in point is the application of alternating-current circuit theory to the solution of mechanical resonance problems. Similarly, the writer has often found it helpful to deal with astatic regulator problems in terms of the design principles usually applied to negative-feedback amplifiers.

Of course, if the regulator system under consideration is entirely mechanical in nature, we must use the conventional transformations to electrical equivalents. That is, mass becomes inductance, force becomes voltage, velocity becomes current, etc.[1] The regulator then becomes, for most practical considerations, a negative-feedback amplifier, because in both cases a signal is applied to the input in such a way as to oppose any change in output.

For a concrete case, consider the voltage regulator scheme of Fig. 1. Here, the peak output voltage of an a-c generator is to be regulated within close limits, regardless of load variations or changes in machine characteristics such as might be caused by temperature variations. To accomplish this purpose, the alternating output voltage is rectified to produce a direct voltage proportional to the a-c peak values. The resulting direct voltage is applied in series with a reference voltage E_R to the input of a d-c amplifier, electronic or otherwise. (The reference voltage determines the operating point of the system, and can be thought of as the signal to be amplified.) The output current of the amplifier is passed through the control field of a Regulex type of generator,[2] which is itself a d-c amplier. The Regulex excites the field of the main generator.

Electrical Analogy of Regulator

It might be said, in objection to the comparison presented here, that mechanical systems such as this are nonlinear in their transfer characteristics, while the mathematical method applied to the design of negative-feedback amplifiers assumes linearity. However, most regulators are fairly linear at their normal operating points. In fact, electronic ampliers are inherently nonlinear themselves, but a great deal of useful information can be obtained by assuming them otherwise. The same is true of regulators.

The ability of the regulator of Fig. 1 to oppose changes in alternating voltage when the generator load changes, can be stated in terms of the internal impedance of the equivalent feedback amplier. To state another similarity, the regulator opposes the change of machine characteristics within its system in the same manner that a negative-feedback circuit minimizes changes in tube constants. And the most serious annoyance in regulators, which is hunting, corresponds to oscillation and poor transient response in negative-feedback amplifiers. These statements are true regardless of the proportion of mechanical or electromechanical elements to electronic elements in the regulator. In fact, some of the linkages in the regulator loop could be chemical, provided only that a linear relation continues to exist between input and output and that there is no action analogous to that of an all-pass filter.

The analogy between regulators and feedback amplifiers has been discussed previously,[3] but usually from the standpoint of operational mathematical methods. Here, on the other hand, the subject will be treated in terms of ordinary undergraduate mathematics.

Negative Feedback Equations

To study the various design considerations mentioned above, we shall briefly review some of the equations that have been derived in connection with negative-feedback amplifiers. While these are familiar to most communications men, it is felt that many engineers in industrial electronics, where regulator design is encountered, are not aware of their usefulness. Still, it is not the purpose to present a complete mathematical treatment. That is readily available elsewhere.[4, 5, 6, 7] It is merely hoped that this paper may serve as a guide to the interpretation of the theory as applied to regulators.

The effective internal output impedance of an amplifier with feedback[8] is

$$Z_{out} = Z_1/(1 - A_1\beta) \qquad (1)$$

where Z_1 = output impedance without feedback.

A_1 = amplifier gain without feedback.

β = voltage feedback factor = (voltage feedback from output to input)/(output voltage).

When the output impedance is to be made as low as possible $A_1\beta$

From a paper presented at the National Electronics Conference, Chicago. 1944.

Applied to Regulators

should be negative and large.

To measure $A_1\beta$ for the regulator of Fig. 1, the circuit is cut at points X, a known change in voltage is applied to the input terminals of the amplifier, and the resulting change in potential at the output terminals of the rectifier is measured. The ratio of the result to the cause here is $A_1\beta$ at zero frequency. In other words, $A_1\beta$ is the complex loop gain of the feedback system.

As applied to vacuum-tube amplifiers, Eq. (1) gives electrical impedance, or complex volts-per-ampere, and the same unit would result from application to the regulator of Fig. 1. However, in a system where voltage is not the quantity being regulated, and perhaps the load quantity is not current, Eq. (1) can still be used as a measure of regulation if the correct units are employed. For instance, in a regulator where speed of a motor is the quantity to be regulated and motor torque is considered as load, Z_1 would be in terms of speed-per-torque increment with regulator disconnected, and $A_1\beta$ would still be the control-gain ratio through the regulator and back around the linear feedback loop, regardless of the types of transducers, electrical, mechanical, or chemical. That is, if the input to the regulator were electrical, $A_1\beta$ would be in units of volts-per-volt, while if the input is controlled by longitudinal displacement, $A_1\beta$ becomes perhaps inches-per-inch.

Effect of Change Inside Regulator

Referring to Fig. 1, there are many changes that can occur in the characteristics of the various machines to cause a change in alternating output voltage. These changes in operating point are analogous to noise in amplifiers and can be studied by means of conventional amplifier equations. The important observation to be made in this connection is that the drift in the operating point of a regulator system is reduced from its value with no feedback by a factor

$$\frac{\text{Noise with feedback}}{\text{Noise with no feedback}} = \frac{1}{1 - A_1\beta} \qquad (2)$$

Equation (2) indicates several well-known regulator design principles from a somewhat different concept. It shows that β, the feedback ratio, should be as high as possible when there is negligible drift in characteristics of the feedback network itself. For example, in Fig. 1, if a certain group of feedback rectifiers can be assumed to have appreciably constant transfer characteristics, then one should select the rectifier that gives the highest ratio of d-c output volts to a-c input volts, and if feasible, the full a-c output of the generator should be applied to the rectifier input. In short, the transconductance of the feedback network should be high when no spurious drift exists there.

Equation (2) also indicates that the stability of the output operating-point in a regulator system can be improved simultaneously with improvement in regulation-versus-load, provided that the earliest stages in the system are sufficiently stable in operating point. Again referring to Fig. 1, the effects of internal changes in the characteristics of the a-c generator and Regulex exciter can be minimized by increasing the gain of the d-c amplifier—provided that increasing the amplifier gain does not materially increase its instability of output operating point. A more detailed analysis of the problem does not fall within the scope of this paper, but it is felt this suggestion of new concepts may lead to further study of the references.

Oscillation or Hunting

So far, we seem to assume that $A_1\beta$, the degree of feedback or overall amplification around the regulator loop, can be increased as much as desired. However, anyone familiar with amplifiers or regulators knows that oscillation will result if $A_1\beta$ is increased too much. All too often the system oscillates before the feedback is increased enough to secure the required regulation characteristics.

To study the hunting problem, the regulator engineer generally sets up the differential equations for his system, and from the solution of these equations finds the conditions for stability.[9, 10] (The cited references give good bibliographies.) To obtain numerical results, this process is usually laborious, even though the solutions for some typical regulator systems have been published. However, these classical analyses do yield important design information, of which the following is typical:

1. The greater the number of time delays, or more accurately, the greater the number of trans-

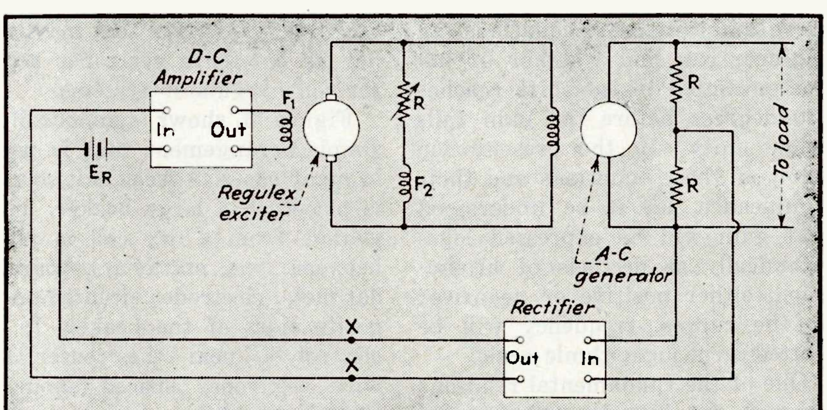

FIG. 1—Typical regulator system

ducers with output lagging the input, the greater the restriction on the maximum value of $A_1\beta$ before the occurrence of oscillation. On Fig. 1, in other words, if anti-hunt circuits are not used, better stability could be obtained for a given value of $A_1\beta$ by omitting the Regulex exciter and raising the gain of the amplifier. This assumes that the time delay in the amplifier remains constant when its gain is increased.

2. Conditions for stability are usually expressed in terms of the time constants of the various components causing time delay. The greater the spread in these time constants, the less the system is liable to hunt.

3. To obtain larger values of $A_1\beta$ and closer regulation without oscillation, two procedures are available. One is to make one of the time constants in the loop a great deal larger than all others. Since this method decreases the speed of regulator response, it is often disadvantageous. The alternative procedure actually increases the rate of response by introducing into the feed-back-loop, control signals proportional to the rates of change of the outputs of some of the components of the regulator. In other words, by the second method an anti-hunt circuit is used that tends to differentiate when a transducer tends to integrate a control signal.[16]

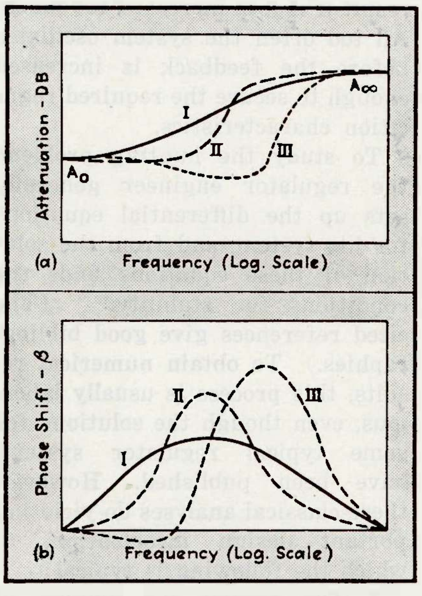

FIG. 2—Diagrams illustrating relation between area under phase-shift curve and the change in attenuation

Much has been accomplished by means of classical analyses, but often, when the problem is whether or not an existing system will hunt before the desired feedback is obtained, the engineer finds the equations difficult to apply. It is for these problems that the amplifier concept is suggested as a possible alternative.

Amplifier Stability

In the design of negative-feedback amplifiers, stability is usually studied by means of certain steady-state equations and frequency response curves. All tests are made with sinusoidal test signals. For instance, if the locus of the complex value of $A_1\beta$, the gain around the feedback loop, is plotted in polar coordinates for all frequencies, and if this curve encloses the point (1, 0°), then the amplifier under consideration would oscillate. Briefly understating, the problem in designing feedback amplifiers is to make the loop voltage gain fall below unity before the phase shift exceeds 180 degrees. From this, the uninitiated all too often infer that gain-versus-frequency and phase-shift-versus-frequency are two independent parameters. However, they are mutually dependent in any network not containing transmission lines or all-pass filters, and in fact, if one has before him a curve of gain versus frequency, it is not too difficult to derive the associated curve of phase shift plotted against frequency. Therefore, the only test data required to study oscillation in a feedback amplifier (or in a regulator) are points for a simple response curve of gain versus frequency.

From the frequency response curve and two basic equations[7] an engineer can find whether or not the unwanted phase shift reaches 180 degrees before the gain falls below unity. In the presentation below of these equations and their significance, let it be understood that gain will be expressed logarithmically as decibels of attenuation, either positive or negative; on the curves, frequency will be plotted on a logarithmic scale.

One of the fundamental relations between the interdependent quantities, attenuation and phase shift, is expressed by

$$\int_{-\infty}^{+\infty} B\,d\mu = \frac{\pi}{17.37}(A_\infty - A_0) \qquad (3)$$

where B = phase shift in radians,

$$\mu = \log_e f/f_r$$

where f is the actual frequency and f_r is any convenient reference frequency, A_∞ = db attenuation at infinite frequency, and A_0 = db attenuation at zero frequency.

The interpretation of Eq. (3) is as follows: when the phase shift B is plotted against a logarithmic frequency scale, the net area under the curve depends only upon the difference between the attenuations at zero and infinite frequencies, and not at all upon the network or the way the attenuation varies between the two limits. Three representative attenuation curves for this condition are shown in Fig. 2 (a), while Fig. 2 (b) shows equal phase areas for three ways of variation between the same limits.

Equation (3) means to the amplifier or regulator designer that if the internal phase shift is to be held below 180 degrees to prevent oscillation, the range of frequencies where the attenuation is changing must be spread out so that the required area under the phase curve is also spread out, and the maximum of the phase shift curve does not rise too high.

0.1-CPS Sine-Wave Generator

It is realized that the concept of measuring the steady-state response of a regulator system to sinusoidal input signals of various frequencies is perhaps uncommon. Nevertheless, if the physical system is actually available, it is not difficult to plot its response curve. The most nearly unavailable piece of equipment required is a sine-wave generator for frequencies that may be as low as one-tenth cycle per second for some regulator systems.

Figure 3 shows symbolically a simple arrangement that is useful in many cases. A weak salt solution is placed in a large beaker, and a voltage from a dry cell is placed between two stationary, parallel, flat metal electrodes situated on opposite sides of the beaker. In the electrolyte, near the center, two wire electrodes spaced about an inch apart rotate, causing an alternating voltage of very good wave form to appear at the output, regardless of the speed at which the wire electrodes are rotated by the small variable-speed motor. To test many regulators with this generator, an appropriate amplifier will be required.

Response-Measuring Procedure

The testing procedure for the system of Fig. 1 would be as follows. First, cut the feedback circuit at the points marked X. Apply the signal from the low-frequency generator to the input of the d-c amplifier. Find a suitable operating point, adjust the a-c input so there is no appreciable distortion in the regulator output, and vary the frequency over a wide range. Measure the output of the rectifier with a cathode-ray oscilloscope or mechanical oscillograph, and plot output-versus-frequency. Figure 4 shows a typical result.

More useful than Eq. (3) for numerical results is the following equation for minimum phase shift associated with a given attenuation characteristic

$$B_c = \frac{\pi}{12}\left(\frac{dA}{d\mu}\right)_c + \frac{1}{6\pi}\int_{-\infty}^{+\infty}\left[\left(\frac{dA}{d\mu}\right) - \left(\frac{dA}{d\mu}\right)_c\right]\log_e \coth\frac{|\mu|}{2}\,d\mu \qquad (4)$$

where B_c = phase shift in radians at the frequency f_c

$dA/d\mu$ = slope of attenuation curve in db per octave

$\mu = \log_e (f/f_c)$, where f is frequency and f_c is the frequency at which B_c is desired.

The first term of Eq. (4) gives a component of phase shift proportional to the slope of the attenuation curve. The second term may or may not be appreciable, since it depends upon how fast the slope is changing in the immediate vicinity of the frequency at which the phase shift is being calculated. The first term alone would account for a phase shift of 180 degrees if the slope were constant at a value of 12 db per octave. The second term has little effect when the slope does not change appreciably within a range of about thirty percent above and below the frequency under consideration.

Transient Response Problem

Assume that it is required to find the value of $A_1\beta$ to produce hunting in a regulator system having the response curve of Fig. 4. Normally the procedure would be to apply Eq. (4) to the curve to find where the phase shift reaches 180 degrees, but in this case it is wise first to find the shift in the higher-frequency range where the slope becomes asymptotic, for only the first term of Eq. (4) is required there. The slope in this region, which is eleven db per octave, produces a phase shift of slightly less than 180 degrees, and since the slope does not vary abruptly at any place on the curve, we can safely assume that the phase shift will never exceed 180 degrees.

Therefore we can conclude that any desired amount of feedback can be used without oscillation. However, with large values of $A_1\beta$, a sudden change of the regulator operating point would probably produce severe overshooting and transient oscillations in the regulator output. Space available for this paper is not adequate to treat the matter of transient response, but if the overall gain-versus-frequency curve for the regulator with feedback is plotted by means of the formula for gain,

$$A = A_1 \frac{1}{1 - A_1\beta} \qquad (5)$$

a sharp peak in the resulting curve will denote poor transient response.

If the study of Fig. 4 had shown a phase shift exceeding 180 degrees at a frequency at which the gain had not fallen below zero db (voltage gain = 1), a corrective network could have been used to prevent the gain from dropping off so steeply. Although this corrective network might assume some of the aspects of a damping circuit of the type conventionally used by regulator engineers, its design will have been reached through an entirely different procedure.

Conclusion

This paper has attempted to point out briefly the applications of amplifier concepts to regulator problems. No attempt has been made to develop a complete design procedure, but it is felt that many engineers and scientists now dealing with regulator problems either understand amplifier design or have the necessary background to get the details from the cited references.

There will be some cases where the experimental procedure outlined here, that of measuring and studying frequency response curves of actual systems, will be very useful. In addition, it is suggested that perhaps most persons can more readily visualize regulator behavior on the basis of conventional a-c circuit analysis than by the complete differential equations.

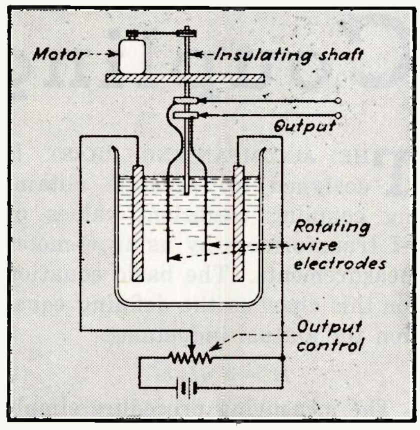

FIG. 3—Diagram of simple low-frequency sine-wave generator for testing the response of a voltage regulator

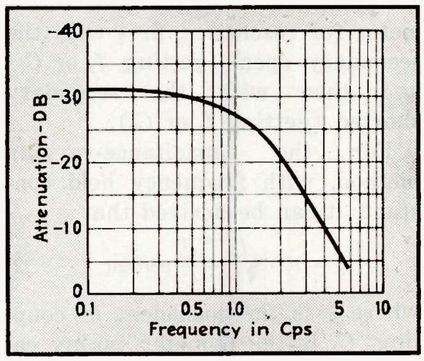

FIG. 4—Frequency-response curve of hypothetical regulator system

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Coupling Coefficient Chart

The coupling coefficient of an r-f transformer can be quickly determined by making two simple measurements with a Q meter and looking up their ratio on the accompanying chart

By L. E. PEPPERBERG
Engineering Dept.
Zenith Radio Corp., Chicago, Ill.

THE ACCOMPANYING CHART is designed to facilitate obtaining coupling coefficient values of r-f transformers by using Q-meter measurements. The basic equation for this chart is the defining equation for mutual inductance:

$$M = k\sqrt{L_1 L_2} \qquad (1)$$

The measuring procedure simply involves connecting the Q meter across the primary of the r-f transformer to be measured, then adjusting either the frequency f or the tuning capacitance C of the Q meter for resonance, first with the secondary open (getting f_1 or C_1) and then with the secondary shorted (getting f_2 or C_2).

For the capacitance-varying method, with frequency held constant, it can be derived that

$$k = 100\sqrt{1 - \frac{C_1}{C_2}} \text{ percent} \qquad (2)$$

where k is the coefficient of coupling, C_1 is the Q-meter tuning capacitance required for the primary inductance of the transformer when the secondary is open-circuited, and C_2 is the Q-meter tuning capacitance required with the secondary short-circuited. In the derivation of this equation only one assumption has been made, that the square of the secondary resistance is much less than the square of the self-reactance of the secondary. This is usually the case in practice.

For the frequency - varying method, with capacitance held constant, a somewhat similar equation for k is obtained:

$$k = 100\sqrt{1 - \frac{f_1^2}{f_2^2}} \text{ percent} \qquad (3)$$

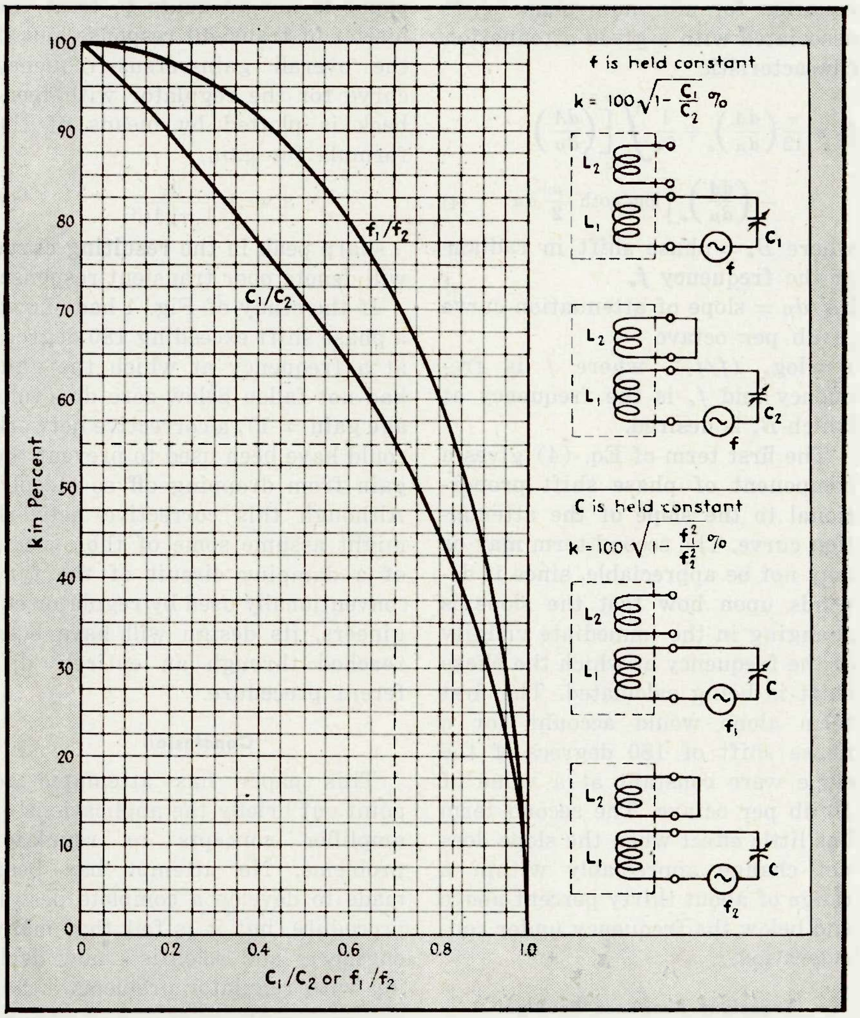
For very large coupling coefficients it is generally more practical to use the two-frequency method because the capacitance range required for large values of k is not always obtainable.

Once the values of frequency or capacitance have been measured and the ratio of values determined, the value of k in percent can be obtained directly from the chart.

Examples

With frequency held constant, a value of 175 $\mu\mu$f was obtained for C_1 with the secondary open, and C_2 was 250 $\mu\mu$f with the secondary short-circuited. This gives 0.7 for the ratio C_1/C_2, and with this value it can be found from the chart that the coupling coefficient is 55 percent.

With the tuning capacitor of the Q meter unchanged, the frequency values obtained with this same transformer were f_1 = 835 kc and f_2 = 1000 kc. With the resulting ratio of 0.835 for f_1/f_2 the same value of 55 percent for the coupling coefficient is obtained from the chart.



The coefficient of coupling k of an r-f transformer can be obtained directly from this chart once the ratio of two Q-meter readings has been obtained by either of the two methods represented in the diagrams

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Electronic Control of X-Ray Exposure Time

TO PROVIDE EXTREME uniformity between films for maximum analytic value, an electronic timer for control of x-ray exposures has been developed. With the unit, the x-rays pass through an object and strike a fluorescent screen where they are made visible. A section of the screen is scanned by a phototube which actuates an electronic amplifier and relay which opens the x-ray circuit when sufficient light for proper exposure of the film has been produced.

The unit has been used in medical radiography for mass chest surveys on miniature roll films, and will undoubtedly be useful for industrial x-ray analysis. Objects such as castings, conducted on conveyors, can be inexpensively, quickly, and uniformly radiographed on miniature roll film using the electronic control. Large, irregular objects need only be positioned before the screen. Technicians can handle twice as many subjects as heretofore.

Operation

The essential units of the electronic timer are shown in the diagram, and consist of a multiplier phototube and a capacitor-thyratron-relay system. When the exposure switch of the x-ray unit is closed, the rays pass through the object positioned before the photofluorographic hood. A grid in the hood filters out undesired, scattered radiations. The x-ray beam, having passed through the object and the grid, strikes the fluorescent screen where light emanates in accordance with the density of the object. Some of the light is focused by a lens onto the film of the photographic camera at the apex of the hood, and some of the light is picked up by another lens and focused onto the cathode of the phototube in a so-called phototube camera mounted on the lower side of the hood.

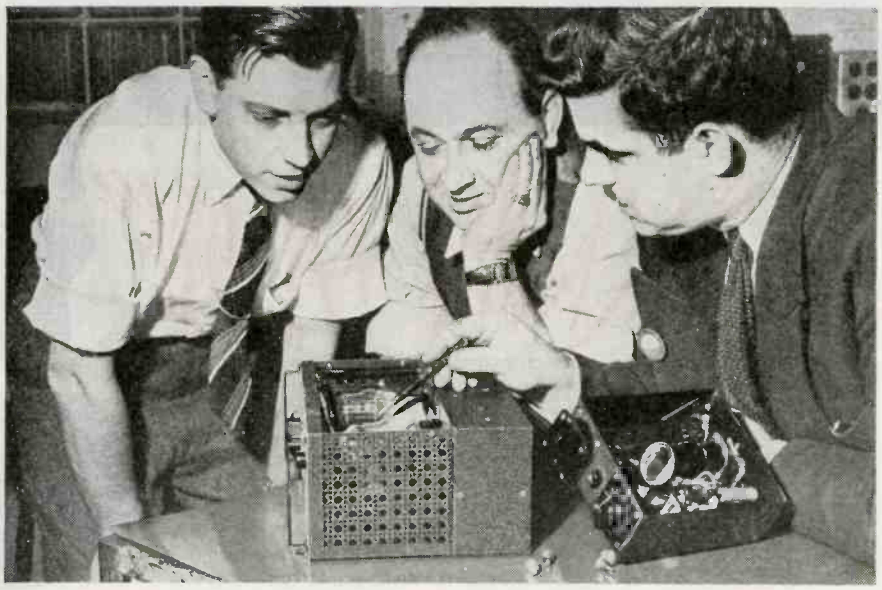
Light entering the phototube initiates a small current proportional to the light intensity of the scanned section of the fluorescent screen. This current charges a capacitor and produces a potential which increases as the collected charge increases. This voltage is impressed between the grid and cathode of a trigger tube and fires the tube when the necessary ionization potential is created. The ionization potential is attained only when sufficient radiation emanates from the fluorescent screen for proper, uniform film exposure. When the trigger tube ionizes and fires, a magnetic relay is energized which opens the x-ray circuit, terminating the operation of the x-ray tube and the exposure of the film.

Technique

In medical radiography prior to the development of the phototimer, the tube current and the distance were the only fixed factors—for example, 200 ma and 40 inches. The technician measured the thickness of the subject and in accordance with that measurement altered the applied x-ray tube voltage in steps of one kilovolt over a range of 60 to 100 kilovolts.

Exposure time was then estimated and set on a separate motor-driven timer. In all, the procedure involved five steps: measurement of the subject, positioning before the fluorescent screen, adjustment of voltage, setting of the exposure timer, and making the x-ray exposure. Moreover, variations in line voltage necessitated constant checkings and adjustments if properly exposed films were to be obtained.

With the electronic control, the



To the right is the phototube camera that scans the fluorescent screen in the electronic timer for x-ray machines. Westinghouse engineers (left to right) F. J. Euler, Jr., J. E. Kalstein and C. T. Zavales discuss their design of the safety timer circuit which protects the x-ray tube against overload or technical failure

current is set at some particular value, but variations of current (or voltage) are of no consequence, and the exposure time is allowed to vary over a range from 1/20 to 1/8 of a second. Only a very rough kilovoltage adjustment is made based on an estimate of subject size, and the thickness of the subject need not be measured. Using the Westinghouse timer, the procedure involves merely the positioning of the subject, a rough kilovoltage adjustment in accordance with a quick visual classification, and operation of an exposure switch. Since the phototube is affected only by the light intensity from the scanned section of the screen, uniformly good exposures are insured regardless of the thickness of the object or of irregularities within the object. A skilled technician cannot compensate for invisible, unknown internal irregularities, but the electronic timer can, since it is only affected by the light intensity on the fluorescent screen.

Details

The timer is adapted for operation with conventional x-ray generator controls which are equipped with an x-ray "on-off" contactor. It consists of two units: the phototube camera and the power supply unit which includes a protective circuit. Seven electronic tubes are used: a photoelectric multiplier tube, a voltage regulator tube, two rectifier tubes, and three gas triodes.

The phototube assembly is mounted beneath the photofluorographic hood, and the lens scans a rectangular portion of the fluorescent screen. The multiplier tube has nine stages of amplification, providing a 400,000 to 2,000,000 gain. From 800 to 1000 volts potential exists between cathode and ground and there is 150 to 200 volts from anode to ground. These ranges are provided so as to compensate for variations in tube sensitivities. A density control mounted on the phototube camera assembly varies the voltage between the eighth and ninth dynodes through a resistor and may be locked by means of a lock nut.

Current flow in the phototube circuit creates a potential across a resistor and capacitor. The resistor is included to compensate for the relay drop-out time—about 1/60 of a second. The trigger tube fires at 70 volts and its resulting plate current energizes a relay which opens the main x-ray contactors in the x-ray control and ends the exposure. In preparation for the next exposure, a shorting relay bypasses to ground any charge left on the capacitor.

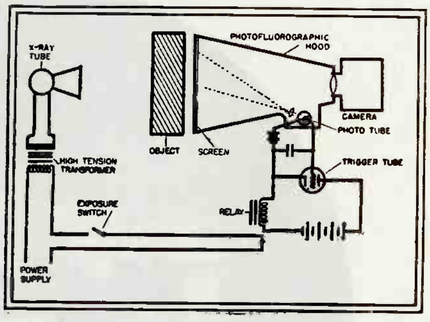


Diagram illustrating the principle of operation of the electronic timer for x-ray machines. When the x-ray tube operates, radiation passes through the object and is converted into visible light by the fluorescent screen. Some of the light is picked up by the lens and phototube arrangement so that the resulting current charges a capacitor. When the capacitor is charged to the proper value, the trigger tube fires and actuates a relay that opens the circuit to the x-ray tube and ends the exposure

Safety Circuits

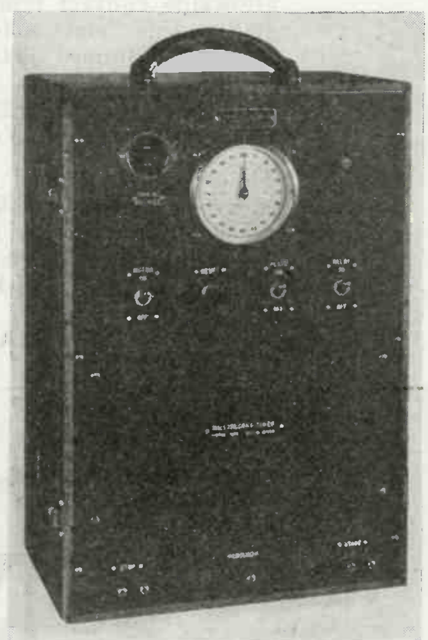
A safety timer, consisting of a trigger tube, an adjustable resistor, a capacitor, two relays and a buzzer, protects the x-ray unit against failure of the phototimer unit and against excessively long exposure times exceeding the capacity of the x-ray tube. Phototimer failure can occur only if an exposure is attempted before the unit has heated or if some component fails. Examination of unduly dense objects results in long exposure times since the phototube does not terminate exposure until proper photographic exposure is secured. There is thus the possibility that the rating of the x-ray tube may be exceeded in exposing unusually dense objects unless an auxiliary control terminates exposure.

One relay prevents an exposure from being initiated until the phototimer is ready for operation. Thus, the circuit will not be closed unless the timer components have heated properly and are functioning. The other relay will open the circuit when the safety trigger tube fires. Protection of the x-ray tube is assured by choosing the circuit constants so that the trigger tube fires before the rating of the x-ray tube is exceeded. The buzzer warns the operator that the safety timer has had to open the contactors and that the film is unexposed or underexposed.

Millisecond Timer for High Speed Operations

OPERATING ON momentary impulses of extremely short duration, a new millisecond timer is designed for use in factory test departments and experimental laboratories. Among its industrial applications are the measurement of pull-in and drop-out timing of high-speed circuit breakers and relays.

The complete timer assembly comprises a millisecond timer movement and an electronic control chassis whose circuit is shown in the diagram. The timer movement is driven by a 115-volt, 60-cycle synchronous motor. This motor is of the high-speed shaded-pole synchronous type with a comparatively high value of WR^2 so that the shock of engagement of a clutching mechanism will not disturb the synchronous operation or cause mom-



Electronic millisecond timer for measuring time intervals from 0.002 to 6 seconds long. One war-time application of the unit is measurement of time delay of fuses

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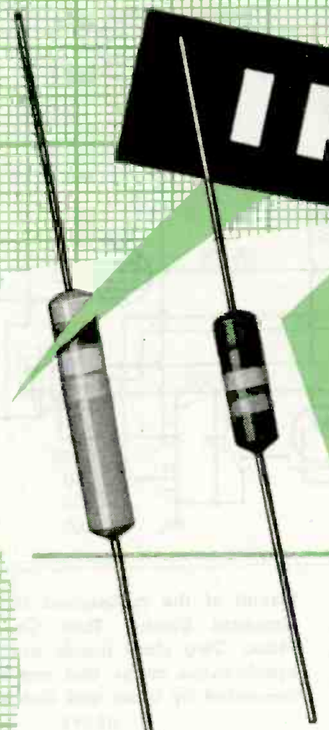

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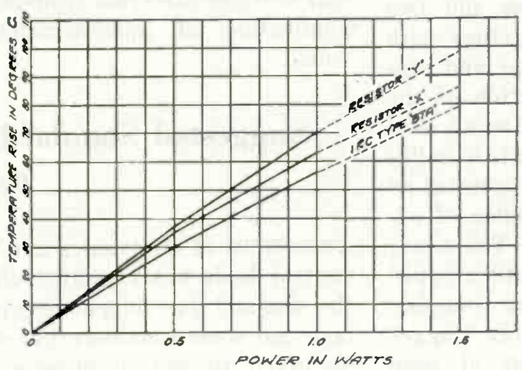

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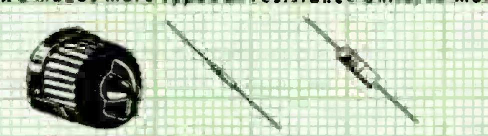

AM 3155 Rheostat

BTR—½ watt Insulated Resistor

BTA—1 watt Insulated Resistor

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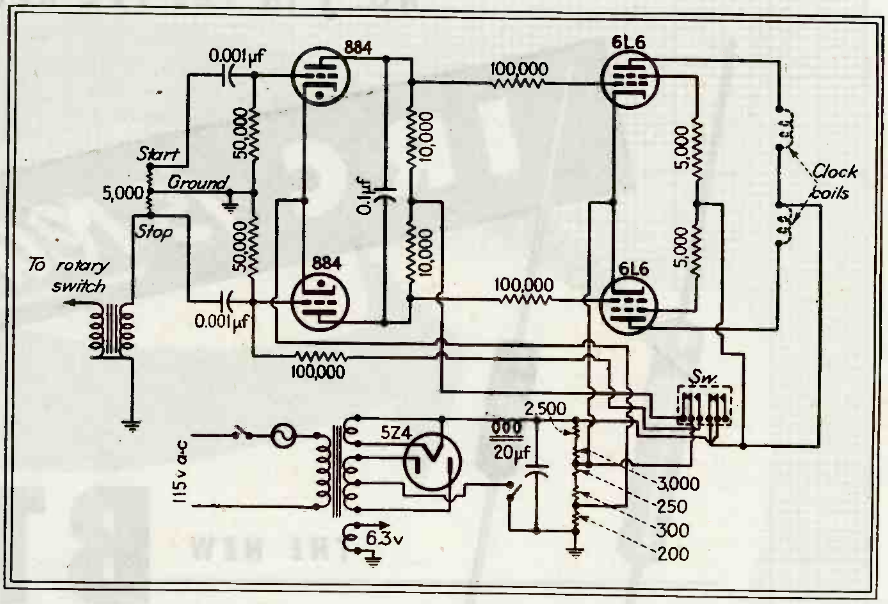
entary slip of the rotor during this operation. The movement is controlled by two clutch coils, one energized while the hands and movement are in a stationary position and the other clutch coil energized while the movement is in a running condition. The clutching mechanism consists of two identical controls that are constructed of light weight materials and low inertia movable members.

The movement drives two hands over a dial that is calibrated in units of 0.0002 seconds and totalizes to 6 seconds before repeating. The faster hand is driven at a speed of 600 rpm. The timer movement is capable of resetting the hands to zero from any position by the manual operation of a reset lever or knob.

The electronic chassis contains two 6L6 amplifier tubes and two 884 thyratron tubes together with the necessary power filter and control elements. The function of the thyratron tube is to act as an electronic lock-in relay so that the millisecond timer starts and operates on a single triggering impulse of extremely short duration. The timer will continue to run until stopped by a similar triggering impulse. The starting and stopping trigger circuits are independent of each other and require application of external d-c voltages during the trigger periods. The timer control circuit will operate from transients or application of approximately 22 volts.



Circuit of the millisecond timer made by Standard Electric Time Co., Springfield, Mass. Two clock hands are driven by a synchronous motor and are electronically controlled by tubes and clutch coils shown above

Suggested Standards for Telephone-Type Relays

By A. W. Clement
Galion, Ohio

THE NEEDS of electronics and other control fields has rapidly increased the demand for telephone-type relays and some consideration should be given toward developing some standards for specifications so that the manufacturer can more completely satisfy requirements at a minimum of cost. Judging from inquiries received by the manufacturer, the average customer often slights pertinent facts that should be specified.

Coil resistance should preferably be as provided by the manufacturer. A relay is basically a wattage device and various types require different amounts of power to operate similar spring loads. Hence, in general, only the current or voltage should be specified, the resistance then being determined by the manufacturer.

Two standards of coil resistance are possible. The simplest and cheapest is to specify the current or voltage, the other is to add the requirement for the highest resistance. In the former case, the manufacturer is free to select a coil economically balanced between power consumption and wire cost, especially when sizes over No. 40 are involved. In the second case, just sufficient power is supplied but the coil might cost several times as much.

Resistance is further controlled bv ambient temperature and again,

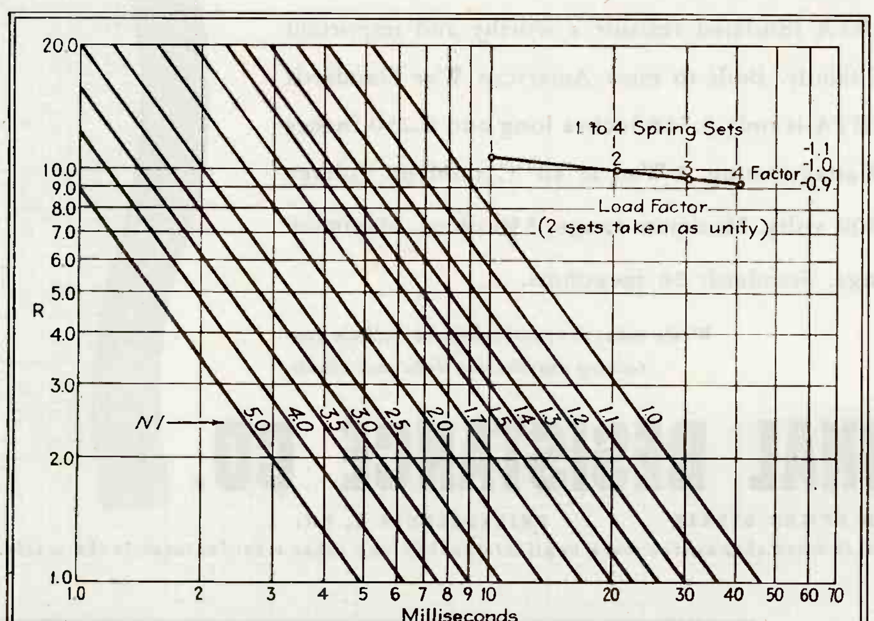


FIG. 2—Typical curves of relay operating time obtained with different values of *NI* and *R*. For example, an operating time of 10 milliseconds is provided by a series resistance of eight times the coil resistance, by 2.6 *NI*, or 1.5 *NI* and 2.6 *R*

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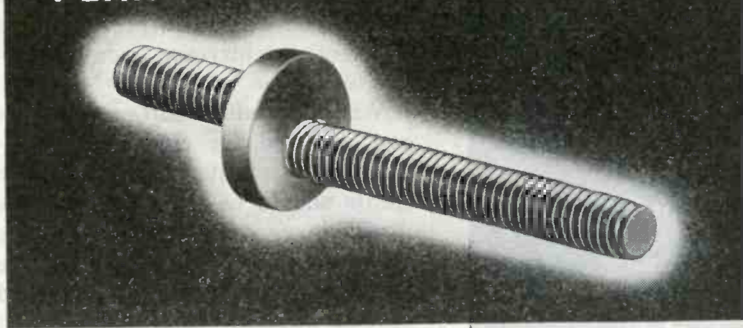


"Cold-forging"—proof #27...more each month

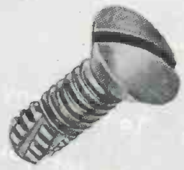
From the standpoint of design, industry is already well started on postwar business. This makes it increasingly important to clarify your plans for fastenings today...proper fastenings for your product can well be the difference between a fast and precise assembly job and one involving slow, costly methods.

Play safe with that "all-important" postwar item and choose fastenings—standard or special—early in the product design stage. It's our job at Scovill to help you with that selection by recommending the best modern fastening for your specific need. It may be a featured standard fastening or a part requiring our ingenuity in special design and cold-forging—such as the specially designed cold-forged item illustrated above—making possible delivery with savings in money—materials—motions.

Call our Fastenings Expert to assist you in your selection...profit by Scovill ingenuity in standard or special design and cold-forging. Call *today*.

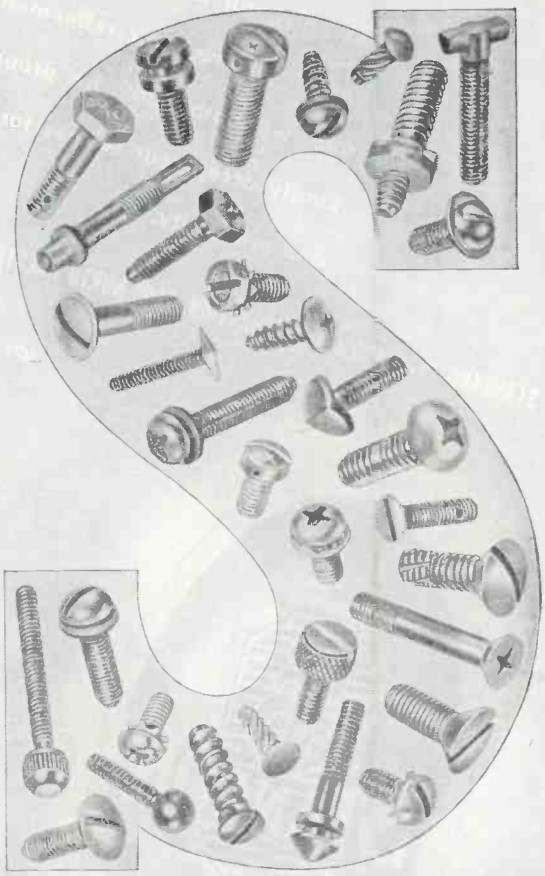
3 Standard Fastenings for Production Efficiency

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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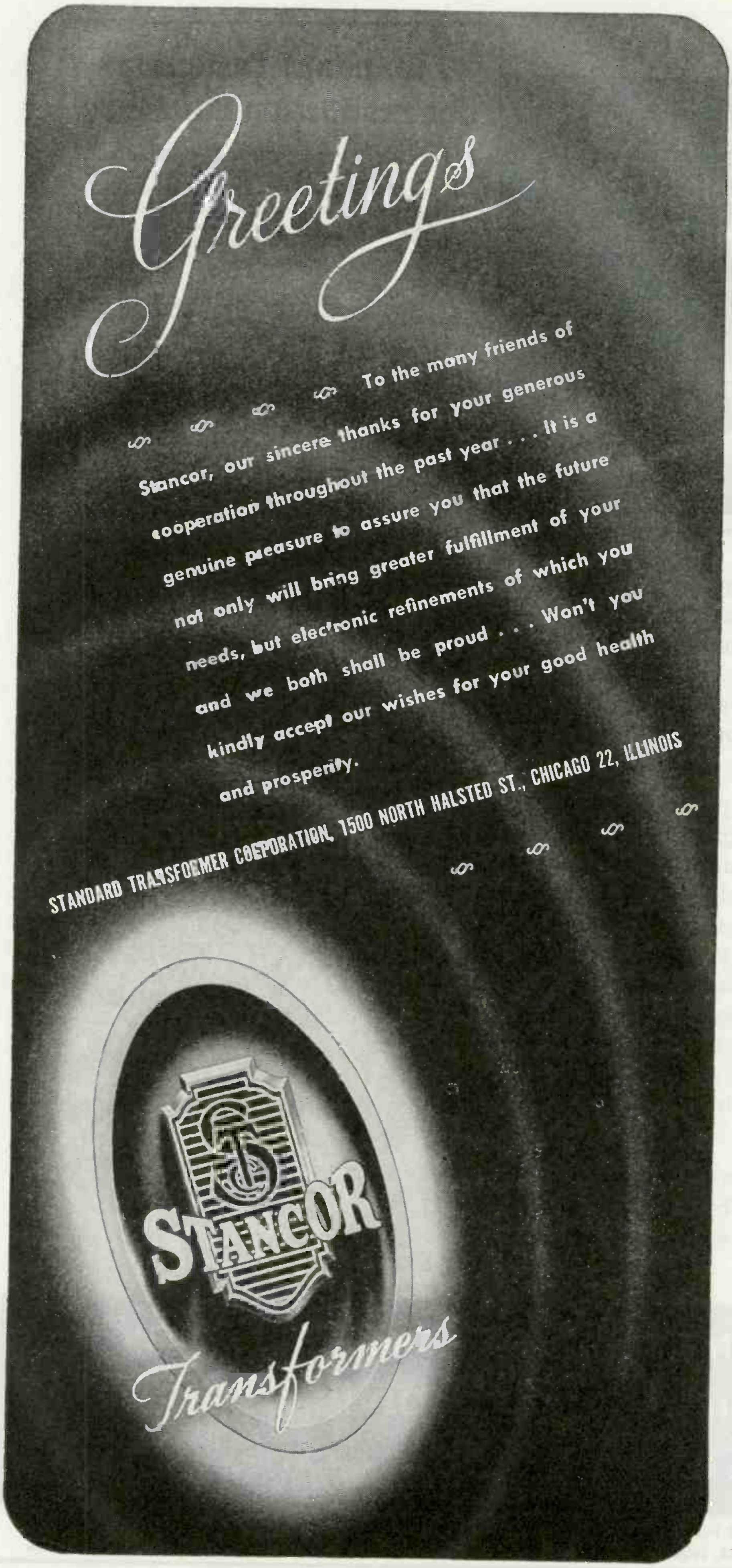


the manufacturer should control the choice. For standardization, certain ambients could be selected which would facilitate the preparation of design charts, impregnation of coils, coding of spring-coil combinations, etc.

Companion to ambient temperature is heating by the carried current. The greatest current or voltage should be stated, preferably as a percentage increase from the lowest test value.

Where certain definite resistances are required for circuit functioning, the highest, lowest, or both limits should be specified with the available current or voltage. This will permit the manufacturer to use his nearest standard coil and avoid special windings costing more and usually less efficient.

It does not take many departures from a manufacturer's standards to greatly increase relay costs. In general, it is better for a customer to submit his requirements, receive the manufacturer's nearest standards and then pass upon their acceptability. This is particularly important when ordering relays of one type to substitute for another type.

Terminology

Standard expressions for operating values would eliminate much speculation by the manufacturer. Three classes of operation can be defined as (1) the "nominal" voltage or current actually applied in service, (2) the "operate" value that will satisfy circuit requirements and (3) a "test" value by which a relay is accepted as purchased or as routine tested in service.

The nominal value is seldom of interest to the manufacturer. The operate value is of interest mainly for judging the margin of safety between it and the test value. The margin will depend largely upon the relay's constancy of performance, best known by the manufacturer but capable of being standardized upon a percentage of operating value. Several grades could be established having relations to cost.

The manufacturer usually adds his own margin of safety between specified test values and factory "adjusted" values.

The choice of specifying current

or voltage operation depends mainly upon how the relay is used. Voltage is used when the relay is connected directly across the power supply and current is used when it is in the plate circuit of a vacuum tube or other more or less constant current circuit. From a manufacturing viewpoint, the current method is the simplest, being independent of resistance variations. When possible, the voltage performance requirements should be translated into current by the customer and so specified. This usually requires consultation with the manufacturer to determine the coil resistance and its tolerances.

Applied Current

Some operating characteristics are not commonly appreciated but should be considered: their control requires specification only as particular cases warrant that costs be minimum.

Current gradually increased to the operating point can be as much as 3 percent greater than a suddenly applied current, especially if the armature has some motion before taking up the full load. There is also a slight reduction of current if there is appreciable resistance in series with the relay. While the effect is small, for closely adjusted relays the difference may affect tests made under different conditions. Ordinary relays having ample margins can ignore this. Standard tests should always be made with suddenly applied currents.

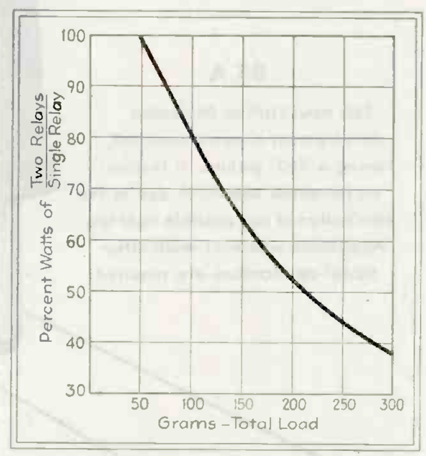


FIG. 1—Total relative watts obtained by equally dividing the load of a single relay onto two relays for use when a power supply minimum justifies using more than one unit

When there is not quite sufficient

Lumarith*

has made a museum-piece of the Black Hand of Corrosion

THE BLACK HAND of corrosion feeds on the free acids released by insulating materials that are in contact with current-carrying copper wire and moisture. In delicate circuits, it can cause the wire to break—in any circuit it can create gaps in the insulation, shorts across the line and consequently interfere with operation of equipment.

Now, Lumarith (cellulose acetate base) has made a museum-piece of the black hand. Lumarith is resistant to electrolytic action. It does not combine with moisture and current, to give corrosion a breeding ground. It is unique among dielectric materials in this respect.

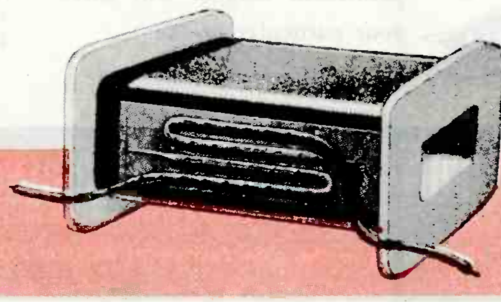
Check on the various forms by which Lumarith can improve your electrical equipment: FOILS for coil linings, coverings and interlayer insulation . . . FILMS for spiral-wound tubes (square or round) . . . MOLDING MATERIALS for molded parts—coils, spools, bobbins, housings, bases, plugs . . .

Lumarith foil can be supplied with a special mat finish (A-78) that increases elongation, helps visibility and prevents wire slippage. Send for Lumarith Electrical Booklet. Celanese Plastics Corporation, *The First Name in Plastics*, a division of Celanese Corporation of America, 180 Madison Avenue, New York 16, N. Y. ***Celanese Yarns and Fabrics offer the same dielectric and corrosion resistant qualities as Lumarith Plastics. For data, address Celanese Corporation of America, 180 Madison Avenue, New York 16, N. Y.***

* Reg. U. S. Pat. Off.

LUMARITH* A CELANESE* PLASTIC

Films . . Foils . . Sheets . . Rods . . Tubes . . Molding Materials



available power to operate a given spring load it is sometimes possible to meet the situation by using two or more relays (in series or multiple) and dividing the load between them. A typical case for the use of two relays is illustrated in Fig. 1 which indicates the reduction of total power as various loads on one relay are divided equally between two. The limit of such dividing is the balance of cost and necessity.

Fast Relays

When the time of operation is specified for "fast" relays, attention must be given to any series resistance. A moving armature alters the magnetic flux which produces counter currents causing the armature to be more or less sluggish. Added resistance weakens the effect, speeding the armature (assuming the same maximum current is maintained by voltage adjustment).

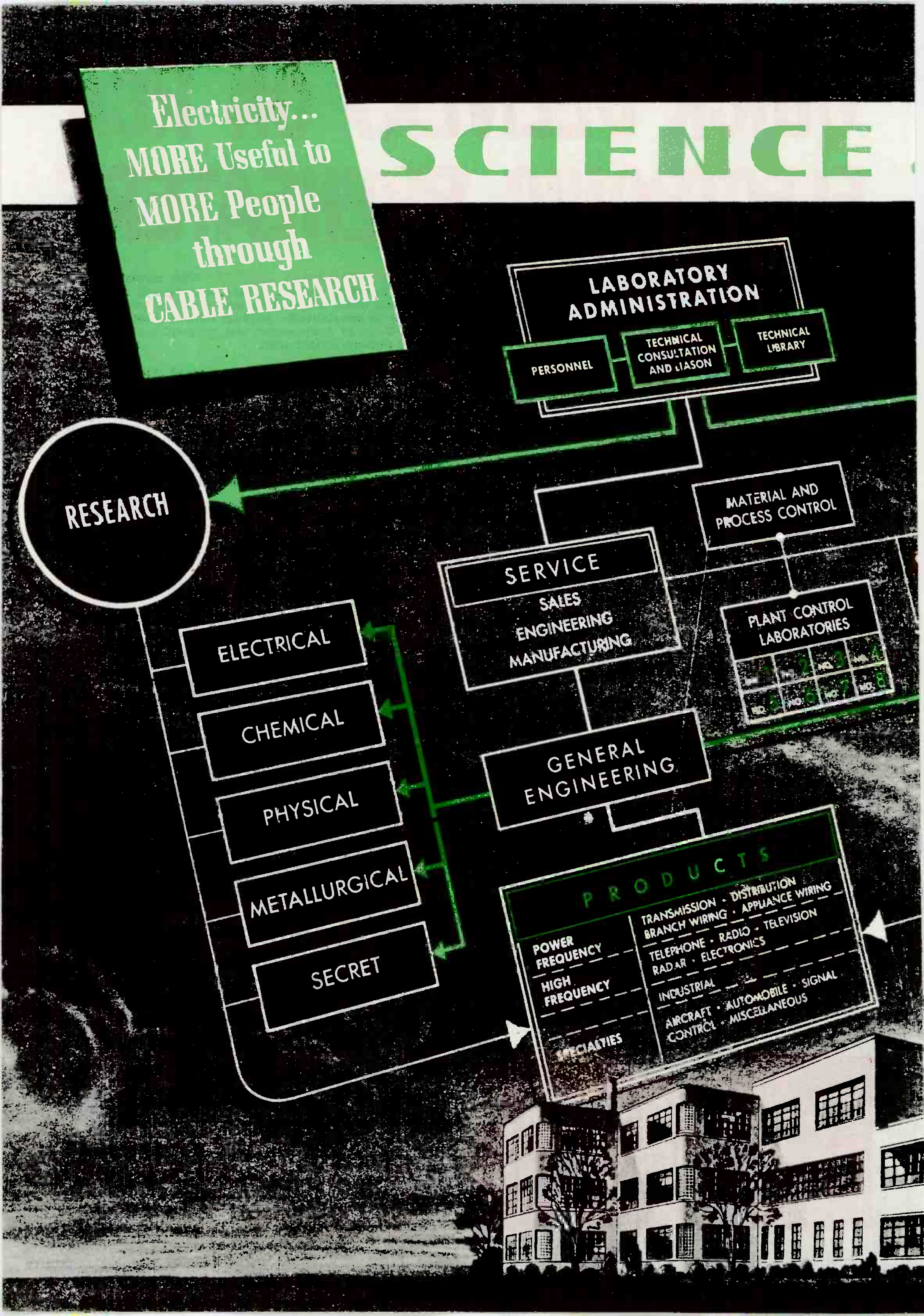
The effect can be judged by a typical case where the addition of a resistance equalling 20 percent of the relay coil speeded the operation 5 percent. Half the coil resistance speeded it 25 percent.

Fig. 2 presents typical curves for the control of operating time by the use of strong currents, series resistance or a combination of both. The actual values will vary with different relays and their adjustments. The operating current is indicated by ampere-turns (NI), unity NI being that which just operates the relay. The resistance scale includes the coil value, R

• • •

CHINESE TUBE PLANT

Girls do most of the work by hand in the manufacture of vacuum tubes at the Number 2 factory of the Central Electric Works, China



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being then unity when there is no series resistance. The time scale is in milliseconds and applies to a typical relay when closing the make contact after applying current to the coil. The curves apply to a full winding of any gauge wire upon a given spool.

Load and Speed

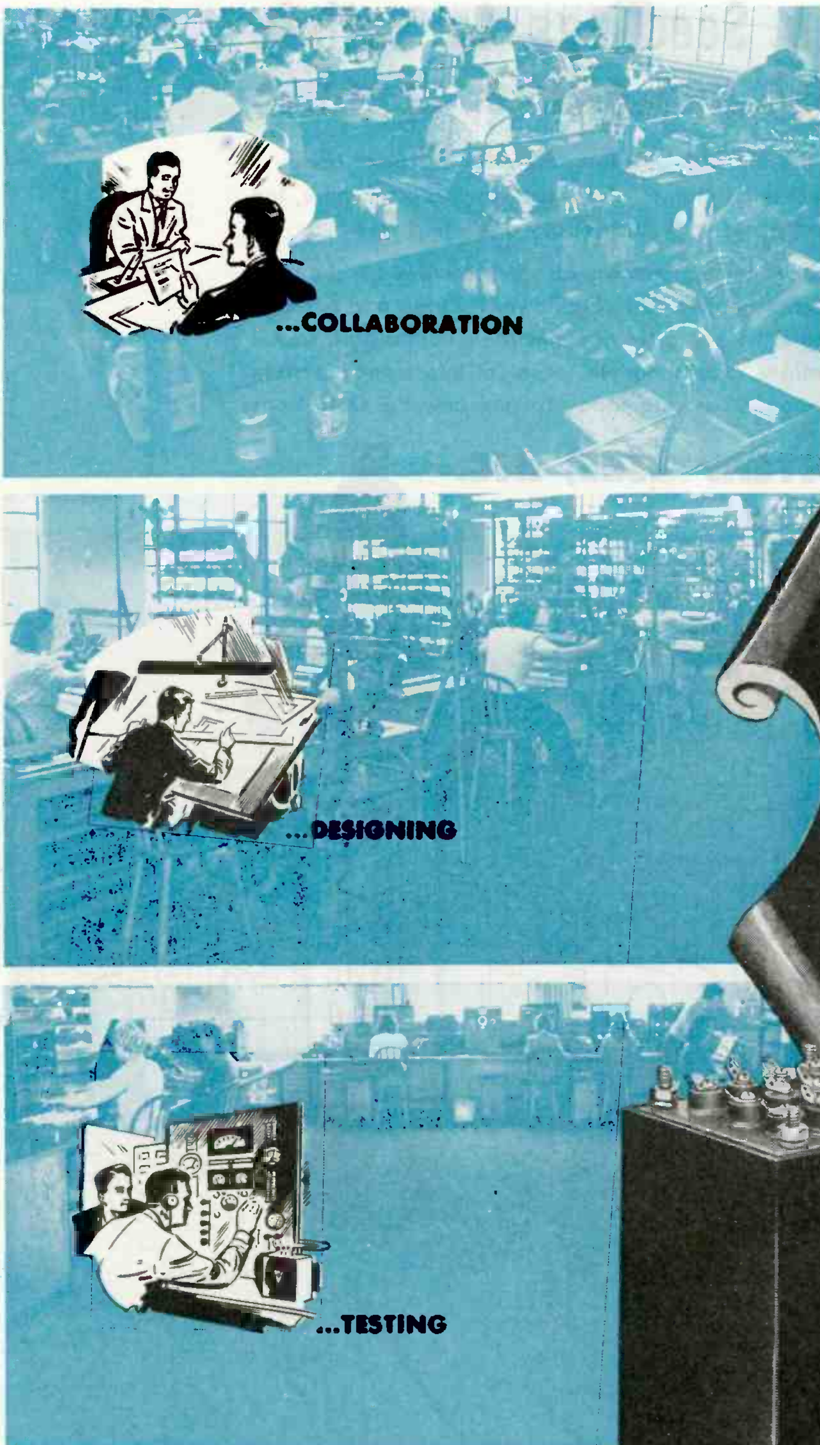
The effect of spring load upon timing is contrary to first thought. Increased load (current increased so unity *NI* is still the "just operating" value) actually speeds operation. The bracketed curve shows this effect and it will be noticed that, with unity placed at the load value of 2, the percentages of time changes are equal and opposite as the load is changed to one-half or twice value. The weight of an armature is insignificant to timing in ordinary relays.

