HUEBNER

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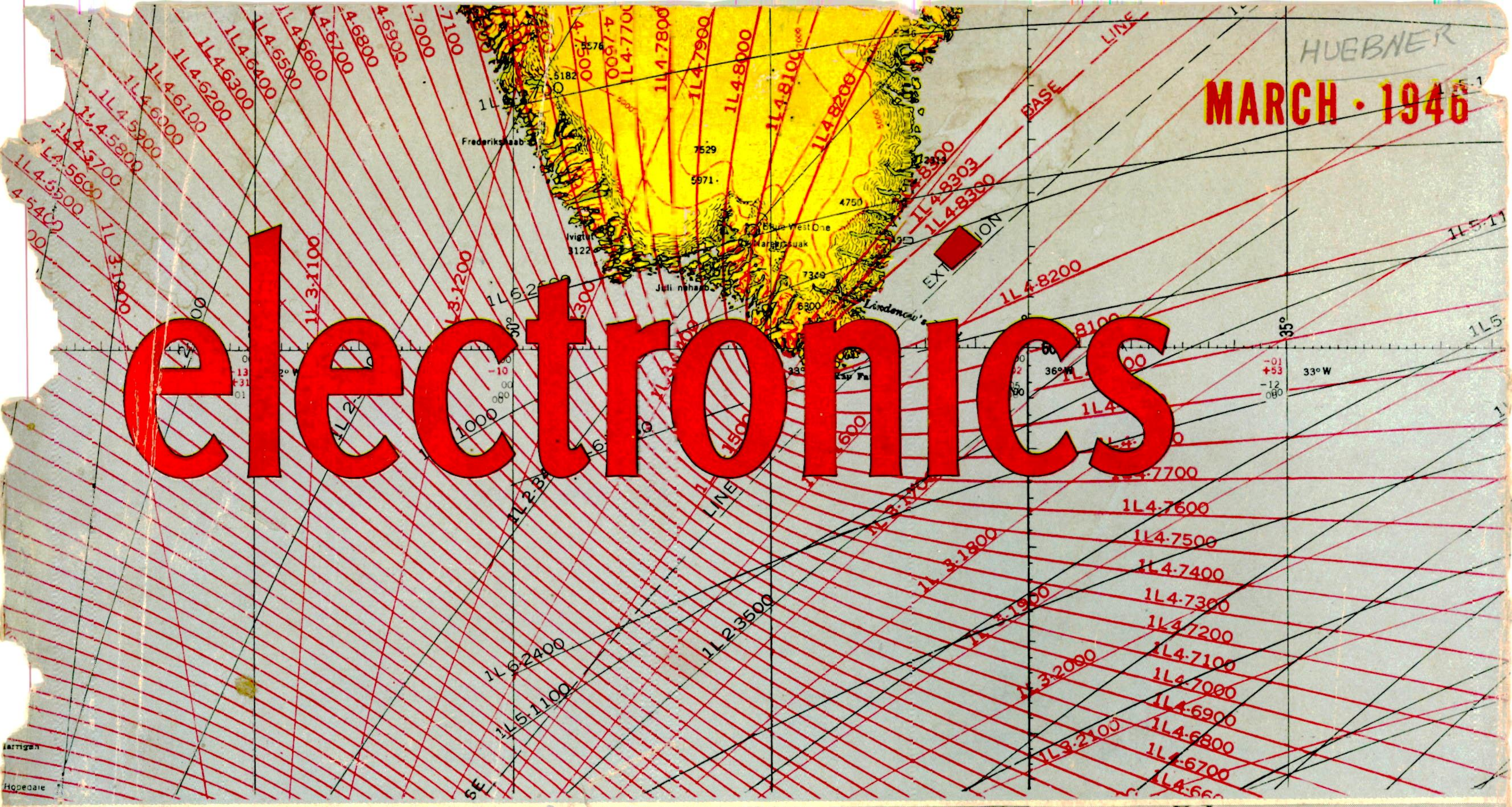

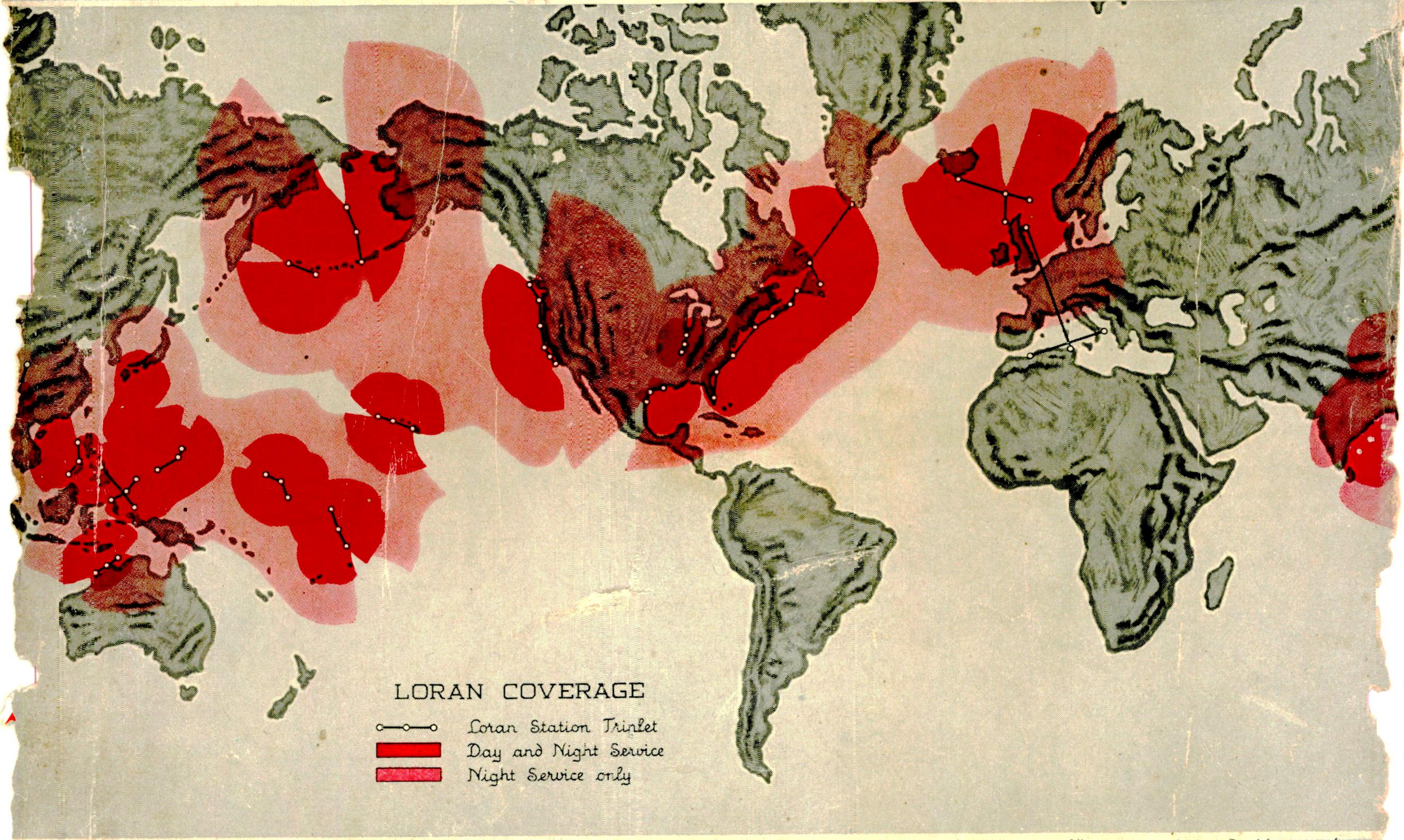

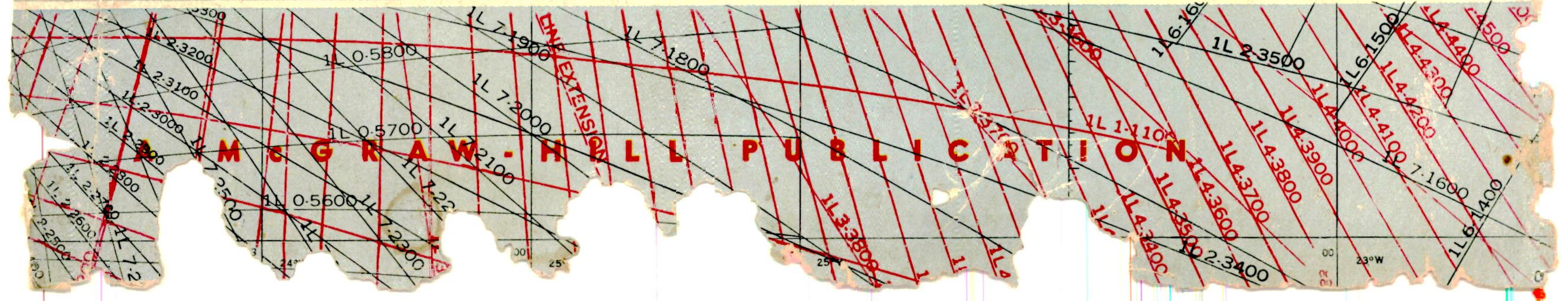

A McGRAW-HILL PUBLICATION

electronics

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MARCH • 1946

McGRAW-HILL PUBLISHING COMPANY, INCORPORATED
JAMES H. McGRAW, Founder and Honorary Chairman

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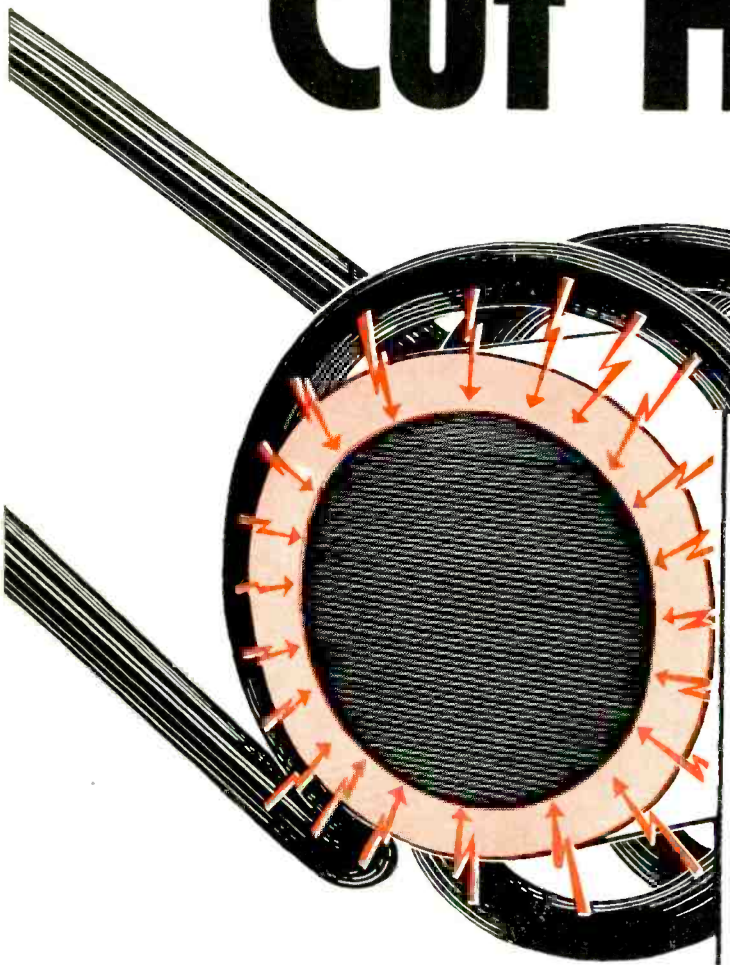
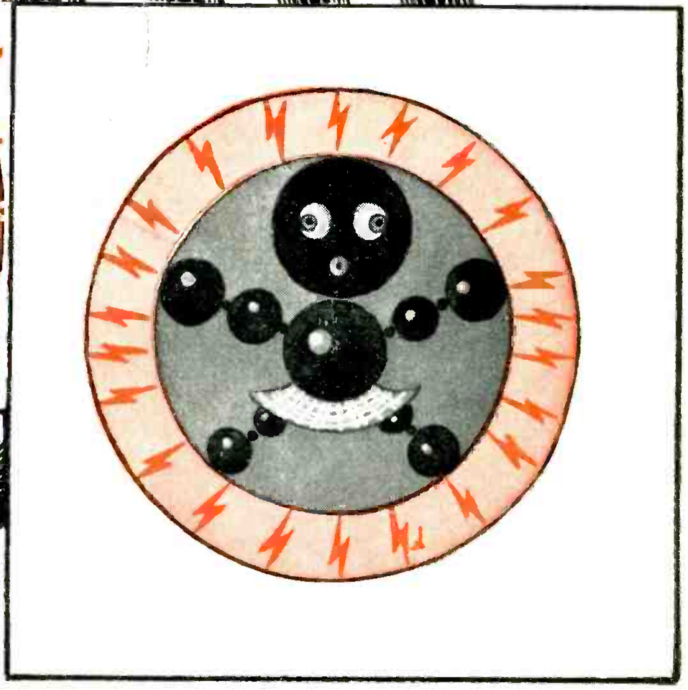
Here are Your LABORATORY FACILITIES for curing every type of
Radio Noise
No matter how complex your radio noise problem, it cannot long withstand attack by the forces at your disposal in the Tobe Filterette Laboratory. Here the cure of radio noise is the exclusive concern of an engineering staff equipped with every necessary instrument for analyzing radio interference. The cumulative experience of this group of specialists has included studies of every known source of man-made "static" . . . and has produced efficient, practical means for minimizing its disturbance of broadcast and short-wave radio reception. These means are well known under the trade name "FILTERETTE" . . . and electrical equipment made radio-silent thru their use can be labeled "FILTERIZED". Colorful tags, furnished free of charge to Filterette users, help build sales for your product. Write today for details of laboratory and label service.
TOBE DEUTSCHMANN CORPORATION
CANTON, MASSACHUSETTS
SUPPRESS MAN-MADE RADIO STATIC
TOBE
FILTERIZED
ORIGINATORS OF FILTERETTES . . . THE ACCEPTED CURE FOR RADIO NOISE

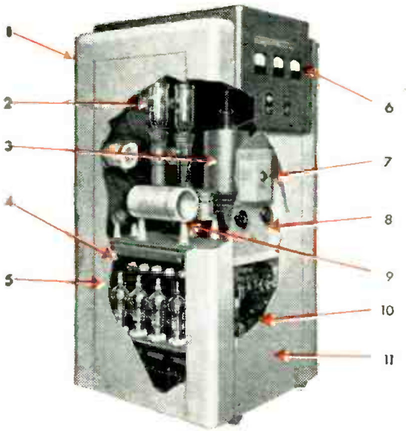
Cut Heating





1 IN MOST CASES, you can cut heating time as much as 85% ... get better, more uniform results for less money! Reason is that you *pre-select exact areas* for hardening or brazing, and control both *amount* and *penetration* of heat! This new production tool is completely automatic . . . requires no experienced help. Just place part in work coil and press button. That's all! High frequency power passing through work coil induces a current in part being processed.

2 THE MOLECULES in the metal resist this induced current and the resistance loss produces instantaneous, localized heat. *Through* heating is also easily obtained with the new Allis-Chalmers Induction heater by using properly designed work coils.



THESE FEATURES MEAN BETTER, LOWER COST PRODUCTION FOR YOU!

1 What's your heating problem? Brazing? Hardening? Soldering? Annealing? Melting? Heating for Forging? This new productive unit handles them all!

2 Sturdy, long-life Oscillator Tubes are fully protected against overloads.

3 New Coupling System developed by A-C keeps losses low and improves the output efficiency

4 Complete 3-Phase Power System with over 90% power factor.

5 Transformer is designed for heavy-duty 'round the clock production. Has large reserve capacity.

6 Large, easily read instruments show when power is on, also indicate grid and plate currents including filament voltage.

7 Automatic Timer controls heat sequence in split seconds from 2 seconds to 20 minutes . . . makes unit easy for unskilled operators to use. Also gives high product uniformity and reduces rejects.

8 All controls are on one panel . . . protected from tampering by door and lock.

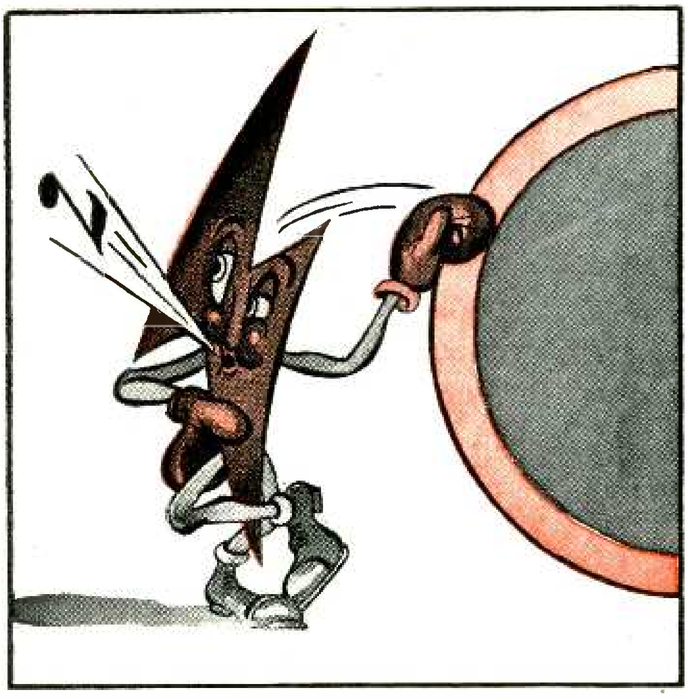
9 Specially designed Choke Coil protects rectifier tubes from damage by high frequency radio currents.

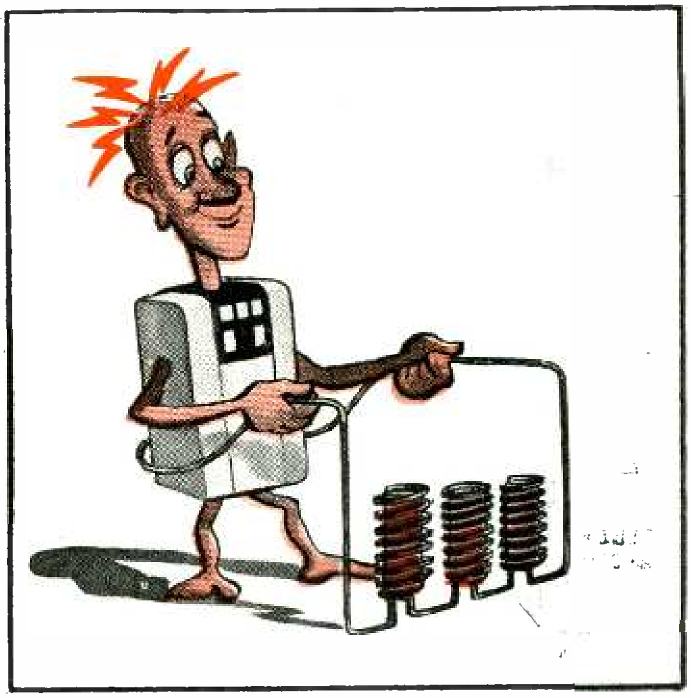
10 Safety Features: Heavy-duty control; high water-temperature switch; fuses; interlocking switches on doors protect operators.

11 Attractive, Compact Steel Cabinet mounted on heavy-duty casters encloses unit. Provides shielding.

Time in Half..

WITH ALLIS-CHALMERS GREAT NEW INDUCTION HEATER





3 HERE'S SECRET of why Induction Heating is especially effective for surface hardening and brazing operations. At a frequency of 450,000 cycles, 98% of induced current remains within two-thousandths of an inch of surface of metal being treated.

4 EVEN GREATER SAVINGS can be realized by processing several parts at the same time. Multiple set-ups of this kind further increase production with reduced process costs. Why not find out how induction heating can save you money?

NEW MOVIE EXPLAINS INDUCTION HEATING

This new A-C movie in full color and sound shows how a typical 5 minute hardening operation is completed in less than 5 seconds . . . other spectacular brazing operations! Contact your nearest A-C District Office for a showing, or write direct to Allis-Chalmers, Milwaukee 1, Wis. for a copy to loan. Film runs 12½ minutes on 16mm sound projectors only.

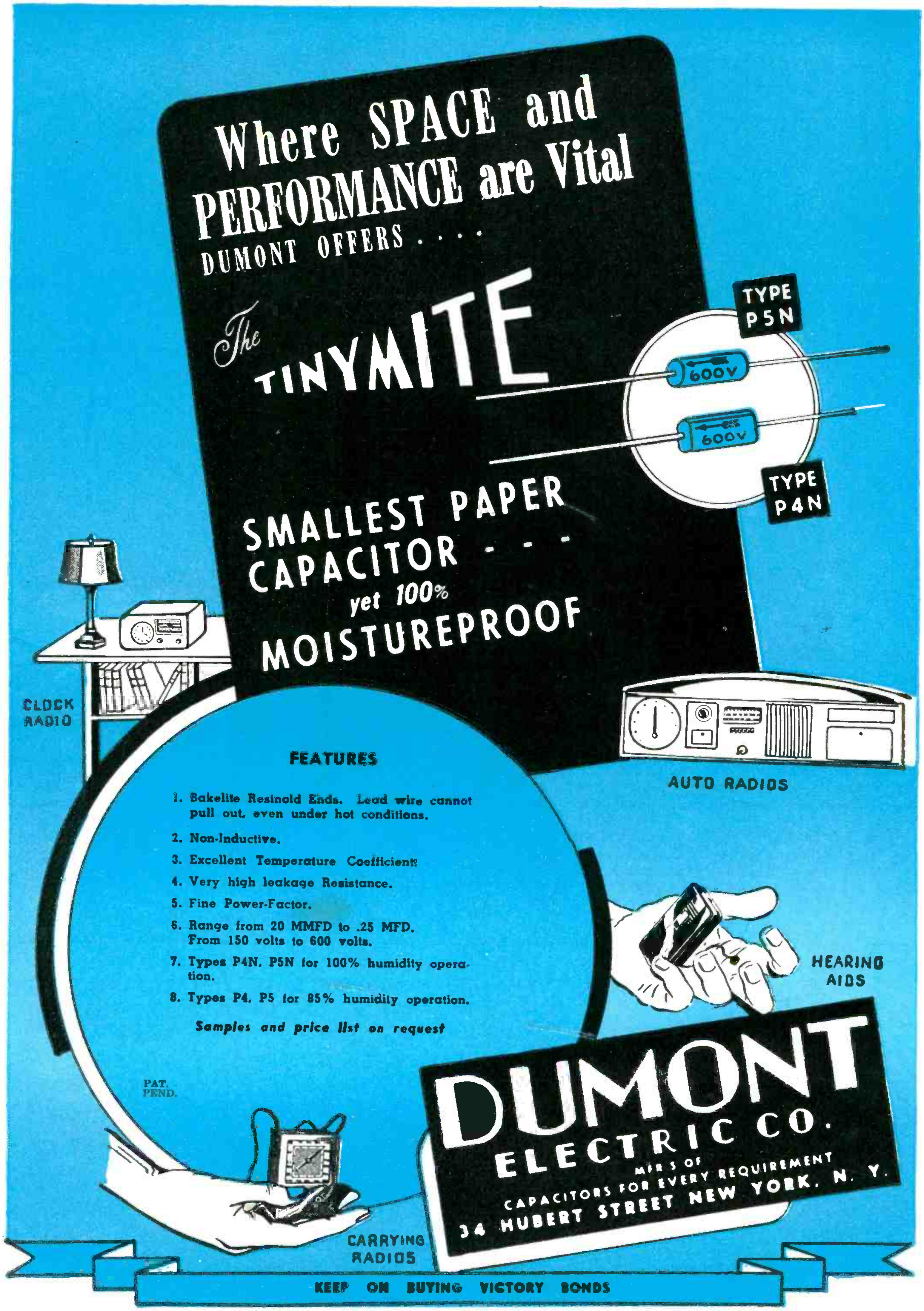
A 1995

ALLIS-CHALMERS

MILWAUKEE 1, WISCONSIN

Pioneer Builders of Electronic Equipment for Industry.

HEAR THE BOSTON SYMPHONY: *Saturday, American Broadcasting Co.*



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The TINYMITE
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SMALLEST PAPER CAPACITOR - - -
yet 100% MOISTUREPROOF
CLOCK RADIO
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FEATURES
1. Bakelite Resinold Ends. Lead wire cannot pull out, even under hot conditions.
2. Non-Inductive.
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6. Range from 20 MMFD to .25 MFD. From 150 volts to 600 volts.
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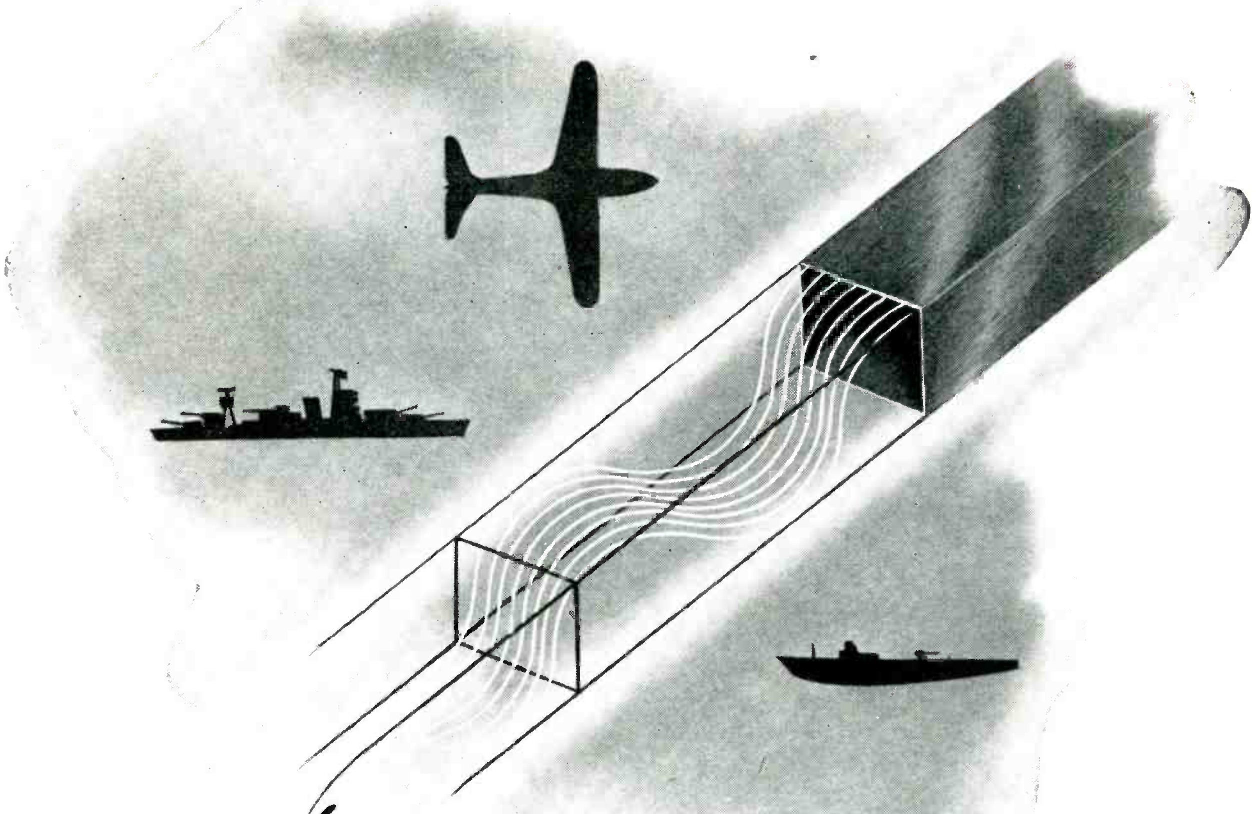
KEEP ON BUYING VICTORY BONDS



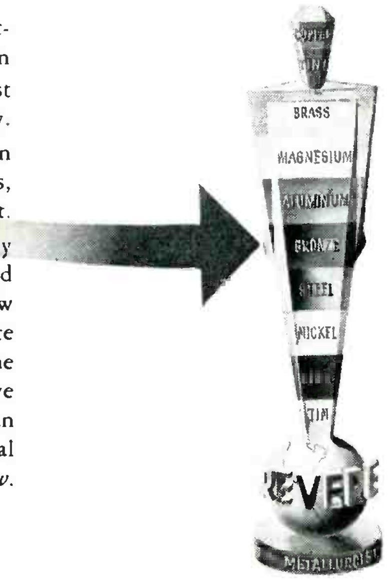
We've got the angle on metals!

Radar's miracle eye responds to no ordinary electric impulse such as that which actuates our radios. So fussy are radar signals that they must often be piped through special hollow tubes called wave guides.

Perhaps the most difficult type of wave guide called for a rectangular metal tube with no curvature in the corners . . . an assignment that any worker in metals will tell you is almost impossible! Yet it had to be done, with top wartime urgency.

So Revere devised a way to do it, on a production basis! And in addition was able to hold inside dimensions to closest tolerances, and to keep the inner surfaces of the tubes flat and free from twist.

This achievement of America's oldest metal-working company shows that, as a result of its 144 years of experience it has acquired the priceless habit of questioning the obvious, of creating new answers to new problems. Yet valuable as such Revere service can be, it is surpassed by the day-to-day help Revere offers the radio industry in the use of Revere's standard products. We have merged the science of the metallurgist with the skill of the artisan to help with your routine problems. Both the Revere Technical Advisory Service and all Revere metals are ready to serve you *now*.



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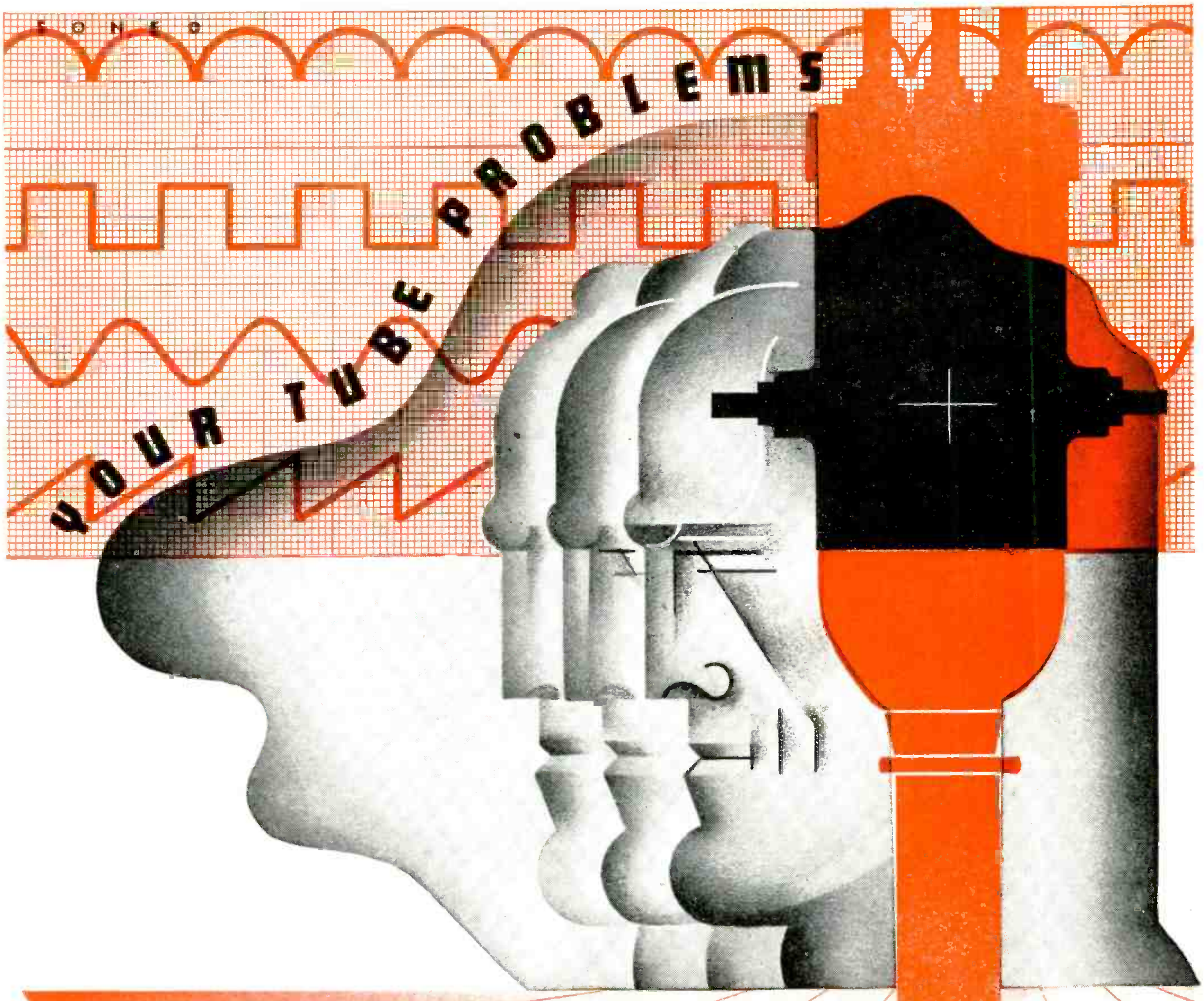
Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.—Sales Offices in Principal Cities.

Listen to *Exploring the Unknown* on the Mutual Network every Sunday evening, 9 to 9:30 p.m., EST.



FOR DECADES AMPEREX RESEARCH PROGRAMS, CREATIVE ENGINEERING AND PRECISION MANUFACTURE HAVE BEEN SUCCESSFUL IN TRANSLATING THE TUBE HOPES AND NEEDS OF EQUIPMENT DESIGNERS INTO ACTUAL TUBES FOR PROJECTED SOCKETS.

Perhaps it is getting more power into smaller space for induction or dielectric heating • or higher power at higher frequencies for communications • or unusual ruggedness for operation under unusual conditions • or a marriage of seemingly antagonistic characteristics • or any one of a host of other "bugs".

ASK AMPEREX TO BRING ITS LONG EXPERIENCE TO BEAR ON YOUR TUBE QUESTIONS . . . YOUR ONLY OBLIGATION IS A STATEMENT OF YOUR PROBLEM.

AMPEREX

POWER TUBE SPECIALISTS SINCE 1925

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AMPEREX
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25 WASHINGTON STREET, BROOKLYN 1, N. Y., CABLES: "ARLAB"

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A PLAIN STATEMENT OF RECORDING METHODS

FOREWORD: *Today, widespread confusion exists in the public mind regarding so-called "postwar" methods of recording and reproducing voices, music and other original sounds. Yet the straight facts are quite simple. As one of the leaders in the sound-recording industry, we have thoroughly explored these facts and weighed them in the balance. The results are contained in the statement below.*

Wm C. Speed

President, AUDIO DEVICES, INC.

* * * *

THE public is beginning to examine, very carefully, some of the postwar dream-products that were breaking into print while World War II was still on.

Certain manufacturers with the good taste not to claim that their products were winning the war, and who therefore had little to talk about, resorted to beating the gun on "postwar planning."

The public was seriously led to believe, for example:

—That glass-and-plastic cars, streaking along express highways at 100 miles an hour, will make all pre-Pearl Harbor models as extinct as the Dodo.

—That full-color television, with 15-minute news broadcasts as standard equipment, will sweep newspapers and radio sets into the discard.

—That invisible electronic fish-fences will fence the big ones in.

—That futuristic pre-fabricated postwar homes, equipped with screenless screens, heatless light and remote-control base plugs, will be mounted on swivels and turn with the sun.

—That the automobile of the future will take wing from a wide place in the highway, and just as easily ford a rushing river.

Certain of the postwar products which thus burst into print can fill a definite public need or desire. Others, however interesting, are either without practical application and were publicized beyond their actual possibilities, or exist only in the fevered imaginations of artists and writers.

Generally speaking, most manufacturers are now aware that publicity of this kind leads only to confusion, and thus tends to tighten, not loosen, America's purse-strings. That the public, already fed up with shoddy wartime quality, is getting just as fed up with postwar gadgets too.

Newness alone is not enough. It's got to be better—better—BETTER.

That's when the purse-strings will loosen. That's when the public will buy.

* * * *

The American peacetime public does not hesitate to discard last year's car when next year's model comes out; junk the old coal-eating kitchen range for a sleek new streamlined wonder with automatic oven control; or jettison millions of ice-boxes to make room for electric refrigerators.

Something not only new but BETTER. That's what built this country and the American way of life.

A pre-war product with postwar improvements, yes.

But a postwar product that has not proved itself any place else than on paper—a loud and resounding *NO.*

* * * *

This brings us to an examination of the industry we represent: *High-fidelity sound and voice recording.*

First of all, we are not—nor do we aspire to be—one of the producers of popular or symphonic phonograph records.

That is not our field. Our place in the picture is more basic.

We make (1) instantaneous recording blanks (audiodiscs) on which voices, music and other sounds are recorded for immediate or later playback. (2) Master audiodiscs used for the original recording in the production of phonograph records.

In the great broadcasting stations from coast to coast; in the great motion picture studios; in the recording studios of phonograph record manufacturers; and in America's leading schools and colleges; our audiodiscs are predominantly used.

Thanks to this universal acceptance, we are the largest manufacturers of professional recording discs in the world.

So we feel it is our obligation and our privilege to place before the public the facts regarding the "sound-recording methods of the future."

* * * *

It is true, of course, that from early 1941 to V-J Day, all sound recording suffered to some extent; not only from wartime scarcities and restrictions but from lack of the best raw materials.

Our own supplies were severely curtailed. Our production of audiodiscs was limited to the Armed Forces, broadcasting stations and similar professional requirements. Manufacturers of recording machines were similarly restricted.

But the manufacturers of recording discs and machines, and the commercial record producers, have not been idle.

Thanks to improved types of disc recording and reproducing equipment, plus improvements in audiodisc manufacturing, it is now more convenient than ever to record, instantaneously, sound-gradations and frequencies whose fidelity is uncanny.

Records made by this method now reproduce original sounds so exactly that the *human ear cannot distinguish the recording from the original "live" studio performance.*

Record producers, too, have so improved their materials and technique that pressed records, often turned out by the millions, can now faithfully reproduce the original recordings.

And thanks to these and still other coming developments in audiodisc manufacture, *these seemingly uncanny results will soon be as easy to attain in an average school or home, as in a professional recording studio.*

So we say to every radio and phonograph manufacturer: *From now on, equip your sets with disc recording and reproducing units.*

For the recording industry will shortly bring to "amateur" recording the same fidelity now realized in the professional radio broadcasting industry.

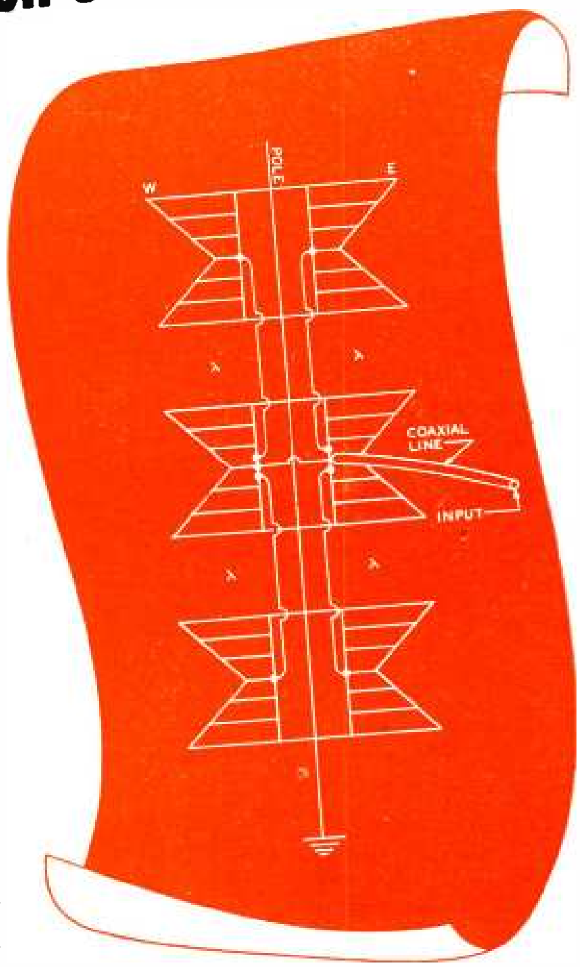
Antenna for FM and Television Stations

This new RCA antenna, we believe, is a real step forward in the art of FM and Television Broadcasting.