Relays are frequently speeded by the use of strong currents but this is not recommended. The release time is increased, travel stops are pounded out of adjustment and if the armature strikes the core, the iron can develop hard spots increasing residual effects. It is preferable to use coils having a larger size of wire and added series resistance (often wound upon the same coil): partially wound spools can be used in some cases. This reduces the maximum armature pull to a sufficiency for the load but speeds its time for operating.

The actual watts drawn from the power source will be essentially the same for any method of speeding to a given time with a small preference for the resistance method. This relation of power to speed is also evident in the magnetic circuit of the relay: inefficient circuits are faster but require more power. Special cases may warrant the use of resistance wire for the coil winding instead of copper.

Series Circuits

Specifications for operating time should state the supply voltage and the nature of any equipment in series with the relay. Shunting equipment can be disregarded unless it and the relay have a common series path through other equipment. In any case, a minimum of 10 ohms in series should be allowed. This permits the manufacturer to use an



N·Y·T

..facilities to meet critical transformer requirements economically

The transformer illustrated is typical of the many immersion-proof designs conceived by N-Y-T. These compact components represent achievements in compactness and immunity to operating hazards.

With current deadline and delivery factors steadily being overshadowed by sharpened-pencil cost considerations, fluctuations in price structure will be in evidence. Adjustment for post-war necessities will, in all probability, be on a downward trend without sacrifice of quality or reliability.

From its inception, N-Y-T has 'majored' in the design of transformers, chokes, filters and solenoids, custom-engineered to meet specific requirements. Aside from meeting exacting requirements, all phases of production—collaboration, design, and manufacture—were 'in line' relative to cost.

This same policy—currently adhered to—is credited with numerous solutions in vital military design problems. Manufacturers projecting peacetime plans should keep in mind the record of N-Y-T in accomplishing 'impossibilities' . . . economically.

NEW YORK TRANSFORMER CO.

26 WAVERLY PLACE NEW YORK 3, N. Y.

electronically controlled and adjustable power supply with a reasonable internal impedance and will include the measuring-instrument resistance. When series inductive equipment is involved, it is preferable that the manufacturer be furnished with it for inclusion in his testing circuit, since the vagaries of iron are difficult to approximate with simple values of resistance and inductance.

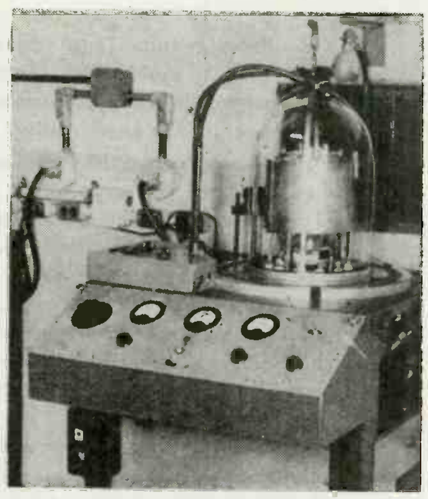
These notes have not attempted to discuss the operation of slow-operating and other relay types nor the releasing characteristics of any relay: the prime object is to draw attention to the real need for a comprehensive set of standards for relay performance independent of contacts.

• • •

Electronics Controls Lens Coating Process

GREATER TRANSPARENCY for the lenses of eyeglasses, cameras, field glasses, telescopes, microscopes, and other optical instruments after the war will result from electronically controlled lens coating processes now in use to increase the efficiency of optical elements in Army and Navy devices.

Apparatus developed by the RCA Victor Division of RCA has been



Two electronic controls are employed in this equipment for coating glass lenses with magnesium fluoride to reduce the amount of light reflected from their surfaces. A phototube and an exciter lamp, suspended above the bell jar, are used to measure the diminishing intensity of light reflected from a test lens to determine when the proper coating thickness is reached. An electronic vacuum gage measures the vacuum in the jar, an important factor in the process

Bell Telephone Laboratories

Exploring and inventing, devising and perfecting for our Armed Forces at war and for continued improvements and economies in your telephone service

Research, in the Bell Telephone System, has always been an expanding activity, growing with the scientific knowledge of the times and contributing to that knowledge. Upon it have been based important inventions and developments.

The telephone, itself, was invented in the laboratory where Alexander Graham Bell was carrying on researches in speech and hearing and laying the foundation for the electrical transmission of speech. As time went on the telephone research program expanded to cover every science which gives any promise of improved telephony and every engineering art which applies to the development, construction, installation and operation of telephone facilities.

These researches and development studies now cover electrical communication of speech—both by wire and by radio—the transmission of pictures (television)—and many important projects for war.

There Is No End to Progress

Every new research gives rise to new inventions and to new lines for development and design. New inventions indicate new lines for more research. Research and development work, invention and design go hand in hand. In the early years, this work was carried in part by the American Telephone and Telegraph Company and in part by the Western Electric Company, the manufacturing unit of the Bell System.

For many years, however, this work has been assigned to a specialized unit, Bell Telephone Laboratories, Incorporated. Theirs is the responsibility for the technical future of the industry. They carry their developments from the first faint glimmerings which basic researches disclose to the final design of equipment and the preparation of specifications for its manufacture. And after manufacture and installation, they follow their products in operation; and continue development work to devise still more perfect equipment, less expensive, more convenient and of longer useful life.

These policies and procedures of Bell Telephone Laboratories are distinguished by two characteristics. In the first place the Laboratories design for service. The consideration is not the profit of a manufacturer through first sales and replacement models but the production of equipment which will give the best service at the lowest annual cost when all factors are considered, such as first cost, maintenance, operation, and obsolescence. The Laboratories make no profit and the equipment they design is owned and used by the telephone companies; and the emphasis is upon that use.

Organized Co-ordinated Research

In the second place the Laboratories design always with reference to the complete communication system in which the particular equipment is to play a part.

Reliable, economical telephone service, which is the product of its efforts, is not so much an assemblage of excellent apparatus as it is an excellent assembly of co-ordinated equipment—all designed to work together reliably and economically for a larger purpose.

It is not enough that Bell Laboratories shall design a new piece of electronic equipment which has merit or a new cable or telephone receiver. They must design with reference to all the other parts of the communication system so that the co-ordinated whole will give the best possible service.

4600 People in Bell Laboratories

Bell Laboratories contributions to the Armed Forces derived in large part from the technical background that the Laboratories had acquired through their steadily maintained program of research. The Laboratories had special knowledge, skill and techniques which could instantly be diverted to war problems.

At the time of Pearl Harbor, over a quarter of the 4600 people in the Laboratories had twenty or more years of service. This breadth of background made possible many engineering developments outside the strict field of communication and these have been of value to the Armed Forces. So far the Armed Forces and the O.S.R.D. have engaged the Laboratories on over a thousand major projects. The majority of these assignments have been completed; and have contributed to our victories on many fronts.

Most of the Laboratories developments, of course, have been in the field of electrical communication. Communication, not simply between individuals as in ordinary telephony, but between mechanisms—as in the electrical gun director. The Laboratories techniques and electronic researches have produced many secret weapons for our country's Armed Forces.

Leader in Electronic Development

For those problems the Laboratories had a remarkable background of experiences in research and development. In World War I, they pioneered by developing radio telephone systems for talking between planes and between planes and ground stations. They also contributed methods and devices for locating enemy planes, submarines, and artillery.

In this war, Bell Laboratories have pioneered in the field of electronics. The Western Electric Company, which manufactures the designs of the Laboratories, is the largest producer of electronic and other war communication equipment in the United States and is now engaged almost exclusively in the manufacture of this equipment

In war, Bell Telephone Laboratories devote their work to the needs of our Armed Forces. In peace, they are constantly exploring and inventing, devising and perfecting for continued improvements and economies in telephone service. Centralized research is one of the reasons this country has always had "the most telephone service and the best at the least cost to the public." ADV.

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Versatility
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The engineer may fill both his electrical and mechanical requirements with National Fabricated Products Terminal Strips and Assemblies . . . Secure mountings, plating that affords ease of soldering and uniformity of assembly are features which distinguish these components by
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used by that company for the past two and one-half years to coat lenses used in military and naval equipment with special chemical films which increase the transparency of the glass by reducing its tendency to reflect light. Electronic tubes and circuits control the critical thickness of the films as well as the vacuum which has a bearing on their hardness.

The low-reflection coating usually consists of a single layer of magnesium fluoride which is deposited on each side of the lens that comes in contact with the air. This film is applied by evaporating chemically pure magnesium fluoride powder in a vacuum bell jar, so as to bring the magnesium fluoride vapor in contact with the lens surfaces under low-pressure conditions. A baking operation is carried on within the jar by means of radiant heaters.

A conventional electron multiplier phototube is used to measure the diminishing amount of reflected light from the lens, thus enabling the operator to stop the coating operation exactly when the proper thickness of film—about five-millionths of an inch—has been established.

The hardness of the magnesium fluoride film is affected by the degree of vacuum obtained within the coating jars. Through the use of vacuum gauges, electronic amplifiers, and meters, it is possible to determine quickly and accurately whether the degree of vacuum within the jar is such as to produce a coating of satisfactory hardness.

• • •

Electronic Casting in a Vacuum

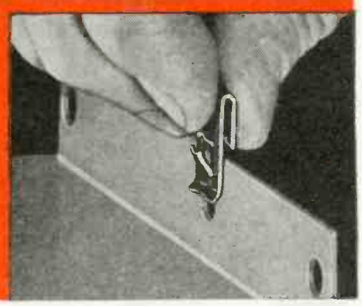
A NOVEL METHOD of casting metal electrodes for vacuum tubes and x-ray tubes is utilized at Machlett Laboratories. Purified copper rod is placed over a mold in a graphite crucible and the whole enclosed within a double-walled quartz-silicon tube. A vacuum of about 10^{-5} mm of mercury is maintained in the tube. A coil surrounds the quartz tube and connects to an induction-heating high-frequency oscillator.

When the oscillator is turned on, the copper melts and flows into the mold. Cooling is precisely controlled by adjusting the position of

ONE OF A SERIES PORTRAYING THE "SPEED NUT FAMILY OF FASTENINGS"

"J" TYPE SPEED NUT

Self-Retaining for BLIND LOCATION ASSEMBLY



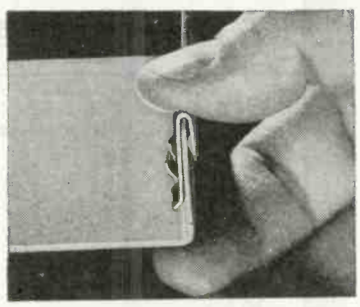
Positioning "J" nut over hole in flange.

● Another exclusive SPEED NUT design to simplify and speed up blind location assembly. The "J" nut is attached by hand and *holds itself in place,* thus eliminating the necessity of welding, riveting, or staking ordinary fasteners.

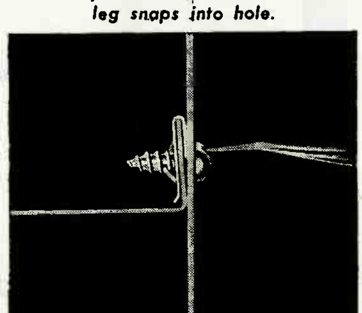
These spring steel SPEED NUTS are pressed over holes along edge of panels or flanges. An extrusion in lower leg of "J" nut *snaps* into hole to retain nut in perfect register. By increasing diameter of hole, any degree of "float" may be obtained, to compensate for misalignment.

The sturdy arched prongs of the "J" nut possess surprising holding power. They eliminate vibration loosening by *absorbing vibration,* yet are sufficiently resilient to prevent damage to enamel, plastic or glass.

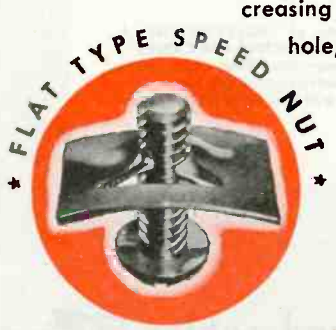
"J" type SPEED NUTS will improve your postwar products, speed up assembly, and reduce costs. Send in your assembly details today and we'll gladly rush samples.



As nut is pressed on, extrusion on lower leg snaps into hole.



With second panel in place, screw is driven. Access to opposite side unnecessary.



THE BASIC PRINCIPLE
of Spring-Tension Lock is
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FASTEST THING IN FASTENINGS

A NEW DIELECTRIC

for high- and low-frequency cables

. . . POLYETHYLENE

In the course of Okonite's research on insulations for electrical wires and cables we have developed or adapted many dielectric materials for specific electrical and electronic applications. One of these is polyethylene which because of its low losses, excellent physical, chemical and dielectric properties, and resistance to ozone and moisture, is now being used for insulating high-frequency cables as well as for radio, communication, control and submarine cables – all for military use. It is also entirely practical for commercial applications.

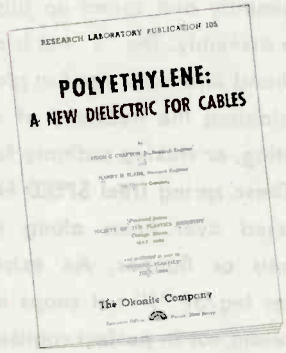
The accompanying table of properties points out some of the advantages of polyethylene.

If you have a problem involving the transmission of electrical power, our Research and Engineering Departments will gladly work with you in designing the wire and cable most suitable for your purpose. It may be that polyethylene will supply the answer, but our work with other insulating materials may point to another insulation for your particular problem. The Okonite Company, Passaic, New Jersey.

PROPERTIES OF POLYETHYLENE AND RUBBER

Property	Polyethylene	Rubber[a]
Dielectric properties		
Dielectric strength, v/m	600-1000	500-700
Volume resistivity, ohm.-cm.	10^{17}	10^{15}-10^{16} (r, v)
Dielectric constant at:		
60 c/s	2.3-2.4	2.3-2.5 (r) 2.4-2.9 (v)
10^3 c/s	2.3	2.3-2.4 (r) 2.7 (v)
10^6 c/s	2.3	2.3-2.4 (r) 2.4-2.7 (v)
Power factor, at:		
60 c/s	0.0002-0.0005	0.002-0.003 (r) 0.004 (v)
10^3 c/s	0.0002-0.0005	0.001-0.002 (r) 0.004 (v)
10^6 c/s	0.0002-0.0005	0.001-0.002 (r) 0.004 (v)
Temp. dependence of dielectric properties	small	small
Chemical properties		
Acids	none	is attacked (r, v)
Alkalis	none	is attacked (r, v)
Oxygenated solvents	none	slight (r, v)
Oil, hydrocarbon solvents	none[b]	soluble (r) swells (v)
Heat (oxidation)	none[c]	considerable (r, v)
Ozone	none	is attacked badly (r, v)
Sunlight	none	considerable (r, v)

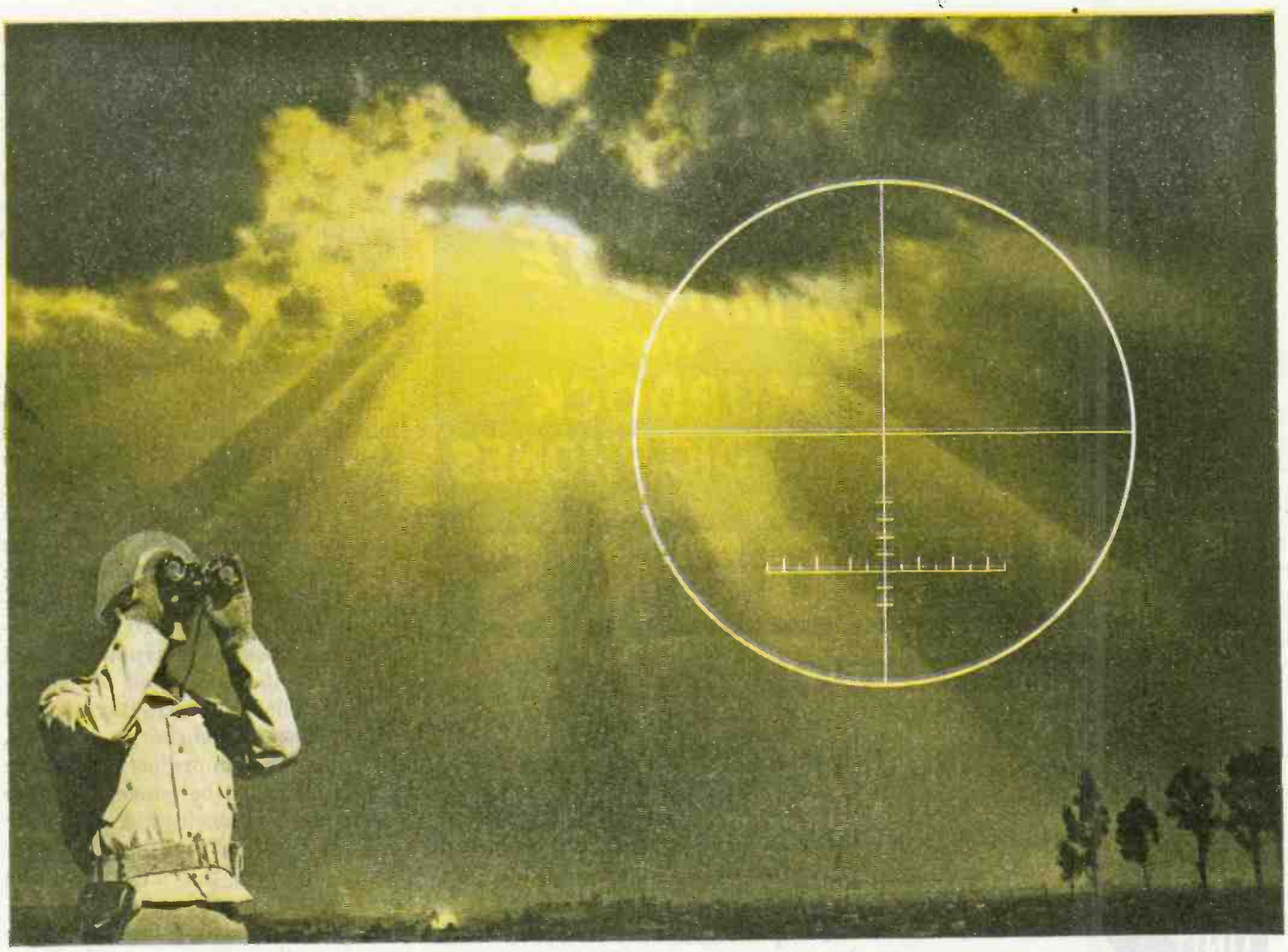
a – (r) and (v) refer to raw and vulcanized (2 percent S) rubber, respectively.
b – Is attacked above 60-70° C.
c – Oxidizes above 100° C.



A copy of "POLYETHYLENE: A NEW DIELECTRIC FOR CABLES", a paper describing many other characteristics of this new material, will be sent you on request.

OKONITE OKONITE SINCE 1878 **insulated wires and cables**

3899



"We have a job that no one can do"

That's what the Ordnance Department of the United States Army said.

They needed reticles for their M3 binocular. But they wanted them in quantities that no one had ever been able to supply. They wanted them quickly in spite of certain stiff technical difficulties that had to be overcome. They got them—on time and up to specifications.

Orders like these, requiring high precision with fast production, have kept us busy all through the war. We have solved many "impossibles" for both the Army and Navy. We'll soon be able to give the same superlative service and craftsmanship to manufacturers of peacetime products.

In this modern plant you will find a compact group of precision lens experts who have been trained to work as a team for other manufacturers. We make no complete products of our own—but concentrate on optical components of high excellence for others. You will find us interested in your problems and able to give you the kind of technical help that naturally results from wide experience in meeting the most exacting requirements.

Our plant is equipped with the latest machinery. We are geared to give you production with precision, quality with economy and original ideas based on sound scientific principles.

for precision OPTICS *come to*

AMERICAN LENS COMPANY, INC.

45 Lispenard Street, New York 13, N. Y.

LENSES • • • PRISMS • • • FLATS • • • REFLECTORS

the heating coil so that crystals form longitudinally for maximum heat transfer under operating conditions. Dimensions of the casting can be held to about 1/10,000 of an inch. No gases can be occluded in the metal of the casting, oxides cannot form, and there are no "pipes" in the casting.

• • •

Aniseikon for Detection of Cracks and Flaws

THE ANISEIKON can be used for the photoelectric detection of cracks and flaws in materials as well as in the field of burglar alarms, where it views the space being protected as a whole and does not depend on the breaking of a beam. In an article in the October, 1944, issue of *Electronic Engineering*, Dr. W. Sommer describes the instrument, based on a circuit first quoted for photovoltaic cells by H. H. Raymond in ELECTRONICS, February, 1933. A binocular system projects the image of the space to be supervised onto a pair of photoelectric cells. By making the focal lengths of the systems unequal, the object will be imaged at unequal sizes.

A balanced circuit is arranged to measure the current output of the two cells and this will vary with the ratio of the areas of the two images. This arrangement will detect the presence of an intruding object in the area being watched.

By placing a grating ruled with variable-area opaque and transparent squares before the cells, the instrument can then detect an object starting to move about in an area where it had been before. The human eye sometimes suffers from a condition known as aniseikonia, in which the images produced on the two retinas are not of the same size and shape. Hence the name of the new instrument.

• • •

Capacitance Relay as Punch Press Safety Control

AN ELECTRONIC GUARD for punch presses which makes use of capacitance instead of the more usual phototube has been developed at North American Aviation's California division. As shown in the illustration, the control unit is mounted on the press and connected through a shielded lead to an aluminum pickup which surrounds the

Franklin's 39

RADIO SOCKET

This series 39 socket has a 39G Contact with a soldering tab which eliminates wiring to ground.

The favorite yesterday, the favorite for tomorrow

THE MANY MILLIONS INSTALLED IN 1941 IS

Positive Testimony to its POSTWAR VALUE

The story of Franklin's series 39 Radio Socket, with patented "U" shaped bow spring action contacts, is most remarkable ... developed and patented early in 1938 it received immediate acceptance and approval by practically all the radio set manufacturers and became standard equipment with most.

Series 39 sockets should be riveted to the chassis to become a permanent part of the set ... no replacement will be necessary as the socket will outlive the set.

Series 39 sockets were the favorite yesterday and will be the favorite tomorrow for standard broadcast receivers.

Illustrating the "U" shaped bow spring action contacts...39H and 39G...used in Franklin's series 39 Sockets.

"U" shaped contact provides separate soldering tail which prevents solder from flowing into contact body

The 39G contact has a soldering tab to eliminate wiring to ground ... can be inserted in any position where grounding is desired.

For the details of the 39, Diheptal, Miniature, Lock-in, Battery and Sockets for other applications, moulded or ceramic...and a complete line of Radio Components...write for the New Franklin Catalog with which is included a complete Buyers Guide for the Electronic Industries.

A.W. FRANKLIN MANUFACTURING CORP.

SOCKETS • TERMINAL STRIPS • PLUGS • SWITCHES • PLASTIC FABRICATION • METAL STAMPINGS • ASSEMBLIES

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175 VARICK ST., NEW YORK 14, N. Y.

THE NEW MULTIRANGE FLUXMETER

MODEL F

FOR THE MEASUREMENT OF MAGNETIC CIRCUIT CONDITIONS AND ASSOCIATED TESTS

ACCURACY ½%

RANGE
5 LINES PER SQ. CM.
TO
30,000,000 LINES PER SQ. CM.

SEARCH COIL RESISTANCE INCREASED TO 15 OHMS.

THIS NEW DESIGN REPRESENTS THE FIRST MAJOR IMPROVEMENT IN THIS TYPE OF INSTRUMENT IN THE PAST 25 YEARS. A COMPLETE TECHNICAL BULLETIN WILL BE GLADLY SENT ON REQUEST.

SENSITIVE INSTRUMENT

RESEARCH COMPANY

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Electrical Instruments of Precision since 1927

IT ALL DEPENDS ON WHERE YOU PUT THE BRUSH

11.5 KVA, single phase, 50/60 cycles, input 115 Volts, output 0-115 Volts, 100 Amps.

Topside or bottom—a hair brush can be applied effectively at either place according to the result desired. But the commutator brush on an a.c. voltage regulator is different. Only **one** place will do for best results and that is where the Transtat's brush track is.

Instead of on the commonly used flat annular section, where brush area is limited, the Transtat brush rides on the curved outside surface of the coil. There, the uniformly laid wires permit grinding smooth, perfectly parallel, evenly spaced commutator segments. That means arc-less, practically stepless control without circuit interruption. This position allows room for the long, sturdy Transtat brushes with their larger heat dissipating surfaces and lower current density per contact area . . . cooler running, longer lasting brushes.

Being transformer type regulators, Transtats will not distort wave form or alter power factor. Their varnish-impregnated cores and coils cannot loosen in service. The balanced collector arms maintain brush setting in any position. For continuous a.c. voltage regulation in testing, heating, plating, light control, speed control and in radio transmitters and other electronic apparatus they are unexcelled. Write for bulletin 51-2.

AMERICAN TRANSFORMER COMPANY · 178 Emmet Street, Newark 5, N. J.

AMERTRAN

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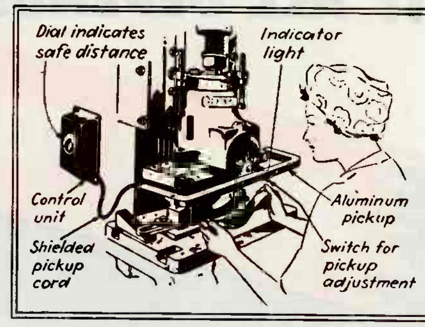
Pioneer Manufacturers of Transformers, Reactors and Rectifiers for Electronics and Power Transmission



An aluminum strip mounted on this punch press acts a pickup unit for the capacitance relay to shut off power when the operator's hands are near the moving mechanisms

danger area of the press. The electronic unit is arranged to operate relays that actuate solenoid air valves and contacts connected to the press mechanism.

When the operator's hands or other part of the body enter the danger zone, the increase of capacitance in the electronic circuit causes it to prevent the operation of the press until the obstruction is removed. A dial on the electronic unit permits adjustment of the critical distance beyond which the punching operation is considered dangerous.

• • •

Insulation Tester for Glass Window Panes

AN ELECTRONIC POTENTIOMETER has been used to compare the heat insulating quality of a new glass called Thermopane developed by Libby-Owens-Ford.

Thermocouples were attached to the inside and outside surfaces of windows in a cabinet. One window was made from ordinary glass, the other from the new material. With the inside temperature near zero, a Brown Instrument Co. electronic potentiometer showed a difference of 20 deg between the ordinary glass surface and Thermopane.

• • •

Induction Heating in Manufacture of C-R Tubes

THE COVER PHOTO of ELECTRONICS for December, 1944 shows the r-f heating method of sealing a contact into the side of a cathode-ray tube. The contact makes electrical connection to the coating inside the bulb wall which acts as the second anode in several types of c-r tubes.

The technique consists of placing the bulb on a fixture that holds a

OUR present production rate permits us to offer sizeable quantities of these precision-machined units on a favorable schedule. Why not anticipate your needs for connectors of this type now and allow us to schedule your requirements to assure delivery when wanted? ● Built to conform in every respect to U. S. Army-Navy designs and specifications, these parts interlock firmly, when coupled, to assure positive, vibration-proof contact. The die-cast zinc housings and other metal parts are heavily silver plated. Contact parts (both pins and sockets) are made of specially tempered spring-brass. Cable plugs and receptacles alike are insulated with low-loss mica-filled bakelite. Plugs may be had in either Connector #50.399-1 (Signal Corps #PL-259), or Connector #50.393 (Navy #CI-49195) models. Connector receptacle #50.392-1 (Signal Corps #SO-239, Navy #CI-49194) is standard for each of these designs.

For more detailed information we suggest you write today for Connector Division Bulletin No. 4.

CONNECTOR DIVISION OF

INTERNATIONAL RESISTANCE CO.

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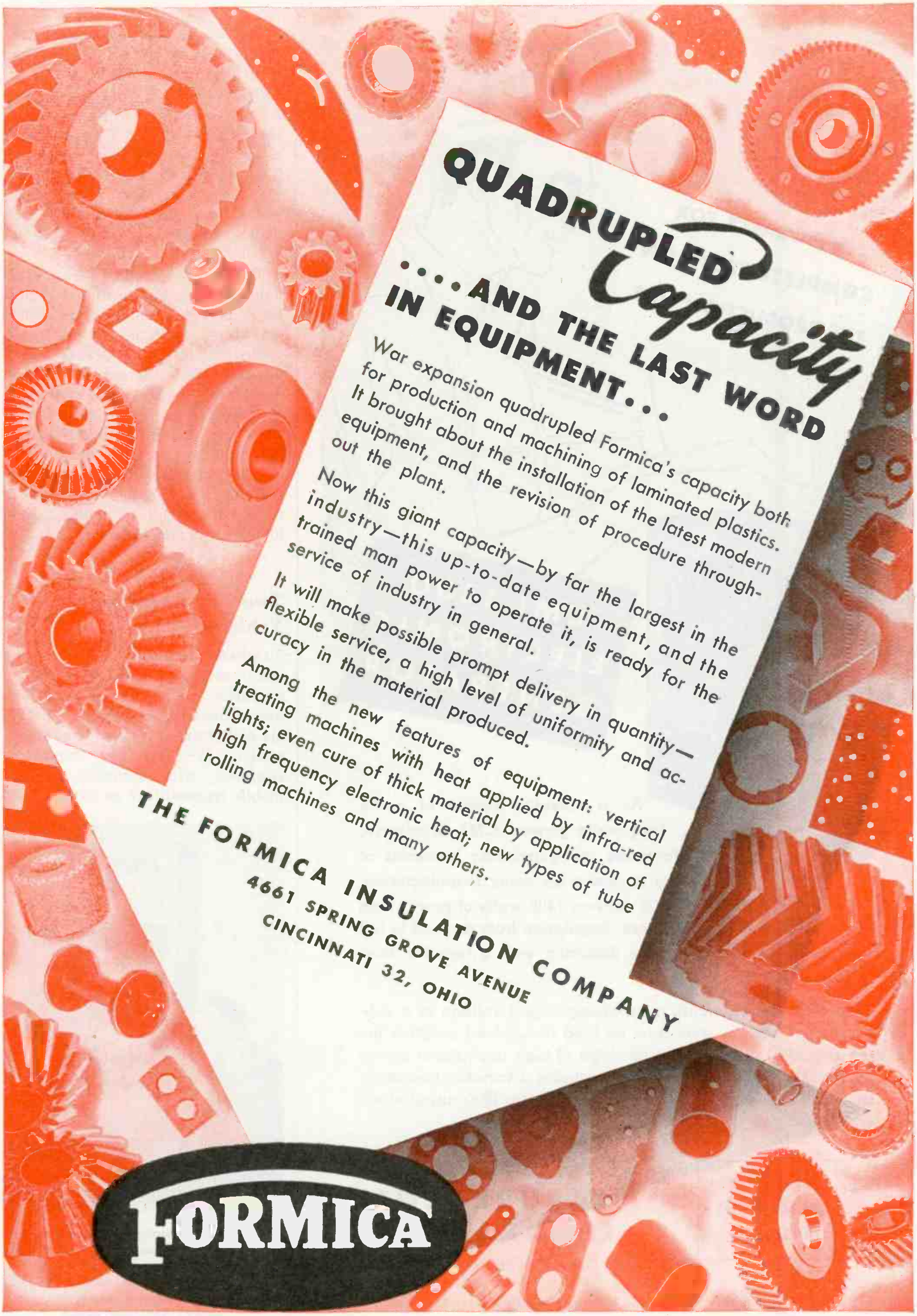
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....AND THE LAST WORD IN EQUIPMENT...
War expansion quadrupled Formica's capacity both for production and machining of laminated plastics. It brought about the installation of the latest modern equipment, and the revision of procedure throughout the plant.
Now this giant capacity—by far the largest in the industry—this up-to-date equipment, and the trained man power to operate it, is ready for the service of industry in general.
It will make possible prompt delivery in quantity—flexible service, a high level of uniformity and accuracy in the material produced.
Among the new features of equipment: vertical treating machines with heat applied by infra-red lights; even cure of thick material by application of high frequency electronic heat; new types of tube rolling machines and many others.
THE FORMICA INSULATION COMPANY
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CINCINNATI 32, OHIO
FORMICA

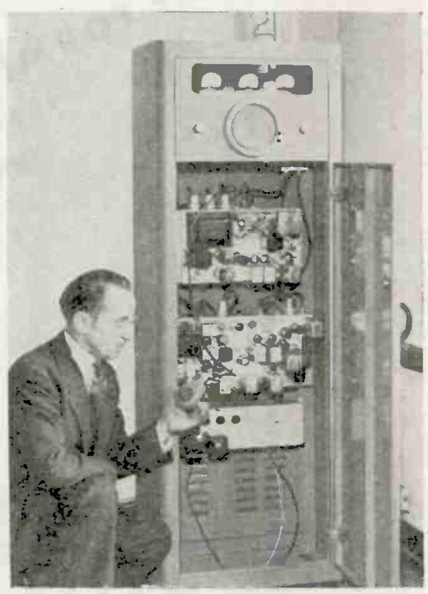
small chrome-iron cup against the inside wall at the point of contact insertion. The cup is placed in the field of a one-turn coil supplied with r-f power and heated until it drops through the glass. The contact is placed in the hole so formed and likewise heated until the surrounding glass flows and seals to the metal. Annealing of the glass removes strains set up during the operation.

The previous method used a glass flame to form the opening but took twice as long, required more skilled operators, and the finished seal varied widely in appearance and quality. With the new technique, developed by the Lancaster, Pa. Works of RCA Victor Division of RCA, the whole process takes about one minute, half the time required by the gas-flame method. Little training time for new operators is required and all seals are nearly identical in appearance.

• • •

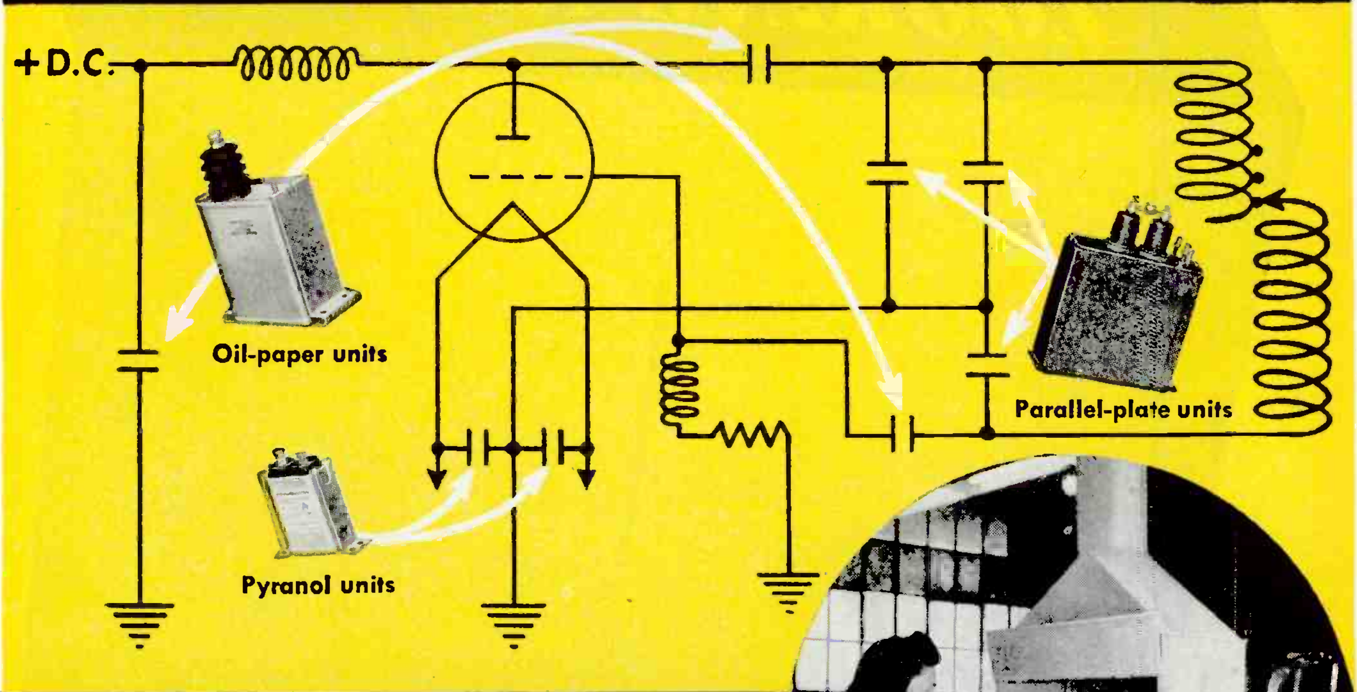
Two-Way Radio for Vehicles

TAXICABS EQUIPPED with two-way radio communication have begun operation in Cleveland. The experimental installation contains Motorola equipment, a 15-watt fixed transmitter, W8XAI, and two cabs equipped with compact 15-watt mobile transmitters mounted in the

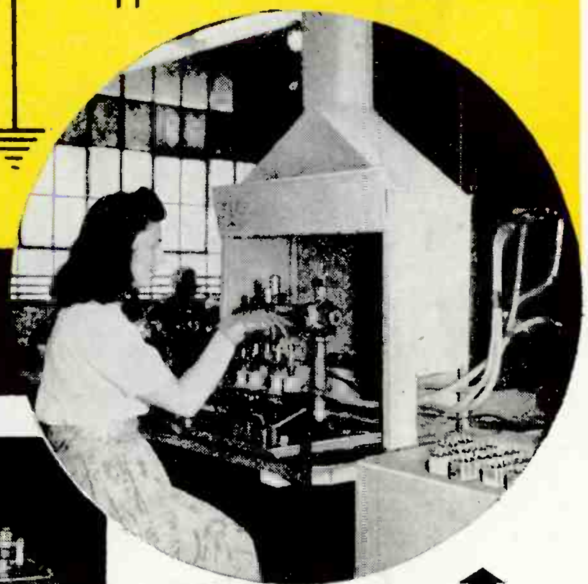


Fixed station equipment installed by Galvin Mfg. Co. for Yellow Cab Co. in Cleveland. Licensed for experimental work, it operates with call of W8XAI and can be received satisfactorily in nearby vehicular tunnel

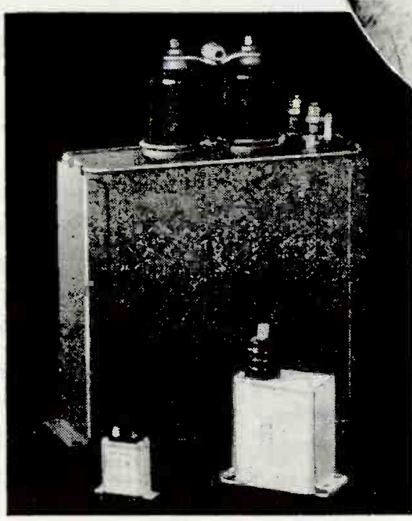
HOW G-E CAPACITORS are being used on new jobs



8 CAPACITORS NOW DO THE WORK OF 31 in this h-f oscillator circuit, and save space, weight, money



Electronic heater being used to solder on the covers of G-E capacitors. Four units are soldered simultaneously.



G-E capacitors designed for h-f oscillator circuits. Large unit: high-frequency, parallel-plate capacitor for the resonant circuit. The others: an oil-paper, high-frequency blocking capacitor, and (smallest) a Pyranol by-pass capacitor.

THE great number and wide diversity of capacitors required by today's electronic circuits make their selection an important factor in the design of the completed electronic device. Capacitors *designed for the job* can often appreciably reduce the over-all weight, size, and cost.

Take the simplified electronic-heater circuit shown above: The *original* circuit called for 31 capacitors. By selecting G-E high-frequency capacitors *designed for electronic-heater applications,* this number was reduced to eight.

Four mica capacitors were replaced with three G-E oil-paper blocking capacitors. This change alone saved more than $50.

In the resonant circuit, it originally took 25 mica units to do the job that three G-E high-frequency parallel-plate capacitors are now doing. These compact water-cooled units permitted an additional saving of more than $200, as well an appreciable reduction in the over-all dimensions of the electronic heater.

As a manufacturer of a wide variety of capacitors—including Pyranol*, oil-paper, high-frequency parallel-plate, and Lectrofilm units—G.E. is in a position to help you make savings like these in *your* electronic devices. Bulletins on our various lines are yours for the asking. See your nearest G-E representative, or write to General Electric Company, Schenectady 5, N. Y.

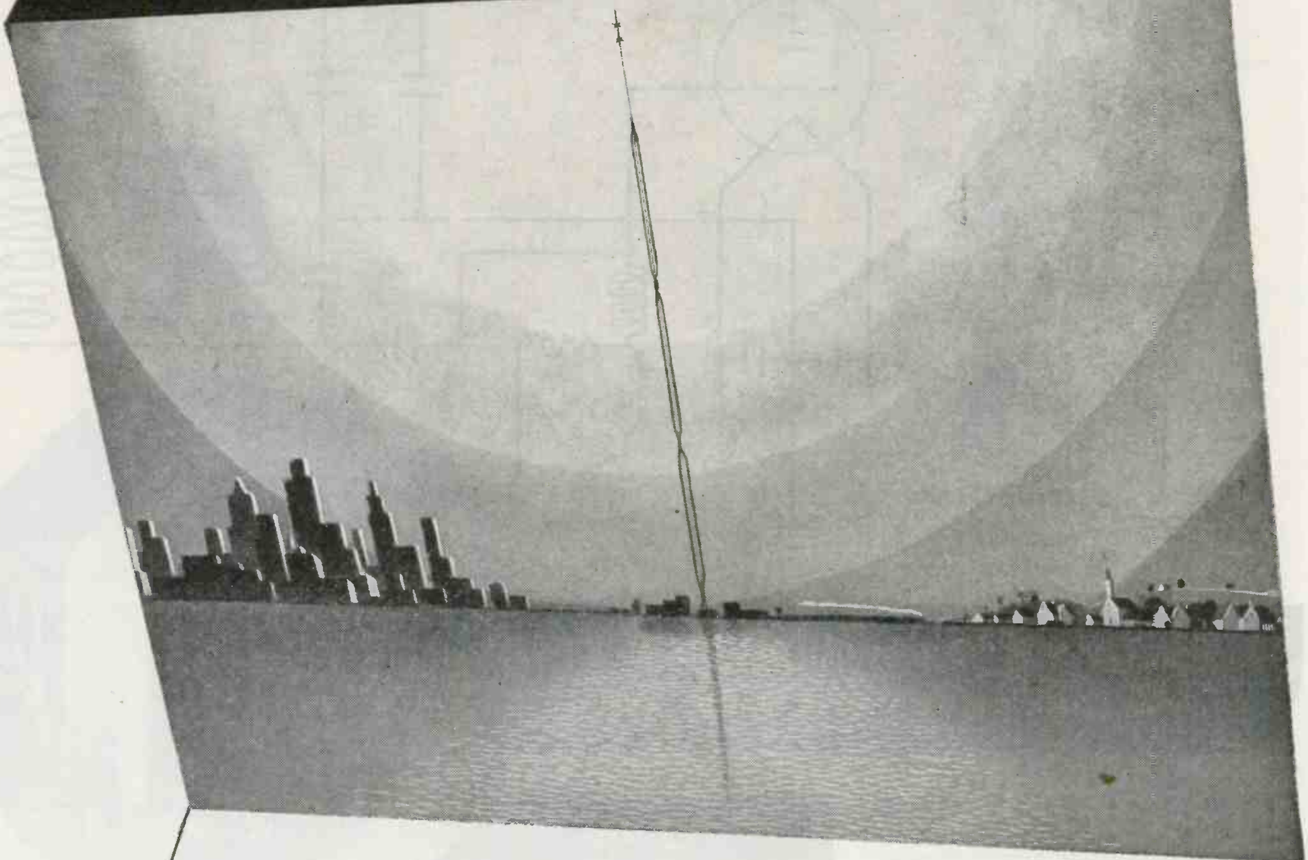
*Reg. U.S. Pat. Off.

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

GENERAL ELECTRIC

407-82-5700

LOOKING AHEAD



NEW ideas and new devices come thick and fast in wartime. America's manufacturers have worked tooth and nail with the Army and Navy to produce all the modern equipment the armed forces need.

Among these manufacturers is Lear. The Lear aircraft radio was well-known long before the war. It was ready for the armed forces when war came. Then Lear explored new fields and produced the special Lear midget motors, the Fastop Clutch, and Lear Actuators which make it possible to move airplanes' flaps, shutters and landing gears accurately by electricity.

All Lear wartime developments couldn't be mentioned here. Many of them and the engineering ingenuity which produced them will be turned to peacetime conveniences and pleasures.

For example, there will be the new Lear home radios — instruments built with the integrity demanded by aircraft radio, and equipped with features unknown in such sets before.

So while everything keeps going to get wartimes over with, we can afford a look ahead to the bright spots in the peace we have been fighting for.

RADIO DIVISION, GRAND RAPIDS 2, MICHIGAN
Home Radio Sales: 230 East Ohio St., Chicago 11, Illinois

Lear INCORPORATED

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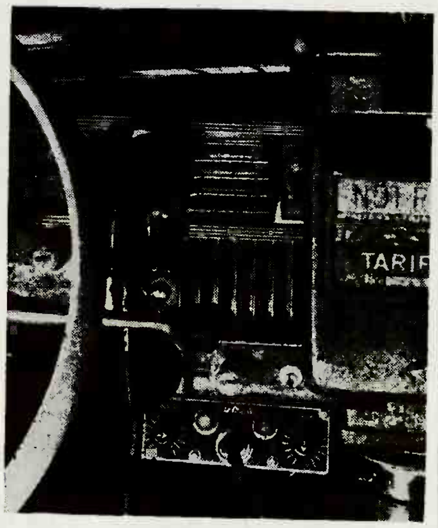
WE TRAVEL FAR
When it is evening in Paris, it is morning in Hawaii and early dawn in the Philippines. Yet our service men and women around the world now hear and enjoy the same radio programs timed to their particular area. Transcriptions on audiodiscs reproduce such programs with the exact quality of a live broadcast. Everyday thousands of these recording blanks are being "cut" for use at home and abroad.
AUDIO DEVICES, INC., 444 Madison Ave., New York
U.S. ARMY
...they speak for themselves audiodiscs

luggage compartment. Frequency modulation on 118.65 Mc is used.

The stationary transmitter is atop the Union Commerce Building, the city's third highest (350 feet), giving known coverage of city and suburbs. Actual dispatching of the cabs is done by wire-line remote control from the Yellow Cab Co. dispatching office. Each broadcast is



The handset and control unit are mounted on the dashboard of the cab. Squelch and volume controls are provided for use by the driver

heard by both cabs, but when the entire fleet of 430 units is equipped, plans are for individual pre-selection for each cab. There will be no intercab communication. Obvious applications for similar systems include physicians' automobiles, ambulances, express services, railroads, utility repair crews, industry and businesses with branch offices.

• • •

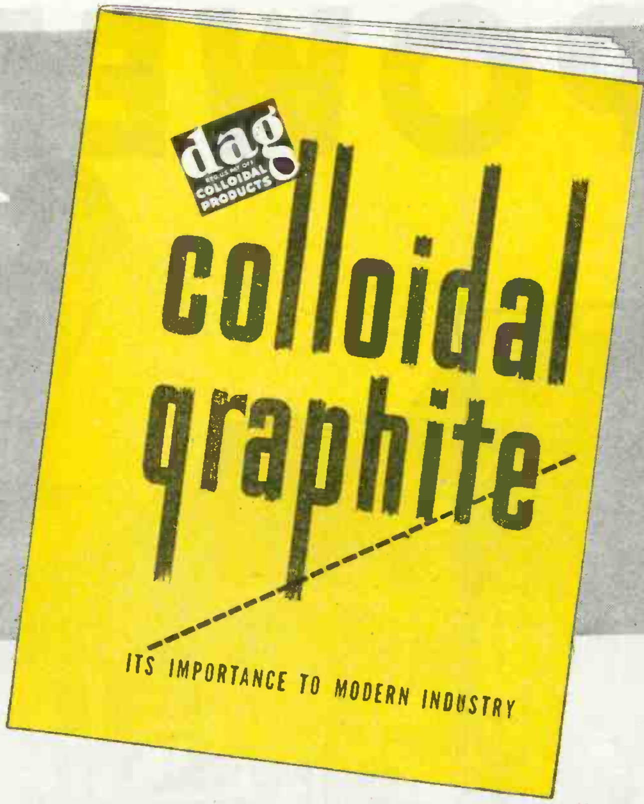
Vibration Meter for Precision Tap Plant

AN ELECTRONIC VIBRATION velocity meter was used recently to detect the cause of vibration in grinding machines at the plant of John Bath & Company, Worcester, Mass., manufacturers of high-precision taps. The vibration in one machine in particular was causing a large number of rejects.

An investigation made with the aid of the G-E instrument revealed that a set of gears in this machine, apparently in good condition, caused the vibration. Replacing the gears eliminated the difficulty.

The Bath concern also found the

This **FREE** booklet will help you SOLVE



PROBLEMS like these:

- **Electrostatic Shielding**
- **Secondary Emission**
- **Positive Contact (Rectifiers, etc.)**
- **Ray-focusing Anodes**
- **Corona Prevention**

Above are just a few of the presumably chronic headaches in the electronic industries which one or another of the versatile dispersions of **dag** colloidal graphite has helped to cure.

dag colloidal graphite is busy on scores of other assignments just as tough as these, in many different war and civilian industries.

Perhaps you have a trouble spot where one of the 18 **dag** dispersions might help. Perhaps you feel you're not as well up on the many valuable properties of **dag** colloidal graphite as you would like to be.

In either case, send for the free booklet, "**dag** colloidal graphite — Its Importance to Modern Industry". At the risk of only a stamp, this brochure may save you both money and time.

dag colloidal graphite

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(Lubricants containing **dag** colloidal graphite are available from major oil companies.)

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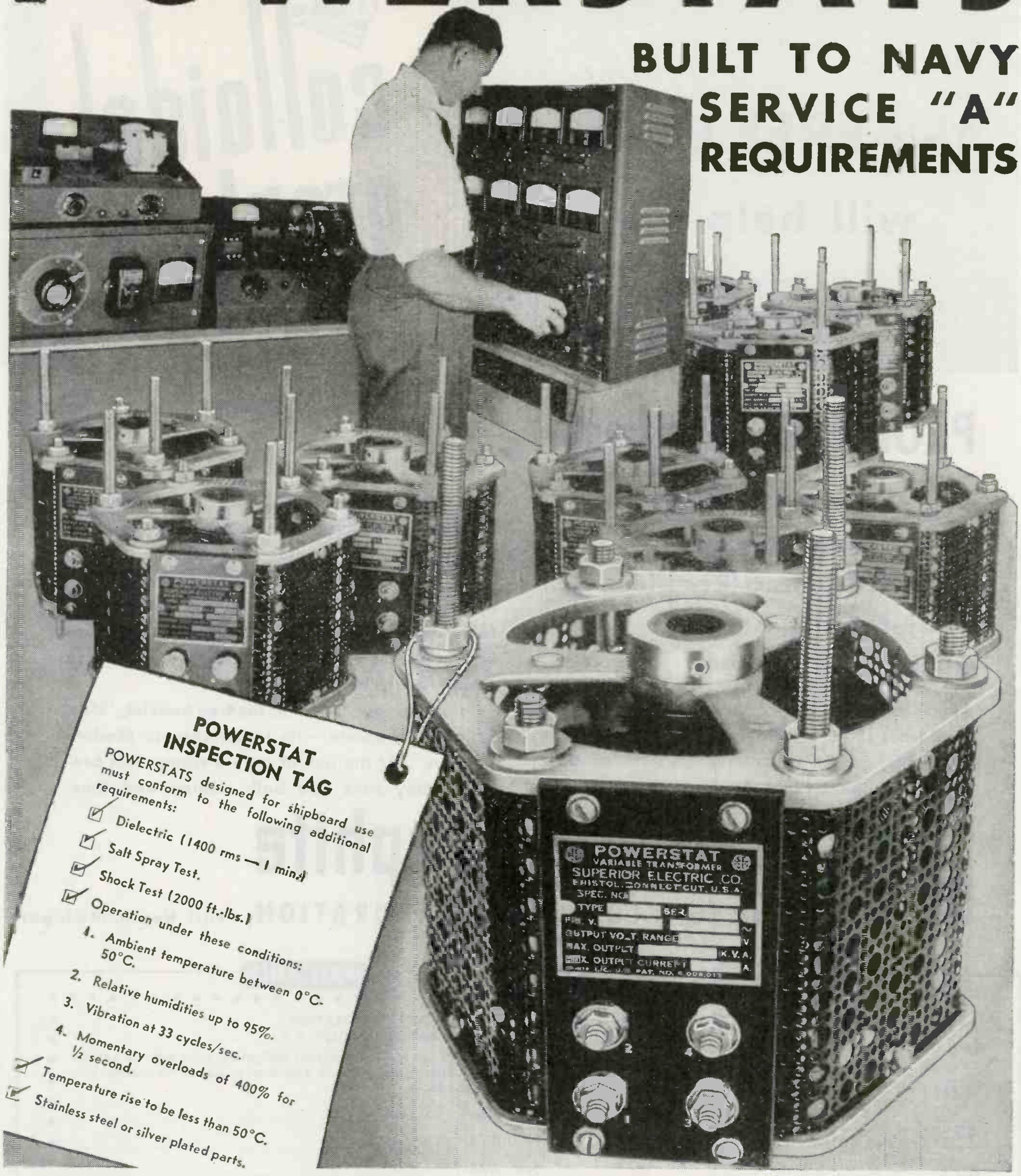

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SUPERIOR ELECTRIC COMPANY

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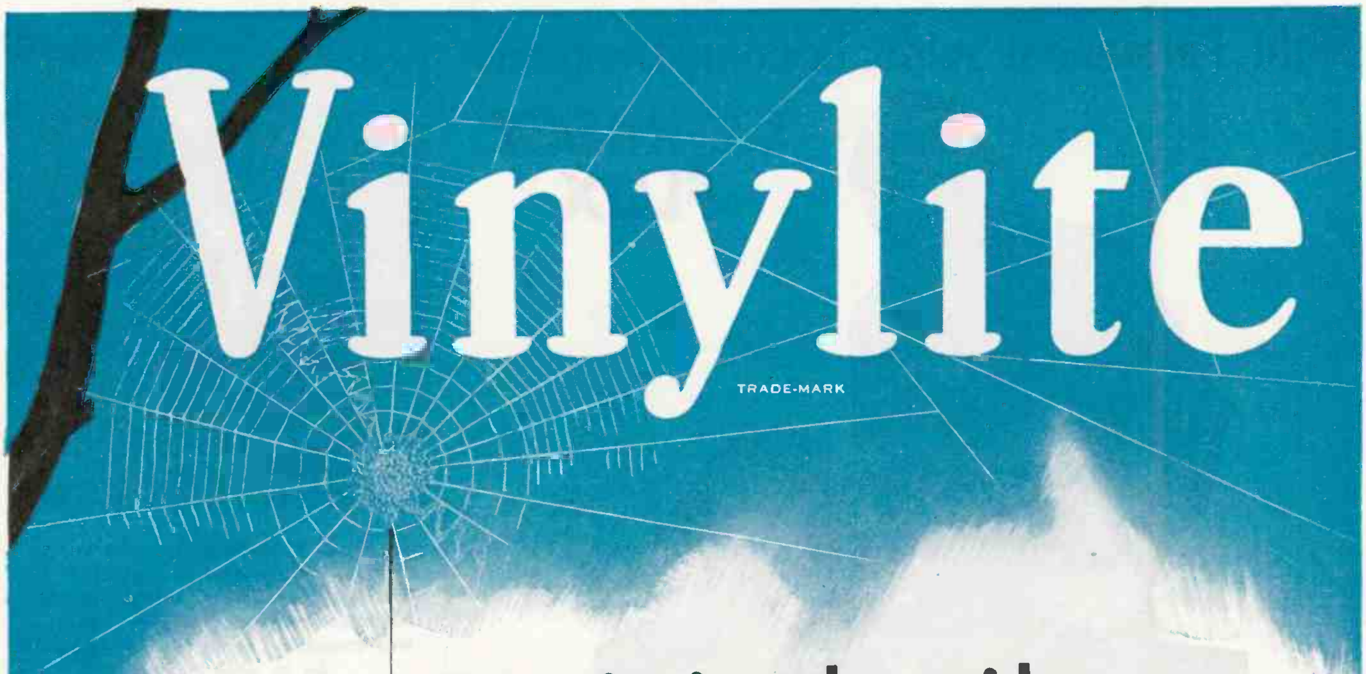

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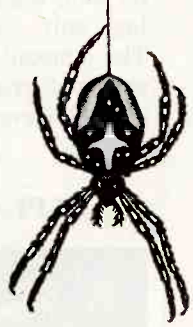


Outspinning the spider

The spider is an engineer—a master of construction and design. While man piled massive stone on stone for the pyramids, the spider built with an extruded material of airy lightness and amazing strength—presaged the whole trend of modern practice.

Today, VINYLITE extruded elastic plastics bring this same invaluable combination to wire and cable insulation. With excellent dielectric properties, they permit new thin-wall construction, with notable reductions in the weight and thickness of insulation on electrical conductors. More circuits can be inserted in existing conduits. And to insulation properties unsurpassed by older types, thin-wall insulation of VINYLITE elastic plastics adds unusual resistance to chemicals, oils, grease, and abrasion. It stays flexible at low temperatures — has a very low rate of moisture absorption. Certain types are non-flammable or slow-burning. It can be made transparent or opaque, in an infinite variety of colors.

Insulation made from VINYLITE elastic plastics sets up new standards of life and service for the full range of conductors, from portable cords to power cables. Write Department 18 for booklet VR. It describes all the VINYLITE plastics for wire and cable insulation, and explains the specific advantages of each for different types of application.

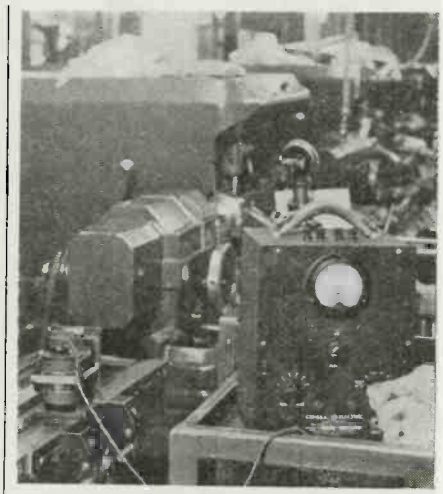
BAKELITE CORPORATION

Unit of Union Carbide and Carbon Corporation

UCC

30 EAST 42ND STREET, NEW YORK 17, N. Y.

Plastics



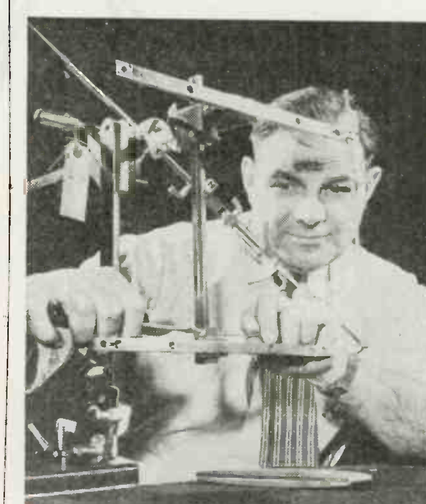
Set up on a precision tap machine, the pickup and electronic amplifier of this General Electric vibration-velocity meter showed that excessive vibration was caused by gears that appeared to be in good condition

meter valuable for detecting low-vibration areas in its plant, thus facilitating the placing of new equipment in areas where maximum operating efficiency was assured.

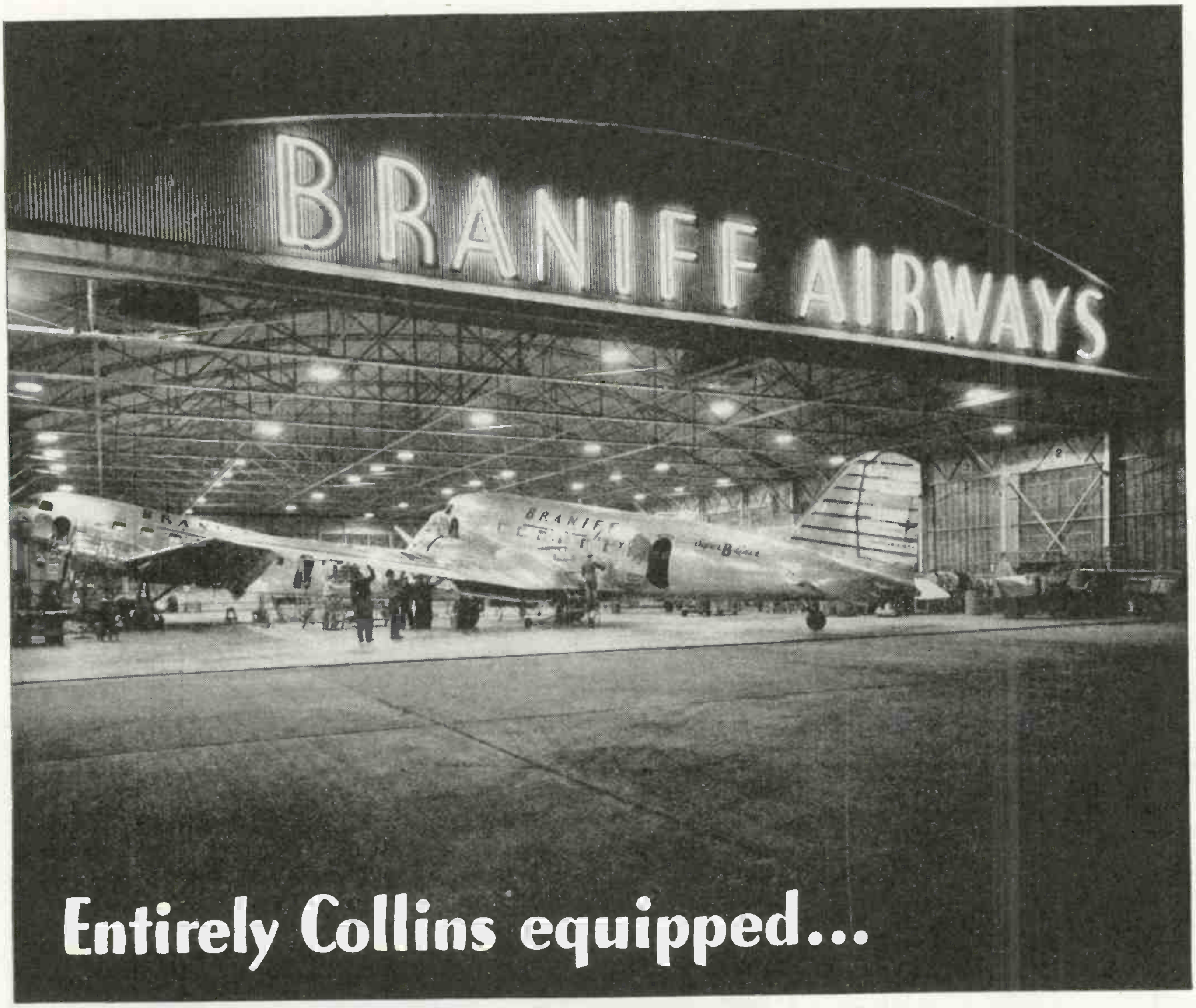
Consisting of a vibration pick-up unit and electronic amplifier unit, the meter measures vibration velocity and, together with an integrating unit, vibration displacement. The amount of vibration can be analyzed graphically by the use of an oscilloscope fed by the amplifier.

• • •

BI-PLANE MARKER



After a portable x-ray unit finds the bullet or lodged fragment in a wounded soldier, this bi-plane marker and re-orientating device measures its depth and position for guidance of the surgeon's knife. In the photo above, a worker in the Westinghouse x-ray division assembles the marker



BRANIFF AIRWAYS, INC. has been using Collins ground transmitters since 1935 and Collins aircraft transmitters since 1937.

It was the first great airline to recognize the superiorities of Collins design, workmanship, and performance, the first to avail itself of the precise, sturdy, reliable Collins Autotune.*

Today Braniff uses Collins multi-channel or Autotune equipment at every point at which it has a radio station, and every ship in its *Super* B *Liner* fleet carries a Collins 17F Autotune aircraft transmitter.

There is a deep satisfaction in having supplied the nerve-system on which Braniff relies in maintaining its magnificent record of safety and operating efficiency.

When Collins turned to war production, it could apply the know-how that came from furnishing communication equipment which met the exacting needs of Braniff and other major airlines. When it returns to civilian design and production, it will add to that know-how the tremendously increased, intensified experience acquired in its services to the Armed Forces. Collins Radio Company, Cedar Rapids, Iowa.

ARMY E NAVY

*The Collins Autotune is a repositioning mechanism which quick-shifts all transmitter or receiver tuning controls simultaneously and with extreme precision to any one of a number of pre-determined frequencies. Patents issued and pending in the USA and other countries.

COLLINS

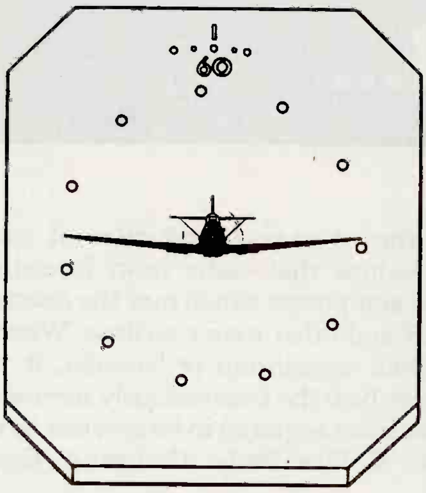
REG. U. S. PAT. OFF.

TUBES AT WORK

Electronics in Gunnery Control for the B-29

HAILED AS the all-electric airplane, the B-29 Superfortress makes use of remote-control armament which consists of five gun turrets mounted in various places on the plane and controlled by gunners in the pressurized cabin. About 30 different combinations of turrets are available to the five gunners aboard.

Each gunner uses a sighting station to aim at and range the enemy fighter. At each station is a precision instrument that permits a gunner to "track" a fast-moving enemy plane smoothly and accurately without stickiness or roughness to disturb his steady touch and throw him off. Mounted on the sighting station is the actual sight through which the gunner looks when he aims at the target. In this sight, he sees a tiny spot of light which is his aiming point. Whenever he puts this spot on the enemy plane, he knows that his aim is correct.



Through the sight, the gunner sees a circle of lighted dots whose size he can control to frame the enemy plane. His aiming point is a tiny dot on the nose of the attacking ship

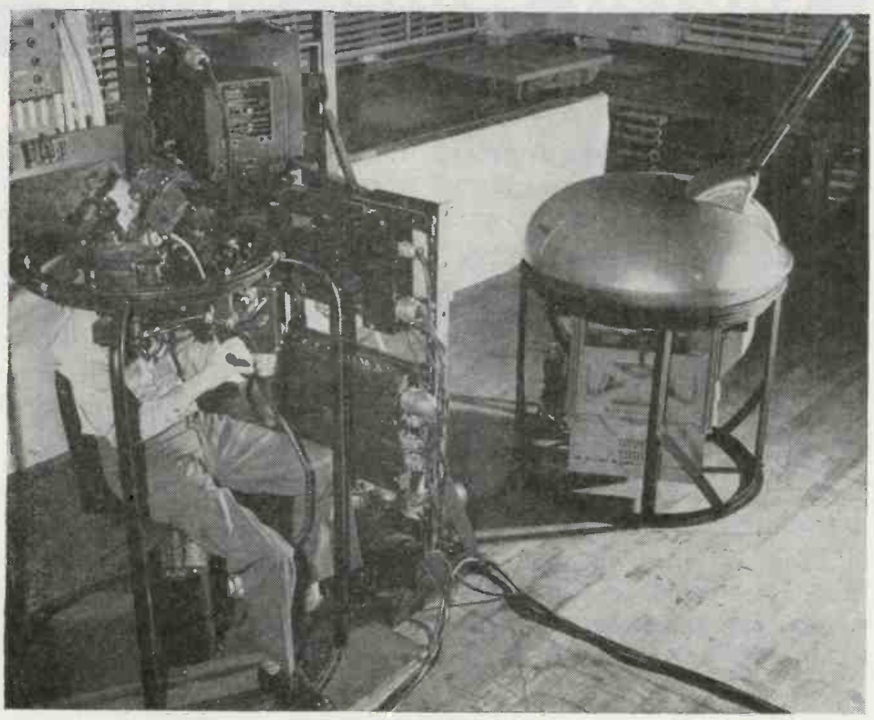
Around the sighting dot is a circle of other tiny dots of light. The size of this circle can be changed by twisting the range control on his handles. When the gunner has his aiming point on the center of the enemy airplane, he adjusts the size of the circle until it just spans the length of the target. Sun or sky filters and a brightness control on the sighting light give the gunner a wide range of adjustment. With the proper settings, he can sight at any target—from a plane coming at him almost directly out of the sun, to a plane coming at him out of the blackness of night.

Electronic Control

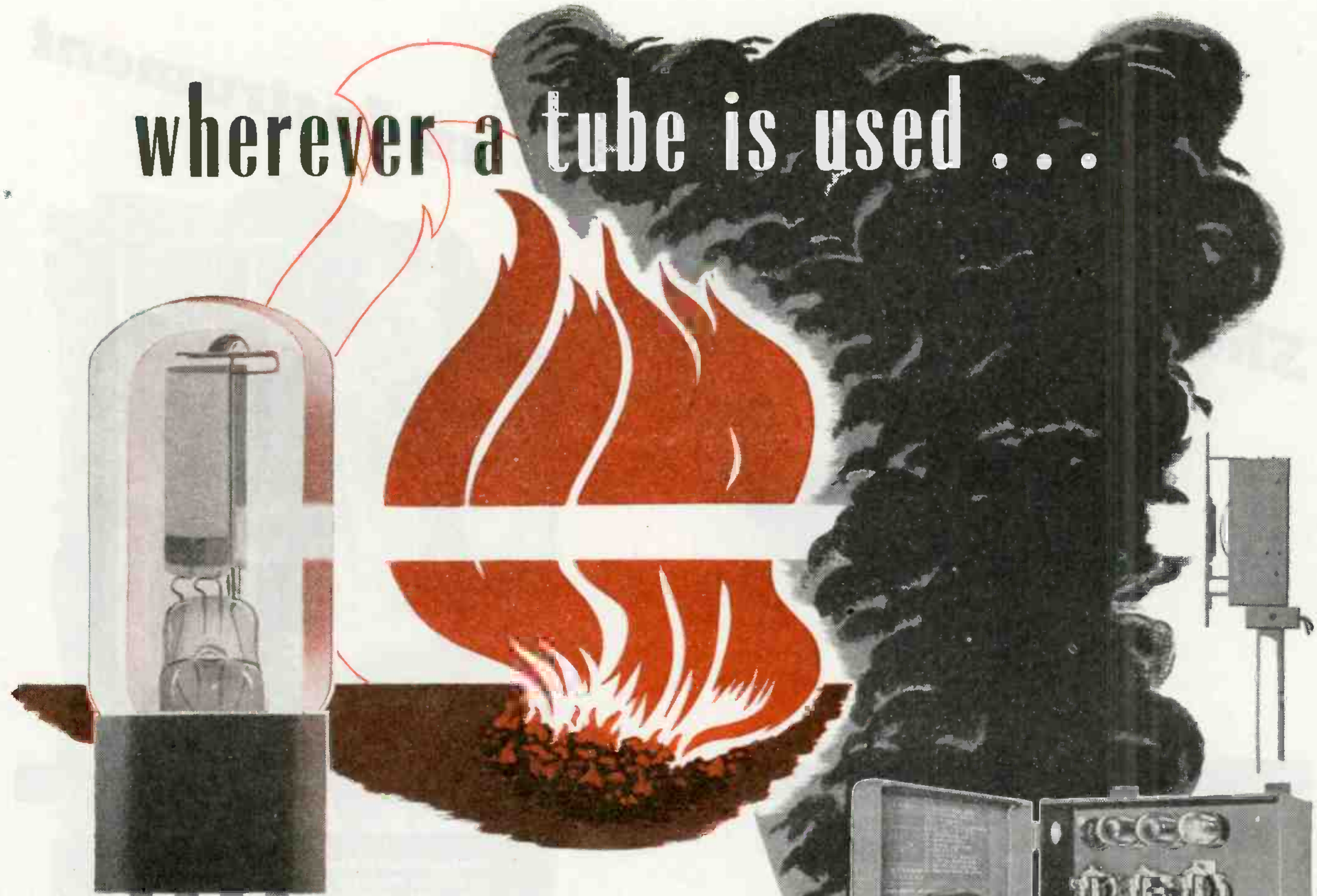
A set of selsyns are a part of the sighting station; from these, electrical connections run to a similar set of selsyns on the turret. Whenever the gunner moves the sight, the selsyns on the sight and the selsyns on the turret compare automatically the line of sight with the line of fire. If a difference exists, an electrical signal representing this difference between directions is fed into an electronic servo amplifier.

The servo amplifier amplifies the signal it has received and decides which way the guns must be moved to bring them into alignment with the sight. It then applies electric current to the field of an amplidyne motor-generator. In doing this, it makes the amplidyne generate a voltage which causes the turret drive motor to run in the proper direction until the selsyns signal that the guns are lined up with the target.

Since the guns and sights are located some distance apart (41 feet



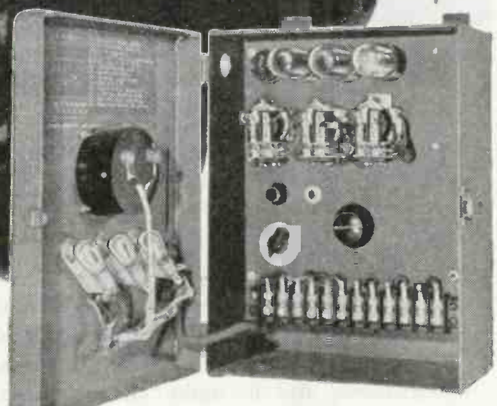
Speed of the enemy plane, gravity, parallax and distance from the B-29 are computed by electronic and mechanical units of the central gunnery control system. In the photo above, an Army sergeant operates the sighting mechanism in a demonstration setup. Developed by General Electric engineers, the system was made public by AAF officers and G-E at a conference of industrial leaders in New York City



COMBUSTION CONTROL

for example:

An abnormal increase in the density of smoke passing through a boiler breeching means a reduction of heat, loss of efficiency, increase in fuel consumption, and probably violation of smoke control ordinances. The electronically operated Worner Combustion Supervisor detects such conditions, turns in an audible or visible alarm, and sets in motion the mechanism that will bring about efficient combustion.



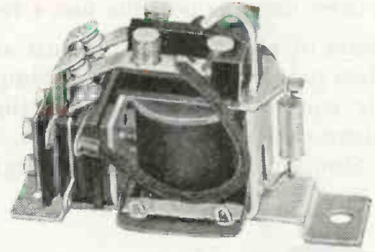
Control Unit

THERE'S A JOB FOR *Relays* BY GUARDIAN

The "Combustion Control Supervisor," made by Worner Electronic Devices of Chicago, is a photo-cell system that responds to any predetermined degree of smoke density. To avoid "false alarms" resulting from momentary puffs of smoke, it is equipped with a time delay feature.

Worner's specified that the three relays used in this system must be sensitive but not delicate; that they require no adjustment; and that they meet Underwriter's requirements.

Guardian engineers developed the Series 155 D.C. relay as the answer to these specifications. This is a compact, sturdy, easily mounted unit with constant spring tension on the contacts. It is widely used on remote selection devices and other low voltage applications. Copper slug time delays up to .05 seconds on attract and 0.15 seconds on release are available. Coils for operation on any voltage up to 230 volts D.C. For further information write for Series 155 bulletin.



Series 155 D.C. Relay

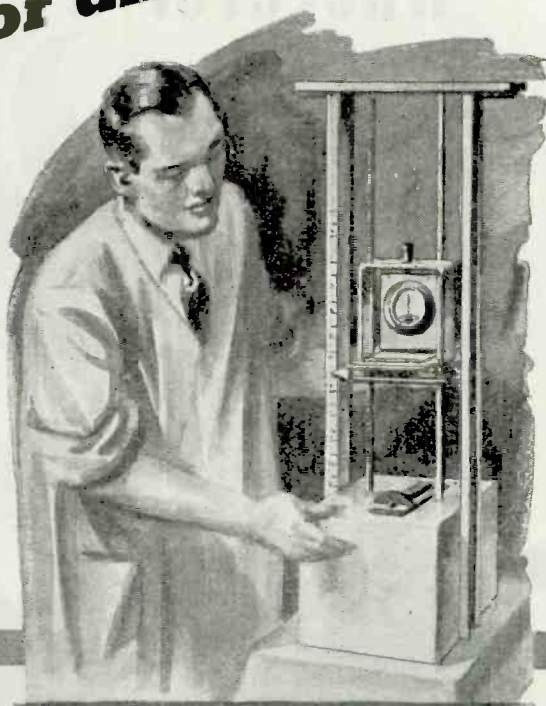
Consult Guardian whenever a tube is used —however—Relays by Guardian are NOT limited to tube applications, but are used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

GUARDIAN G ELECTRIC

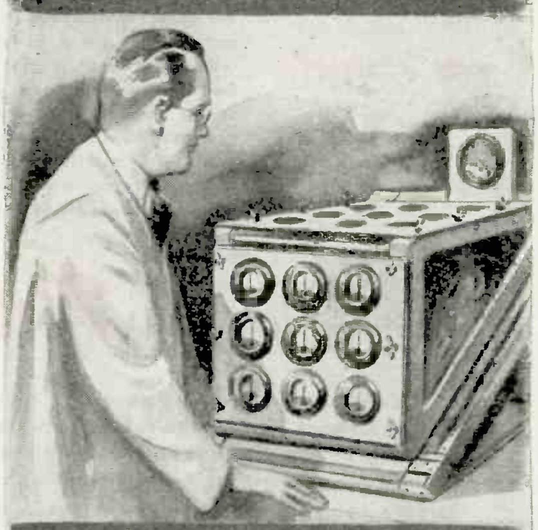
1625-A W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

Shocking Treatment for an Instrument



Simpson Shock Test—Instrument is mounted in sliding carriage, and dropped against bottom plate. Vertical scale permits shock of impact to be computed in multiples of g, the acceleration of gravity.



Simpson Vibration Test—Specially designed equipment provides rapid movement of instruments in three different planes. Variable speed regulator permits vibration of any desired intensity.

WHILE electrical instruments are delicate by their very nature, the conditions under which they must serve are seldom ideal—these days especially. Before entrusting them with vital responsibilities, it frequently becomes necessary to learn just how much abuse they can withstand.

With Simpson Instruments performance can be proved beforehand right in the Simpson laboratories. Complete facilities are provided to simulate practically any operating conditions, and to make an instrument live many, many years in a day.

Important innovations in design and construction have resulted. Exhaustive breakdown tests show that the Simpson Instruments of today are far more rugged than would have been thought possible just a few years ago.

To users of electrical instruments and testing equipment, this fact points out the value of Simpson's long experience. While constant research and testing can isolate specific problems of design or construction, it's the practical know-how Simpson has stored up through more than 35 years that supplies the answers.

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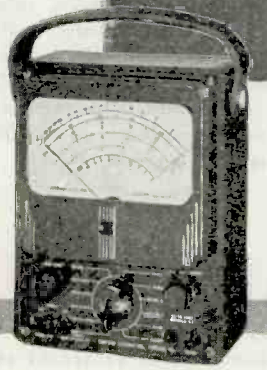
5200-5218 Kinzie St., Chicago 44, Ill.



Model 260
High Sensitivity Tester

Ranges to 5000 volts, both AC and DC, at 20,000 ohms per volt DC, and 1000 ohms per volt AC. Current readings from 1 microampere to 500 milliamperes. Resistance readings from ½ ohm to 10 megohms. Five decibel ranges, —10 to +52 DB.

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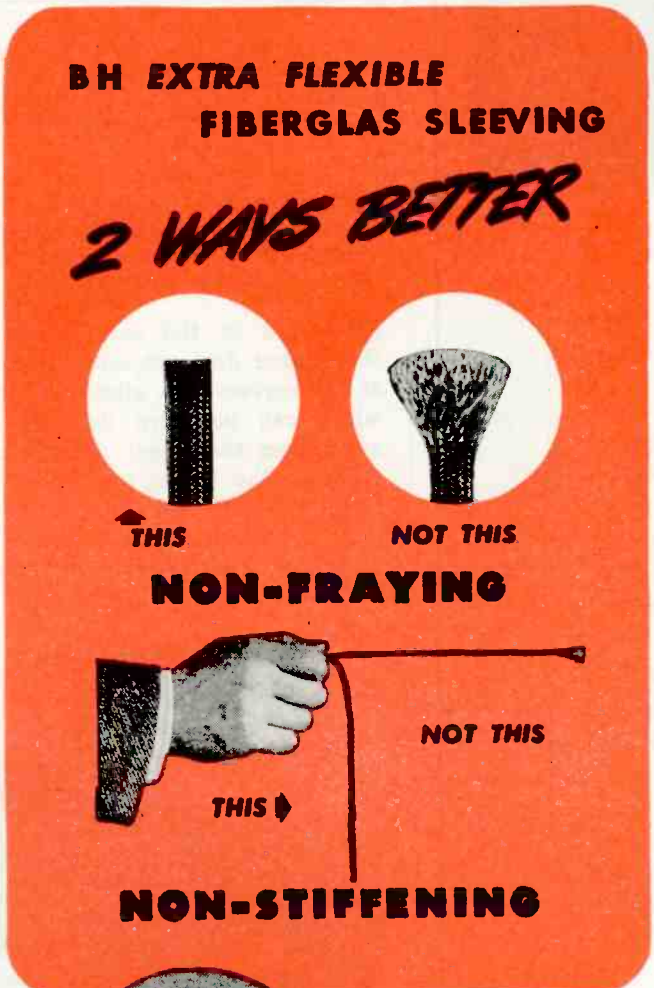
ENDS "WIRE THREADING" WORRIES



INSERTING bare wire in rough sleeving that frays out on the ends is time- and patience-consuming. The job is much simpler and less irksome when you use BH *Extra Flexible* Fiberglas Sleeving, the non-fraying, smooth bore insulation that takes fine-stranded wires without a hitch.

Special-processed BH Sleeving is *permanently* flexible and non-fraying. It won't harden and crack with age, and it won't burn. In addition, it has all the other desirable electrical and physical features of inorganic Fiberglas.

If you're looking for an easy-working, long-lasting insulation, why not try BH *Extra Flexible* Fiberglas Sleeving? It's available in all standard colors and sizes from No. 20 to 5/8", inclusive. Write for samples today!

BH SPECIAL TREATED FIBERGLAS SLEEVING CUTS CLEAN, DEFIES HEAT

Here's another high quality BH Fiberglas Sleeving. No saturant is used in the exclusive BH process, yet the sleeving will not fray when cut and withstands heat up to 1200° F. Made in natural color only—all standard sizes. Try it!

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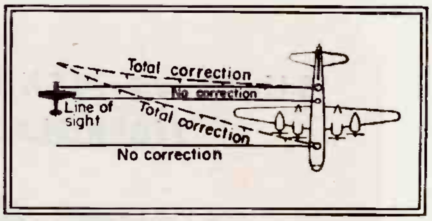
BENTLEY, HARRIS MANUFACTURING CO.

Dept. E Conshohocken, Penna.

in the case of the rear turret), correction for parallax must be made. At the same time, corrections for windage, gravity and the relative motion of the enemy plane must also be made.

Calculator

A computer was designed to solve automatically all of these problems and make the guns point to hit the enemy fighter when the gunner aims at him. The computer automatically calculates the parallax, windage, gravity drop, and lead corrections and then adds them together into a total correction. This total correction, which might be more than 10 deg, is superimposed on the sight direction signal that is sent to the turret and fools the turret into pointing its



Total correction provided by the computer combines prediction, ballistic, and parallax corrections

guns—not at the target—but so the gunner does not have to guess at the correct gun aiming point—which can be more than 500 ft away from the target. He can aim right at the target and know his bullets will hit.

A gunner concentrating on "tracking" a fast-moving enemy

• • •

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Just before landing—Canadian assault force and radio equipment in a rocky inlet on the Isle du Levant, six miles from the French coast

a NEW *Industrial* POWER TUBE by *Federal*

Federal presents a new and rugged power tube that fills an immediate demand — a power tube that has been *specially* designed for industrial use in high-frequency heating equipment, both dielectric and induction.

Really built to withstand the constant jars, shocks, and vibration commonly encountered in manufacturing operations, this heavy-duty vacuum tube is very conservatively rated, and will stand up under extremely hard usage.

Widely spaced, unusually sturdy filament and grid elements, without internal ceramic insulation, give this tube a ruggedness that makes it the logical choice for dependability in the design of industrial heating equipment.

For industrial power tubes, and also for rectifier and transmitting tubes, see Federal first... because "Federal always *has* made better tubes."

FEDERAL FTR TELEPHONE & RADIO

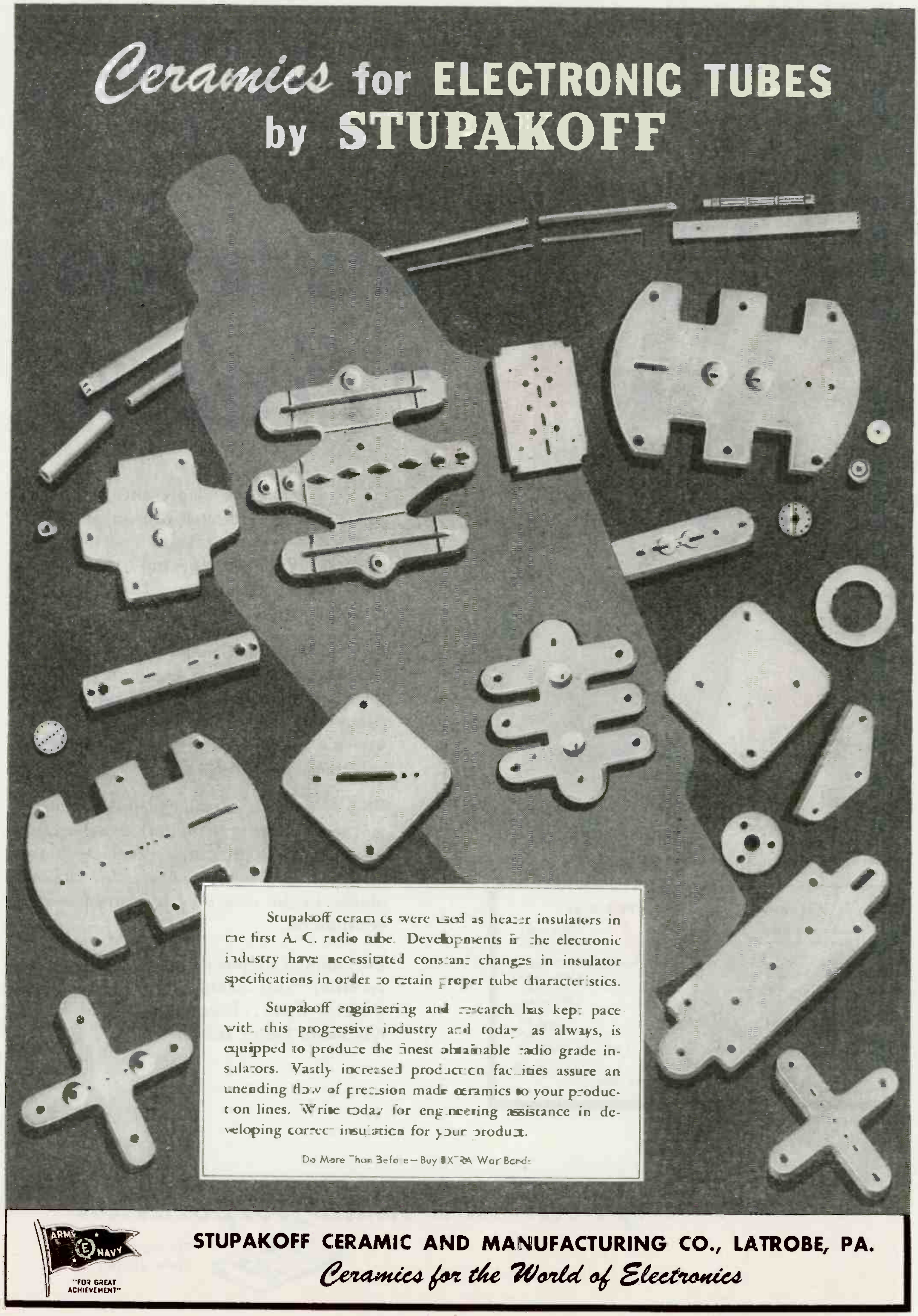
TECHNICAL DATA FOR TYPE F-5303

Filament Voltage	11.0 volts
Filament Current	27.5 amps.
Maximum Ratings for Maximum Frequency of 50 Mcs.	
DC Plate Voltage	3500. volts
DC Plate Current	1.0 amp.
Plate Dissipation	1200 watts
Overall Height	app. 7"
Maximum Diameter	3⅓"
Supplied with 6" flexible copper leads, 2 on each terminal.	
Type of Cooling	Forced-air
(Also supplied for water-cooling, type F-5302.)	

Federal Telephone and Radio Corporation

AN IT&T ASSOCIATE

Newark 1, New Jersey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Stupakoff ceramics were used as heater insulators in the first A. C. radio tube. Developments in the electronic industry have necessitated constant changes in insulator specifications in order to retain proper tube characteristics.
Stupakoff engineering and research has kept pace with this progressive industry and today as always, is equipped to produce the finest obtainable radio grade insulators. Vastly increased production facilities assure an unending flow of precision made ceramics to your production lines. Write today for engineering assistance in developing correct insulation for your product.
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"FOR GREAT ACHIEVEMENT"
STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.
Ceramics for the World of Electronics

airplane might swing the line of fire from his guns through parts of his own ship. Automatic fire interrupters stop the guns from firing at the gunner's own plane and relieve him of this responsibility. At the same time, however, these interrupters permit him to fire within inches of parts of his own plane, so that he loses the least possible fire coverage.

Six electric motors are used to operate each turret and point its guns as the gunner aims his sight. A total of 150 electric motors of 49 different types are installed in the plane. The only units not actuated electrically are the propellers and brakes.

• • •

AVC Amplifiers for Bridge Null Detectors

By LAWRENCE FLEMING
Naval Ordnance Laboratory
Washington, D. C.

IMPEDANCE BRIDGES operating at 1000 cycles are widely used for measuring inductance and capacitance with a pair of headphones as the null detector. For close work, a tuned amplifier ahead of the phone is quite helpful.

One requirement which is seldom considered is that the amplifier should employ automatic gain control in order that the sensitivity may be highest near the null point, and overloading may be avoided when the bridge is far off balance.

Figure 1 shows a two-stage unit successfully employed with a General Radio 716-B capacitance bridge. It permits measurements of both capacitance and loss factor as closely as the dials can be set.

A delay voltage is introduced into the automatic gain control cir-

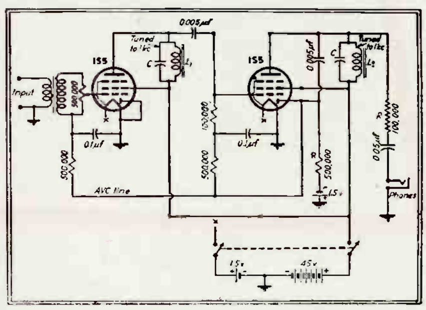

Fig. 1—Circuit of null amplifier with avc for use with precision capacitance bridge. Capacitors marked C are approximately 0.005 μf and are used to tune inductors L_1 and L_2 to 1000 cycles

$3\frac{1}{2}$ ounces...

WITH TWELVE CONTACT SPRINGS.

PHOTO IS ACTUAL SIZE

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Like other General Control lever switches, the contact possibilities are unlimited . . . contact assemblies can be removed from the frame by removing a single bolt . . . all parts are non-corrosive . . . easy, positive roller action, regardless of number or arrangement of contacts on each side of the switch . . . a single hole only is required for panel mounting . . . rated from 5 to 10 amperes, 125 volts A.C.

The standard "Midget" has either three positions as shown in illustration, or can be supplied with two positions (no neutral).

General Control Company will be pleased to send complete information, and arrange delivery schedules to meet your requirements.

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is compactly constructed for restricted space. It is only 2¾" long x 1¼" wide x 1¼" thick.

The New "Midget"

has all the quality construction features of the well known "Master" Line of MCL Cam Lever Switches built by General Control Company.

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cuit of Fig. 1 by a 1.5-volt battery in series with resistor R. The signal voltage from the output tube is coupled by a capacitor to the diode plate of the same tube to get the avc voltage.

Figure 2 shows the input-output curve. The avc action is not made "flat" because if it were, it would not be possible to tell in which direction to turn in order to balance the bridge. This characteristic makes the bridge considerably easier to operate.

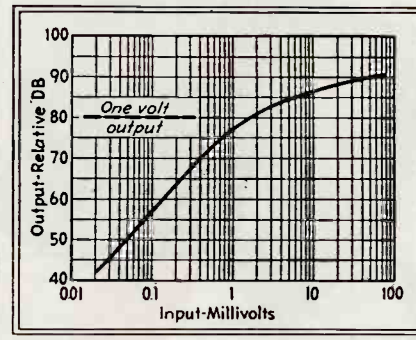

Fig. 2—Input plotted against output for the circuit shown in Fig. 1 to illustrate the avc action

Tuned circuits are formed by 0.005-μf capacitors and L_1, L_2 which have an inductance of about seven henries and a Q of 7 at 1000 cycles. Resistor R between the headphone jack and the tuned circuit permits the use of either crystal or magnetic headphones without detuning the circuit.

Other Bridge

Figure 3 shows a visual-indicating null detector designed for use

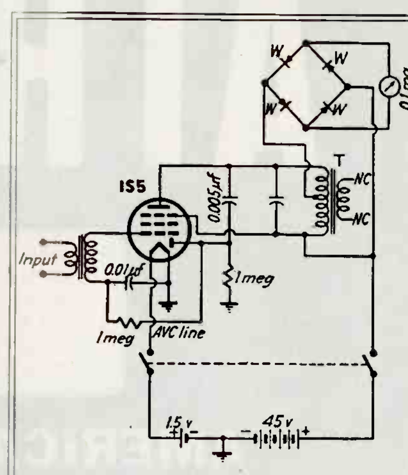

Fig. 3—Visual indication is provided by this circuit of a single-stage amplifier. Transformer T is a midget radio push-pull output type

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with a General Radio type 650-A impedance bridge. Subjectively, the accuracy is approximately the same as with magnetic headphones and no amplifier. The avc action of the single stage gives a logarithmic type of input-output level curve. An auxiliary copper-oxide rectifier W is used across the tap on the output choke T to deliver greater current to the indicating instrument. Too much step-down to rectifier W cannot be used because of the curvature of the rectifier characteristic at low voltages. The speed and damping of a 1-ma instrument movement make it more satisfactory than a more sensitive instrument for this application.

Amplifier Without AVC

Figure 4 illustrates a very simple amplifier without avc found useful with headphones for use with the same type bridge. Two points are of interest: first, the external field of the 1000-cycle microphone hummer in the bridge induced a noticeable background signal in the input transformer originally used, so this was eliminated; second, a resistor

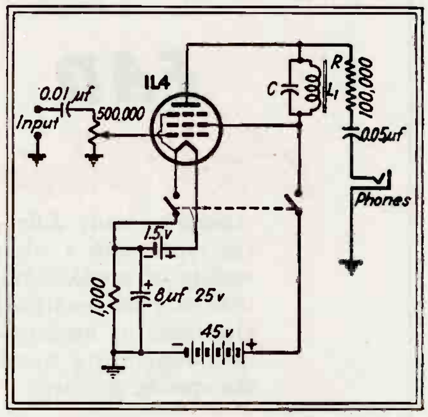


Fig. 4—Single-stage amplifier without avc. Resistor R minimizes detuning effect of phones

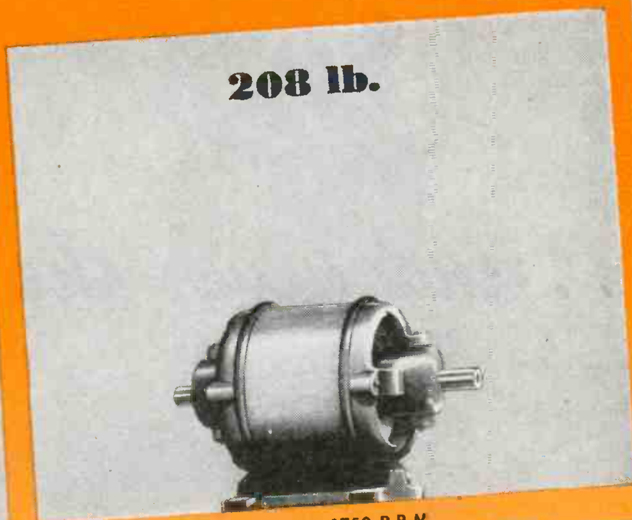
R is employed as in Fig. 1 to eliminate the reaction of the headphones on the tuned circuit L_1C with a very small loss in gain. Crystal headphones are as useful as magnetic phones with this amplifier. The crystal type cannot be employed at all without this type of unit because of the phone's high response to harmonics of the 1000 cycle tone.

Where large numbers of bridge measurements must be made, consideration should be given to the visual-indicating method with avc

Can Motor Weight be Cut 50%

—with longer life at elevated temperatures?

10 H P at 1750 R P M



10 H P at 1750 R P M

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Electrical and mechanical characteristics are satisfactory. Resistance to decomposition is greater.

Silicone-Bonded Vitrotex is available in round, square and rectangular shapes in sizes from 6 to 40.

In addition to Silicone-Bonded Vitrotex, prospective users also should consider using heat-resistant insulations such as Fiberglas cloth coated with Silicone and Fiberglas cloth bonded or laminated to mica with Silicone.

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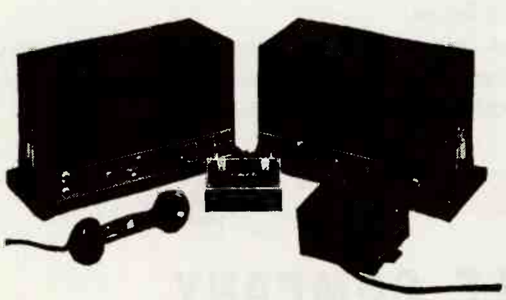

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E L E C T R O N I C S

SETTING THE PACE FOR PROGRESS IN COMMUNICATIONS

HARVEY-WELLS ELECTRONICS, INC. SOUTHBRIDGE, MASSACHUSETTS

as suggested in Fig. 3, because it is far less fatiguing to the operator than the use of the ear, and is capable of great accuracy if the proper avc characteristics are obtained. A two or even three-stage amplifier may be necessary. It also is essential to use an instrument with a fast, well-damped movement. The tube filaments can be operated from a-c for this type of service.

Filament-type tubes for the units described were chosen because the bridges are used intermittently. The annoyance of waiting for heater-type tubes to warm up tends to cancel the convenience of the amplifier.

Chokes L_1, L_2, used in the tuned circuits of Fig. 1 and 4, can be improved in Q up to about 20, with a corresponding drop in inductance, by increasing the air gap. Little difference in Q has been found between various sizes and makes of radio filter chokes, so that the smallest size is the best for this application. The actual inductance of most such chokes which are rated at 10 to 30 henries measures quite close to 7 henries at 1000 cycles. Too high a Q is undesirable.

• • •

Variable Frequency Oscillator for 25 Centimeters

TO INCREASE FREQUENCY in the average uhf oscillator, the inductance and capacitance of the tuned circuits are decreased. This method of frequency control is adequate to frequencies of 10 to 60 megacycles, but above this range, the inductance of the tube leads and the inter-electrode capacities become appreciable and eventually, with increasing frequency, the oscillator reduces to the tube and its inherent capacity and inductance. Above 60 megacycles, the loss in efficiency and power output is due to these three main factors:

(a) Transit time of electrons between cathode and plate, which increases the effective grid-conductance of the tube and shifts the phase of the plate current with respect to the grid voltage.

(b) Limitation, by the physical structure of the tube, of the extent to which the parameters of the oscillator circuit can be reduced.

(c) Increase of power loss in the oscillating circuit as a result of skin effect; large capacitance charging

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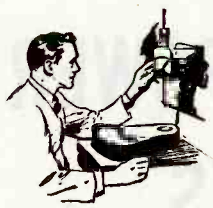
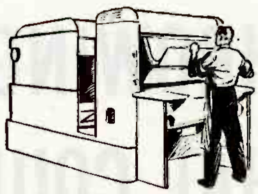


CALIBRATION OF ELECTRIC DEVICES



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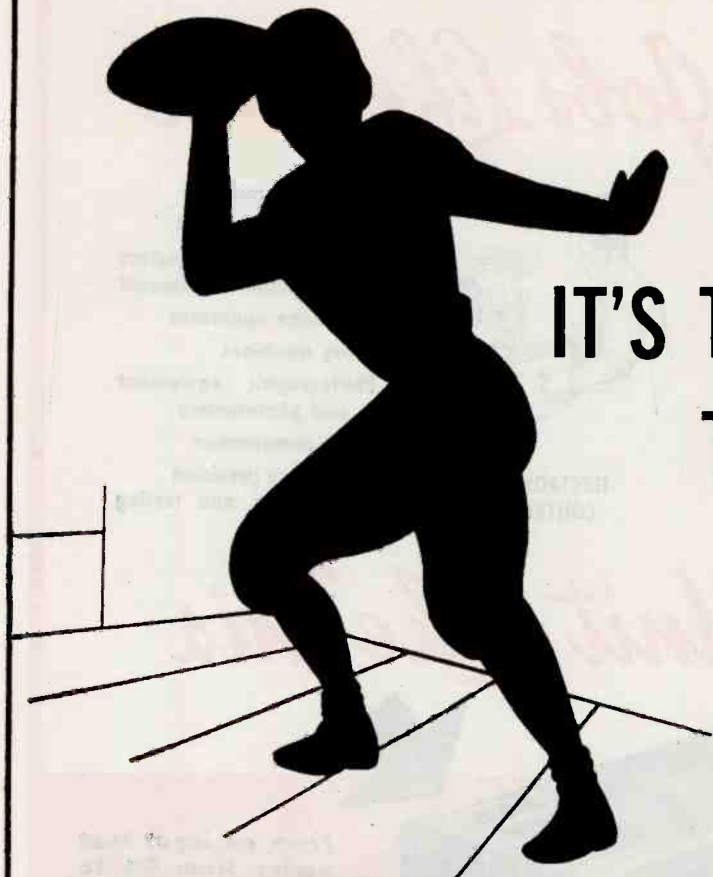

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current, which results in large I^2R loss; electromagnetic radiation from the circuit; dielectric losses in the tube base and envelope.

In an oscillator constructed by George Pihl at Northeastern University and described by H. G. Ryan in a paper delivered before the Boston AIEE, it was found that most of these factors could be controlled by the choice of a proper tube. The Western Electric 368A was the only commercial tube available which met the requirements of the oscillator as to frequency and stable output. This was used in the tuned-grid tuned-plate oscillator circuit shown in Fig. 1.

The tuning elements are coaxial stubs and a sliding capacitor. The use of the stubs results in a negligible radiation loss since the field is confined to the inside of the ele-

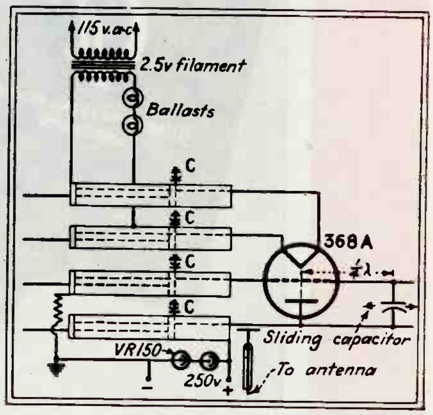
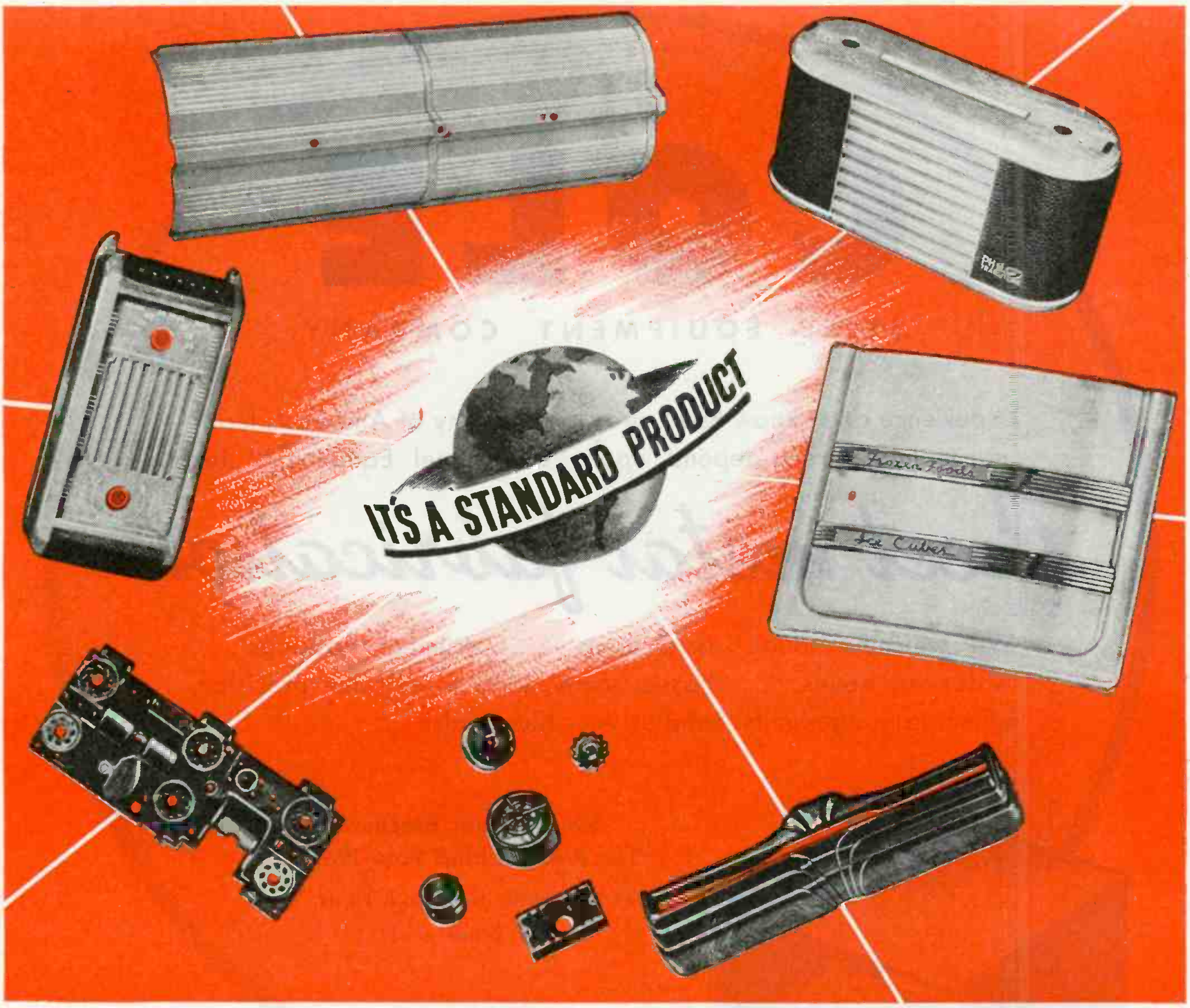


FIG. 1—Circuit of 25-cm oscillator for demonstration of wave guides and resonant cavities

ments, and the high frequency current is confined to the inside of the lines. This arrangement also simplifies the problem of applying direct voltages to the elements without allowing the high frequency currents to flow in the supply lines. Using these stubs also eliminates body capacity effect. The filament circuit also has tuned stubs to isolate the high frequency currents and to keep the center of the filament at zero r-f potential.

The sliding capacitor, used between the grid and plate for frequency variation, varies the length of a ¼ wave section, since at high frequencies the reactance is very small and the capacitor acts effectively as a shorting bar.

Two WE ballast tubes are used in the filament circuit to stabilize the current through the filament. Two VR150 regulator tubes are used to



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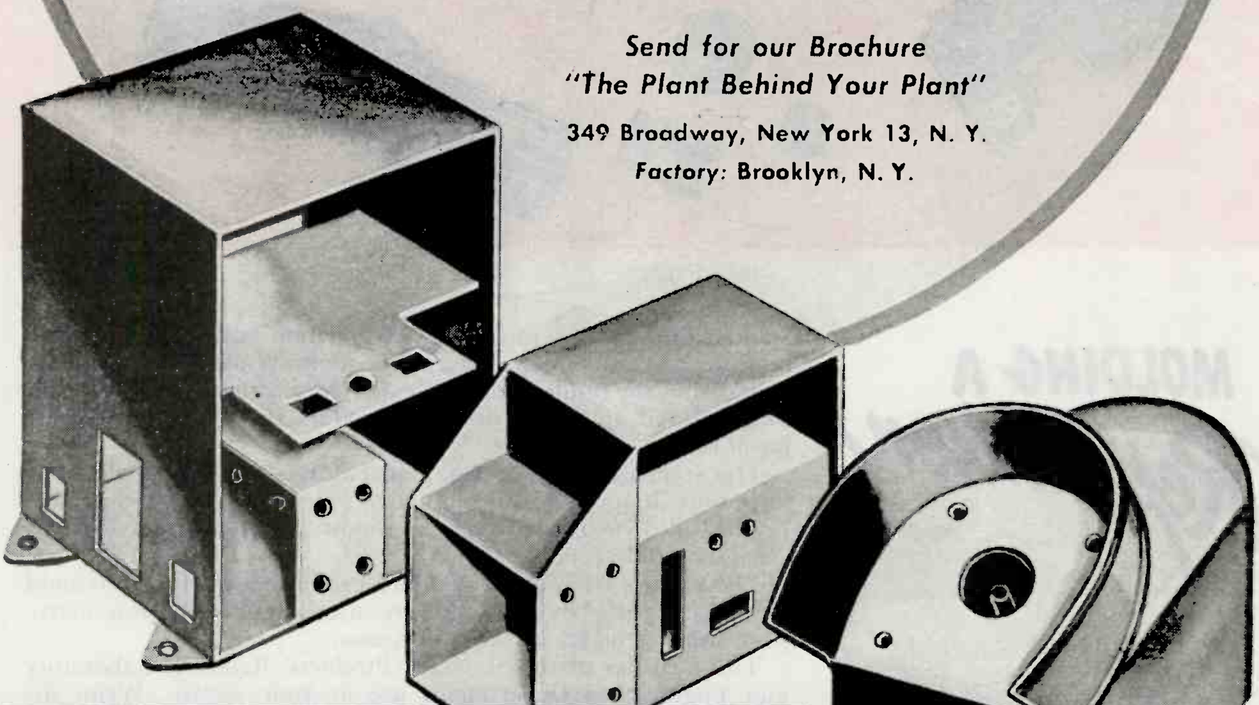

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Designers and Builders of Special Fractional HP Motors and Electrical Apparatus

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limit the voltage variations in the oscillator, since voltage variations in a self-excited oscillator are one of the main reasons for instability.

Mountings

The oscillator tube is mounted on an aluminum bracket composed of two sections with a semi-circle cut in each section of the bracket; the completed circle has the same diameter as the tube. The tube fits in the hole in a vertical position and is rigidly mounted. This method allows convenient mounting of the tuning stubs and sliding capacitor.

The tuning stubs are mounted on another aluminum bracket by means of a clamping sheet of polystyrene. Bypass capacitors must be used between the grid and ground and plate and ground. Flanges of sufficient area were soldered to the ends of the stubs, and the stubs were clamped to a sheet of aluminum with a suitable dielectric to provide the required bypassing.

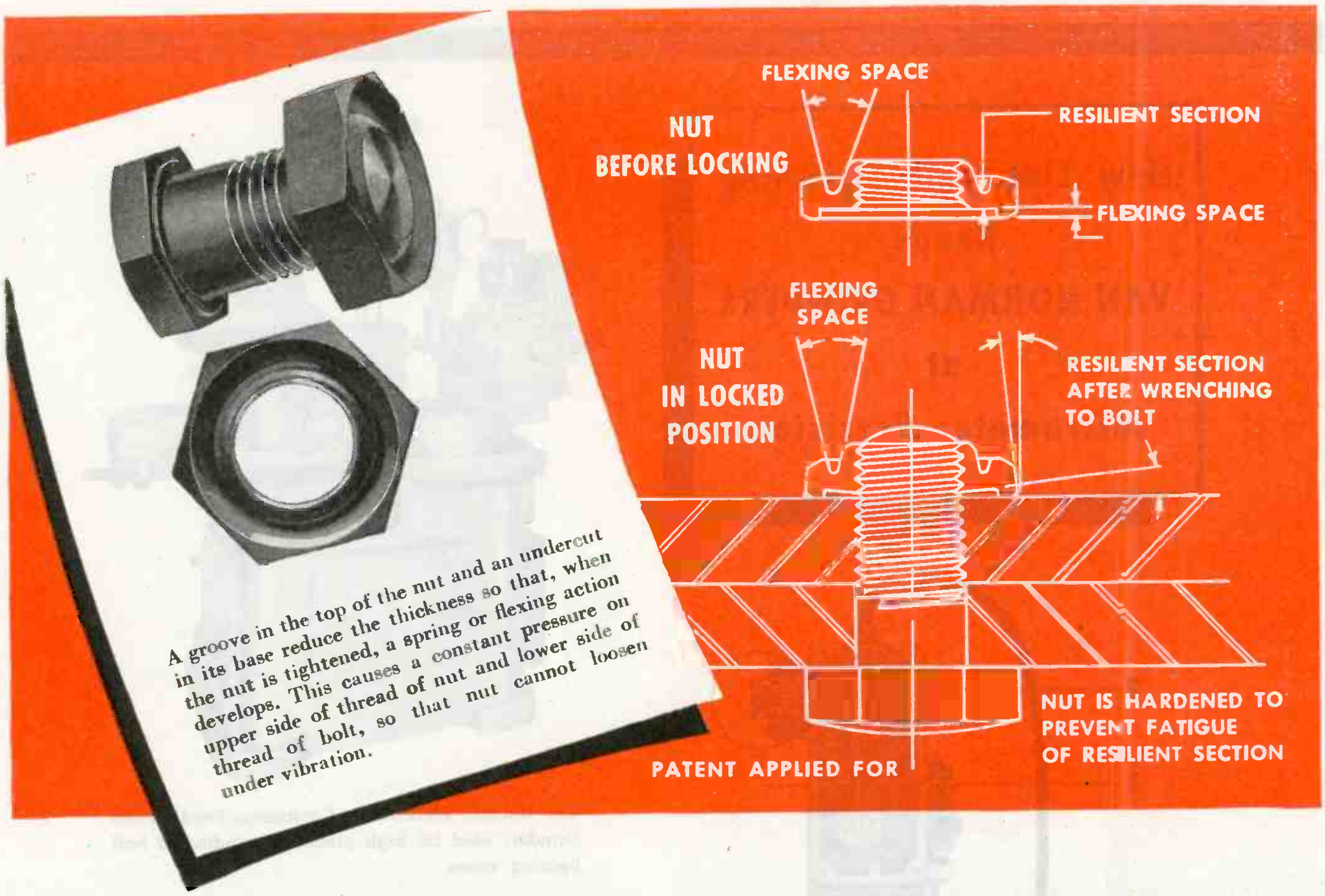
The stubs are 3 inches long to tune the oscillator to resonance at the desired frequency. The stubs consist of sections of coin-silver tubing with an outside diameter of $\frac{5}{16}$ in. The center conductor is another section of coin-silver tubing, O.D. of 0.05 in.

To provide a low-resistance path for the high-frequency current, a section of coin-silver tubing was arranged to telescope into the main tube. This contact tube was slotted to compensate for any irregularities in the main tube's diameter and to provide a tight, wide-area contact. To connect the outer tube to the inner tube, this section of tubing was soldered to a brass plug, a hole was drilled in the brass plug, and the plug slotted to permit a sliding fit over the center conductor.

To provide bypassing, $\frac{3}{4}$-in. flanges were soldered to the end of the outer tube to provide the necessary capacitance to ground.

The handles for tuning consisted of two brass rods soldered to the sliding contacts and brought out to a piece of polystyrene rod. These rods were fused into the polystyrene piece to complete the stub, and a brass end plate soldered on the outer tube.

The sliding capacitor was built to slide on an extension of the grid and plate leads, essentially a short Lecher wire system. Alternate



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:*

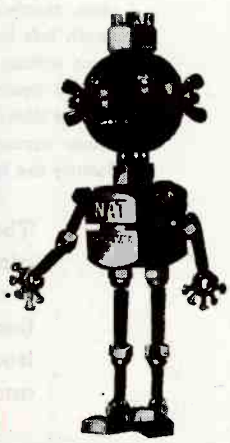
The American Fork and Hoe Company, in redesigning their new line of "True Temper" products, needed a bolt and nut assembly for certain applications that would lock up tight, yet permit delicate adjustment for proper functioning of the tools, and be capable of easy disassembly for sharpening.

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.

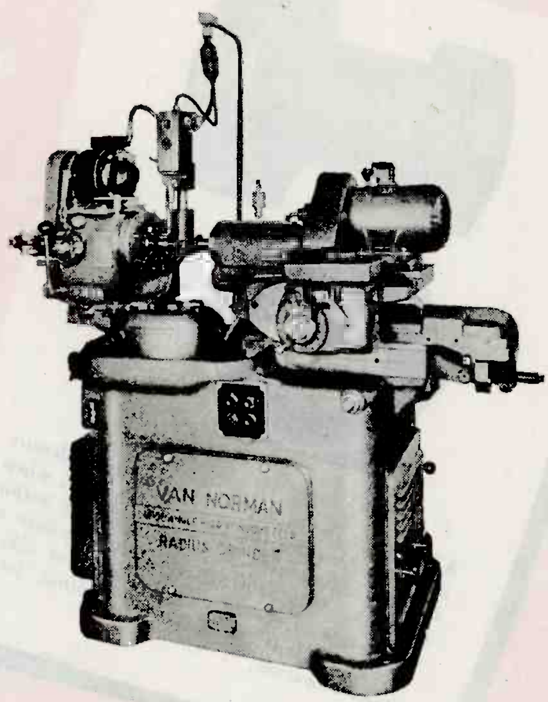
Let us diagnose *your* products for possible fastener improvement. It's often surprising what can be done.