Its most notable feature is the use of bat-wing-shaped "current-sheet" radiators in place of the dipole arms of prewar turnstiles.

The chief effect of the "current-sheets" is to broaden the antenna's operating characteristic so that the impedance reflected on the transmission line is almost equal to that of the line itself over a frequency range of 20 per cent—nearly twice the entire FM band! Hence, there are no tricky field adjustments to worry about.

Write today for a copy of our new leaflet which fully explains how this unique antenna works, and why it assures you the long list of advantages summarized at the left. Radio Corporation of America, Dept. 30-C, Broadcast Equipment Section, Camden, N. J.



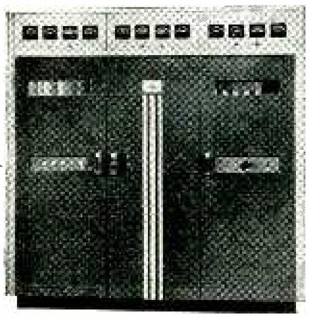
The West-East current sheets showing the transmission-line connections. The sheets are fed in push-pull. For television, the connections are made as shown here, i.e., the outer conductor of the coaxial line is attached to the one sheet and the inner conductor to the other sheet. For FM, separate coaxial lines feed the two sheets of each dipole. The North-South radiators (not shown) are fed in a similar manner, but with a 90-degree phase displacement.

BROADCAST AND TELEVISION EQUIPMENT

RADIO CORPORATION of AMERICA

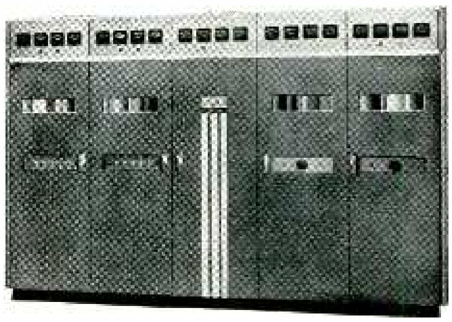
ENGINEERING PRODUCTS DIVISION, CAMDEN, N. J.

TRANSMITTERS FEATURING "DIRECT FM" AND "GROUNDED GRID"



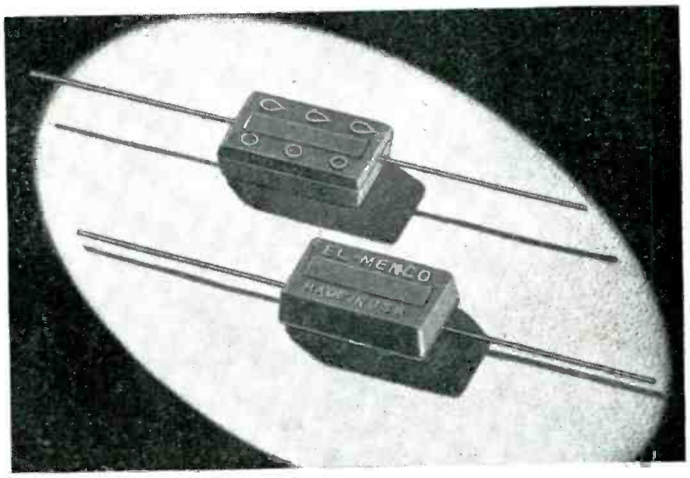
← **The 3-kw FM transmitter.** A new hollow base frame on all ratings provides space for inter-unit wiring. No under-floor conduits required.

The 10-kw FM transmitter. Controls for all ratings centralized on flush-mounted strips accessible through centers of doors. (25- and 50-kw ratings will also be available.) →



PERFECTION

In every field, one product stands out for its surpassing perfection. In the capacitor field El-Menco enjoys that distinction. Tested and proved under the severest wartime conditions, El-Menco Capacitors are right for the important role they are expected to play in the products of today and tomorrow. Write, sending in your specifications.



THE ELECTRO MOTIVE MFG. CO. • WILLIMANTIC, CONNECTICUT

El-Menco

MOLDED MICA **CAPACITORS** **MICA TRIMMER**

WAR'S Secret

Opens New Peacetime

In War

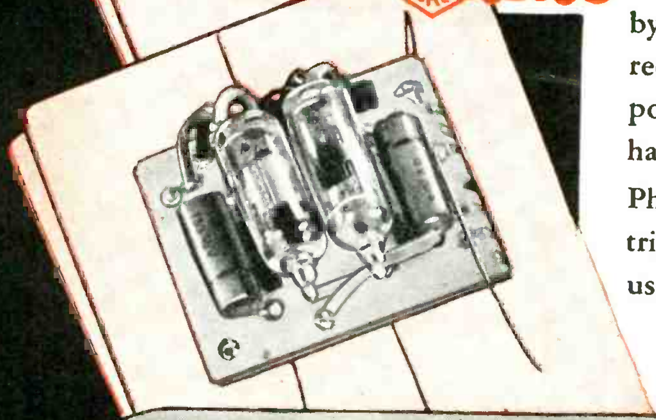
Centralab

developed in collaboration with the National Bureau of Standards the SMALLEST generator-powered radio proximity fuze. The Proximity Fuze is now recognized as our No. 2 Secret weapon of the war.

Centralab

engineering "know how" made the development of a radio circuit device so small as to virtually eliminate the third dimension. Illustration shows the complete self-powered transmitter-receiver fuze compared in size to a 6L6 vacuum tube.

Centralab



by hitherto secret industrial processes has effectively reduced "Electronics to Lithography." Briefly, components such as resistors, condensers, and wiring have been deprived of their third dimension.

Photograph shows a ceramic plate amplifier and trigger circuit complete with tubes similiar to that used in mortar fuse Project V. T. M.

Centralab DIVISION OF

DOING ONE THING WELL

Thirty-six years ago, in one small plant, we set out to do just one job—and do it well. Today, in six large plants—we're still at it—doing one thing well.

We like to feel that it is for this reason that more engineers specify C-D Capacitors. And for this reason too, that there are more C-D's in use today, than any other make.

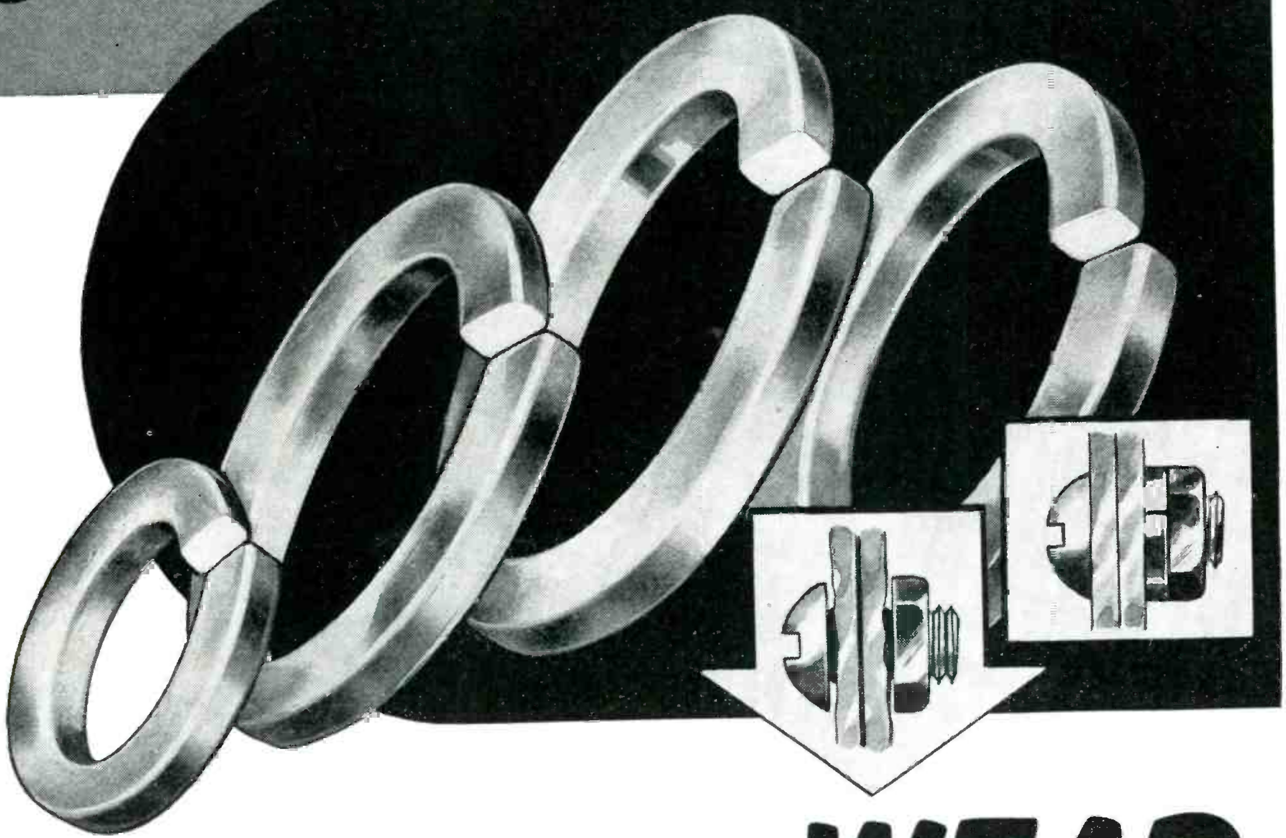
This accumulative engineering and manufacturing "know-how" has enabled us to design over one hundred thousand different types of capacitors in the past year. Actually, these designs encompassed every conceivable type of capacitor from the tiny tubulars used in the "Proximity Fuze" to the giant tank units used in the world's most powerful transmitters.

C-D Capacitors—of whatever type you may require—will add quality and dependability to *your* products. Creative, far-sighted engineering, extensive plant facilities—plus the knowledge and techniques of over thirty-six years of specialization—are yours to command. Catalog on request. Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey. Other plants at New Bedford, Worcester, Brookline, Mass.; and Providence, R. I.

Cornell-Dubilier *World's Largest Manufacturer of* **Capacitors**

MICA • DYKANOL • PAPER • ELECTROLYTICS

USE SPRING LOCK WASHERS



AS PROTECTION AGAINST WEAR

Vibration . . . friction . . . wear—that's the story even under normal service conditions. Result? Bolts and screws won't hold tight, assemblies become loose and breakdowns often occur.

How to prevent this? Use a good spring lock washer built to provide positive spring tension as the wear occurs . . . to keep the assemblies tight . . . and prevent breakdowns. That positive Controlled Tension is found in every Diamond G Lock Washer and only in Diamond G's. It assures unfailing spring tension . . . plus thrust washer bearing.

With a Diamond G equipped assembly you can tighten the bolt fully and depend on a safeguard against excessive vibration, shock and wear.

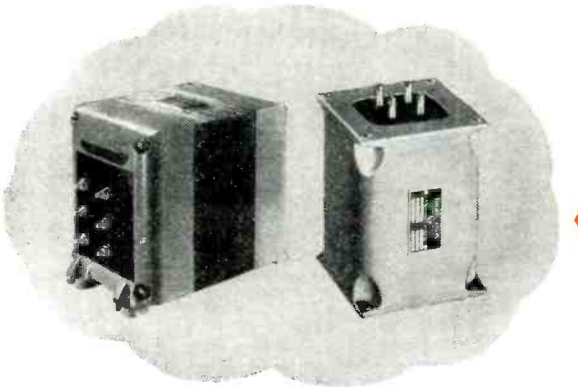
Next time specify Diamond G for safety. For complete details on the new ASA and SAE specification on spring lock washers write for our new, free folder.

GEORGE K. GARRETT CO., INC.
1421 CHESTNUT STREET, PHILADELPHIA 2, PA.
MANUFACTURERS OF

DIAMOND G PRODUCTS

LOCK WASHERS • • FLAT WASHERS • • STAMPINGS • • SPRINGS • • HOSE CLAMPS • • SNAP AND RETAINER RINGS

FOR
PRECISION-BUILT ELECTRONIC PRODUCTS!

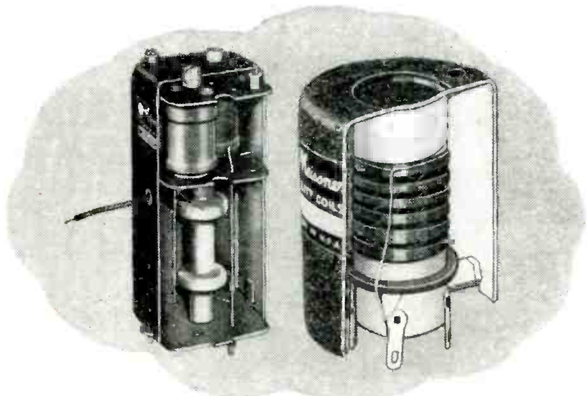


THORDARSON TRANSFORMERS

Over fifty years experience in the manufacture of quality-built transformers for all applications—replacement, communications, sound amplifier, industrial, experimental and amateur. Thordarson also originated Tru-Fidelity Amplifiers.

MEISSNER COMPONENTS

The Meissner reputation, gained and maintained by furnishing high quality components, including antenna, R.F. and oscillator coils; standard and Ferrocart transformers; windings, chokes and accessories. Meissner also makes the finest in service equipments.



RADIART VIBRATORS

Radiart Exact Duplicate Vibrators are individually engineered to meet the physical and electrical requirements of each application. This assures longer life, minimum R.F. interference, low hum level, etc. Radiart also makes rust-proof aerials to fit all cars.

WRITE FOR COMPLETE INFORMATION TODAY!

MAGUIRE INDUSTRIES, INC.

936 NORTH MICHIGAN AVENUE, CHICAGO 11, ILLINOIS

The Burning Question–
knocked cold!

DANGER in crowded assemblies? . . . in compactly grouped conductors in close cabinets? Today you can eliminate one fire hazard in such installations, for properly formulated wire and cable insulation of VINYLITE plastics is *non-flammable!* This modern insulation performed invaluable wartime service in marine, aircraft, and radio use. Now you can adopt it as a dependable safeguard in built-up forms and a wide range of critical applications.

Availability in non-flammable form is *one* notable feature of VINYLITE plastic insulation. Its sum total of properties, however, make it your outstanding specification for wires and cables, indoors and out. Extremely flexible, it is ideal on moving mechanisms. On overhead lines it is outstandingly resistant to weathering and the effects of sunlight. In underground installations it affords superlative protection against acid and alkaline soils.

THEY'RE COILED, PULLED, twisted, and walked on! But VINYLITE plastic insulation gives cords for household appliances and portable tools both maximum dependability and service life. Extremely tough, this modern insulation is highly resistant to abrasion, impact, grease, alkalies, most acids, and aging. Some types are non-flammable, others slow burning. Its dielectric strength permits the thin-wall construction that means light weight and ease of handling. Bright and pastel colors lend added appeal to many consumer items.

YOU CAN MODERNIZE old buildings with utmost economy — double the number of circuits in existing conduits — by installing wires with thin-wall, small-diameter VINYLITE plastic insulation. And of course every *new* building merits the extra safety, dependability, and long life of this superlative insulation. The non-flammable types bring maximum security from damage by fire. All types are highly resistant to alkalies, oils, grease, and most acids, and all have an unusually low rate of water absorption.

WRITE DEPARTMENT 28-1V for booklet W-4, "VINYLITE Plastics for Wire and Cable Insulation." It shows typical applications and the specific advantages of this insulation in the public utility, communications, industrial, and construction fields, and for marine, radio, and aircraft applications. Bakelite engineers are also ready at all times to help you determine how VINYLITE plastic insulation can best be used, technically and economically, for present projects and those still in the planning stage.

VINYLITE
TRADE-MARK
PLASTICS

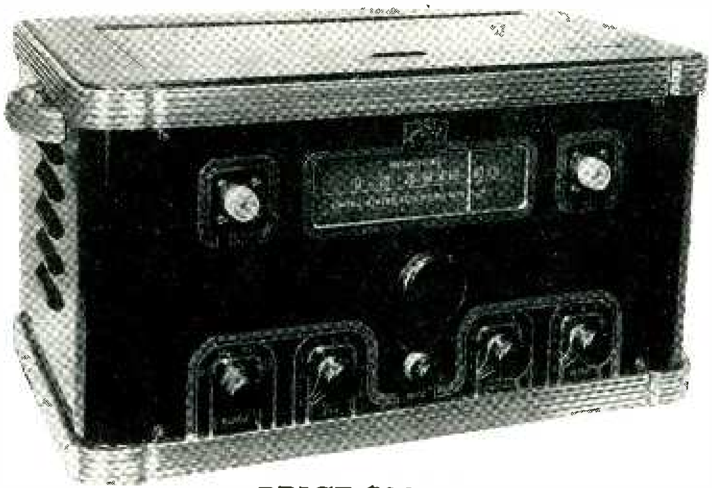
BAKELITE CORPORATION, *Unit of Union Carbide and Carbon Corporation* UCC 30 EAST 42ND STREET, NEW YORK 17, NEW YORK

UST FIRSTS

The First All-Electronic

SWEEP GENERATOR

For FM • TELEVISION • RADAR



PRICE $395.00

- 1 volt maximum, 500 Kc. to 110 Mcs., 100 ohms, 10 mc. Sweep width
- Covers new FM bands
- Covers new commercial television channels
- Fully Electronic
- **Compact**—14½" x 8" x 8"
- **Light**—only 16 lbs.
- **Lower in cost**

Saves Time in Laboratory and in Production

Covers a continuous range between 500 Kc. and 110 Mc. Designed primarily for use for field, laboratory, or production alignment of wide band r.f. and i.f., radar, direction finders, television, etc. Sweep range is adjustable from 10 Mc. down to 5,000 cycles at any frequency within the above range. Self-contained power supply. Input 110 V., 50-60 cycles, A.C., 60 watts. Two internal "markers" are provided which show throughout the band at intervals of 10 Mc. and at intervals of 1 Mc. (The amplitude of these markers is adjustable from the panel). The main dial is marked in megacycles/sec. An attenuator reduces the peak-to-peak output signal of .1 V. to about 30 microvolts.

Another First

HIGH VOLTAGE RF POWER SUPPLIES

10 KV for 10, 15, or 20 inch direct-vision Kinescopes, and with DC converters for laboratory testing.

UST
Window to the World

ALSO ICONOSCOPE YOKES
PROJECTION TUBE YOKES
KINESCOPE YOKES

Write for preliminary technical data. A limited number of orders placed now for these units can be filled immediately.

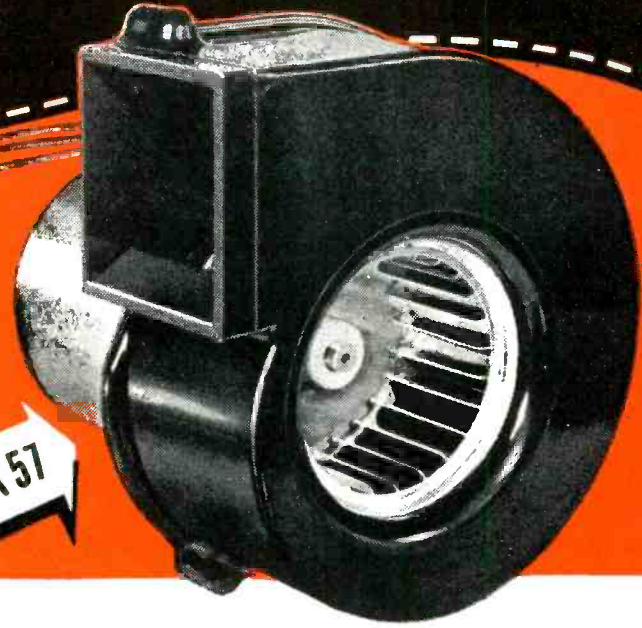
UNITED STATES TELEVISION MFG. CORP.

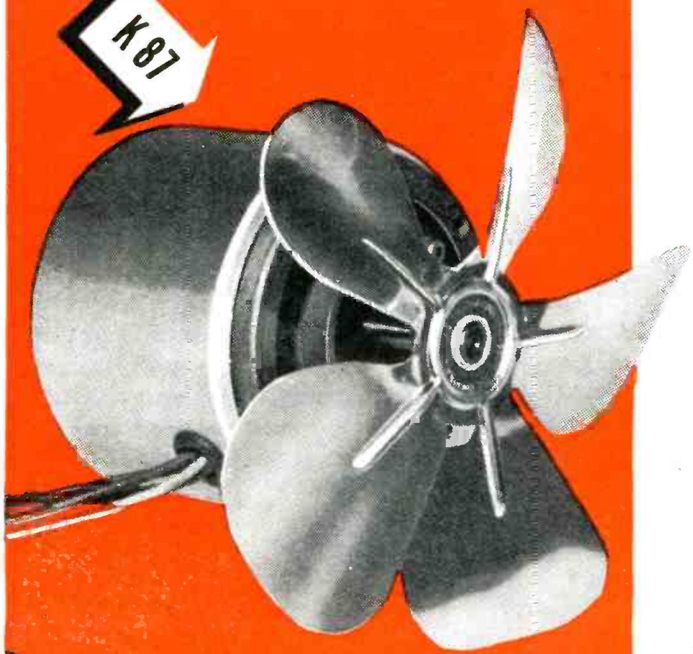
106 Seventh Avenue • New York 11, N. Y. • CHelsea 2-1154

RADIO • TELEVISION • ELECTRONIC PRODUCTS

EASTERN AIR DEVICES NEW 'K' SERIES OF BLOWERS

IMPROVED! EFFICIENT!





War Time Performance ... Modified Peace Time Prices

These motor-driven blowers and fans are the result of the improvements and advanced designs that went into our war-time "J" series. They are quiet, efficient and economical.

Units in the new Eastern Air Devices "K" series are especially recommended where maximum C.F.M. performance is desired in small size and light weight. They are available with either sleeve bearings or ball bearings.

We Invite Inquiry

We shall be pleased to send further data upon receipt of your engineering specifications. Prompt orders will insure early delivery.

MOTOR DRIVEN FANS AND BLOWERS

115 Volt—60 Cycle—Single Phase—Capacitor Start and Run

CENTRIFUGAL BLOWERS-CONTINUOUS DUTY

MODEL	H. P.	C. F. M.	R. P. M.
K54	1/300	6	3400
K50	1/300	10	3300
K50E	1/300	20	3200
K57	1/50	110	3300

PROPELLER FANS—CONTINUOUS DUTY

MODEL	H. P	C.F.M.		R. P. M.
		NEMA.	NAFM.	
K80A	1/300	170	65	3200
K87	1/50	475	175	3300

EAD

EASTERN AIR DEVICES, INC.

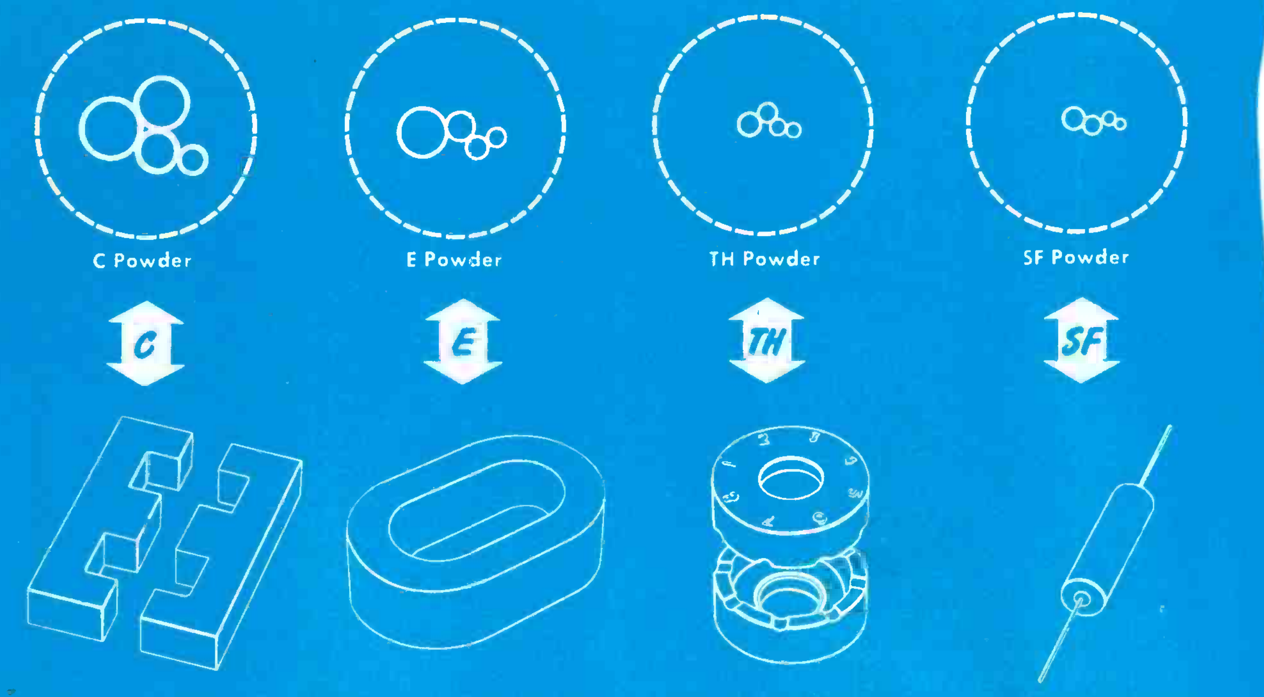
585 Dean Street • Brooklyn 17, N. Y.

An Affiliate of The Fred Goat Co., Inc., Est. 1893

MANUFACTURERS OF SMALL FRACTIONAL HORSE POWER MOTORS AND BLOWERS

CARBONYL IRON POWDERS AND SOME OF THEIR PRESENT USES

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



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

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

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

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

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

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

TABLE 2

Carbonyl Iron Grade	Effective Permeability at 1 kc	Relative Quality Factor at 10 kc	150 kc	200 kc	1 Mc	100 Mc
L	4.16	100	96	90	43	1
C	3.65	94	100	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.)

Further information can be obtained from the Special Products Sales Dept., General Aniline & Film Corporation, 270 Park Ave., New York 17, N. Y.

G.A.F. CARBONYL IRON POWDERS

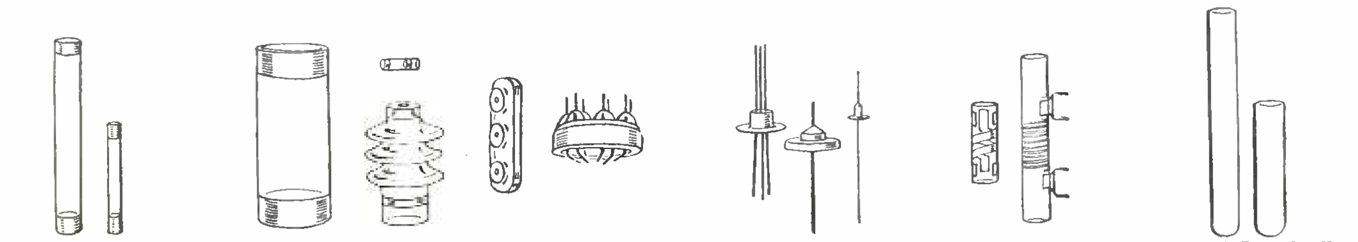
IN SMALL PLACES

MANY of the new electronic devices are small, and it is hard to wire them efficiently where the leads have to come out of a hermetically sealed unit. Corning headers like the ones shown take the grief right out of such installations, making it easier for the designer and simplifying the assembly operation.

They are available either with or without metallizing, depending on whether or not you want a true hermetic seal. In either case they are economical of space, time and labor. For with them you can get a number of leads in a small space, and yet they assemble in one operation. And they're rugged, resisting thermal shock and soldering. They have a high insulation resistance and a low loss factor. And they can be made quickly in large quantities.

You know best what your own problems are. So look at the products shown below. If hermetic seals or assembly troubles are dogging you, there's probably a Corning Electronic product to do the job for you. To make sure, write, wire or phone The Electronic Sales Department, E-3, Technical Products Division, Corning Glass Works, Corning, New York. One of our engineers will be knocking at your door immediately to see if he can help. Don't put it off. Get in touch with us today.

NOTE—*The metallized Tubes and Bushings, Headers and Coil Forms below are all made by the famous Corning Metallizing Process. Can be soldered into place to form true and permanent hermetic seals. Impervious to dust, moisture and corrosion.*



Metallized Tubes *for resistors, capacitors, etc. 20 standard sizes ½" x 2" to 1¼" x 10". Mass-produced for immediate shipment.*

Metallized Bushings. *Tubes in 10 standard sizes, 5/16" x 25/32" to 1" x 4 7/32" in mass production for immediate shipment.*

Headers — *The best way to get a large number of leads in a small space for assembly in one operation.*

Eyelet Terminals — *Single or multiple eyelets permit design flexibility. Standard items readily available in quantity.*

Coil Forms — *Grooved for ordinary frequencies—metallized for high frequencies. In various designs and mountings.*

VYCOR Brand cylinders — *very low loss characteristics. Stands thermal shock up to 900°C Can be metallized.*

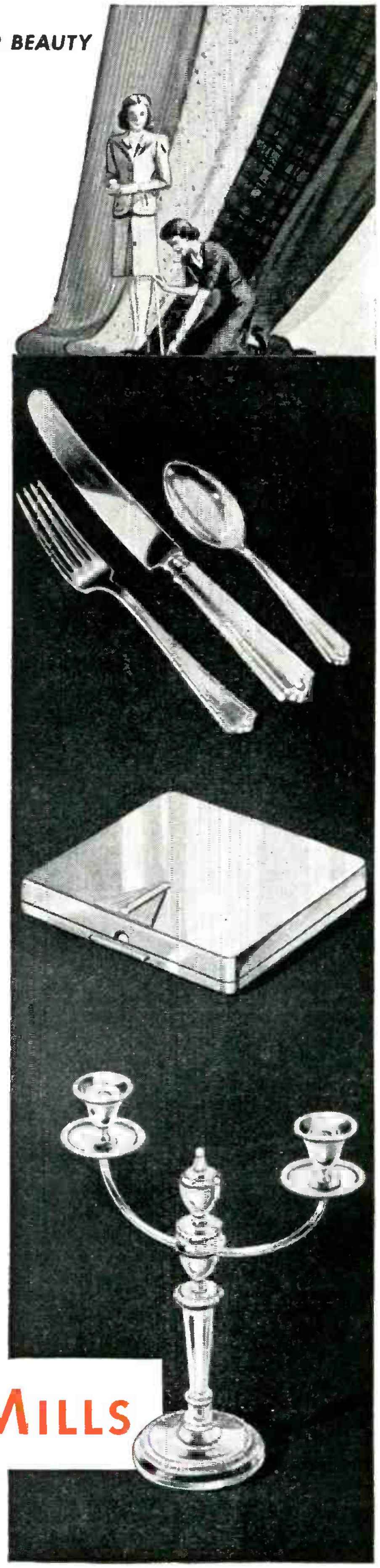
"VYCOR", "CORNING" *and* "PYREX" *are registered trade-marks and indicate maufacture by Corning Glass Works, Corning, N. Y.*

Electronic Glassware

TRADE MARK VYCOR REG. U.S. PAT. OFF.
T. M. REG. CORNING U.S. PAT. OFF.
T. M. REG. PYREX U.S. PAT. OFF.

FOR UTILITY

FOR BEAUTY



Depend on "Tailor-made" ALLOYS to fit your most Exacting Needs

After thousands of years of expanding service and lasting ornament, brass and other copper-base alloys still are among man's most versatile materials. New ways to use them are being found constantly.

If you are planning some of the utterly new products or redesigning long-absent things that consumers await eagerly, perhaps brass can make them serve better or appear more inviting. We can supply you with brass or other copper-base alloys exactly as you specify—sheets, rolls, strips, coils or stampings . . . in temper, dimensions, ductility or rigidity to suit your precise requirements.

Western alloys are used extensively in manufacturing motor cars, aircraft, railroads and electronic equipment, watches, clocks, refrigerators, electrical appliances, business machines, sporting goods, household equipment and many other products.

Western BRASS PRODUCTS
WESTERN BRASS MILLS

WESTERN BRASS MILLS

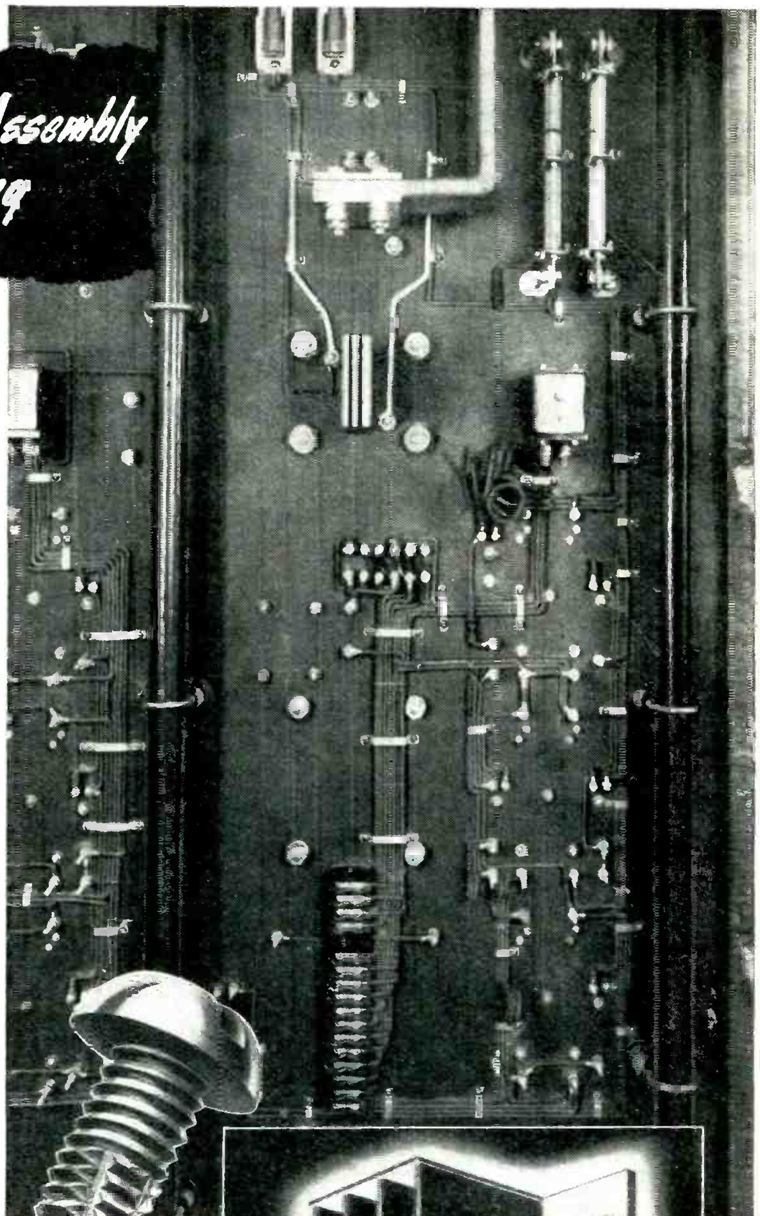
DIVISION OF OLIN INDUSTRIES, INC.

East Alton, Illinois

DIVISION OF OLIN INDUSTRIES INC.

BRONZE • PHOSPHOR BRONZE   BRASS • NICKEL SILVER • COPPER

Common Sense Assembly Engineering



SAVES A MINUTE... AND MULTIPLIES IT BY THOUSANDS

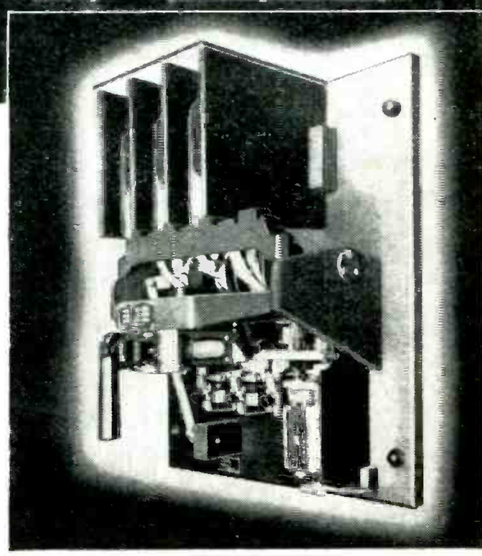
It's certainly sound common sense to save any assembly time which does not add to your product or your profits. The way the I. T. E. Circuit Breaker Company of Philadelphia saved it . . . in assembling switchboards and circuit breakers. They used P-K Self-tapping Screws everywhere possible, in many kinds of materials. The minutes saved by eliminating individual tapping operations are multiplied many thousands of times in assembling this kind of apparatus. That rates as *common sense assembly engineering!*

You don't know . . . we don't know . . . whether or not P-K Screws would save you money on *your* assembly job. But we do know that in *7 out of 10* jobs submitted to us, P-K Screws do the job better, for less. Why not find out if your job is one of the lucky seven?

Let a P-K Assembly Engineer prove it

The way one manufacturer makes fastenings with P-K Self-tapping Screws illustrates only a small part of the advantages of these unique fastenings. Maybe your product needs some of the many other advantages of P-K Screws. With the help of a P-K Assembly Engineer you can find out . . . either by his calling on you, or your mailing in assembly details . . . both without obligation. Parker-Kalon Corp., 208 Varick St., New York 14, N. Y.

Sold Only Through Accredited Distributors



The P-K Type "F" Self-tapping Screw is used for a multitude of fastenings . . . for wire cleats, insulation, switch covers, name and calibration plates, and even functions as terminals in these I. T. E. switchboards and circuit breakers. It cuts a clean, snug fitting thread as it is driven, and makes secure fastenings in such materials as the slate, ebony asbestos, and bakelite used in these switchboards.

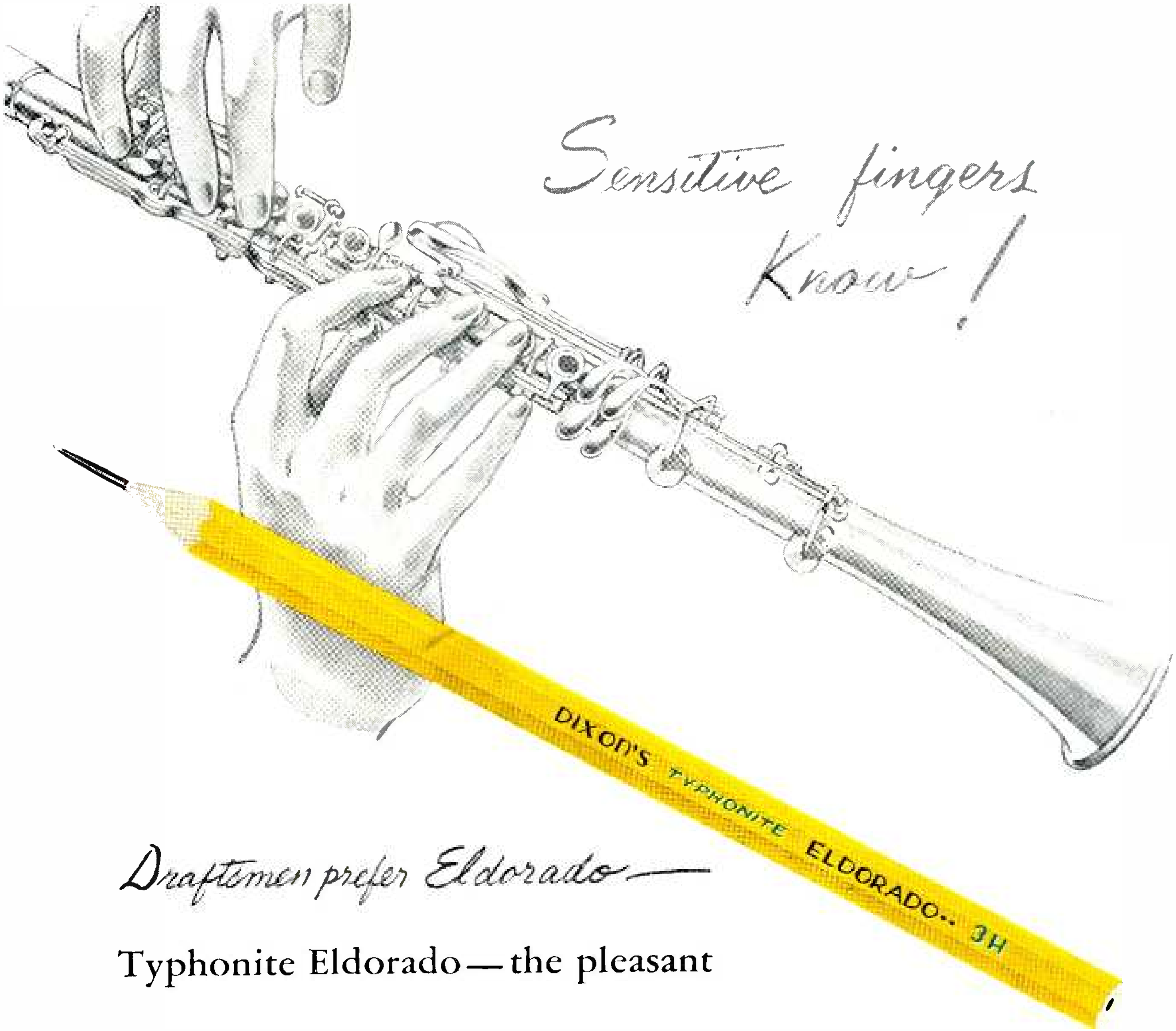
TYPE "A" TYPE "Z" HEX HEAD

P-K

TYPE "Z" PHILLIPS TYPE "F" TYPE "U"

PARKER-KALON **SELF-TAPPING SCREWS**

A FASTENING FOR EVERY METAL AND PLASTIC ASSEMBLY



Sensitive fingers Know!