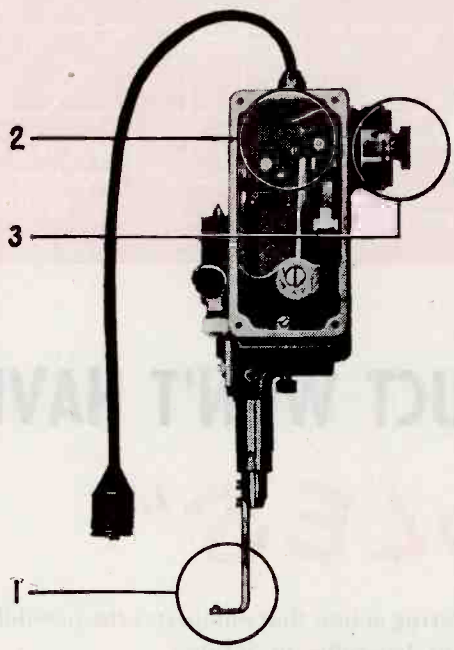
National HEADED AND THREADED PRODUCTS

THE NATIONAL SCREW & MFG. CO., CLEVELAND 4, O.

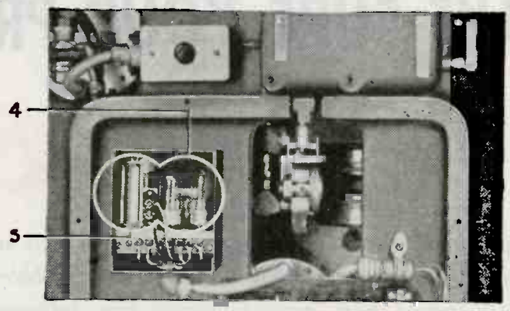
How Electronic Switching Keeps VAN NORMAN GRINDERS at Micrometer Precision



Van Norman Wide Angle Continuous Feed Radius Grinder, used for high precision grinding of ball bearing races.



The "finger" (1) of this control head contacts the ball bearing race, mechanically closing the switch (2) when the proper depth has been reached. Thus constant precision of measurement within .0003 of an inch is maintained. This depth is set by the operator, on the vernier type dial (3). Only a tiny current flows through the switch, since heavier currents would cause arcing or pitting of contacts, either of which would destroy the high accuracy of control necessary in this machine.

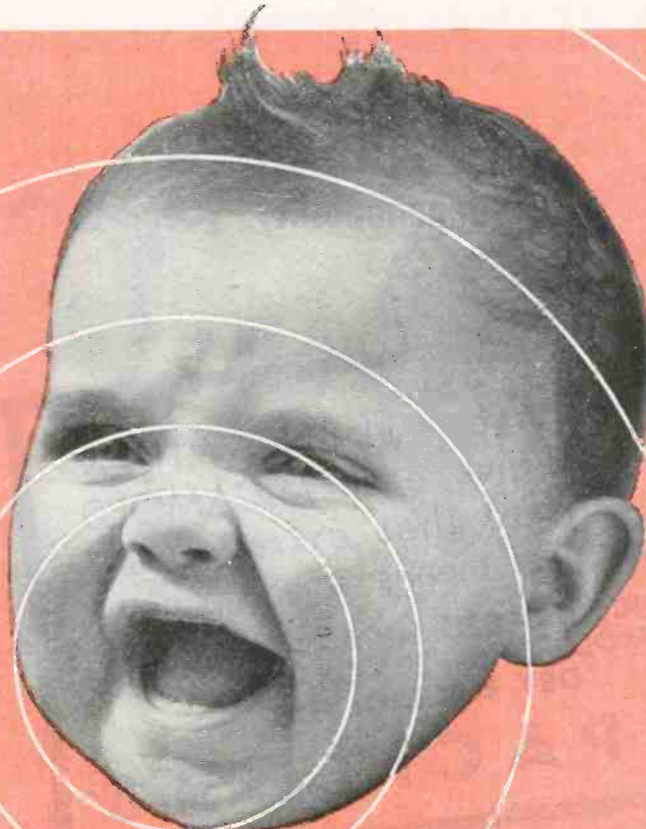


The current flowing through the switch in the photograph to the left is applied to an electronic tube (4) of the United Cinephone electronic switch. Only 3/1,000,000 ampere actuates this tube, which in turn operates a relay (5). By means of an auxiliary relay, full current is then instantaneously applied to the machine controls.

The applications of this and other United Cinephone electronic controls are almost without limit. If you have a problem of measuring, gauging, stopping, starting, counting, sorting, heating, or some other mechanical or manual operation in your plant, you will want to investigate our extensive facilities for electronic design, engineering and manufacturing. Your inquiry will be welcomed and will have our prompt attention.

UNITED CINEPHONE CORPORATION

TORRINGTON, CONNECTICUT



the newest member of the family makes the loudest noise!

The newcomer in the G. I. family of radio components is a lusty youngster bound to make itself heard. Set manufacturers who have long looked to us for high precision, high performance, high production standards in condensers, tuning units, actuators and record changers will welcome our latest arrival — *Speakers!*

When the mammoth capacity, the engineering genius and production know-how developed by our large-scale participation in the war effort can be diverted to peacetime activities, we are prepared to do a real job on speakers.

Set manufacturers who, like us, are figuring ahead, will undoubtedly be interested to know that we plan to make our new speaker subsidiary a dominant industry factor and an important part of G. I.'s production of precision radio components.

GENERAL ELECTRONIC APPARATUS CORPORATION

A SUBSIDIARY OF

GENERAL INSTRUMENT CORPORATION

829 Newark Avenue • Elizabeth 3, New Jersey

The first in our industry to be so honored — ARMY E NAVY sheets of copper and mica were soldered to two brass sleeves which form the sliding contact. The whole assembly is mounted on a piece of sheet polystyrene.

To vary the frequency of the oscillator over its whole range, the capacitor has to be moved only a very short distance. At (a) in Fig. 2 is shown the method of mounting it so that rotation of the polystyrene shaft moves the capacitor along the Lecher wires.

For stops, a free collar and a fixed collar were put on the $\frac{1}{4}$-in. shaft. To the collars, were affixed arms that permitted two complete revolutions of the shaft, the free collar being stopped by a projecting screw on the mounting bracket in one revolution and the fixed collar

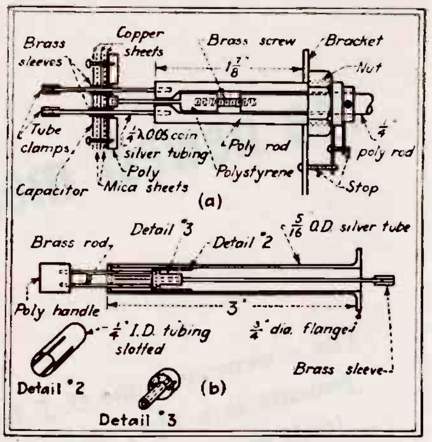


FIG. 2—At (a) is shown the sliding capacitor and its mounting details. Construction of the tuning stubs is shown at (b). The section of Detail #3 was turned down on a lathe and soldered inside Detail #2 at the unslotted end

being stopped by a projecting screw on the free collar, permitting the second revolution of the shaft. These two revolutions of the shaft give the oscillator a frequency range of 10 megacycles at 1500 megacycles. With this frequency range and control, it was found that the oscillator fulfilled all the requirements for fine frequency control and frequency limits.

Adjustment and Tuning

In an oscillator of this type, the grid current is the best indication of oscillation (the plate current not being changed appreciably since the losses are rather high).

To tune the oscillator for oscillation, a low value of plate voltage is

used and all the tuning stubs set at approximately the same position. The setting of the plate and grid stubs is varied until the grid current starts to flow. In an oscillating condition, this current will be approximately 1.4 ma. In a non-oscillating condition, the grid current will be negligible.

Once the oscillator is in an operating condition, the grid current meter is removed from the circuit and the filament stubs tuned for resonance. This is done by means of a crystal rectifier and microammeter lightly coupled to the Lecher wires. A maximum indication on the microammeter shows that the oscillator is tuned to resonance.

In the initial adjustment of the oscillator, the capacitor is not touched other than to have it at approximately a ¼ wavelength from the center of the plate. However, the oscillator should be slightly detuned so that the output of the oscillator is fairly constant. In this condition, the capacitor does not tune through resonance which would increase the output sharply.

Uses

This oscillator was built to provide a means of measuring the Q of resonant cavities. In the past, the Q of cavities has been measured by using a fixed frequency and

• • •

INDIAN SIGNAL CORPS

Subadar Bhagwan Singh uses a portable radio unit to report to headquarters that a forward position has been taken by Sikh troops in the Pratomagne mountains northwest of Arezzo. Italy

INSL-X TROPICALIZATION COATINGS

NOW IN USE IN CONFORMANCE WITH U. S. ARMY & NAVY SPECIFICATIONS

CORROSION AND FUNGUS prevention methods have now had a year's testing in the field. Answers to many questions concerning the protection of electrical equipment and component parts may be found in the paragraphs following:

PHENOLIC PARTS

Dehydrate in oven. Coat with INSL-X 85-1-T before hardware is attached or with INSL-X 95-T after. This seals all cut edges and punch holes, and provides exceptional protection from surface arcing. An alternate recommendation is wax impregnation with a good high temperature wax, blended with INSL-X I-1-T, a fungicidal concentrate incorporated in microcrystalline wax.

HOOK-UP WIRES

Dip or spray INSL-X 25X, a coating developed to replace standard coatings approved under Specification No. 71-2202A, which are often incompatible with lacquer on hook-up wires, thereby causing tackiness for a considerable period of time.

WAX COATINGS

Wax is probably more susceptible to fungus attack than any other material used in electrical equipment. By blending INSL-X I-1-T with standard wax, the wax is rendered fungistatic.

OVERALL SPRAYS

We recommend INSL-X No. 25A, containing a phenyl mercuric salt, or INSL-X No. 25-SA, a non-mercuric fungicidal coating, both of which exceed Signal Corps requirements by a wide margin.

TEXTILE COVERED CORDS AND CABLES

In order to fungus proof and improve the moisture-resistance of cords and cables, we have developed INSL-X JC-16-T. This may be procured in two forms: 1—As a cold dip in a 25% solvent solution. 2—In a wax-like 100% solid form to be used as a hot-melt.

FIBRE GASKETS & TUBES

Coat with INSL-X 95-T or INSL-X 85-1-T or impregnate with wax protected with INSL-X I-1-T.

DYNAMOTORS • GENERATORS

For dynamotors in production, varnish-impregnate the armature and field coils in the usual manner and coat with INSL-X 95-T. Spray-coat all other circuit elements according to No. 71-2202A using INSL-X 25A.

For dynamotors already manufactured, if seal coat is already applied, no more need be done. If there is no seal coat, apply INSL-X 95-T. Spray all field coils and other circuit elements according to No. 71-2202A, as above.

COMPONENT PARTS (In Stock)

Coat with INSL-X 200-T, according to Spec. No. 72-95.

LEATHER AND FELT

Saturate with INSL-X SN-3T, a fungicidal solution prepared according to military requirements. As an alternate, a wax-like compound, INSL-X W-1-T may be used.

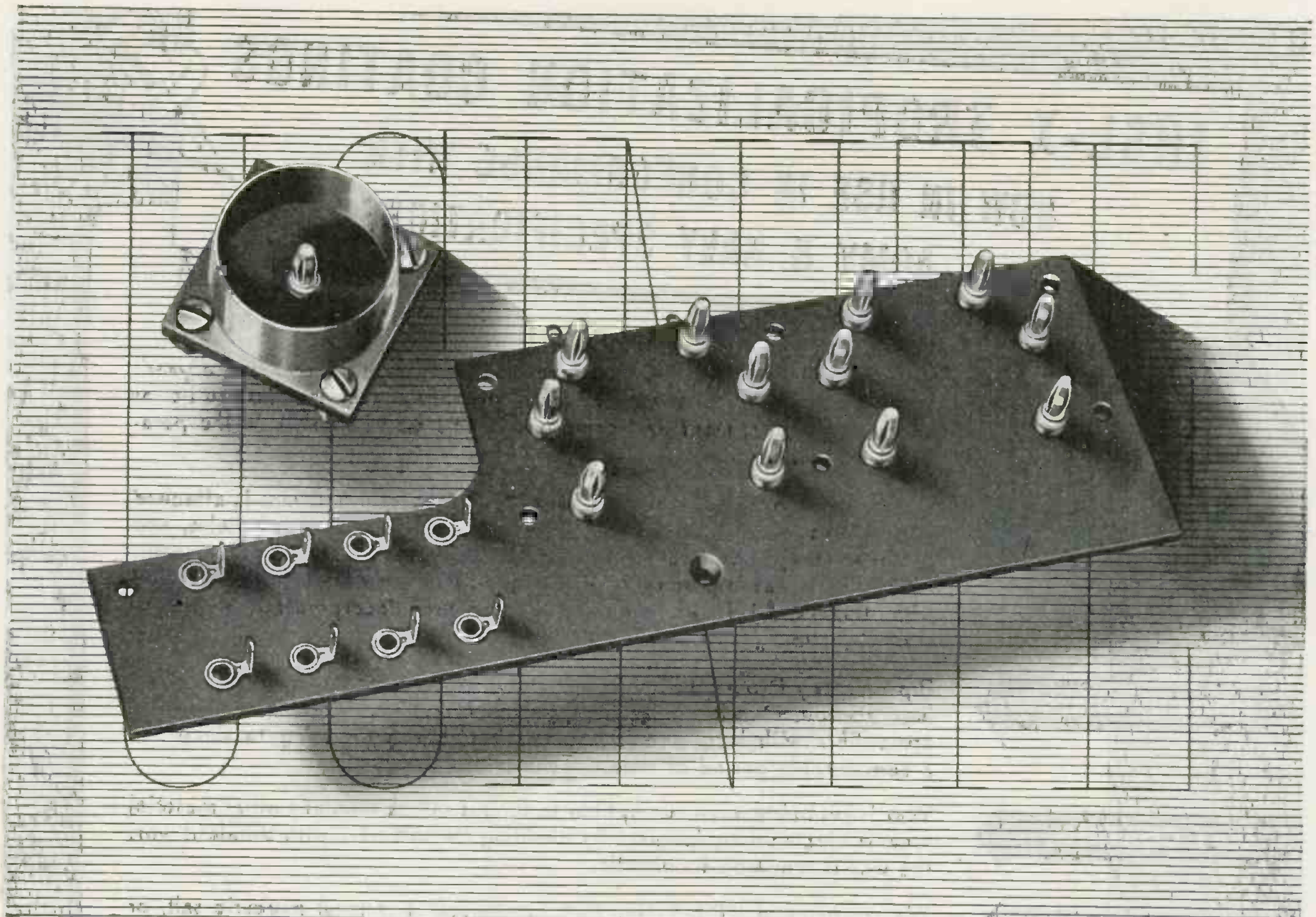
LUBRICATION MATERIALS

Corrosion causes moving metal parts to freeze. By using lubricating oils or greases in which is to be incorporated an INSL-X fungicide, metal parts may be protected. The structure of oils or greases is subject to severe fungus attack.

NEW MANUAL ON FUNGUS PREVENTION • AVAILABLE UPON REQUEST

THE INSL-X CO., Inc. • 857 Meeker Avenue • Brooklyn 22, N. Y.

Chicago *Detroit* *Los Angeles* *Philadelphia*



Up our alley

Banana pins are one of our basic products at Ucinite. Turning them out in large quantities is a run-of-the-mill job for us. We do it, nevertheless, with unfailing accuracy and care.

We can design banana pin assemblies for your particular needs and produce them—from start to finish—under one roof and one management.

Small jobs get the same attention at Ucinite as the big ones. We have the staff as well as the capacity to take them all in stride.

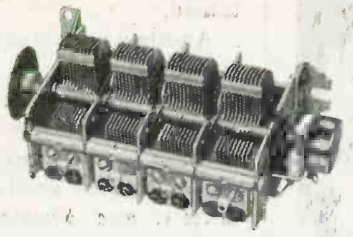
The UCINITE CO.

Newtonville 60, Mass.

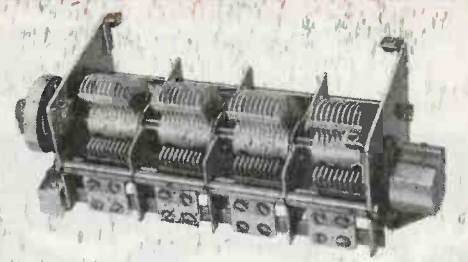
Division of United-Carr Fastener Corp.

Specialists in **RADIO & ELECTRONICS**
LAMINATED BAKELITE ASSEMBLIES
CERAMIC SOCKETS • BANANA PINS & JACKS • PLUGS • CONNECTORS • ETC.

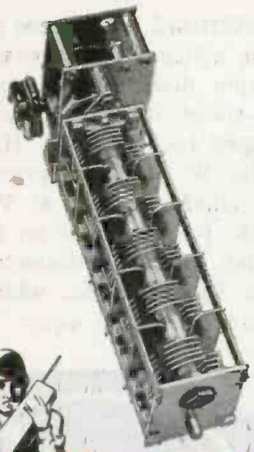
...THAT VITAL MESSAGES OF OUR FIGHTING FORCES WILL BE RECEIVED *—Distinctly!*



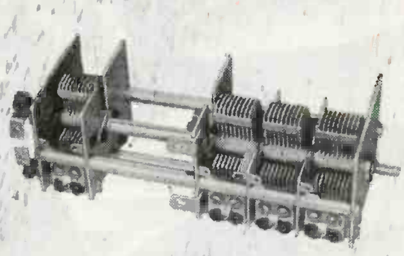

America's planes, once they're pointed toward the enemy, must receive every radio communication message *distinctly!* Accurate radio tuning is assured with Radio Condenser Company's variable air condensers.




Ships making their way in strange waters — they, also, use Radio Condenser Company's variable air condensers, so that there is accurate tuning to receive each message.




Even small radio communication sets, strapped to our soldiers as a vital part of their equipment, use these variable air condensers. Distinct tuning is the reward.




Of no less importance are the radio communication sets in our big, powerful tanks. They, too, play an important part, and even when the going is rough-and-tumble, these air condensers provide accurate radio tuning.

The variable air condensers of Radio Condenser Company are today being used by our armed forces . . . not only on radio apparatus in tanks, but on planes and all types of radio communication sets.

This means, currently, that we are engaged 100% in war work. But, after the war, we will again be in a position to provide manufacturers of radio sets with a new, modern line of air condensers and push button tuning devices. So, in planning your post-war radio manufacture, plan to use Radio Condenser Company products.

RADIO CONDENSER CO.

CAMDEN, N. J.

RADIO CONDENSER CO. LTD., TORONTO, CAN.

tuning the cavities through resonance, varying the cavity dimensions to do so, but the Q is changed somewhat by this method since the dimensions and input of the cavity must be constant and so a true curve of the cavity is not obtained. With this oscillator, a closer and truer picture of cavities can be obtained.

Another important use of the oscillator is to use it in conjunction with demonstration wave guides. At the frequency of operation (25 cm), large sections of wave guides may be excited and the field pattern and distribution may be probed, since at 25 cm the guide may be 10 inches in diameter. In our case, ordinary tinned iron stove pipe was used.

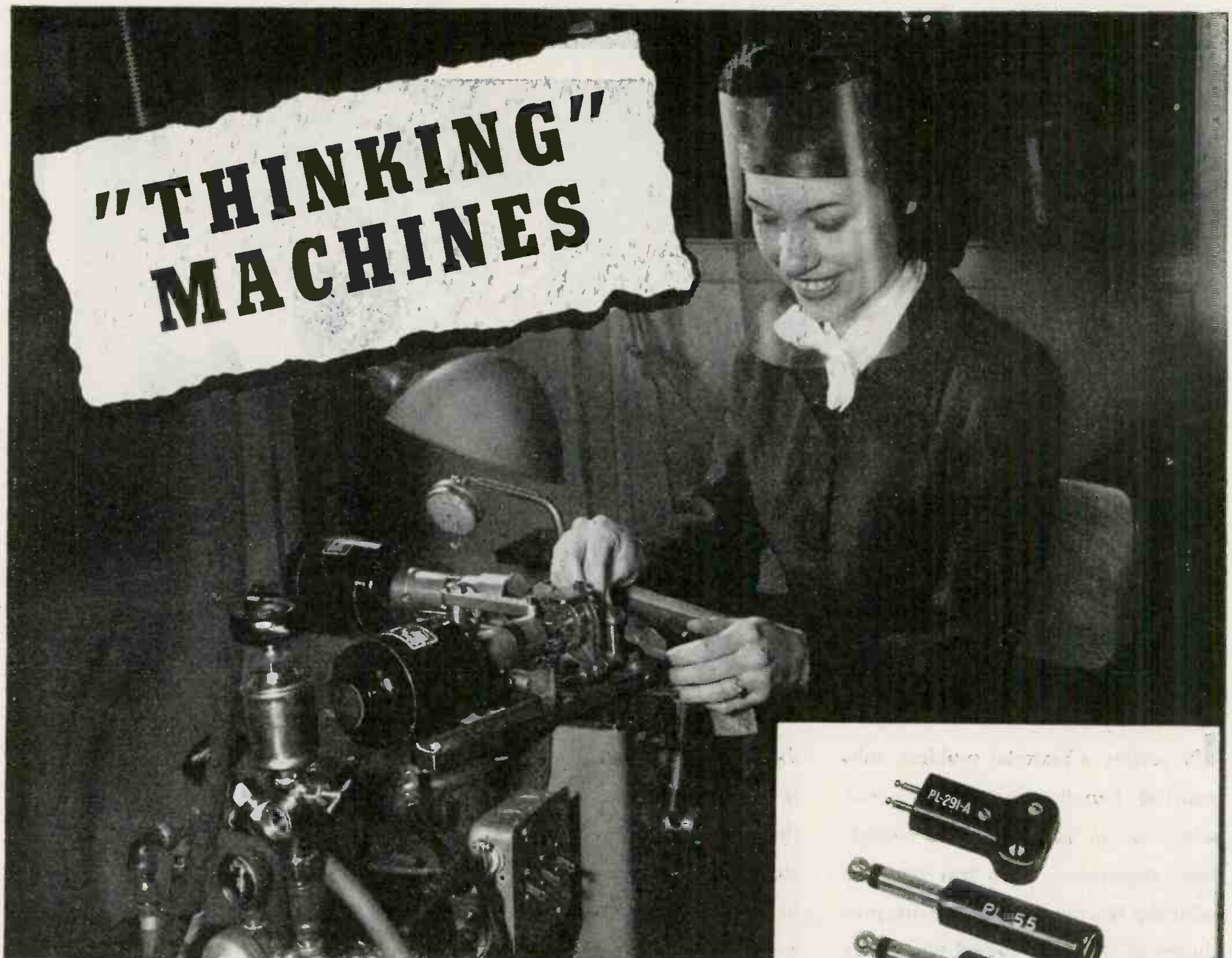
• • •

Two-Speed Turntable for Transcriptions

IN RESPONSE to the need for a turntable which would prevent playing 78-rpm discs at 33⅓ rpm, a new two-speed turntable has been developed by Arnold B. Hartley and Hillis W. Holt, program director and chief engineer of WOV, New York. It consists of an inner table twelve inches in diameter for use with 78-rpm discs, which is surrounded by an outer ring, two

Developed by engineers at WOV, this turntable eliminates over 90 percent of the speed-changing operations necessary with the ordinary type. The inner disc turns at a speed of 78 rpm and the outer at 33⅓ rpm, making it virtually impossible to fit a platter to the wrong table

inches wide and slightly elevated above the inner table, running at 33⅓ rpm. One motor supplies both sections, and the construction results in unusual stability at both speeds. As a result of tests at WOV, it has been found that the machine will definitely eliminate more than 90 percent of the speed-



Machine designed by Remler to perform multiple operations: automatic slotting; indexing; drilling; milling and reaming.

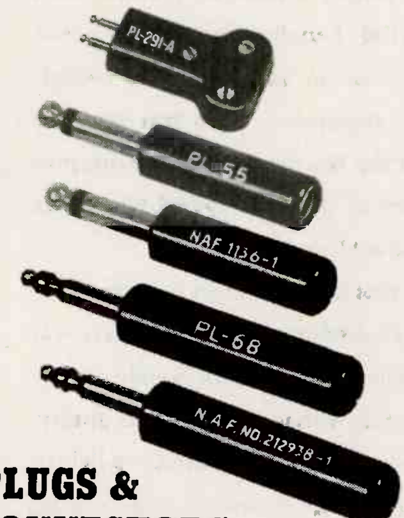
REMLER ENGINEERS design and build robots with "brains" to improve production techniques. Ingenious jigs and dies, and in many instances entire machines are constructed to combine intricate operations. These innovations contribute to the precision accuracy of Remler products; release man-power for other tasks; reduce costs and speed up deliveries. • For complete sound transmitting systems; radio; plugs and connectors and other electronic components in metal and plastic, consult . . .

REMLER COMPANY, LTD. • 2101 Bryant St. • San Francisco, 10, Calif.

REMLER

SINCE 1918

Announcing & Communication Equipment



PLUGS & CONNECTORS

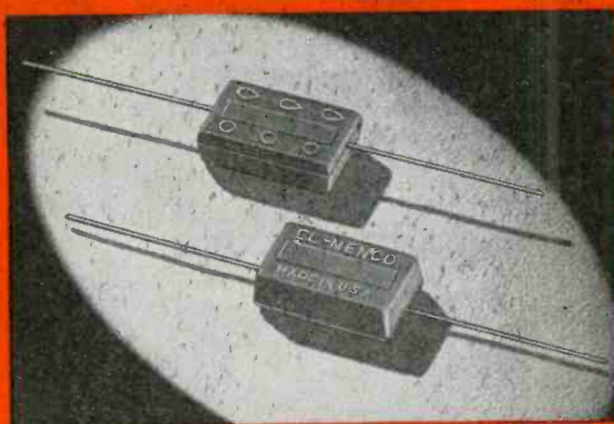
Signal Corps · Navy Specifications

Types:	PL				NAF
50-A	61	74	114	150	
54	62	76	119	159	
55	63	77	120	160	1136-1
56	64	104	124	291-A	
58	65	108	125	354	No.
59	67	109	127		212938-1
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			

OTHER DESIGNS TO ORDER

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.

Electronic Equipment Manufacturers: Write — on company letterhead for new Capacitor Catalogue

THE ELECTRO MOTIVE MFG. CO.
Willimantic, Connecticut

ARMY E NAVY

El-Menco

MOLDED MICA — MICA TRIMMER
CAPACITORS

changing operations necessary with the ordinary turntable. Acoustical effects often credited to Donald Duck, due to the error of playing a 33⅓ rpm disc at 78, are thus prevented, as is the contrary error. Station managers and chief engineers who were permitted to see the new machine during its period of development expressed interest in the Hartley-Holt concentric turntable.

• • •

C-R Tube Finds Armature Faults

By using a cathode-ray tube, the British G. E. Co. has reduced the time spent in finding a fault in a d-c armature from ten minutes to one minute. Two pairs of brushes rest on the commutator while the armature revolves at normal speed. One pair feeds current, while the other pair bears on adjacent or next-to-adjacent sectors. A third pair bears on a revolving contact maker which short-circuits them once per revolution and so triggers the time base of the cro. A good armature produces a series of equal and parallel ordinates on the screen, while a faulty one gives ordinates which are unequal in height. Reversed and open-circuited coils can be detected, as can sections with too few or too many turns.

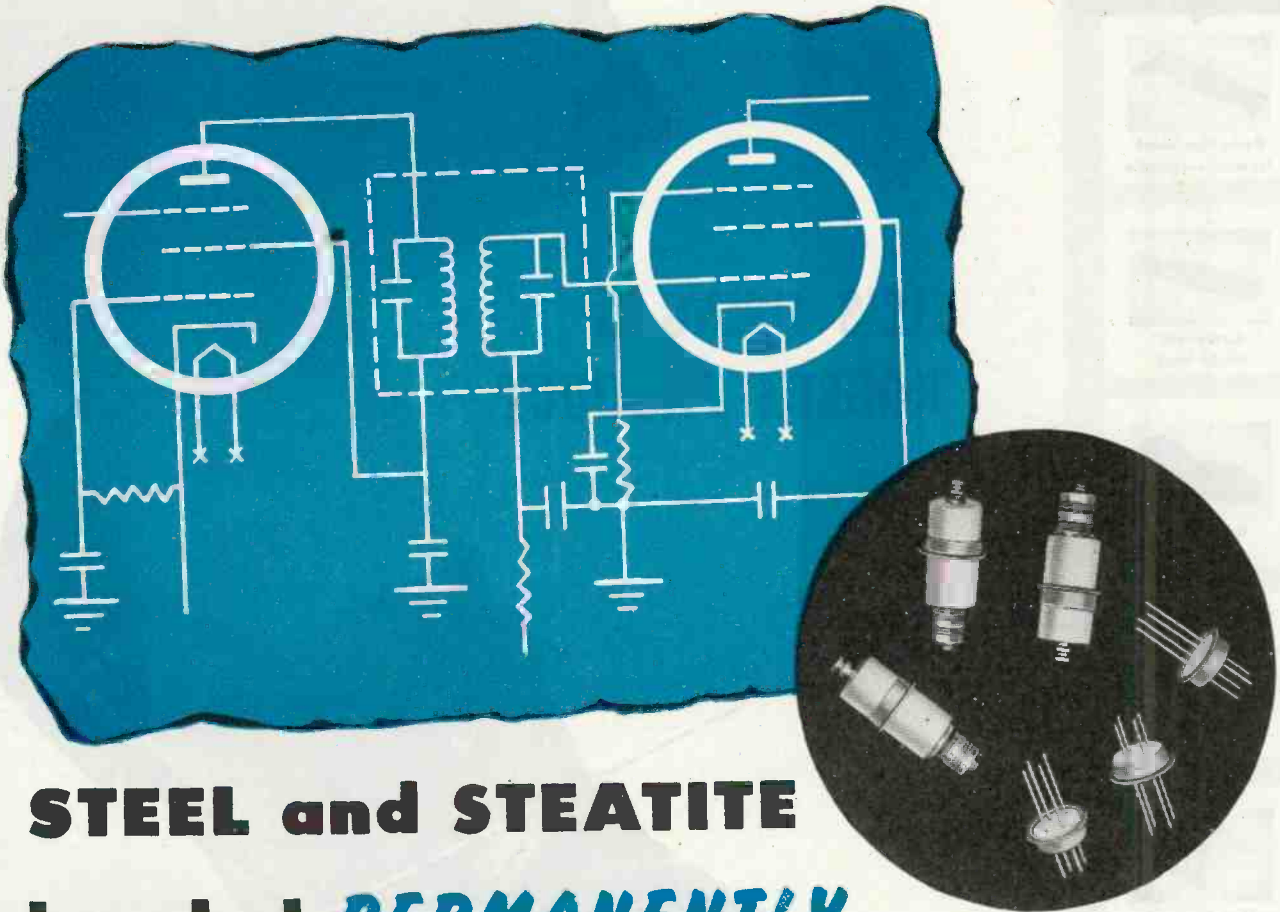
To mark the defective section, the contact maker is turned until the unequal line on the screen is at the end. Since this corresponds with the triggering position, the latter can be found when the armature is turned slowly by hand and hence the bad coil ascertained.

Alternating current at a frequency of 3000 cps is found to be very suitable for feeding into the armatures, the feed points being 180 electrical degrees apart.

• • •

Tubes At Work in Australia

Electronic commodities produced in Australia include: unfilled glass bulbs for radio tubes; hot cathode rectifiers of the small high-voltage variety; arc welding equipment, small type, alternating current; transmitting tubes up to 1 kilowatt; cathode-ray tubes; grid-controlled rectifier tubes; paper ca-



STEEL and STEATITE bonded *PERMANENTLY*

The high mechanical strength of steel and the excellent, permanent insulation qualities of STEATITE have been combined by General Ceramics through its development of a new method of hermetically sealing and permanently bonding together STEATITE and metals in various combinations.

These SEALEX combinations successfully withstand the most severe temperature changes, and show no vibration fatigue. The metal parts are tinned to facilitate soldering where desired.

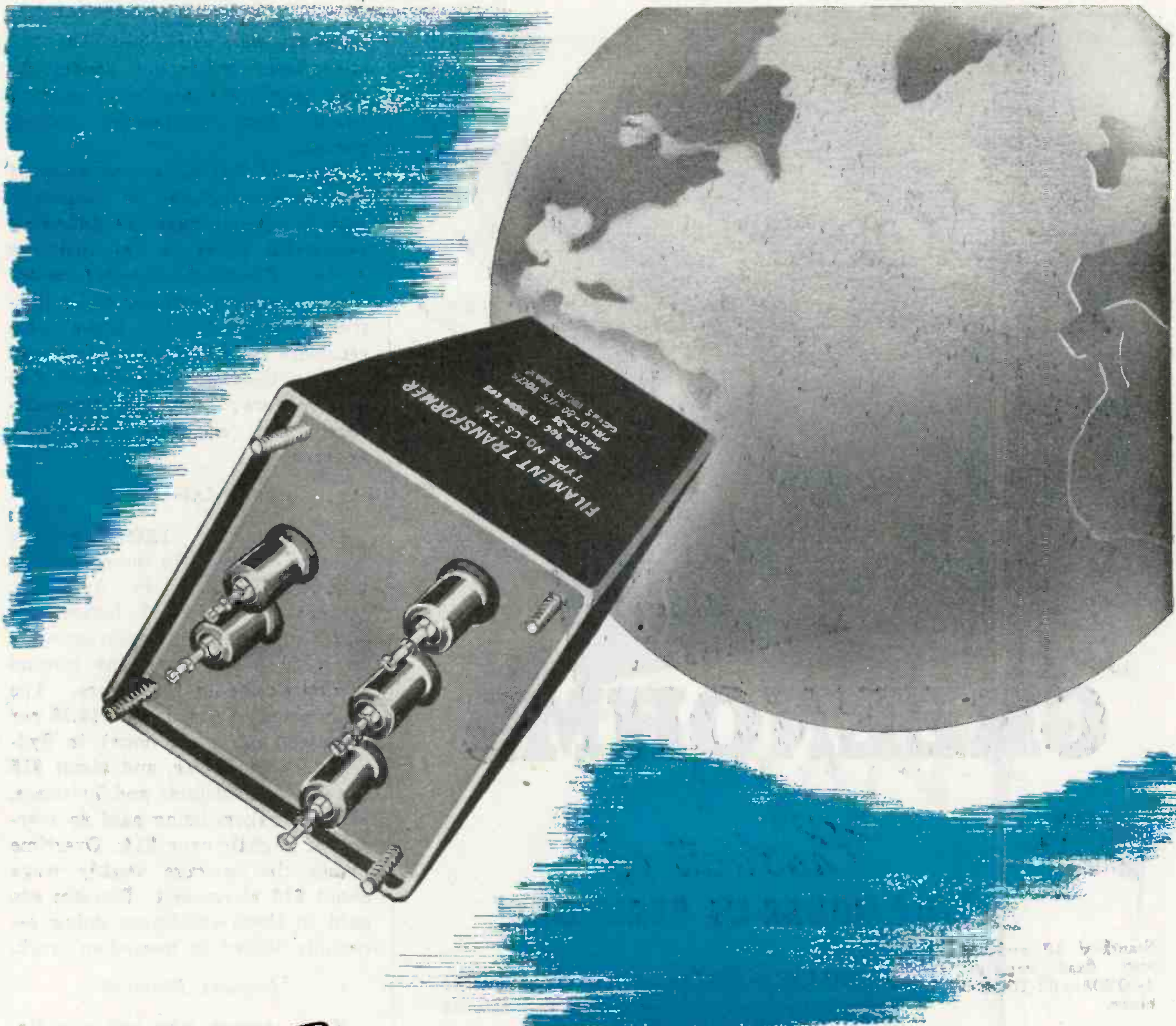
The General Ceramics method of fusing steatite and steel solves the problems of hermetically sealing and permanently protecting equipment against moisture.

For long-life, dependable, efficient service specify "Steatite" and "Sealex" Combinations.

ARMY E NAVY

General Ceramics
AND STEATITE CORP.
GENERAL CERAMICS AND STEATITE CORPORATION
KEASBEY NEW JERSEY

7241



Light? We call it "LIGHT FANTASTIC"!

. . . a transformer headed for 65,000 feet "altitude" . . . at 350 degrees temperature!

And to top it off, it had to be "lighter than anything on the market," *they said. What, we asked, was it for? They couldn't tell us, and we don't know to this day, but we do know it was badly needed.

"It has to operate not only on a 60-cycle current at ground level, but from 400 to 2600-cycle current, and what's more, at a simulated altitude of 65,000 feet."

Thermador built this special transformer equipment. It passed the above mentioned requirements. That wasn't enough. They gave it another test, in which they changed the temperature from ambient (the temperature of a fairly warm room) to 350—in two hours. It passed that test, too. This is all we know of one of the most mysterious jobs we ever did, in the not-mysterious method in which we built all of our tansformers.

*For reasons of military security names cannot be given.

BUY WAR BONDS

THERMADOR TRANSFORMERS

DEFEAT HEAT • COLD • HUMIDITY

THERMADOR ELECTRICAL MANUFACTURING CO.

5119 SOUTH RIVERSIDE • LOS ANGELES 22, CALIFORNIA pacitors; mica capacitors; ceramic capacitors; inductors; loudspeakers; small, inexpensive recording heads; and inexpensive microphones.

Some of the large producers of electronic products in Australia plan to manufacture the following additional items in the post-war period: Electronic-operated motor starters and controllers; other electronic control devices; home radio receivers for reception of f-m programs; television receivers; f-m transmitters; television transmitters; f-m adapters ; television adapters.

Labor

Approximately 12,000 persons are now employed in the electronic-products industry in Australia, compared with 7,500 before the war. Practically all employees work on a full-time basis, the normal workweek being 44 hours. The basic wage is now about $15.70 per week (36 cents per hour) in Sydney and Melbourne, and about $15 per week in Adelaide and Brisbane, female workers being paid an average of slightly over $14. Overtime makes the average weekly wage about $18 at present. Bonuses are paid to those employees doing especially skilled or hazardous work.

Licenses Required

Every person who has a radio-receiving set in Australia must have a broadcast listener's license, issued by the Postmaster General's Department. The fee is approximately $3.22 per year. All aliens, except enemy aliens, may freely take out these licenses.

For the fiscal year ended June 30, 1943, there were issued 1,370,000 listeners' licenses for one radio receiver and 49,793 licenses for more than one receiver. It is estimated that there are about 1,500,000 radios in use in Australia, about 600,000 being equipped to receive international short-wave broadcasts. Approximately 50,000 radio-phonograph combinations are in use, probably 40,000 equipped to receive international shortwave.

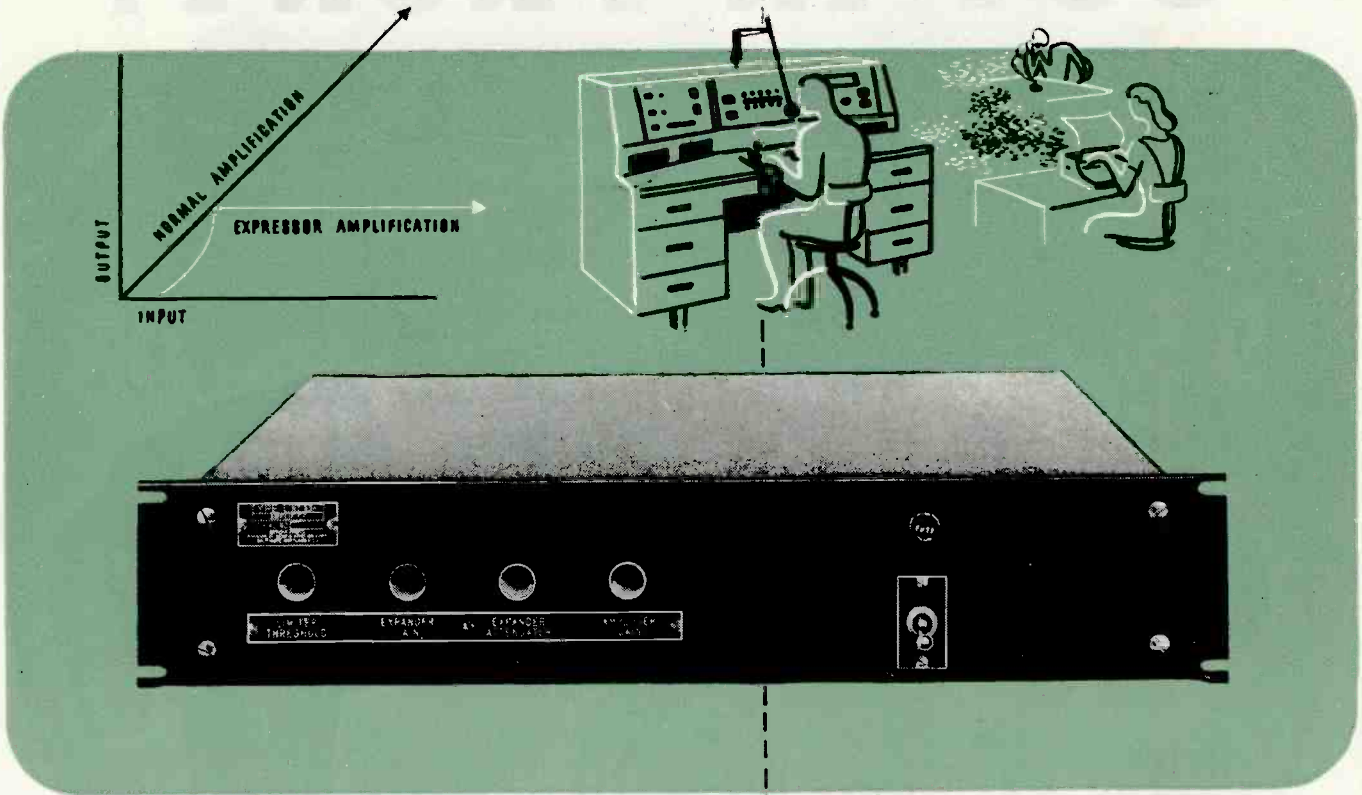
Service and Equipment

There are in Australia about 605 fixed radio transmitters, exclusive of military and naval transmitters. Included in this number are: 73

BENDIX

EXPRESSOR AMPLIFIER

Maintains selected threshold level | **Attenuates background noise**



Designed to fit standard 19-inch relay racks, this unique amplifier occupying only 3½ inches of panel space provides definite advantages—for it unites in one compact unit both an expander and a compressor.

In fact the name "expressor" has been coined by Bendix to denote the combination of these features—a union which effectively solves two major problems of communications equipment operation from noisy control points.

The compressor so sharply limits gains beyond a selected threshold level that a 20 db increase in input level above threshold selected results in no more than a 1.5 db increase in output level.

The expander effectively attenuates background noise and other undesirable interference until modulation is supplied. The amount of expansion and the levels at which expansion and compression become effective are adjustable by screw driver slots in the panel.

An outstanding example of Bendix Radio Creative Engineering, this development is available to all users of communications equipment.

For complete details write direct to the Sales Department.

Bendix RADIO DIVISION

BENDIX AVIATION CORPORATION, BALTIMORE 4, MARYLAND

STANDARD FOR THE AVIATION INDUSTRY

Civil Aviation Department transmitters; 94 operated for ambulance, forestry, police, and other services; 12 stations for oversea communications; 18 coast stations; 28 medium-wave stations, and 6 short-wave stations operated by the Australian Broadcasting Commission; and 98 commercial medium-wave broadcasting stations.

Also included are 275 stations in connection with internal point-to-point service. These are for public and private correspondence and include the "Flying Doctor Service," also known as the "pedal wireless," consisting of simple radio-telephone equipment whereby individuals in remote districts are able to communicate with about 100 outposts in order to summon the flying doctor. The base stations operate with powers of 35 to 350 watts, and the outpost stations with pedal wireless usually operate with 6 to 10-watt power. The pedal method of obtaining power has been superseded largely by a battery-powered power-pack utilizing a vibrator.

The power ratings of the 605 fixed transmitters include 1 station of over 10,000 watts; 18 between 5,000 and 10,000 watts; 578 between 100 and 5,000 watts; and 8 stations having less than 100-watt power.

• • •

Stripping Fine Wire of Formex Insulation

CLEAN-STRIPPING the Formex coating from fine wire (No. 36–44) with a new technique has been announced by George Rattray, chief engineer of Fairchild Camera & Instrument Corp. The new method has been used on 10,000 small motor armatures, where the lead terminations average 14 leads per armature. Since each lead stripping operation can be completed in less than thirty seconds, Fairchild estimates that a 50 percent saving in normal man-hours has been achieved. Further, no wire failures have been noted since the new method was adopted.

Fairchild has applied for a patent on the wire-stripping method, which was developed and tested by two members of its engineering staff, Victor J. Canziani and Frank W. Stellwagen. In the new method, two materials are involved—material A and material B—each per-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forming one of the steps. Material A serves as the starter. Material B is the accelerator and can be one of several substances comprising a solvent for material A and which renders mechanical removal of the Formex easy and harmless to the fine wire.

Material A is heated electrically in a temperature-controlled pot to 425-450 deg F, the optimum working point, and is apparently harmless to the operator, a vented hood being used, however, to remove its slightly unpleasant smoke.

The useful life of material A at the working temperature is about four hours, after which it is discarded, and the pot wiped with a clean cloth. Fresh material A is then placed in the same pot. Failure to discard spent material A results in complete failure of the method. The pot does not have to be cooled off to make this change.

Material B is a colorless liquid and is heated in a temperature-controlled water bath to an optimum working temperature, ranging from 120 to 140 deg F. Higher temperatures increase its evaporation rate.

Procedure

The wire to be stripped is dipped to the desired depth into hot, liquid material A for the time required to complete the starting action, 5 to 10 seconds.

The wire is next dipped into

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Vertical-bar-type grid elements are wound on a mandrel and spot welded by girl operators in the Eimac tube plant

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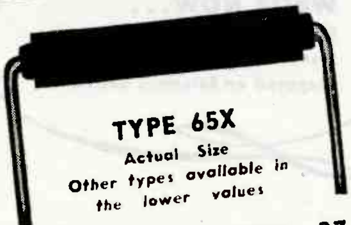

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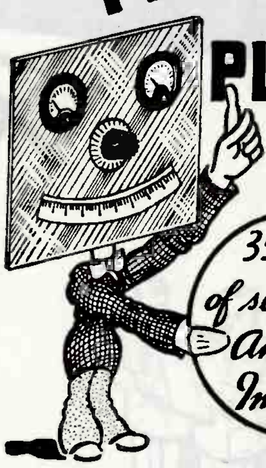

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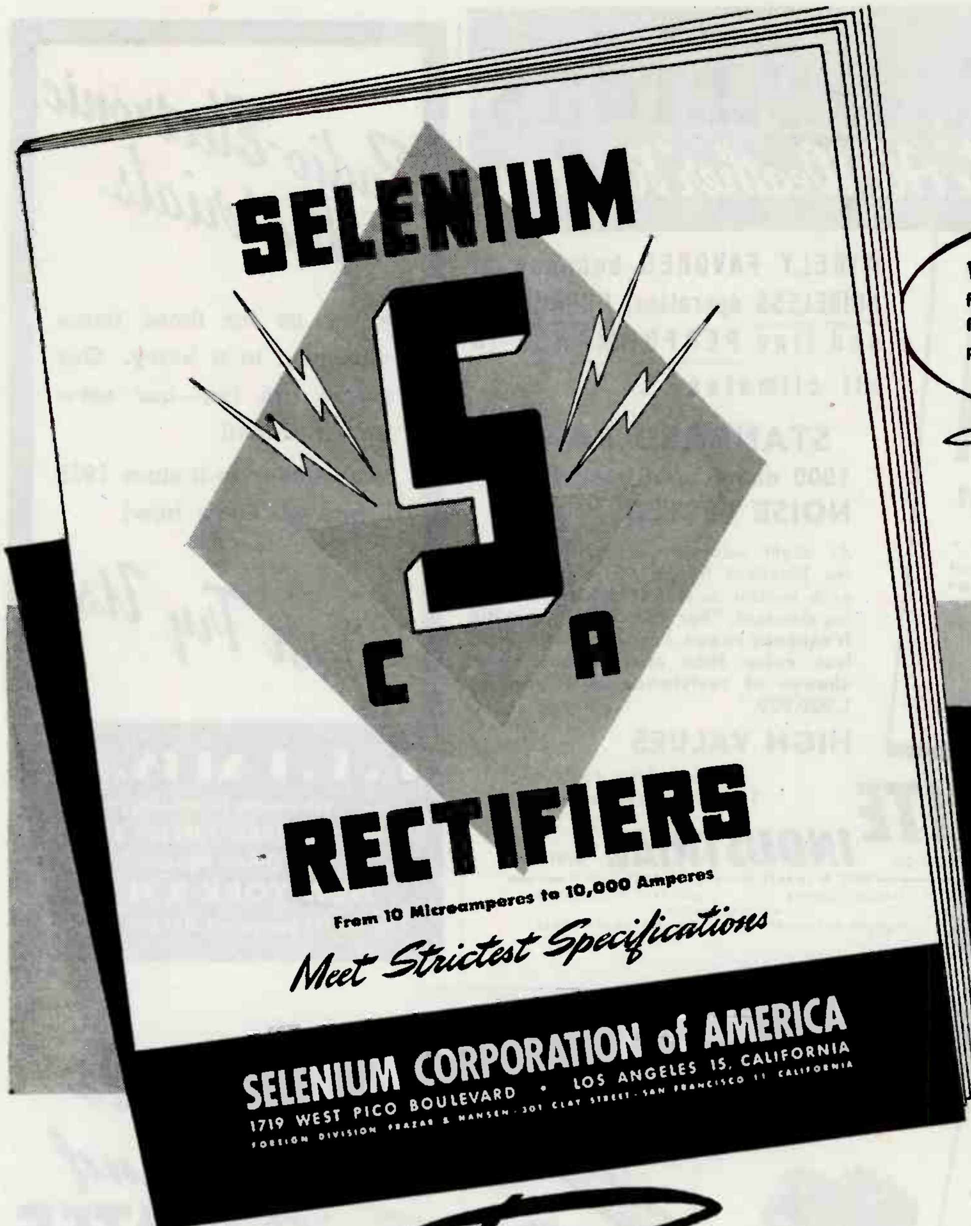

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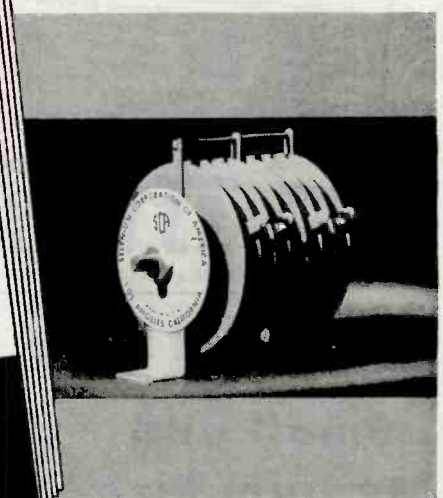

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FOREIGN DIVISION: FRAZAR & HANSEN · 301 CLAY STREET · SAN FRANCISCO 11, CALIFORNIA warm material B for approximately the same time as required for the material A dip, and to a slightly greater depth.

Immediately upon removal from material B, the wire is stroked gently one or more times as required, between the thumb and forefinger to remove the softened Formex which generally slides from the wire as a soft tube after one or two strokes without re-dipping.

The stripped wire is now ready to be tinned at temperatures slightly above the liquid point of the solder to be used. Thus, all stripping and tinning operations are carried out at temperatures under approximately 600 deg F. The method is not reversible; that is, the two materials A and B cannot be used in reverse sequence with good results.

The new method of stripping Formex-coating from wire was first tried by the Fairchild company on a small production group of critical generator armatures wound with No. 40 heavy Formex wire. Results similarly as successful as obtained in laboratory tests came about. This method is now used on a wide production basis and has materially speeded up the manufacturing process on the items where it is used.

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C-R TUBE CONVEYOR

After washing, bulbs for c-r tubes get the fluorescent screen at the beginning of a conveyor line in the Dobbs Ferry plant of North American Philips. At succeeding positions, Aquadag is applied and then the tubes are fed into an automatic baking oven

THE ELECTRON ART

Papers Delivered at the Rochester Fall Meeting

A RECORD ATTENDANCE of 700 radio and electronic engineers met at the Hotel Sheraton for the Rochester Fall Meeting, a two-day technical session held on November 13 and 14. Fourteen papers were presented during the program which wound up with a banquet for 300, the total capacity of the dining room. Major-General Roger B. Colton of the Army Air Force was the guest speaker at the banquet.

After registration on November 13, a paper, "The Reactance Theorem for a Resonator," was presented by W. R. Mac Lean of Polytechnic Institute of Brooklyn. The paper elaborated on the theorem originated by Foster of Bell Laboratories and considered a resonator of any shape connected to a transmission line.

A paper entitled "A Resonant Cavity Method of Measuring Dielectric Properties at Ultra-High Frequencies," prepared by C. N. Works, T. W. Dakin and F. G. Boggs, was delivered by Mr. Dakin. He reviewed methods of measurement commonly used up to 1,000 megacycles and pointed out that they were inaccurate and inconvenient. The new method he described utilizes a double re-entrant cavity excited by a loop and having a Q of 2,000. This was connected with a 316A in the butterfly type of oscillator circuit. The dielectric sample to be tested is placed between internal electrodes of the cavity.

Calculations were shown for determining the dissipation factor of the sample as well as the equivalent Q form and it was pointed out that although higher Q of the resonant circuit could be obtained it was not practical to do so with high-loss samples because of inaccuracy.

A description of the RCA Laboratories at Princeton, N. J. was given by E. W. Engstrom of RCA which included the facilities available for research in various allied fields. The technique of designing the laboratories from a modest beginning with a sample room in the Camden plant of the company to the present stage of construction was thoroughly followed. Begun a few weeks before Pearl Harbor, the present laboratory buildings will be added to in the post-war period when materials are available.

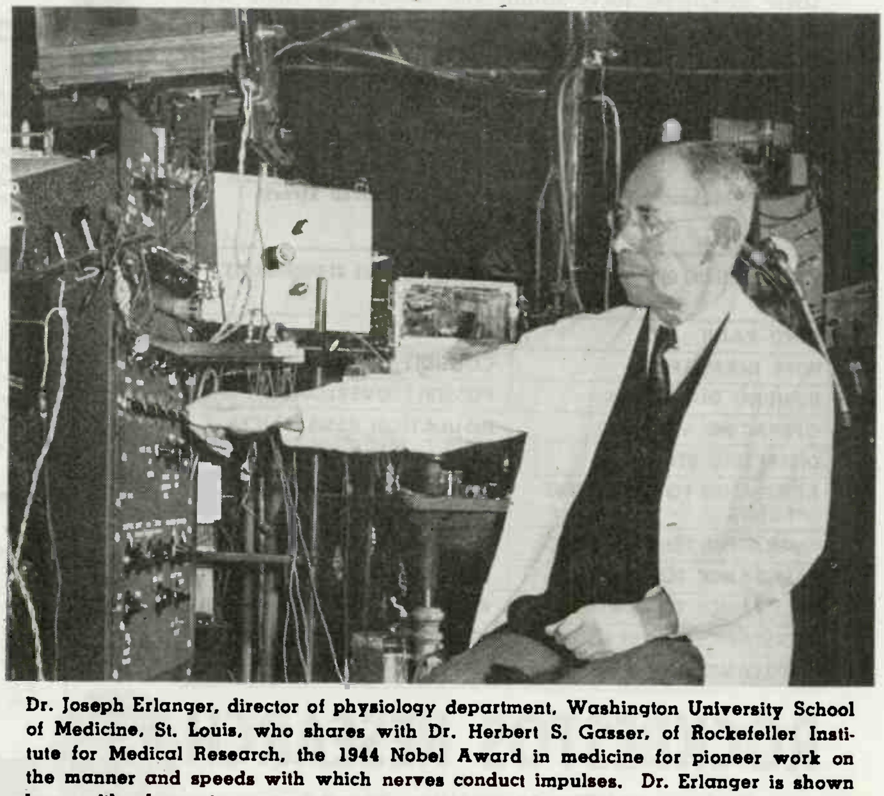
Television Amplifiers

"Low-Frequency Compensation of Multi-Stage Video Frequency Amplifiers" was the title of a paper, delivered by M. J. Larsen of Stromberg-Carlson, that investigated the contribution of the impedance elements in the control grid, screen grid and plate circuits. These cause distortion of a transmitted square wave, manifested as a rounding of the flat top. Design criteria were derived to give control of the amount of rounding in the initial design of the amplifier.

Amplifier compensation effected by inclusion of a discrete impedance in the screen grid circuit was discussed, and design formulae derived. Comparisons of this type of compensation with that where compensation is effected exclusively in the plate circuit were made.

Although combined screen and plate compensation was shown to offer appreciable gains in performance, its range of applicability is limited by practical considerations such as variations in dynamic

1944 NOBEL AWARD WINNER



Dr. Joseph Erlanger, director of physiology department, Washington University School of Medicine, St. Louis, who shares with Dr. Herbert S. Gasser, of Rockefeller Institute for Medical Research, the 1944 Nobel Award in medicine for pioneer work on the manner and speeds with which nerves conduct impulses. Dr. Erlanger is shown here with electronic equipment with which he developed his research on nerve pulsation. The pulse of a nerve, extracted from a frog, is amplified 100,000 times by means of an amplifier developed by himself and Dr. Gasser

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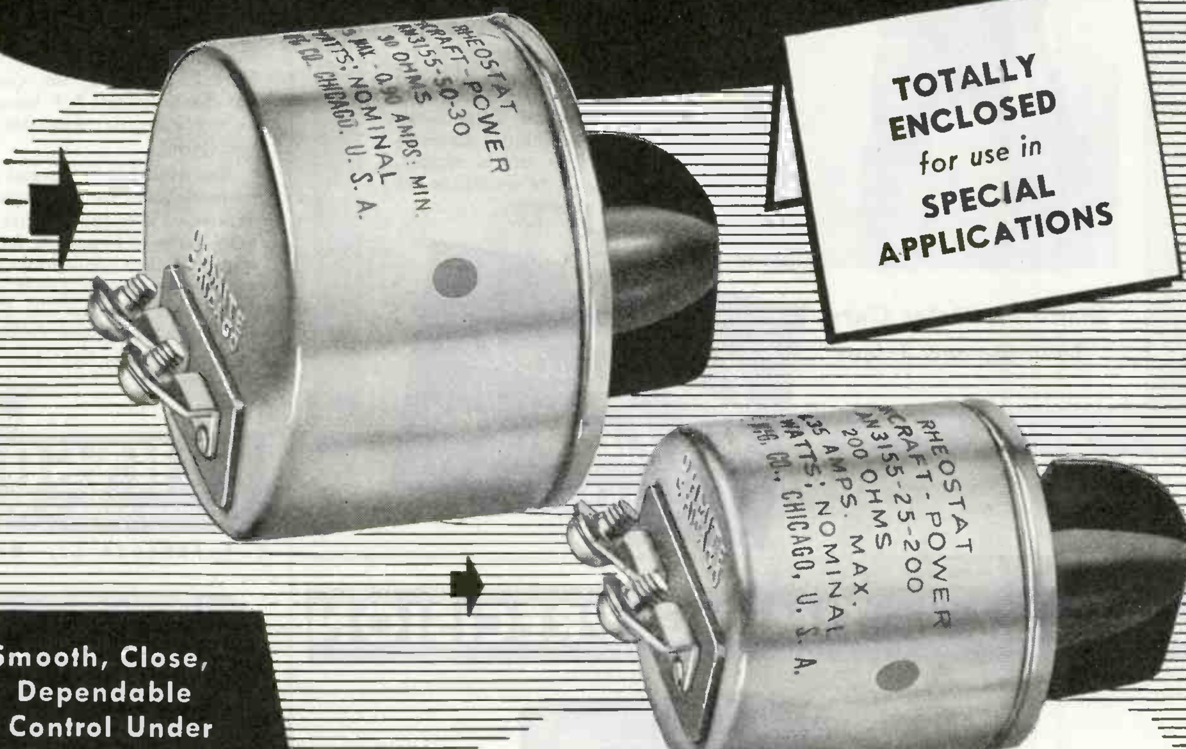

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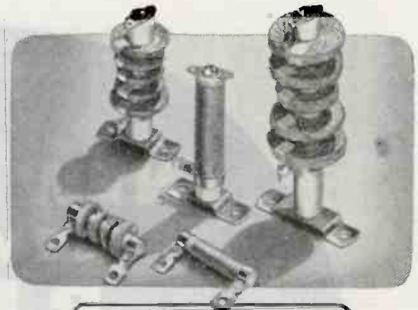

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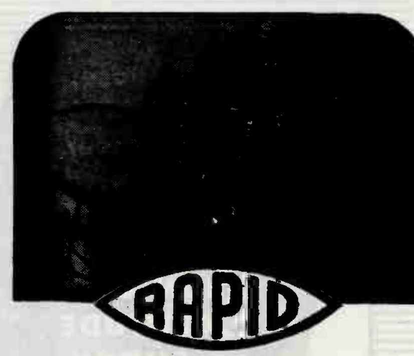

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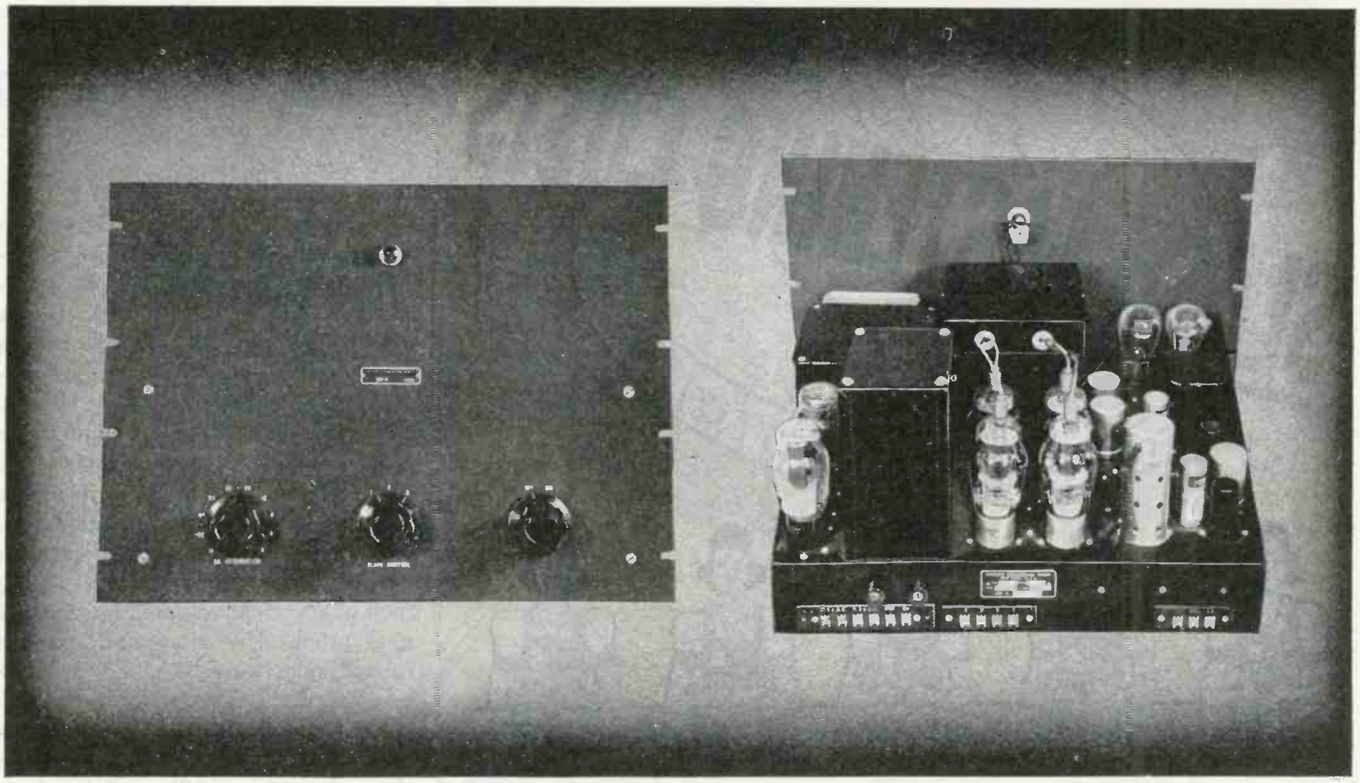

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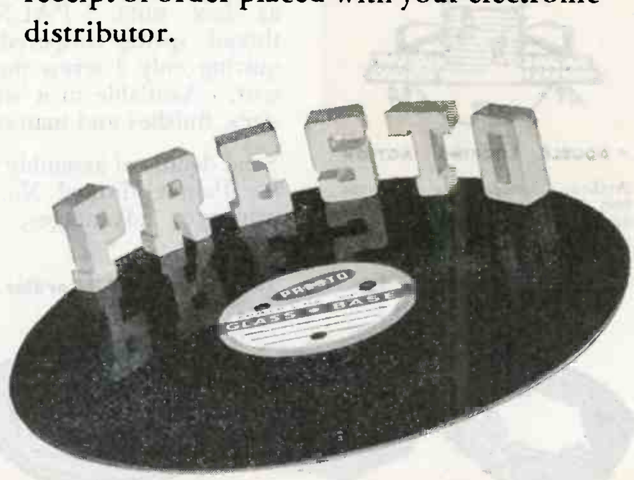

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screen resistance, increased susceptibility to overall amplifier regeneration and possibility of amplitude distortion where large screen and plate swings occur simultaneously.

Tube Progress

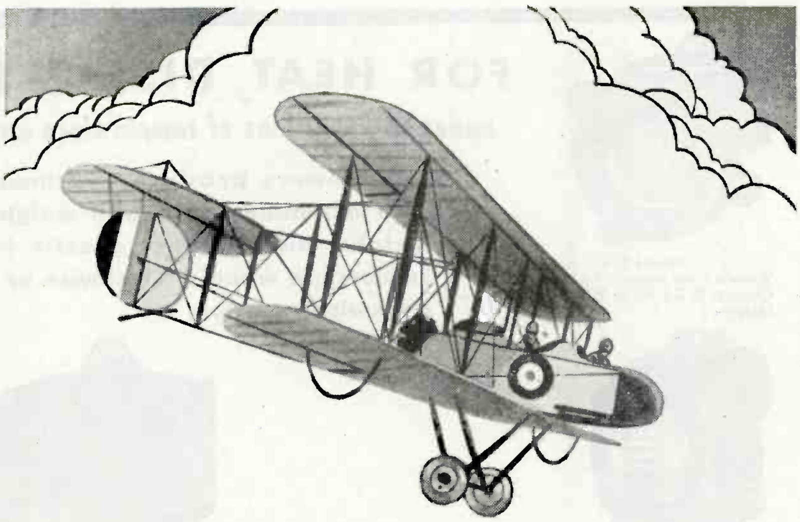
"Trends in Receiving Tube Design and Application" were reviewed from 1920 to 1944 in a paper by L. R. Martin of RCA. Slides were shown of curves that traced the essential characteristics of typical tube types over these years. Such subjects as transconductance and equivalent noise resistance, plate circuit efficiency and power sensitivity of power output tubes, cathode current per watt of cathode power, watts dissipation per cubic inch of physical volume, and control grid pitch, wire sizes and spacing to cathode were covered by the speaker.

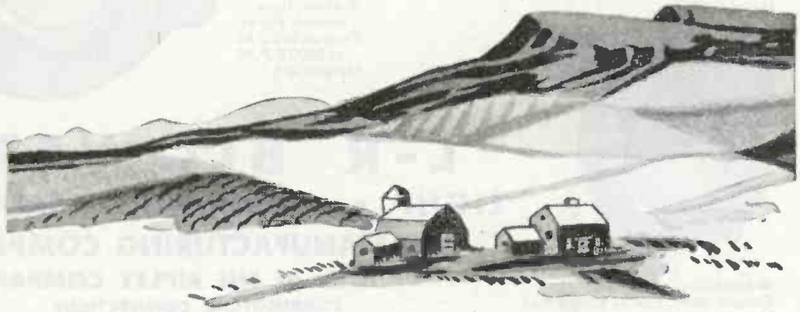
"Standardization of Capacitors for Civilian Equipment" was the title of a paper delivered by J. I. Cornell of Solar. He discussed aspects of standardization and pointed out that the post-war supply of components will be almost as difficult to maintain as in the wartime situation. Suggested specifications for civilian use for several types of capacitors have been sent out to the industry and Mr. Cornell made a plea for prompt action from interested engineers in submitting their recommendations on the subject to expedite the development of standards for fixed capacitors.

A paper, "Unpublicized Facts About Frequency Modulation Broadcasting," delivered by Sarkes Tarzian, consulting engineer, presented a pessimistic view of this form of broadcasting. The difficulties inherent in selling the general public the value of high-fidelity reception, comparative cost of f-m and a-m receivers, and properties of the frequencies involved in both methods were among the subjects reviewed. After delivery of the paper, a telegram was read from Major Armstrong which took an optimistic tone of the future of fm and pointed out that "pressure groups," which Mr. Tarzian had stated as originating fm, did not exist in the days when Major Armstrong and Paul DeMars were the only proponents of this method of broadcasting.

The next speaker, K. W. Jarvis,

. . . Hardly had man learned to fly than he began to feel the urgency of the need to communicate between ground and plane.





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consulting engineer, read a paper, "One Look Backwards—and Two Ahead" in which he paid tribute to the memory of several well known engineers lost to the industry in recent years. Following his usual custom, he forecast the future of radio and warned that the present war production figures show that the industry could produce 250,000,000 receivers per year, far beyond any peacetime consumption. A discussion period followed in which a lively interchange of opinions took place between Mr. Tarzian and interested engineers.

The second day of the meeting opened with the report of RMA director of engineering, W. R. G. Baker of G-E, which was read by L. C. F. Horle, consulting engineer. The report gave the scope of the present post-war organization of the RMA engineering department in considerable detail and emphasized the fact that the scope is to be expanded to match the expansion of the electronic industry.

Future Trends

"The Organization of Research in the Radio Industry after the War" was the subject of a talk by Rupert Maclaurin, economist of MIT, who has spent the past 18 months in studying the radio industry under a grant from the Rockefeller Foundation. The project examines various industries to find the manner in which research is organized and carried out and the impact of the patent system on the industries studied. He suggested that engineers attempt to sell management on the idea that research pays dividends to stockholders and that research and engineering departments be protected from the business cycle.

"Electronic Tube Trends" is the title of a paper delivered by R. M. Wise of Sylvania who pointed out that the number of companies manufacturing receiving tubes has not appreciably increased because of war needs. On the other hand, cathode-ray tubes and other special types are now made by a number of companies that did not previously make them, as well as by entirely new companies. He reviewed the effect of war standardization on tube manufacture and discussed problems such as tipping, stem construction, use of nickel and

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Curve tracing by means of cathode-ray tubes is faster, more accurate, more economical, and permits simultaneous comparison of several curves

Electrical measurement with RCA cathode-ray oscillograph tubes has saved countless hours for radio-set manufacturers. They use this method to trace the resonance curves of the r-f stages of receivers—and for many other purposes, too.

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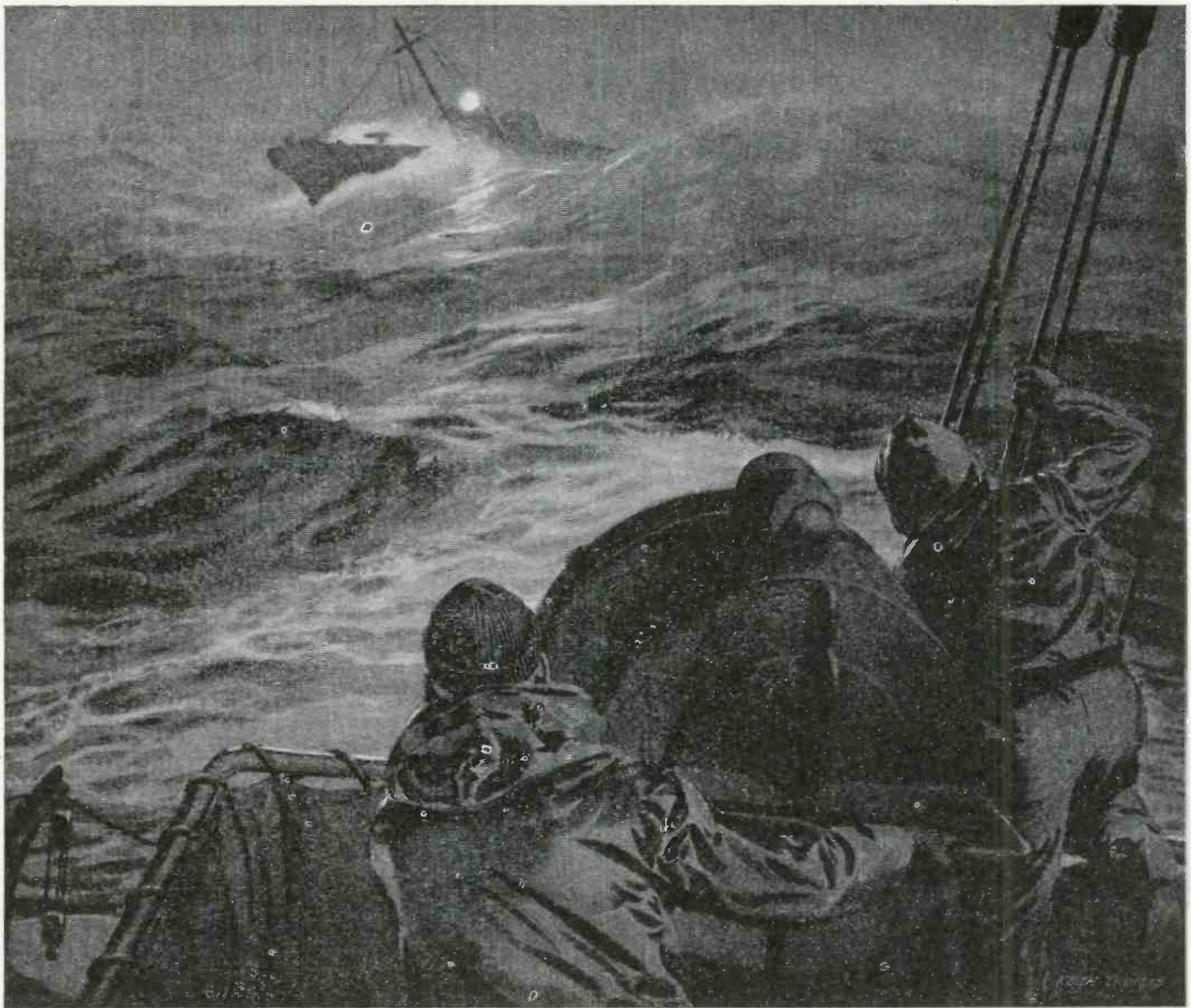

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carbon for leads through glass and plating of base contact pins.

"Silicone Products of Interest to the Radio Industry" were presented by Shailer L. Bass, of Dow Corning Corp., in a paper by himself and T. A. Kauppi of the same company. Curves were shown of the change in dielectric constant with temperature for several of the Corning liquids (derived from sand, brine, coal and oil) compared with a sample of transformer oil having a petroleum base.

"Pulse-Time Modulation" was explained by E. Labin of Federal Tel. & Radio who was forced to generalize because of military restrictions. Copies of the paper were distributed to the engineers present to permit reference to the diagrams used in the discussion. One application of the system is transmission of 20-channel wire telephony over long distances.

"Designing Thoriated Tungsten Cathodes" is the title of a paper by H. J. Dailey of Westinghouse, which showed how the data available for design of pure tungsten filaments can be used in design of thoriated tungsten filaments, a subject about which little is available. A formula was given for use with a 1-cm filament.

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Direct-Reading Audio-Frequency Meter

AN AUDIO-FREQUENCY METER that converts the incoming signal to a square wave which is used to charge a capacitor is described by S. A. Lott in *A. W. A. Technical Review* (554 Paramatta Road, Ashfield, N. S. W., Australia) for August, 1944.

The circuit described is an adaption of the circuit of Seely, Kimball and Barco. The capacitor charging current is proportional to frequency and by placing a meter in the capacitor circuit, a direct indication of frequency is obtained. The circuit is shown in the accompanying diagram.

The 6J7G amplifies the incoming signal. The 6V6G is driven beyond cut-off and to saturation, thereby producing a square wave. A bank of capacitors and corresponding meter shunts provide the various frequency ranges. The 6H6GT separates the charging and discharg-


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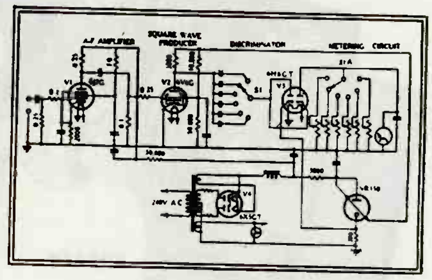
ing currents of the capacitor so that a direct-current meter can be used for frequency indication. The meter is placed in the plate circuit of one diode to permit bucking out the tube contact-potential.

The basis for C and R for each range is that $(1/2fRC) > 4.6$. With this design limitation and the circuit values given, the meter is linear within 2 percent for input voltages from one to over 300 volts rms. If, because of harmonics or other distortion, the input signal falls below one volt during a half



Electronic circuit (shown in *A.W.A. Technical Review*) for measuring audio frequencies by utilizing the charging current of a capacitor

cycle, the meter will read high. Because of changes in cathode emission of the duo-diode, the meter reading varies with power supply voltage. This variation is approximately 2 percent for a 10 percent change in power-supply voltage.

As designed, the meter has ranges in multiples of 100 and 300 cps. Each range is from 0 to its upper limit. The highest range is 30,000 cps. The meter current will be $I < (V/2R\ 4.6)$ in ma. The output voltage, V, from the 6V6G is 125 volts with the circuit constants shown. A meter having a full scale deflection of 1 ma was used in the interest of mechanical rigidity since the instrument was made for portable use.

• • •

Calculating Antenna Impedance

A GENERAL THEORY for calculating the transmitting and receiving properties of antennas and which contains a different derivation of Hallèn's one-dimensional equations for antennas which consist of thin wires appears in *Philosophical Magazine and Journal of Science* (Red Lion Court, Fleet Street, E. C. 4, London) for July, 1944. The com-

Here all similarity ends...

from this point on, it's craftsmanship!

In one important respect there is a striking similarity between the millions of Bliley crystals which we now produce and the mere handful of custom made units that constituted our annual production when radio was still young.

In those early days of radio, when each quartz crystal was painstakingly cut and ground by hand, a tradition was born. It was a tradition of craftsmanship that has grown with the years—a tradition that Bliley engineers have successfully translated into the more intricate techniques of volume production.

Etched crystals are an outstanding discovery and development of Bliley research engineers. This technique, by means of which crystals are finished to frequency by acid action rather than abrasive action, was an established part of Bliley production long before Pearl Harbor. It has since proven to be an essential element in the manufacture of crystals that have the dependable characteristics necessary for military communication in global warfare.

We have been called upon to solve some knotty problems. But that is nothing new at Bliley. It has been our habit to parallel new developments in radio with the right crystal for each application.

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plete discussion, by J. Aharoni, applies to any form of conductor.

From Maxwell's wave equations, general expressions for the properties of both transmitting and receiving antennas are developed. The method is to assume lines of flow from which an impedance kernel is written thereby obtaining the characteristics of a Hertzian dipole. To this result is added the mutual impedances between two conductive elements and the result integrated, thereby giving the terminal impedance of an antenna. The relation of the approach and results to the works of Hallèn, Brillouin, Carter, L. V. King, and R. King and Blake are discussed. As an illustration of the basic technique, lumped-constant circuit equations are obtained from Maxwell's expressions. To show the use of the final results, the characteristics of a long thin lossless straight symetrical antenna are evaluated. These results check with those of Hallèn.

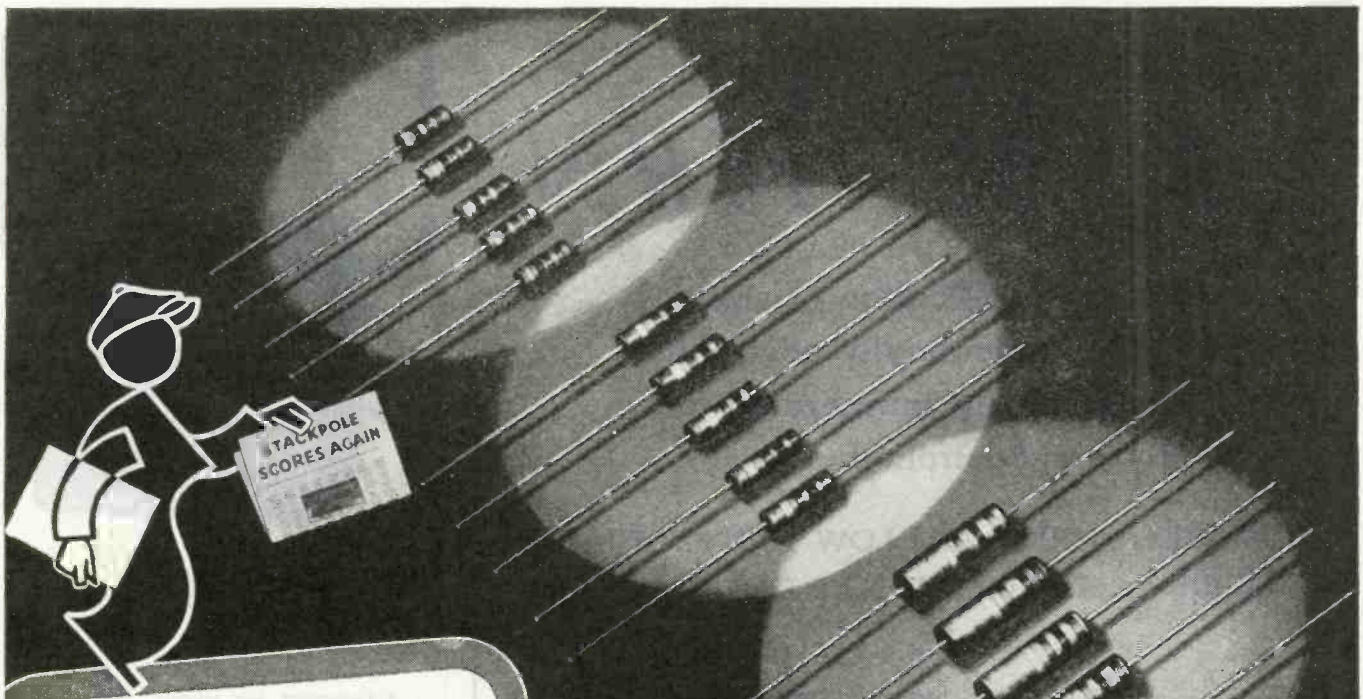
In the same issue, a paper by F. F. Roberts and J. C. Simmonds considers the mathematical relations of the recurrent-exponential or probability-function pulse previously presented. The pulse is of the form $A\epsilon^{-(t/T)^2}$ and therefore is readily manipulated mathematically. Of the several problems considered, the greater part of the paper deals with the effect of amplifier response on the pulse and on cross-talk in multichannel time-division communication systems.

Measurement of the residual parameters of a Q meter is discussed in an article by W. F. Lovering. Residual capacitance and inductance in the variable capacitor are determined by a series of pairs of measurements made at different frequencies. From these a plot is made of the apparent change of total circuit capacitance with frequency. Series and shunt resistance inherent in the resonant circuit are separately determined using the corrected value of capacitance by measuring the circuit Q at various frequencies.

• • •

Measurement of Electric Carrier

RESULTS OF inertia measurements of the carrier of electricity in copper and aluminum by C. F. Kettering and G. G. Scott, Research Lab-



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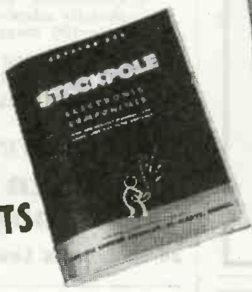

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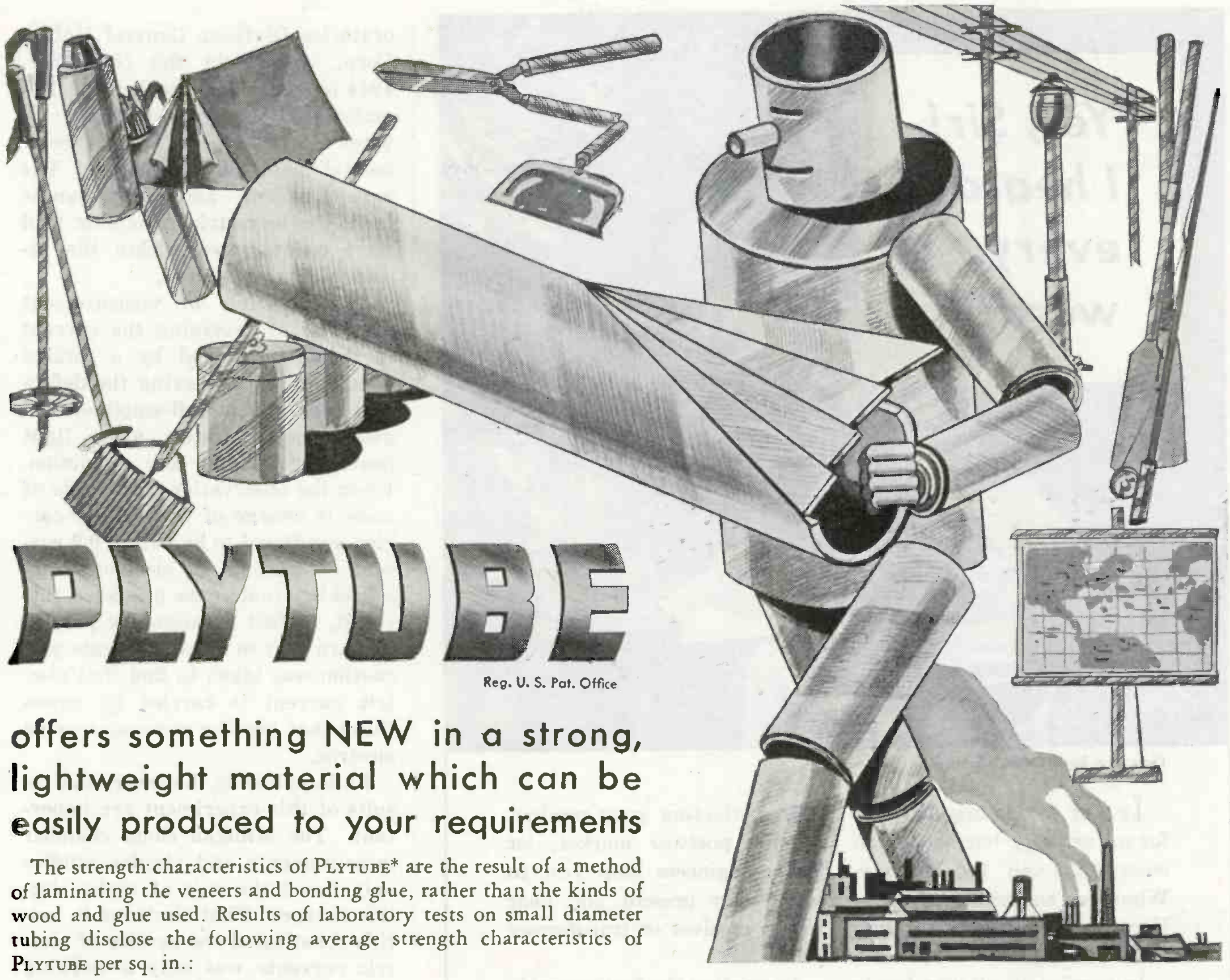

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offers something NEW in a strong, lightweight material which can be easily produced to your requirements

The strength characteristics of PLYTUBE* are the result of a method of laminating the veneers and bonding glue, rather than the kinds of wood and glue used. Results of laboratory tests on small diameter tubing disclose the following average strength characteristics of PLYTUBE per sq. in.:

Ultimate Compressive Strength	11,500
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Compressive Proportionality Limit	6,000
Tensional Proportionality Limit	6,000
Deflection, Young's modulus	1,500,000
Axial Expansion, Young's modulus	1,700,000
Buckling Failure, Young's modulus, Euler's formula	11,000
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PLYTUBE has already been put to valuable, effective use. Applications thus far made predict fields of utility in which its great strength and light weight can be taken advantage of in improving product design, construction and manufacture. Fabrication is simple and economical. Handling is greatly facilitated because of its form and lightness in weight.

All the advantages of PLYTUBE as a material of construction can be made available in countless ways in an almost unlimited variety of products. These advantages are of such importance as to command your careful investigation. A study of the possibilities of PLYTUBE *now* will open up applications for its use that can well revolutionize your future manufacturing plans. Our engineers are prepared to work with you on your ideas and apply our research facilities in developing whatever uses you consider advantageous. Ask for further data on PLYTUBE, using coupon below. Samples will be sent on request.

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oratories Division, General Motors Corp., appear in the November, 1944 issue of *Physical Review.* The major portion of the paper is devoted to a description of the experimental setup and procedure. The variations of and disturbances from the terrestrial magnetic field were counteracted within the region of the equipment.

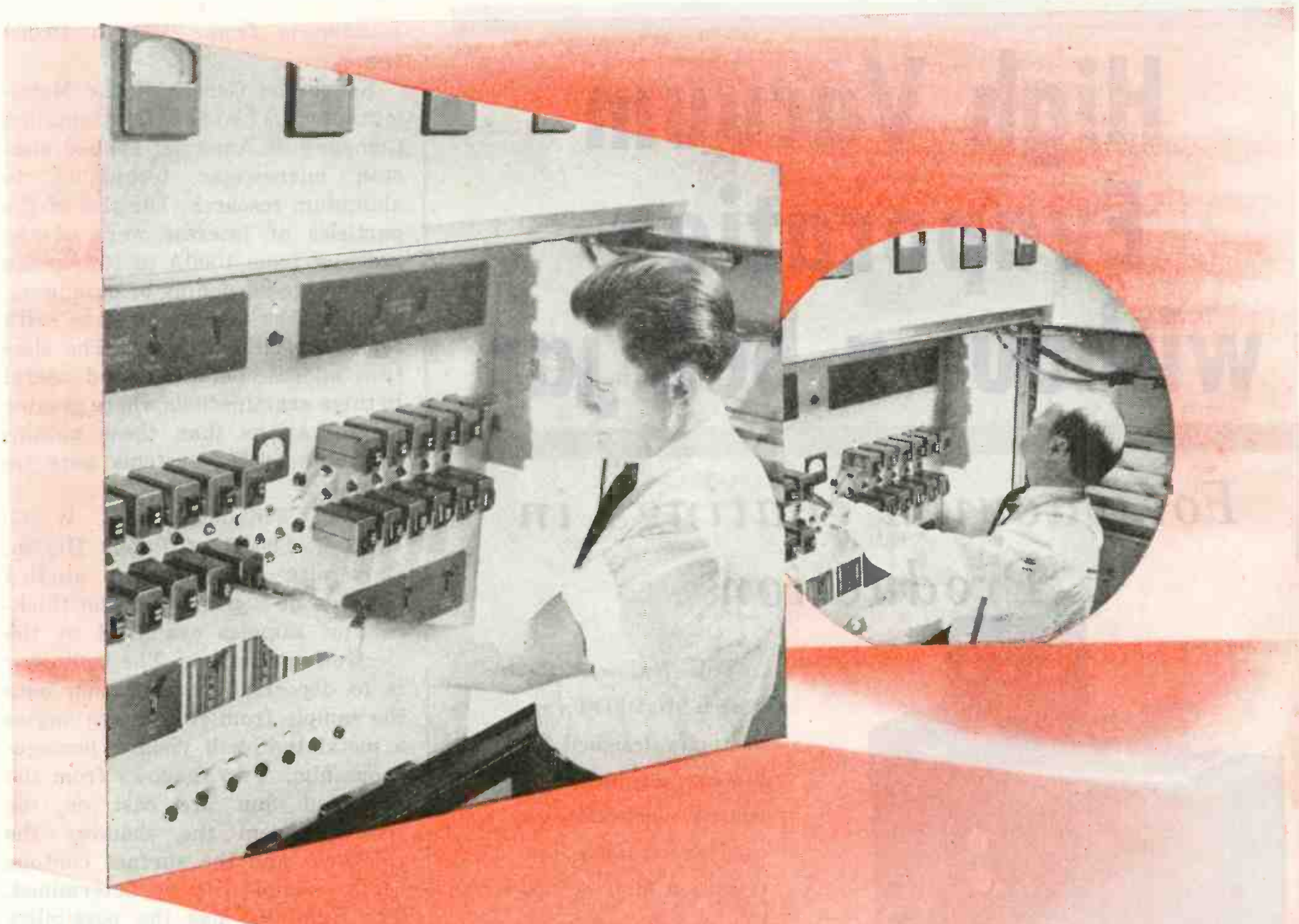
The principle of measurement was that of reversing the current in a coil supported by a torsion pendulum and observing the deflection over a photocell-amplifier and galvanometer system of a light beam reflected by the pendulum. From the observations, the ratio of mass to charge of the electric carrier was found to be within 0.2 percent of that of an electron. Any school boy could have predicted this result, in fact he might be puzzled to learn that so much elaborate precaution was taken to find that electric current is carried by something that has the same m/e as an electron.

Philosophically, however, the results of this experiment are important. The Millikan cloud chamber measurements and similar studies only found the m/e of static electric charges. That electrons in motion constituted the carrier of electric currents was only a working scientific hypothesis. This experiment, by showing the charges in motion have the same m/e, adds one more verification to our interpretive picture of the exact nature of things.

• • •

Techniques for Electron Microscopy

Applications of the electron microscope are described in three papers in the October 1944 *Journal of Applied Physics.* Charles S. Barrett, Metals Research Laboratory, Carnegie Institute of Technology, surveys the methods of transfering metal surface details to a replica. The paper is illustrated with studies of several metallurgical properties examined by this technique. The author suggests that because of the reduced field, extremely high magnifications with the electron microscope are undesirable. Instead, enlargement of the electron micrograph should be used. The useful magnification obtainable in this



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Keller and Geisler of the Metallography Division, Aluminum Company of America, applied electron microscopic techniques to aluminum research. The size of the particles of interest were of the order of from 1000A to 10A in the case of age-hardening of aluminum. Most of the work was done with replicas of the surfaces. The electron microscope was found useful in these examinations where greater magnifications than those obtainable with optical systems were required.

R. C. Williams and R. W. G. Wyckoff, School of Public Health, University of Michigan studied methods of determining the thickness of samples examined by the electron microscope. The technique is to deposit by evaporation onto the sample from two known angles a metal that will yield a homogeneous film. Two shadows from the deposited film are cast on the screen. From the shadows the thickness and the surface contour of the sample can be determined. The technique has the possibility of showing the existence of objects below the resolving power of the electron microscope and of indicating thicknesses in the range of molecular dimensions.

Two other articles of interest to electronic engineers are a historical review of the advances in electron optics with especial attention to electron microscopes by C. J. Calbick of the Bell Telephone Laboratories. The paper concludes with a brief bibliography.

Using the Applegate diagrams for the double-resonator and Reflex Klystrons, A. E. Harrison of Sperry Gyroscope Company describes qualitatively the action of velocity modulated tubes.

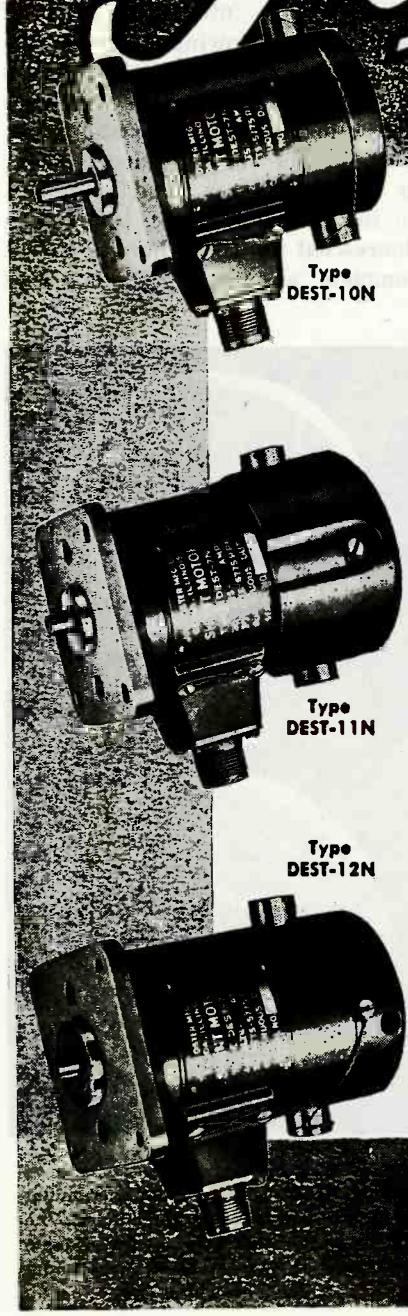
• • •

London Letter

By John H. Jupe
London Correspondent

Supersonic Waves and Biology. Although the biological effects of supersonic waves were thoroughly studied by Wood and Loomis in 1926-7 it is only recently that an attempt has been made to project a focused beam into deep tissues so that a change is only brought about at the focusing point. The

3 Oster Motors that have proved their ability to perform dependably in aircraft applications



Type DEST-10N

Totally enclosed. Approximately 9/16" shorter than types DEST-11N and DEST-12N. Rated at approximately 50% of tabulated values. Suitable for applications requiring a totally enclosed motor where space is limited.

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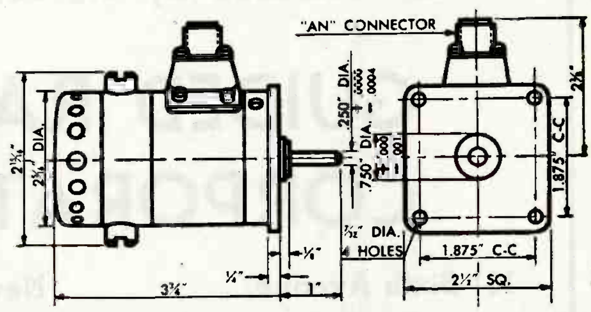
Typical ratings of types DEST-11N and 12N, Series Wound			
R.P.M.	7500	5800	3800
Max. H.P.	1/20	1/25	1/40
F.L. Amps at 24 volts	2.4	2.1	1.5
Starting torque in % of F.L. torque	600 to 800	400 to 600	300 to 500



All ratings and data are approximate.

M-21

Oster FRACTIONAL H.P. ELECTRIC MOTORS

John Oster Manufacturing Co.
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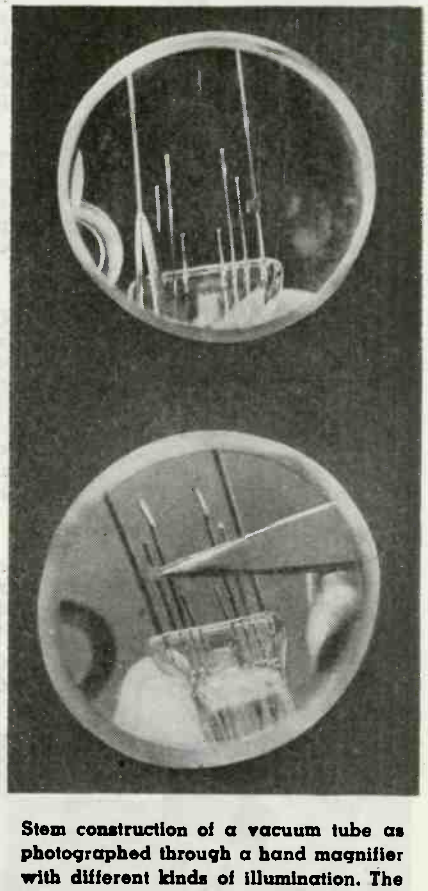
Journal of General Physiology (Vol. 26 No. 2) gives some details of an electronic unit for producing the waves. In essentials, it is a ½-kw radio transmitter, consisting of a crystal-controlled master oscillator tuned to 834-836 kc, a buffer stage and an output stage incorporating a supersonic crystal of 835 kc. The whole outfit is tuned to resonance to avoid hunting for the crystal frequency. Three tubes are used, in addition to a mercury-vapor rectifier in the power pack. The master oscillator uses a type 56 or 76 triode, the buffer stage a beam power tube and the output amplifier uses a T200 tube.

Discharge Lamps versus Tungsten. The G. E. Co. in Britain recently produced an interesting pair of photographs showing the great difference in these two kinds of lamps when used to illuminate processes in the manufacture of radio tubes. Both prints are reproduced below as seen through a hand magnifier. In the second example, taken with fluorescent lighting, there is almost complete absence of shadow and



Stem construction of a vacuum tube as photographed through a hand magnifier with different kinds of illumination. The photo at top was taken under a tungsten light source, the bottom one under fluorescent lighting

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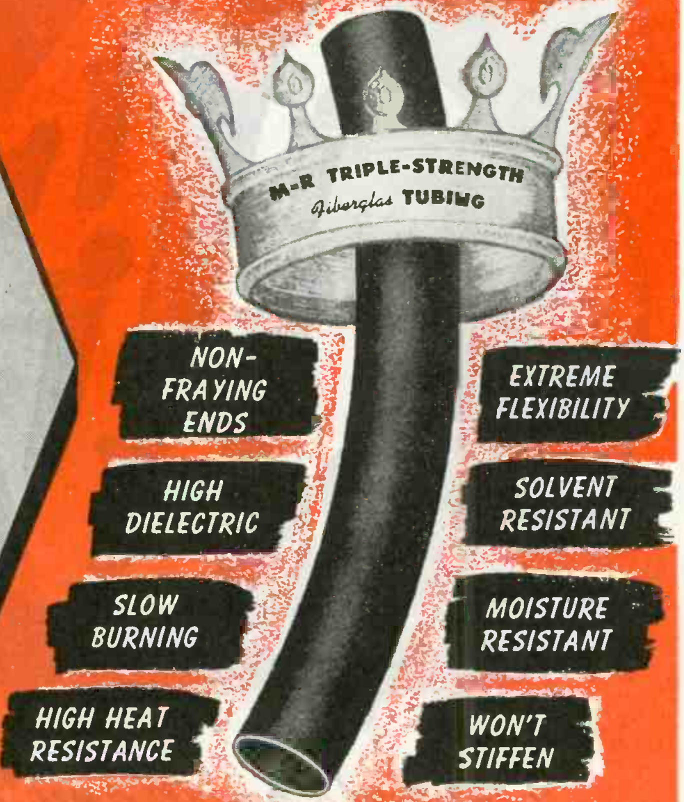

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WILL remain flexible, withstand high dielectric, high humidity, moisture, solvents, twisting, bending.

WON'T bruise or fray, stiffen, break down under high dielectric, rough handling, twisting or bending.

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hard reflections, the illumination being even and soft over the whole area.

Dangers of Television. I was talking recently to a radio dealer over here and the question of dangers associated with high voltages and television arose. He agreed with me that there are some nasty problems to be solved in the television field but thought that they will be overcome by careful organization, etc. The real danger lies in the fact that there is always a fellow who thinks he knows how to fix the dead radio. These gentlemen will come along after the war and try to fix television sets. A number will die from cathode-ray tube voltages and the general public will soon get the impression that television receivers are too dangerous to have about the house. This will be particularly true if one of the big newspapers takes it into its head to run an anti-television campaign, for some reason or other.

It seems, therefore, that before television is launched fully onto the market we have got to make the sets intrinsically safe with interlocks, etc, and also to try and devise some safeguard against the non-professional serviceman attempting to repair them.

The thoughts on the above lines made me think about dangers due to the implosion of c-r tubes, a possibility very slight in practice but still of some interest. In this case, the danger arises from the fact that the pieces of glass are impelled towards the center of the tube and attain sufficient velocity to make them overshoot and scatter in all directions with considerable force.

Some years ago an English firm examined the problem with some interesting results. Twelve-inch tubes were mounted in consoles and imploded by rifle fire from the side and in line with the screen, the necks of the tubes being mounted in felt-lined wooden brackets. The fronts were supported by a rubber ring surrounding the screen opening and carrying a sheet of plate glass.

Results showed quite conclusively that ¼-inch armor-plate glass is the minimum for real protection. Ordinary glass, celluloid, etc., proved quite unsuitable. In some cases, parts of the tube and protec-

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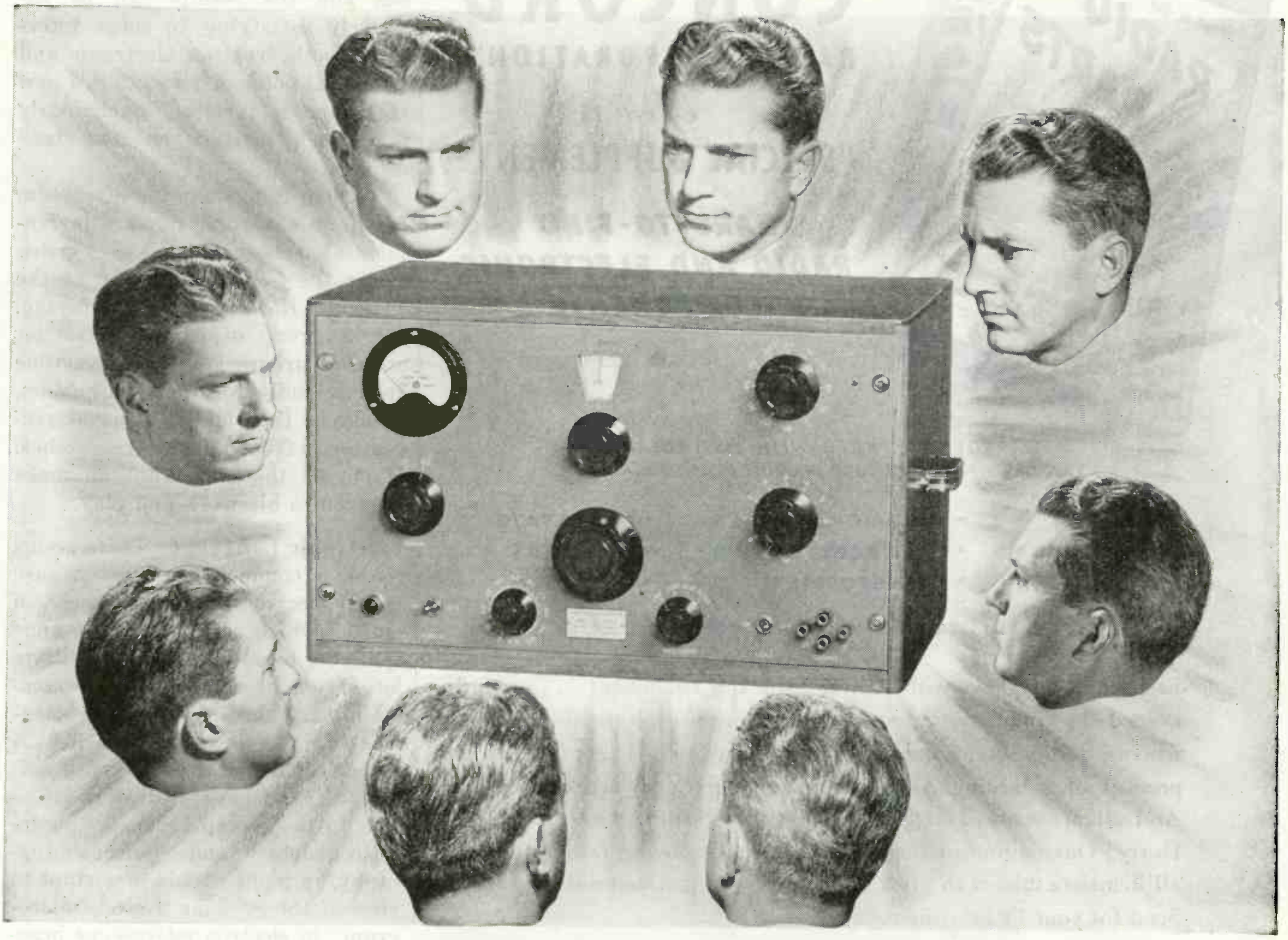
...a signal generator for use below 100 kc



This new *-hp-* Audio Signal Generator embodies many new features which are very desirable. Outstanding among these is the new main frequency dial which enables the engineer to make extremely accurate settings. Parallax is completely void and the vernier adjustment is smooth and positive. A spring loaded gear drive, built on a heavy cast frame, maintains accuracy of settings. The Model 205-AH consists of an *-hp-* Resistance-Tuned Audio Oscillator, an output meter, an impedance matching system and an attenuator set. The frequency range is from 1 kc to 100 kc, maximum power output is 5 watts, the hum level is at least 65 db below output voltage and the frequency response is ± 1 db from 10 kc reference. The output attenuator provides 0 to 110 db in 1 db steps, while the output meter is calibrated directly in volts at 500 ohms and in db above 1 milliwatt level.

A limited number of preliminary specification sheets are ready for engineers who write immediately.

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tive glass were thrown as far as 12 feet from the cabinet.

Perhaps after experience with "doodle bugs" the folk in southern England will not worry about such trifles but what of others?

Electronic Music. It seems that this subject is going to be quite popular over here after the war. The experimental field is tremendous and the results can be extremely satisfying to those interested, both from an electronic and a musical point of view. But a new technique is involved, particularly over such matters as new tone colors.

To help things along a discussion group on electronic musical instruments has been started in London under the helpful guidance of the journal *Electronic Engineering*. For a group of engineers to get such a group going in wartime speaks loudly for their enthusiasm, or maybe they find it pleasant recreation from war researches. Happy is the man who can make electronics his work and play.

Electronic Language. There seems to be a common tendency to use many electronic terms loosely, a matter which seems to gripe some folk over here. But there is quite a lot of sound sense in their complaints and the first duty of a scientific engineer is to be scientific. A correspondent in the *Journal of Scientific Instruments* draws attention to the mixup between "photomicrography" and "microphotography," a point that is important in view of the growing use of "microgram" in electron microscope practice.

Another bad group comprises the terms used to denote an x-ray shadow photograph. People indiscriminately use "radiogram," "roentgenogram," "skiagram," "radiograph," although the first and last appear to be commonest.

The correspondent points out that microphotography is the production of very small photographs (generally of large objects); whilst photomicrography is the production of much enlarged photographs of very small objects.

Applying the same principle we should use, "ultra violet micrography" for micrography with u.v. light; "electron micrography" for direct micrography using electron

beams, and "x-ray micrography" for the kind using these rays.

It is also pointed out that the suffix "-scope" means an optical instrument without photographic recording; "-graph," an optical instrument with recording and "-gram," the record.

Are Gauges Really Necessary? The *Production and Engineering Bulletin* for March told of some interesting happenings when blind women were being interviewed for employment as inspectors. The first was given three ring-nuts as a specimen of the work she would handle, and, on feeling them, laid one aside as being the smallest.

A micrometer showed that it was 0.017 in. undersize. Another applicant was given the remaining two nuts and she amazed her interviewer by saying that one was smaller than the other. So it was, to the extent of 0.004 in. Tests have shown that in suitable types of work, blind inspectors have a 50 percent greater output than those able to see.

• • •

Application of High-Frequency Phenomena in Medicine

IN A PAPER PRESENTED before the National Electronics Conference, Chicago, 1944, fundamental theories underlying the heating of human tissues in medical diathermy were reviewed by H. J. Holmquest of General Electric X-Ray Corp. and Northwestern University Medical School. The following material, abstracted from this paper, emphasizes the importance of a scientific approach in medical applications to secure maximum beneficial results.

Historical Resume

All evidence indicates that the therapeutic use of high-frequency currents was first suggested by Nikola Tesla in a paper published in December, 1891, in which he noted that currents of high frequency were capable of raising the temperature of the living tissues without other obvious physiologic effects. The following year d'Arsonval demonstrated that high-frequency currents could be used for the coagulation of proteins.

The therapeutic application of high-frequency currents developed

rapidly and was given the name diathermy. The apparatus was originally a spark-gap oscillator generating a series of damped oscillations. With the development of vacuum tubes, tube oscillators came into wide use, employing a wide range of frequencies. The frequency must be sufficiently great to avoid a neuromuscular response, yet generate heat in tissues. When the application is such that visible destruction of tissue results, the application is surgical.

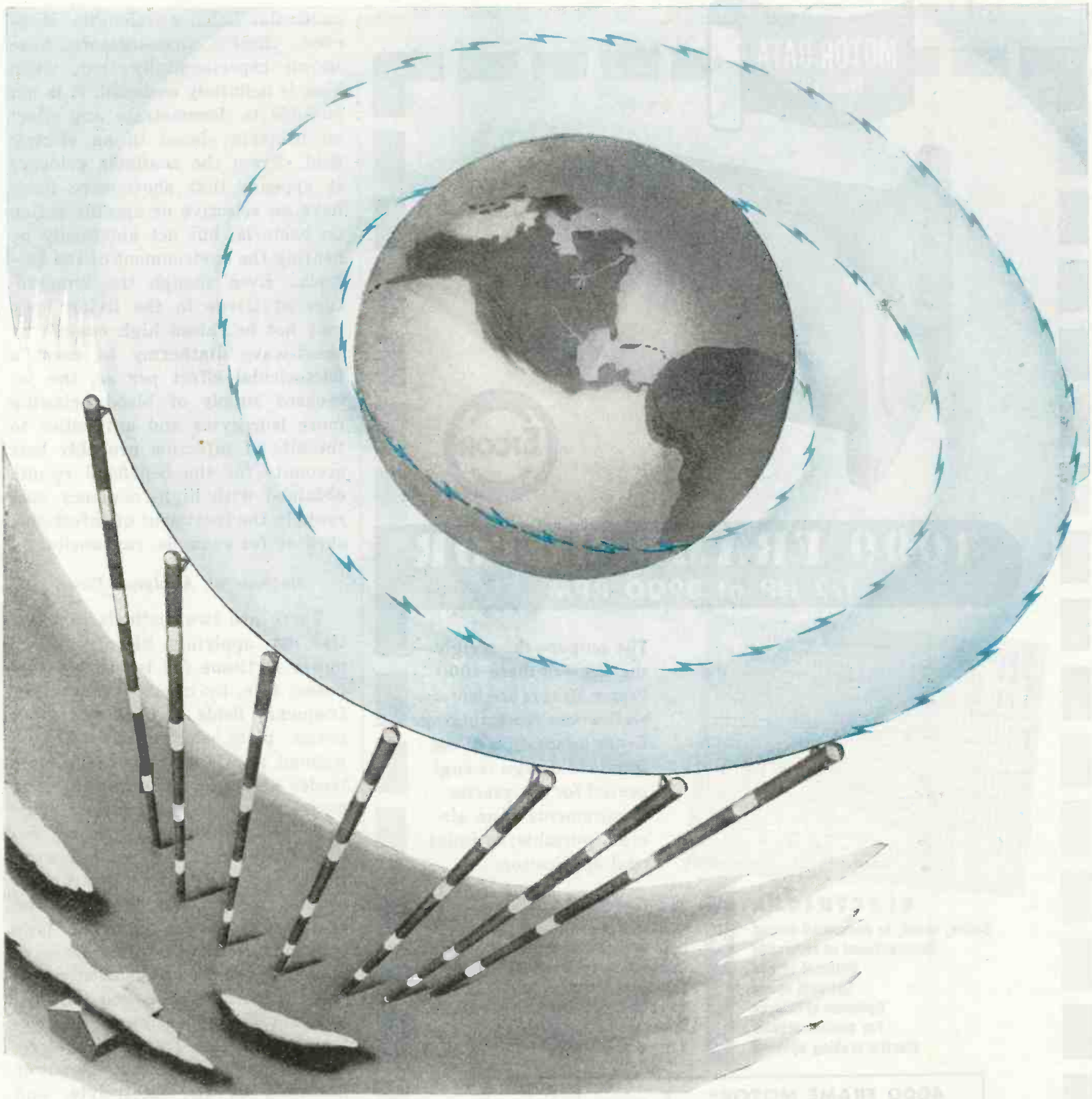
Factors Affecting Temperature Rise

To intelligently administer high-frequency energy, individualizing each treatment technique to the pathological condition present a knowledge of the fundamental physical laws involved is necessary. The degree to which tissues or organs demonstrate a temperature rise will depend on the following factors: (1) The efficiency of the circulating blood in dissipating the heat generated; (2) the thermal conductivity of the contiguous tissues; (3) the thermal capacity of the tissues absorbing the high-frequency energy; (4) the rate at which energy is being absorbed; (5) the total time energy is being absorbed.

The rapid transfer of heat to other tissues by the circulating blood and by thermal conduction may render the differences of temperature negligible. Selective heating of an organ or of tissues is not likely to occur. If the rate of energy input into the tissues exceeds the rate at which the tissues can dissipate the heat, the temperature will rise. The relative proportion of the total energy input that is converted into heat in tissue components which differ markedly in their electrical characteristics can be controlled within limits by varying the frequency of the field and the method of application. To this extent, and to this extent only, are we justified in claiming selective heating effects for short-wave diathermy.

No Lethal Wavelengths of Bacteria

Claims have been made that high-frequency electric fields exert a specific bactericidal effect which is not due to the heat generated but to other effects of the field, presumably electrical. It has been claimed that every bacterium has its own



particular lethal wavelength. However, careful investigators have shown experimentally that, when heat is definitely excluded, it is not possible to demonstrate any effect on bacteria placed in an electric field. From the available evidence it appears that short-wave fields have no selective or specific action on bacteria, but act abiotically by heating the environment of the bacteria. Even though the temperature of tissue in the living body may not be raised high enough by short-wave diathermy to exert a bactericidal effect *per se*, the increased supply of blood bringing more leucocytes and antibodies to the site of infection probably best accounts for the beneficial results obtained with high-frequency currents in the treatment of infections, such as for example, carbuncles.

Methods of Applying Power

There are two methods in practice of applying high-frequency power to tissue for treatment purposes: One, by means of the high-frequency fields such as exists between plate electrodes, with or without an air space between electrodes and skin, and the other, by means of the high-frequency magnetic field, which is set up by the high-frequency current flowing through a coil which is wound around the part to be treated or wound into a flat pan-cake type coil and placed over the tissues in which it is desired to generate heat.

By a mathematical and physical analysis of the heating of an electrolyte in a high-frequency electric field, it can be shown that the power absorbed by the electrolyte, and consequently the resultant heating, is a function of the frequency of the field and the specific conductivity and dielectric constant of the electrolyte. As the frequency of the field is increased, the conductivity at which maximal heating occurs increases. These conclusions have been confirmed experimentally.