Draftsmen prefer Eldorado—

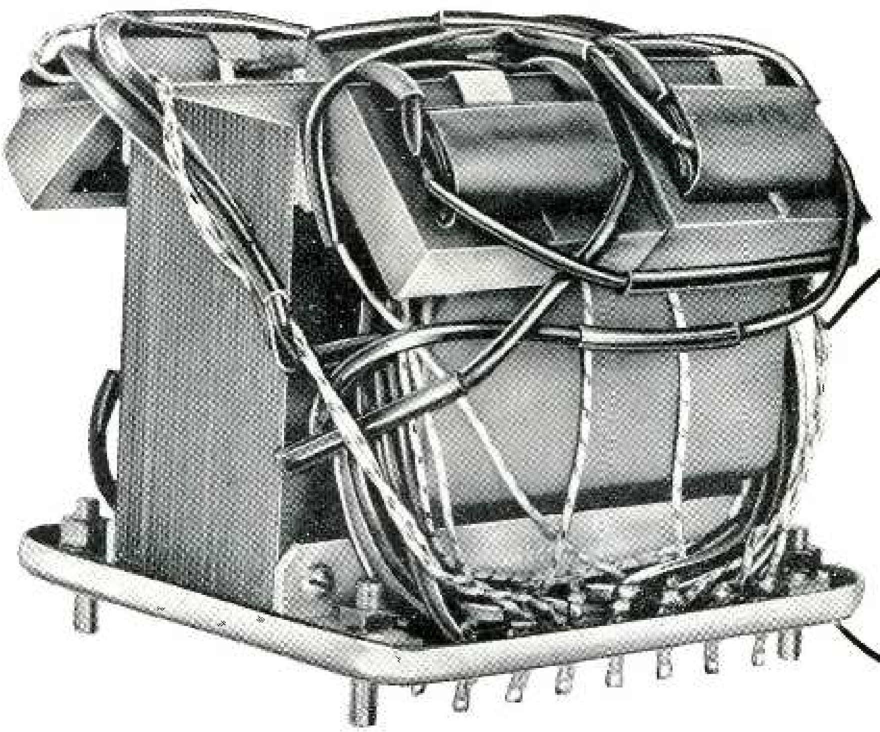
Typhonite Eldorado—the pleasant pencil designed to speed your work and lighten your day. Eldorado works with you—produces the best job on every job!

DIXON'S *TYPHONITE*

ELDORADO

PENCIL SALES DEPARTMENT, JOSEPH DIXON CRUCIBLE CO., JERSEY CITY 3, N. J.

NATVAR No. 400
Can Take Soldering Operations



New York Transformer Company's Type 11071 is a self-regulating power supply transformer. This interior view shows leads protected by NATVAR No. 400 high-heat-resistant extruded vinyl tubing before hermetic sealing in potting compound at elevated temperature.

NEW YORK TRANSFORMER COMPANY uses NATVAR No. 400 tubing in this rugged, high-efficiency transformer to provide maximum protection for the leads. When these leads are soldered to the pins, the tubing does not have to be cut back, because NATVAR No. 400 has remarkable heat resistance.

There are many other superior characteristics of NATVAR No. 400 which make it worthy of consideration for applications wherever extruded vinyl tubings can be used to advantage.

Write, wire or phone us for full description and specifications. We can deliver immediately either from the stock of a wholesaler near you, or from our own.

Natvar

- Varnished cambric — straight cut and bias
- Varnished cable tape
- Varnished canvas
- Varnished duck
- Varnished cellulose acetate
- Varnished special rayon
- Varnished Fiberglas cloth
- Varnished papers
- Varnished tubings and sleeving
- Varnished identification markers
- Lacquered tubings and sleevings
- Extruded vinyl tubing
- Extruded vinyl identification markers

Write for Catalog No. 20

THE NATIONAL VARNISHED PRODUCTS Corporation

TELEPHONE RAHWAY 7-2171

CABLE ADDRESS NATVAR: RAHWAY, N. J.

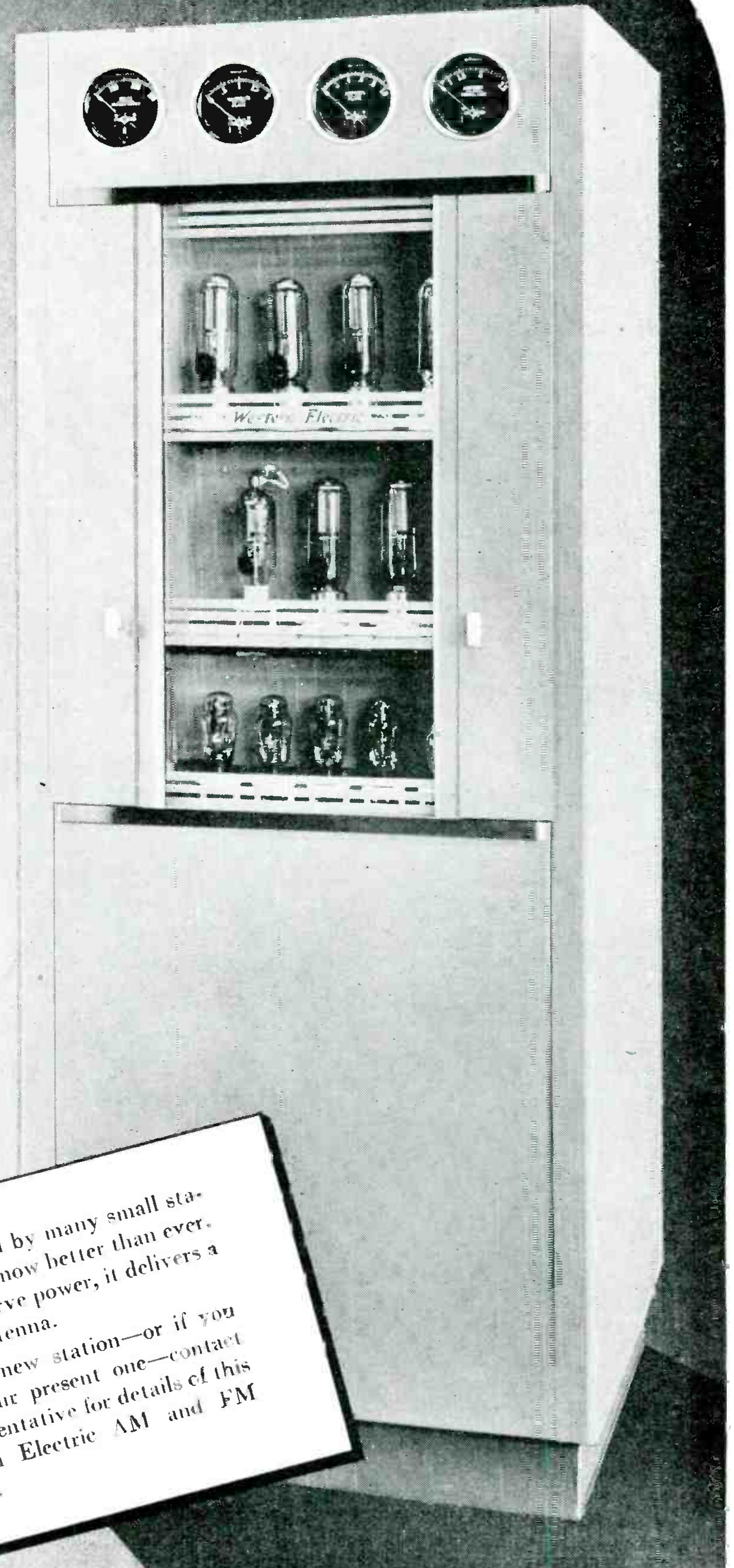
201 RANDOLPH AVENUE ★ WOODBRIDGE NEW JERSEY

3-NVP-1

We are in production
Deliveries have begun...

Western Electric

250 WATT AM TRANSMITTERS



COMPLETE AM LINE

In addition to the 250 watt transmitter, 1 kw units are now in stock, 5 kw's will be ready shortly. The superb Western Electric 50 kw is also in production.

Western also has in stock line branching, phase shifting, phase monitoring, and antenna coupling equipment to complete your installation.

Enthusiastically endorsed by many small stations, this transmitter is now better than ever. Packed with ample reserve power, it delivers a full 250 watts to the antenna.

If you're building a new station—or if you want to improve your present one—contact your Graybar representative for details of this and other Western Electric AM and FM transmitters today.

Western Electric

Distributed by GraybaR

ORDER YOURS NOW!

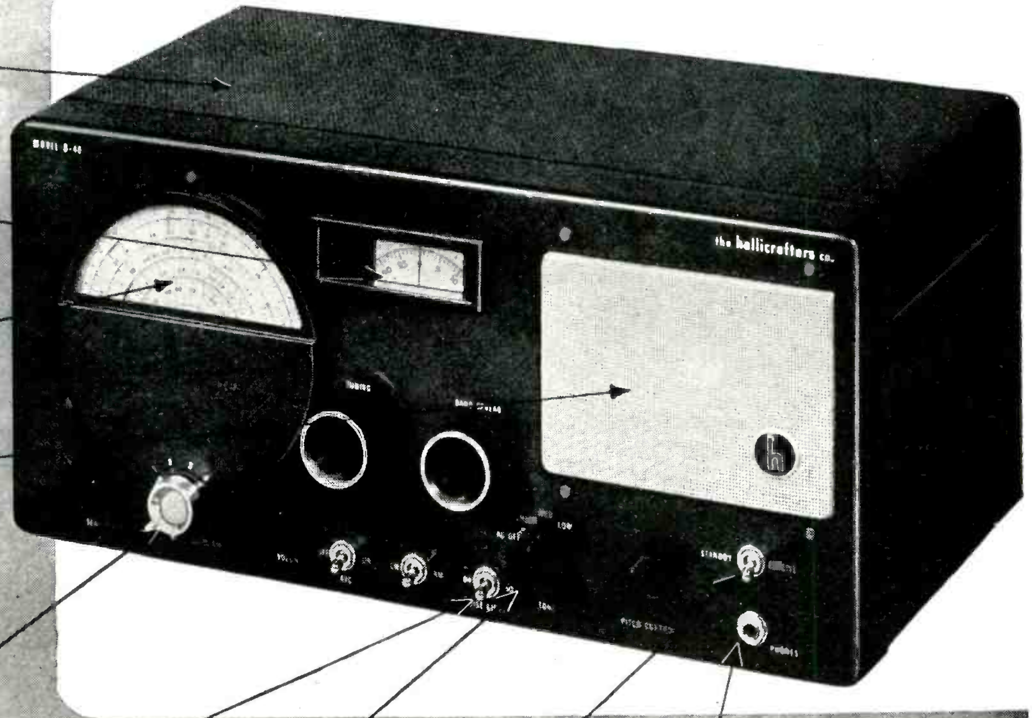
PERMANENT MAGNETS MAY DO IT BETTER!

Precision Grinding of Permanent Magnets to Close Tolerances

For accurate grinding to critical tolerances, a large battery of diversified machines is required. Conventional-type grinders are capable of many essential operations, but numerous machines have been designed and installed to do special work more efficiently and economically than could be done on standard grinding machines. On some magnets, only a single plane must be ground; but *as many as twenty-two planes* have to be ground on others. Because of the wide range of magnet shapes and sizes, our grinding department is equipped with machinery for practically every conceivable magnet grinding task.

Our engineers will be pleased to consult with you in solving your engineering problems. For data on permanent magnet application, write for new "Permanent Magnet Manual" prepared by *The Indiana Steel Products Company.*

hallicrafters *new Model* S-40



New beauty and perfect ventilation in the perforated steel top

Separate electrical bandspread with inertia flywheel tuning.

Tuning range from 540 kc to 42 Mc continuous in four bands

Self-contained, shock mounted, permanent magnet dynamic speaker

All controls logically grouped for easiest operation. Normal position for broadcast reception marked in red, making possible general use by whole family.

Automatic noise limiter

3-position tone control

Standby receive switch

Phone jack

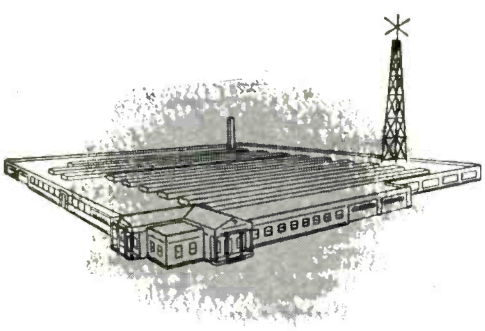
New design, new utility in a great new communications receiver . . .

(APPROXIMATELY) $79^{50}

Here is Hallicrafters new Model S-40. With this great communications receiver, handsomely designed, expertly engineered, Hallicrafters points the way to exciting new developments in amateur radio. Read those specifications . . . it's tailor-made for hams. Look at the sheer beauty of the S-40 . . . nothing like it to be seen in the communications field. Listen to the amazing performance . . . excels anything in its price class. See your local distributor about when you can get an S-40.

INSIDE STUFF: Beneath the sleek exterior of the S-40 is a beautifully engineered chassis. One stage of tuned radio frequency amplification, the S-40 uses a type 6SA7 tube as converter mixer for best signal to noise ratio. RF coils are of the permeability adjusted "micro-set" type identical with those used in the most expensive Hallicrafters receivers. The high frequency oscillator is temperature compensated for maximum stability.

From every angle the S-40 is an ideal receiver for all high frequency applications.



hallicrafters RADIO

THE HALLICRAFTERS CO., MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT, CHICAGO 16, U. S. A.

Sole Hallicrafters Representatives in Canada: Rogers Majestic Limited, Toronto - Montreal

PLASTICON* CAPACITORS

*PLASTICONS—
plastic film dielectric capacitors

An Improvement in Condensers!

Smaller, lighter, more economical. Specified by Signal Corps, Air Corps and Navy for more severe operating conditions than oil-paper capacitors. Closer tolerances, wider temperature range, greater safety factor, longer life. Now available at the following prices:

PLASTICONS TYPE AOC

Mfds.	*DC-WV*	*Dimensions*	*List Price*	*Your Price*
4	600	4" x 2" x 1¼"	$2.80	$1.68
1	1000	2⅜" x 1¾" x 1"	3.65	2.19
2	1000	3½" x 2" x 1¼"	4.70	2.82
4	1000	4⅝" x 2½" x 1 3/16"	5.85	3.51
6	1000	4⅝" x 3¾" x 1¼"	7.65	4.59
8	1000	4⅝" x 3¾" x 1¾"	8.40	5.04
1	2000	2⅜" x 2" x 1¼"	5.20	3.12
2	2000	3½" x 2½" x 1 3/16"	6.10	3.66
3	2000	3½" x 3¾" x 1¼"	7.50	4.50
4	2000	3½" x 3¾" x 1¾"	8.40	5.04
1	3000	4" x 2½" x 1 3/16"	11.00	6.60
2	3000	4" x 3¾" x 1¼"	14.00	8.40
4	3000	4⅝" x 3¾" x 1¾"	19.35	11.60
1	4000	4" x 3¾" x 1¼"	25.00	15.00
2	4000	4 7/16" x 3¾" x 1¾"	30.00	18.00
1	5000	4" x 3¾" x 1¾"	30.00	18.00
2	5000	3½" x 3¾" x 4 9/16"	37.50	22.50
1	7500	3½" x 3¾" x 4 9/16"	45.00	27.00
1	10000	4" x 3¾" x 4 9/16"	80.00	48.00

ALL PLASTICON CAPACITORS are guaranteed for six months.
Order from your distributor. If he cannot supply you, write direct.

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Condenser Products Company

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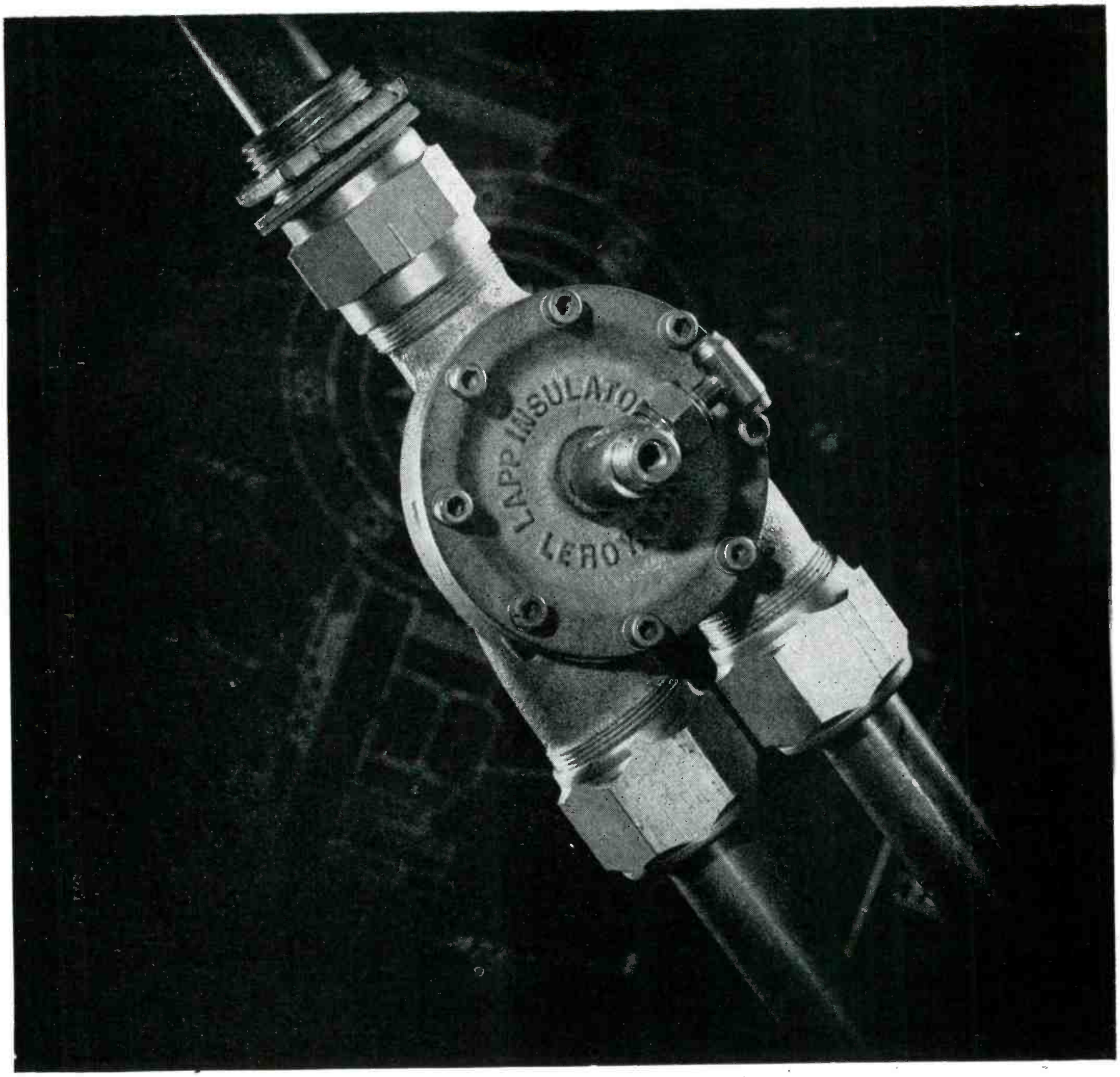


Electronic Parts: ENGINEERING AND PRODUCTION

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

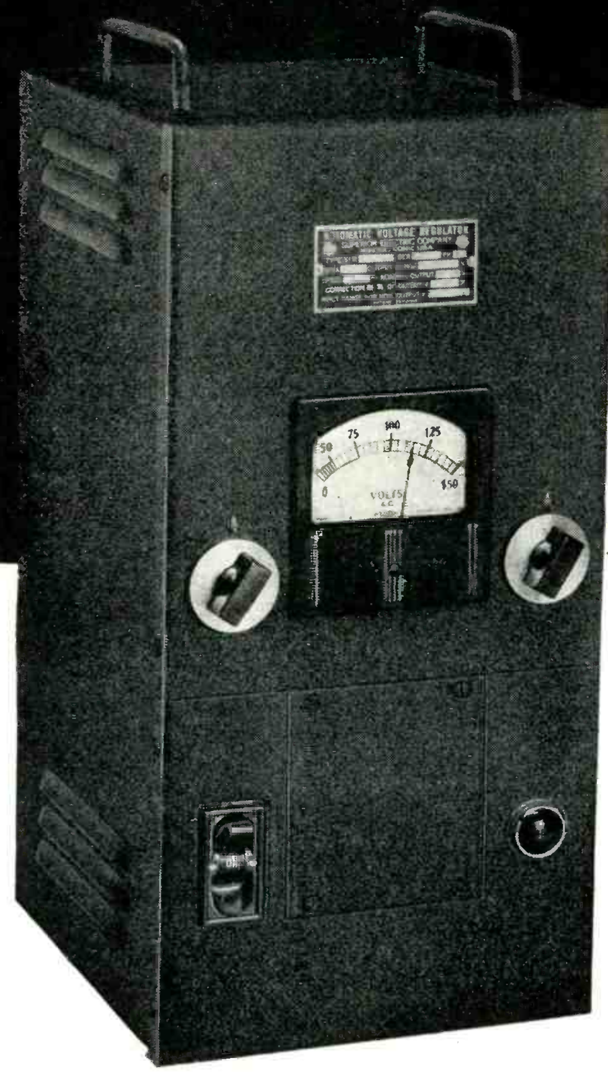
To this type of construction, Lapp brings several innovations and improvements. For example, such a line from Lapp parts is genuinely leak-proof. Every gasket is under spring loading, so there's no leakage created by vibration or thermal change.

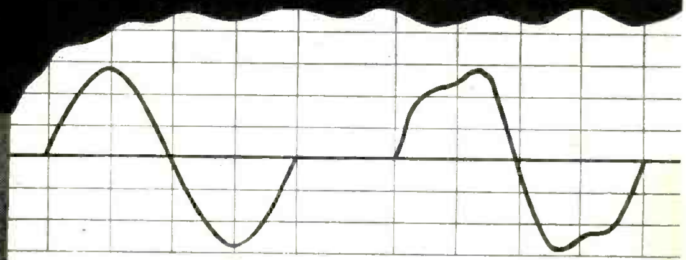
Whether or not you're interested in gas-filled transmission lines, you ought to know about Lapp. Here is an organization of engineers and manufacturers with broad basic knowledge of ceramics and their application. With experience in hundreds upon hundreds of special-purpose electronic parts, we have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

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

Lapp

NO WAVE-FORM DISTORTION





WITH

SECO AUTOMATIC VOLTAGE REGULATORS

IN designing electrical apparatus, the engineer not only specifies a definite operating voltage but also assumes that the wave-form of the specified voltage will be a sine wave. If these two factors are not considered, the efficiency and utility of the equipment is drastically reduced if not completely eliminated. Although the SECO automatic voltage regulator can not manufacture a sine wave, it will maintain a constant output voltage without wave-form distortion regardless of variations in input voltage or output load current.

Such desired performance is obtained by combining an electronic detector circuit with a motor-driven variable auto-transformer. There is no dependency on saturation of core material for regulating action. In direct contrast, the variable auto-transformer together with its auxiliary transformer are designed to operate far below the saturation point assuring the zero wave-form characteristic.

This feature, plus many other decided advantages, has prompted the exclusive use of SECO regulators for countless applications. An investigation may prove it ideal for your particular requirement.

Send for Bulletins LE

SUPERIOR ELECTRIC COMPANY

703 LAUREL STREET, • • • BRISTOL, CONNECTICUT

STOCKED BY LEADING DISTRIBUTORS IN THE UNITED STATES AND CANADA

NEW power triode with
NEW high efficiency, for
NEW h-f transmitter circuits

Type GL-592
$15.50

GENERAL ELECTRIC introduces Type GL-592 as a triode which sets entirely new standards of efficiency for power tubes in the high-frequency class.

Operating at frequencies (for max ratings) up to 110 megacycles, a plate input of 600 watts with dissipation of 200 watts gives Type GL-592 preference for both transmitter and electronic heating applications. Here is an h-f tube that really conserves power, with maximum results in usable output!

Small, compact, with solidly mounted and braced filament, grid and plate, Type GL-592 is thoroughly modern in design. All leads are short, and two grid leads to separate side terminals further reduce lead inductance. Fernico metal-to-glass seals make possible (1) elimination of a base with its attendant dielectric losses, (2) the non-soldered plate terminal to withstand high temperatures successfully. All terminal contacts are silver-plated for greater efficiency.

Ask your nearest G-E office or distributor for further facts about this new, *modern* G-E h-f triode. Or communicate direct with *Electronics Department, General Electric Company, Schenectady 5, New York.*

General Electric tube engineers are at your service, to assist you with applications of h-f tubes to your new transmitter and industrial circuits.

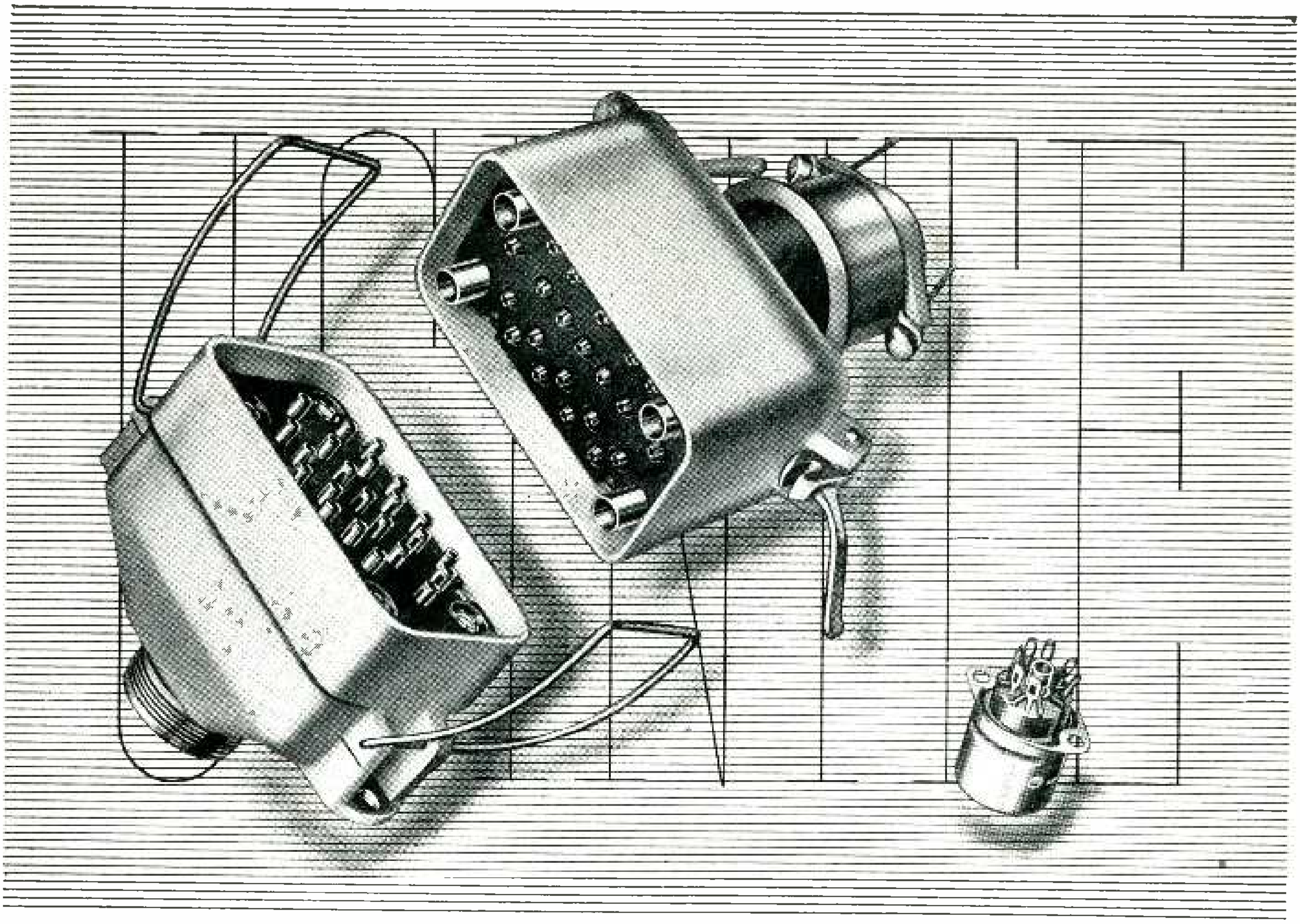
CHARACTERISTICS

FILAMENT VOLTAGE	10 v
FILAMENT CURRENT	5 amp
MAX. PLATE RATINGS, CLASS C TELEGRAPHY	
VOLTAGE	3,500 v
CURRENT	250 ma
INPUT	600 w
DISSIPATION	200 w
PLATE POWER OUTPUT, TYPICAL OPERATION	425 w
TYPE OF COOLING	FORCED-AIR

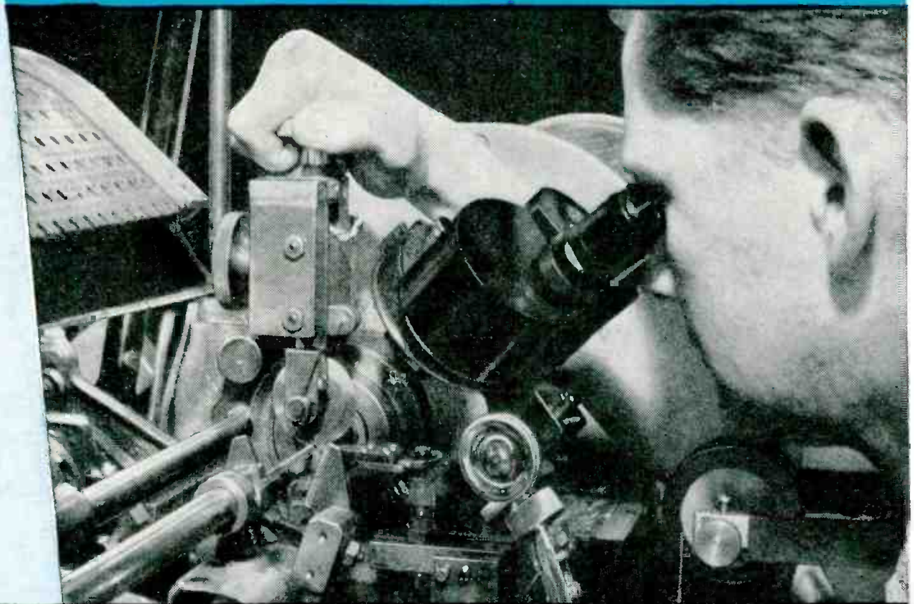
GENERAL ELECTRIC

161-E5-8850

TRANSMITTING, RECEIVING, INDUSTRIAL, SPECIAL PURPOSE TUBES • VACUUM SWITCHES AND CAPACITORS



MAKING TUBES IS EASY *If* YOU KNOW HOW!



● On this automatic grid winding lathe, the two heavy side-post wires — drawn from two large spools — are pulled taut over a mandrel form. A cutting wheel nicks these support wires, as the mandrel, wires, and spools revolve on the lathe. Very fine lateral wire is simultaneously wound from another spool into these nicks, with the mandrel providing the proper cross-sectional shape. A swedging wheel presses the side-post rods, thus anchoring each lateral turn firmly into place. Finished grid strips approximately twelve inches long are then cut to the required lengths. Excess turns are removed from each end of these short lengths preparatory to assembly. The completed grid is finally micro-gaged and micro-inspected.

HERE'S AN EXAMPLE OF HYTRON KNOW-HOW..

NOTE THE SMALL DIMENSIONS OF THESE GRIDS

Tube	Grid	Turns Per Inch	Length of Winding	Width of Winding
HY69	Screen	30	1.417 in.	0.570 in.
12BE6	Control	76	0.776 in.	0.135 in.
6AK5	Control	200	0.322 in.	0.100 in.

12BE6 and 6AK5 grids cannot successfully be illustrated, because of their minute size.

MASS production and a watchmaker's precision usually are strangers — especially if unit cost is low. Here you see a job setter adjusting a precision lathe on which tiny grids are wound to tolerances as tight as .0005 inch. Keen eyesight, patient perseverance, and the skill of a fine toolmaker, are his requisites. Pitch, turns per grid, inside and outside diameters, cross-sectional shape must be right on the nose. Furthermore, they must be kept there despite engineering changes in specifications, variances in materials, and wear and tear of the machine.

With this lathe turning up to 1000 rpm, grids form faster than the eye can travel. It is amazing to watch the tiny parts take shape — to examine with a microscope the rugged manner in which each lateral turn is swedged into the side-post rods.

Yet as you see these grids produced at top speed, it all looks easy. Nothing to it—*if you know how*. Then you stop to think. You realize skilled hands and precision machines are part of the Hytron know-how which makes tough jobs easy—which gives you tubes of dependable, jewel-like precision at prices absurdly low.

OLDEST MANUFACTURER SPECIALIZING IN RADIO RECEIVING TUBES

HYTRON RADIO TUBES

HYTRON

RADIO AND ELECTRONICS CORP.

MAIN OFFICE: SALEM, MASSACHUSETTS

LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY

NEW -*hp*- DISTORTION ANALYZER

continously variable over entire AF spectrum

OUTSTANDING NEW FEATURES

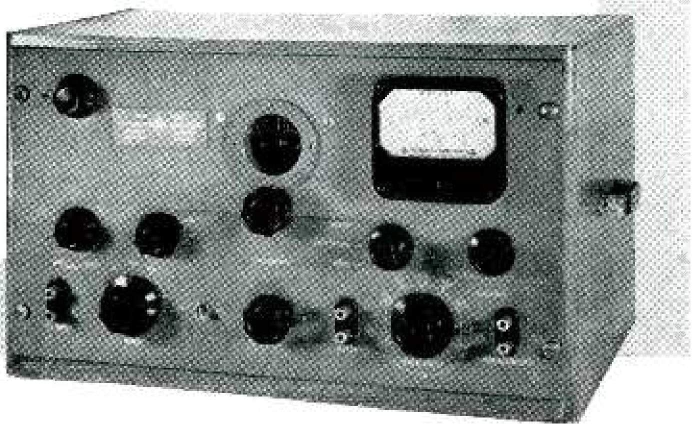
Covers Audio Spectrum

Measures Noise as Small as 100 Microvolts

Linear r-f Detector

Ball-bearing Frequency Control Dial

High Order of Accuracy and Stability



MODEL 330B

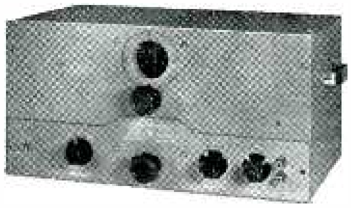
In the Model 330B Distortion Analyzer, the now-famous Hewlett-Packard resistance-tuned circuit is used in conjunction with an amplifier to provide many new and outstanding advantages. Here is an instrument which will measure "total" distortion at *any* frequency from 20 cps to 20,000 cps. Thus for the first time an instrument which covers the audio spectrum is available for distortion measurements. The Model 330B will also make noise measurements of voltages as small as 100 microvolts. A linear r-f dectector makes it possible to measure these characteristics directly from a modulated r-f carrier. This feature, coupled with the convenience, high sensitivity, accuracy, stability, and light weight which are traditional in all -*hp*- instruments, make the Model 330B uniquely valuable for broadcast, laboratory, and production measurement.

USES

The flexibility of the Model 330B leads to a wide number of applications. It may be used to measure the total distortion at any frequency of an audio signal, or of an audio-modulated r-f carrier. It may also be used as a voltmeter for measuring voltage level, power output, amplifier gain, or for any other use for which a high-impedance, wide frequency range, high sensitivity voltmeter is desirable. The frequency selective amplifier can be used as an audio-frequency meter to determine the frequency of an unknown audio signal. The Model 330B may also be used as a high-gain, wide-band, stabilized amplifier, having a maximum gain of 75 db.

This new Model 330B Distortion Analyzer is particularly adapted for use as an all-round measurement device in the broadcast studio and broadcast transmitting room. Speed and ease of operation commend it for laboratory and production testing. Write today for complete data, prices and delivery information on -*hp's*- newest and finest distortion measuring instrument, the 330B Distortion Analyzer.

1156



NEW MODEL 201B RESISTANCE-TUNED AF OSCILLATOR

In FM and other fields where high fidelity is important, this new -*hp*- Model 201B Audio Frequency Oscillator will meet every requirement for speed, ease of operation, accuracy, and purity of waveform. Outstanding new features include: 3 watts output, distortion less than ½ of 1%, low hum level, new dial with ball-bearing drive, accurate expanded frequency calibration, improved control of output level. Because of its low distortion it is a distinguished companion instrument for the new Model 330B Distortion Analyzer. Write today for complete specifications on this new -*hp*- Resistance-tuned Audio Oscillator.

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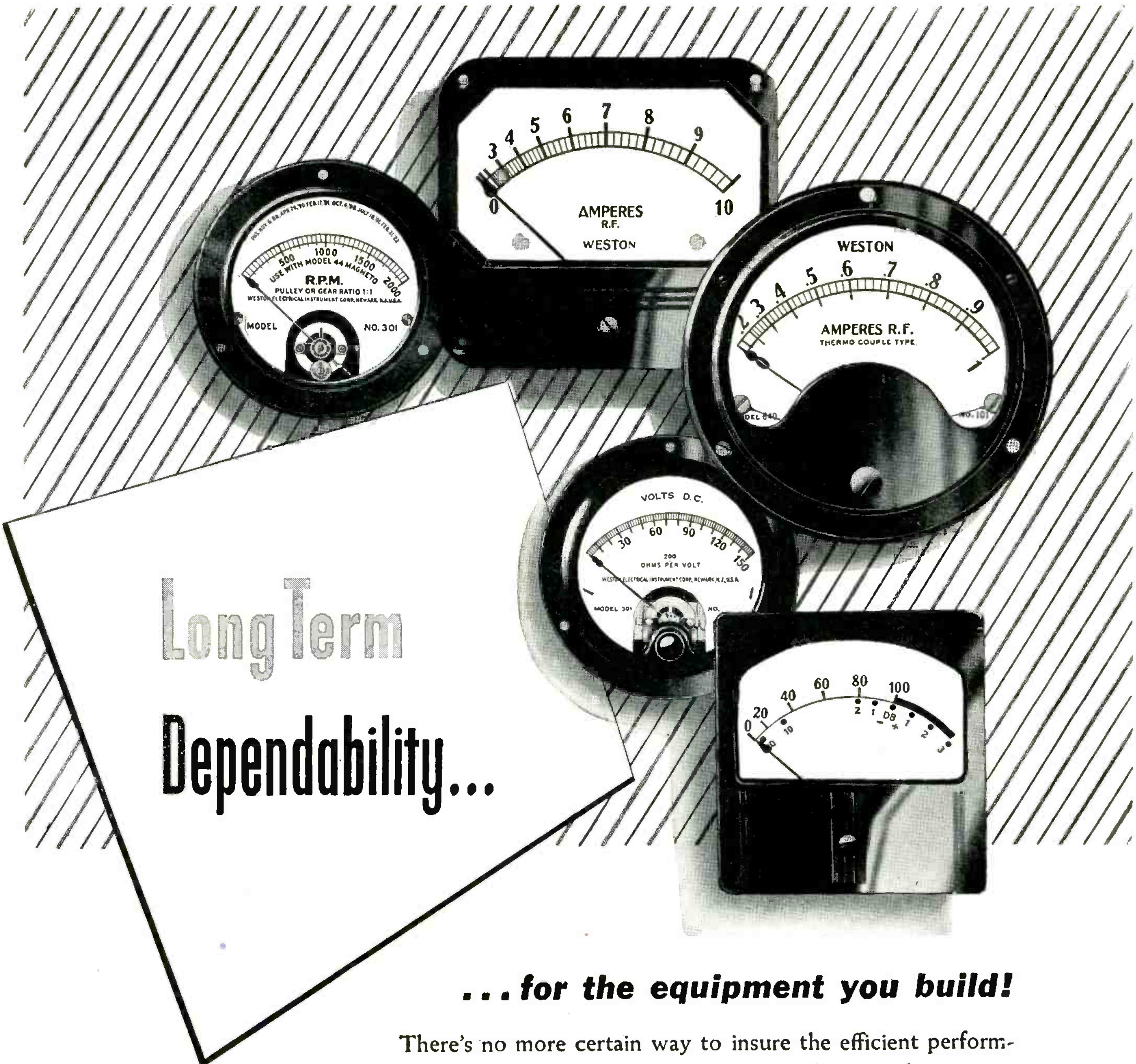
Audio Frequency Oscillators · *Signal Generators* · *Vacuum Tube Voltmeter* · *Noise and Distortion Analyzers* · *Wave Analyzers* · *Frequency Meters* · *Square Wave Generators* · *Frequency Standards* · *Attenuators* · *Electronic Tachometers*



Long Term Dependability...