Choice of Frequency

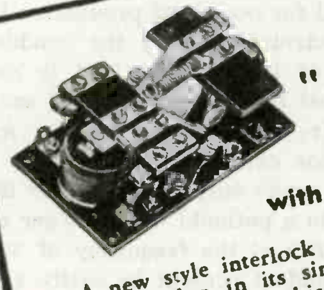
The definitely demonstrable effects of short-wave diathermy are the production of heat and the physiologic effects that normally follow the production of heat in tissue. A frequency should therefore be chosen which will produce maximal heating in the vascular

FIVE OF THE 5,312 RELAY TYPES

VACUUM SWITCH KEYING RELAY

The extreme reliability with which this Struthers-Dunn Type 78CCA100 Vacuum Tube Keying Relay holds its adjustments is the direct result of a rigid and simplified design utilizing an absolute minimum of parts. Exceptionally sturdy—designed for aircraft. All parts readily accessible.

7 poles including one D.T. pole handling high-voltage r-f currents by means of a vacuum switch. High-voltage parts rounded to reduce corona.



A NEW "MEMORY" RELAY

with simplified interlock

A new style interlock represents latch-in relay construction in its simplest, most dependable form. Design of this Struthers-Dunn 50XBX series simplifies make-before-break, or break-before-make contact combinations. Contacts do not interrupt coil circuit until the "throw" is completed and they are latched in new position. Built to aviation specifications.

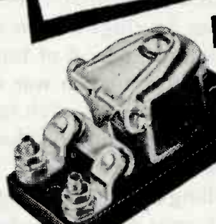
SENSITIVE SNAP-ACTION

in a new, simplified design

Applications for the Struthers-Dunn Type 79XAX Sensitive Snap-Action Relay range from vacuum tube circuits, to overcurrent protection, pulsing circuits, and jobs where extremely close differential or extreme sensitivity are required. Contacts remain in position *with full pressure* up to the instant of transfer. Write for Bulletin No. 251.

SHOCKPROOF to 90 G's

Here's a relay that won't operate unintentionally as a result of shock or vibration—the Struthers-Dunn Type 17AXX designed to meet exacting B2A specifications. Small in size, light in weight, it meets and exceeds all specifications for such services.



EXTRA HEAVY-DUTY CONTACTS

Struthers-Dunn Nutcracker Type 61HXX100 meets the call for relays for extreme services, particularly where severe overloads may cause trouble on units having a less generous heavy-duty contact safety factor. Typical applications include those such as aircraft landing light controls, or controlling a number of solenoids simultaneously. Readily adaptable to different specifications.

WRITE—*for your copy of the big Struthers-Dunn Relay Catalog and Data Book . . .*

STRUTHERS-DUNN, INC., 1321 ARCH ST., PHILA. 7, PA.

STRUTHERS-DUNN

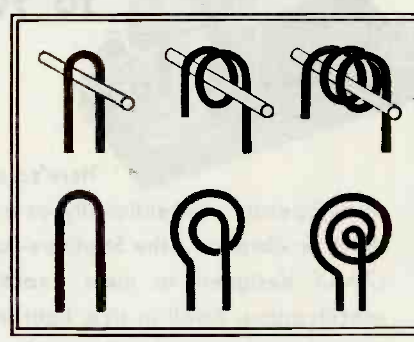
5,312 RELAY TYPES

DISTRICT ENGINEERING OFFICES: ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND DALLAS • DENVER • DETROIT • HARTFORD • INDIANAPOLIS • LOS ANGELES • MINNEAPOLIS • MONTREAL NEW YORK • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO • WASHINGTON tissues. To assure a high rate of heat production in such tissues, relatively high frequencies in comparison with those used for induction heating must be employed.

Theoretically, a frequency of some 300,000,000 cycles per second, corresponding to a wavelength of the order of 1 meter, would have to be used for peak heat production in an electrolyte having the conductivity of blood plasma. It is not practical to use oscillators of such high frequency in treatment. An oscillator capable of generating a useful power output (i.e., power input into a patient) of the order of 200 watts at the frequency of 300 Mc would at present be costly and of inconvenient size.

Electrodes and Coupling

If application of the electric field is to be made by air-spaced electrodes, with an air space of ½ in. between tissue and electrode to assure a more favorable ratio between deep tissue heating and skin or superficial heating, relatively



Loop and pancake coils formed from insulated cable for application of high-frequency induction field to tissue

high frequencies should be used so that the requisite current may be passed through the series capacitive reactance, introduced by the air spaces, and the tissue to be treated to avoid the necessity of impressing an excessively high voltage on the electrodes. Frequencies of the order of 40–50 Mc have been found satisfactory for this method.

The induction field produces tissue heating by inducing eddy currents in the conductive tissues. The intensity of the eddy currents is greatest in the tissues of greatest conductivity. However, the coil applicator has an electric as well as a magnetic field. There is a potential gradient between the turns of the

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.

SPERRY GYROSCOPE COMPANY, INC. GREAT NECK, N. Y.

Division of the Sperry Corporation

★

LOS ANGELES • SAN FRANCISCO • NEW ORLEANS
HONOLULU • CLEVELAND • SEATTLE

GYROSCOPICS • ELECTRONICS • RADAR • AUTOMATIC COMPUTATION • SERVO-MECHANISMS coil and the patient. The patient and the coil are capacitively coupled, and current will flow from turn to turn through the superficial tissues in direct proportion to the voltage gradient and in inverse proportion to the capacitive reactance. Since the heating by capacitive coupling tends to heat only the superficial tissues because of the relatively close spacing between turns and tissue surface, while the heating by the magnetic field tends to heat the deeper conductive, or vascular, tissues, a frequency should be employed that will minimize the heating due to capacitive coupling.

The capacitive reactance of the capacitive coupling to the patient increases with decrease in frequency. Hence, as low a frequency should be employed as other conditions will permit. For a given power input into the patient, as the frequency is decreased the current in the coil must be increased. Under practical conditions the maximal current in the cable should not exceed 10 amperes. Frequencies between 10 and 15 Mc are a quite satisfactory compromise, taking into consideration current flow in cable and ratio of capacitive heating to inductive heating. These frequencies correspond to wavelengths of the order of 20 to 30 meters.

If higher and higher frequencies are used, the capacitive heating component increases while the inductive heating component decreases, until finally the cable tends to act like a distributed cuff electrode with current flowing from turn to turn through the patient's tissues, resulting in a relatively high surface heating. In fact, the use of very high frequencies and many turns of the cable may result in the type of heating obtained in the electric field of air-spaced electrodes.

LATIN AMERICAN interests in Argentina and Brazil have filed trademark applications covering the terms "radar" and "electronic" in those countries. After protests by RMA, the State Department instructed the American Embassy at Buenos Aires to oppose the attempted trademarks.

NEWS OF THE INDUSTRY

Postwar Radio Surveys; Television's first conference; educational activities; Conventions to Come; Washington on component shortages and production

Electronic Parts and Materials Standardization

MOST OF THE COMPONENT PARTS and materials used by the Signal Corps have been covered by specifications completed under the program of the Signal Corps standards agency at Red Bank, N. J. A point has now been reached where major emphasis can be placed upon the applications of these specifications to Signal Corps procurement. A tentative specification, 71-4902, will be the medium for this accomplishment.

Objectives of the program are simplification in the number of types and sizes of parts, and uniform designations. This will increase production, reduce inventories, facilitate replacements, insure interchangeability of all components, increase the effective supply, maintain quality, reduce requirements for critical material, facilitate use by designers of the minimum satisfactory grades of parts, and reduce tests, reports, correspondence, conferences, and travel, by both industry and government agencies.

Signal Corps standard specifications fall into the following categories: Signal Corps Tentative Specifications, used only by the Signal Corps; Army Specifications, approved by the entire Army Service Forces; American War Standards promulgated by the Bureau of Ships, the Signal Corps, and industry under the auspices of the American Standards Association working under contract from WPB; Proposed Joint Army-Navy Specifications, prepared by Army-Navy electronics standards agency; and Joint Army-Navy Specifications, which have received the approval of all services of the Army and all the bureaus of the Navy.

There are at present twenty-one subjects covered by JAN (Joint Army-Navy) specifications which have been approved. These include: radio electron tubes, fixed mica capacitors, fixed composition resistors, crystals, coaxial cables, variable wire-wound resistors, ceramic-dielectric capacitors, rheostats, sockets, and vacuum switches.

Award at Rochester

FOR HIS "many years of unselfish service to the radio and electronic industry through the technical press," Keith Henney, editor of ELECTRONICS, was awarded at the Rochester Fall Meeting the plaque of honor for 1944.

Keith Henney, recipient of the Rochester-Fall-Meeting plaque of honor for 1944

Illustrated herewith, the award includes in its design a book—of obvious significance—superimposed on the torch of enlightenment. The spherical triangle behind it is blue, to represent the blue-sky character of the limitless field for his future endeavors. On

the left-hand page of the book is the symbol for an electron tube. This represents the campaign for standardization of electronic symbols for which Mr. Henney has so energetically striven. The question mark on the right-hand page signifies the undisclosed nature of his next similar activity.

In previous years, corresponding awards have been given to others active in the field. In 1941, W. R. G. Baker was awarded a plaque for his accomplishments in the organization and direction of the National Television Systems Committee. L. C. F. Horle got the award in 1942 for accomplishments in the RMA material bureau. Last year, R. A. Hackbush was honored for his work in forwarding the technological war effort by direct action in the elimination of unnecessary detail.

Conference on Effects of Climatic Extremes

PRECAUTIONS TAKEN in electronic equipment to guard against the effects of tropical and other extremes of climate are estimated to be about 90 percent concerned with moisture protection and 10 percent with fungus protection. This was the concensus brought forward in a conference covering the subject in New York during November.

Among subjects discussed by the group were (a) The necessity for treatment, with its bearing on maximum protection against moisture and fungus and a consideration of the problems of accomplishing the goal; (b) Methods of protection,

with notes on design, selection of materials, protective treatments, and the comparative efficacy of component vs overall-treatment; (c) Toxicology, including hazards involved in treating and handling and precautions necessary; (d) Corrosion and decomposition effects of treatments; and (e) Methods of test and standards for each type of fungicide.

Present at the meeting were representatives of most of the groups whose activities bear on the general problem. They included: Lt. Col. C. R. Dunlap, Lt. Col. L. H. Hitchcock, Maj. R. H. Noyes, and Capt. H. F. Randolph of the Signal Corps; Maj. R. J. Frame of the Air Corps; S. C. Hyman of the signal laboratory; A. H. Petit of Wright Field; J. B. Wonsetter of the Signal Corps standards agency; F. B. Lincoln of NDRC; R. G. Zender of WPB; R. E. Bright, Sperry Gyroscope; Eddison Clifford, RCA; K. G. Compton, Bell Laboratories; J. C. Cook, Celanese Corp. of America; W. R. Dohan, RCA; J. H. Edwards, Rome Cable; W. J. Everts, GE; H. H. Glenn, Bell Laboratories; J. E. Heath, Bendix Aviation; John Leutritz Jr., Bell Laboratories; P. O. Nicodemus, G. E.; S. C. Nowicki, Federal Telephone & Radio; H. L. Spencer, Bendix Aviation; A. C. Titus, G. E.; M. B. Turner, Dow Chemical; R. W. Waring, Sperry Gyroscope; and R. W. Work, Celanese Corp. of America.

Public Sees Bombsight

AT THE MUSEUM of Science and Industry in New York during November, the Navy put on display for the first time the Norden bombsight. Although it works in conjunction with the electronic autopilot described in ELECTRONICS (October, 1944) the present model bombsight is not in itself electronic.

Electronic Sales and Profits

FIGURES PUBLISHED by the Securities and Exchange Commission (SEC) provide a convenient compilation of data on profits and operations of a number of concerns in the electronic field. Only those companies are listed which have securities on national exchanges under the Securities Exchange Act of

1934 and which are required to file annual reports under the Securities Act of 1933.

Twenty-four companies are listed ranging from General Electric with net sales for 1943 of $1,534,094,000 to Allen B. DuMont Laboratories with $4,648,000. In profits, Cornell-Dubilier Electric Corp. tops the list with 30.7 percent before income taxes and 8.1 percent after. This factor ranges down to National Union Radio Corp. with 7.5 percent profits before and Raytheon Mfg. Co. with 1.9 percent after taxes.

IRE Elections

FOR THE THREE-YEAR term, 1945–1947, membership of the Institute of Radio Engineers has elected as

president, W. L. Everett, head of the department of electrical engineering, University of Illinois; and as directors, S. L. Bailey, Jansky & Bailey; Keith Henney, ELECTRONICS; and D. E. Shackleford, Radio Corp. of America.

Radio-Receiver Survey

A HIGH DEGREE OF INTEREST in f-m radio reception was recently indicated in replies to a questionnaire returned by 16,635 stockholders and 1,538 radio dealers circularized by General Electric Co. Nine out of ten indicated a desire to buy an f-m set postwar, while 26.9 percent indicated their readiness to buy as soon as receivers became available. Eighty percent knew about fm, while one out of every ten had already bought an f-m receiver.

War shortages of parts and tubes were blamed by 15 percent of the respondees for the existence of unserviceable radios in their homes. Twenty percent had one set currently out of order while 10 percent had two or more. As to models, 38.9

TYPE 649—Provides 240 volts at 50 ma. Available at other standard ratings, and for operation from 6 or 12 volt batteries. Type 647, not illustrated, provides 240 volts at 75 ma.

Use this West Coast source for vibrator power packs

Kaar Engineering Company offers prompt delivery of standard and special types of vibrator power packs for operation from 6, 12, or 32 volt sources. In addition, laboratory facilities are available for a variety of power packs designed to your own specifications.

Take advantage of this convenient West Coast source of exceptionally efficient low-drain packs, designed for simplicity and dependability.

KAAR
ENGINEERING CO.
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***Export Agents:* FRAZAR & HANSEN**
301 Clay Street • San Francisco 11, Calif.

MOBILE RECEIVERS—Crystal controlled superheterodynes for medium and high frequencies. Easy to service.

CRYSTALS—Low-drift quartz plates. Fundamental and harmonic types available in various holders.

TRANSMITTERS—Mobile, marine, and central station transmitters for medium and high frequencies. Instant heating, quickly serviced.

MICROPHONES—Type 4-C single button carbon. Superb voice quality, high output, moisture proof.

CONDENSERS—Many types of small variable air condensers available for tank circuit and antenna tuning.

percent possessed table types, while 13.5 percent had console radio-phonograph combinations. However, showing postwar preferences, only 22.2 percent want table models while floor-model radio-phonographs showed a choice of 33.8. Almost 85 percent indicated a desire to buy a portable unit when they become available.

New Symbols Standards

SINCE EARLY IN THE YEAR, before which time there was chaos, graphical symbols have been standardized under a temporary American war standard issued by American Standards Association (ASA). This publication was to be used only until the regular standards could be brought into line.

"Graphical Symbols for Telephone, Telegraph and Radio Use—Z32.5-1944" is the first of the regular standards to be thus revised. It has just been published and is available from ASA, 70 East 45th St., New York 17, N. Y., at 30 cents a copy.

Postwar F M Receivers

MORE THAN 5 MILLION F-M home receivers will be on the market within eighteen months after the end of the war, in the opinion of H. A. Crossland of General Electric Co., who addressed the National Association of Music Merchants in Chicago recently. Within five years he expects the total to go as high as 20 million.

Plans at GE call for f-m receivers in all but the lower price brackets, with the first postwar line including f-m models to the extent of approximately 20 percent by units and 60 percent by dollar volume. In the prewar period 60 to 70 percent of all sets produced were small table models. Omitting these from the postwar picture, 80 to 90 percent of all remaining types in the GE line will probably include f-m.

A Pocket Manual for Aircraft Radio

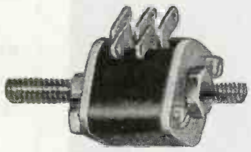
LEARNING THE RULES of aircraft radio operation requires wading through a book nearly the size of the New York telephone book, according to Sydney Nesbitt, of Lear

NEW RECTIFIERS FOR SIMPLIFICATION OF CIRCUIT DESIGN PROBLEMS

STANDARD MODELS OF COPROX RECTIFIERS

Coprox Model CX-2E4-A9, ring-connected and mounted in tube base, detects phase differentials in A.C. currents and small D.C. potentials applied to balanced A.C. circuits. Maximum 4.5 volts continuous. Shown here in actual size.

Coprox Model CX-1C2B1, a center tap, full wave rectifier. Completely enclosed in Bakelite. Low capacitance. Rectifies high frequency current. Conservatively rated up to 4.5 volts A.C., 3.0 volts D.C., 500 microamperes D.C. Other models and capacities to meet all needs.

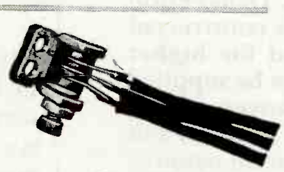


Coprox Model CX-4D4F23, a full wave rectifier with high conversion efficiency, for electronic control work. Rated at 5 volts A.C., 40 milliamperes D.C. continuous. Fully enclosed. Mounts on a single screw.

Coprox CX-3E8C3 double bridge rectifier with current and temperature current characteristics balanced to better than 1% over a range of −40°C to +70°C. Rated up to 4.5 volts A.C., 3 volts D.C. 5 milliamperes D.C. Other models and capacities to meet all needs.

Coprox CX-2E1H5 (Not illustrated) Single half-wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 2.5 milliamperes D.C.

Coprox CX-2E4F2 (Not illustrated) Full wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 5 milliamperes D.C.



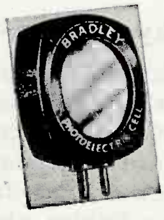
Coprox CX-2E2D4 (Above) Double half-wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 2.5 milliamperes D.C.

Many variations are possible with the basic Coprox Rectifier models described at the left. Bradley's application experience can help you, not only in the use of these units but also in the development and production of special rectifiers for special jobs. Here are the special features of all Bradley Coprox Rectifiers:

- *Gold coating of "pellets" to combat aging.*
- *Pre-soldered lead wires, or special terminals, to prevent overheating during assembly.*
- *High leakage, low forward resistance, for efficient operation.*
- *Waterproof lacquering or wax potting, for perfect sealing.*
- *Highly adaptable mountings.*
- *Ratings are very conservative.*

For samples and special data which will help you design more efficient circuits that will stand up longer than others, write Bradley. Ask any questions you have in mind.

LUXTRON PHOTOCELLS



A Bradley booklet is available, to suggest the many ways in which Luxtron* photocells can be used for control and testing purposes. These cells generate sufficient current to operate instruments and instrument relays without amplification. They, too, are built for long life and have varied mountings and a wide range of sizes. (*Trade Mark Reg. U. S. Pat. Off.)

BRADLEY LABORATORIES, INC.
82 MEADOW ST., NEW HAVEN 10, CONN.

Inc. Mr. Nesbitt is a member of the Civil Aviation Joint Legislative Committee which is cooperating with both houses of Congress to improve legislation bearing on private flying.

He thinks the present work of eight hours could easily be slashed to thirty minutes and all the essential regulations boiled down to a pocket-size manual. Without such a sweeping revision, post-war private flying may be seriously hampered.

Honors in Television

ONE OF THE ACTIVITIES of the First Annual Conference of the Television Broadcasters Association in New York during December, was the awarding of honors to those individuals identified with the growth and development of television.

In the technical division, gold medals, bearing the new official device of the organization as illustrated herewith, went to Dr. Vladi-

mir Zworykin for his pioneering; to F. J. Bingley for his connection with the first regular television relay system; to Allen B. DuMont for mass production of tubes; to Lloyd Espenschied for his work on coaxial cable; to Philo T. Farnsworth for basic inventions; and to Dr. Peter C. Goldmark for research on color television.

Integrated Physics Course

COOPER UNION SCHOOL of Engineering has a new arrangement by which future physics students will get classroom and laboratory instruction from the same faculty member and in a fashion which is

expected to give an improved relationship between the two. In general, students will be enabled to approach their experiments with an advance understanding of what is to be determined and how. Also, emphasis is to be put on ability to speak interestingly and informatively on a subject as well as answer questions about it by wider use of oral reports on experiments and even semester projects.

NAB Conference—Broadcasting's Future

PREDICTIONS AS to the line of development expected from a-m, f-m, television, and facsimile broadcasting were a major feature of interest at the NAB Executive War Conference, held in Chicago recently.

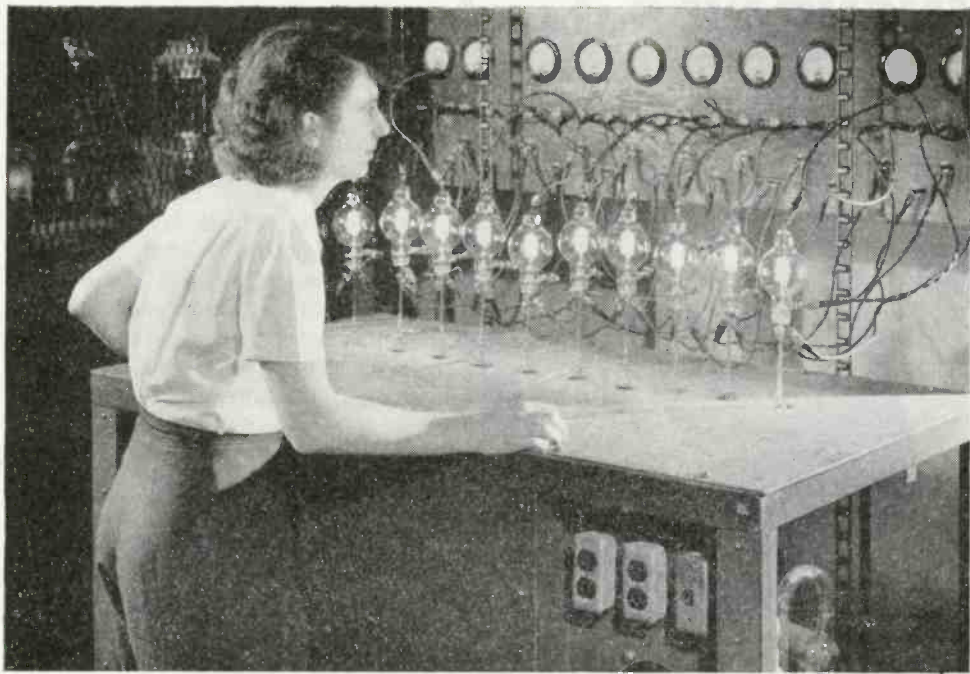
In the sound broadcasting field, it was predicted that fm will eventually supplant all local, most regional, and some high power a-m stations. This will clear up the present a-m band and make more clear channels available for high power and possibly superpower a-m stations.

Television was summed up as a more difficult problem for the broadcaster. Where fm is a technical improvement in a present procedure, television is an entirely new art requiring a combined know-how not presently existing.

Its major applications were considered under the two classifications of *industrial* and *broadcast*. Not much was said about the details of network television.

Results of a statistical analysis were given to show that in five years after resumption of commercial television, transmitters serving 157 key cities should be making television available to a primary market consisting of 72,159,000 people in 17,252,000 wired homes—constituting 61.5 percent of U. S. purchasing power. In addition, ten million people should be getting television program service by secondary network developments. At this point, receiver sales might be at the rate of 2,500,000 units per year at an average retail price of $200.

Need for more space in the television spectrum was emphasized in connection with the proposal that a move be made to the region above



VACUUM PUMPING WITH MODERN EQUIPMENT IN THE I. C. E. PLANT

ICE VACUUM TUBES

Specified by Engineers for Precision

On drafting tables postwar electronic equipment takes shape designed to use I. C. E. vacuum tubes, condensors and relays. This confidence is not alone due to records of dependable performance by I. C. E. products under extreme conditions all over the world. There is a strong bond of partnership that goes much deeper. Forward looking engineers know that I. C. E. research in the field of vacuum tubes is matching their own work in the industry. They know I. C. E.'s unexcelled manufacturing facilities and methods builds products meeting their exacting specifications for precision.

HELP WITH YOUR PROBLEMS

Consult I. C. E. engineering and research departments on designing and production of tubes required in your plans for electronic equipment or applications. This service is available by writing or wiring.

NEW CATALOG NOW READY . . .

For complete information on I. C. E. precision products write today for your copy of our latest catalog.

ICE

PRECISION ELECTRONIC TUBES

Research · Designing · Production

INDUSTRIAL & COMMERCIAL ELECTRONICS

BELMONT, CALIFORNIA

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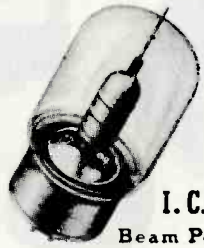
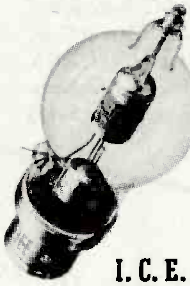
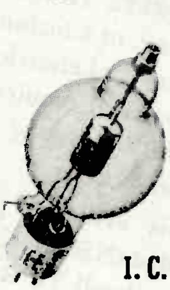


I. C. E.
Beam Pentode



I. C. E. 250th



I. C. E. 100th

I. C. E.
Vacuum Relay

I. C. E.
Condensors

Sizes VC-12...25...50 and 100

300 Mc. Simultaneous addition of higher definition and color was mentioned.

Facsimile was pictured as the Cinderella of the broadcast industry. It was pointed out that 1,000 words per minute or 48 sq in. of picture per minute can be transmitted by modern facsimile methods. Facsimile and television have some overlapping characteristics, but each has its own points of advantage. Where television can show motion, it leaves no permanent record and requires the undivided attention of the observer. On the other hand, facsimile, which can only reproduce still pictures, leaves a permanent record and requires no attention from the observer. The futures of sound, television, and facsimile broadcasting services were characterized as complimentary rather than competitive.

Speakers included James L. Fly, chairman, and George P. Adair, chief engineer of FCC; Major Edwin H. Armstrong, Columbia University; Paul Chamberlain, General Electric Company; T. F. Joyce, Radio Corp. of America; William B. Lodge, CBS; William S. Hedges, NBC; and John V. L. Hogan, Interstate Broadcasting Co.

Radios at Work

AMONG U. S. RADIO-OWNING households in a 4,500-unit survey, 8 percent have none in working order. These figures were disclosed by the office of civilian requirements of WPB. Although more than half of the appliances in the survey are five or more years old, 85 percent of the radios were found to be in good shape. However, 28 percent of the households with radios state they have needed some sort of repair since January 1 and almost half reported that they have had difficulty in obtaining repairs. Excluding auto radios, figures for the entire country estimate the total number of radios in households at 46,275,528.

Meanwhile, as reported by *Radio Daily*, 25,000 American radio sets which have been distributed in Great Britain are presenting a serious servicing problem. About 120 types of sets have been sent over, each varying basically in structure and in a variety of minor details. Besides a shortage of com-

more efficient ...in miniature

The dainty watch that graces a lady's wrist is just as efficient a time piece as the huge chronometer of the century past. Modern engineering has made it so. Likewise, the modern miniature electronic tubes will do everything the large, old style tubes will do. The minute dimensions of miniature tubes themselves and their sockets open up entirely new possibilities in the compactness of electronic equipment.

Manufacturers of radio sets are invited to consult with TUNG-SOL engineers preferably while their equipment is in the blueprint stage. While continuing to make the old style tubes, for replacement, TUNG-SOL is now producing many of the same types in miniature and is preparing to produce others when set manufacturers require them. Of course, your future plans will be held in strictest confidence.

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors ponent parts, speed of repair is apparently hampered by unfamiliarity on the part of repairmen. Britain produced 65,000 sets of its own last year for home civilian use, expects to make 250,000 during the coming year—175,000 a-c and the remainder battery-operated units. Standard designs will be used.

Electronics in Military Aircraft

Emphasis in the recent Los Angeles technical meeting of AIEE was on electrical considerations related to military aviation. Papers having electronic implications included:

AC vs DC for Radio Power Supply, by D. E. Fritz and C. K. Hooper, Westinghouse.

V-H-F-Radio Noise Elimination, by T. B. Owen, Douglas Aircraft.

New High-Frequency Capacitor, by W. M. Allison and N. E. Beverly, Sprague Electric Co.

Radio Noise Elimination, by G. Weinstein, H. H. Howell, G. P. Lowe, and B. J. Winter, Boeing Aircraft.

Vacuum-Tube R-F Generators in Induction Heating, by T. P. Kinn, Westinghouse.

*Electronic Frequency Changers, by G. W. Brucker, G. E.

*Electronic High-Voltage Regulators, by W. H. Pickering, A. W. Schardt, and S. C. Snowden, Calif. Inst. of Tech.

*Physical Aspects of Electroshock and Electronarcosis, by Dr. M. S. Plesset, Calif. Inst. of Tech.

*Physiological Effect of Electric Shock, by C. F. Dalziel, Univ. of Calif.

Electrical Control in Autopilots, by C. M. Young, E. E. Lynch, and E. R. Boynton, G. E.

Electronics for Flight Control, by W. H. Gille and R. J. Kutzler, Minneapolis Honeywell Regulator.

Automatic Pilots, by P. Halpert and O. E. Esval, Sperry.

Influence of Electricity on Instrumentation, by C. F. Savage, G. E.

Instrumentation of 400-cycle Systems, by A. J. Corson, A. G. Stimson, and W. A. Soley, G. E.

Gyrosyn Compass, by O. E. Esval, Sperry.

Papers marked with an asterisk (*) are not intended to be published, either in *Transactions* or in advance-copy form. Others can be purchased from the order department of AIEE, 33 West 39 St., New York 18, N. Y.

Scholarships to Stimulate Physical Sciences

NAMED IN HONOR of Frank B. Jewett, five scholarships are to be awarded annually by American Telephone & Telegraph Co. Intended to stimulate and assist research in the fundamental physical sciences, the awards will finance post-doctorate activities with an annual honorarium of $3,000 to the holder and $1,500 to the institution at which the recipient elects to do


Extra
hands

research. Recommendations will be made by a 7-member committee from the scientific staff of Bell Laboratories.

Techniques of High Vacuum

BECAUSE OF THE LACK of published data on the materials and processes associated with high vacuum techniques, the Illinois Institute of Technology is conducting a graduate course on the subject. The course is being taught by Dr. Serge Pakswer of the Continental Electric Co., Geneva, Ill.

Jobs for Engineers

OFFICE OF WAR INFORMATION is looking for radio engineers and technicians to serve in Pacific war areas with a vital role in the speeding up of psychological warfare. These activities involve taking sound equipment directly into the front lines from where music, news reports, and speeches are directed at persuading the enemy to give themselves up by means of surrender leaflets dropped from planes. Should you live in or west of Denver, write to OWI Overseas Branch Office, 111 Sutter St., San Francisco, Calif.; otherwise write to 119 West 57th St., New York, N. Y.

Radio Telegraph Consolidation

ASSUMPTION OF A RIGHTFUL POSITION in world commerce and international relationships for the United States depends upon consolidation of all seven American cable and radio-telegraph companies into one organization under government regulation, in the opinion of Frank C. Page, vice president, International Telephone & Telegraph Corp. Addressing the National Foreign Trade Council in New York recently, he pointed out that the war development of Army and Navy communication systems was made necessary largely by lack of unity in commercial operation.

Accrediting Program for Technical Institute

A PLAN TO INSPECT THE WORK of technical institutes is to be carried out in a manner similar to that used by Engineers' Council for Profes-

sional Development among engineering colleges. The plan has been submitted to the Council after several years of study by a committee under the chairmanship of Dean H. P. Hammond of Pennsylvania State College. It has been approved by the constituent societies.

A new accrediting committee, now being formed with Dean Hammond as chairman, will include representatives of industry as well as of various types of institutions offering technical courses.

CONVENTIONS TO COME

Jan. 16-18. GREAT LAKES POWER CLUB and CHICAGO LIGHTING INSTITUTE. Conference on Dielectric and Induction Heating, Marquette Auditorium, 140 South Dearborn St., Chicago, Ill. Carl W. Zersen, assistant secretary, 72 West Adams St., Chicago 3, Ill.

Jan. 19-20. AMERICAN PHYSICAL SOCIETY. Columbia University, New York, N. Y. Karl K. Darrow, secretary, Columbia University.

Jan. 22-26. AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Winter Technical Meeting, New York, N. Y. H. H. Henline, secretary, 33 West 39 St., New York 18, N. Y.

Jan. 30-Feb. 1. INSTITUTE OF THE AERONAUTICAL SCIENCES. Thirteenth Annual Meeting, Pupin Physics Laboratory, Columbia University, New York, N. Y. Meetings Committee, 1505 RCA Building West, 30 Rockefeller Plaza, New York 20, N. Y.

Jan. 24-27. INSTITUTE OF RADIO ENGINEERS. Winter Technical Meeting, Hotel Commodore, New York, N. Y. W. B. Cowilich, assistant secretary, 330 West 42 St., New York 18, N. Y.

WASHINGTON NEWS

INDUSTRIAL INSTRUMENTS. A new WPB amendment exempts industrial instruments and their associated circuits in certain classifications from restrictions of L-265. Instruments covered are those for measuring or controlling tempera-

ture, pressure, flow, liquid level, relative humidity, specific gravity, acidity, alkalinity, speed, power load, and frequency.

ELECTRON TUBES. With first-quarter-1945 tube production for the Army, Navy, and Lend-Lease requiring 9,100,000 miniature receiving tubes alone, WPB is faced with monthly shortages of 200,000 to 250,000 of various kinds of tubes.

Predictions for the cutback which may be expected on V-E day have declined to a meager 15 percent, while less than half enough radio receiving tubes have been available during the past two years to replace those worn out in civilian receiving sets. The shortage is expected to continue for several months after the defeat of Germany and Japan. Civilian demand is placed at about 115 million radio receiving tubes.

These tube bottlenecks are blamed by WMC (War Manpower Commission) on the critical shortage of women workers in industry. This is particularly serious in the twelve major plants producing radar tubes and is responsible for the fact that the radar program has been lagging. More than 11,000 jobs are now open in plants manufacturing radar equipment. Following V-E day there also will be shortages in capacitors, loudspeakers, and wire-wound resistors. However, it appears that there will be adequate supplies of raw materials and tools. Combined with a gradual return of labor to industry as hostilities terminate, this factor should assist in easing the situation as time goes along.

CONTRACT TERMINATION COURSES. In preparation for the time when it will become necessary to terminate Signal Corps war contracts, special courses are being given to officers and enlisted men with specialized training. Under the direction of the Office of the Chief Signal Officer, this instruction is being provided at Fort Monmouth, N. J.

TIN FOR SOLDER. Revision of Tin Order M-43 permits 50-percent-tin solder to be used for the manufacture, repair, and maintenance of radio and radar equipment and for the manufacture and repair of any type of indicating, recording, meas-

The demand for Wilco tubing, wire and other products used in various electronic applications for the Army and Navy has caused the H. A. Wilson Company to increase its manufacturing facilities and develop 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 products—

WILCO RADIO TUBING

Silver Tubing (Fine, Coin, Sterling)
Gold Tubing (any karat)
Gold on silver (on one or both sides)
Gold on bronze (on one or both sides)
Silver on copper (on one or both sides)
Tubing made to order from special materials or any combination of materials.

WILCO RADIO WIRE

Silver (Fine, Coin, Sterling)
Silver-jacketed Invar
Silver-jacketed Brass and Bronze
Silver-jacketed Copper
Gold Wire
Gold on silver
Gold-jacketed Bronze and Brass
Any other type of jacketed wire desired

Let us analyze your problems. Write

THE H. A. WILSON COMPANY

105 Chestnut Street, Newark 5, N. J.

Branches Detroit • Chicago

uring, or controlling instruments and their associate control valves. excluding manufacture and repair of gas meters.

AUTOMATIC PHONOGRAPHS. Production of parts for the repair or renovation of used automatic phonographs is again permitted by WPB, but only to the extent that use of material for the purpose is permitted by materials conservation orders. The manufacture or assembly of automatic phonographs from either new or old parts is still prohibited by Limitation Order L-21. However, persons who wish to make or assemble these parts may apply for permission under terms of Priorities Regulation 25.

PRODUCTION INDICES. Figures released by WPB for communication and electronic production in September showed a slight reduction from August and five percent below schedule. Total value was $343 million. Airborne radio output was 16 percent below the Navy's goal, four percent below the Army's.

ELECTRONIC PARTS. Under recent rules, electronic parts and equipment may be sold to distributors or wholesalers without WPB authorization on orders bearing an AA-5 preference rating. Formerly, specific WPB authorization was required before such sales could be made. In addition, rejected components for electronic equipment may now be sold freely (without authorization of preference rated orders) if the services certify that such equipment has no military value.

BUSINESS NEWS

RADIO MANUFACTURERS ASSOCIATION, Washington, D. C., has organized a new marine equipment section as part of its transmitter division.

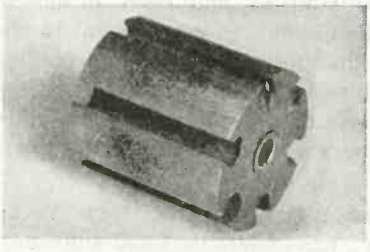
BRADLEY POLYTECHNIC INSTITUTE, Peoria, Ill., is working out plans for television education in its curriculum.

RAYTHEON MFG. CO., Waltham, Mass., has in mind to establish television and f-m broadcasting service

WHEN gods and goddesses ruled the earth, they used to favor some mortals with The Elixir of Life . . . a potent draught which gave everlasting life.

Today, we do what the immortals did centuries ago . . . but with surer and more useful results. When we give a permanent magnet a "shot" of magnetism, we are in a sense giving it everlasting life. For it is one of nature's phenomena that the energy of a permanent magnet remains unchanged in an electrical circuit providing the demagnetization forces remain constant.

This is one reason why permanent magnets are so useful to industry and the sciences. The energy is always there.



Typical of the many varieties of Permanent Magnets designed and made by Cinaudagraph

CINAUDAGRAPH CORPORATION

2 Selleck St. • Stamford, Connecticut

between Boston, New York, and Washington; Cleveland, Detroit, and Chicago; and Los Angeles and other Pacific Coast points. Application has been made to FCC for frequencies at 1900, 3900 and 6800 Mc.

WESTINGHOUSE ELECTRIC & MFG. CO., Pittsburgh, Pa., has formed a new educational department to coordinate the company's relations with schools, colleges and universities. Located at Pittsburgh, the new department will have three main divisions: school service, university relations, and student training..

STROMBERG-CARLSON CO. has provided a cost-free x-ray service for more than 2,860 employees.

FIRESTONE TIRE & RUBBER CO., Akron, Ohio, will offer radio receivers, transmitters, and direction finders for private fliers when restrictions end.

CONCORD RADIO CORP., Chicago, Ill., has inaugurated a hospital and medical protective insurance plan for all its full-time employees. Costs are borne equally by the employee and the corporation, and from the standpoint of reduction in labor turnover the policy has already proved effective.

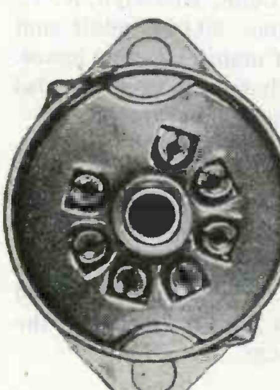
UNIVERSAL MICROPHONE CO., Inglewood, Calif., intends to add recording components for specification within radio chasses produced by other firms.

EMPRESA NACIONAL DE RADIOCOMMUNICACIONES has been proposed by the Colombian government to effect the unification of all telephone, radio-telegraph, and broadcasting services of the country under public operation.

PRESS WIRELESS INC., New York. N. Y., has orders on hand sufficient to keep both its Chicago and Hicksville, L. I. plants busy through 1945.

NATIONAL ASSOCIATION OF BROADCASTERS, Washington, D. C., is marking the end of the first quarter century of broadcasting in America by working up a musical signature to combine the now fam-

This is the APPROVED MINIATURE TUBE SOCKET THAT MEETS ARMY-NAVY SPECIFICATION JAN-S-28



Photographs Twice Size

TWO TYPES OF SOCKET

Navy Grade G Steatite and General Purpose Type with Mica Filled Plastic

WRITE TODAY FOR SAMPLES AND PRICES

HUGH H. EBY INCORPORATED
18 W. CHELTEN AVE.
PHILADELPHIA 44, PA.

MINIATURE TUBE SHIELDS

QUICK REFERENCE CHART

Tube Type No.	Description	EBY Tube Shield Catalog No.	Height
1A3	H-F Diode	7797	1¾"
1L4	R-F Amplifier Pentode	7797	1¾"
1R5	Pentagrid Converter	7797	1¾"
1S4	Power Amplifier Pentode	7797	1¾"
1S5	Diode-Pentode	7797	1¾"
1T4	Super-Control R-F Amplifier Pentode	7797	1¾"
2D21	Thyratron (Gas-Tetrode)	7797	1¾"
3A4	Power Amplifier Pentode	7797	1¾"
3A5	H-F Twin Triode	7797	1¾"
3Q4	Power Amplifier Pentode	7797	1¾"
3S4	Power Amplifier Pentode	7797	1¾"
6AG5	R-F Amplifier Pentode	7797	1¾"
6AK6	Power Amplifier Pentode	7797	1¾"
6AL5	Twin Diode	7798	1⅜"
6AQ6	Duplex-Diode High-Mu Triode	7797	1¾"
6C4	H-F Power Triode	7797	1¾"
6J4	U-H-F Amplifier Triode	7797	1¾"
6J6	Twin Triode	7797	1¾"
9001	Detector Amplifier Pentode	7798	1⅜"
9002	Detector Amplifier Triode	7798	1⅜"
9003	Super-Control R-F Amplifier Pentode	7798	1⅜"
9006	U-H-F Diode	7798	1⅜"

ous Beethoven musical theme with "XX", also as represented in Morse Code, to total XXV.

HOFFMAN RADIO CORP., Los Angeles, Calif., has a new-products committee which is developing postwar plans for the manufacture of things other than household radio receivers.

PHILCO CORP., Philadelphia, Pa., is organizing, among its distributors, self-service super-markets for radio parts distribution.

INTERNATIONAL THEATRICAL AND TELEVISION CORP. has been organized with offices at 18 West 48th St., New York, N. Y., to promote the postwar development and expansion of the 16-mm. film industry. Projectors and television equipment will be manufactured through a connection with General Aircraft Equipment Co.

NATIONAL TELEVISION COUNCIL has been formed with offices at 43 E. Ohio St., Chicago 11, Ill. Its objective is to keep the public informed on the latest developments in television.

WORNER ELECTRONIC DEVICES has moved to enlarged quarters for the second time within a year. The new address is 609 West Lake St., Chicago 6, Ill.

SOUND EQUIPMENT CORP. OF CALIFORNIA has moved from Hollywood into newly acquired space at 3903 San Fernando Road, Glendale 4, Calif.

GAROD RADIO CORP., Brooklyn, N. Y., takes on some 30,000 additional square feet of manufacturing space. Facilities include new experimental and development laboratories.

SPERTI OF CANADA, LTD., Toronto, Canada, is the new Canadian subsidiary of Sperti, Inc., Cincinnati, Ohio. The new company will promote export business in the United Kingdom as a joint project with the parent company.

UNITED ELECTRONICS CO., Newark, N. J., has a pension plan which covers all employees of more than 18-months standing. All contributions are made by the company and pen-

sions are at the rate of approximately 21½ percent of the employee's base pay.

GIODVAD GRELL, 119 E. 36th St., New York, N. Y., is the U. S. issuing agent for licenses relating to h-f heating of dielectric materials under the patents of Leduc and Dufour.

MINNEAPOLIS - HONEYWELL REGULATOR Co., Minneapolis, Minn., has completed its 30,000th electronic automatic pilot. The first production unit was installed on a Flying Fortress on Jan. 1, 1942.

JOHNSON FARE BOX CO. has established a new division designated as Product Designers, which will undertake development, design, engineering, tooling, and packaging services in the electronic industry.

BENDIX AVIATION CORP., Baltimore, Md., and Bendix Home Appliances, Inc. are suing each other to see who has rights to the name "Bendix".

PERSONNEL

DR. ALEXANDER J. ALLEN is appointed Westinghouse graduate professor of Engineering at the University of Pittsburgh, Pittsburgh, Pa.

COMMANDER JOHN R. MILLARD, former design engineer, has been made

vice-president and chief engineer of Burlec Ltd., Toronto, Canada.

EZEQUIEL MARTINS DA SILVA, chief of the Radio Escuta of Brazil, has been awarded a fellowship under the interdepartmental committee on cooperation with the American republics, to study in the U. S. under guidance of FCC.

H. J. HOFFMAN, Machlett Laboratories, Springdale, Conn., has been re-elected chairman and D. Y. Smith, RCA Victor Division of

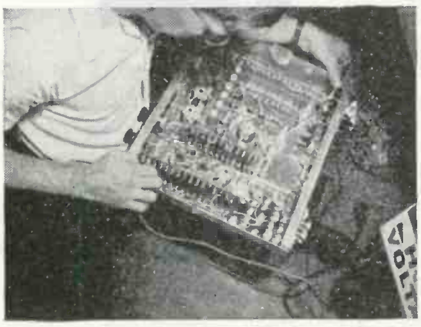
SYLVANIA NEWS

Electronic Equipment Edition

JANUARY *Published in the Interests of Better Sight and Sound* 1945

Electronic Devices Broaden Sylvania's Service to Industry

The manufacture of electronic equipment for certain specialized communications and industrial applications is an important phase of Sylvania service. Manufacture of this type of equipment is carried on in a separate Industrial Apparatus Plant located at Williamsport, Pa.



An electronic device undergoes test in the laboratories of Sylvania's Industrial Apparatus Plant.

This aspect of Sylvania's activities is a natural outgrowth of the company's intensive experience in the design and application of electron tubes.

Did You Know. . .

That Sylvania Tungsten Lamps are standard equipment for signaling purposes on many telephone switchboards? They are made in a range of electrical characteristics for use in any type of switchboard.

* * *

That Sylvania Near Ultra-Violet Lamps activate the fluorescent dials on airplane instrument panels? Lamps are small, compact, designed to operate from a 24-28 volt direct current source.

Sylvania Begins Survey of Public Interest in Television Receivers

Findings Will Assist Manufacturers in Gaging Markets, Determining Price Range

Thousands of personal interviews and an intensive advertising campaign in the pages of leading consumer publications form the twin phases of a comprehensive survey which Sylvania is launching to gage the interest of consumers in the purchase of television sets, and to learn the extent of the potential market for receivers in various selling price ranges. The results of this survey are expected to be of great value in guiding the planning of the manufacturers of television sets.

Television, moreover, is but one of the aspects which will be covered in this nation-wide poll. Consumers will also be queried on such points as their interest in FM; the desirability of short-wave bands; reaction to push button tuning. The reasons why people decide on new set purchases will also come in for scrutiny.

As the survey progresses, findings will be reported from time to time in future issues of Sylvania News.

The type of set people prefer—floor or table model, radio only or radio-phonograph combination — will also be studied in the Sylvania survey.

LOCK-IN TUBES IDEAL FOR UHF

The trend toward the use of ultra-high frequencies brings to the fore the outstanding advantages of Sylvania's Lock-In Tubes. While the name of this line of tubes has tended to emphasize the physical details of mounting, one of the chief motivating forces in their design was the desire of Sylvania engineers to improve the electrical characteristics of tubes, particularly at the higher frequencies.

The Lock-In feature itself has been responsible for the extensive use of these tubes, particularly in automobile radios; electrical features point to wide utilization in television and FM.

SYLVESTER SURVEY

"I wonder if I could have your views on what the postwar radio will be like."

SYLVANIA ELECTRIC

SYLVANIA ELECTRIC PRODUCTS INC., *Radio Division,* Emporium, Pa.

MAKERS OF RADIO TUBES, CATHODE RAY TUBES, ELECTRONIC DEVICES, FLUORESCENT LAMPS, FIXTURES, ACCESSORIES, INCANDESCENT LAMPS

Radio Corp. of America, vice chairman of the Electronic Section of NEMA (National Electrical Manufacturers Association).

A. J. HALL has become production and research engineer at Universal Microphone Co., Inglewood, Calif. He was formerly engineer in charge of design, research, and development at Kellogg Switchboard & Supply Co.

LESTER C. STORK has been made vice-president in charge of manu-

facturing and engineering at Kelley-Koett Manufacturing Co., Covington, Ky., where he was factory manager.

AL KOENIG has been made commercial engineer at Hytron Corp., Chicago, Ill.

NORMAN J. FOOT has been appointed development engineer at Hallicrafters Co., Chicago, Ill. He was formerly assistant engineer at Station KWNO, Winona, Minn.

A. A. KUCHER, director of research, has been made vice-president at Bendix Aviation Corp., Detroit, Mich.

WILLIAM SHAW has been made chief inspector of Taylor Tubes, Inc., Chicago, Ill. He was formerly an engineer at General Electric X-ray Co.

ISIDOR ISAAC RABI, Columbia University, New York, N. Y., wins the Nobel prize for physics in 1944. He received the $29,000 award for his

LEADING SOURCE OF PLASTICS IN SHEET, ROD, TUBE & FIBER FORMS

PLAX SUPPLIES *these materials* ↓ *in these forms* →	Film & Slab	Rod	Tubing	Fiber
	Depending on the material, film and slab come from .001" to 2.0" thick . . . rod from ⅛" to 6" diameter . . . tubing, to order . . . fiber from .005" to .090" diameter.			
Cellulose Acetate *In all colors, clear to pearlescent*	✓	✓	✓	✓
Cellulose Acetate Butyrate *In all colors, clear to pearlescent*	✓	✓	✓	✓
Ethyl Cellulose *In all colors, clear to pearlescent*				✓
Methacrylate *In all colors, clear to pearlescent*		✓	✓	✓
Polyethylene	✓	✓	✓	✓
Polystyrene *In all colors, clear to pearlescent*	✓	✓	✓	✓
Styramic	✓	✓		

Exclusive Plax developments have included the tough and flexible Polyflex* Sheet and Polyflex Fiber forms of polystyrene. Continuous research work, and a ready understanding of all application problems, make "PLAX FOR PLASTICS" more than a slogan. It should prompt you to ask today for scientific help. Write Plax Corporation, 133 Walnut St., Hartford 5, Conn.

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research in the resonance method of registering the magnetic quality of atoms.

L. M. LEEDS becomes manager of the electronics laboratory in the electronics department of General Electric Co., Schenectady, N. Y. Since 1943 he has been a consultant both to the company and to the Secretary of War on radar and radio.

CARL H. ODELL, formerly of Federal Telephone & Radio Corp., has been

made assistant manager of the instrument division of Thomas A. Edison Inc., West Orange, N. J.

J. BERTSCHI has been made chief designer at Carter Motor Co., Chicago, Ill. He was formerly a development engineer.

CHARLES P. WEST has been made manager of switchboard engineering in the switch gear and control division at Westinghouse Electric & Mfg. Co.

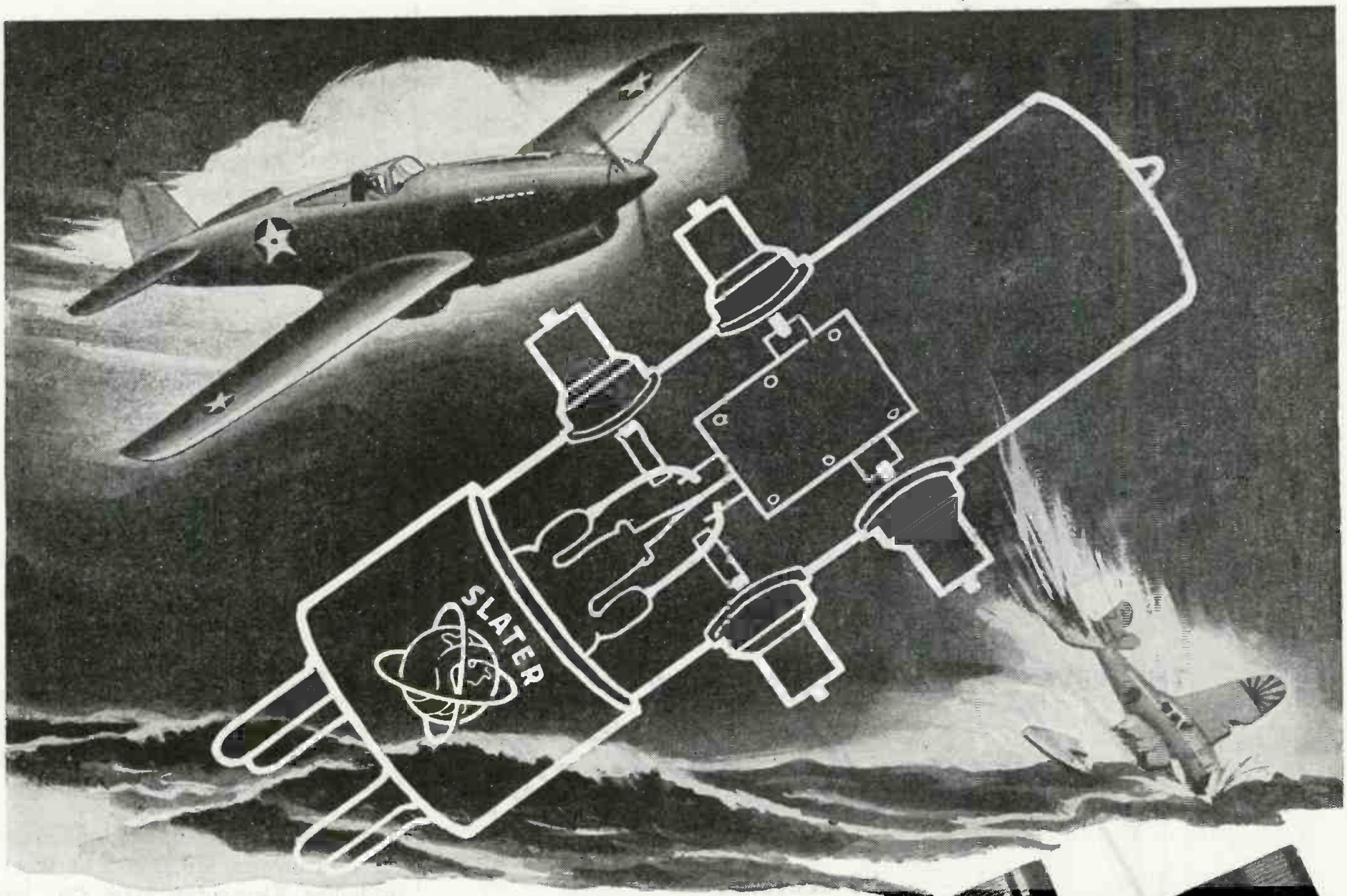
MARTIN F. SHEA, formerly in charge of the Washington office, has been made assistant manager of the industrial radio division of Philco Corp., Detroit, Mich.

ROBERT H. WORRALL has been made senior radio engineer in the radio material office of the Navy Yard, Pearl Harbor, T. H.

E. J. KERRIGAN has been elected vice-president at Press Wireless, Inc., New York, N. Y. He was assistant managing engineer.

PHILIP D. ZURIAN has been made director of research and development at Press Wireless Inc., New York, N. Y. He was formerly vice-president in charge of engineering.

DANIEL SAGE MORA, in charge of radio broadcasts and amateurs in the Chilean department of radiocommunications, has been awarded a fellowship under the interdepart-



A VETERAN
OF THE FIGHTING FRONTS

Jap-infested islands in the Pacific . . . cold, bleak beachheads on the Normandy coast . . . wherever our fighting men advance, electronic tubes join the attack. For the vital life line of communications must never be broken . . . and here the electronic tube does its job. And SLATER tubes built with watch-like precision, subjected to rigid factory tests, give efficient and effective performance along the fighting fronts.

SLATER ELECTRIC & MFG. CO.

MANUFACTURERS OF STREET LIGHTING LAMPS AND ELECTRONIC TUBES

BROOKLYN, NEW YORK

mental committee on cooperation with the American republics, to study in the U. S. under guidance of FCC.

GARRARD MOUNTJOY, former head of the licensee consulting section of

RCA Laboratories, has been made head of the New York radio laboratories of Lear Inc.

EDWARD J. OBERLE, who directed commercial engineering at Arpin Mfg. Co., has been made director of commercial engineering at General Electronics Co., Paterson, N. J.

FRANK E. TIGHE, superintendent of the Lansdowne, Md., plant of Westinghouse Electric & Mfg. Co., has been awarded the company's Order of Merit for outstanding work in the production of radar equipment.

FORREST S. MABRY, Section engineer at Westinghouse Electric & Mfg. Co., has been awarded the Order of Merit by the company for outstanding work in the production of radar equipment.

MURRAY G. CROSBY joins the research and development staff of Press Wireless, New York, N. Y. For 20 years he has been a research engineer in the communications division of RCA Laboratories.

ARNOLD PETERSON has been appointed application engineer at United Electronics Co., Newark, N. J. He has been working as a radio instructor with the Navy Department.

GLENN MAY, formerly corporal in the U. S. Marine Corps, has been made assistant engineer in the production department of Hallicrafters Co., Chicago, Ill.

W. C. WHITE has been appointed electronics engineer in the research laboratory of General Electric Co., Schenectady, N. Y. He was for-

merly in charge of the electronic laboratory in the electronics department.

D. MARTIN is the newly appointed chief engineer at Wilcox-Gay Corp., Charlotte, Mich. He had previously

been associated with Westinghouse, DeForest, Federal Telephone and Radio, Radio Receptor and J. H. Bunnell

FRANK A. TURNQUIST has become production manager of the National Union Radio Corp., Newark, N. J. He was formerly manager of industrial engineering in the Harrison, N. J., tube plant of Radio Corp. of America.

AWARDS

Workers of the following concerns in the electronic field have been awarded Army-Navy E burgees for excellence in production:

American Type Founders
Elizabeth, N. J.
Crystal Research Labs.
Hartford, Conn.
Hoffman Radio Corp.
Los Angeles, Calif.
United Transformer Co.
New York, N. Y.
Westinghouse Elec. & Mfg. Co.
Belleville, N. J.
Bloomfield, N. J.
Fairmount, West Va.
Lima, Ohio
Trenton, N. J.

For meritorious conduct and outstanding ability in serving the Signal Corps, the War Department has bestowed on the following individual the Legion of Merit:

Brig. Gen. Frank C. Meade

A Distinguished Civilian Service Award, the Navy's highest civilian honor, has been made to mark exceptional performance by:

Frank M. Folsom
RCA Victor Div.
Radio Corp. of America
Camden, N. J.

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.

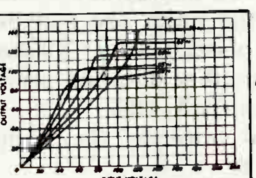
Raytheon Voltage Stabilizers are entirely automatic. They require no adjustments or repeated maintenance. No moving parts assure long life. Write for bulletin DL 48-537.

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.

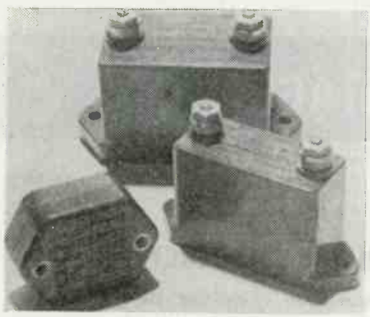
Devoted to research and manufacture of complete electronic equipment; receiving, transmitting and hearing aid tubes; transformers; and voltage stabilizers.

NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

Lectrofilm Capacitors

LECTROFILM CAPACITORS, for use in r-f blocking and by-pass applications, are available in Case-60, -65, and -70 types, which are mechanically interchangeable with mica capacitors Types CM60, 65 and 70 as listed in American War Standards Specification C75.3. Electrofilm is a new synthetic dielectric material and is characterized by its uniform quality and stability under high ambient temperature. The internal foil and Lectrofilm assem-

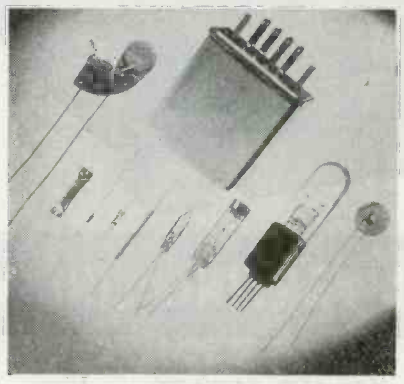


blies of the unit are arranged for minimum inductance and low foil losses. They are treated to assure a rigid assembly and permanence of characteristics under vibration, shock, and wide temperature changes. To guard the interior assembly, the units are supplied in low-loss plastic cases. Characteristics and other data are contained in bulletin GEA-4295.

General Electric Co., Schenectady, N. Y.

Resistors

FOR MANUFACTURERS of communications equipment who are planning their postwar products, Western Electric Company (195 Broadway, New York 7, N. Y.) announces a new resistor which is designated as a thermistor and which was developed by Bell Telephone Laboratories for the Armed Forces. Thermistor is a small circuit element made of a mixture of metallic oxides which are pressed into discs, extruded into rods, or formed into tiny beads. These metallic oxides act as semi-conductors and are



characterized by negative temperature coefficients as high as 5 percent per degree C. They may be used in electrical circuits wherever temperature changes can be produced. Laboratory tests have indicated that the thermistor's characteristics are stable and substantially unchanged after more than a half-million heating cycles.

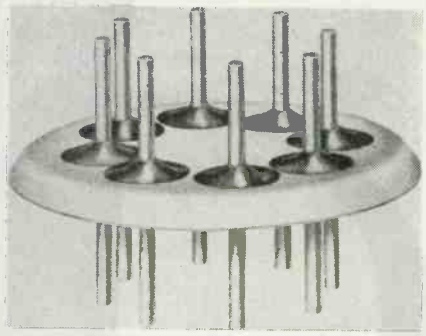
FM Coverage Calculator

THIS CALCULATOR is available for $1.00 from the manufacturer, and it is intended to be used in estimating the urban and rural coverage of FM stations of various powers when a standard RCA turnstile antenna of 1, 2, 4 or 6 layers is employed. The calculator is based on information obtained from the FCC propagation curves (FCC Standards of Good Engineering Practice).

Radio Corp. of America, RCA Victor Div., Camden, N. J.

Multi-Terminal Hermetic Seal Panels

THE CINCINNATI Electric Products Company (Carthage at Hannaford Ave., Cincinnati 12, Ohio) was formed primarily to manufacture hermetic terminals (designated as Fusite) which meet shock and other test specifications. The terminals are made of interfused glass and cold-rolled steel and are fabricated



into one integral unit which requires only one sealing operation when used to hermetically seal component parts. Multi-terminal panels are available with two standard types of terminals; one is approximately 1¼ in. in diameter, containing from two or nine terminals, the other slightly under 1 in. in diameter, carrying from two to seven terminals.

Vacuum Coating Unit

DEPOSITION OF low-reflection films, manufacture of front surface mirrors, metallizing of piezo crystals and plastics, and the production of thin, uniform, and controlled coat-

ings of different salts and metals are all functions performed by a new vacuum coating unit, designated as LC1-500-3. A high vacuum valve operates the diffusion pump continuously. Distillation Products, Inc., Division of Eastman Kodak Co., Rochester, N. Y.

WHAT'S GOOD FOR THE PEOPLE IS GOOD FOR BUSINESS

This is the ECA Outlook . . . AND THIS GUIDES OUR PRODUCTION, OUR LABOR RELATIONS AND OUR CONSUMER RELATIONS

ECA *Products* . . . currently we are producing special electronic testing equipment for the military services. After the war, we will manufacture ECA Radios of superlative quality at competitive prices.

ECA *Labor Relations* . . . a production team captained by a Labor-Management Committee. At ECA, harmony between worker and executive results in a high degree of production efficiency through the contribution of labor-saving ideas and a conscientious attitude toward the job at hand.

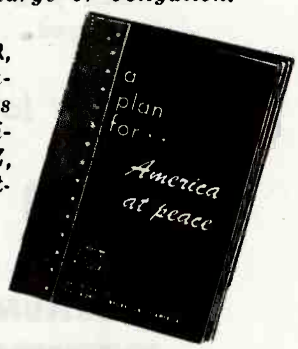
ECA *Consumer Relations* . . . ECA is people-minded. *We know* that the health of our business depends upon the health of America's economy as a whole, and that we can prosper only when the people enjoy sustained buying power and a high standard of living. *We believe* in an expanding democracy where every American gets a break . . . and we express that belief in our advertisements and in our sponsorship of radio news commentators who share our faith in America and its people. *We believe* in the democratic principle that all men are created free and equal . . . and we practice that belief in our plant where peoples of different races and religions work together harmoniously, and enjoy equal opportunities for advancement. *We believe* in giving the consumer his money's worth . . . and we express that belief in the ECA Radio . . . a better radio at a lower price, produced under ideal conditions, and sold to you through reliable dealers.

We believe that the ECA Outlook is sound. We know that millions of Americans endorse this outlook and will want to do business with our kind of corporation. Every time you buy an ECA product, or urge others to do so, you are encouraging ECA to continue to tell America that our nation can live with its neighbors in peace, and go forward in the postwar era to an economy of abundance for all . . . regardless of race, color or creed.

"A PLAN FOR AMERICA AT PEACE"

a 44-page book, prepared for ECA by distinguished economists and writers, containing a sound, realistic and workable plan for a postwar world of abundance and lasting peace. We'll gladly send you a copy, free of charge or obligation.

ECA presents **WILLIAM S. GAILMOR,** *and his personal interpretation of the news. Five nights a week, Monday through Friday, at 11:05, on Station WJZ, Key Station of the Blue Network.*



ARMY E NAVY

eca

ELECTRONIC CORP. OF AMERICA

45 WEST 18th STREET • NEW YORK 11, N. Y. WATKINS 9-1870

Flux Meter

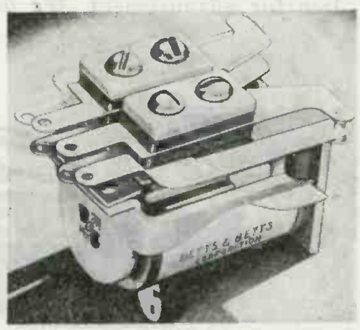
FOR THE COMPARISON of all flux density in all types of shapes of permanent or electro magnets there is available Model No. 256 magnetic flux meter which operates from 105–120 v 50-cycle a-c. Magnetic flux measurements can be compared within plus or minus 3 percent. The meter of the unit measures 4 in., is rectangular in shape.

and is calibrated in arbitrary units. Furnished with the unit is one standard exploring inductor that can be used to measure air gaps ½ in. or larger, or bar or disc type magnets. Extra inductors are available.

The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio.

Telephone-Type Relays

MIDGET-TYPE RELAYS (Type RAC) meet AAF tests for altitude, vibration, shock, humidity, and extreme temperatures, and are designed for communication, electronic and aviation applications. The units measure approximately $1\frac{7}{16}$ x 1 x $1\frac{1}{16}$ in. The coils in the units have a voltage range from 1½ to 70 v dc, and are protected against moisture, corrosion, and electrolytic action. A magnetic circuit permits operation within plus or minus 25 percent fluctuation. Each unit is subjected by the manufacturer to a 1,000-v

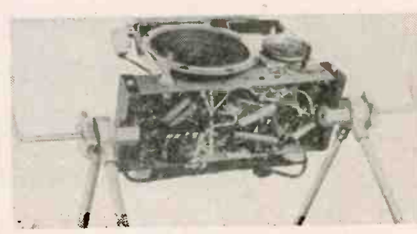


break-down test. The insulation used is an inorganic-base plastic to assure minimum high frequency loss and mechanical strength. Contact springs are made of a resilient alloy, with over-all welded silver contact surfaces. Any arrangement of up to 12 contacts can be supplied for making, breaking, or both. Contact capacity is 2 amp at 100 watts.

Betts & Betts, 551 West 52 St., New York 19, N. Y.

Chassis Cradle

ASSEMBLY, INSPECTION, testing, aligning, repairing and other operations are speeded up by the use of a chassis cradle which is equipped with supporting legs and locking clamps. The work can be rotated and locked in position by a



flick of the finger. The unit is also equipped with an automatic stop. For sub-panels and other flat pieces there are available straight clamps which also enable the cradle to be used for a reel.

Acro Tool and Die Works, 4892 N. Clark St., Chicago 40, Ill.

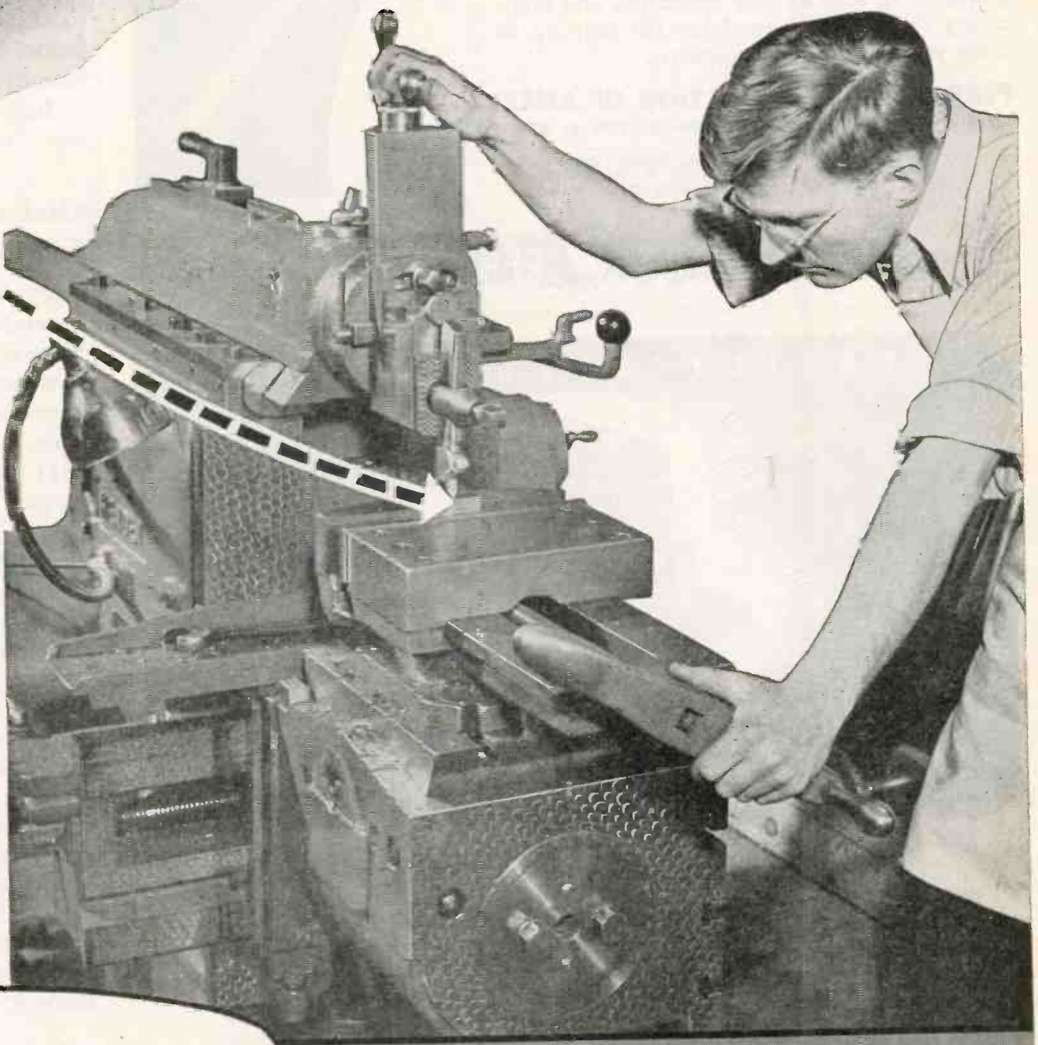
Electrical Ratio Meter

THIS METER, developed a few years ago and manufactured exclusively for the armed forces, was used in conjunction with a temperature-sensitive resistance bulb to indicate temperatures at various critical points, but its application to a number of other uses is in process of development. The design of the meter movement involves the use of a small moving permanent-magnet vane, the position of which is governed by the ratio of the currents in two sets of stationary actuating coils, placed at an angle with one another. This arrangement provides rugged construction and permits the elimination of all hair springs. The movement may be adapted to any service in which it is desired to indicate the ratio be-

PRECISION FABRICATION

BEGINS HERE

We won't go so far as to say that our manufacturing operations are the most precise in the world—but when it comes to keeping tolerances within .001 in the fabrication of plastic parts—well, that's a different story. Precision fabrication within these limits is a routine matter on many jobs we produce. Accuracy is controlled from start to finish and strictly according to customer specifications . . . from the making of the jigs, dies and fixtures in our own tool department right on through to the finished piece.



Send us the specifications for your *next* fabricated part and let us prove to you that we can produce it *better . . . faster* and *more economically!* You are also invited to use the facilities of our engineering department either for consultation or design ideas pertaining to your parts requirements.

Precision FABRICATORS, INC.
EAST ROCHESTER, N. Y.

Specification Fabricators of
VULCANIZED FIBRE, CORK, CORPRENE, PHENOL FIBRE RUBBER, ASBESTOS AND OTHER MATERIALS

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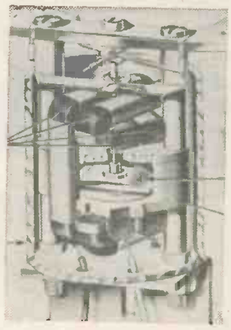

tween the values of two currents or voltages, independently of their magnitude. A small pull-off magnet can be attached to the upper bridge of the instrument when it is necessary to have the pointer swing off one end of the scale when de-energized. Coil resistances up to 1000 ohms are feasible, and the instrument will operate dependably at currents down to 300 microamp. The scale span ordinarily covers 120 circular degrees.

Instrument Div., Thomas A. Edison, Inc., West Orange, N. J.

Carbonyl Iron Powder for H-F Applications

TYPE TH CARBONYL iron powder, heretofore used exclusively for military communications equipment, is now available for civilian use. Its price has been reduced to $1.20 a pound (which is less than half the 1941 price). This powder had good magnetic and electrical properties and is especially useful for application in television and f-m units. The powder, especially developed for high frequency application in the range above 3 Mc, is characterized by the highest Q value obtainable in this frequency range. The manufacturer states that because of its small particle size, there is an extremely low eddy current loss in cores made from this powder. Heat stability and consistency of permeability are other characteristics of this product.

General Aniline Works Div., General Aniline and Film Corp., 230 Park Ave., New York, N. Y.

Antenna Tuning Unit

THE PRIMARY PURPOSE of Type 48 antenna tuning unit is to couple efficiently a vertical tower antenna to a coaxial transmission line. It does this by means of an L network, the elements of which are variable


"Checked up on Bridgeport?"
"You Bet! Bridgeport will be our best postwar source for coils and chokes . . . and just look at their location!"
THIS IS BRIDGEPORT, ILL.
YES, LOOK AT IT. Right near the population center of America. Right for deliveries to all your plants with fast trunk-line service. Here in Bridgeport, in wartime, skilled technicians are building search coils and variometers to meet the most exacting requirements of the Armed Forces. They're doing a big war job well. After victory, Bridgeport will do your big postwar job equally well. You'll find them your most dependable source of supply for R. F. coils and chokes, I. F. transformers and transmitting coils and chokes. Write to Bridgeport today to insure early postwar delivery of the parts you need.
BRIDGEPORT
MANUFACTURING COMPANY
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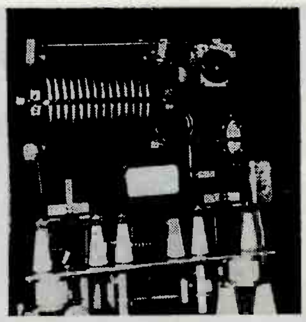
R. F. Coils • R. F. Chokes • I. F. Transformers
Transmitting Coils • Transmitting Chokes



to permit adjustment for optimum performance. One feature of the unit is a built-in isolation filter, to permit connecting a coaxial transmission line to a u-h-f antenna on top of the tower. This permits operation of a high frequency talk-back antenna on top of a low frequency tower. (A standard broadcast station would use this feature to connect a coaxial transmission line to a phase sampling loop, or to an f-m antenna.) Other features include: Built-in tower lighting filter to facilitate feeding aircraft-warning lights on top of tower; plug in meter positions to facilitate temporary metering in all branches of the circuit during adjustment; convenient outlet box for soldering iron, extension light, etc; steatite insulation throughout; and a steel waterproof cabinet.

Andrew Co., 363 East 75th St., Chicago 19, Ill.

Geiger-Counter X-Ray Spectrometer

RECENTLY EXHIBITED at the National Metal Congress in Cleveland, was a new type of industrial x-ray equipment, designated as a Geiger-counter x-ray spectrometer, which provides an accurate method for measuring distribution and intensities of x-ray reflections, and which provides a rapid method for directly determining location and intensity of diffracted rays, without computations or film development. A scanning device, having a Geiger-counter tube arranged to traverse a

graduated quadrant, is used in combination with scaling circuits. The intensity measurements are quantitatively accurate and can be used to determine composition of crystalline mixture. Analysis of mixtures can be obtained in a few minutes. The unit operates on a 115-v 60-cps a-c outlet. Its overall dimensions are 30 x 44 x 44 x in. North American Philips Co., Inc., 100 East 42nd St., New York, N. Y.

Nylon Electrical Coating

A NEW NYLON PLASTIC compound that permits coating of electrical wires at rates of more than 1,000 feet per minute is announced by the Plastics Dept., E. I. du Pont de Nemours & Co., Wilmington 98, Del.

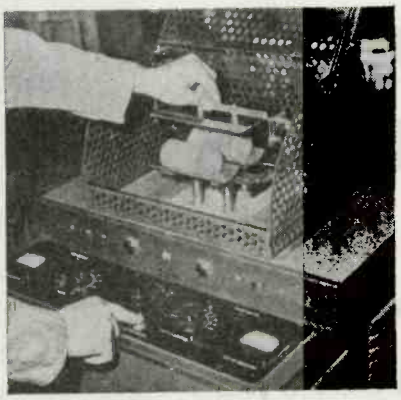
Constant Voltage Transformers

SMALL, COMPACT, hermetically-sealed constant voltage transformers (for through-chassis mounting) are designed for applications where precisely regulated supply voltage is necessary. They are available in capacities up to 15 va, 60 cycle operation and are supplied with a separate capacitor unit for external mounting. At any reasonable transformation ratio of input to output, a single output voltage is provided constant to within ±1 percent of the rated requirements regardless of line voltage variations of ±12 to 15 percent. Bulletin No. DCV-105 gives electrical and mechanical specifications.

Sola Electric Co., 2525 Clybourn Ave., Chicago 14, Ill.

Curved Electrodes for Plastics Preheating

A SPECIAL OUTPUT electrode arrangement for effective preheating of domed plastic preforms is used as standard equipment in this manufacturer's electronic preheating equipment. Comprising dual curved lower electrodes in combination with a standard flat upper electrode, the new arrangement effects uniform heating of the domed preforms. These new electrodes also preheat conventional cylindrical preforms, eliminating heating ir-

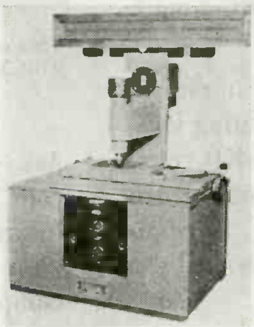


regularities due to variations in preform thickness. The lower electrode assembly is readily removable to facilitate the transfer of the preheated material to the molding press. Another feature of the preheater is an air-gap adjustment on the upper electrode assembly which regulates the air gap between upper platen and preform charge.

Airtronics Mfg. Co., 5145 W. San Fernando Rd., Los Angeles, Calif.

Transmission Photometer

THIS NEW TRANSMISSION photometer is for use wherever spectrographic analysis is employed (in the metal field, or for microcolorimeteric and microchemical analyses, or for measuring light transmission through solutions.) The



unit consists essentially of a light source, an optical system, a galvanometer, a light-sensitive cell, and a mechanical stage for accommodating the plate.

General Electric Co., Special Products Div., Schenectady, N. Y.

Interstage Filters

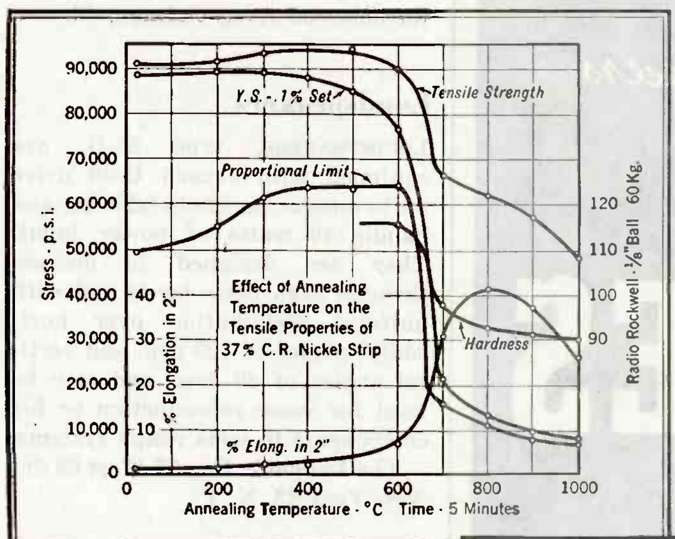
ILLUSTRATED IS a band pass unit (type BPI and BPL) which provides a 2:1 step-up ratio, with band pass attenuation of 40 db per octave. A dual alloy magnetic shield reduces inductive pick-up to 150 mv

RUGGED-

LIKE THE MEN WHO USE THEM

Radio transmitters and receivers are fine, sensitive instruments. • But they aren't delicate—at least not the ones in military service. • The terrific jolting and jarring received in tanks battling over desert terrain, and the tremendous strain encountered in bombers diving at enemy positions require radios that can really take it. And that's just what the U. S. Army Signal Corps and radio manufacturers have developed. • Such an achievement called for skillful design and construction, and *materials that can stand the gaff.* • Delicate elements in radio tubes are made of rugged, durable nickel. The following high mechanical properties of nickel account for its wide and successful use in tube elements.

STRENGTH AT ROOM TEMPERATURES—Strength properties of "A" Nickel can be altered over a wide range by rolling and annealing. However, for many radio applications a tensile strength of about 60,000 to 65,000 p.s.i. is desired in annealed nickel.

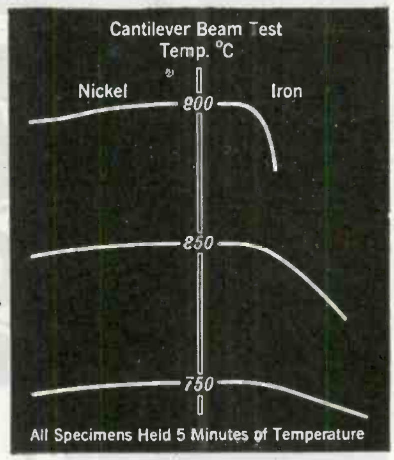


HIGH MODULUS OF ELASTICITY

Nickel's figure for tensile modulus (Young's) is 30,400,000 p.s.i. Assures minimum elastic displacement of tube elements. This, plus the high damping coefficient of nickel, aids in the war against microphonics.

STRENGTH AT HIGH TEMPERATURES

Tube parts of "A" Nickel give excellent results because of their strength at continuous elevated temperatures and withstand bombarding temperatures amazingly well.



STRENGTH AT ARCTIC TEMPERATURES

As temperatures fall, nickel increases in strength, but unlike many ferrous metals, does *not* lose its normal ductility and toughness as measured by Charpy impact tests.

MATERIAL	Condition	Temperature °F.	Yield Strength 0.2% Offset psi.	Tensile Strength psi.	Elongation in 2 in. per cent	Reduction of Area per cent	Hardness Rockwell	Charpy Impact Strength ft.—lb.
NICKEL	Cold-drawn	Room —110	97,400 101,800	103,400 112,300	16.3 21.5	66.9 60.9	19C 22C	204 215

For additional information and copy of the new booklet "The Properties of Pure Nickel," please write:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

NICKEL INCO ALLOYS

MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • "Z" NICKEL • NICKEL

Sheet...Strip...Rod...Tubing...Wire...Castings...Welding Rods (Gas and Electric)

per gauss. The unit is housed in a hermetically-sealed case. Dimensions are $1\frac{1}{2}$x$2\frac{1}{2}$x$2\frac{1}{2}$. Filters of this type can be supplied for any band pass frequency from 200 to 10,000 cycles. Type BPI has a primary impedance of 10,000 ohms to operate from the plate of a triode tube to a succeeding grid. The gain is approximately 2 to 1. Type BPL is designed to operate from a line impedance of either 500 or 600 ohms to the grid of a tube. The gain is about 9 to 1.

United Transformer Co., 150 Varick St., New York 13, N. Y.

Plastic Condensers

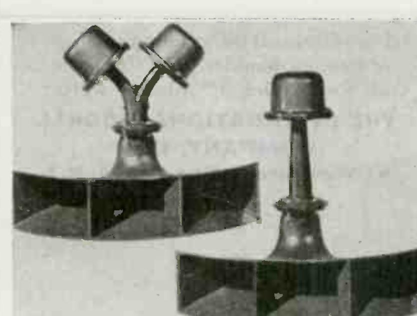
A COMPLETE NEW line of condensers, designated as Amcon plastic condensers, are now in production in limited quantities. The units come in all standard capacitance values and working voltages.

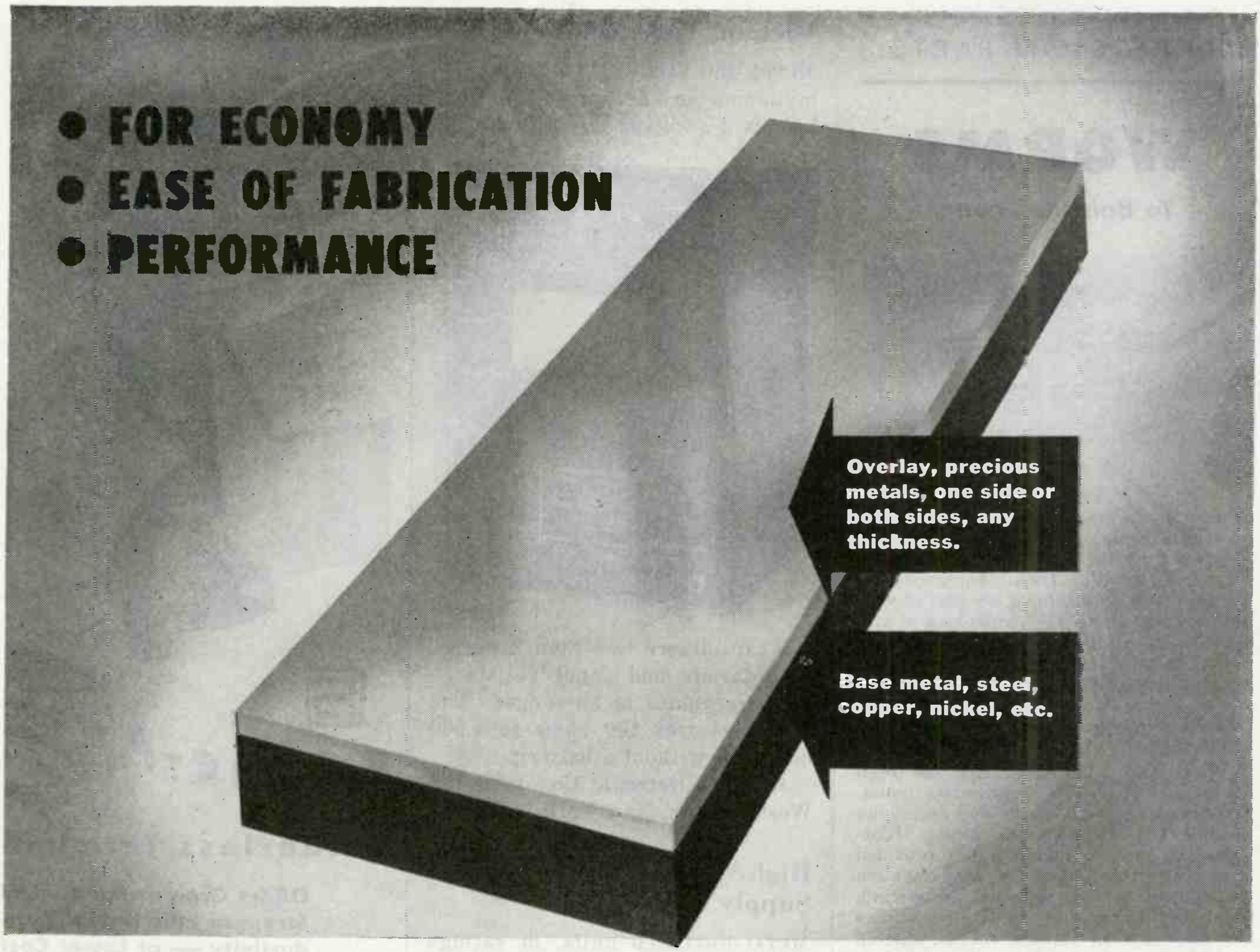
American Condenser Co., 4410 Ravenswood Ave., Chicago, Ill.

Loudspeakers

LOUDSPEAKERS, type 26-B, are equipped with Jensen U-20 drive units measuring 22x$14\frac{1}{2}$x20 in., and handle 40 watts of power input. They are designed to operate through high noise levels and with uniform distribution over horizontal angles of 120 deg. and vertical angles of 40 deg., and may be used for voice reproduction or h-f components to wide range systems.

The Langevin Co., 37 West 65 St., New York 23, N. Y.





INVESTIGATE *General Plate Laminated Metals*

For your Peace Products

No matter what your contemplated peacetime products . . . from peanut radar tubes to giant turbines, . . . General Plate Laminated Metals can offer you many worthwhile advantages from economy to better performance.

Made by permanently bonding precious metals such as silver, gold, platinum to inexpensive base metals, they are more economical because they give precious metal performance at a fraction of solid precious metal cost. The laminating process makes the precious metal harder assuring long life, while the base metal adds strength and workability.

Many base to base metal combinations which provide performance characteristics not found in solid base metals are also available.

Now, while your products are still in the design stages, is the time to investigate General Plate Laminated Metals. They are available in rawstock, inlaid or wholly covered or as fabricated assemblies. Write specifying your problems, and our engineers will make recommendations.

GENERAL PLATE DIVISION

OF METALS & CONTROLS CORPORATION

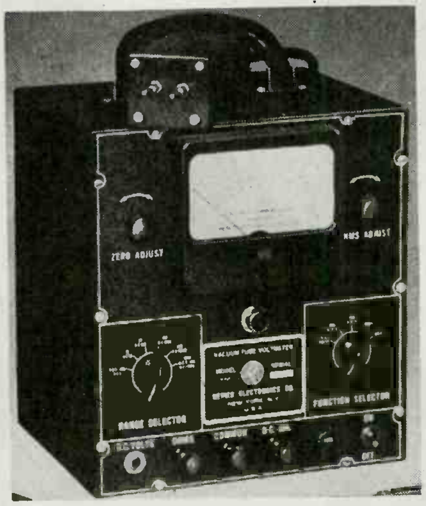
Metals and Controls Corporation Divisions manufacture the following products: Laminated & Solid Precious Metals, Electrical Contacts, Rolled Plated Precious Metals to Base Metals in all forms — Truflex Thermostat Metals.

ATTLEBORO, MASSACHUSETTS

50 Church St., New York, N. Y.; 205 W. Wacker Drive, Chicago, Ill.; 181 E. Main St., Centerbury, Ohio; 2635 Page Drive, Altadena, California; Grant Bldg., Pittsburgh, Pa.

Vacuum Tube Voltmeter

MODEL 450 VACUUM TUBE volt-ohm-milliammeter (50 cps to 500 Mc) has six d-c voltage ranges, with in-

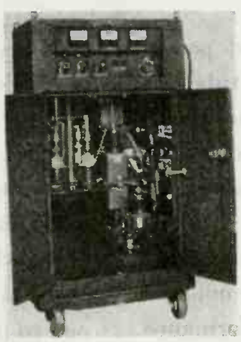


put capacitance less than 2 micro-microfarads and input resistance of 11 megohms in all ranges. The unit measures 100 ohms to 1,000 megohms without a battery.

Reiner Electronic Co., Inc., 152 West 25th St., New York 1, N. Y.

High-Voltage, D-C Power Supply Units

METAL-ENCLOSED units, in ratings up to 50,000 volts d.c., (the model illustrated is rated 27,000 v d-c, 100 milliamp) provide power for testing electric equipment. Each unit consists of a full-wave kenotron rectifier, a filter to limit voltage ripple to 1 percent or less, and



complete control equipment, dust filters and ventilators. Portable and units for built-in applications are available. Among the several safety features incorporated in the unit is an automatic solenoid-operated discharge switch. Complete information is contained in publication GEA-4317.

General Electric Co., Schenectady 5, N. Y.

ELCO meets the challenge of the Jungle with

FUNGUSIZED*

PRECISION *wire-wound* RESISTORS!

ELCO engineers not only met the new requirements of the U. S. Signal Corps, but exceeded them by several hundred percent. Further evidence of the way ELCO tackles a job.

ELCO *FUNGUSIZED RESISTORS are so treated to combat the destruction powers of parasitic organisms. They are made to stand up in stifling jungle heat and humidity.

IF YOUR RESISTOR SPECIFICATIONS CALL FOR ANTI-FUNGUS TREATMENT—*CALL ELCO*

***PROMPT DELIVERIES** as usual!*

SPECIFICATIONS:

"A-1"—15/32 long x ½" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 300,000 ohm value—½% standard accuracy—non inductive pie wound—½ 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.

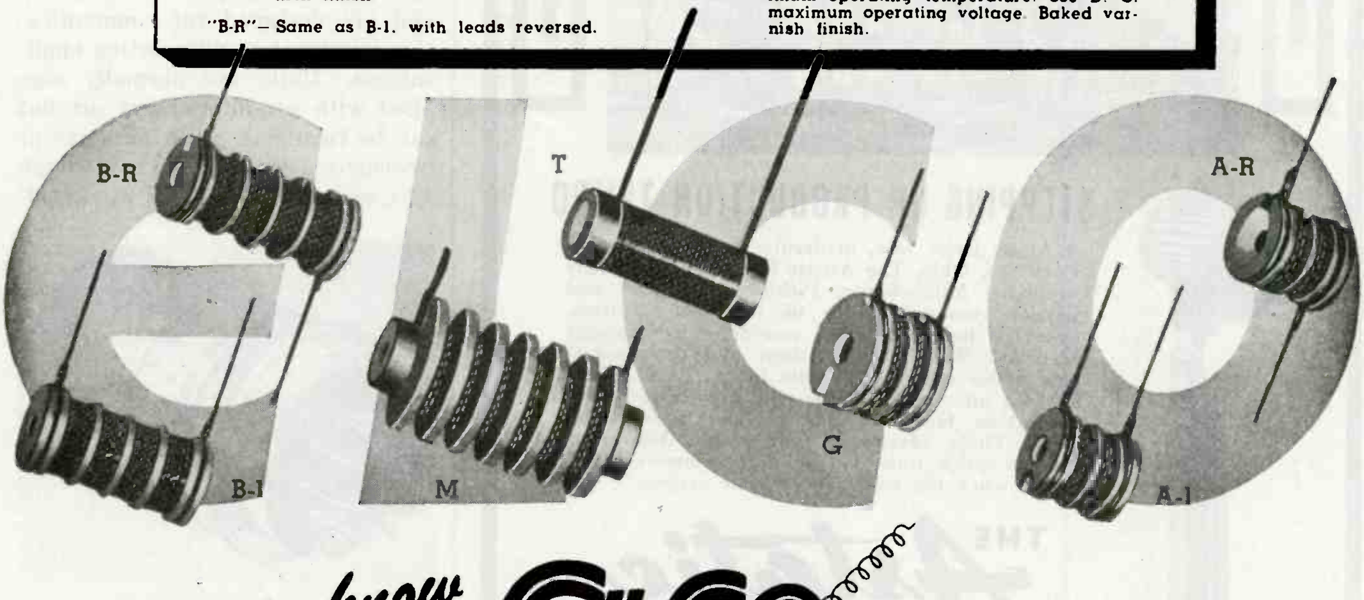
"B-1"—15/16 long x ½" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value—½% standard accuracy—non inductive pie wound—1 watt. 30° C. temperature rise in free air—100° C. maximum operating temperature—300 D. C. maximum operating voltage. Baked varnish finish.

"B-R"—Same as B-1, with leads reversed.

"T"—1-1/32 long x 7/16" dia.—Inductively wound—⅛ 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 ¼" dia.—Mountable with 6-32 screw—⅛ 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 ½" dia.—Mountable with 6-32 flat or filester head screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value. ½% 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.



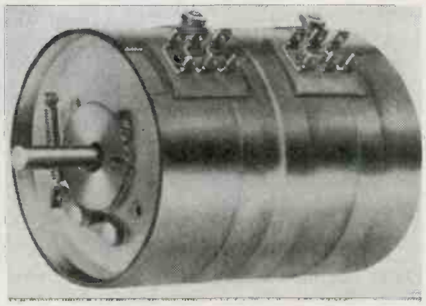
Get to know **ELCO**

RESISTORS COMPANY

114 West 18th Street, New York, N. Y. Telephone - Watkins 9-4774-5

Dual-Unit Attenuators

THESE UNITS incorporate improvements over the manufacturer's standard single unit attenuators, and are designed for applications in balanced H attenuators, special multi-circuit controls of potentiometer, T, Ladder, L, and rheostat

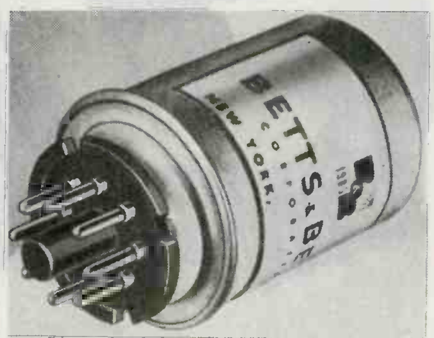


types. Electrical characteristics are the same as previous models. Improvements include separable coupling, improved shielding, a new detent device, certain stop, greater compactness, captive terminal board, anti-fungus treatment and silver alloy contacts.

The Daven Co., 191 Central Ave., Newark, N. J.

Corosealed Midget-Type Relays

COROSEALING IS the manufacturer's trade name for a new process of hermetically sealing electrical devices. These relays are corosealed and are designed for communication, electronics and aviation applications. Units are normally supplied with pre-filtered dry air but can be furnished with inert gas or pressurized content. They weigh 4 oz, and measure $1\frac{11}{16}$x$2\frac{7}{8}$ in. includ-

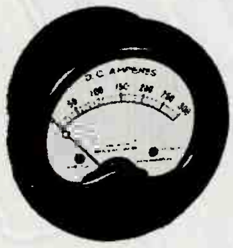


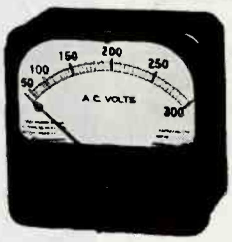
ing prongs. Coil winding can be supplied for voltage ranges from 1.5 to 70 v, d-c, and are wound to exact number of turns. Inorganic base plastic insulation minimizes high frequency loss and assures

"STEEL-SIX" Portable TESTING INSTRUMENTS

PANEL INSTRUMENTS

Included in the broad range of electrical instruments that bear the R-S mark are the 3.5" miniature panel instruments shown below. These are built in commercial types and to A.S.A. War Standard C 39.2-1944. Other R-S instruments include switchboard and portable types to meet practically every industrial, power and laboratory need. Let us quote prices and deliveries on your instrument requirements.





Roller-Smith "Steel-Six" portable testing instruments were designed primarily for general testing where a highly accurate, and moderately priced instrument is required. The rugged all-metal case is both dust- and moisture-proof and also furnishes full magnetic shielding of the movement. Large window openings combined with well-designed dials set exceptionally close to the front of the case afford unusual readability. Instruments are approximately 6" square by 4" in depth. Ratings cover a broad range of testing requirements.

"Steel-Six" testing instruments are supplied with single or multi-ranges for the measurement of direct current in amperes, milliamperes, volts and millivolts; for alternating current measurements of amperes, milliamperes, volts, watts, power factor and frequency. Catalog 4340 contains complete information. Send for a copy today.

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 permanent dielectric and mechanical strength. Contact arrangements are made to handle 2 amps at 100 watts.

Betts & Betts, 551 West 52 St., New York 19, N. Y.

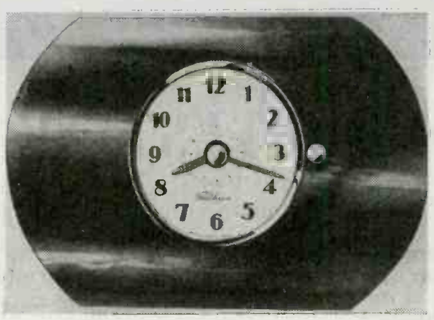
Microphones

SOON TO BE available in four impedances is Universal's new D-20 Series dynamic microphones which have a response of 50 to 8,000 cycles. Units housed in chrome-finished cases, with the manufacturer's new micro-adjust swivel, come supplied with dust-proof hoods, and 25-ft of cord. Production will be resumed on other dynamic microphone models including types KD and 15MM; the No. 200 Series and Types X-1 and XX.

Universal Microphone Co., Inglewood, Cal.

Home Radio Preselector

THE TELECHRON ALARM clock provides the basic mechanism for this new device for the radio industry which, by means of a front set knob, automatically turns on a radio set at a preselected time. It is operated by a 2-watt Telechron synchronous motor on a-c, and can be



furnished for 115-v or 220-v operation on any standard commercial frequency. The manufacturer, Warren Telechron Company (Ashland, Mass.) is prepared to cooperate with designers, engineers and manufacturers with respect to sizes and dial designs for the new unit.

Generators

AN ADDITION TO the line of Mag-Motor Series (described in October ELECTRONICS) are generators built with capacities up to 80 watts intermittent and 35 watts continuous duty, in a wide range of a-c and d-c

voltages. No motor is included. Drive is accomplished by direct couple, gear train or pulley. Each unit measures 5¾ x 3⁵⁄₁₆ x 2½ in. and weighs 4¾ lbs.

Carter Motor Co., 1608 Milwaukee Ave., Chicago, Ill.

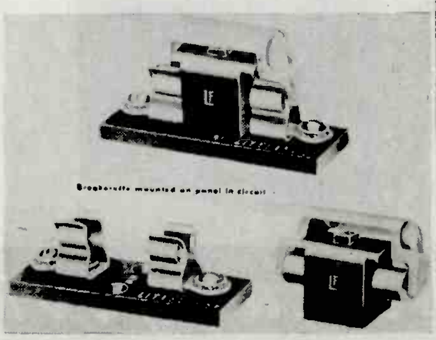
Terminal Blocks

TERMINAL BLOCKS (Bee type) will lock a wire to a wire without soldering or attaching terminals or lugs, or twisting wires around posts. A connector strip (available in Series A-200 with terminal posts staggered in V formation, and Series A-300 with terminals set in a straight line) consists of practically any desired number of terminal posts, each terminal post capable of handling from two to as many as eight wires in the smaller ranges. The binding post stud of each unit has a slotted channel which holds the wires firmly, in position, and without danger of loose strands getting away. Units are vibration, moisture and humidity proof. They are light in weight, and have an average contact resistance of 0.00031 ohm after 90 hours salt spray.

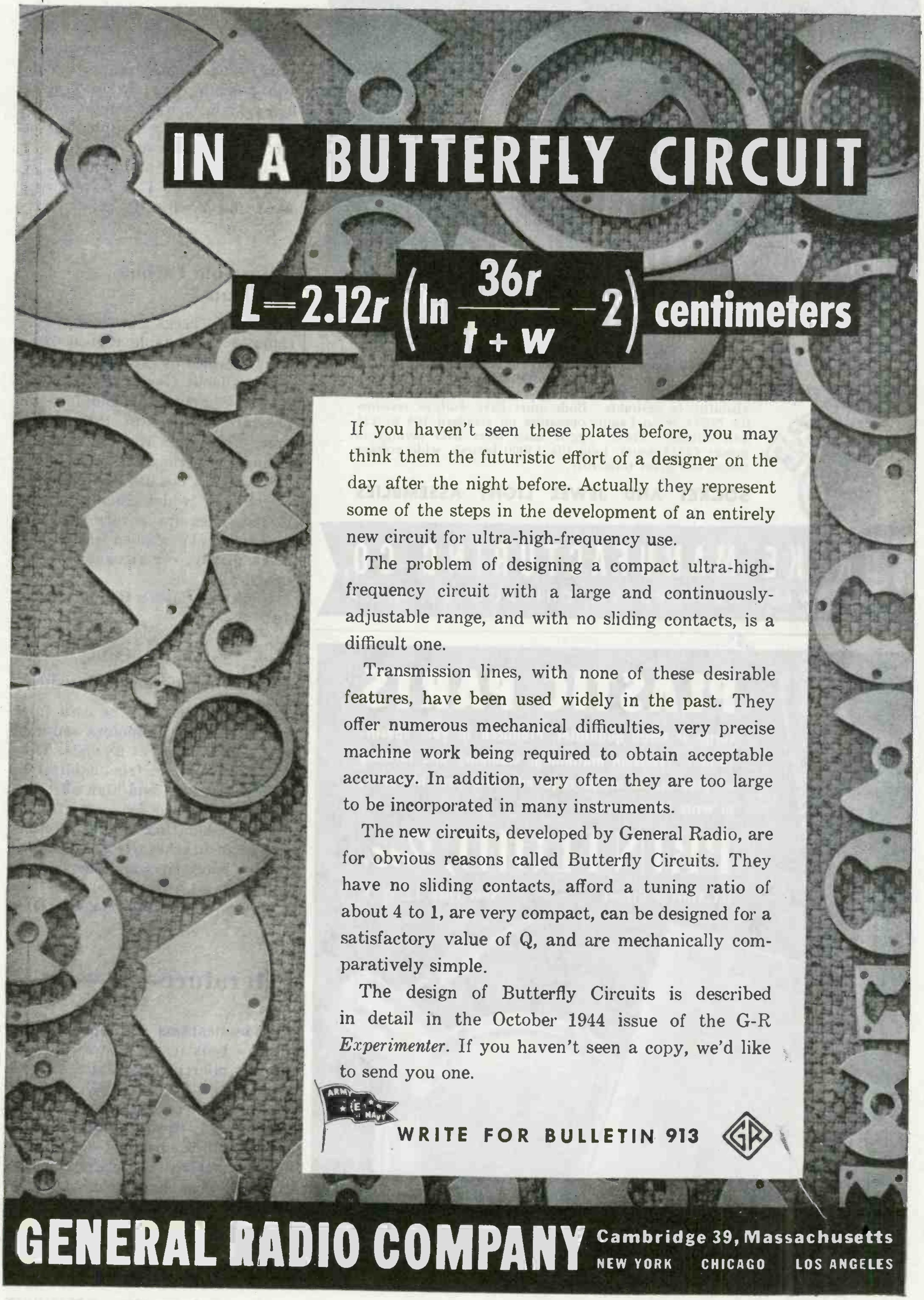
L. S. Brach Mfg. Corp., Newark 4, N. J.

Fuse

BREAKERETTE No. 1561 is a push breaker type, with only two moving parts, which provides reset protection in breaker form, is interchangeable with all 5 AG size fuses, or Navy midget size, and is rated 3 to 50 amps, 32 v a-c or d-c. It has snap action break, is capable of interrupting short circuits of 1000 amps in ratings up to 5 amps; and 2500 amps, in ratings over 5 amps. Other features include high time



Breakerette mounted on panel in circuit


IN A BUTTERFLY CIRCUIT
$L = 2.12r \left(\ln \frac{36r}{t+w} - 2 \right)$ centimeters
If you haven't seen these plates before, you may think them the futuristic effort of a designer on the day after the night before. Actually they represent some of the steps in the development of an entirely new circuit for ultra-high-frequency use.
The problem of designing a compact ultra-high-frequency circuit with a large and continuously-adjustable range, and with no sliding contacts, is a difficult one.
Transmission lines, with none of these desirable features, have been used widely in the past. They offer numerous mechanical difficulties, very precise machine work being required to obtain acceptable accuracy. In addition, very often they are too large to be incorporated in many instruments.
The new circuits, developed by General Radio, are for obvious reasons called Butterfly Circuits. They have no sliding contacts, afford a tuning ratio of about 4 to 1, are very compact, can be designed for a satisfactory value of Q, and are mechanically comparatively simple.
The design of Butterfly Circuits is described in detail in the October 1944 issue of the G-R *Experimenter*. If you haven't seen a copy, we'd like to send you one.
ARMY E NAVY
WRITE FOR BULLETIN 913
GR
GENERAL RADIO COMPANY
Cambridge 39, Massachusetts
NEW YORK CHICAGO LOS ANGELES

lag; construction which provides trip free, and non-trip free features; small size (extreme dimensions being 1⅞ in. long, ¾ in. wide, overall height with trip shield measuring 1¼ in.); light weight (15 to 18 gms.) The unit fits into clips on ⅞ in. spacing or more.

Littelfuse Inc., 200 Ong St., El Monte, Calif., or 4757 Ravenswood Ave., Chicago 40, Ill.

Adjustable Carbon Rheostats

MANY NEW TYPES and sizes of continuously adjustable carbon rheostats (formed of carbon disc piles) are available from this manufacturer. Simply by changing the pressure applied to these piles, every possible resistance value within their range is made available without opening the electrical circuits in which they are connected. Pressure to vary the resistance may be applied electrically, mechanically, centrifugally or hydraulically.

Stackpole Carbon Co., St. Marys, Pa.

Silver-Impregnated Brushes

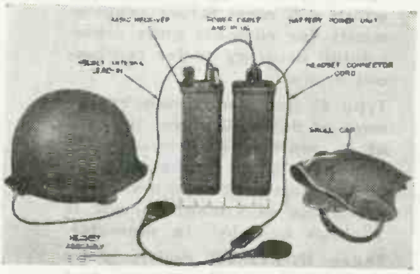
THESE BRUSHES may be used in 6-volt systems or in motors and generators operating at 28 volts. They are relatively free from oxidization at both sea level and high altitudes and are designed for long life and good commutation. Eight different grades of brushes are available, as well as many sizes and shapes.

Superior Carbon Products, Inc., 9115 George Ave., Cleveland 5, Ohio.

Literature

Communications Microphones. A 6-page booklet illustrates and describes microphones of the following types: Differential, lip-type model 245; hand-held model 205-S; hand-held carbon microphone, model 210-S; moving coil model 630-C; moving coil model No. 725 Cardak; and hand-held, dynamic model 600-D (which is described in this column in December). Electro Voice Corp., 1239 South Bend Ave., South Bend 24, Ind.

"The radio that told it to the Marines"



When the U. S. Marines stormed ashore in the South Pacific to get a situation well in hand, they received their orders by portable radio.

You can imagine the apparently impossible conditions under which such a radio receiver must operate: immersion, shock, heat, cold, storm — and Noise, with a capital N.

Emerson Radio and Phonograph Corporation designed the Marine "Raider" Receiver to withstand just such conditions. It is so compact that it leaves the operator's hands and arms free for action, and does not distinguish him from his companions as an especially inviting target.

The earphones are built into a fabric cap which fits into the metal helmet. The helmet is the antenna.

The pride which the Emerson people feel in this unique receiver is shared by the Wheeler Insulated Wire Company, Inc.

For we at Wheeler supply the wire for certain parts of this rugged little apparatus.

In our 35 years of wire-making experience, Wheeler Insulated Wire Company, Inc. has sold its entire output of quality products to comparatively few customers. *But they have been mighty good customers!*

We hope to introduce Wheeler products to many other companies in the electrical industries when wartime demand permits.

The Wheeler Insulated Wire Co., Inc.

BRIDGEPORT 4, CONN.

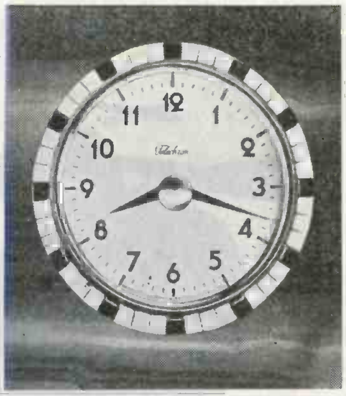
Manufacturers of Magnet Wire . . . Litz Wire
Coil Windings . . . Transformers

Federal Telephone & Radio Literature. This department, October, described five basic types of high frequency, solid dielectric cables. Two of these basic types are coaxial and dual cables. Now four separate catalog sheets are available which describe Intelin types K-45, K-45-A, K-48, K-49, K-49-A coaxial cables. Another catalog sheet describes type K-56 dual cables.

Other separate pieces of literature from this manufacturer describe the following: Type FTR-800 compact, high speed, automatic, multi-contact switch; a high-frequency, 20-kw international radiotelegraph transmitter unit; all-in-one marine units consisting of types FTR-105, FTR-106, and FTR-102; a booklet entitled "Some Federal Products for War and Peace" which describes products of the Federal Telephone & Radio Corp., Newark, N. J.

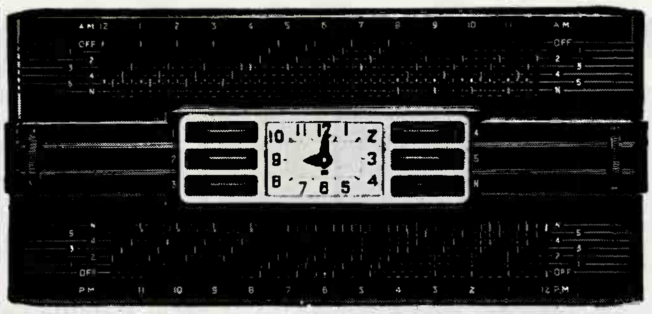
Industrial Newsletter. The American Industrial Newsletter is a set of pages stapled together. It is intended as a concise monthly report of industrial developments and serves as a reference manual for manufacturers and production engineers. It is published in three editions: domestic, British, and Latin-American. The contents includes such subjects as new products, manufacturers' bulletins, recent patents, and a listing of technical articles appearing in current American technical magazines. No price is given. Another feature of the newsletter is its announcements of manufacturers which includes notices by manufacturers who desire to establish agency representation or to license the manufacture of their products in Britain or in the Latin-American republics. American Industrial Newsletter, 8 West 40th St., New York 18, N. Y.

Tubes and Lamps Catalog. Nine types of electronic tubes are described in a 24-page catalog designated as Bulletin No. 202. These products include strobotrons for the study of reciprocating and rotating motion; Pirani and thermocouple tubes for measuring vacuum; voltage regulator tubes; facsimile tubes; germidical tubes; black light and near ultraviolet lamps. Technical sections giving specification,



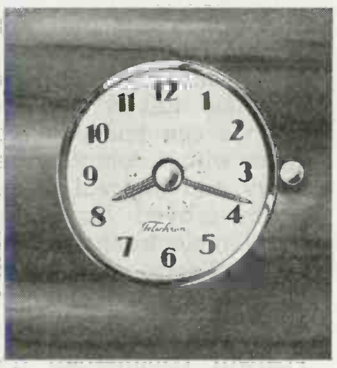
Telechron Timer C32

Offers complete automatic preselection 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.



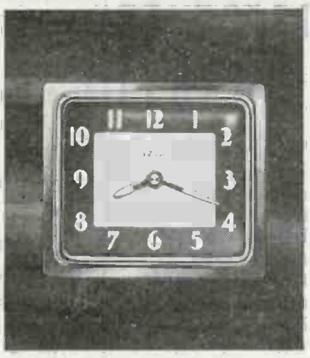
Telechron Timer 8009

A fully automatic radio timer, for use with receivers equipped with automatic tuning. Permits preselection of any one of 5 different stations. Operates the radio for any predetermined 15-minute interval over a 24-hour period. Selects stations automatically, and turns the radio on and off. For panel mounting.



Telechron Timer C40

Especially suitable for installation in low-cost receivers. Semi-automatic—turns the radio on at a preset time and enables user to be awakened by favorite program. Furnished in dial sizes and styles to meet requirements. For panel mounting.



Telechron Timer C37

A handsome Telechron Electric Clock, with rectangular dial. A built-in electric clock increases consumer acceptance of any radio—the Telechron name, added to your own, steps up the value. For panel mounting.

Profitable Telechron time

BUILT INTO ANY RADIO AT LOW COST

ELECTRIC TIME is a post-war radio must! Telechron offers a complete line of low-cost radio (and other home appliance) timers — each powered by a Telechron self-starting sealed-in-oil reservoir type motor — approved by the Underwriters' Laboratories. Telechron will gladly co-operate with manufacturers in designing special shapes, dials, hands and colors. Dials can carry manufacturers' imprint and Telechron trade-mark when specified. Give your low, medium or high priced post-war radio this big competitive advantage! Write or wire for information to Automatic Control Division, Dept. K.

Telechron
REG. U. S. PAT. OFF.

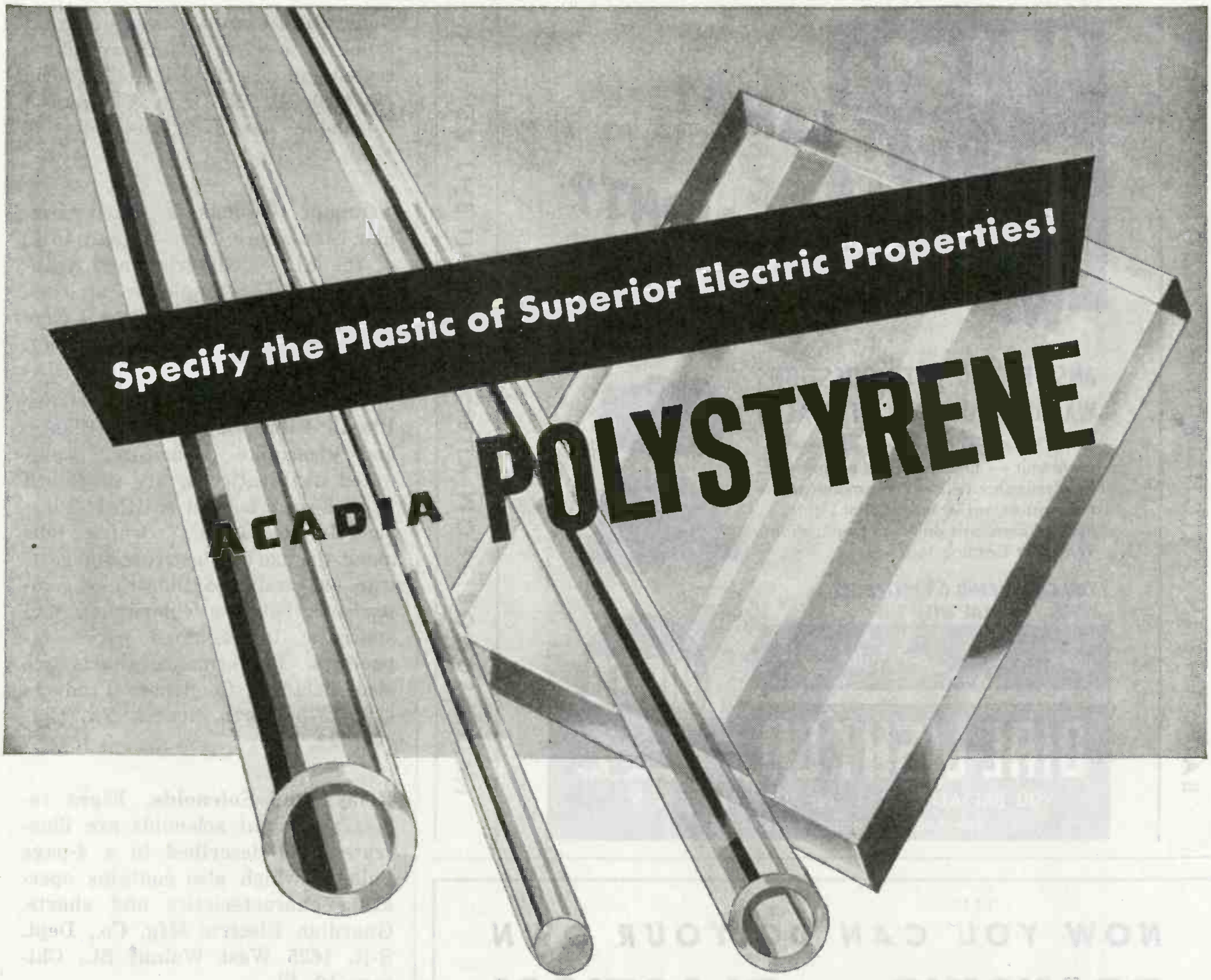
WARREN TELECHRON COMPANY • ASHLAND, MASS.

basic circuit diagrams and suggested applications for products and accessories are included. Fluorescent lamp characteristics are given in tabular form and curves. Sylvania Electric Products Inc., Special Products Div., 60 Boston St., Salem, Mass.