...for the equipment you build!

There's no more certain way to insure the efficient performance in your customers' hands of the machines or devices you build, than to equip their panels or controls with *trustworthy* instruments. And for that very reason, the name WESTON on a panel instrument helps build buyer acceptance and goodwill for the products on which they are installed.

WESTON instruments are available in all the types, sizes and ranges essential for panel or built-in requirements. Complete information, or engineering cooperation, is available on request. Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark 5, New Jersey.

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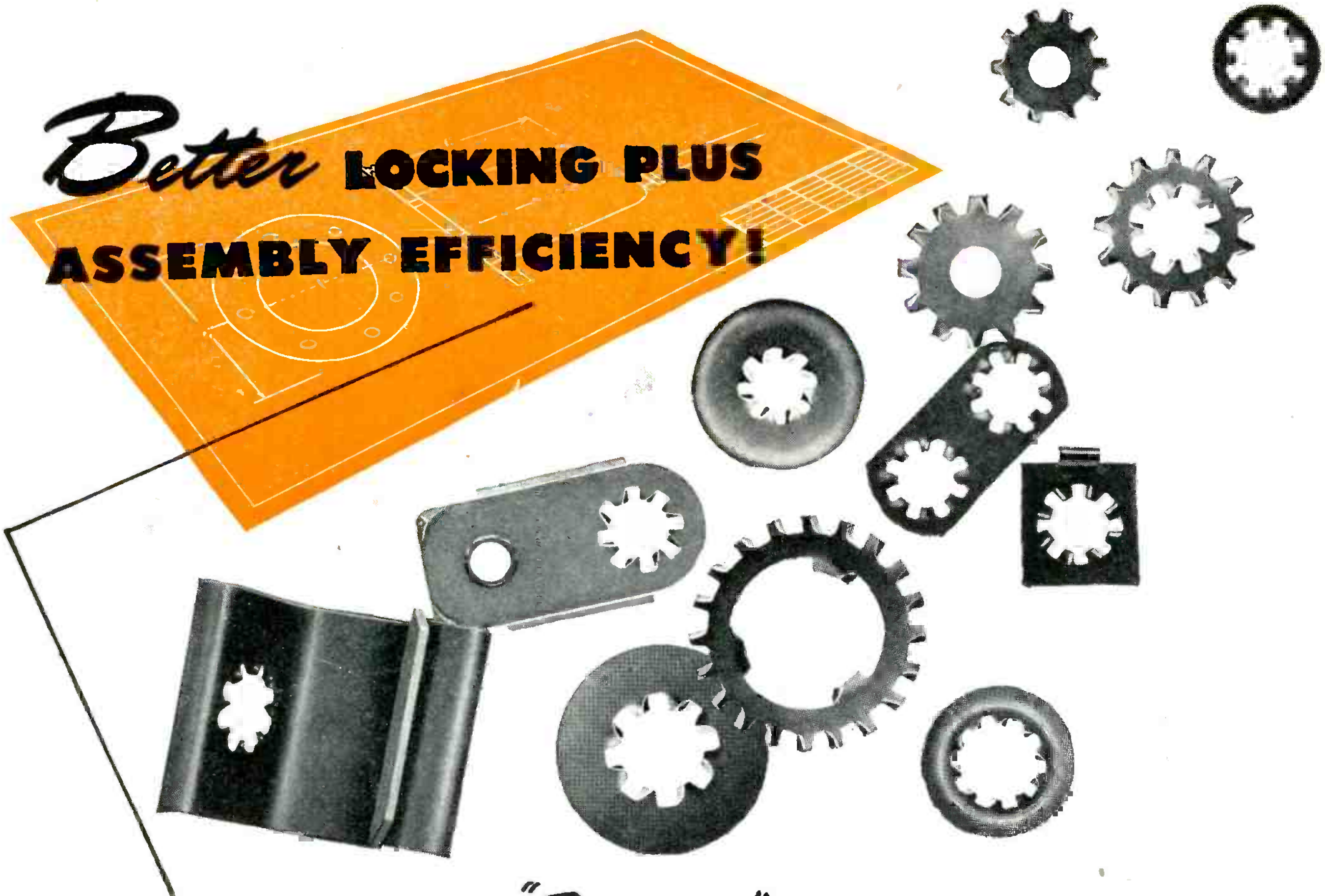
Better LOCKING PLUS ASSEMBLY EFFICIENCY!



SHAKEPROOF *"Engineered"* LOCK WASHERS PROVIDE THE CORRECT LOCKING POWER . . . FASTER, LOWER COST ASSEMBLY!

Don't be satisfied with just any lock washer. Let Shakeproof engineers give you the benefit of their years of experience in analyzing and solving the fastening problems of leading metal-product manufacturers. If you have applications where lock washers are used in large volume, a special type designed to meet your particular locking needs may improve performance and facilitate assembly. Often, the locking teeth can be "built-in" to a part—definitely reducing costs. Decide now to contact Shakeproof for a study of your lock washer requirements.

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SEND FOR FREE TEST KIT!

The Shakeproof tapered-twisted tooth locking principle provides positive protection against the loosening action of vibration. With this sample kit which contains various sizes and types you can quickly prove its outstanding efficiency. Write for Kit No. 21, today!

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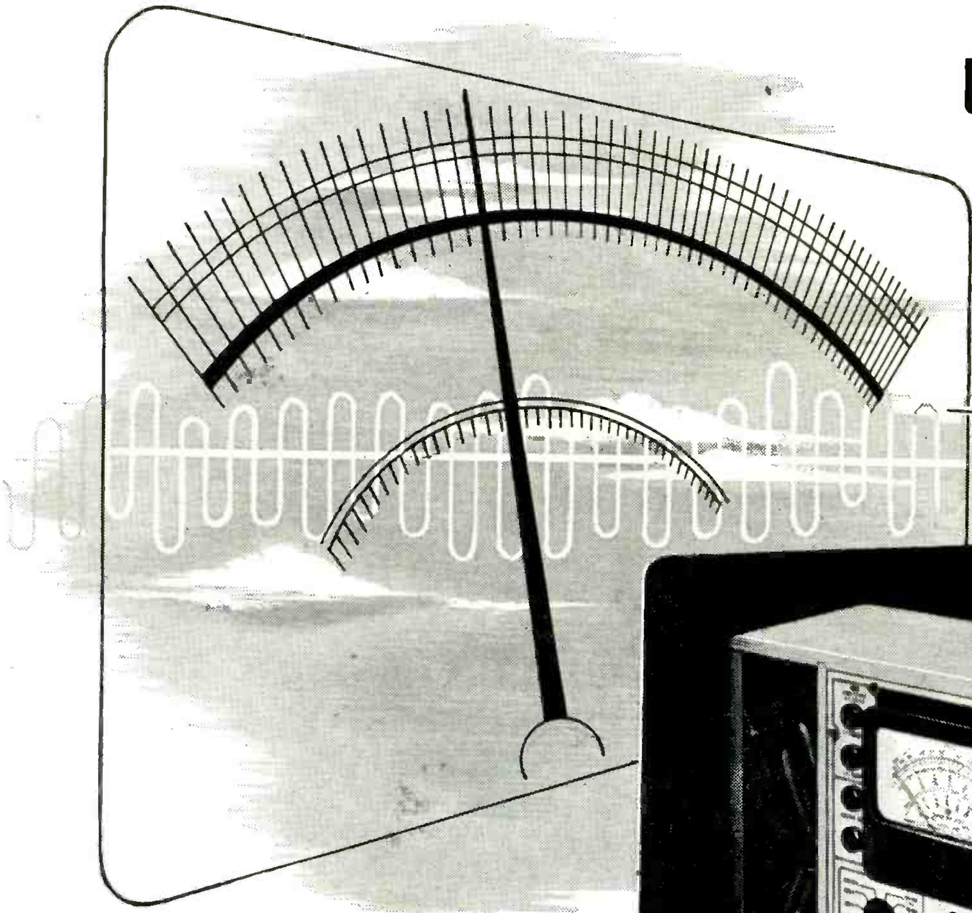

ultra-sensitive R. C. P. multitester

MODEL 488A—

Dual DC Sensitivity: 20,000 and 1,000 ohms per volt *plus* AC Sensitivity of 1,000 ohms per volt.

The experience and "know-how" that are built into this quality multitester make it ideal for precise testing of radio and electronic equipment in the field, shop or laboratory.

FEATURES

Wide spread, easy reading ohmmeter scales. Full scale to center scale ratio 75 to 1. Current readings in both AC and DC in ampere ranges. High voltage measurements to 6000 volts AC and DC. High voltage test leads included.

RANGES

DC Voltmeter: 0/3/12/60/300/600/1,200/6,000 volts.
AC Voltmeter: 0/3/12/60/300/600/1,200/6,000 volts.
Output Voltmeter: 0/3/12/60/300/600/1,200/6,000 volts.
DC Microammeter: 0/60/300 microamperes.
DC Milliammeter: 0/3/20/120/600 milliamperes.
DC Ammeter: 0/12 amperes.
AC Ammeter: 0/3/6/12 amperes.
Ohmmeter: 0/3,000/300,000 ohms; 30 megohms

MODEL 488A. Size: 13" x 12½" x 5½". Weight 10½ lbs. Complete, ready to operate, with battery and heavy duty high voltage test leads in a convenient carrying case of sturdy oak with removable cover.

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START THINGS M-O-V-I-N-G WITH alliance MOTORS

You can Start!—Stop!—Reverse!—or "Keep things moving!"

Alliance Power-pakt motors will do one or *all!* They'll multiply automatic operations, provide better control, and speed up performance.

Operating characteristics and power ratings are variable. For radio, electronic, electric and heating controls—for remote actuation, continuous and intermittent duty, there's probably an Alliance motor already "built to your order".

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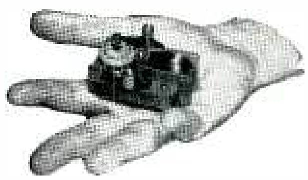
ALLIANCE MOTORS are made with centerless ground precision shafts; large, self-aligning, graphite bronze oilless-type bearings; and with adequate mounting facilities to incorporate them in any device. Shaded pole induction type motors for A.C. voltage from 24 to 250, and frequencies of 40, 50 or 60 cycles have starting torques from one-half ounce-inches at 10 watts, to two ounce-inches at 36 watt input. Spl t phase resistor type, enclosed reversible control motors for intermittent duty, with or without integral gear reduction are made for 60 cycles, 24 or 117 volts. Typical weights run from less than 13 ounces to more than two and one-half pounds.



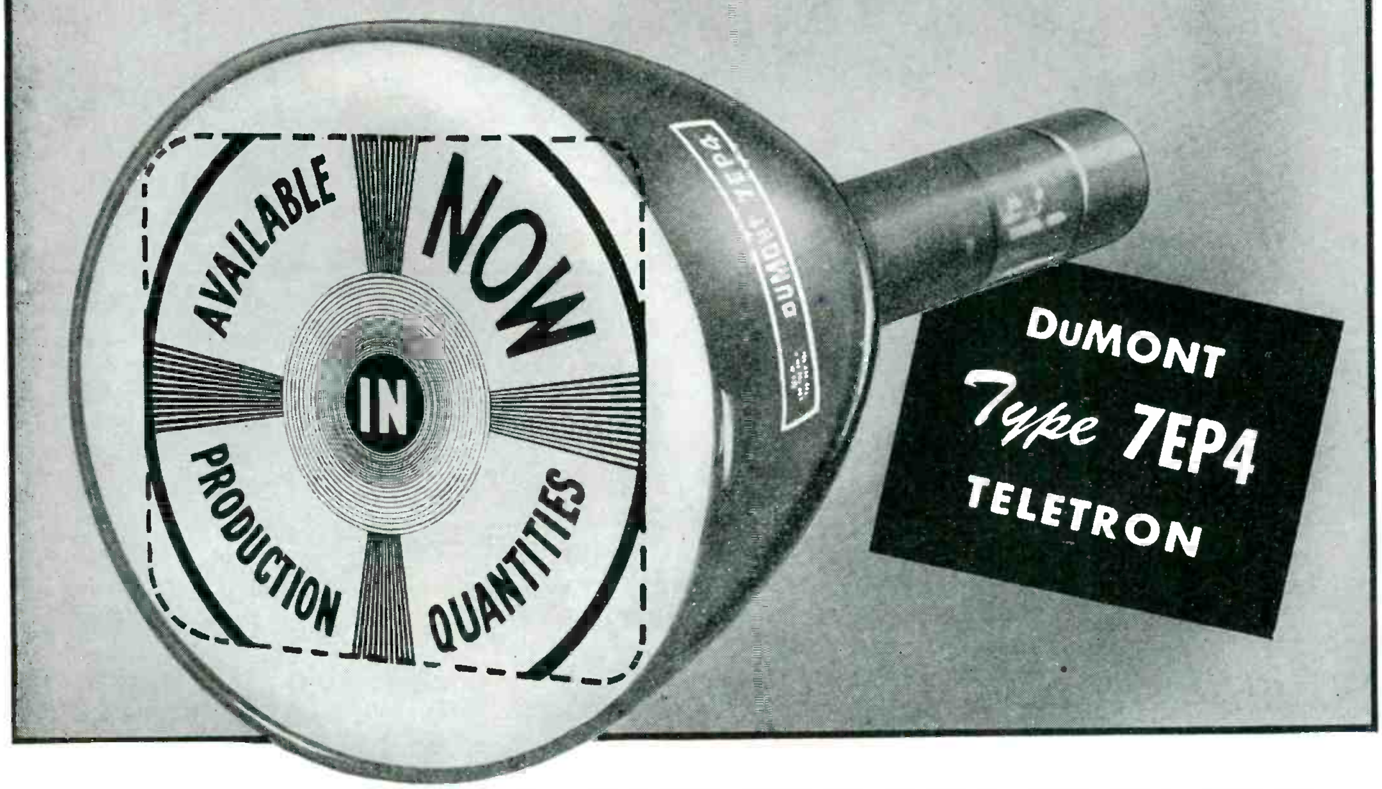
MINIATURE MOTORS THAT KEEP 'EM MOVING

WHEN YOU DESIGN—KEEP alliance MOTORS IN MIND

ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO

ALLIANCE TOOL AND MOTOR LTD., TORONTO 14, CANADA

AMERICA'S *inexpensive* 7" TELEVISION RECEIVER TUBE



HERE'S HOW THE DuMONT TYPE 7EP4 HELPS KEEP RECEIVER MANUFACTURING COSTS AT ROCK BOTTOM:

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2. Low operating voltage requires simple, low-cost power supply
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4. High deflection sensitivity; exceptionally good light output
5. Special DuMont "Eye Comfort" soft-quality screen
6. Stellar performance that "sells" receivers to a mass market...and at a profit

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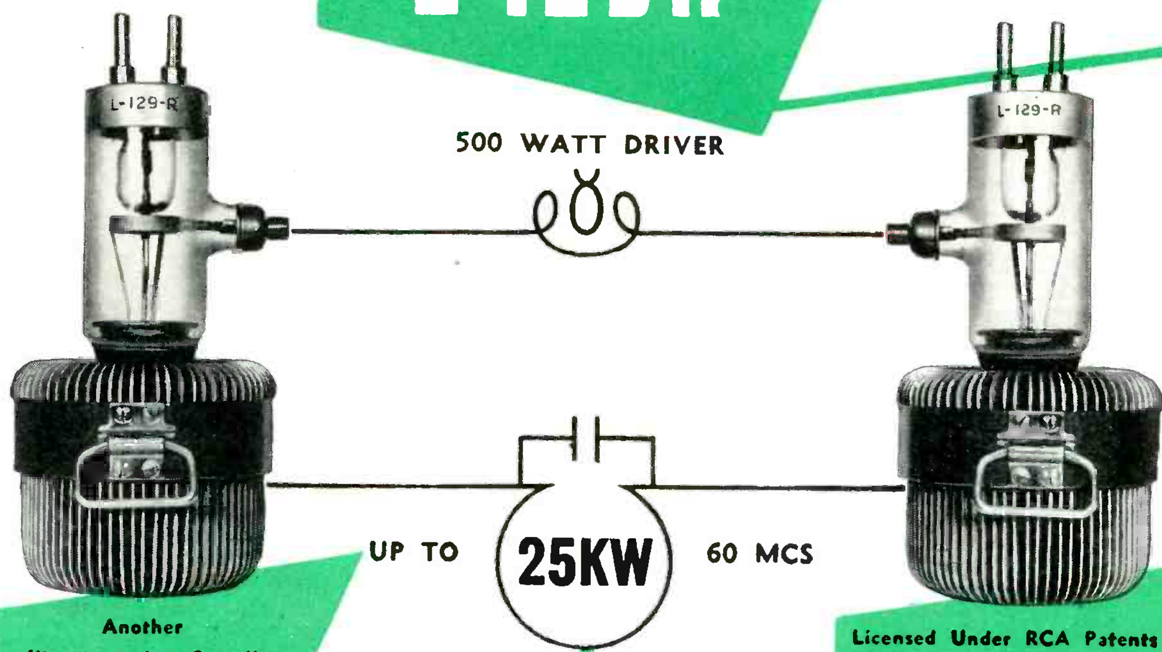
IN A SMALL PACKAGE

L-129R



Another "Lewis at Los Gatos" Transmitting Tube

Licensed Under RCA Patents
List Price
$375.00

Only 14 inches high and approximately 6 inches in diameter at maximum dimensions—yet two Lewis L-129-R transmitting tubes can deliver 25 kw of useful power at industrial heating frequencies. This, with a self-excited oscillator or, if frequency stability is essential, with an external driver of only 500 watts capacity.

No extensive heat transfer unit is required as only 650 cu. ft. of air per minute are necessary for forced air cooling of 2 tubes. Expensive water systems for anode cooling are eliminated.

Built "rugged and reliable" by "LEWIS AT LOS GATOS" the L-129-R will give long and trouble-free life under strenuous industrial operating conditions.

Wire or write for our representative.

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An example of Cinaudagraph Speaker Engineering—the fifteen-inch electrodynamic speaker of Aireon's Electronic Phonograph, most perfect of commercial music machines.

There's a better Aireon Cinaudagraph Speaker

for every electroaccoustical application

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In Aireon's scientific laboratories individual and special problems of electroaccoustical reproduction are under constant study, so that the finest, truest tonal reproduction may be combined with unusual stamina and long service life.

As a result, electronic perfection never before achieved has been incorporated in Cinaudagraph Speakers—for public address systems, radio, commercial phonographs and many special purposes.

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Results? No shopping around, no wasted time. Instead, better design, uniform control and lower costs with Printloid engineering supervision at every step of the job.

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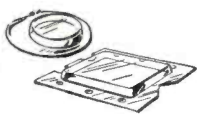

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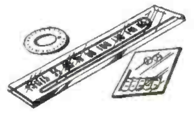
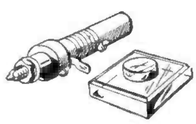


MACHINING



Printloid is experienced in precision work to .001" in all machining and finishing operations. Typical of our complete facilities is 2½ inch through spindle lathe capacity for machining.

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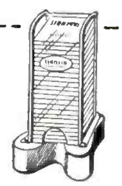

Printloid experts work to your specifications or execute your original designs. Displays have been created for leading national advertisers. Our engineers invite you to consult them on your problems.

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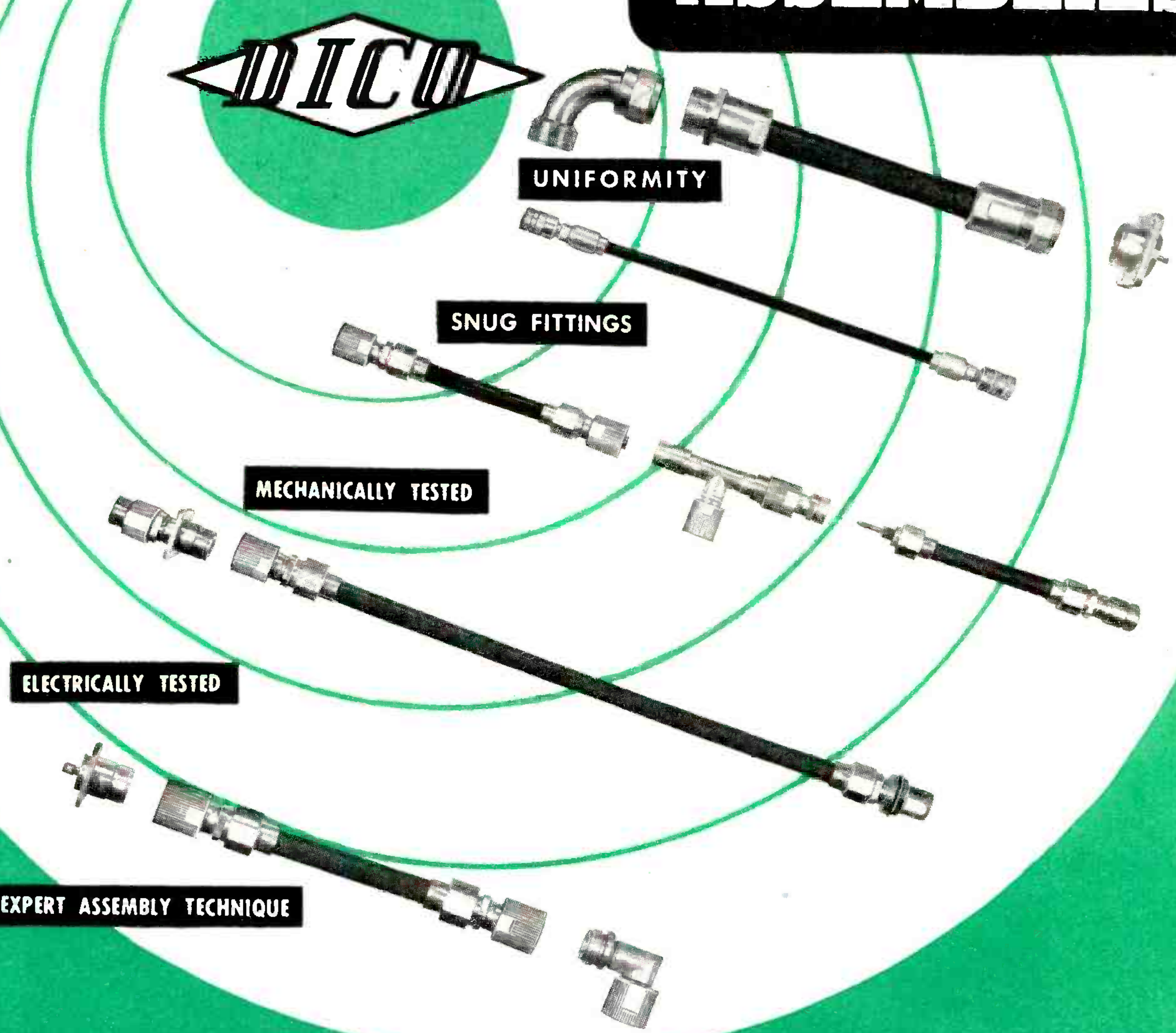
The new Printloid catalog tells the story of complete plastic production under one roof. Includes a useful Plastics Glossary. Write for your copy.

Printloid INC.
PLASTIC FABRICATION

CO-AXIAL *Connector* AND CABLE ASSEMBLIES



Pioneers in the design, development and production of coaxial connectors used for cable assemblies, DICO is most dependable where unfailing performance is a requisite in the field of communications.

For quality and precision, DICO can handle your most exacting demands for standard and special connector and cable assemblies.

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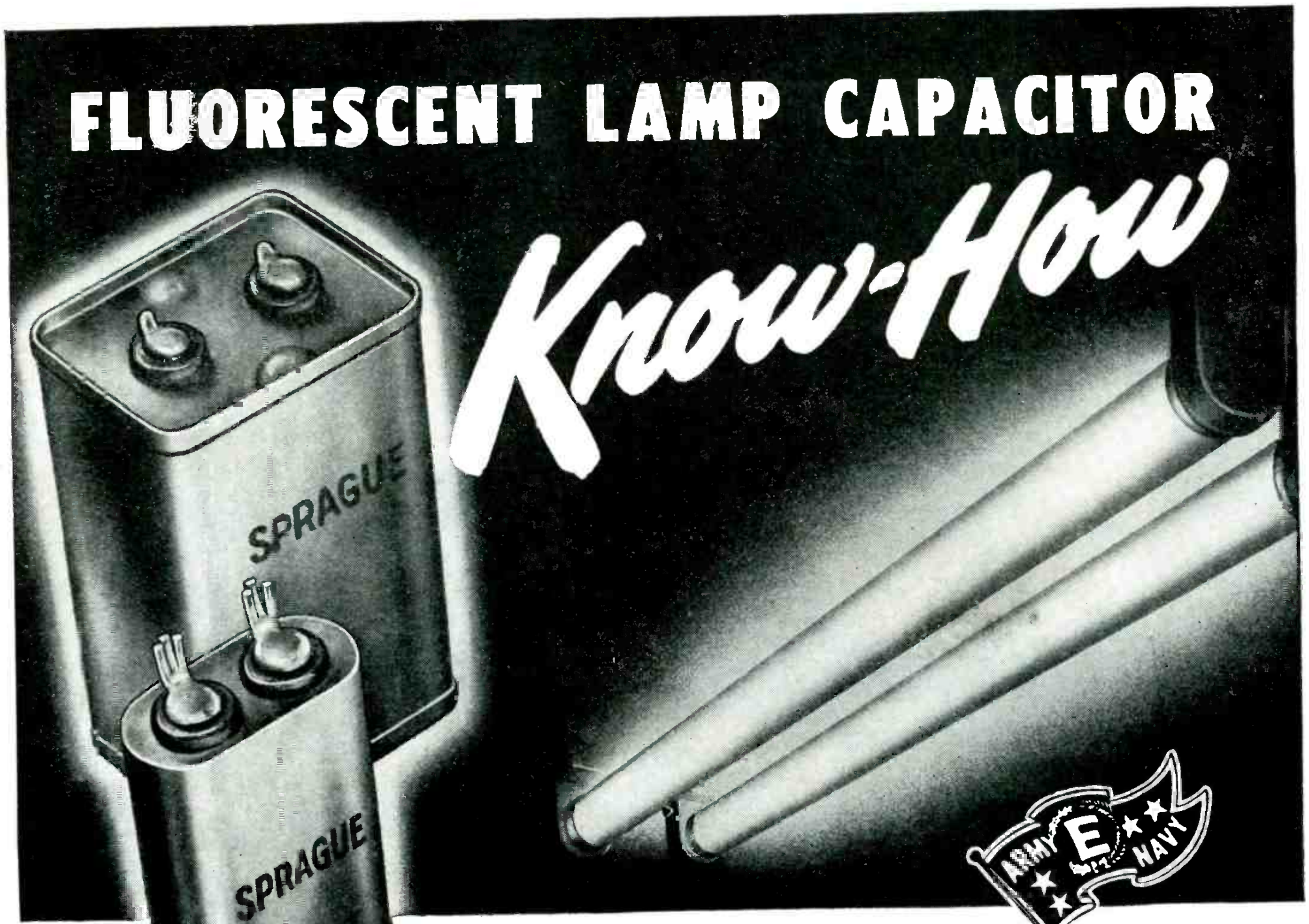

SPRAGUE has the answers to fluorescent lamp capacitor requirements. Standard units of proved dependability meet most needs. Beyond this, Sprague engineers welcome the opportunity to match their broad experience in this field against special applications. Whether your problem is one of shape, size, or mounting, heat, harmonics, or other operating conditions, submit it to Sprague for recommendations.

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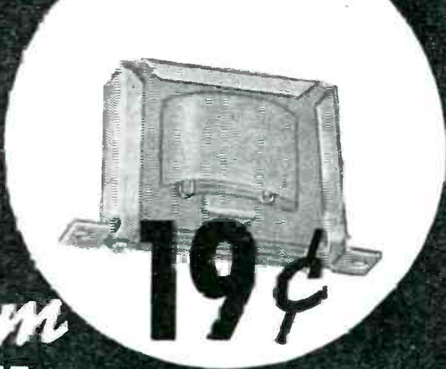

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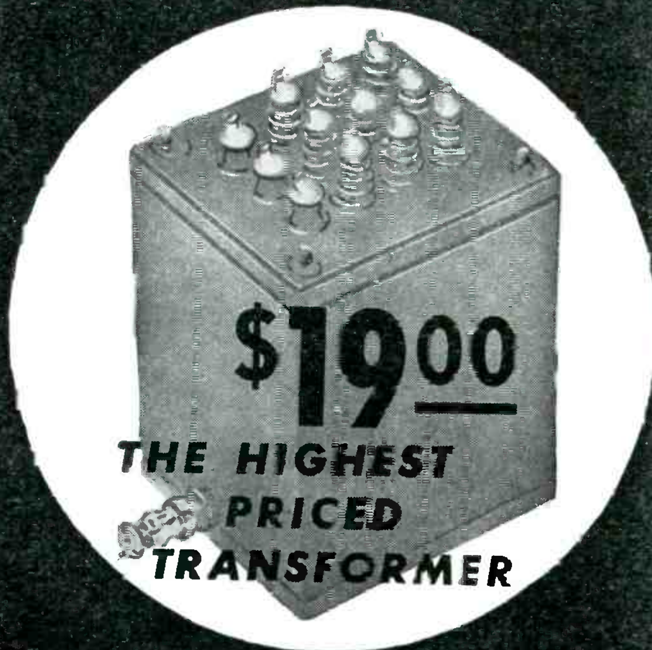

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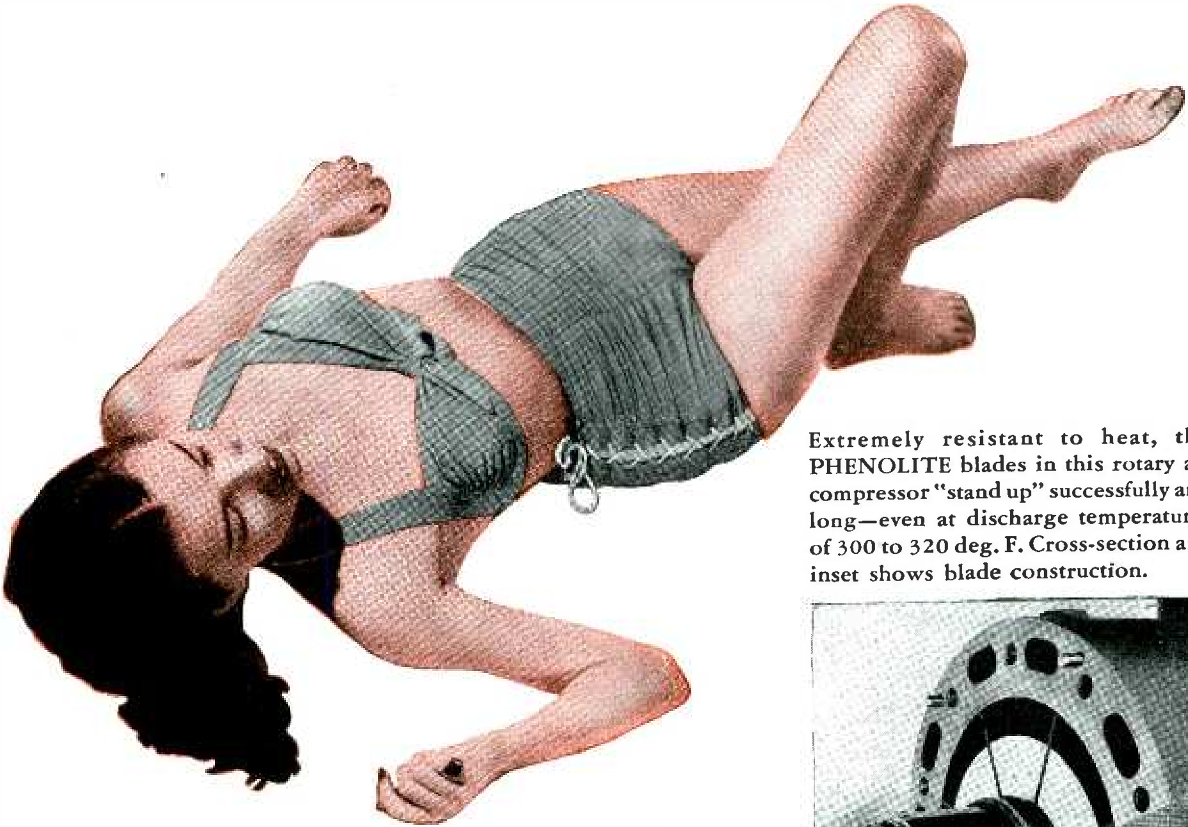
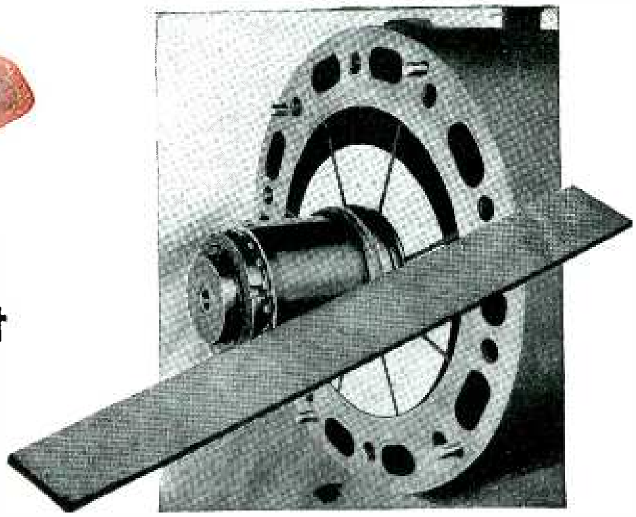


Extremely resistant to heat, the PHENOLITE blades in this rotary air compressor "stand up" successfully and long—even at discharge temperatures of 300 to 320 deg. F. Cross-section and inset shows blade construction.



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LAMINATED PLASTIC

improves product performance and efficiency

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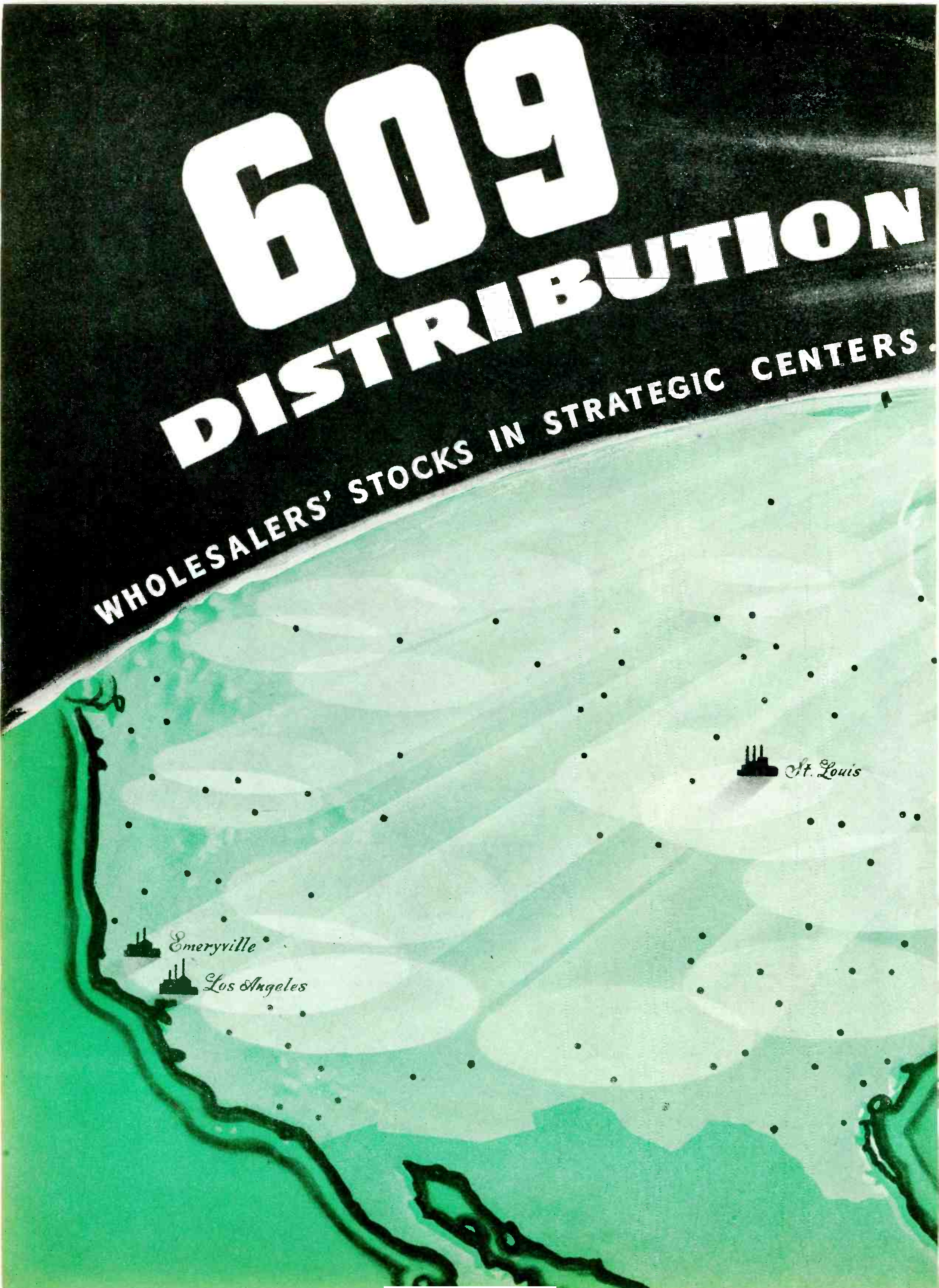
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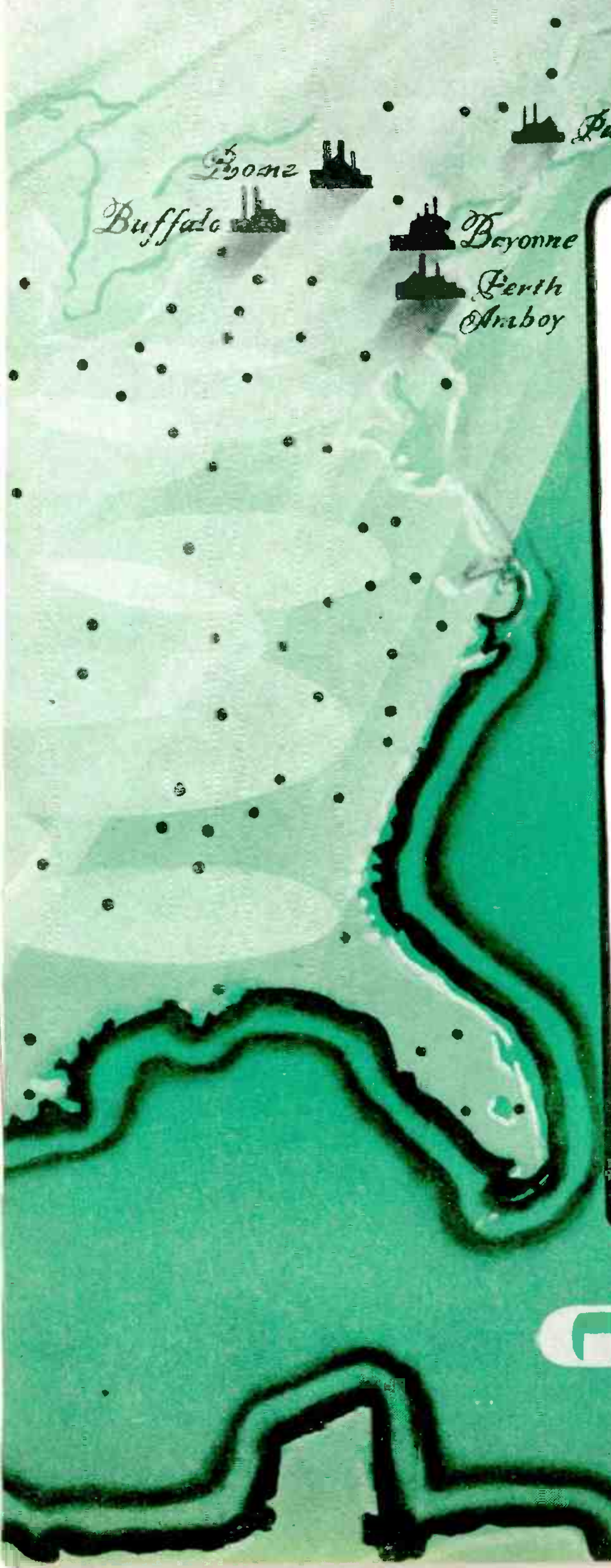

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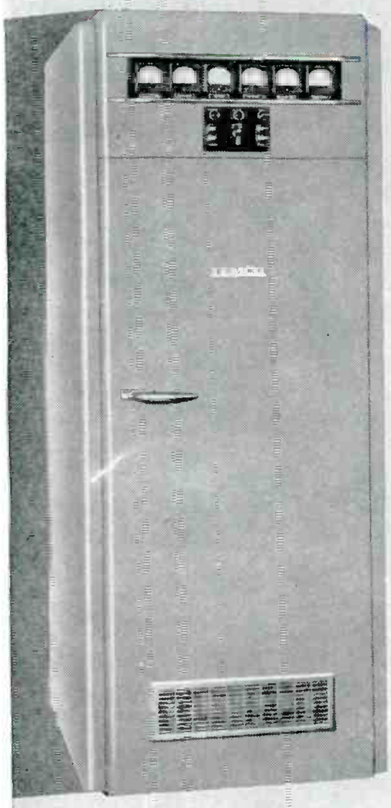

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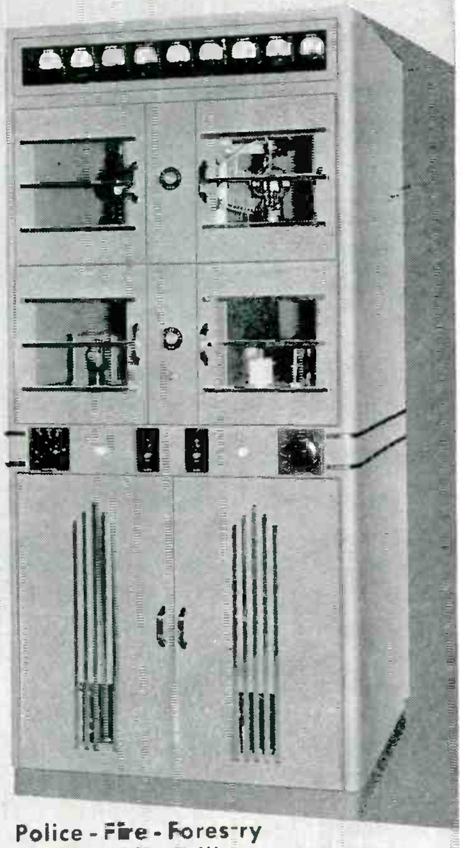
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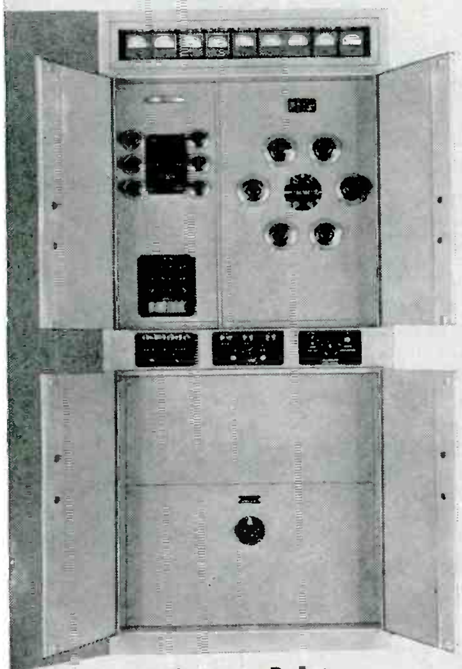
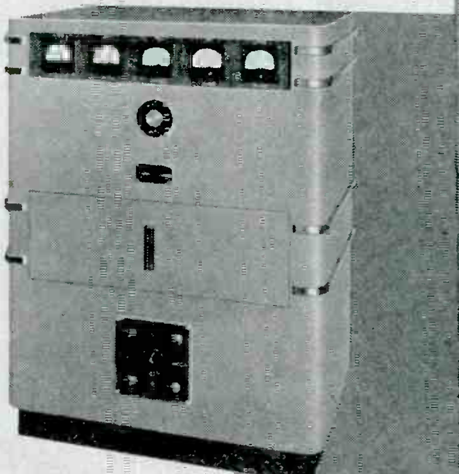
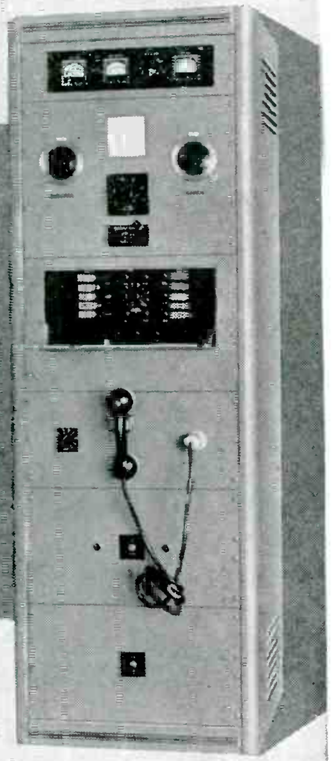

Point - to - Point Commercial


Amateur and Citizen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- **RADAR ASSEMBLIES**

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PHONOGRAPH TURNTABLE UNIT The need at this time for large quantities of phonograph turntable assemblies has prompted us to quickly design and tool up for the immediate production of this item. Engineers will find this compact turntable meeting all of their requirements for performance.

PERFORMANCE: — Correct and uniform speed is secured through the use of a motor of ample capacity, preloaded to operate on the flattest portion of the torque-speed characteristic.

QUIETNESS: — Is assured by full-floating rubber motor mountings and rubber cushioned drive. Permanent freedom from turntable wobble is guaranteed by an extra rigid turntable, an extra long bearing and precision machining of these parts.

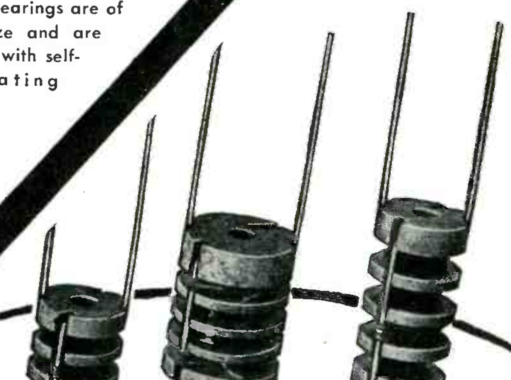
RELIABILITY: — The motor is fan-cooled and will operate continuously with an exceptionally low temperature rise. All bearings are of ample size and are provided with self-lubricating features.

Type C
Maximum resistance 500,000 ohms.

Type A
Maximum resistance 1,000,000 ohms.

Type B
Maximum resistance 1,000,000 ohms.

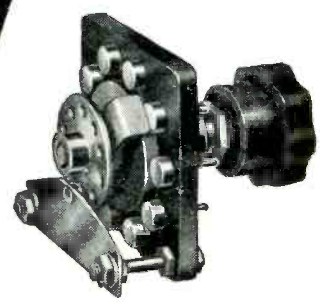
We will make special resistors to any value or tolerance.



Type C   Type A   Type B

Type XM
Instrument resistance shunt .1 ohms or lower. 25 watts.

★ ★ ★



ROTARY SELECTOR SWITCH

Designed for use where low contact resistance and mechanical sturdiness is required. Its construction insures long wear with low contact resistance of less than .001 ohm. May be arranged to have several sections to obtain multi-polar switching.

Well suited for precision test instruments; shunt ammeters, thermo-couple types, Wheatstone Bridges, and similar devices.

Eastern Electronics Corp.

41 CHESTNUT STREET, NEW HAVEN, CONN.

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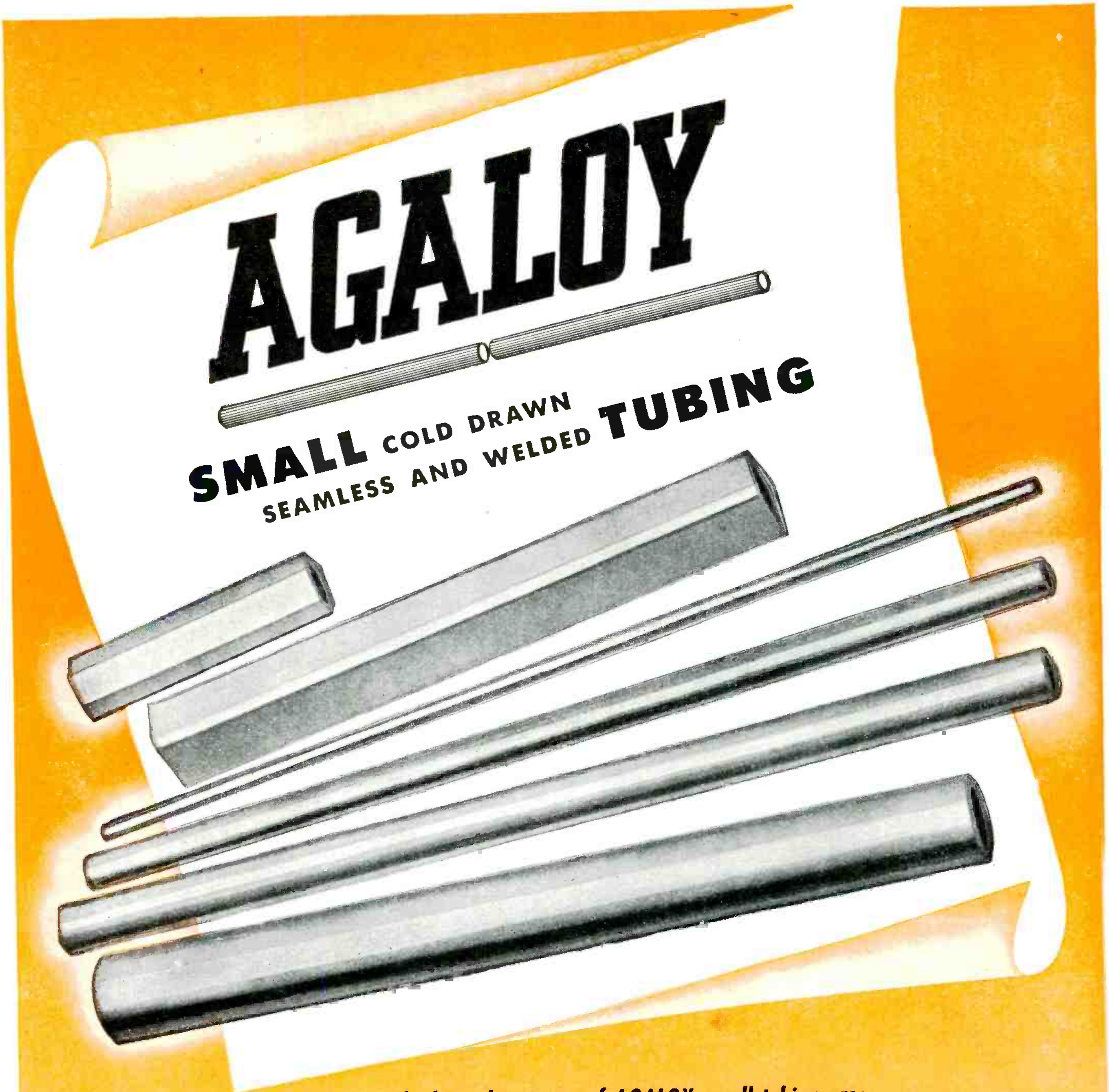

The big advantages of AGALOY small tubing are:

Proper inside and outside surface conditions . . . Processed to bend and form as required. Corrosion-resistant, heat resistant, accurate.

Stainless (Types 304, 308, 316, 317, 321, 329, 347, 410, 430, 446 and others) . . . Monel metal . . . Nickel . . . Inconel . . . L Nickel.

Available in sizes 5/8-inch outside diameter and smaller

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Chicago Office:
221 North La Salle Street, Chicago 1, Illinois

Mill:
Springfield, Ohio

Send for your copy "Plan with Agaloy Tubing"

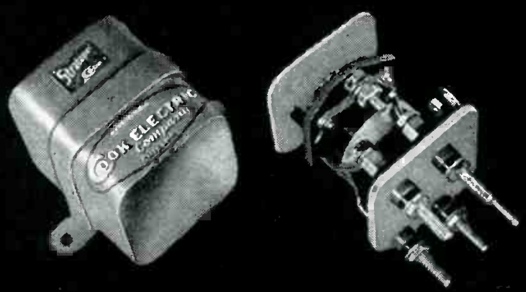
Here are the advantages when you Stratopax your electrical devices and components -

The science of Stratopax is the sealing of electrical devices in metal enclosures in an inert pressurized gas atmosphere. Stratopax, a service of Cook Electric Company available to all manufacturers of electrical devices and components, is the modern concept of the hermetic seal, with new and greatly improved techniques in sealing, inert gas filling and tightness testing.

Illustration of Stratopax relay used with a machine control unit ready for plug-in connection (left) and with cover removed before gas filling and sealing (right).

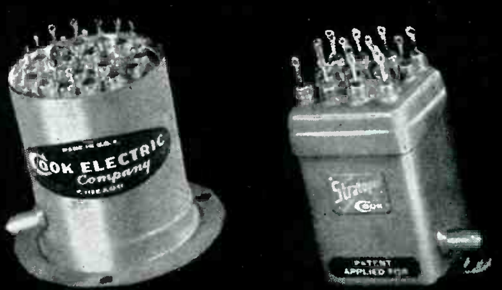
Here are the five basic features of Stratopax

1. PREVENTS CORROSION resulting from atmospheric changes, chemical conditions and fungus, by the use of specially compounded inert Nithelon gas.
2. PREVENTS EXPLOSION where gas and dust atmospheres are present.
3. PREVENTS ARCING AND BREAKDOWN in high altitudes for aircraft applications.
4. ADDS TO LIFE OF INSTRUMENT by permitting maximum service from contact points and through improved heat dissipation.
5. PREVENTS TAMPERING with factory adjusted equipment, and provides easy replacement if necessary.
6. RELAXATION OF SPECIFICATIONS and consideration of discontinuance of plating metal parts, insulation of coil windings, complete removal of coil winding wrappings, moisture and fungus proofing, design features for appearance only, and numerous other factors that become superfluous when Stratopax is used.



Contactor ready for Stratopaxing before covering. Wrap around mounting bracket, blister on cover for adequate terminal clearance, and binding post terminals meet specifications for unit.

While the packing and sealing of instruments may at first seem relatively simple, the steps involved in Stratopaxing already existing equipment are, however, more complex. How Cook engineers adapt existent equipment to Stratopax with consideration of present mounting and space limitations, and the steps taken in preparation of Stratopax are completely described in the Cook Stratopax Engineering Report. Fully illustrated, it explains thoroughly the need for, and features of, Stratopax techniques used in filling, sealing, testing and selection of gases. A request on your letterhead will bring you a copy immediately.



Two typical Stratopax enclosures showing fill tube protectors, glass seal terminals and variations of design and mounting to meet requirements.

A service of the Stratopax Division of

COOK ELECTRIC Company

CHICAGO 14, ILLINOIS

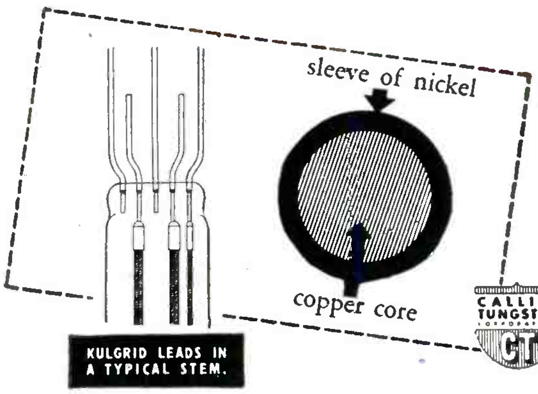
high vacuum controlled to one-billionth of an atmosphere! the National Union ionization gauge with Callite Kulgrid* welds . . .

A recent electron tube development — the National Union Research Laboratories' ultra-sensitive Ionization Gauge — is capable of recording pressures of .00001 of a micron! The simple rugged construction of this NU-R1038 Gauge includes two and three-piece tungsten welds using Callite's Kulgrid "C" strand.

Kulgrid* is a composite wire having an inner core of copper bonded to a nickel sleeve. When stranded into a flexible cable, Kulgrid has 70% of copper's conductivity — all of nickel's resistance to oxidation at high temperatures. Kulgrid eliminates flake deposits in the tube press, does not become brittle — is shock-resistant. Kulgrid welds readily to itself, to nickel, copperclad, tungsten, molybdenum and other related metals.

Kulgrid is only one of Callite's many metallurgical developments. When selecting components, check our complete range of metallurgical specialties. Write for our catalog. Callite Tungsten Corporation, 544 Thirty-ninth Street, Union City, New Jersey. Branch Offices: Chicago, Cleveland.

*Kulgrid is covered by U. S. and foreign patents.



CALLITE TUNGSTEN CORPORATION

Callite

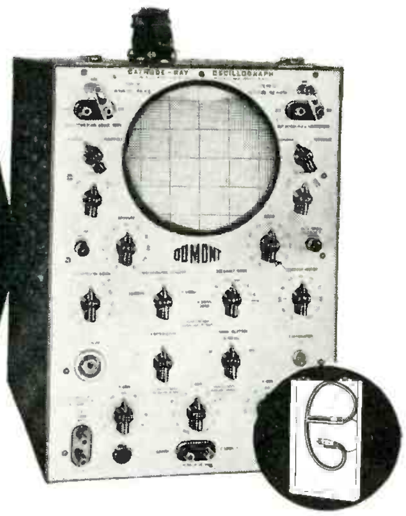
TUBE COMPONENTS

Hard glass leads, welds, tungsten and molybdenum wire, rod and sheet, formed parts and other components for electron tubes and incandescent lamps.

FOR 26 YEARS PIONEERS IN TUNGSTEN METALLURGY

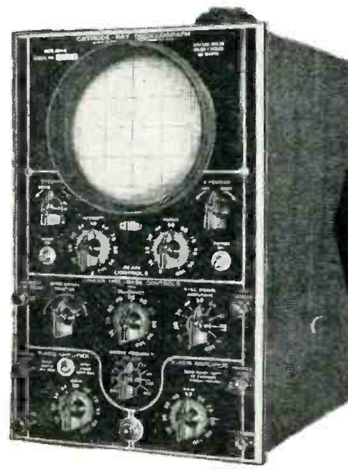
Now Available—

...the DuMONT Cathode-Ray Oscillograph you've been waiting for!



TYPE 241

Specially designed for the observation of audio and video signals. 5" CRT. Provision for grid modulation. Includes front cover, probe, and shielded cable.



TYPE 208-B

General purpose oscillograph. 5" intensifier CRT. High-gain amplifiers. Frequency range extending from very low to radio frequencies. Wide sweep frequency range.

TYPE 224-A

Suitable for studies involving signals such as pulses or square waves, having frequency components as high as 5 mc. 3" CRT. Provision for grid modulation.

TYPE 248

Micro-second accuracy in a combination oscillograph and synchroscope. 5" CRT. Precision features unrivalled in a commercial instrument. Separate power supply unit.

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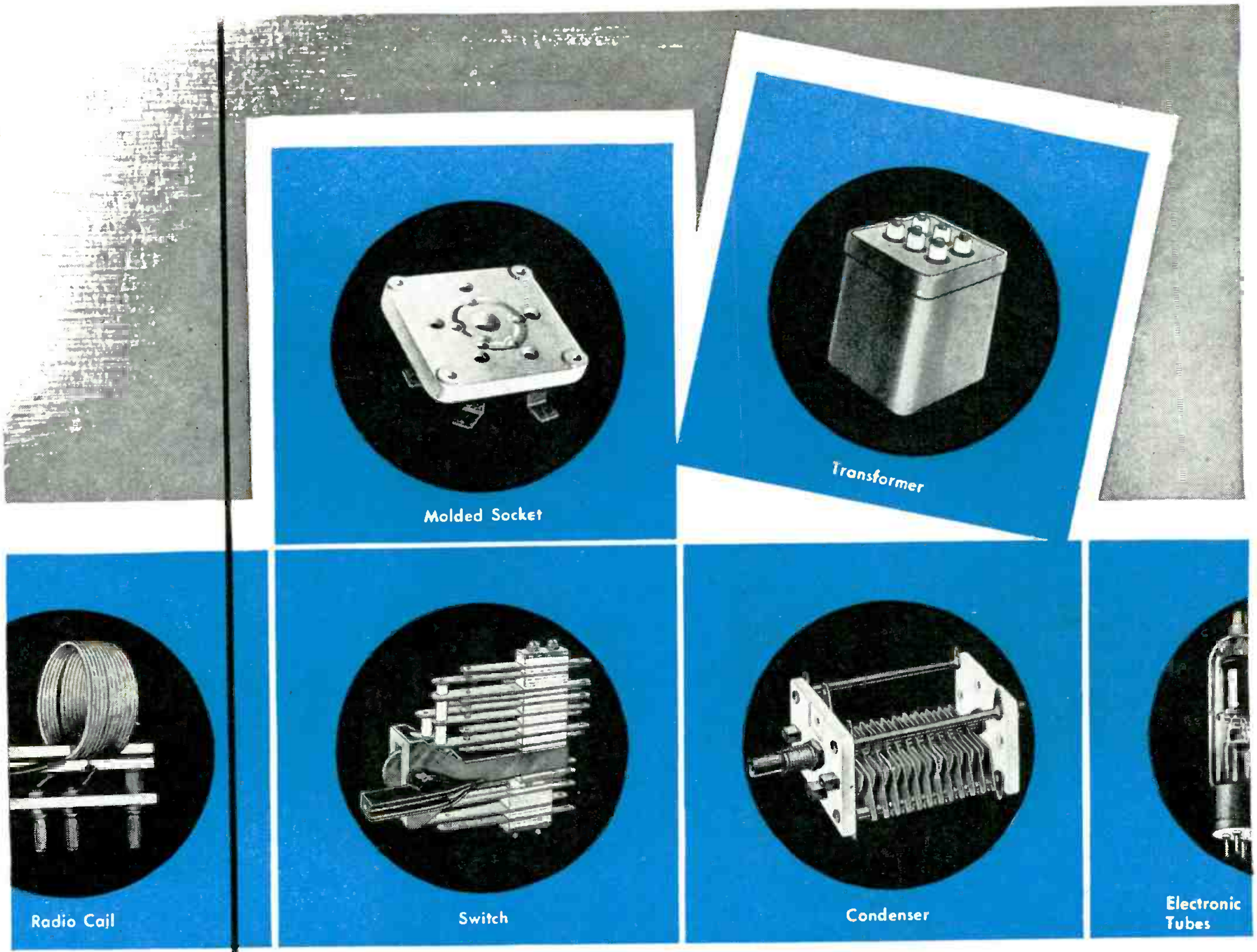

HOW MYCALEX BUILDS BETTER PEACETIME PRODUCTS

As high frequency insulating standards become more exacting, the more apparent become the many advantages of MYCALEX over other types of materials . . . in building improved performance into electronic apparatus.

For 27 years MYCALEX has been known as "the most nearly perfect" insulation. Today *improved* MYCALEX demonstrates its superior properties wherever low loss factor and high dielectric strength are important . . . where resistance to arcing and high temperatures is desired . . . where imperviousness to oil and water must be virtually 100%.

New advancements in the molding of MYCALEX now make available the production of a wide variety of parts with metal inserts or electrodes molded in to create a positive seal.

It pays to become familiar with the physical and electrical properties of all three types of MYCALEX — MYCALEX 400, MYCALEX K and MYCALEX 410 (MOLDED). Our engineers invite your inquiries on all insulating problems.

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ERIE RESISTOR has developed and manufactured a complete line of Ceramic Condensers for receiver and transmitter applications; Silver-Mica and Foil-Mica Button Condensers; Carbon Resistors and Suppressors. Complete technical information will be sent on request.

Electronics Division

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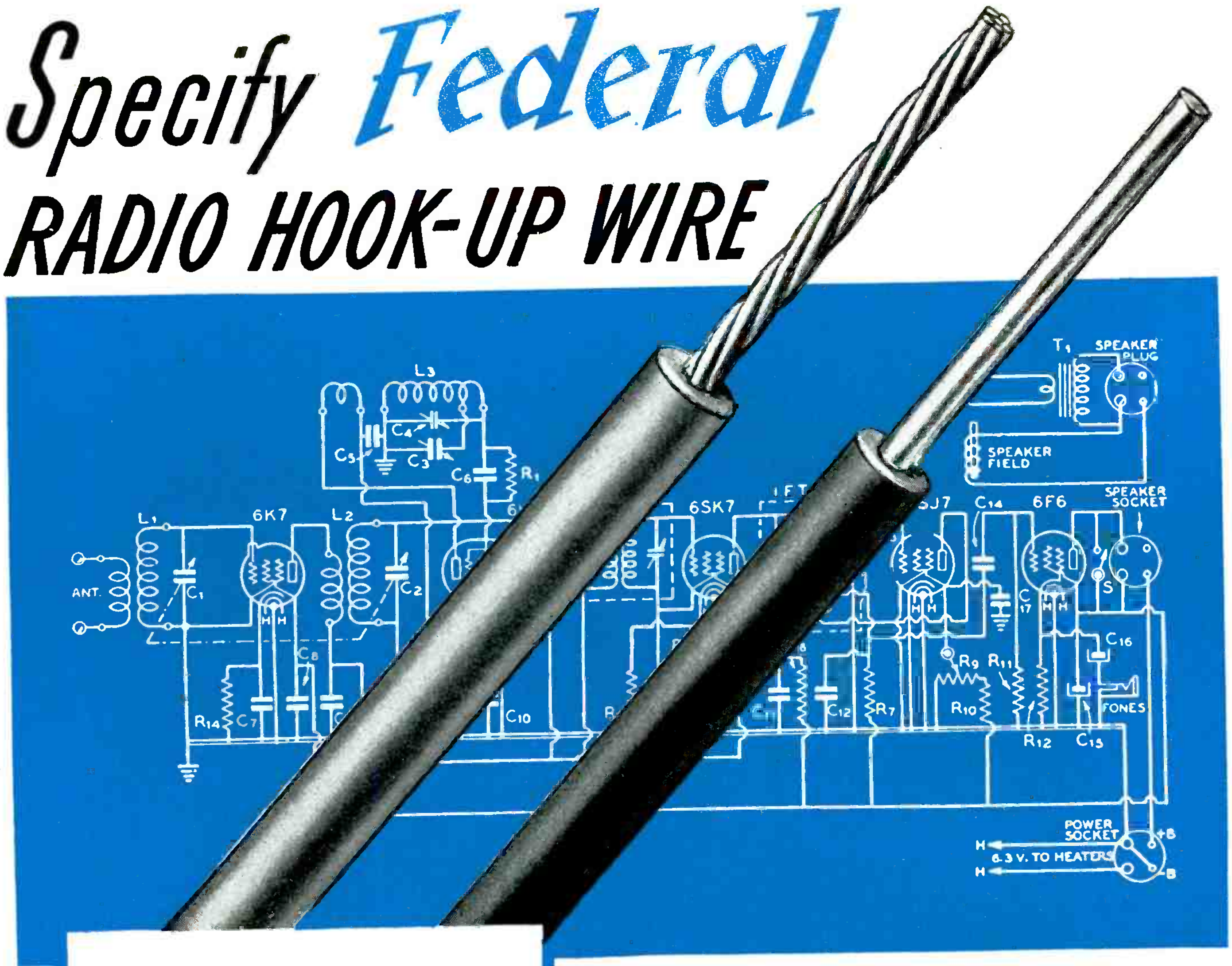
Specify Federal
RADIO HOOK-UP WIRE



LONG LIFE

FLAME RESISTANT

LOW MOISTURE ABSORPTION

RESISTS OXIDATION

HIGH DIELECTRIC STRENGTH

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FOR SUPERIOR QUALITY AND SERVICE

Federal's light-weight, pliable, thermoplastic insulated hook-up wire . . . fitted to your job . . . means better assembly with wire possessing superior dielectric strength and exceptional mechanical stamina.

Resistant to flame, moisture and oxidation . . . this tough but flexible thin-walled thermoplastic insulation covers all Federal's hook-up wire and combats aging, water absorption, abrasion, oils and greases.

Available in solid or stranded types . . . for high or low voltage needs in radio, electronics, appliances, communications, and allied fields . . . these labor-saving light-weight hook-up wires come in 14 brilliant colors and range in size from 24 to 14.

Whether your needs be large or small, get complete details . . . write to Federal now.

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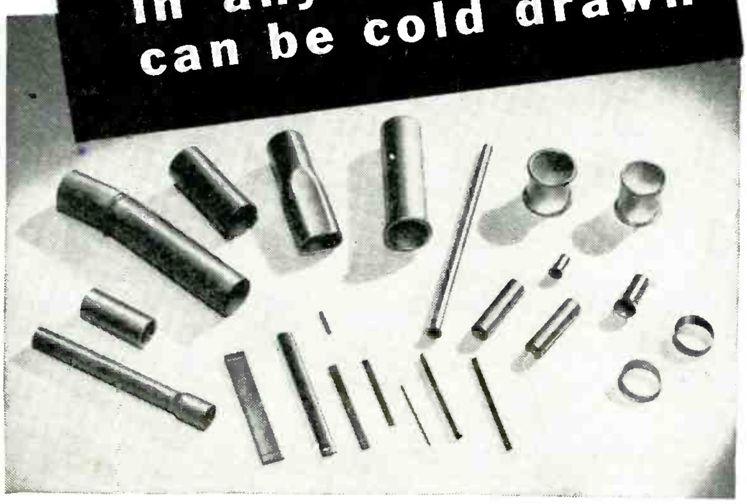
in any metal that can be cold drawn



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SUPERIOR Shaped Tubing — made to your specification, cut to the exact size you need, or in random lengths. Squares, ovals, ellipses, rectangles, etc.

Consult **SUPERIOR** about additional forming operations to your individual requirements. **SUPERIOR'S** experience and facilities are at your disposal.

For the Electronics Industry

Cathodes and anodes by **SUPERIOR**, the pioneer in design and production in this specialized field. Send your specifications to **SUPERIOR** for anodes and cathodes of standard or new design.

SEAMLESS — Nickel of electronic quality in random lengths, or Nickel Cathode Sleeves to exact lengths. Plain or Beaded (embossed), and also to *Shaped* specifications.

LOCKSEAM* — Nickel Cathode Sleeves, Round or Special Shapes, Plain, or Beaded to specified lengths.

LAPSEAM — Nickel Sleeves produced mechanically for special purposes.

ANODES — Stainless Steel — Nickel of electronic quality — Monel — Inconel. For Cathode Ray Tubes and Power Tubes. In random lengths or to exact specifications.

* Produced under Superior's Patents.

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SUPERIOR TUBE COMPANY NORRISTOWN, PENNSYLVANIA

COLLINS

FM

Collins FM research, begun long before the war, went into high gear immediately following VJ day. An intensive engineering program is developing a series of FM transmitters to cover the power range of 250 watts to 50,000 watts.

These transmitters will be available, beginning with the 250 watt type 731A in midyear, 1946, and the 1000 watt type 732A soon thereafter. 3, 10, 25, and 50 kw transmitters are scheduled to follow in rapid succession.

With typical Collins thoroughness, these FM transmitters are designed to specifications well within FCC and RMA requirements and recommendations.

Notable achievements in circuit design assure efficient and dependable operation. Power output can be increased as desired, with a minimum of changes. The styling is attractively modern, and will blend well with up-to-date station layout.

Collins is prepared to supply your FM transmitter and all accessories. Our engineering staff is available at all times for consultation, and will assist you in effecting early installation and operation. Write today.

Collins Radio Company
Cedar Rapids, Iowa
11 West 42nd Street New York 18, N. Y.

FOR BROADCAST QUALITY, IT'S . . . . COLLINS

CARE begins with the CORE!

The weighing of cores is an important detail

The AmerTran

Trade Mark is found on quality

Audio Transformers and Reactors
Modulation Transformers (to 500KVA)
Hermetically sealed Transformers
Plate and Filament Transformers
Filter Reactors
Wave Filters High Voltage Rectifiers
Microphone and Interstage Transformers
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CONFORMING *to dimensions* is not enough—the cores must contain the correct *amount* of iron. By weighing the laminations to meet a specific "normal" for each type of core, uniformity—independent of possible variation in lamination thickness, is secured.

Checked against core area, this weighing procedure uncovers any physical distortion of laminations. It contributes to evenly distributed flux density and low exciting current.

Care is used in *every* AmerTran operation. It is reflected in the excellent operating characteristics of AmerTran Transformers of all types.

AMERTRAN

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

AMERICAN TRANSFORMER COMPANY

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We look at magnet wire

THROUGH A USER'S EYES

That's why we know FORMEX means faster winding of trustworthy coils

There are no magnet-wire customers more exacting than our own G-E people who use it to make motors and refrigerators and other equipment in which a small coil-flaw can cause a big servicing headache. These men right in the G-E family have *user experience* which verifies our claim that FORMEX magnet wire will take the abuse of high-speed winding, high-temperature baking, and extreme deformation.

Every foot of FORMEX wire we ship — inside the Company or out — must meet the tests and performance standards required by the world's biggest user of magnet wire for its own protection. So, you and every other FORMEX user can have the same peace of mind as to coil performance that we have.

For full information on FORMEX* magnet wire (round and rectangular) ask for our bulletin GEA-3811. Or, see your G-E representative. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

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FORMEX
MAGNET WIRE

GENERAL ELECTRIC

Start with the RIGHT RESISTORS

Plans for new products and the modernization of existing ones are on every drafting board. In the electrical and electronic industries manufacturers are indeed entering a competition of design. You and every other manufacturer are studying available components. When selecting resistors, give consideration to the developments that have been made to meet the severe conditions of the past several years. A resistor that better meets your requirements will add to the utility of your product.

The new Ward Leonard Hand Book "RESISTORS" gives a complete resume of available types. It discusses the advantages of each, gives resistance values, and shows terminals, mountings and enclosures. Send for a copy today.

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Electric control devices since 1892

WARD LEONARD ELECTRIC COMPANY **32 SOUTH STREET • MOUNT VERNON, N. Y.**

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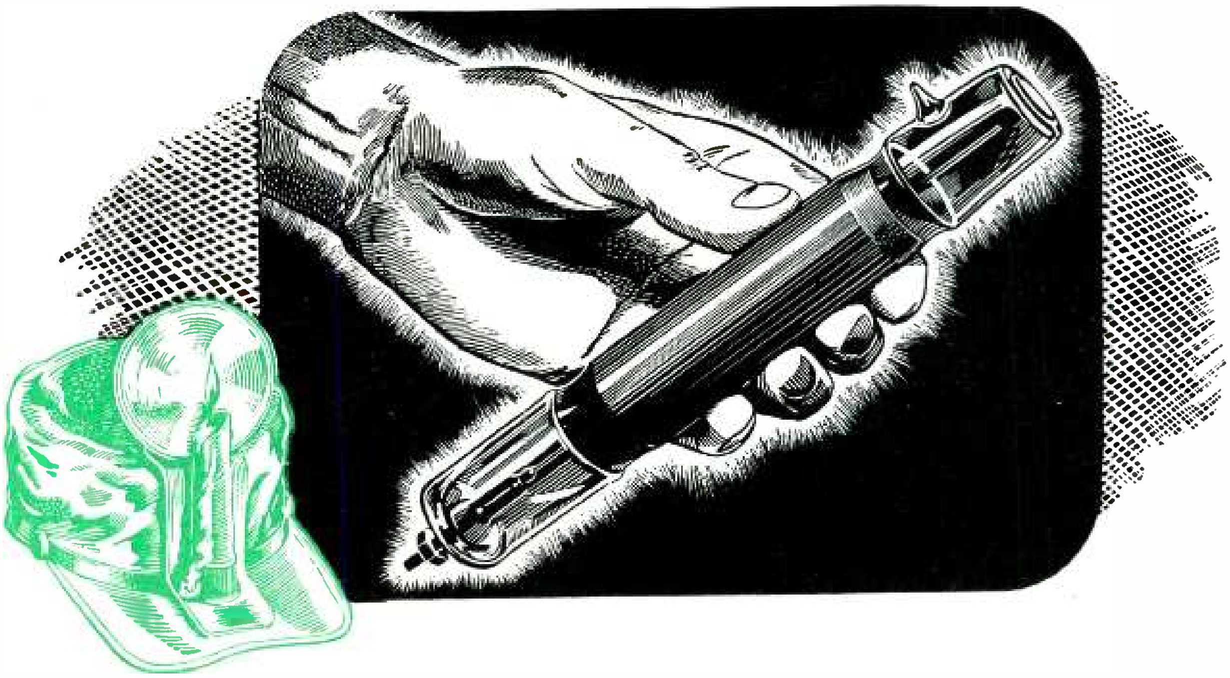

What has a miner's cap to do with invisible radiation?

When the flame of the old style miner's lamp grew dim, he knew that danger was lurking in the bowels of the earth.

Invisible radiation, as you know, has no such simple visual test. After the atom bomb was exploded in New Mexico, scientists dressed in protective clothing and equipped with proper testing equipment, checked the stray radiation still present. Heart of the testing equipment they used was a Geiger Counter electronic tube.

The Geiger Counter tube is a highly sensitive and dependable medium for the detection of weak forms of radiation. A new gas and quench combination has been developed for the tube, which makes it even more useful in industry.

This advancement made possible the introduction of the NORELCO Geiger Counter X-ray Spectrometer.

The NORELCO Spectrometer has many present and potential uses in industrial research. In addition, it has found application in production control through the analysis of materials before and during manufacture.

Through the use of the Geiger Counter X-ray Spectrometer and a graphic recording mechanism, the analytical procedure can be simplified. Many times just a single line on the graph can serve as a criterion for acceptance or rejection of a given material.

The application of the NORELCO Geiger Counter tube and the NORELCO X-ray Spectrometer to the problems of industry are further evidence of the Philips principle of wedding science and productive ability in the electronics field.

An organization with a background of over 50 years in electricity

Among the products of North American Philips are: Quartz oscillator plates, cathode ray tubes, industrial and medical x-ray equipment, fine wire, diamond dies, tungsten and molybdenum products.

Norelco
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NORTH AMERICAN PHILIPS COMPANY, INC.