Non-Metallic Basic Materials. Bulletin GF-16 consists of 12 pages devoted to six non-metallic basic materials which include vulcanized fibre, a general purpose material; Dilecto, a laminated phenolic plastic; Dilectene, a synthetic resin containing no cellulose filling materials; Celeron, a phenolic impregnated fabric material; Micabond, for use in insulating parts and commutator rings; and Vulcoid, an intermediate insulation material. Continental-Diamond Fibre Co., Newark, Del.

Megatherm Heating. Literature on the subject includes one booklet entitled "Megatherm, High Speed Induction Heating" for case hardening, annealing, brazing and tempering applications. Another is entitled "Megatherm Electronic Heat" for surface hardening, brazing, soldering and annealing of metals; a third booklet is called "Megatherm, The Inside Story" and deals with dielectric heating for bonding of plywood and paper, molding of plastics and rubber, food dehydration, etc. Federal Telephone & Radio Corp., Newark, N. J.

Thermonic Dielectric Heating. Thermonic is the trade name for heat treating equipment and three separate booklets are available. The first is called "Thermonic" and it describes the fundamentals of induction heating, the thermonic method of induction heating, surface hardening, brazing, internal heating, heating of conveyor type fixtures. The second booklet called "Thermonic Dielectric Heating" illustrates and describes Model M200 and Model M700 dielectric generators and gives a brief on dielectric heating. The third pamphlet is a reprint of an article entitled "Short Waves and Transfer Molding" from Modern Plastics. The article refers to Model M200 generator. Induction Heating Corp., 389 Lafayette St., New York 3, N. Y.



Acadan "B"

Flexible at —100°F and has many of the electrical properties of Polystyrene. Ideal for numerous electrical applications. Write for information on forms now available, and data on physical and electrical properties.

Write Today

Send for complete data giving physical properties of Acadia Polystyrene, plus a table of specifications on its electrical properties.

• For any electrical application, Acadia Polystyrene is the outstanding plastic in the field. Combining highly desirable electrical properties, Acadia Polystyrene offers dielectric strength and power factor superior to any other commercial plastic, and comparing favorably with mica and ceramics.

Compression molded sheets of Acadia Polystyrene have properties superior to sheets fabricated by other methods — no shrinkage at normal temperatures — better heat resistance.

Consider also these additional values: zero water absorption; relative freedom from adverse effects by acids, alkalies, alcohol, stack gases, weather, etc.; an excellent dielectric constant value, and high tensile strength of 3500 to 5000 lbs. per sq. in. Add to these Acadia's wide experience in the plastics field, and you have the reasons why Acadia Polystyrene merits your investigation.

Complete details are available on request—for quick reference some of Polystyrene's outstanding values are given 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 .0008
Dielectric Strength, Volts/Mil 1/8" 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

ACADIA *Synthetic* PRODUCTS

Processors of Synthetic Rubber and Plastics • Sheets Extrusions • Molded Parts

DIVISION WESTERN FELT WORKS

LARGEST INDEPENDENT MANUFACTURERS AND CUTTERS OF FELT

4035-4117 Ogden Avenue • Chicago 23, Illinois • *Branch Offices in All Principal Cities*

BACK THE INVASION—BUY MORE BONDS NOW!

Generating Plants. Seven different types of electric plants are illustrated and described in folder form No. 690. D. W. Onan & Sons, 39 Royalston Ave., Minneapolis 5, Minn.

Trimmer Condensers. Mica trimmer condensers, types 45 and 46W, of the El Menco series, and available in either single or multiple mounting are described in a 4-page folder. The Electro Motive Mfg. Co., Willimantic, Conn.

Plastic-Film Capacitors. Plastic and glassmike capacitors, designated as Plasticons, are described in an 8-page booklet entitled "Plastic-Film Capacitors" which tells about the use of Plasticons for postwar use and also illustrates comparisons between chlorinated and synthetic impregnated paper capacitors. Performance charts are also included. Condenser Products Co., 1375 North Branch St., Chicago 22, Ill.

Relays and Solenoids. Eight relays and eight solenoids are illustrated and described in a 4-page bulletin which also contains operating characteristics and charts. Guardian Electric Mfg. Co., Dept. S-R, 1625 West Walnut St., Chicago 12, Ill.

Electronic Tubes. "Cetron Electronic Tubes" is the title of a general catalog on this subject. The many Cetron tube types are illustrated and described. Continental Electric Co., Geneva, Ill.

Revolving Field Generators. Series 667 and 670 revolving field generators in sizes 5, 10, 15 and 25 kw, 4 pole (1800 rpm) and in sizes 10, 15, and 25 kw, 6 pole (1200 rpm) are described in a new folder available from Kato Engineering Co., Mankato, Minn.

X-Ray Inspection Unit. A new 250-kv x-ray inspection unit for a wide range of inspection requirements is described in Bulletin No. 266. Kelley-Koett Mfg. Co., Covington, Ky.

Wallace & Tiernan Literature. A torsional relay for remote control and a constant speed motor mechan-

"COIL? ALBION CAN SHIP YOU ALL THE COILS YOU NEED."

SUPER-QUALITY COILS AT REASONABLE PRICES

More and more every day, the industry is turning to Albion for fast, quality and quantity production of coils, chokes, and transformers. That's because here you benefit from the unbeatable combination of management "know how," skilled workmanship, streamlined facilities, and central location. Your requirements will be given prompt and thoughtful attention.

ALBION
COIL COMPANY

ALBION, ILLINOIS

R. F. AND TRANSMITTING COILS AND CHOKES; I. F. TRANSFORMERS ism (for coding, keying, monitoring, programming and other timing applications) are described in two separate sheets. Wallace & Tiernan Products Inc., Belleville 9, N. J.

Vibration Control. Instrument panel shock mounts and radio equipment shock mounts are described and illustrated in a 16-page catalog entitled "Vibration Control" which also contains many performance curves. Robinson Aviation, Inc., 730 Fifth Ave., New York 19, N. Y.

Thermocouple Data Book and Catalog. This is the title of Bulletin No. S2.5 which contains 40 pages of descriptive material and is designed to serve as a manual for thermocouple users. Wheelco Instruments Co., Harrison & Peoria Sts., Chicago 7, Ill.

Electrical Instruments. Catalog No. 23 contains 42 pages of description of panel, aircraft, and portable meters, switchboard types and miscellaneous instruments manufactured by The Hickok Electrical Instrument Co., 10527 Dupont Ave., Cleveland 8, Ohio.

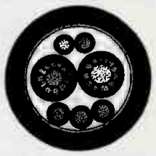
Molding Material. Chemaco polystyrene is a thermoplastic molding powder for use in injection and extrusion molding. It is described in a folder which also gives the formulae and colors available. Chemaco Corp., Berkeley Heights, N. J.

• • •

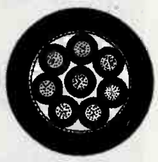
PARARADIO

A Number 22 Wireless set tucked in its container and ready for service with British airborne troops

Custom-Made Cables Available for You



B.I.W. *83-B

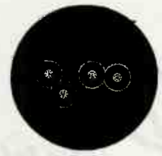


B.I.W. *44

B·I·W·

These special cables comprise the proper conductors, insulation, and shielding for particular war applications. Your product may require one of these cables. They are available for war use and can be manufactured to order for important peace time applications.

B.I.W. #49



B.I.W. #121

MULTI-CONDUCTOR FLEXIBLE INSTRUMENT CABLES

B. I. W. NO.	NUMBER AND SIZE OF CONDUCTORS
1	4#14,2#18
2	4#22,4#22S
3	2#16,3#22S,4#22
4	6#20
5	3#20,2#20S
6	9#22
7	1#22,4#22S
8A	2#22 IS
9	2#18S
10	16#20,4#20S OS
11	6#20,6#20S OS
12	19#20,2#10
13	7#22
14	12#22
15	19#22
16	27#22
17	12#23
18	2#14,3#20 IS
19	3#16
20	3#20,2#16,2#12
21	9#20,3#20S,4#16
22	4#20
23	3#8
24	2#8,4#16
25	4#16
26	2#16S
27	4#20,1#20S
28	2#20
29	8#20,1#16
30	9#20,2#20S,4#16
31	6#20,2#20S,3#16
32	3#16,2#8
33	3#20,2#12
34	4#20,1#20S,2#16
35	5#18
36	2#4,5#12
37A	1#20,2#16 IS
38A	4#18,2#18S IS
39	3#18 IS

B. I. W. NO.	NUMBER AND SIZE OF CONDUCTORS
40	14#22 IS
41	5#20 IS
42	4#18,2#12 IS
43	1#14S HV
44	6#18,2#18S IS
45	2#20 IS
46	5#20 IS
47	12#22
48	12#16
49	1#20HV,2#20
50	6#16 Triplets
51	21#16 Pairs
52	2#16 OS
53B	6#22,6#22S
55	2#20S,6#20, 2#16 IS
56	2#20S,10#20, 2#16 IS
57	2#20S,2#10,2#14, 9#20 IS
58	1#14,4#16,2#18 IS
58A	2#4,2#12,2#14,2#20 IS
59	(3#18)S,11#18 IS
60	15#20,3#16(2#20)S IS
61	3#16,4#20(3#20)S IS
62	7#20(3#20)S IS
63	2#10 IS
63A	2#12 IS
64	2#14,2#16,3#18,7#20
65	1#16,2#18,7#20
65A	1#16,3#20
66	9#20 IS
67	4#18,2#20S
68	6#18
69	5#22 IS
70	10#18
71	5#20
72	3#14
74	3#20,4#18,1#16,2#20S
75	8#14,12#16(2#18)S (3#18)S

B. I. W. NO.	NUMBER AND SIZE OF CONDUCTORS
76	4#14,10#16(2#18S) (3#18S)
77	3#20,4#14
78	6#22,3#22S
78E	3#14,6#22
79	5#20,3#14 IS
80	6#20 IS
81	2#18
82	1#12,4#16,2#18 IS
83B	2#4,5#12 IS
84	2#22S,2#16,2#18,29#20
85	6#16,6#18 IS
86	2#14,7#18 IS
87	(3#22)S(2#22)S,1#18HV, 7#20,3#16 IS
88	9#20(3#22)S IS
89	2#20,3#16,2#18(3#22)S IS
90	4#18 CoX,3#16S
91	(2#16)S(3#16)S,2#16S, 11#16,2#14
93	10#20,2#20S
94	2#16,7#20,(3#20)S
95	3#16
96	8#22,4#22S
97	7#20 IS
98A	2#4,3#12 IS
99	3#20
100	2#20 IS
100A	2#20 IS Heavy
101	1#16S
104	1#18S
110	8#18 IS
111	2#8
112	4#18 IS
116	3#16,8#22 IS
117	2x(2#18)S
118	12#16,3#10,3#6
119	2#16,2#10,3#6
120	4#6

B. I. W. NO.	NUMBER AND SIZE OF CONDUCTORS
121	2x(2#20)S
122	13#20,(3#22)S IS
123	3#20
124	10#22 OS
125	14#18
126	13#18 IS
127	4x(3x#18)S
128	(3#22)S(4#20)S(5#20)S
129	6#20,3#20S
129C	3#20,3#22S
130	3#14,6#20
131	4#20,2#20S
132	6#16
133	2#10 IS
134	1#18,6#20, 2#16 IS
135	2CoX,6#14,3#16,5#18 IS
136	(2#20)S,3#20S
137	2#10,2#18 IS
138	8#18 IS
139	1#14 H.V. IS
140	3#16 IS
141	10#22 OS
142	6#22 OS
143	3#22 OS
144	2#22 OS
145	6#20,3#20S
146	3#20,1#16,3#22S
147	3#18,2#14, 1#18HV IS
149	2#14
150	1#18 CoX IS
151	6#20,2#14
152A	4#20,2#14,2#18S
153	2#6,2#10,4#16
153A	5#18S
154	3#30,2#20S IS
155	2#8,3#16
156	6#12,2#12HV
157	1#16,2#16HV
158	10#16,2#16HV

B. I. W. NO.	NUMBER AND SIZE OF CONDUCTORS
159	2#16,5#20
160	2-70 ohmCoX,2(4#20)S
161	2#14,3#18
162	3#18HV,1#16S IS
162A	3#18HVS,1#16S
163	11#22(5#22)S IS
164	3#18(2#18)S
165	9#22
166	2(2#20)S(4#20)S
167	2#6,6#18
168	6#22 IS Armor
169	5#20
169A	3#20,2#20S IS
170A	2#12,5#16,5#16S
171	2#12,1#16,4#16S
172	2#20S
173	1#20,5#20S
174	8x(2#20)
175	3#16,3#14,2#10
177	2#20,6#16
178	4#18,2#16
179	27#22
180	5#18
181	1#10
182	2#18
183	5#18
184	3#14HV IS
185	4#8
186	2#14
187	4#16
188	2#14,4#16 IS
189	4#18 HV IS
190	3#16 IS Armor
191	5#16,27#22
192	6#16,2#16S
193	(14#22)S,4#22,3#18, 3#22S
194	4#12
195	4#22

SYMBOLS INDICATE: HV-High Voltage; CoX-Coaxial Line; S-following gauge Shield Over Conductor; ( )-indicates Grouped Conductors; IS-Inner Shield; OS-Outer Shield Covering.
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NEW BOOKS

Theory and Applications of Electron Tubes

By HERBERT J. REICH, *Professor of Electrical Engineering, University of Illinois, on leave to the Radio Research Laboratory, Harvard University. McGraw-Hill Book Company, Inc., New York, second edition, 716 pages, $4.50.*

FOR THE PRACTICING design engineer this compendium of practical tube theory stands out as a valuable reference book. The first four chapters cover the basic theory of electron-tube circuits. Aside from a chapter on conduction in gases, the remainder of the book deals with applications.

The chapters on amplifiers, already extensive in the first edition, are brought up to date. The chapter on modulation and detection has been greatly revised to include recent advances in circuits and circuit design analysis. The chapter on instruments and measurements comprises a short laboratory manual in itself.

Of growing interest are trigger and pulse circuits. This subject being Reich's special interest, his chapter is more complete than are comparable chapters in other works.—F. R.

• • •

Radio . . . Fundamental Principles and Practices

By FRANCIS E. ALMSTEAD, KIRKE E. DAVIS AND GEORGE K. STONE. *McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y., 219 pages, price $1.80.*

THIS tightly written volume is the first publication of a set of teaching notes used in high school, in evening classes for adults and in naval recruit training. It covers fundamental practices and principles of radio with a minimum of lost motion.

Text and diagrams have both had the benefit of six years of trial and experiment in actual use. They are closely keyed together by references, and diagrams are purposely schematic rather than pictorial so the student may become accustomed to dealing with standard symbols. While most users will be grounded in physics and algebra, nevertheless the work is so arranged that this background is not essential. Topics are all developed from the elementary concepts.

Subjects covered include: electron theory, energy and power, vacuum tubes, instruments, inductance, capacitance, resonance, coupled circuits, power supply, sound, receiver circuits, oscillator circuits, amplifiers, transmitters, wave propagation, antennas and transmission lines.

As a source for quick, clear, and simple descriptions, the book may have a utility besides its instructional one. For instance, the entire subject of television is covered in 35 lines of type.—F.H.

• • •

College Physics

By C. E. Mendenhall, A. S. Eve, D. A. Keys, and R. M. Sutton. *D. C. Heath and Co., Boston, Mass. 693 pages, price $4.00, 1944.*

Intended primarily as an introductory course in physics for college students, this book is a revision of an earlier text by three of the authors and is based on many years of teaching experience. Subject matter has been rearranged somewhat as a result of practical use of the earlier text and

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much new material has been added. Development in certain modern fields is presented with references to recent work in order to show what physicists are trying to do and how they are doing it. Mathematical requirements are minimized but a moderately analytical approach is used to stress quantitative aspects of the subject. Typical graded problems at the end of each chapter enable students to test their knowledge.

The book is divided into six general subjects: mechanics, sound, heat, electricity and magnetism, light, and atomic physics. The 56 chapters are subdivided into 500 consecutively numbered titles. A chapter on radio briefly treats the electronic field, with descriptions of vacuum tubes and how they operate, the meaning of radio terms, how radio waves travel, photoelectricity, piezo-electricity, and the electron microscope.

The material is presented attractively and includes nearly 600 illustrations and diagrams, which do much to clarify the subject and add to the interest.—M.G.V.

• • •

Radio's 100 Men of Science

By ORRIN E. DUNLAP, JR., *Harper & Brothers, New York 16, N. Y., 1944, 287 pages, $3.50.*

THERE IS LITTLE WRITTEN on the contributions to radio of its great men from the personal viewpoint. The author—publicity director for RCA—by outlining the lives and inventions of pioneers in radio attempts to fill this gap. In addition to an introductory chapter on the genesis of radio, the book is divided into two parts, the first covering electrical pioneers, the second, radio pioneers most of whom are contemporaries (45 in all are still living). There is an interesting insert containing portraits of 96 of the men covered in the text. The selection of the 100 men is a difficult task excellently executed.

The inclusion of men noted chiefly for their contributions to radar, such as A. H. Taylor, R. A. Watson-Watt, Irving Wolff and R. H. Varian, attests to the up-to-dateness of the selection of men. Interesting also, and perhaps puzzling to many, is the inclusion of Harold DeForest Arnold, 1833–

1933, who produced a higher-vacuum tube than DeForest; the author tantalizingly omits explaining the source or significance of this man's middle name.

To the experienced engineer reading to augment his knowledge of his colleagues the popular treatment of technical material and the necessarily brief biography of each man may be disappointing. The layman and embryonic engineer will find this book more interesting, and can fill out the material which it presents by following the footnote clues to more detailed books about those men in whom he becomes particularly interested.—F. R.

• • •

Electronics for Boys and Girls

By Jeanne Bendick. *Whittlesey House, New York, N. Y., 1944, 148 pages, price $1.50.*

THOSE ACCUSTOMED to taking their electronic reading neat may experience some shock at a statement like: "Most electron tubes are vacuums. A vacuum is a space in which there is no air at all. Of course it must be inside of something or air would keep rushing in to fill it. An electric light bulb is a vacuum and so is a radio tube. But a radio tube is an electron tube, and an electric

• • •

BRITISH PLANE TALK

At isolated Fleet Air Arm airports, the traffic of planes onto and off the runway is directed from camouflaged trucks stationed at the end of the runway. In the photo above, a WREN flashes Aldis lamp signals to an outgoing pilot, and can also use radio equipment to communicate with the pilot and control tower


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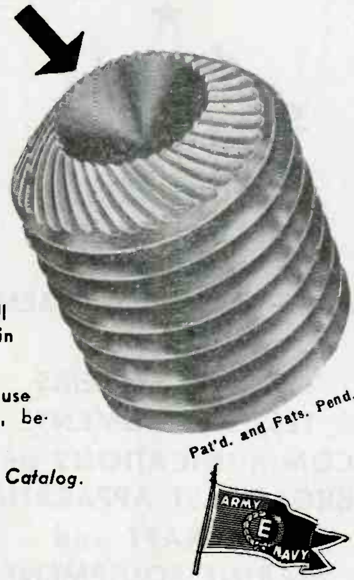
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light bulb is not". However, the boys and girls to whom this volume is addressed may very well find their understanding of the electron art advanced by descriptions of that sort.

The work is lavishly illustrated by cartoon-type drawings which show electrons as animated arrowheads derived from their orbits and performing their tasks in such an anthropoid manner as to make the author say, "...electrons have no minds of their own and go obediently where they are pushed or pulled".

Chapters cover the basic description of an electron, the 2600-year history of electricity, the 50 years of development of electronics, notes on waves, what electron tubes do, the ubiquity of electronics, its utility in industry, electronic policemen, guards for health, electronics in science, entertainment, war, and the future.

In general, the subject suffers little in accuracy from the popularization it has undergone, although there are a few misleading analogies and unfortunate choices in the use of terms. Presumably anachronisms like the illustration of Fleming's valve and De Forest's first grid-containing tube in modern pinch-top envelopes will be lost on the teen-agers for whom the book can be recommended as an introduction to the subject of electronics.—F. H.

• • •

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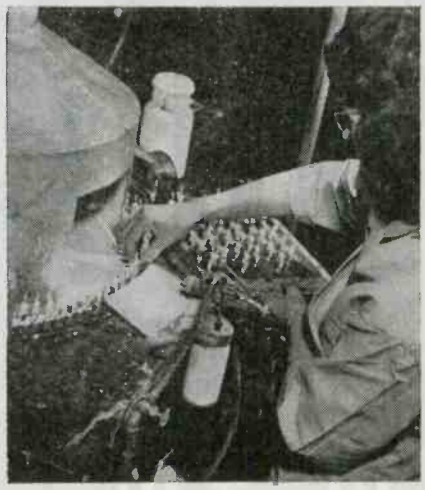

Filaments for electronic tubes are placed in a rotating rack at North American Philips plant. The operator sprays them with an insulating coating and they then pass into an oven to be baked

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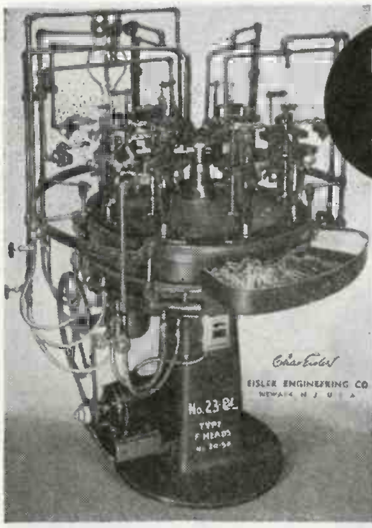

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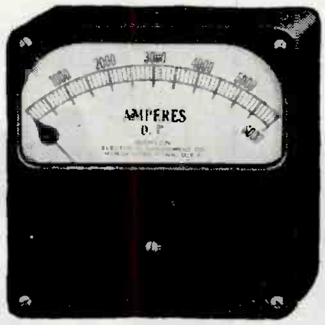

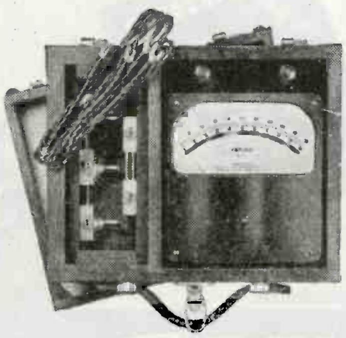

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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronic industry or comment on articles which ELECTRONICS has published.

Shortnin' the War

Dear Mr. Henney:

I WAS QUITE DELIGHTED to learn in your August issue, under Cross Talk, that Mr. Craig Walsh was using Crisco to flow electro-tin plating. I personally tried the process, and found that at 250 deg C this was very true. Another kitchen product, Spry, also worked, and I tried a third, a mineral oil—Nujol. The Nujol worked, but not as well as the Crisco or Spry, and the temperature had to be watched because of flash-over of the oil. The Nujol flashed at a lower temperature than the Crisco.

The reason for this letter is to reiterate former statements of mine, that regardless of how busy we so-called engineers are today, we should always take time out to glance through an excellent publication like ELECTRONICS. This little short-cut to electro-tin plating, will, in turn, be a short-cut to the end of the war, in a meager sense, as it facilitates our production. I hope this item may be of interest to other men in the electronic field.

DON FOSTER
A. P. Foster Company
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• • •

On Support for Hams

Dear Mr. Henney:

MR. WARNER has seen the August issue of ELECTRONICS and asked me to express his personal appreciation in addition to the thanks of the ARRL for your testimony in behalf of the radio amateurs. (*Cross Talk*) While the great value of amateur radio to the nation is generally recognized throughout the industry and various government agencies, only too seldom does it receive public acknowledgement. It is all the more encouraging therefore when

such support comes from a publication with the prestige of ELECTRONICS.

It is true that many amateurs are worried about the future but in every case where we have attempted to discover the reason for this alarm it has been proved to be without foundation. To the best of our knowledge no individuals or organizations of any standing have suggested eliminating or seriously curtailing the amateur service. If you can inform us of any specific threats to amateur radio, based on evidence more positive than those rumors of which we are all aware, we will be most grateful for your assistance.

CYRUS T. REED, W9AA
Assistant Secretary
American Radio Relay League
West Hartford, Conn.

• • •

More Heat Flow

Dear Sir:

I HAVE READ with considerable interest the article by Linvill and Hess in your June issue. They discuss a very interesting application of the electric-analogy method for studying transient heat flow problems. The idea of analyzing heat flow problems by means of electric analogy is itself not new. For steady-state Langmuir[1] has published a solution as far back as 1913. For transient operation C. L. Beuken[2] has published work in 1937 and since then a number of publications have appeared in this country based on work with the heat and mass flow analyzer at Columbia University since 1941.[3]

The work by the authors is based on the same principles as the heat and mass flow analyzer at Columbia University, the difference being that the authors use very low time constants and very short times for their experiments, whereas in the heat and mass flow analyzer large time constants are used.

The method with low time constants is less expensive in resistors and capacitors but calls for more expensive control circuits, particularly if problems have to be solved in which boundary conditions and/or thermal properties are not constant. In such a case operation with short times makes it necessary to devise more or less complicated circuits to yield within the short time

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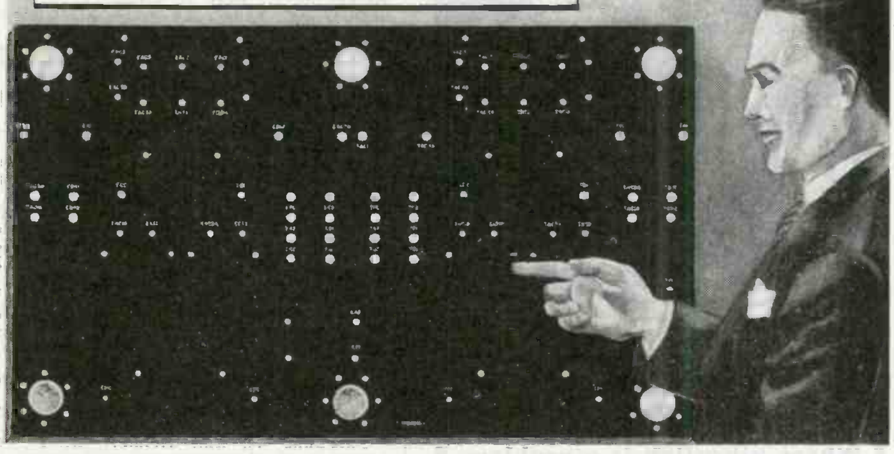

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1606 Milwaukee Ave. Carter, a well known name in radio for over twenty years. Cable: Genemotor of experiment the desired changes, whereas the heat and mass flow analyzer operates in sufficiently long times to permit the change of these conditions either manually or by simple mechanical devices.

The short time operating device as described by the authors has its main merits if the same type of problem with only very minor changes in conditions has to be investigated over and over again.

VICTOR PASCHKIS
Research Associate
Columbia University
New York 27, N. Y.

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• • •

Department of Rectification

Dear Sir:

THE ARTICLE by Mr. Richard W. Crane in the September issue entitled "Influence of Feedback on Source Impedance" contains two errors which the writer feels should be corrected.

First, Mr. Crane makes the statement that the commonly used phase-invertor, in which the load impedance is divided between the plate and cathode circuits, does not give perfect phase inversion due to the difference in source impedance seen in looking back into the plate and cathode circuits. It can easily be shown as follows that the voltages appearing in the plate and cathode circuits are equal in amplitude and opposite in phase provided the load impedances are equal.

In Fig. 1(a) is shown the circuit in question—simplified to indicate a-c components only. The load impedances in plate and cathode circuits are made different to give the

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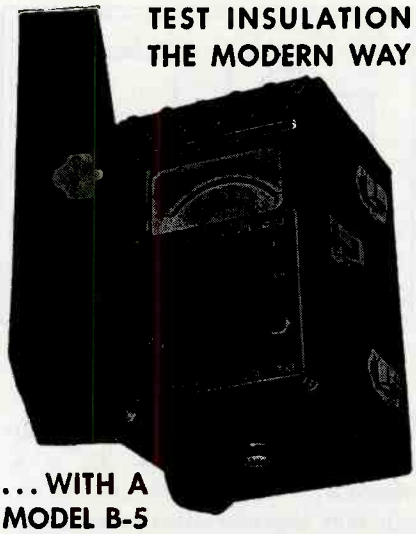

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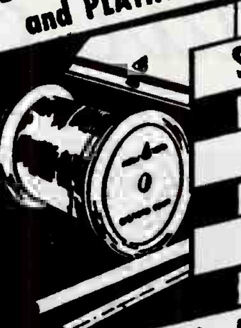

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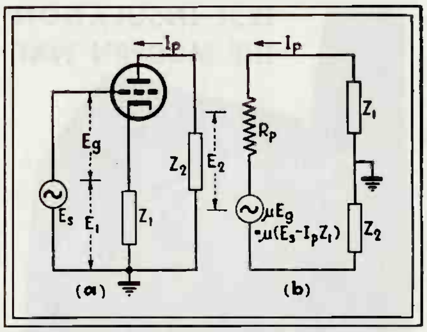

FIG. 1—Circuit of phase inverter, (a) simplified to indicate only a-c components, and (b) in equivalent form

most general case. The grid voltage is, of course, $E_g = E_s - E_1$ where $E_1 = I_pZ_1$. An equivalent circuit may therefore be drawn as per Fig. 1(b). Solving for the a-c plate current gives

$$I_p = \frac{\mu E_s}{(1+\mu)Z_1 + Z_2 + R_p} \qquad (1)$$

The cathode load voltage is

$$E_1 = \frac{\mu E_s Z_1}{(1+\mu)Z_1 + Z_2 + R_p}$$

and the plate load voltage is

$$E_2 = \frac{\mu E_s Z_2}{(1+\mu)Z_1 + Z_2 + R_p}$$

The two voltages are, of course, equal in amplitude and phase if $Z_1 = Z_2$.

This result could have been seen directly from Fig. 1(a) since I_p is common to the plate and cathode circuits and E_1 must equal E_2 if Z_1 equals Z_2. It was this point that Mr. Crane missed. The effect of the difference of source impedance is to make the variation of I_p (and therefore E_1 and E_2) with Z_1 different from the variation of I_p with Z_2.

Taking the partial derivatives of (1) with respect to Z_1 and Z_2 gives

$$\frac{\delta I_p}{\delta Z_1} = -\frac{(1+\mu)\mu E_s}{[(1+\mu)Z_1 + Z_2 + R_p]^2}$$

and

$$\frac{\delta I_p}{\delta Z_2} = -\frac{\mu E_s}{[(1+\mu)Z_1 + Z_2 + R_p]^2}$$

which shows that the rate of change of I_p with Z_1 is $(1+\mu)$ times as great as the rate of change of I_p with Z_2.

The second error in Mr. Crane's article is in the method of obtaining the grid bias shown in his Fig. 3, 4 and 5. With the circuits shown, the feedback obtained will not be that given by the equations associated with the various figures. In fact, as drawn with the grid-ground circuit open, no feedback exists in any of the circuits since the grid and cathode must obviously be at the same potential.

Of course, in a practical case

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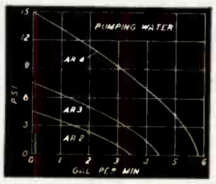

Performance up to 11 P. S. I. and up to 5 gallons per minute. Models are available in standard 12 and 24 volt D. C. ratings. Shown are performance curves for the AR2, 3 and 4. All models have long life and are rated for continuous duty with the exception of model AR4, which under 8 P. S. I. is rated for intermittent duty. While the curves shown are those for which production is now standard, it is readily possible to obtain other characteristics where quantity is involved.

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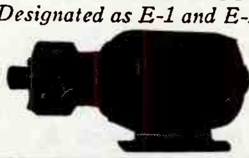

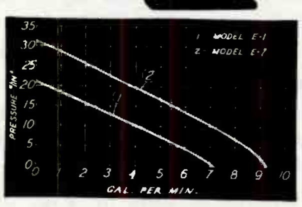

Both are centrifugal pumps, powered by General Electric Universal Motors. Model E-1 is 7" x 3⅜" x 3⁹⁄₁₆". 1/15 H. P., weighs 6 lbs. and has a Maximum Pressure of 20 lbs. P. S. I. with a Maximum Capacity of 7 G. P. M. Model E-7 is 9" x 4" x 4", ⅓ H. P., weighs 8 lbs. and has a Maximum Pressure of 30 lbs. P. S. I. and a Maximum Capacity of 9 G. P. M. Performance curves for both models are shown above. Both of these models are designed for long life. They are equipped with mechanical rotary seals which completely seal the pumps against leakage. While the curves shown are those for which production is now standard, it is readily possible to obtain other characteristics where quantity is involved. They can be obtained with motors to meet Navy Specifications.

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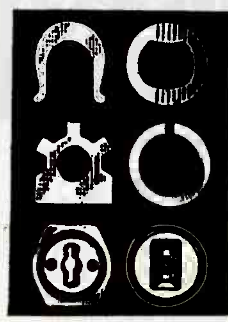

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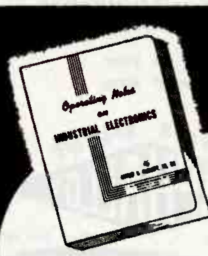

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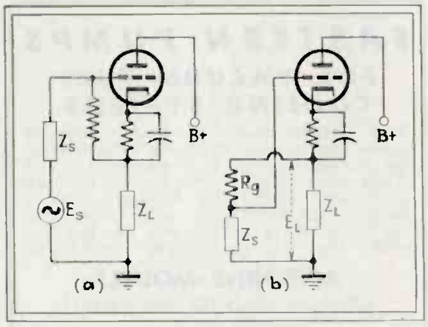

FIG. 2—Representation of Fig. 5 from reference article, (a) with signal source indicated, and (b) rearranged to show disposition of voltage across the load

these circuits are always excited from a source having finite impedance. Figure 2(a) is Mr. Crane's Fig. 5 with the signal source indicated. Rearranged as Fig. 2(b) it is plain that the full voltage across the load is not applied to the grid of the tube and β does not equal -1 as Mr. Crane suggests.

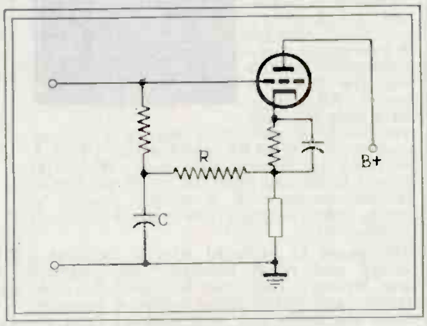

FIG. 3—Suggested arrangement for isolating grid and cathode circuits without disturbing correct bias

The actual value of β is $-R_g/R_g + Z_s$. If Z_s is the paralleled plate and load resistance of a pentode tube it may approach R_g in value in which case $\beta = -0.5$. For β to equal -1 the grid circuit must be isolated from the cathode circuit. To do this and keep the bias correct the grid resistor can be returned to a positive voltage of the correct value or the circuit of Fig. 3 can be used in which the reactance of C is small compared to R at the lowest frequency to be passed.

J. H. PRATT
RCA Victor Co., Ltd.
Montreal, Canada

Dear Mr. Pratt:

YOU ARE ABSOLUTELY right about the phase-inverter circuit giving perfect inversion if the two load impedances are equal, and I was wrong. The two loads are, in effect, in series across the generator, and

if equal must develop equal output voltages, even though each load sees a different source impedance. Low values of load impedance should be used, however, to minimize the effect of the input capacitance of the next stage on the high frequency response.

As to the method of obtaining grid bias in my Fig. 3, 4, and 5, the circuit you show in your Fig. 3 is the theoretically correct one and the one I should have used. In most practical applications, though, the circuits as I have drawn them will give very satisfactory results since the value of the grid resistor is usually many times that of the plate and load resistances of the previous stage in parallel. In Fig. 3 and 4 the reduction in the amount of feedback obtained by using my grid bias arrangement is an advantage rather than a disadvantage, and in Fig. 5 even if β is not quite equal to -1 the source impedance will still be extremely low.

Thank you for bringing these errors to my attention.

RICHARE W. CRANE
Concord, N. H.

• • •

Pi-Network Comments

Dear Sir:

THE ARTICLE in August ELECTRONICS (page 140) on Pi Networks is very interesting. It, however, contains what I think is an error. The condition for resonance, $X_L = X_T$, requires that

$$\sqrt{R_G R_A - X_L^2} = 0.$$

This substituted in Eq. (1) gives $X_L = X_T$.

But the condition for eliminating the output capacitor X_o is

$$R_A = \sqrt{R_G R_A - X_L^2}$$

Therefore, at resonance R_A equals zero. Since R_A is one of our objectors we cannot start with conditions that only obtain for a zero value.

This is a useful and valuable article provided these basic calculations are correct. I would like very much to know if I have overlooked something or if this *is* an error.

MONTAGUE FERRY
Haverford, Pa.

Dear Mr. Ferry:

THE CONDITION which you noticed, and of which I was not previously aware, is caused by Eq. (5). This equation is that of a series, and not a parallel resonant circuit. How-

ever, it is so nearly exact for the usual circuits dealt with at radio frequencies, that I, as many others have done, used it without explaining that it was only an approximation.

Equation (5), exactly stated, should read $X_T = X_L + R_G^2/X_L$.

When this is substituted into Eq. (1), R_A will not assume a value of zero. An exact statement of Eq. (7), then, would be $R_G = X_L^2/R_A + R_A$.

If you will use this, rather than the approximate equation given, the difference in the answer found will be but 1 part in about 100, which is beyond the possible accuracy of the measurements being made.

FREDERIC D. SCHOTTLAND
Kew Gardens, N. Y.

• • •

Notes on a Transitron

Gentlemen:

IN REFERENCE TO ELECTRONICS for March, I am interested in constructing a transitron oscillator of the type described by Mr. Newitt in Fig. 5 of his article, but with a much lower frequency range, and would like to obtain data on the values of resistance and capacitance required. In Fig. 5 he specifies the values of R and C for a frequency range of 7–26 kc. My plans are for a frequency range of 50–1000 cycles and for square, isoceles, sawtooth, and sine wave forms.

I have set up the circuit with many different combinations of resistance and capacitance values according to transitron formulas but have been unsuccessful so far in obtaining the correct values, and, therefore, will appreciate any possible assistance.

L. C. EDWARDS
Assistant Engineer
Bureau of Tests & Inspection
Pacific Gas & Electric Co.
Emeryville, Calif

Dear Mr. Edwards:

I HAVE YOUR LETTER to Mr. Henney regarding your circuit troubles with the transitron. The values on the accompanying schematic will give you a sawtooth waveform at approximately 30 cps which is just below the lower end of the range you desire. This will give you the correct starting point, and if the suggestions as given in my article are followed you shouldn't encounter any trouble producing the

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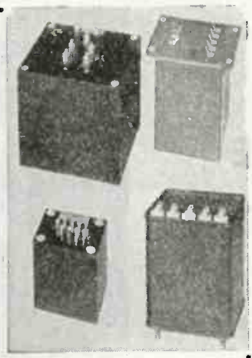

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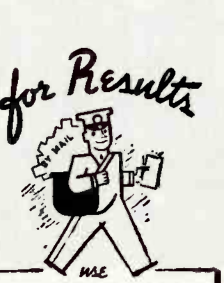

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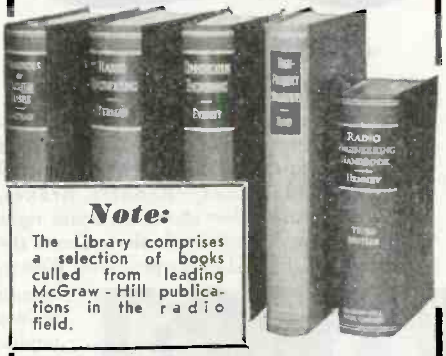

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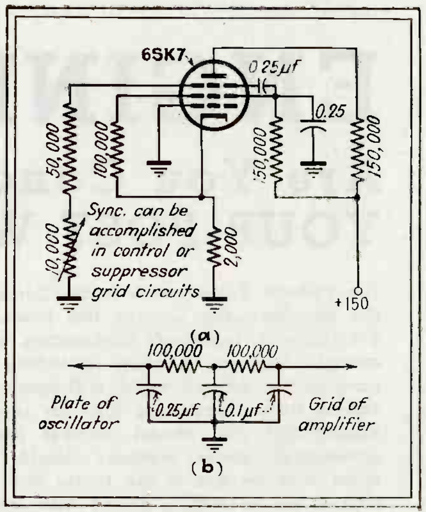


Oscillator values for a transitron to produce a sawtooth wave at about 30 cycles. Synchronization can be accomplished in either the control- or suppressor-grid circuits, (a). A sine wave filter for 30-60 cps is shown in (b)

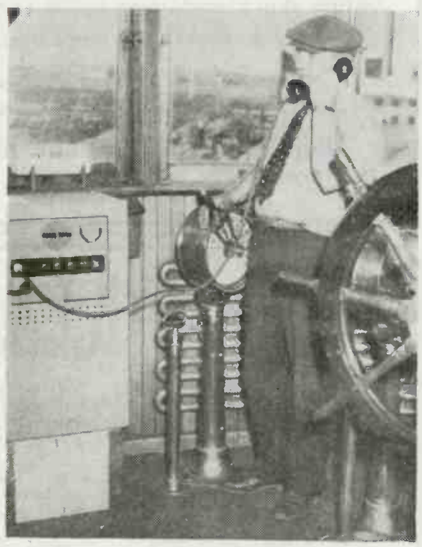
waveform and range you desire.

As mentioned in my article, it is not possible to preserve one particular wave shape over a wide frequency range without complex control of the circuit. Sine waves of low frequencies are more easily produced with the phase-shift type of oscillator, although it cannot be synchronized.

I should like to know how you make out with your experiments. The enclosed circuit has been used successfully to produce isoceles

• • •

RADIO ON FERRY



On the Great Lakes, acting captain Walter Dummer of the car ferry, S.S. Madison, talks to the Port Washington, Wisc., station of Lorain County Radio Corp. using f-m equipment developed by G-E engineers

waveforms at 30 cps and sine waves were derived from the filter shown. We therefore have a system of producing a sine wave oscillation that can be synchronized over a considerable (2:1) frequency range; something that cannot be done with conventional sine wave oscillators.

J. H. NEWITT
Federal Tel. & Radio Labs.
New York, N. Y.

• • •

Whither Away?

Dear Mr. Henney:
REGARDING THE ITEM in *Cross Talk* for August, about public credit for engineers, no one quick answer can suffice, but—chemists are not disturbed about being proficient in chemistry. By contrast, electrotechnicians are torn between interest in techniques and the feeling that they should succeed in the business world.

Chemists do have an unconscious arrogance regarding their techniques which other applied scientists could do well to investigate. They are not backward about stating their importance to business, industry, and management. Other technicians are tempted to explain why they are not sales managers or vice presidents-in-charge-of-advertising.

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This growing company has a well-established peacetime product sold internationally, and several other big postwar projects including one in the business machine field with large postwar market. Now working on war contracts of highest urgency.

Our Chief Engineer must have a broad manufacturing background and experience in design, engineering, processing and tooling for electrical manufacture and assembly.

If you have such qualifications, please apply . . . if you haven't, please don't. However we need several more electrical and mechanical engineers (preferably under 40) who need not have such broad experience. We shall be very glad to hear from these.

WRITE TO W. E. DITMARS, President, telling your experience, background and qualifications in detail, and salary expected. Your letter will be treated with complete confidence by Mr. Ditmars and no further investigation will be made without your express permission.

THE GRAY MANUFACTURING COMPANY
16 Arbor Street, Hartford, Conn.

We need a
RADIO COST
ESTIMATOR:

A shrewd analyst to derive cost from blueprints and assemblies of home radios. Postwar program in offing. Must know modern fabrication and operation throughout machine shop and assembly, and be familiar with writing operation and process sheets.

MAGUIRE INDUSTRIES, INC.
Electronics Division
342 W. Putnam Ave., Greenwich, Conn.

ELECTRICAL DRAFTSMAN

Permanent position in century-old manufacturing company. Minimum of two years experience in electrical drafting in industrial construction. Prefer one who has had limited experience as an electrician.

ANSCO
BINGHAMTON, NEW YORK

WANTED
Radio or Electronic
ENGINEER

For design and development of Army-Navy Electronic Equipment. The position offers an excellent opportunity with a well-established and expanding company in Connecticut, employing over 100 personnel. The company's big postwar program in the industrial electronics, audio and aircraft communication fields assures a continued opportunity to engineering personnel for advancement.

P-743, Electronics
330 West 42nd St., New York 18, N. Y.

SENIOR RADIO ENGINEERS

Project development engineering positions open with excellent postwar future assured. Salaries open. Confidential inquiries respected. International Detrola Corporation.

P-734, Electronics
520 N. Michigan Ave., Chicago 11, Ill.

WANTED NOW!
ELECTRONIC
Tube and Radio
DEVELOPMENT ENGINEERS, TECHNICIANS
WAR PROJECTS
Electronic Devices

Plan
YOUR FUTURE
in television, ultra-high frequency
Write qualifications

P-770, Electronics
330 West 42nd St., New York 18, N. Y.

CHIEF ELECTRONIC ENGINEER

Company with seven years background in the field of designing and building automatic photo-electric equipment has Postwar plans that include a great opportunity for an individual who will be expected to handle developmental activity of electronic department. He will supervise electronic department personnel, coordinate activity of plant and field engineers, assume responsibility of entire department as executive head. Applicant should be thoroughly trained in practical as well as theoretical electronics, capable of supervising optical and electronic experimental activity. Should be capable of visualizing electronic coordination with mechanical equipment, able to assist design engineering in development of new units and supervise assembly, wiring, and eventual incorporation of units in completed machines; supervise installation of our machines in customers' plants.

P-765, Electronics
520 N. Michigan Ave., Chicago 11, Ill.

WANTED—NOW OR POST-VE
Instructor or Research Associate

To participate in research and teaching of physics and technology of medical instrumentation. Should be familiar with physical measuring methods, electronics and instrumentation and have interest in medical applications. Physics Ph.D. desirable. Give full professional and personal data including recent photo.

P-769, Electronics
330 West 42nd St., New York 18, N. Y.

WANTED
DEVELOPMENT ENGINEERS

Mechanical and electrical. Graduate or equivalent training. Required for development work in the following branches:

1. Electro-mechanical devices, communication systems. Must be interested in development and familiar with magnetic circuits.
2. Measuring and control instruments. Background should be in electrical engineering, including electronics.

Statement of Availability Required.

P-773, Electronics
330 West 42nd St., New York 18, N. Y.

INDEX TO ADVERTISERS

ciety is prompt in taking institutions off their accredited list. The old-line engineering societies and the SPEE usually do nothing realistic.

Engineering keeps trying to use some technical ability as a wedge to produce business executives. This adds to the confusion of technicians and helps maintain them as "awe-struck lieutenants of the captains of finance."

May I presume to say the comment should have been "nothing else was to have been expected," instead of the wistful tone of the printed item. The chemists are merely one up on the rest of us.

ANDREW DOUGLAS
Anniston, Ala.

Come, come, let's not be too pessimistic—(Ed.)

• • •

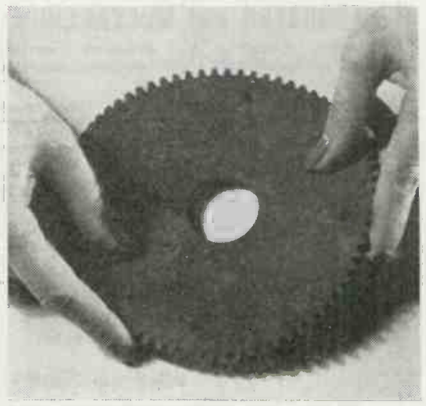
Three-Way Stretch

Dear Mr. Henney:

IN THE MAY ISSUE OF ELECTRONICS, in *Cross Talk*, you mentioned that mechanical engineers were loath to use electronic circuits for certain applications because of the wider manufacturing tolerances of electronic components as contrasted to the closer tolerances of mechanical components, indicating that in mechanical devices, gears did not have rubber teeth to introduce engineering problems.

On a recent visit to the factory of the McElroy Mfg. Corp., Boston, we noticed that his high speed code tapepuncher employs a gear made of synthetic rubber. A sample of this gear is being sent to your attention separately.

RAY PERRON
Ray Perron and Co.
Boston, Mass.



So help us, it's just like he says. See cut. To Dr. Paul G. Weiller, who was originally quoted as saying "gears do not have rubber teeth", condolences on the death of a picturesque metaphor. (Ed.)

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.

POSITIONS VACANT

DESIGN ENGINEER—2 years university training minimum experience in development and design of amplifiers and vacuum tube control devices. Good postwar future with progressive Chicago manufacturer. P-756, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

WANTED: BY Midwestern manufacturer radio transmitters and associated equipment—several junior project engineers qualified to supervise or assist development of transmitters, speech input systems, control apparatus, and similar items. Salary average $2,500 per year. Give full details first letter. P-775, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

OPPORTUNITY, With New York Distributor, for man thoroughly experienced parts jobbing, as executive assistant and purchasing agent. Must know parts and values. Write full history, experience, abilities, references, salary. P-776, Electronics, 330 W. 42nd St., New York 18, N. Y.

EMPLOYMENT AGENCY

ELECTRONICS—More positions are coming in daily for well qualified men in Electronics. Our service is Nation wide and covers all branches of Engineering. More than 51 years at the same address. The Engineering Agency, Inc., 53 W. Jackson Blvd., Chicago 4, Illinois.

EMPLOYMENT SERVICE

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.

POSITIONS WANTED

PRECISION INSTRUMENT maker with creative ability in research, design and production, excellent knowledge of entire mechanical field. Seeks connection where ability in development of new products is needed. Capable of organizing and supervising an experimental department. PW-777, Electronics, 330 W. 42nd St., New York 18, N. Y.

EXPERIENCED RADIO engineer, graduate of accredited school, has available time and facilities to consider radio design job. PW-778, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

REPRESENTATIVE AVAILABLE

WANTED PRODUCTS in electronic field for representation in metropolitan area engineering and sales experience. Large following. RA-779, Electronics, 330 W. 42nd St., New York 18, N. Y.

DEVELOPMENT LABORATORY

with drafting and machine shop facilities desires design or development work on Electromagnetic Devices: small motors, solenoids, special transformers, instruments.

WROBLE ENGINEERING CO.
1067 Davis Terrace, Schenectady 3, N. Y.

SELLERS BUYERS TRADERS

More for your Dollar! **IRON & STEEL PRODUCTS, Inc.** 39 Years' Experience!

13422-A S. Brainard Ave., Chicago 33, Illinois
"ANYTHING Containing IRON or STEEL"

New SEARCHLIGHT Advertisements

received by January 17th will appear in the February issue, subject to space limitations.

Departmental Staff
ELECTRONICS
330 W. 42nd St., New York 18, N. Y.

WANTED ELECTRICAL ENGINEER

For old established eastern manufacturer. One who can design and manage transformer department, who understands all phases of transformer design and building. Only engineers thoroughly familiar with building and calculating on all types of air and oil cooled transformers need apply. Steady position and good salary to right man.

P-771, Electronics
330 West 42nd St., New York 18, N. Y.

WANTED DESIGNER

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-772, Electronics
330 West 42nd Street, New York 18, N. Y.

WANTED Electrical or Radio ENGINEER

Should have general experience in Electrical or Radio Measurements. Graduate engineer (radio or electrical) from recognized engineering school, desirable. Long-established radio-electrical components manufacturer in New England, doing war work at present. Postwar future for right man. Give detailed outline of experience, etc., salary requirements.

P-781, Electronics
330 West 42nd St., New York 18, N. Y.

WANTED

SURPLUS WANTED

Meters—Transformers—Rheostats
Control Devices
Electronic Components

ELECTRO-TECH EQUIPMENT CO.
331 Canal St. New York, 13, N. Y.

WANTED STROBOTAC, OSCILLOGRAPH and SOUND METER

Advise specifications and price

VIKING AIR CONDITIONING CORP.
5600 Walworth Ave., Cleveland 2, O.

INSTRUMENT ENGINEER WANTED

Engineer needed to develop and apply electronic instruments for measuring vibrations, strains, pressures and temperatures. Experience with electro-mechanical devices desirable. Position of permanent nature and at present concerned with measurement of aircraft and engine characteristics on projects of war urgency. Apply in writing stating education, experience and salary expected.

Persons now utilized at highest skill in essential industry need not apply as all hiring is done in accordance with Hartford area stabilization plan.

PRATT & WHITNEY AIRCRAFT
Installation Engineering Department
East Hartford 8, Connecticut

NO PRIORITY?

You don't need one to buy Andrew Type 737 7/8 DIAMETER

COAXIAL CABLE

Soft Temper, in 100 ft. coils

Surplus material, released by the War Production Board for sale without priority

ANDREW CO.
363 East 75th St.
Chicago 19

FOR IMMEDIATE SALE 40—#892 OSCILLATOR TUBES

DEFECTIVE ELECTRICALLY

Write FS-786, Electronics
330 West 42nd St., New York 18, N. Y.

Meters—Panel instruments 3½" size, microammeters, voltmeters, ammeters, R.F. meters, milliammeters. Large variety. Multi-range small portables. Prompt deliveries. Advise what you want for quotation. Hallicrafters SX-28, 25.

HATRY AND YOUNG
203 Ann Street, Hartford 3, Connecticut

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.
65-67 East 8th St. New York, N. Y.

Additional Employment Advertising on pages 336, 381, 383, 391, 393, 398 and 399

LARGE EASTERN RADIO MANUFACTURER has an opening for a CHIEF ENGINEER in its BROADCAST RECEIVER SECTION.

EXCELLENT opportunity for the right person. Must have adequate experience and background. Salary $8,000 to $12,000 per year depending upon ability and experience of applicant. War Manpower Commission regulations apply.

Address all replies to

P-749, Electronics
330 West 42nd Street, New York 18, N. Y.

HELP WANTED

TRANSFORMER & SMALL ELECTRIC MOTOR MEN

ENGINEERS
DESIGNERS
DRAFTSMEN
TECHNICIANS

For war time and post-war design and development of intricate, specialized, hermetically sealed transformers, and special purpose fractional h.p. motors.

Write giving details about age, experience, past salaries to

SPERRY
GYROSCOPE COMPANY, INC.
Research Laboratories
Stewart Ave. & Clinton Rd.
Garden City, New York

WANTED

CHIEF LOUD SPEAKER ENGINEER

The Rola Company, Inc. requires the services of an engineer who has had several years experience and is capable of heading this division.

Present work is on 100% urgent war products.

Excellent post-war opportunity with an outstanding, financially sound, long-established manufacturer of radio loudspeakers and transformers.

This Company now has definite plans for an extensive expansion in its Engineering and Manufacturing Divisions.

Salary open.—Write to

THE ROLA COMPANY, INC.
2530 Superior Avenue **Cleveland 14, Ohio**

FIELD SERVICE ENGINEERS

FOR DOMESTIC AND FOREIGN SERVICE

Must Possess Good Knowledge of Radio

Essential workers need release

HAZELTINE CORPORATION
58-25 Little Neck Parkway
Little Neck, Long Island

ENGINEERS WANTED

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-768, Electronics
68 Post St., San Francisco 4, Calif.

RADIO RECEIVER ENGINEERS!

Are you making plans today for your position of tomorrow? We have a definite postwar program in home radio and have openings for several engineers with prewar experience in complete design of home allwave receivers. Write personnel Manager

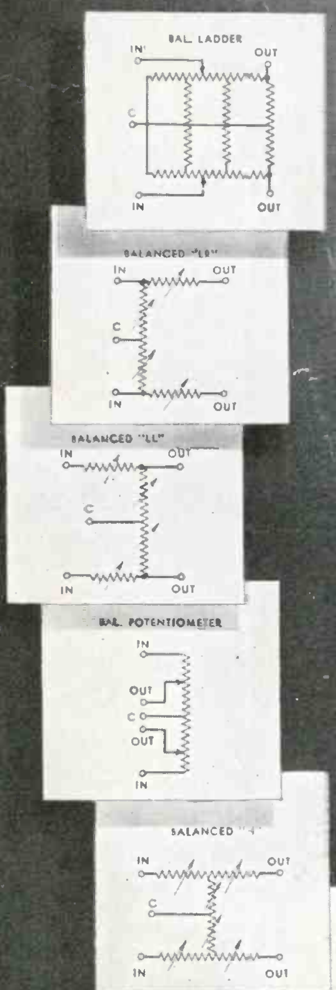
MAGUIRE INDUSTRIES, INC.
Electronics Division
342 W. Putnam Ave., Greenwich, Conn.

DAVEN

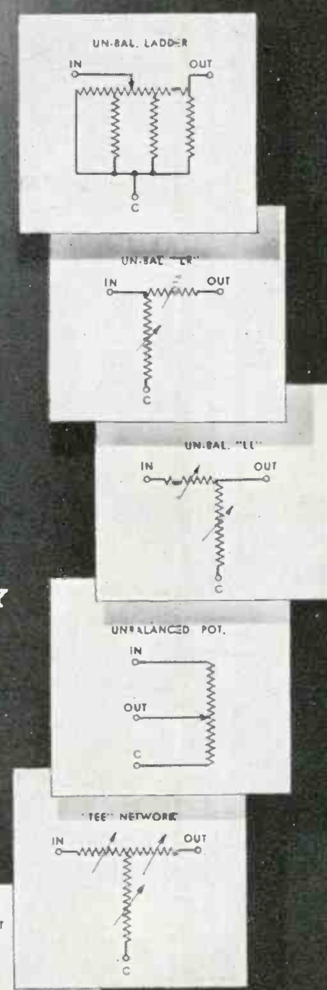
ATTENUATORS

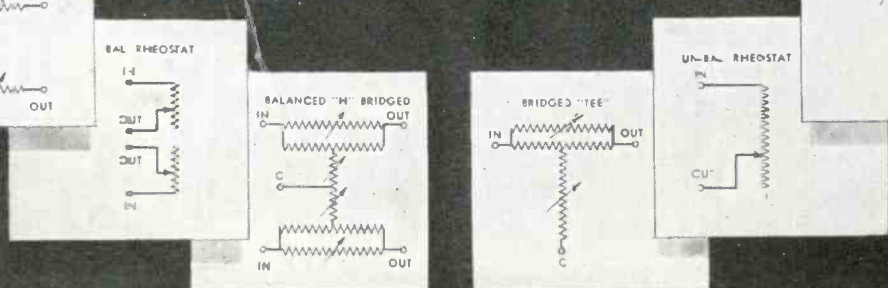
The many different networks (illustrated) and the wide selection of characteristics variations comprising the standard lines of DAVEN attenuators, are features of great convenience to the engineer—in Radio Broadcasting, in Sound Recording, Sound Projection, in Television and in the Laboratory Equipment field. Likewise, advanced designing as embodied in recent DAVEN announcements, plus a long standing reputation for making a good product, are facts that merit consideration in your present and post-war plans.

Balanced Circuits



Unbalanced Circuits





BETTER DELIVERIES

Several standard types of DAVEN Attenuators are available in moderate quantities for prompt deliveries. 30 to 60 day delivery is being made at this time on many other standard and some special types.

THE **DAVEN** COMPANY

191 CENTRAL AVENUE
NEWARK 4, NEW JERSEY

BUY MORE . . . HOLD MORE . . . WAR BONDS