DEPT. C-3, 100 EAST 42ND STREET
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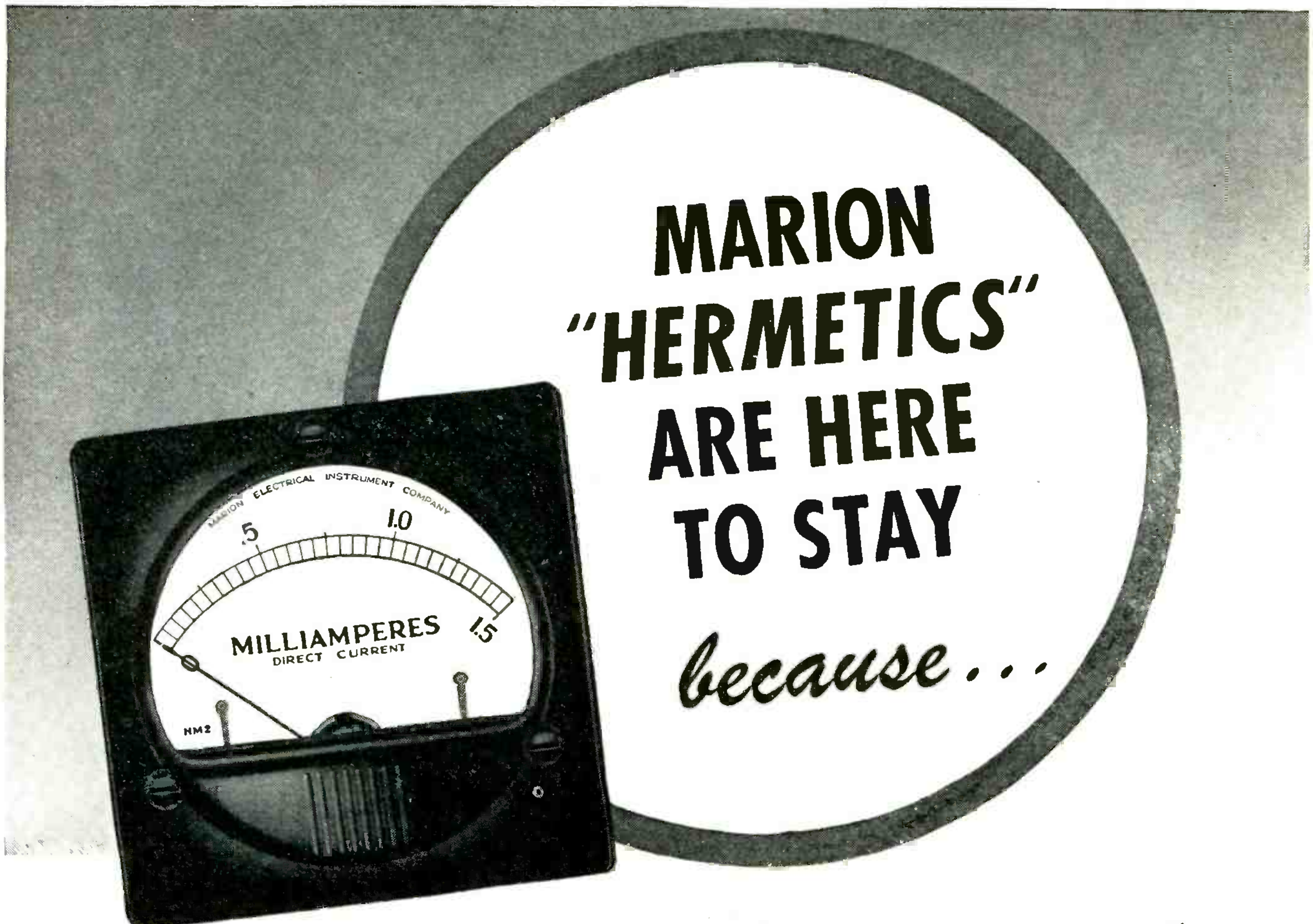

. . . they're dustproof and moisture-proof — foreign matter which oxidizes pivots and attacks bearings and thus shortens the life of an instrument cannot enter.

. . . sustained performance over a longer period of time is assured and rejects of complete equipment due to instrument failure are minimized, if not eliminated.

. . . the magnetic and electrostatic shielding obviates the need for special calibration for different types of panels or separate shielding of instruments in order to prevent RF leakage through the case.

. . . interchangeable colored flanges, in both round and square shapes, are available at no extra charge; finer in performance, Marion "hermetics" are also smarter in appearance.

. . . they are 100% guaranteed for six months — after that, regardless of condition and provided the seal has not been broken, we will replace any 2½" or 3½" instrument from 200 microamperes upward for $1.50; any 2½" and 3½" type with sensitivity greater than 200 microamperes for $2.50.

Marion Glass-to-Metal Truly Hermetically Sealed 2½" and 3½" Electrical Indicating Instruments

Note: Marion "hermetics" cost no more than most standard unsealed instruments—and they are positively interchangeable. Write for the new Marion Catalog.

MARION ELECTRICAL INSTRUMENT CO.
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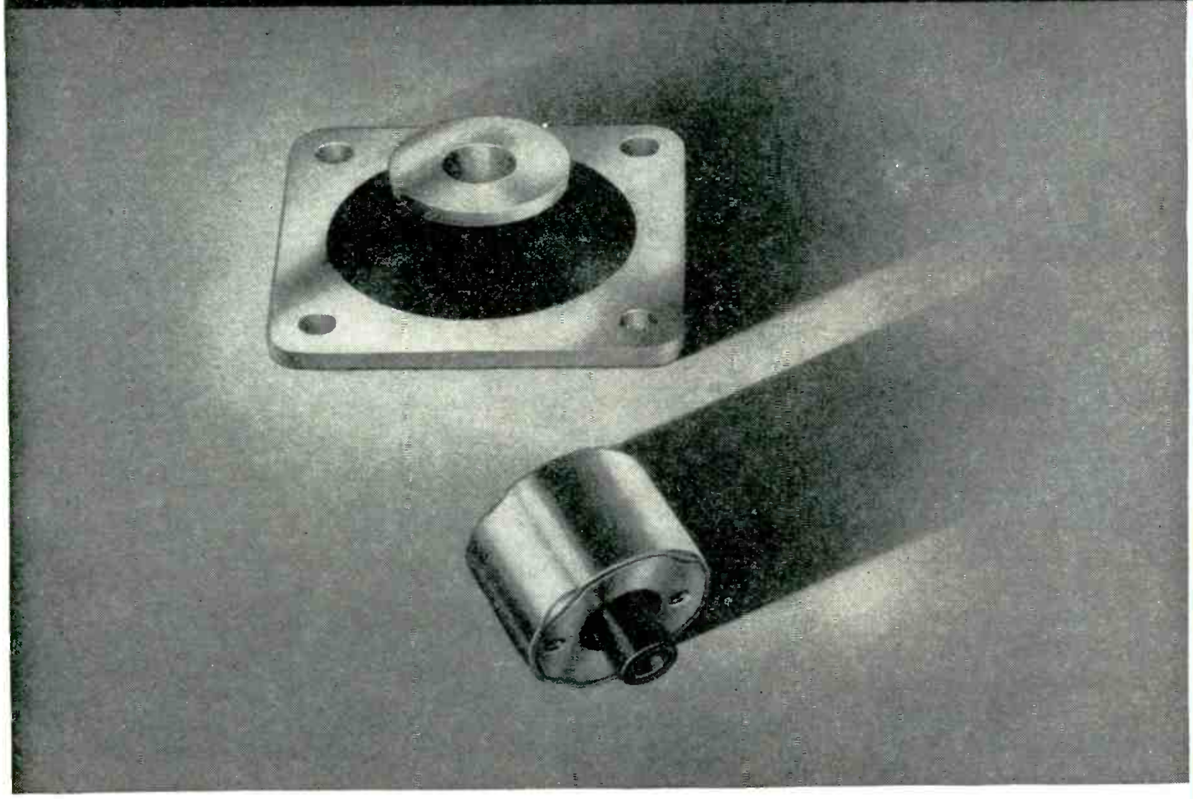
IN CANADA: THE ASTRAL ELECTRIC COMPANY, SCARBORO BLUFFS, ONTARIO

6-WAY VIBRATION CONTROL!



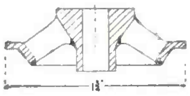
MB ISOMODE MOUNTINGS

BAR VIBRATION . . .
ABSORB ITS PUNISHMENT . . .
IN ALL 6 POSSIBLE MOTIONS!

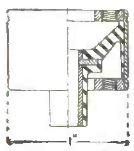
THESE NEW MB UNITS mean *positive* vibration control in your new products—for both possess this unsurpassed feature:

With carefully planned design and dimensions, taking full advantage of rubber's properties—MB's able, experienced engineers have built these units with the same spring rate in all directions. Result: They control *translational* vibrations in all directions...as well as *rocking* motions set up by coupling forces!

Compact Isomode mounts combine soft flexibility and sturdy stability. Easily installed, they prevent vibration's passage through the supports, reduce its destructive effects, cut down noise. They're a reversible remedy also...stop external shock and vibration from affecting sensitive equipment.



For loads under 70 pounds per unit, MB Isomode unit type 17 gives outstanding results. It has ample rubber for high deflection capacity, and is self-snubbing for overloading shocks. Built to A-N standard mounting dimensions.



For loads from 1.6 to 38 pounds per unit, MB Isomode units type 11 (tension) or type 12 (compression) have the advantage of extra small size and metal enclosure to protect rubber. They have high deflection capacity, interlocking metal parts, and are self snubbing.

All of the foregoing underlines this fact: MB experience, plus MB engineered mounts add up to vibration control for your product that's done economically, effectively, without need for design changes. There are MB mounts for many applications...from electronic equipment to heavyweight engines. Let us send you the details.

"ISOLATE ALL MODES FOR POSITIVE VIBRATION CONTROL"*

**Copyright The MB Manufacturing Company, Inc.*

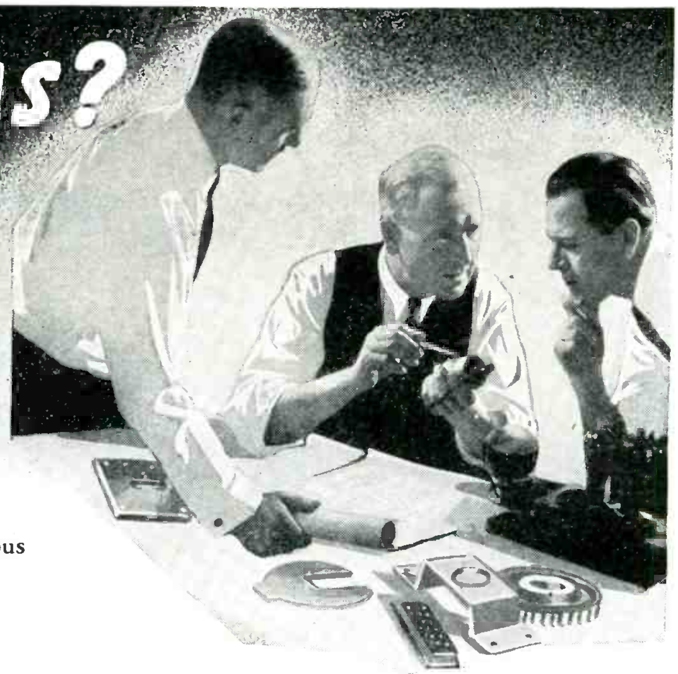
THE MB MANUFACTURING COMPANY, INC.
327 East Street, New Haven 11, Conn.

VIBRATION DIVISION

VIBRATION ISOLATOR UNITS AND MOUNTINGS • SPECIAL VIBRATION TEST EQUIPMENT

NEW PROBLEMS?

C-D has new electrical insulating materials to help you solve them



Here are some representative improved properties of various new C-D Electrical Insulating Materials.

Power Factor (at 10^6 cycles per second)	**0.011**
Dielectric Strength, volts per mil.	**750**
Arc Resistance, seconds	**185**
***Insulation Resistance, megohms**	**30,000**

New higher standards are also obtainable on mechanical properties, heat and moisture resistance, dimensional stability and fabricating.

The parts illustrated were fabricated from new grade GB 128 M DILECTO which is a glass fabric base laminate employing a melamine the equivalent of Navy Type GHG. This new grade of DILECTO provides higher heat resistance, greater dimensional stability, superior arc resistance and improved mechanical properties, and is noncombustible when compared to standard paper and cotton fabric base phenolic laminates.

These new C-D insulating materials may be the answer to your "What Material?" problems, and will save you much time and worry. Investigate them while your products are in the planning stage. Wire, phone or write our nearest office and a C-D technician will be made available to you

*Insulation Resistance values based on samples conditioned for 96 hours at 90% ± 2% relative humidity at 35° ± 1°C.

Continental-Diamond
C-D
Engineered Dielectrics

RHC—46

C-D PRODUCTS

The Plastics

DILECTO—Thermosetting Laminates.
CELORON—A Molded Phenolic.
DILECTENE—A Pure Resin Plastic Especially Suited to U-H-F Insulation.
HAVEG—Plastic Chemical Equipment, Pipe, Valves and Fittings.

The NON-Metallics

DIAMOND Vulcanized FIBRE
VULCOID—Resin Impregnated Vulcanized Fibre.

MICABOND—Built-Up Mica Electrical Insulation.

Standard and Special Forms

Available in Standard Sheets, Rods and Tubes; and Parts Fabricated, Formed or Molded to Specifications.

Descriptive Literature

Bulletin GF gives Comprehensive Data on all C-D Products. Individual Catalogs are also Available.

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Established 1895.. Manufacturers of Laminated Plastics since 1911—NEWARK 16 • DELAWARE

Special formulations FOR SPECIFIC NEEDS!

Fibron

PLASTIC TUBINGS AND TAPE

Users of flexible plastic tubings and tape secure a large increment of efficiency and economy when they specify "Fibron by Irvington." For the product they receive has been especially formulated for their own specific need. Should the *major* requirement be operation at elevated temperatures, a Fibron formulation for exactly that job can be supplied. Likewise for temperatures as low as —70° F; or for services requiring resistance to acids, alkalis, corrosive fumes, and abrasion. In each case the correct Fibron formulation is supplied. Each formulation of course, furnishes the high electrical and mechanical properties essential for efficient, long lasting insulation.

It is this Irvington policy of *"engineering* and *formulating* for specific applications," that accounts for the long service which Fibron plastic products provide . . . as well as for Irvington's continuing leadership in electrical insulation!

Fibron plastic tubings are produced in all standard opaque colors as well as transparent — diameters from .034" to 2" — in coils or cut lengths. Fibron tapes are obtainable in black and clear, in widths ½" to 3", thicknesses .004" to .030" and in convenient length rolls for hand application. Fibron wire markers are available plain or stamped, in inside diameters from .053" to ½".

An outline of *your* special requirements will receive immediate attention. Write Dept. 106.

STANDARD OF THE WORLD — IRVINGTON INSULATION — TRADE MARK REG. U.S. PAT. OFF.

IRVINGTON
VARNISH & INSULATOR CO.
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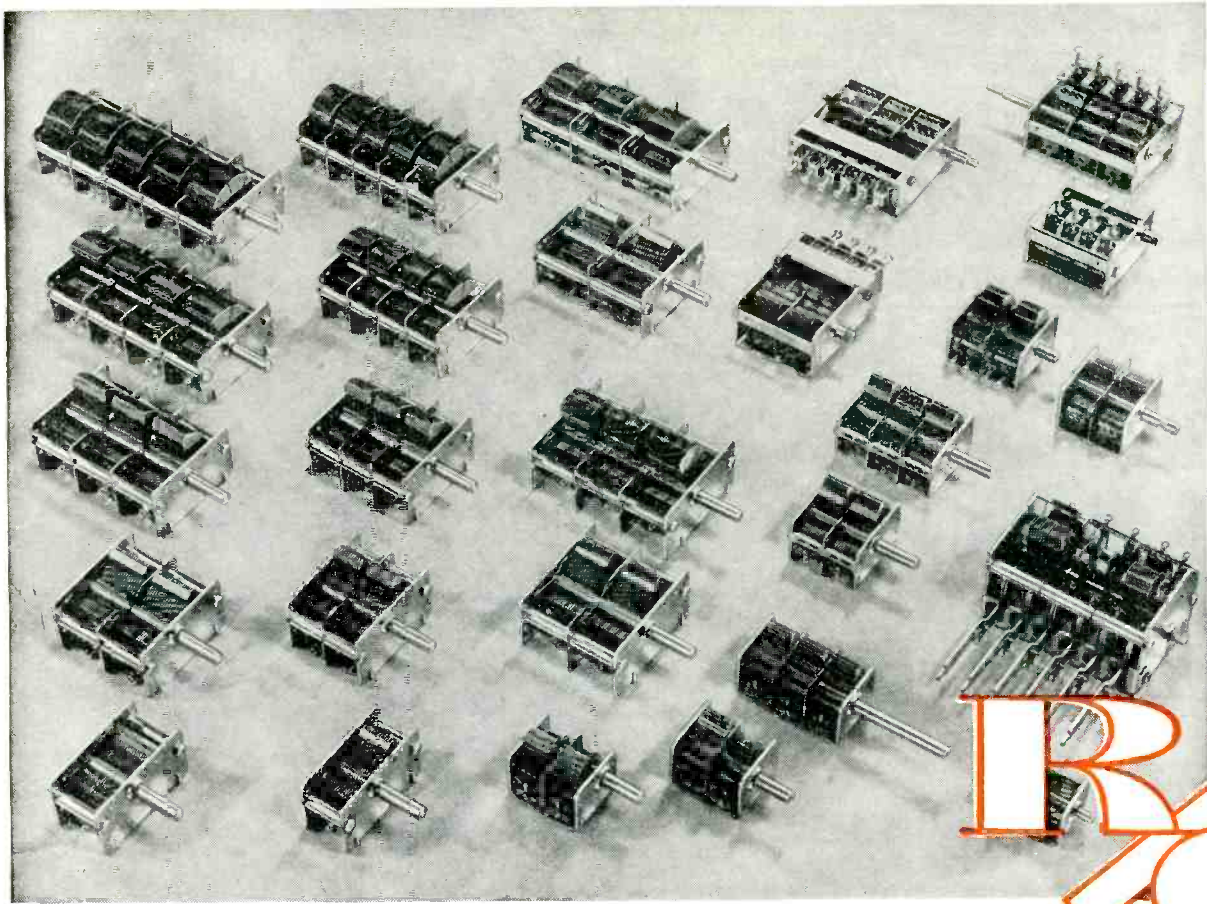

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SYLVANIA NEWS

CIRCUIT ENGINEERING EDITION

MAR. *Published by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. 1946

TINY T-3 TUBE ASSURED A BIG SUCCESS IN RADIO

New Wonder Tube Developed by Sylvania for Midget Portables

The development by Sylvania Electric of the tiny T-3 radio tube is an important factor in making possible light weight, "vest pocket" radio sets.

Ever since the announcement of Sylvania's development of a peanut-sized electronic tube for the famous "war secret" proximity fuze, manufacturers and circuit engineers have been busy making plans for producing super-small radio sets and walkie-talkies that would capture the public's imagination. Now that the Sylvania T-3 (commercial version of the proximity fuze tube) has been perfected, these revolutionary radio ideas are becoming more and more practical.

Future designs of this versatile tube will permit a wide variety of applications, ranging from sets no larger than a package of cigarettes up to deluxe farm receivers. The tiny tube features extremely small size with feather-weight. It has a life of hundreds of hours, is rugged and exceptionally adaptable to operation at high frequencies.

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HALLOWELL KEY SOCKET SCREW KIT

with interchangeable bits

NEW! CONVENIENT! For Men Who Like Fine Tools

Yes, *really new!* Always handy! . . . this ultra modern materially simplified Key Kit. Imagine! Nine interchangeable bits—for driving socket set and cap screws, Phillips and Slotted Head screws —contained in one small, hollow, indestructible plastic handle. Note the *swivel chuck!* You can *lock* your bit in any one of the *five different positions!* (see small cut), providing increased leverage and enabling you to reach those hard-to-get-at places.

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Key Kit #25 contains: 7 hex, 1 Phillips, 1 slotted screw bit.

Key Kit #50 contains: 6 hex, 2 Phillips, 1 slotted screw bit.

If your distributor does not carry "Hallowell" "Unbrako" Key Kit, send his name, along with yours, and you will be taken care of promptly.

Illustration shows different positions to which swivel chuck permits bit to be swung.

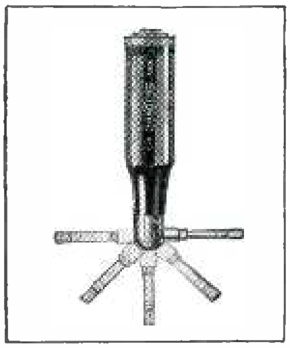
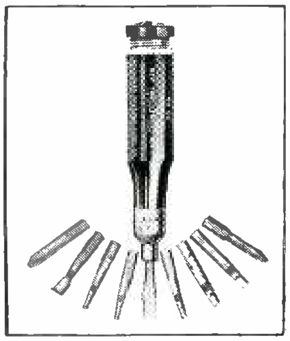


Illustration shows nine interchangeable bits contained in handle.



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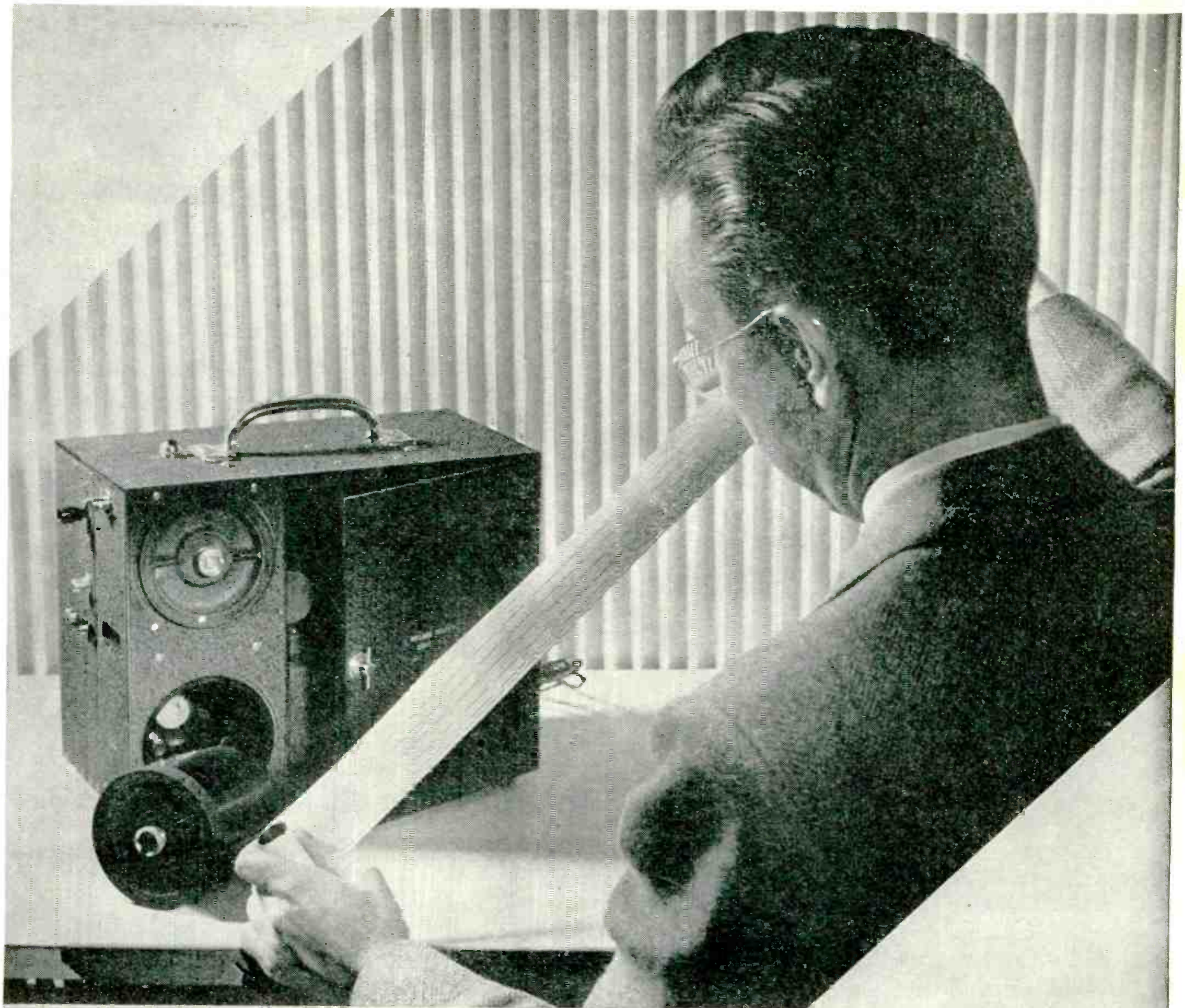

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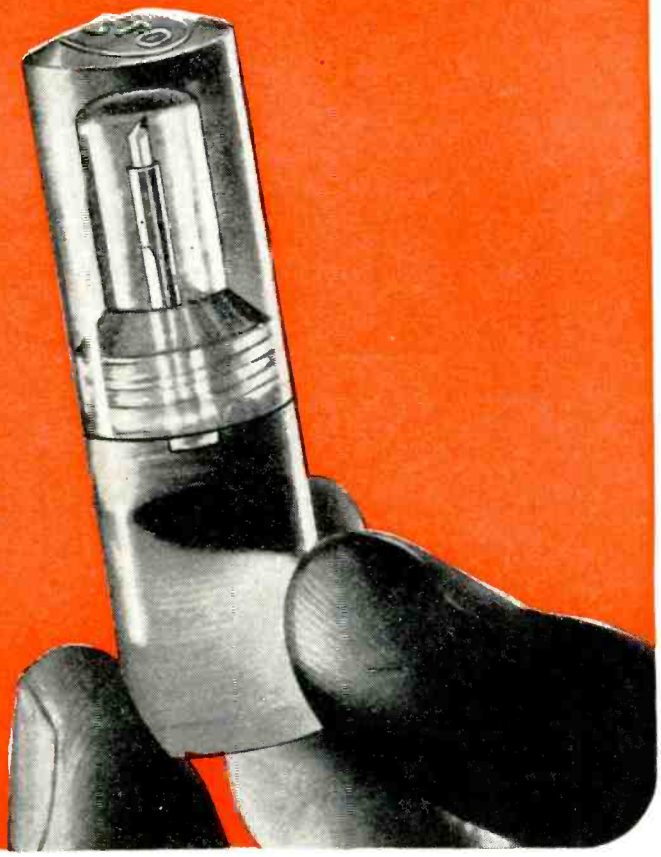
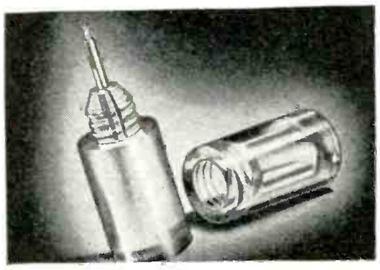
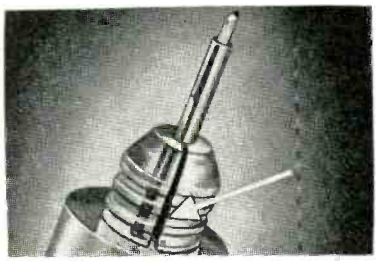


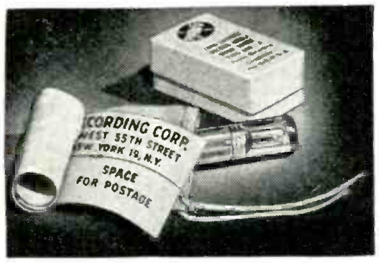
FOR YOUR CONVENIENCE! Presto Sapphire Recording Needles *now* come to you in a *new* package, designed for utmost needle protection in shipping and handling.



NEW! A transparent lucite container keeps Presto Cutting Needles *safe.* Nothing can harm the precision ground point and cutting edges.



TIGHT! This ingenious chuck holds the needle *tight*—no chance of damage to the point in shipment.



EASY! Just slip used needles (safe in their containers) into this handy mailing bag and send them off to Presto for resharpening.

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PRESTO Cutting Needles are packed in a Distributor's Carton of six. Each needle container is individually boxed with mailing bag. Order a dozen. Keep 6 in use—6 in transit.

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Production efficiency and high standards of quality-control won a special award of the Navy Ordnance "E" for Solar's Bayonne and Chicago plants.

Today, the same production facilities and skilled personnel that turned out these exceptionally small tubulars for the national defense are already supplying them for the Vest Pocket and Purse-Sized Radios and Hearing Aids of *Tomorrow*.

In applications where space and weight are all-important, the TTR tiny tubular or its flat counterpart TTF, is the answer to your needs.

These midget units are just another example of the combination of research facilities, engineering know-how and production capacity which has made Solar the logical supply source of industry for paper, electrolytic and mica capacitors.

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THE PRESIDENT'S WAGE-PRICE POLICY WON'T WORK

THE AMERICAN public had every right to expect that the long-awaited wage and price policy would break the impasse blocking the way to the swift and orderly reconversion of industry from war to peace.

The policy announced offers little promise of such solution, and this may well constitute a national calamity.

There is only one thoroughly constructive feature of the Presidential Statement of February 14 and its implementing Executive Order. It is the first Government pronouncement since the defeat of Japan to clearly define inflation as the major danger confronting us in the period immediately ahead.

That is a correct appraisal, and one long overdue. Up to now Government spokesmen, almost invariably, have sought to carry water on both shoulders. The Administration has justified its policy of promoting wage increases as a measure necessary to forestall deflation — to keep purchasing power from falling and forcing the economy into a violent tailspin. The strict holding-of-the-line on price ceilings has been defended as necessary to prevent runaway inflation. Unfortunately, while the President now exhorts all to enlist in a crusade against inflation with a voice that is clearly Jacob's, his program for dealing with it still employs the hairy hands of Esau to promote the very danger which he is urging everyone else to combat.

The "new" policy provides for a continuation of the wage increases that have been pressured through by Government mediators, "fact-finding" boards, and direct seizures until they have been made general throughout industry upon the dimension established in recent patterns. It offers industry the single concession of prompt hearings and decisions upon claims for price advances, but the yardsticks for judging such claims are exactly those which OPA has applied in the past. Since the past procedure has led us into our present difficulties, it is hard to see how it will serve now to lead us out of them.

Past Government Policy Fostered Dissension

At the war's end, it was obvious to everyone that what was needed was the swiftest possible reconversion of industry. It should have been equally apparent that we were faced with the difficult problem of controlling tremendous inflationary pressures which would be particularly insistent until peacetime production could be mobilized at high volume. This was made almost inevitable by the huge backlog of accumulated demand, for both capital and consumer goods, and by the unprecedented volume of liquid funds at the disposal of individuals of all classes. The only circumstance that could have modified the inflationary complexion of the postwar picture was the possibility of such wholesale and prolonged dislocation and unemployment in the process of readjustment that people would have been frightened into freezing onto their savings instead of spending them.

It soon was apparent that just the opposite was taking place. The early transition was extraordinarily swift, unemployment was lower than anyone had dared hope, and civilian spending outstripped all previous records. The circumstances called for strong anti-inflationary fiscal measures, along with a firm maintenance of price and wage controls alike.

Instead of adopting such a balanced program, the Government immediately discarded all wage controls, and in addition started an active campaign for promoting large wage increases. The President, upon a number of occasions stated flatly that American industry generally could and should grant substantial pay advances without any compensating price rises. His Office of War Mobilization and Reconversion estimated that average increases were practicable to the extent of 24 per cent. Given such Governmental encouragement, it was inevitable that labor leaders should do exactly what they did—file extravagant wage demands at the beginning of the reconversion process, when accurate appraisal of production schedules and costs were least susceptible of calculation, and when the shortage of civilian goods multiplied the inflationary effect of any increase in purchasing power.

At the same time, the OPA was fighting to hold the price line in a good cause, but with singularly inept procedure. It acted, seemingly, upon the premise that it was always better to give less price relief than was needed rather than enough, that relief provided under its formula was preferably to be granted later rather than on time, and that the interests of lower-bracket income receivers should be protected by a particularly tough resistance to raising prices of cheaper goods. The latter procedure seems to have boomeranged by virtually driving many of the lower-priced lines off the market.

The sum of these wage-price procedures resulted in work-stoppages of epidemic scope. Many business concerns faced with the prospect of immediately unprofitable operation, uncertain that new wage demands would not be made with Government support as soon as volume production was established, and without assurance as to when price controls would end, refused to assume inevitable losses even when confronted with combined union and Government pressure. The fight was on.

"New" Policy Differs Little From Old

With inflation now clearly recognized as the immediate danger, it might have been expected that the new wage policy would reverse the former practise of lending active encouragement to new wage advances. But that would have brought down upon the Administration the wrath of all organized workers who had not yet been granted increases already bargained through by other groups. This was avoided by directing the National Wage Stabilization Board in effect to approve any wage increases necessary to give general advances comparable to those already made. The only brake applied on the wage side lies in a directive to the Board not to approve, as a basis for price relief, wage advances that go beyond the established pattern.

On the price side, the new directives to the OPA entail no important departure from its past procedures. Even the concession to review "hardship" cases promptly rather than after six months is only a pious hope, since it is unlikely that OPA is equipped to deal rapidly with the thousands of cases that will arise. A hardship case is defined as one in which, after absorbing an approved wage advance, an industry or establishment in a twelve months' period of normal-rate operation is judged by the Price Administrator likely to operate at a rate of profits to net worth less than it averaged in the base period of 1936-1939.

Let us see what this really means. In the first place, the rate of manufacturing profits in the base period was only moderate. But since the average net worth of manufacturing corporations has increased one-third over what it was in the base period, the application of the OPA formula, *assuming that its Administrator correctly appraises the twelve-month outlook,* seems to provide for absolute profits one-third higher than the 1936-1939 average.

The OPA formula, however, applies to profits *before taxes.* What really matters to stockholders is profits *after taxes.* Corporation taxes have been increased from an average of 17 per cent in the base period to 38 per cent now. This means that the price adjustments granted by OPA on average will yield profits *after taxes* no larger in dollar terms than in the 1936-1939 period, although 1946 manufacturing sales are expected to be more than twice as high. Under this procedure the *ratio* to net worth of profits *after taxes* will be one-fourth lower than the 1936-39 average. This clearly undermines the incentives upon which production at high level depends.

The workers get wage increases which promote inflation. The Government, bailed out from its previous mistakes, gets political credit for raising wages. And the entire bill is handed to American industry for payment.

But the Danger of Inflation is Real

Under these circumstances, there is a growing demand on the part of business groups that price controls be rescinded immediately. It is argued that, once the restrictive influence of price controls is relaxed, capacity production soon will supply sufficient goods to prevent undue price inflation.

It is understandable that business should wish to be rid of Government controls which have operated in such a thoroughly inconsistent and damaging fashion. Unfortunately, there is ground for believing that more harm might result from this cure than from the disease.

There is nothing in our situation that could bring on the kind of inflation that has been experienced by certain countries of Europe and Asia — in which the value of currency deteriorates until it takes a cartload to buy a pair of shoes. But our situation now is definitely more threatening than it was in 1919, after the first World War. At that time wholesale prices and the cost-of-living skyrocketed almost 25 per cent within twelve months. If we discard all controls now, as we did then, prices might easily go up from 25 to 50 per cent in a year's time.

An inflation of that dimension can do tremendous damage. While it lasts, all those dependent upon fixed incomes are damaged — all bondholders, including those who hold war bonds, all life insurance and annuity beneficiaries, all pensioners. Generally, the purchasing power of wages and salaries would shrink, with white collar and unorganized production workers hardest hit. Controlled-rate industries, such as railways and other utilities, would be squeezed. General business would suffer least of all — while the boom lasted.

But such soaring booms cannot last. The 1919 boom burst in mid-1920. By summer of 1921 industrial prices had fallen 40 per cent and industrial production was off 35 per cent; farm prices had fallen 50 per cent. This time the boom might soar higher and last longer, but that would merely result in an even more precipitous drop. Business would be hard hit along with everyone else, and high wage rates would mean nothing to the unemployed.

Controls Must be Consistent and Progressively Relaxed

But if the Nation cannot afford to risk disastrous inflation by immediately abolishing controls, neither can business afford to accept the program which the Administration now proposes.

The wage-price policy will not hold the inflation line so long as the Administration is leading the assault to breach that line on the wage side, as it has done ever since VJ-Day.

The Administration is now going before Congress to ask for a broad extension of its wartime powers for an additional year beyond June, 1946.

Congress must see that this is not granted except upon terms that guarantee the use of such power with a consistency that has been conspicuously absent up to now.

1. It must provide sufficient price relief to yield profits normal to high-level operation.

2. The basis for price relief must be clearly defined and geared to actual costs of operation at the earliest possible date.

3. OPA administrative procedures must be speeded-up and streamlined, or the delays that characterized past administration will become intolerable.

4. It must see that, once established, the new line is held as long as wartime controls are continued by enforcing restrictions on wages as well as prices.

5. It must set an early date for the termination of all wartime controls and provide for progressive and bold steps for de-control to be taken before that date, as soon as production levels in any field are sufficiently high to restrain runaway prices.

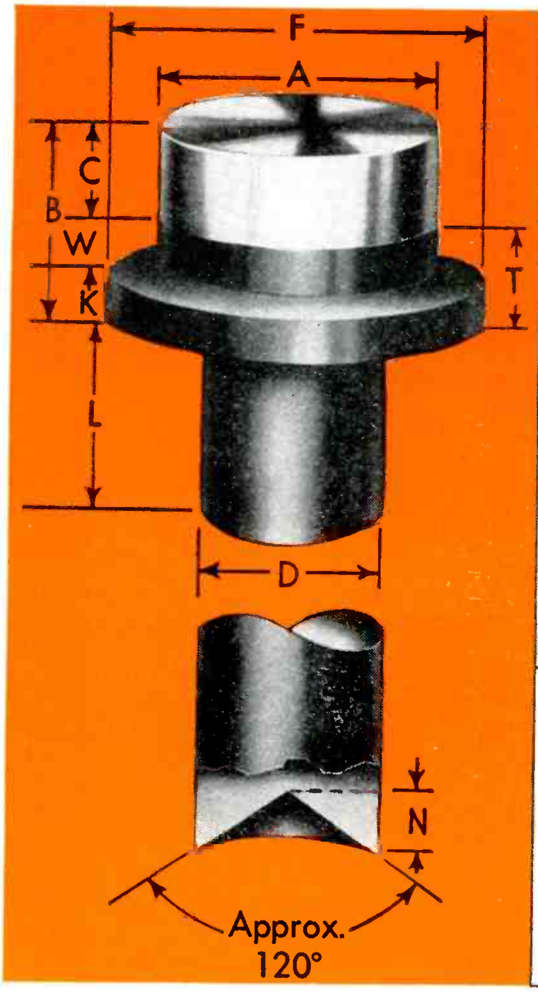
6. It must proceed without delay to marshal fiscal and monetary policies to combat inflation, in order that price controls may be discarded at the earliest possible date.

Unless Congress does this — and it will not be easy in an election year — we are headed for an explosion. It will come in one of two forms — either in a continuance of industrial strife, or in a rocketing inflationary boom that can only end in collapse and depression.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Co., Inc.

THIS IS THE 45TH OF A SERIES



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.093	.060	.156	.040	.078	.055	.234	.093	.125	Type 3—967
.125	.042	.187	.022	.078	.055	.234	.125	.156	Type 3—1247
.125	.060	.187	.040	.093	.065	.279	.125	.156	Type 3—1269
.150	.050	.218	.035	.093	.065	.279	.156	.187	Type 3—1559
.150	.043	.230	.028	.124	.087	.372	.156	.187	Type 3—15412
.187	.075	.250	.050	.124	.087	.372	.187	.218	Type 3—18712
.218	.060	.281	.040	.124	.087	.372	.218	.250	Type 3—21612
.218	.075	.281	.050	.140	.098	.420	.218	.250	Type 3—21714
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CROSS TALK

► **JAP** . . . In the January issue of the *American Scientist,* Talbot Howe Waterman has some "Notes on Japanese Electronics at the Close of the Pacific War", resulting from an interrogation of one of Japan's research men. The last paragraph of Mr. Waterman's article is as follows:

> "In response to a query as to why his company's recent research activities had been directed toward the study of centimeter radar and why this was desirable, this worthy fellow replied, 'Dr. Hamada here can give you the engineering answer to that question, but speaking as a non-technical man I can give you my own answer, too. We were working on centimeter wavelengths because the Americans employed them in their equipment. We knew that if the Americans were using them they must be very desirable!' Recalling the polished diplomacy of the Japanese in Washington on December 6, 1941, I would suggest that the reader should not feel too smug over this. In fact Mr. Suda undoubtedly realized that words were cheap, especially if they put us in a good mood for expediting delivery of the issues missing from his subscription to ELECTRONICS."

► **WINDFALL** . . . Appearance of much surplus electronic material on the market reminds one of the all-time high in such dealings which occurred at the end of the last war. The exact facts are a bit hazy but they are about as follows.

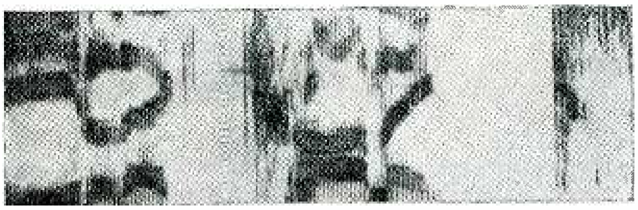
In a warehouse in Philadelphia were some 300,000 Western Electric VT-1 and VT-2 tubes, well known to old timers. Upon breaking open one of the cases many tubes were found to have broken arbors made of glass rod. It was thought that the breakage would be high and so the whole lot was unloaded for 50¢ each, the purchaser believing that the platinum would be worth about one dollar per tube. The lucky buyer found that very few arbors were broken; his next discovery was that amateurs would pay \$5 or \$6 for each tube.

And speaking of surplus, a curious cycle has come to light. It seems that the quickest way to get some telephone equipment for a rush field experiment during World War II was to purchase from a local department store some of the World War I field telephones then on sale. After V-J day the telephones were turned over to the Army together with the field stations in which they were used. The Army promptly turned the telephones back into the surplus account and, by now, somebody else is talking over these surplus items of two world wars!

► **DISCOVERY** . . . An agent in USSR sent in a statement that scientists in that great country had developed a most successful substitute for piezoelectric quartz. In fact the monthly output was several hundred kilograms, over a million instruments being in use employing the new crystals. The source of this new-found ersatz quartz was the wine industry, the material itself was sodium potassium tartrate.

This seemed like pretty hot news but upon looking the matter up it was found that the wonderful stuff was only our old friend Rochelle salts.

► **FCC** . . . Best statement of the IRE Winter Meeting period was that of Chairman Porter who hoped that broadcasters would be as successful reaching the American farmer on 118 mc as the Signal Corps was in reaching the moon on 112.



The word Electronics as it appears in visible speech patterns on equipment designed by engineers of Bell Telephone Laboratories (ELECTRONICS p 200, Jan. 1946)

Four Years of ENGINEERING ADVANCES

Papers presented at the 1946 Winter Technical Meeting of the IRE reflect. quantitatively and qualitatively, the many developments stimulated by wartime needs. and provide a significant key to reconversion problems. Speakers covered the entire gamut from microwave radar through audio and video broadcasting to industrial electronics

INTO THE FOUR WAR YEARS, engineering advances which might not have been achieved in two decades of peace were compressed. Thus papers presented at the 1946 Winter Technical Meeting of The Institute of Radio Engineers were particularly significant.

So important as a key to reconversion problems was the meeting that ELECTRONICS assigned its entire editorial staff the job of reporting all technical sessions. That this was an arduous task will be appreciated when it is considered that always two and frequently three of the 16 separate sessions were held concurrently.

By the end of the week of January 26, over 7,000 engineers had signed registration cards; untold other thousands had milled about looking at two floors of exhibits; newspaper and magazine reporters had been treated to a worldwide human-interest story, the bouncing of radar echoes from the moon by Army and civilian scientists at Camp Evans Signal Laboratory, Belmar, N. J. The popular side of the moon story has been well covered by the newspapers and the techniques involved will be adequately described in the literature soon.

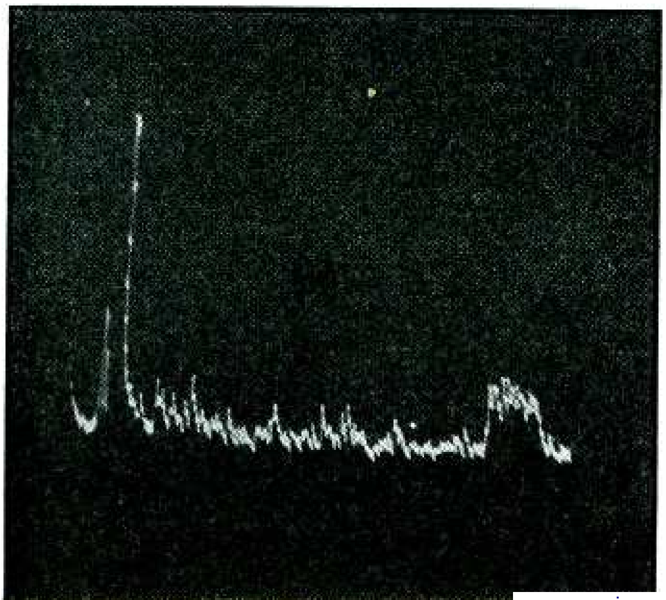
Military Applications

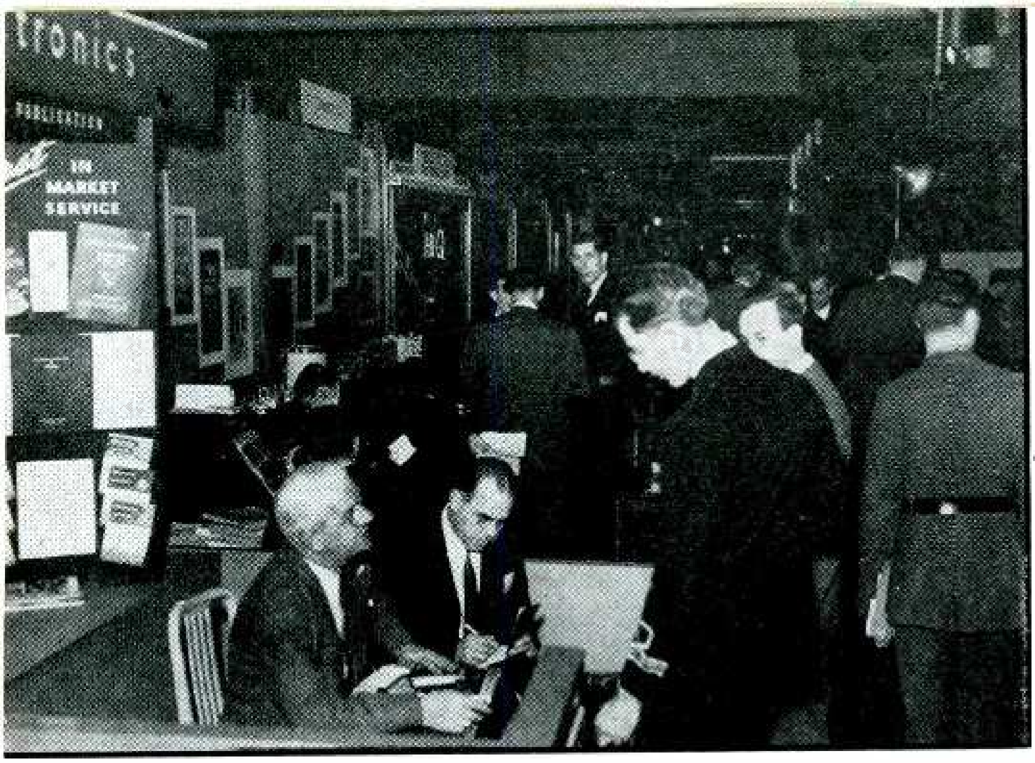
Before one opening-session audience filling the huge main ballroom of the Astor Hotel in New York, four speakers paid tribute to the important role played by electronic equipment in modern warfare, reviewing developments now declassified and citing specific engagements in which electronic equipment was a decisive factor.

The effectiveness of radar in naval warfare was dramatically illustrated by Commodore J. B. Dow of the Bureau of Ships, who gave a play-by-play description of 23 minutes of action by one of our cruiser forces in the Pacific. At 11:38 pm, radar contact was made at 14,000 yards with five ships, determined to be an enemy cruiser force. The main battery of one of our cruisers was laid on the target corresponding to the largest pip, and firing commenced at 11:46. Hits were observed after the first salvo, and the target was hit continuously thereafter until it sank at 11:50. In similar fashion our ships knocked out the other four enemy vessels one by one, with full radar control. At 12:01 the radar screens showed no more targets and the order was given to cease firing. The role of sonar in contributing to the sinking of 2,500,000 tons of Japanese shipping was similarly emphasized.

In the early days of the war 19

Official announcement of the Signal Corps radar contact with the moon was made at the IRE banquet by Major General Van Deusen. Below, left, is a photo of the indicator scope, showing the strong half-second transmitted pulse and the echo from the moon (at extreme right of the trace) received 2.4 seconds later. The equipment used 3-kw pulses on 111.6 mc and received echos over a very narrow bandwidth (50 cps) to limit noise to about 0.01 microvolt. In the photo at the right are Lt. Col. J. H. DeWitt, Jr., who directed Signal Corps work, and Dr. George Valley of the Radiation Laboratory staff with Don Fink, executive editor of ELECTRONICS, who were called in to check findings before official announcement was made





Held concurrently with the IRE technical sessions was the first large-scale exhibit of postwar electronic equipment. 135 firms displaying their merchandise on two floors of the Hotel Astor in New York January 20-26. Pictured here is a typical scene around the booths

"human servos" were required to operate a battery of our antiaircraft guns. Now a mechanized team consisting of the SCR-584 radar, an electronic gun director, and the proximity fuse makes such batteries almost completely automatic in operation. Captain F. B. MacLaren of Army Ordnance described the electrical and hydraulic servos used, and pointed out that batteries so equipped got 89 out of the 91 buzz bombs that came over England in the last six days of the flying-bomb attack. Further improvement in the effectiveness of our antiaircraft guns involved increased projectile velocity and the use of homing devices still in the secret category.

Infrared and Sonar

Infrared communication is now about at the stage of radio in the spark-gap days according to Commander J. M. Fluke, of the Bureau of Ships. It nevertheless has military potentialities because it provides line-of-sight communication that will go only just so far, with no skipping or other transmission phenomena to make interception or jamming easy. It is only good for night work at present, however, and will not penetrate haze or fog as readily as it does clear atmosphere. Various systems were described, including the latest version using a new thallosulfide cell having high sensitivity to infrared in the 0.8-1.2 micron range. A caesium lamp used with plastic filters shows most promise at the moment as an infrared source that can be modulated at voice frequencies.

Captain R. Bennett of the Bureau of Ships traced the history of underwater sound from 1917 up to 1941 and showed illustrations of typical early gear. General principles of sonar were described, along with an early quartz-steel projector, a later magnetostriction projector, and a new Rochelle-salt crystal projector having a mosaic of crystal blocks in series-parallel. Some of the sea-water refraction and attenuation problems confronting sonar engineers were outlined. The need for further improvements was emphasized in view of the fact that atomic bombs may make the submarine an even more important vessel than ever before.

F-M and A-M Broadcasting

A brief review of international and domestic frequency allocations was given by Paul D. Miles of the FCC, first speaker at a second opening session. He described the steps taken in the past two years by this country in preparing for the next international conference on telecommunications. During a discussion of problems yet to be solved, an innova-

IRE PAPERS PRESENTED, AND ABSTRACTED HERE

MILITARY APPLICATIONS

Navy Radio and Electronics During World War II.....by J. B. Dow, Bureau of Ships
Role of Electronics in Antiaircraft Gunfire Control.....by F. G. MacLaren, Frankford Arsenal
Developments in Light-wave Communications.....by J. M. Fluke and N. E. Porter, Bureau of Ships
Basic Principles of Underwater Sound Equipment Design.....by R. Bennett, Bureau of Ships

F-M AND A-M

Frequency Allocations.....by P. D. Miles, FCC
Field Intensities at 45.5 and 91 Mc. by C. W. Carnahan, N. W. Aram and E. F. Classen, Zenith Radio
P-M and F-M Method..by R. Adler, Zenith Radio, F. M. Bailey and H. P. Thomas, General Electric
Antenna for F-M Station WGHF.....by A. Alford, consultant

CIRCUITS AND THEORY

New Angular-Velocity Modulation System Employing Pulse Techniques..by J. F. Gordon, Bendix Radio
Pulse-Time Modulation Radio Relay System.....(Motion Picture) Federal Telecommunication
Stagger-Tuned Wide-Band Amplifiers.....by H. Wallman, MIT
Electronic Frequency Stabilization of Microwave Oscillators.....by R. V. Pound, MIT

TELEVISION

Television in the Ultra-High Frequencies.....by P. C. Goldmark, CBS
Television Studio Equipment.....by J. J. Reeves, CBS
Sight and Sound on One Carrier.....by K. Schlesinger, CBS
UHF Television Transmitters and Antennas.....by R. Serrel, CBS
UHF Television Receivers.....by H. T. Lyman, CBS
Electro-Optical Characteristics of Television Systems.....by O. H. Schade, RCA Victor
Kinescope for Home Projection-Type Television Receivers.....by L. E. Swedlund, RCA Victor
C-R Tubes With Metal-Backed Screens.....by D. W. Epstein and L. Pensak, RCA Labs.
Image Orthicon.....by A. Rose, P. K. Weimer and H. B. Law, RCA Labs.

(Continued on next page)

IRE Papers (continued from preceding page)

NAVIGATION AIDS

Introduction to Hyperbolic Navigation..by J. A. Pierce, MIT
Ground-Controlled Approach..................by E. Storrs, W. Devitt, and B. Green, Watson Labs.
Aircraft Automatic Position Plotter...............by A. C. Omberg and W. L. Webb, Bendix Radio
Pulse Altimeter...........by I. Wolff, W. D. Hershberger, G. W. Leck and R. R. Welsh, RCA Labs.
F-M Altimeter....by W. R. Mercer, R. C. Sanders, Jr., Raytheon, I. Wolff and J. C. Smith, RCA Labs.
Theory and Application of the Radar Beacon..by R. D. Hultgren and L. B. Hallman, Watson Labs.
Visual-Indicating Radio Direction Finder.........by A. Scandurra and S. Stiber, Evans Laboratory
Frequency, Power and Modulation for Navigation Systems..by P. R. Adams, Federal Telecommunication

VACUUM TUBES

Joint Electron Tube Engineering Council......................................by O. W. Pike, JETEC
Triode for 600 MC........by S. Frankel, J. Glauber and J. Wallenstein, Federal Telecommunication
Microwave Triodes Adapted to Modern Usage......................by E. Goodell, Sylvania Electric
C-W Power at VHF........by W. G. Dow, J. N. Dyer, W. W. Salisbury and E. A. Yunker, Harvard
Design of Small-Size High-Voltage Rectifier Type 1Z2..................by G. Baker, National Union
Glass Problems in Manufacture of Miniature Tubes....................by H. J. Miller, RCA Victor

MICROWAVE VACUUM TUBES

Microwave Magnetrons ....by G. B. Collins, MIT
Magnetron Cathodes..by M. A. Pomerantz, Bartol Foundation
Secondary-Emission Cathodes by J. W. McNall, H. L. Steele, Jr. and C. L. Shackleford, Westinghouse
Cascade Amplifier Klystrons....................................by E. C. Levinthal, Sperry Gyroscope

ANTENNAS

Design Considerations in Broadside Arrays................ ....by J. Ruze, Evans Laboratory
Beam-Shaping Methods in Antenna Design .... by L. C. Van Atta, MIT
Metal-Lens Antennas.................................... ....by W. E. Kock, Bell Telephone
Model Aircraft Antenna Measurements..by G. Sinclair, E. W. Vaughan and E. C. Jordan, Ohio State
Broad-Band Antennas and D-F for VHF by A. Alford, J. D. Kraus, A. Dorne and J. Christensen, Harvard

RADAR

Airborne Interception Equipment....................................by P. E. Koenig, Wright Field
Naval Airborne Radar.....................................by L. V. Berkner, Bureau of Aeronautics
Radar Aspects of Naval Fire Control.............................D. P. Tucker, Bureau of Ordnance
Radar Aircraft Fire-Control Systems........by E. A. Massa, I. Paganelli and Fred A. Best, Jr., ATSC
Electronics in Naval Warfare.......................................by R. Bennett, Bureau of Ships
Radar Model XAF..by R. M. Page, Naval Research Lab.
Test Equipment for Airborne Radar Field Maintenance........by E. A. Blasi and G. C. Schutz, ATSC

MICROWAVE TECHNIQUES

From Wiring to Plumbing..by E. M. Purcell, MIT
Microwave Power Measurement... ....by T. Moreno and O C. Lundstrom, Sperry Gyroscope
Directional Couplers...by W. W. Mumford, Bell Telephone
Spectrum Analyzer for Microwave Pulsed Oscillators.................by F. J. Gaffney, PIB Products
Metalized Glass Attenuators....... ....by E. Weber, Brooklyn Poly
Three-Beam Oscillograph for Recording Up to 10,000 Mc......by Gordon M. Lee, Central Research
Equivalent Circuits for Wave-Guide Structures................................by J. Schwinger, MIT

CRYSTAL RECTIFIERS

Microwave Converters...by C. F. Edwards, Bell Telephone
Crystal Rectifiers in Superheterodyne Receivers...............................by H. C. Torrey, MIT
Noise Spectrum of Crystal Mixers..............................by P. H. Miller, Univ. of Pennsylvania

INDUSTRIAL ELECTRONICS

New High-Speed Recording Potentiometer........................... by V. L. Parsegian, Tagliabue
Speedomax Power-Level Recorder......by A. J. Williams, Jr., and W. R. Clark, Leeds and Northrup
Linear Servo Theory...by R. E. Graham, Bell Telephone
New System of Radio Telemetering........................by D. W. Moore, Jr, Fairchild Camera
One-Millionth Second Radiography and Its Applications.............by C. M. Slack, Westinghouse
Duplex Operation of Oscillators for Induction Heating..........by W. C. Rudd, Induction Heating

COMMUNICATION SYSTEMS AND RELAYS

Naval Wartime Communications Problems.......................by J. O. Kinert, Naval Operations
VHF and UHF Receivers for the Naval Service................by T. McL. Davis, Naval Research Lab.
Multichannel Microwave Radio-Relay Equipments for the Army....by R. E. Lacy, Coles Signal Lab.
Enemy Radio and Radar Equipment.............by E. L. Luke and J. C. Link, Naval Research Lab.
VHF Receivers..G. E. Hulstede, J. M. Pettit, H. E. Overacker, K. Spangenberg, R. R. Buss, Harvard

RADIO PROPAGATION

Propagation Research and Application........by J. H. Dellinger and N. Smith, Bureau of Standards
Role of Atmospheric Ducts in Propagation of Short Radio Waves..........by J. E. Freehafer, MIT
Propagation Measurements.....by M. Katzin, R. W. Bauchman and W. Binnian, Naval Research Lab.
Measurement of Angle of Arrival of Microwaves................by W. M. Sharpless, Bell Telephone
Microwave Propagation..........by S. D. Robertson, A. P. King and G. E. Mueller, Bell Telephone

BROADCAST RECEIVERS

Impulse Noise in Ideal F-M Receivers.......................................by D. B. Smith, Philco
Discriminators for F-M Receivers.......................................by S. W. Seeley, RCA Labs.
Capacitance-Coupled I-F Amplifiers.............by M. J. Larsen, L. L. Merrill, Stromberg-Carlson
Miniature Tubes for F-M Conversion....by R. M. Cohen, R. C. Fortin and C. M. Morris, RCA Victor
Magnetic Recorder as an Adjunct to the Home Receiver........by S. J. Begun, Brush Development

QUARTZ CRYSTALS

Standardization for Military Equipment.....................by C. J. Miller, Jr., Squier Signal Lab.
Characteristics of Crystals......by W. D. George, M. C. Selby and R. Scolnik, Bureau of Standards
Analysis of the Simple Crystal Filter............................by A. H. Ross, Squier Signal Lab.
H-F Plated Quartz-Crystal Units...by R. A. Sykes, Bell Labs.

tion introduced at the Cairo Conference and intended to satisfy the broadcasting needs of certain tropical areas which cannot effectively use the standard band was mentioned. Such operations have resulted in severe interference to our fixed and mobile communications. Use of f-m was urged as the ultimate solution.

When considering the postwar allocation problem, it became necessary to examine all radars in existence and in development to decide which ones would probably prove most suitable for postwar civil applications. Bands have been established at 420-460, 950-1,215, 1,600-1,700, 2,700-3,700, 4,000-4,200, and 8,500-10,000 mc. Several systems for long-range air and surface navigation, such as loran, "decca", "popi", and "gee" were discussed at the Third Commonwealth and Empire Conference on Radio for Civil Aviation, London August 1945. The conference attempted to determine which should be proposed as a worldwide system. Loran was so designated but, according to the speaker, limited usefulness over land indicates that it may not provide a final solution. Certain elements in the United Kingdom are inclined toward decca, console or popi, principally because such systems do not require special receivers and are said to be more economical to operate.

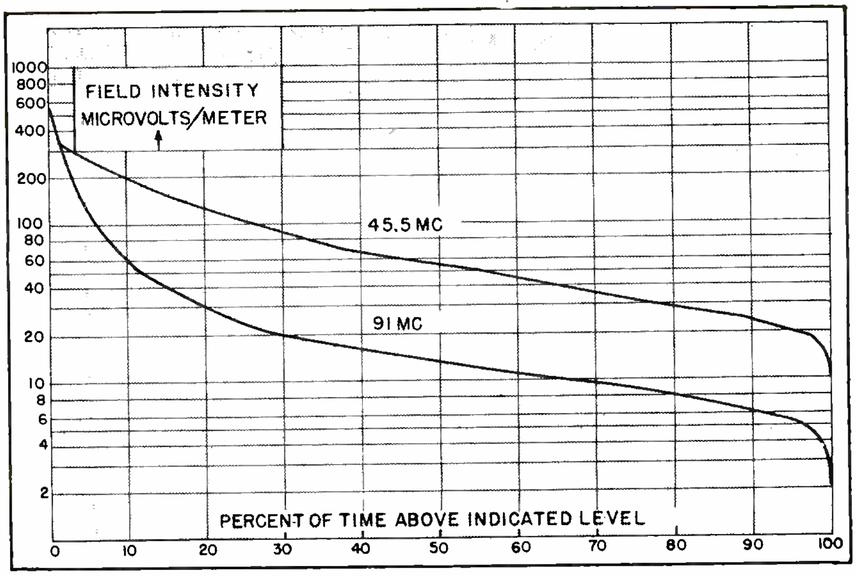
The United States proposes that the next conference should effect the establishment of a permanent International Frequency Registration Board, to be composed of five members and three alternates to be elected by the conference as custodians of an international public trust, to undertake the task of effecting the international registration of frequencies.

Results of a field monitoring survey using transmissions from f-m station WMFM on 45.5 mc and an experimental transmitter on 91 mc were presented by C. W. Carnahan of Zenith. Receiving antennas consisted of half-wave folded dipoles at both frequencies and, since a typical receiver would have a limiting sensitivity of not less than 10 μv, it was decided to base conclusions on a five μv per meter strength on 44.5 mc and a ten μv per meter field strength at 91 mc. The average signal on 45.5 mc was above the specified value 100 percent of the time, but the average signal on 91 mc was below specified value about 35 percent of the time. The condition in which the signal was below the receiver limiting level was called dropout and this condition existed for 13 percent of the time on 45 mc and 73 percent of the time on 91 mc.

New Techniques

A cylindrical antenna that has been installed at Finch station WGHF, New York, was described by Andrew Alford, formerly with the Radio Research Laboratory. The antenna makes use of a slot, voltage across the short dimension of the slot producing currents that radiate when the slot is resonant. The radiation is horizontally polarized and essentially omni-directional. One radiating element gives considerable gain over a dipole in the vertical plane. The cylindrical antenna is 11 ft high and acts electrically like a stack of loops mounted one above another. The bandwidth is satisfactory for frequency modulation but not wide enough for television without compensation. The driving-point impedance is capacitive, and when inductance is added it is 175 ohms for the single unit. A double-ended unit which has a driving point impedance of 100 ohms was also described.

A new method of obtaining frequency modulation with a recently developed "Phasatron" tube was discussed by Robert Adler of Zenith, who described the construction of the first experimental tube and traced the successive improvements that resulted in a final laboratory model.



Field intensities of two f-m transmitters recorded at Deerfield, Illinois. The average 45.5-mc signal is well above the predicted value, while the 91-mc signal is below it most of the time

This was used as a phase modulator in a transmitter to drive a 6AC7 quadrupler at 8.4 mc. The transmitter delivered about 25 watts at 33.5 mc and contained four tubes.

The development of a production tube from the experimental model was described by F. M. Bailey of GE. The main step in this development involved simplification of the Adler tube by substituting a unipotential surface for the upper three-phase deflector electrode (called the "neutral plane"). This change made it possible to make the tube single-ended. The suppressor grid was eliminated and internal shielding introduced. Mechanical features of the production model, including the deflectors, were presented.

The application of the Phasatron tube to a commercial f-m broadcast transmitter was covered by H. P. Thomas of GE. The transmitter has 250 watts output and is planned for use as an exciter for high-power transmitters as well as for a complete low-power unit. An overall multiplication of only 432 is required, compared to 7,000 with conventional phase modulators. No heterodyning is needed. The phase-splitting circuit was described in detail. The audio channel, which consists of two twin triodes, produces output current inversely proportional to the modulating frequency in the field coil (because of the inductance of that coil) and so provides frequency modulation directly.

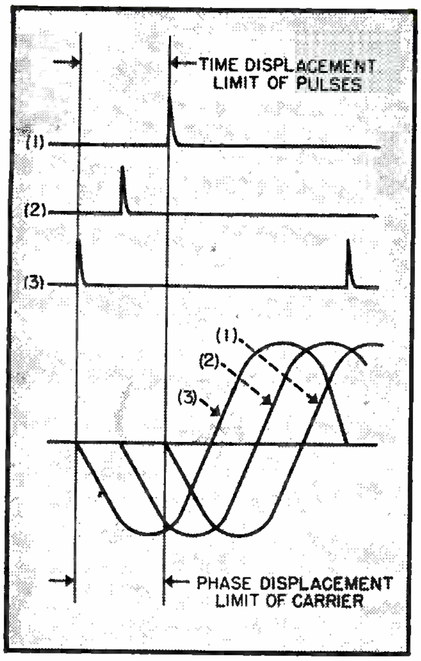
Circuit Developments

Pulse techniques, wide-band amplifiers, and microwave oscillators have come into their own through new circuit developments. This became apparent soon after Keith Henney, Editor of ELECTRONICS and Acting Chairman of the third opening session, started it off.

An interesting method of obtaining an f-m crystal-controlled carrier was described by J. F. Gordon of Bendix. The modulation circuit consists of a symmetrical multivibrator, synchronized by a pulse developed from a crystal oscillator. The electrical symmetry is upset by the modulation signal. In this way the crossover time of the multivibrator is changed, giving rise to time-modulated pulses. These pulses control the phase of the r-f carrier generated by a class-C amplifier. The phase-modulated carrier is multiplied before being amplified, thereby obtaining the necessary frequency deviation. The system has advantages of large deviation and freedom from amplitude modulation. Chief design problem is to obtain a multivibrator whose crossover time is a linear function of grid voltage on one tube.

P-T-M, Wideband Amplifiers

A motion picture illustrating the system functions of pulse-time modulation was presented by the Federal Telecommunication Laboratories. In introducing the film, D. D. Grieb explained that pulse-time modulation



Time - modulated pulses from crystal-controlled multivibrator excite class C amplifier producing phase-modulated carrier. Pulse must be sharp enough to give strong excitation, but not so sharp as to excite spurious oscillations.

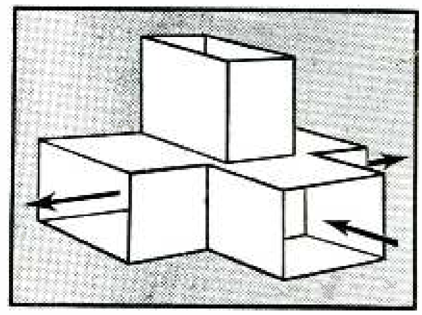
consists of scanning discretely at a supersonic rate the signal to be transmitted. In multiplex, the discrete portions of each of several signals are time-interlaced in sequence.

The pulse method of intelligence transmission has the advantages of eliminating cross-talk arising from circuit nonlinearities, freedom from distortion in multiple relaying and reduced noise interference. Of special interest in the system is the cyclophon tube. By means of this tube the multiplex signal is separated into its several channels and the time-modulated pulses are converted to intensity variations of the familiar type handled in communication circuits. The system is capable of transmitting direct currents for dial selection over wireless links.

Wideband amplifiers can be designed using single-tuned coupling sections, if they are stagger-tuned. The technique, as described by H. Wallman, Radiation Laboratory, affords greater gain-bandwidth than synchronous-tuned amplifiers. By selection of the proper individual middle frequencies and selectivities, flat-top transmission characteristics can be obtained; much higher gain-bandwidth factors, however, are obtainable if a few db variation in gain over the band can be tolerated. Using cascade pairs of three-stage, stagger-tuned amplifiers, bandwidths up to 20 mc at center frequencies in the hundreds of megacycles have been obtained, with gains of from 80 to 100 db. Stagger-tuned amplifiers are aligned by conventional procedures carried out successively at each of the middle frequencies of the resonant couplings.

Stabilized Microwave Oscillators

Microwave oscillators must be frequency stabilized against rapid, random frequency-modulation. The fluctuations can be controlled by electronic frequency stabilizers described by R. V. Pound, Radiation Laboratory. The technique consists of comparing the oscillator output frequency with that of a highly selective cavity. Essential to the operation of the method is a hybrid-T

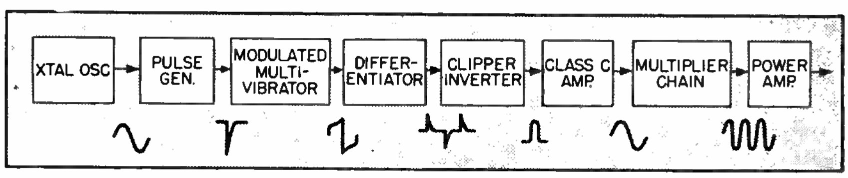


Hybrid or magic T waveguide section feeds two channels from one, no signal appears in fourth channel. Signal entering at any channel goes out two adjacent channels but not out opposite channel

("magic tee") waveguide section. In the frequency-stabilization circuit, the oscillator output is fed by a tee to a crystal detector and to the comparison resonator. The resonator returns to the system the frequency to which it is tuned. This signal is separated by the hybrid-T and, in one system, amplitude modulated. One sideband so produced is delivered by the hybrid-T to the first-mentioned crystal detector, where it produces a heterodyne signal representative of the oscillator frequency error which is used to correct the oscillator frequency.

This method of frequency stabilization has the advantage that an intelligence signal can be applied in series with the stabilization potential to produce frequency modulation about the stabilized frequency.

Sequence of wave-shaping steps in producing frequency modulation without amplitude modulation



Television Advances

Two important developments highlighted recent research in television, as described in a series of papers by CBS and RCA engineers. Advanced system designs for color television at 490 mc were, perhaps, the most startling of the developments discussed, but improvements in black-and-white camera and receiving tubes which increase the sensitivity of pick-up devices and yield pictures of improved contrast and brilliance, shared the limelight.

Since the end of 1945 CBS has had in operation at W2XCS a uhf television transmitter operating on 490 mc with an effective power output of about 4 kw. This will be increased to 20 kw after new antennas are installed. The three-color system described by Peter Goldmark uses 525 lines per frame and has a field frequency of 120 frames per second.

The several television papers delivered by Messrs. Reeves, Serrell and Lyman of CBS gave the details of the uhf transmitters and antennas employed, as well as details concerning receivers and studio equipment.

P-F Modulation

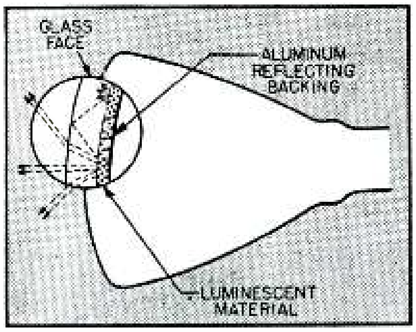
Kurt Schlesinger described a

method of pulse-frequency modulation which simplifies receiver tuning, makes the receiver more stable in operation, and eliminates the need for separate i-f channels for video and audio signals. The single-carrier (duplex) receiver has the advantages of smaller chassis size and less cost than double-channel i-f systems previously used. The single-carrier system, which enables video and audio channels to be incorporated in the same carrier by sandwiching the audio signals between successive lines of the video signal, is suitable for color or black-and-white television signals.

Two types of color television receivers have been used in experiments. One employs a kinescope and viewing lens producing an image about letter-head size. The other uses a projection kinescope and Schmidt optical system to produce an image 15 by 21 inches in size. In both cases Wratten tricolor filters are used in the color disk to produce the image in full color.

Manufactured by Federal Telephone and Radio, the CBS transmitter has a bandwidth from 0 to 10 mc. The actual power output is 1 kw, which is increased fourfold by a directive antenna. The transmitter makes extensive use of the 6C22 tube, developed during the war and previously known as the L600N.

Since December 20, CBS has had in operation a transmitter for studying wave propagation as a further aid in the development of uhf communication. This transmitter operates on a carrier frequency of 700 mc with 300-cps pulse modulation, and has a power output of 600 watts. Various receiving observation stations are located along the east coast from New York to Florida and an observing post is also maintained at New Orleans.



New Kinescope with reflecting metallic film showing gain due to improved distribution of light

Improved Video Tubes

A systematic study of the electro-optical characteristics of television systems, discussed by O. H. Schade of RCA, pointed the way toward improvements in pick-up tubes. Thin films of aluminum, ¼ to 2 microns thick, on the inner surface of the fluorescent screen, result in marked improvement in the brightness and contrast of orthicon and kinescope tubes. To be effective, the aluminum coating must be smooth, mirror-like and opaque to light. At the same time it must be transparent to electrons. The desired characteristics are obtained by coating the inner surface of the screen with an organic film and depositing the aluminum on this preliminary surface.

The thin metallic deposit protects the fluorescent screen, eliminates the ion spot which has characterized kinescopes of the past, and improves contrast by reducing stray light and reflections within the tube. In addition, the conductive coating avoids secondary emission. The new and old types of tube screens were shown in slides illustrating a paper by Epstein and Pensak of RCA.

Projection picture tubes operating at 30 kv for home receivers and 70 kv for theater use, both producing high-intensity light and using a Schmidt optical system, have been developed for projection television and were described by L. E. Swedlund of RCA Victor. The 5TP4 is an example of a commercial high-intensity projection television tube.

An Image Orthicon, described by Albert Rose of RCA, approaches in intensity the theoretical limit of pickup tube sensitivity. A very effective demonstration which was given showed that usable television images could be produced with the new Image Orthicon when the illumination of a single candle lighted the source. The distance between source and object was about 2 feet.

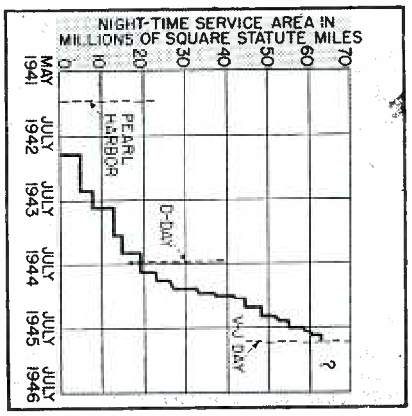
Navigation Aids

The Loran system of pulsed hyperbolic navigation has provided accurate fixes for ships up to 1,400 nautical miles from shore, operating on 1,950 kc. J. A. Pierce of Radiation Laboratory revealed that experimental developments using a frequency of 180 kc have potentially extended loran coverage, especially over land, although the accuracy becomes somewhat less at long distances. However, a new technique which matches individual r-f cycles instead of pulse envelopes has yielded average line-of-position errors of only 160 feet at a distance of 750 miles.

During the discussion a transatlantic circuit was opened up to a meeting of the IEE in London. IRE President Llewellyn exchanged greetings with Dr. Dunsheath, president of the British IEE. In conclusion, Sir Robert Watson-Watt in New York praised the value of loran and its British complementary high-frequency system, gee.

P. R. Adams, Federal Telecommunications, summed up propagation and noise information, new and old, to conclude that for a non-pulsed type of navigation system reliable up to 1,500 miles the best radio frequency is probably 17 kc.

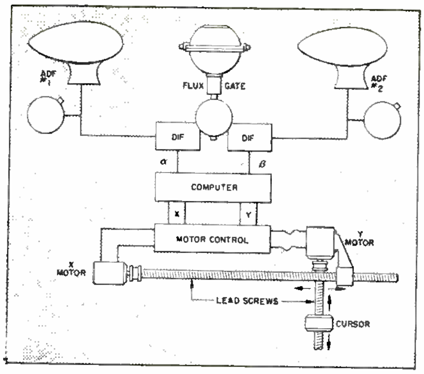
Determination of a fix by determining the direction of arrival of signals from two transmitters of known locations and the correlation



Growth of Loran service area, night-time (maximum coverage) of this information, first changing polar coordinates into rectangular, was outlined by A. C. Omberg of Bendix. Automatic computation and presentation results in a light spot cast upward through map of the region to show the position of the plane.

L. B. Hallman, Jr., and Captain R. D. Hultgren, Watson Laboratories, presented the elements and possible uses of secondary radar systems, usually known as beacons. Consisting of receiver-triggered ground-station transmitters, the beacons, or transponders, may be used singly or in groups for various navigational functions by craft equipped with radar iff transmitters. A 4-lb. emergency rescue beacon now in development utilizes the system in reverse, permitting the use of more accurate receiving equipment at the fixed stations.

Regardless of its future value as an aid to aerial navigation, the ground-controlled-approach system of talking a pilot down a glide path has already saved equipment exceeding the cost of the project, and many human lives. The system involves a radar set with an antenna pattern designed to look up and over local obstructions, surveying a radius of 30 miles to an altitude of 4,000 feet. Once the plane has been picked up, deviations from the glide path of as little as 7 feet at 2 miles are visually presented on numbered scales to a controller who informs the pilot by ordinary radiophone. Army equipment described by Ernest Storrs, Watson Laboratories, requires a 7-man crew, weighs 48,000 lb. and costs $200,000.



Pictorial block diagram of two loops, flux gate compass and integrating mechanism which drives a cursor to project a light spot upward through a map

A battery-operated, jeep-mounted, cross-loop direction finder with vertical sense-antenna has been produced, giving cathode-ray tube indication accurate to 1 degree under ideal conditions. Directivity of received signals in the range 1.5-18 mc was described by Aldo Scandurra. His associate, Samuel Stiber of Evans Signal Laboratory, explained the circuits used for integrating the signal information.

Evolutionary development of the pulse-type absolute altimeter to a single-scale, 50,000-foot-indicating, 30-lb. equipment was traced by Irving Wolff of RCA Princeton Laboratory. J. C. Smith, also of RCA, described a later f-m model, weighing 24½ lb., operating on a center frequency of 440 mc.

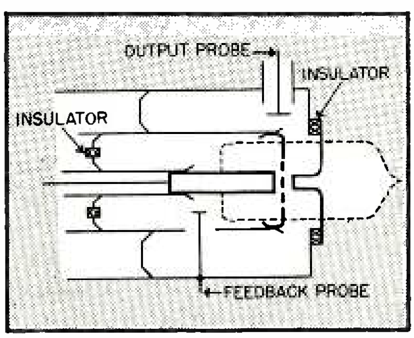
Vacuum Tubes

Outstanding tube developments of the war period, particularly those techniques involved in the manufacture of types for the generation of high-power continuous waves in the microwave region, received considerable attention in several technical papers.

O. W. Pike of the Joint Electron Tube Engineering Council discussed activities, aims and policies of his group. The Council plans to set up standards for the industry, publish data, and sponsor an educational program. Committees have been selected to handle the various activities. Information regarding all phases of the work can be obtained by writing to the secretary of JETEC at the NEMA headquarters in New York.

Development and manufacture of high-power triodes for c-w operation around 600 mc was the subject of paper by S. Frankel, J. Glauber and J. J. Wallenstein of Federal Telecommunication. The liquid cooled 6C22 is capable of generating 500 watts at 600 mc with an efficiency of 35 percent. This c-w type was developed from earlier pulse-type tube research.

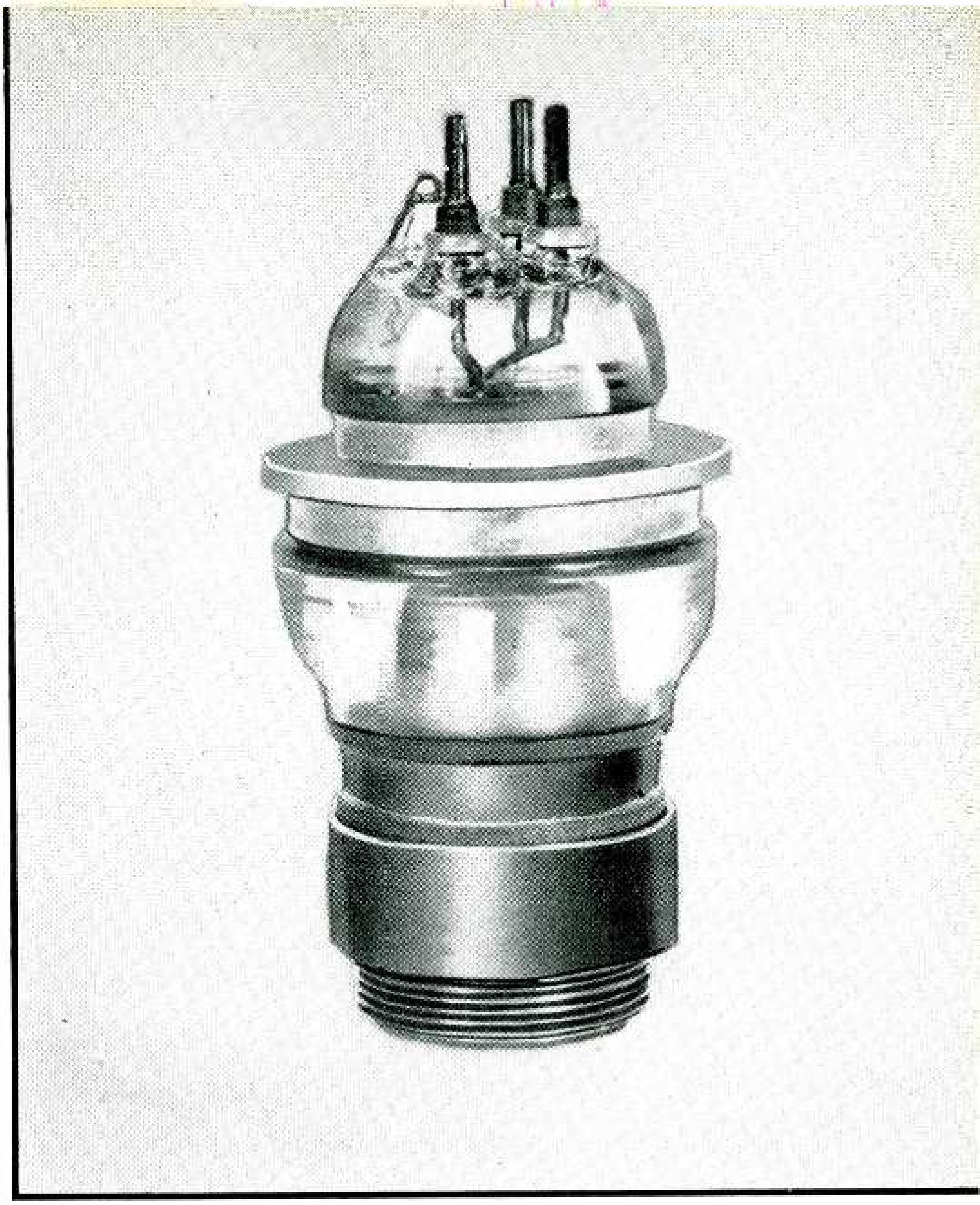
Everett M. Goodell of Sylvania discussed the development of the disc-seal tube. Considerable attention was given to the radical differences existing between such types and more conventional tubes. The discussion included in detail the transition from standard tube structures to the new diodes and triodes suitable for efficient operation up to 3,000 mc.



2C37 disc seal triode in a typical quarter-wave concentric line oscillator circuit

Three triodes were shown, the 2C37 for c-w, the 2C36, and experimental tube SB846B for pulsed operation. A novel method of obtaining internal feedback by coupling studs from the plate disc to the grid disc is employed in the 2C36. The tubes are designed to operate in concentric line oscillators.

J. N. Dyer presented the first of two parts of a paper by himself, W. G. Dow, W. W. Salisbury and E. A. Yunker, all of Radio Research Laboratory, concerning oscillators capable of generating 150 to 200 watts at frequencies up to 2,500 mc. Slides showed magnetrons of the liquid-cooled type, and type-8012 tubes in parallel-line oscillators. The second part of the paper, presented by W. G. Dow, described the resnatron and magnetrons capable of power outputs of 1,000 to 2,000 watts at frequencies from 500 to 4,000 mc. It was stated that the resnatron operated with efficiencies as high as 70 percent with outputs up to 60 kw. Tuning ranges with both tubes were given as 1.5 to 1. Bandwidths as low as 2 to 3 mc have been achieved with



Transit time has been reduced by modification and close electrode spacing in this tube designed for operation around 600 mc

the magnetron, while maximum bandwidth with the resnatron has been 4 mc at 500 mc.

Miniature Types

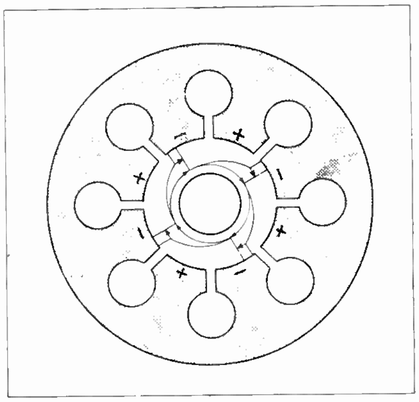
George Baker of National Union discussed design problems in the development of miniature h-v rectifiers, type 1Z2. The most troublesome of the two major difficulties encountered was back emission due to cold-field emission, evidenced by fluorescence on the inside of the glass envelope. Improvement was obtained by modification of the plate and filament structure. Polishing, and finally gold plating the plate surface, corrected the trouble. External flashover was prevented by properly spacing the leads.

Solution of production problems in the manufacture of miniature tubes was discussed by Henry J. Miller of RCA Victor, who pointed out that evidence of success is shown by the monthly production total which jumped from 300,000 per month in 1943 to 3,000,000 at the end of the war. Delayed failures in early production were due to lack of rigidity in the base, stresses from bending the pins, and improper temperature gradient in the base.

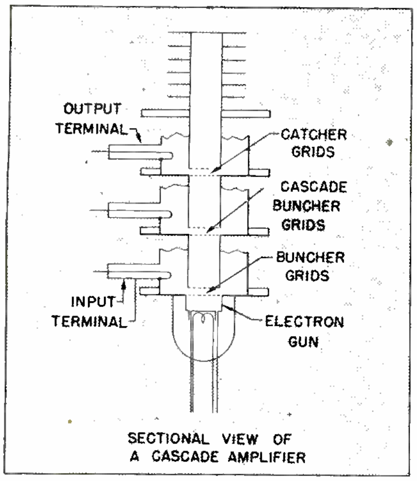
Microwave Tubes

Magnetrons have raised the economically available high-frequency limit of the radio spectrum by a factor of ten. To accomplish this objective it has been necessary to determine the wave phenomena and electron ballistics taking place within the magnetron. With an understanding of these functions it has been possible to produce cathodes which emit the requisite number of electrons.

Theory and practice in microwave magnetron design were reviewed by G. B. Collins, Radiation Laboratory. Electrons leaving the cathode of an oscillating magnetron have two possible types of motion. If the electron enters a retarding field, it spirals outward, passing alternately through retarding and accelerating portions of the r-f field and finally reaching a positive portion of the anode. The electron will have remained in the field for several cycles and will have transferred most of its energy to that field before reaching the anode. On the other hand, if the electron enters the r-f field at an accelerating point it returns in a short, circular path to the cathode. Although this electron absorbs energy from the r-f field it remains in the field so briefly that it removes little energy. The



Revolving electron cloud delivers energy to radio field to sustain magnetron oscillation



Three resonator Klystron provides greater power output from the beam modulation than two resonator or reflex types, for same input power

result of this action is to produce a revolving cloud of electrons having half as many arms as there are cavities in the anode block.

Limitations to the power a magnetron can develop are the maximum anode potential, which is limited by sparking, and the maximum cathode emission. Larger anode blocks are used for higher power magnetrons. Once the dimensions of the magnetron have been determined its operation has also been determined. Because of this dependence upon dimensions it is impossible to amplitude-modulate magnetrons over fifty percent without producing appreciable frequency change.

Emission Phenomena, and Klystrons

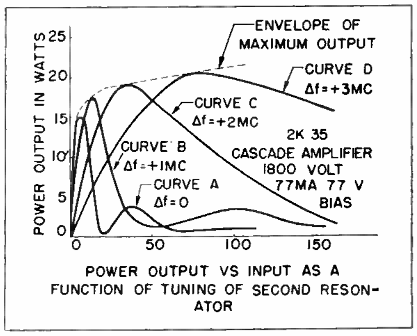
To obtain high cathode currents it is necessary to obtain high emission. To do this, advantage can be taken of the electrons returned to the cathode. M. A. Pomerantz, Bartol Research Foundation, described research to determine the effects of these returned electrons on oxide, temperature limited cathodes. High secondary emissions were obtained, raising the total emission to densities as high as 150 amperes per square centimeter, but practical considerations limit this to 50 amperes per square centimeter.

Tests on numerous cold, secondary-emitting surfaces conducted by engineers at Westinghouse and presented by J. W. McNall, H. L. Steele, Jr., and C. L. Shackelford indicate that Dow metal on copper, and silver-magnesium compound are best. An auxiliary primary emitter is necessary to initiate the chain action, which reaches equilibrium so quickly that it does not effect microsecond pulse operation of magnetrons.

Ideal bunching of klystrons is produced by increasing saw-tooth potential across the input-cavity gap. To simulate this action two cavities, suitably spaced, can be used for bunching. The action is as though the fundamental and second harmonic of a saw-tooth potential bunched the beam. To obtain the proper phase of the apparent second harmonic, the second bunching-cavity is slightly detuned. A third cavity recovers the bunched energy in conventional manner.

A theoretical analysis and substantiating experimental evidence on the three-cavity Klystron was presented by E. C. Levinthal of Sperry Gyroscope.

To produce necessary phase relations in the bunching cavities, the second cavity is detuned from the resonant frequency



Antenna Design

A brief review of wartime work with antennas at the Radio Research Laboratory was delivered by Andrew Alford in a paper prepared jointly with J. D. Kraus, A. Dorne, J. Christensen. A number of broad-band antennas for v-h-f were illustrated and described. These were used on countermeasure radar equipment.

To cover a wide band of frequencies, it was found necessary to have a small taper in the transition from a guided wave to a space wave. For the equipment used, standing-wave ratios of less than 2 to 1 were found necessary for self-excited-oscillator jamming transmitters using triodes or magnetrons. For equipment having pentode amplifiers, greater standing-wave ratios could be allowed. For receiving, a standing-wave ratio of 5 to 1 was permissible for general search and use.

Crisscross dipoles, corner reflectors, bent-sheet reflectors and horn-type antennas were shown. One antenna illustrated consisted of a slotted or deformed horn which was mounted flush against a plane fuselage from the inside. A slot cut in the fuselage was covered with Fibreglas so that no blister appeared outside the plane. Two bars inside the horn acted as a compensating transmission line. This construction was used effectively at frequencies from 700 to 1,250 mc.

Broadsides, Parabolas

Design considerations in broadside arrays, and their effect on antenna bandwidth determined by pattern deterioration, were discussed by John Ruze of Evans Signal Laboratory. Methods of lobing a broadside array were discussed and illustrated by slides of radar antennas that operate between 100 to 1,000 mc. The eight-bay array of the SCR-270, having 26 db of side radiation over a frequency variation of 10 percent, was described. Two of these arrays, mounted one above another to form a square 40 x 40 feet, were used in the recent transmission and reception of radar signals to the moon.

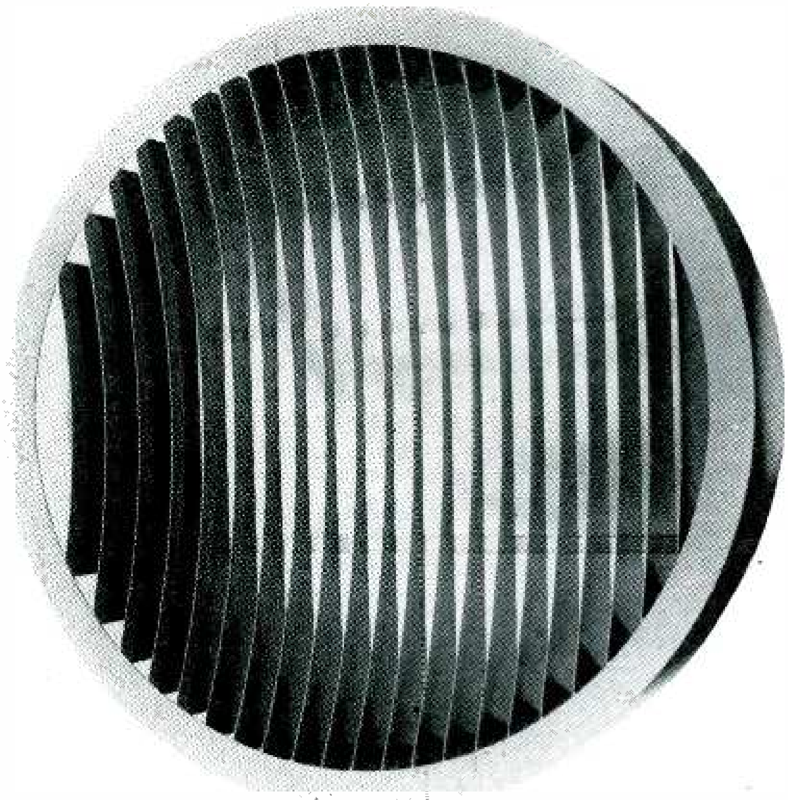
That modifications of a parabolic antenna system for focusing can be made by providing an extended antenna-feed, or by distorting the shape of the parabola, was pointed out by L. C. Van Atta of Radiation Laboratory. The beam width of such an antenna is due to deflection of the radiation at the aperture. The aperture was defined as that part of a plane surface through which the major portion of the radiation passes.

The modifications of the beam were compared with an optical searchlight beam, in which the angular width is determined by the extended light source placed at the focal point of the parabola used as a reflector, and by inaccuracies in the reflector shape.

In a parabola antenna, the focusing properties can be modified by either of two methods; an extended-source method in which a single-point source such as a dipole is displaced upward from the center of the parabola, and the shaped-reflector method in which the phase front is moved forward by advancing the top half of the reflector. With a sufficient number of wavelengths across the aperture, a wide variety of patterns is available. Some of the beams that can be formed are square-angle beams, straight-sided beams, and those that are sharp on one side and take a cosecant form on the other side.

Because the time and effort involved would have been prohibitive using full-scale planes, model aircraft antenna measurements were undertaken by Divisions 13 and 15 of NDRC. Pioneer work on the project was done at Wright Field. This was described by George Sinclair of Ohio State in a paper prepared by himself, E. W. Vaughan and Edward C. Jordan. Models were constructed using a 1/16 inch per foot scale. Some models were constructed of copper applied over wooden shapes, the wood later being removed after the copper sections had been soldered together. Others were carved out of wood which was then metalized by a spray-metal process. Conducting paint has also been used.

The models were mounted on a plywood mast, arranged with motor drive so that they could be rotated to any position. Two axes of radiation were provided and disturbing influences of the control equipment were compensated by metal-cloth spaced a quarter-wave below the model's antenna. The antenna in the model plane could be used for either transmitting or receiving in checking field strength patterns. The associated equipment included a receiver, a wave analyzer and a compressor circuit that produced an output voltage proportional to the square root of the input voltage, so that practical recording was possible with a bolometer-type detector. Much of the work was done at frequencies of 500 to 10,000 mc. Recordings were made directly on polar-coordinate paper.

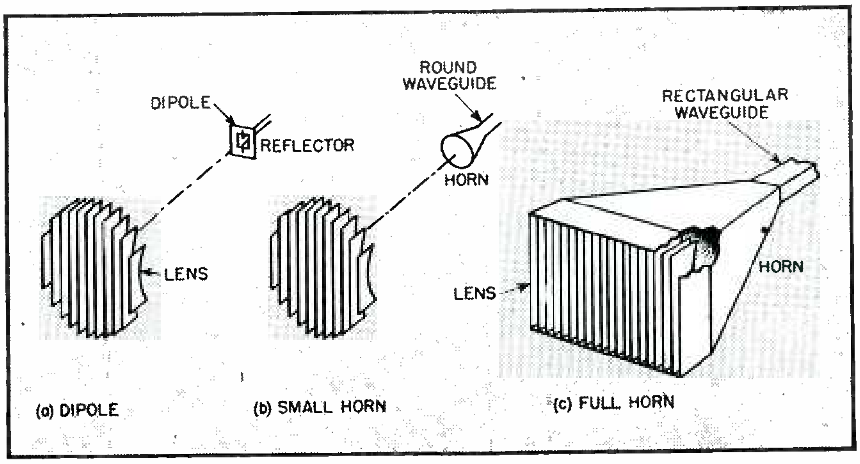


A plano-concave antenna having an aperture of 14 wavelengths

Metal-Lens Antennas

Engineers were reminded that optical design techniques are useful with radio waves, by W. E. Kock of Bell Laboratories. By employing the proper shape, thin metal sheets can act as a focusing mechanism or lens antenna. The focusing action is apparently caused by the high phase-velocity of the wave passing between the metal plates. A row of parallel plates thus forms a refractive medium whose index of refraction is less than unity. The shape is the opposite to that of an optical lens. A typical lens illustrated was 14 wavelengths in diameter and had an *f* rating of 1.67. The lens antenna can be fed by a small dipole array, or other types of directive antennas such as an electric horn or a second lens fed by a waveguide. Lenses can be designed to produce various types of beam shaping in either vertical or horizontal directional patterns.

A lens in the aperture of a horn antenna materially reduces the horn length. Increased gain is also achieved, since the gain can be made to approach that of a horn having an infinite length. An optimum horn flared to an aperture of 40 wavelengths in the electric plane would be 800 wavelengths long; a lens having an aperture of 40 wavelengths



Three methods of energizing a metal lens antenna requires a horn only 38 wavelengths long. If the horn extends to the edges of the lens, effective shielding is provided. Results of tests on several experimental models were given. A horn-lens combination was found to have a power gain of 12,000 over an isotropic radiator. At 1.8 degree off the axis of the beam, the power gain dropped to 0.01 of its maximum value.

The metal lens can be twisted about its axis and still produce a satisfactory beam. Profile tolerance is about five times that of a parabolic reflector. Other feature of the lens antenna are no shadow of feed lines, standing-wave loss at a minimum, and no spillover between antennas when the units are operated back-to-back in relay or repeater installations. A demonstration using a microwave transmitter and receiver was made with two types of lenses, one a metal-vane construction and the other a plastic-and-metal-film combination.

Radar

With the single exception of range determination, where existing radars so far surpass optical competitors that further precision would be meaningless, needed improvements in radar performance and the vital necessity for continued radar research were stressed by practically every speaker in the radar session.

P. E. Koenig of Wright Field, described airborne interception (AI) equipment and its tactical uses. AI was the seeing eye for night-fighter aircraft, and also operated in connection with ground-controlled radar in support of offensive ground forces. The first equipment used a wavelength of 1.5 meters, with Yagi antennas rigidly mounted on the planes. Maximum range was 2,500 yards, since extended to 5 miles. In fighter planes, AI gear had to be divided into small packages due to space limitations. Many fundamental problems still remain to be solved, as present equipment is wholly inadequate against the weapons of the future.

The basic units of modern search radar for reconnaissance planes were described by Captain L. V. Berkner of the Navy Bureau of Aeronautics. Both all-around scanning and forward-looking scanning are provided. Some of the problems still requiring solution are cloud returns and sea returns, both interfering with interpretation of patterns. Search radar also carries provisions for radar beacon utilization, as the position of a plane in space can be established by making contact with a single beacon.

The radome on this Navy PJB aircraft bulges like a bullet at the tip of the starboard wing. Similar units, described in detail by P. E. Koenig in his talk on airplane interception, are similarly mounted on the wings of night fighters

Paying a tribute to all who contributed to the radars that saved so many lives in the Pacific and appreciably shortened the war, Captain D. P. Tucker of Navy Ordnance discussed uses for radar in naval fire-control. Modern fire control is so accurate that in one instance a ship that failed to get its target in the dark with the second salvo at the 15-mile extreme limit of range was ordered to go back and practice some more. Increased range-finding accuracy is the important contribution of radar to fire control; if two radars on a ship do not check within a few yards at 15 miles, repair technicians are bawled out.

Watching shell-fire splashes on a radar screen requires narrow angle determination, and this has been achieved in two different systems, namely rapid scanning and lobe comparison. The latest practical fire-control radars use lobe switching for both azimuth and elevation angles to give completely automatic aiming far excelling the most skilled human gunners.

Air-to-air firing presents the most difficult fire-control problems encountered by radar. Lt. Col. E. A. Massa of ATSC described the equipment used in the three basic types of aircraft installations for control of fixed guns in fighters or in inhabited turrets as in the B-17, and in remotely controlled turrets as in the B-29. Operation of the range gate for automatic tracking on the target was explained.

Naval Antenna Problem

On VJ-day the Navy had 1,019 separate electronic projects in various stages of design, according to Captain R. Bennett's survey of electronics in surface warfare. A naval vessel presents the most difficult type of antenna problem conceivable what with five or six antennas rating top position on a ship and there being at most only two such high points available. Some antennas should be big to get greater accuracy, yet then they get in the way of gunfire; some should be isolated to avoid interaction with others, yet there isn't enough space for this. On a battleship, top positions go to the large antennas for air-search radar, with surface-search antennas slightly below and fire-control radar scattered about the ship near or on turrets.

According to Captain Bennett teletype has become essential for radio communications, and the radio operator of the good old days will soon be as extinct as the coherer.

Problems encountered during the period 1934-1938 at Naval Research Laboratory in developing the XAF equipment radars were described in reminiscent vein by R. M. Page. This radar had a carrier frequency of 200 mc, and used 3-microsecond pulses. Tubes developed for radio amateurs have contributed greatly.

Cavity boxes, thermistors, directional couplers, microwave field-type signal generators, and other types of test equipment required for maintenance of airborne radar in the field were described by Captain E. A. Blasi of ATSC. His co-author, G. C. Schutz of ATSC, followed with details of techniques for using these instruments. Frequency determination is the simplest measurement required, and receiver sensitivity is the most difficult to measure.

Microwave Techniques

An interesting contrast in methods of obtaining workable waveguide structures was presented by E. M. Purcell and Julian Schwinger, both of Radiation Laboratory. Despite the work which had already been done up to the outbreak of the war, early efforts were necessarily directed towards cut-and-try methods to combine mechanical strength and flexibility with predictable electrical behavior. While mechanical problems were being solved, the theoretical group worked out techniques to enable the use of equivalent lumped-constant circuits in considering wave-guide structures. Military radar requirements resulted in almost complete dependence upon heavy brass wave guide and fittings. Most of the unit sections were silver-soldered or machined, although die casting was often useful. Wider use of metal-covered plastics seems promising since the depth of penetration of the waves is less than that of a stable film of metal.

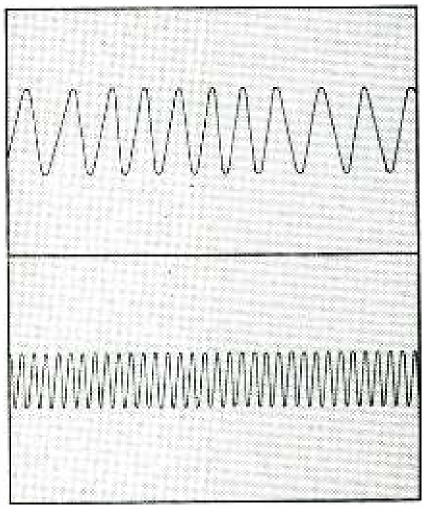
Microwave Measurements

Of the several low-frequency techniques for measuring r-f power, those which convert r-f energy to heat seem to have proved most satisfactory for use in the microwave region. Calorimetric devices which depend upon heating a flow of liquid and measuring the rate of temperature rise are bulky and insensitive. T. Moreno, Sperry Gyroscope, described a bolometric wattmeter of comparable accuracy, capable of more rapid measurements of microwave power over an extremely wide band of frequencies.

The directional coupler, stemming directly from microwave techniques, provides another means of measuring r-f power, particularly at high levels. It is a device for sampling the direct and reflected waves in a transmission line. W. W. Mumford of Bell Laboratories pointed out its value in determining the impedance match between lines or a line and some connected device. Adjustment for minimum mismatch can be accomplished simply on either coaxial lines or wave guides.

The spectrum analyzer described by F. J. Gaffney of PIB Products has had a large number of uses and soon becomes an indispensable tool in radar work. It presents on a cathode ray tube the Fourier transform of the pulsed-oscillator under study by tuning a receiver across the pulse at the same time the tube is being swept. It is comparable to panoramic reception, but differs in that the frequency band is large compared to the band width of the i-f amplifier. When the input to the analyzer is a continuous wave the resultant pip can be compared with a standard frequency source. If shielding and attenuation are provided, power measurements are possible on a comparative basis. It has been particularly useful in testing magnetrons and in overall field service of radar equipment.

Power-absorbing elements to be inserted in coaxial lines and waveguides for use as calibrated attenuators were made in large numbers during the war. E. Weber of Brooklyn Poly described the problems and the equipment involved in evaporating controlled thicknesses of various metals on glass for this purpose. The design was simplified to an extent that semi-skilled workers were able to manufacture them successfully. Variable attenuators were less satisfactory and required great ingenuity, particularly those for use in waveguides.



Magnified portion of a micro-oscilloscope trace showing (top) a 10-cm wave and (bottom) a 3-cm wave. Twelve such traces can be recorded on a plate 1½ x 15/8 in.

Decreasing sensitivity of an oscillograph with increase in the frequency of the signal to be photographed requires changes in technique, of which one variation was introduced by G. M. Lee of Central Research Laboratories. The principle of the micro-oscilloscope, suggested but never used by von Ardenne, has been employed in part. The resultant three-beam micro-oscillograph is capable of recording 10,000-mc oscillations with a calculated reduction of deflection sensitivity of but 40 percent. Although the beam writes directly upon the photographic emulsion, thus requiring a vacuum lock and continuous pumping, less than ten minutes is required to completely insert and remove a 1½ by 1⅜-in. plate holding 24 pictures. Ten- and 3-cm waves are shown.

Crystal Rectifiers

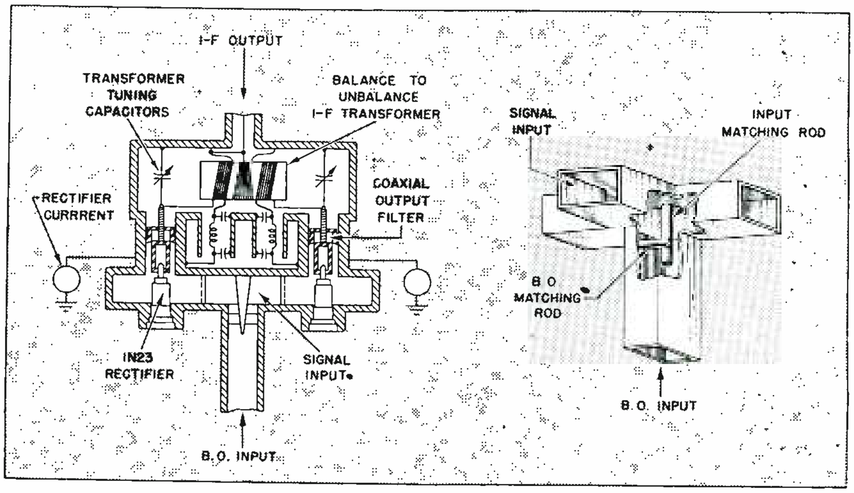
Three papers presented in the crystal rectifier group were concerned with the selection of crystals and the development of circuits for their use as mixers at very high frequencies. Interesting converter arrangements, designed for use in radar sets during the war, were shown.

C. F. Edwards of Bell Telephone discussed problems in the design of microwave converters using point-contact silicon rectifiers. Use of the hybrid coil and resonant-line impedances to produce balanced converters having uniform performance characteristics over a wide band of frequencies was illustrated. Emphasis was placed on the effects of impedance-frequency characteristics of the input and output networks on converter performance. Several converters were described, for operation at wavelengths between 3 and 30 cm.

Superiority of crystal rectifiers as frequency converters in superheterodyne receivers of microwave signals was discussed in a paper by H. C. Torrey, Radiation Laboratory. Basic considerations in the selection of crystals are: noise temperature, conversion loss, mechanical and electrical stability, and uniformity. Conversion loss and noise temperature are combined in a quantity called the noise figure. Application of linear network theory to the circuit, representing the mixer as a three-terminal pair device with terminals at signal, image sideband, and i-f output helps in estimating the effect on conversion loss of image sideband termination and of parasitic impedances. It was stated that d-c characteristics of crystals have no bearing on r-f impedance at these frequencies.

Studies of the noise spectrum of crystal mixers were reviewed in a paper by P. H. Miller of the University of Pennsylvania. These studies were carried out over a range from 50 cycles to 7 mc. In the audio range a band-pass filter employing a three-terminal Wein bridge was used to perform the analysis. At higher frequencies a communications receiver having a square-law detector was used. Noise temperature was definitely shown to be a function of frequency, rising to a high level at audio frequencies. Low noise levels at the higher frequencies can be obtained by careful selection. No suggestion as to the cause of the noise was made.

Crystal rectifiers in balanced mixer showing hybrid coil connections to i-f amplifier



Industrial Electronics

While search was made for a projector F. H. Shepard, and Paul Zottu of Girdler, gave extemporaneous talks on the role of industrial electronics and the interest of the IRE in this comparatively new phase of application of radio techniques. It was said that many of the problems of communication engineering could be transferred bodily to the field of industrial electronics. Indeed, the analysis of industrial processes, and the establishment of electronic control mechanisms are closely analogous to the analysis of communication systems. The automatic control of processes is similar to feedback-amplifier systems, with process stabilization having its counterpart in the stability to be derived from feedback amplifiers; process lag in the industrial operation has its counterpart in the electrical lag produced by *RC* networks.

The tasks of the industrial electronics engineer are multifold and cover a wide range of topics. Technically he must design a process or system such that it produces for his client or employer the desired end result, and this must be done with economic justification. It follows that while it is possible to apply electronics to almost any industrial process, it is often desirable to obtain a specific type of operation by other than electronic methods.

Electronic Recorders

Considerable emphasis was placed on the application of electronic tubes and circuits for use with industrial recorders.

The Tagliabue recorder, described by V. L. Parsegian, consists of three elements, the fundamental bridge balancing system, the amplifier and motor mechanism actuated from unbalance of the bridge, and the printing-recording system operated by the motor in the second element.

The system is so designed that when unbalance occurs in one direction there is a 180-degree phase reversal from unbalance in the other direction, and the direction of rotation of the motor is controlled by this phase reversal. The motor actuates the printing mechanism. An *RC* timing circuit actuates the writing pen at intervals of about 1 second, whereas the position of the recording pen is determined by the motor, which depends upon the amplified unbalance of the bridge.

W. R. Clark of Leeds and Northrup described a new Speedomax recorder which is a-c operated, produces an ink record and has a frequency response flat to within 1 db for frequencies between 25 and 150,000 cps.

Servo Systems

Linear servomechanism theory was highlighted by R. E. Graham of Bell Laboratories. It was pointed out that a servo system may be composed of mechanical, thermal, pneumatic, hydraulic, mechanical or electronic elements, or a combination of all of them. However, all servomechanisms are systems in which the output is fed back to the input in such a manner as to control the output. Because all servo mechanisms are functionally alike, they lend themselves readily to analysis by means of linear differential equations provided all portions of the system are operated over limited ranges to assure linearity of response.

The transmission of instrument readings from a pilotless aircraft to its controller on the ground or in another plane by means of radio telemetering was covered by David W. Moore, Jr. of Fairchild Camera.

X-ray snapshots at exposure times of the order of a millionth of a second are now possible with a special tube in which electrons are jerked out of a cold metal cathode by a momentary high voltage to create a peak anode current as high as 2,000 amperes. Ballistic uses of this equipment during the war were described by D. C. Dickson of Westinghouse, along with such commercial applications as performance studies of machinery and pictures of the transfer of metal during welding.

Techniques and problems involved in operating two high-power oscillators in tandem for induction heating, to secure more power than can be obtained from a single unit, were described by W. C. Rudd of Induction Heating. The chief problems are interconnection of tank circuits in such a way that the frequencies of the two oscillators are the same, and equal sharing of the load by the two power supplies. Two 25-kw units have been successfully operated in duplex to provide 50 kw.

Communications Systems

Developments in the communications field during the war with definite peace-time applications were described, among them being multichannel relay links and wide-band tunable receivers for the microwave bands.

Captain J. O. Kinert of Naval Operations stressed the necessity for coordination of design between the services and for sets designed for successful handling by inexperienced personnel. Interchangeability of components relieves the pressure on maintenance stocks in times of stress. Failures in action were attributed to the planning by inexperienced personnel, actual equipment failures, and failures due to enemy action, with that due to inexperienced personnel predominating.

Receivers designed for the Navy for use in the vhf and uhf ranges were discussed by T. McL. Davis of NRL. Ship installations present peculiar problems in selectivity because of the congestion in antenna equipment. Very high voltages are frequently induced in receiving antennas due their proximity to transmitting antennas. Unusual demands are thus placed on preselector requirements. I-f circuits must have high gain, low drift and at least 60 db discrimination against adjacent-channel interference. Recent models of standard equipment have six double-tuned i-f transformers. Early receivers had little or no gain in preselector circuits. Later equipment had better gain, a tuning ratio of 1.4 to 1 and an overall image-rejection ratio of 90 db. Interchangeable units for preselector, i-f, and power supply have been designed for ease in maintenance.

Transportable microwave radio sets TRC-5 and TRC-6 were described by Raymond E. Lacy of Coles Signal Laboratory. In these two sets, microwave techniques (1,350-1,500, and 4,350-4,800 mc) employed in radar are used to maintain two-way communication over relay links up to 2,800 miles. Both sets use pulse-time modulation, with an 8-channel multiplex system. Both also use waveguide-fed, parabolic-dish receiving and transmitting antennas mounted on the same mast. In the case of the TRC-6, the r-f units of both transmitter and receiver are mounted on the backs of the parabolas. In special cases, improved reception under adverse conditions has been obtained by diversity reception, with two vertically spaced receiving antennas on the same tower.

Enemy Equipment

Captured German and Japanese radio and radar equipment was described by Lt. Comm. E. L. Luke and John C. Link of NRL. It was stated that German radar research was stopped in 1941 and not resumed until 1943 when Germany discovered from captured allied microwave equipment that their own equipment was obsolete. German airborne radar operated in the band from 485 mc to 550 mc. Late models were in larger quantities but of much poorer quality. It was not until January 1945 that 9-cm models appeared. Due to manufacturing difficulties few were made. While German communication equipment compared favorably with ours at the beginning of the war, Japanese radio and radar equipment was always of inferior quality. It was usually copied from American or German designs. Plans for the Wurtzburg radar were flown to the Japs in 1943, but only one set was produced.

Special Receivers

Development of receivers to meet the exacting requirements of direction-finding and wave analysis in combating enemy radar was described by G. E. Hulstede, J. M. Pettit, H. E. Overacker, K. Spangenberg and R. R. Buss of RRL. Advanced receiver techniques were incorporated in sets tunable over frequency ranges of 2 to 1, with single-dial control and high sensitivity. The receivers give continuous coverage to 10,000 mc. Late models had high image-rejection at the microwave frequencies. Butterfly tuners were used with acorns to 1,000 mc.

Plug-in, butterfly-tuned r-f units containing preselectors, heterodyne oscillators using acorn tubes, and crystal mixers were used with standard 30-mc, broad-band i-f units up to 1,000 mc. The i-f band widths were 3 and 4 mc. Image rejection at 1,000 mc was 10 db and better than 40 db at lower frequencies. From 1,000 mc to 10,000 mc concentric-line oscillators employing reflex klystrons were used. The 200-mc i-f amplifier, consisting of ten 6AK5 tubes, was stagger-tuned to obtain a bandwidth of 20 mc at the peak and 24.5 mc, 6 db down. Image rejection with two-cavity preselectors was 40 to 60 db. A total gain, through the second detector, of 97 db was realized in late models. Reflector voltages on the klystrons ranged from 300 volts at the lower end of the band to 1,250 volts at the higher frequencies. Mechanical tracking was successfully employed between klystron cavity tuning and reflector voltage.

High efficiencies in the r-f circuits were due largely to refinements in tunable cavity structure. Cavities were developed with no sliding contacts and in most cases no dielectric in the r-f circuit. Leakage of r-f energy past the tuning shafts was prevented by resonant line impedances built into the cavity tuning plungers.

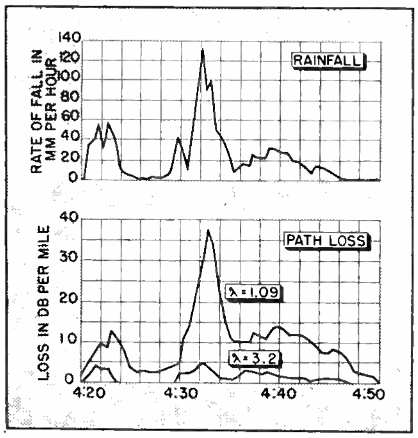
Propagation Studies

Utilizing pulse techniques, the National Bureau of Standards has long been conducting measurements for the prediction of sky-wave transmission. Six locations contributed data to the bureau in 1936. Today roughly 40 locations contribute.

From correlation of ionosphere data, meterological measurements, sun-spot activity, and actual transmission characteristics, it has become possible to forecast major transmission disturbances. The bureau is now issuing for general distribution a monthly publication predicting radio propagation three months in advance. Information contained in this bulletin was described by N. Smith following an introduction by J. H. Dellinger. Charts and nomographs for F_1, F_2 and sporadic-E enable one to determine ionosphere absorption, atmospheric noise, lowest usable frequency, and highest usable frequency for a given path. These charts cover the world.

Atmospheric Ducts

Measurements of the atmospheric conditions producing ducts, and detailed study of ducts over water were described in two complementary papers. J. E. Freehafer, Radiation Laboratory, explained how variations with altitude of air temperature and moisture content can produce a varying index of refraction giving wave propagation action comparable to that of waveguides. However, the altitude over which such a condition must extend is large compared to a wavelength, so that only in the microwave region is the effect appreciable. The atmospheric ducts account for the greater than line-of-sight communication and radar transmissions. These ducts can not be relied upon over land.



Transmission loss and rate of rain fall measured during a rainy day show relation of moisture content of air and microwave attenuation

The persistance of ducts over water was demonstrated by experiments conducted over the Pacific and reported by M. Katzin, R. W. Bauchman, and W. Binnian of NRL. Measurements were made on 9 and 3 cm at heights above mean sea level up to 94 feet. Definite correlation between heights of optimum transmission and heights of duct-forming atmospheric conditions was obtained. Transmissions over paths ten to twenty times the line-of-sight path were obtained. The conditions over windswept water are ideal for production of atmospheric ducts.

A similiar diffraction phenomenon of microwaves was studied by engineers of the Bell Laboratories, and reported by W. M. Sharpless. The particular problem was to determine variations in the angle of arrival of 1 and 3-cm waves over line-of-sight paths above land. During the day the angle of arrival was that calculated from the earth's radius and the array positions. At night the radio waves came in from slightly higher angles, but never more than a degree higher. These variations limit the sharpest beam that can safely be used for microwave relay links.

To measure absorption of microwaves by rain S. D. Robertson and A. P. King made an early study of the effects at 1 and 3 cm and G. E. Mueller repeated the study using waves of 6-mm length. The work, done at Bell Laboratories, indicated that although there was measureable absorption at these wavelengths, it was only appreciable for precipitations approaching cloudburst magnitudes. Under these conditions transmission at these wavelengths is interrupted less than three percent of the time in the temperate zone.

Following the formal presentations C. L. Pekeris, Columbia University, enumerated the results of theoretical determinations which agreed well with the measurements of duct transmission over water.

Broadcast Receivers

Noise in f-m broadcast receivers was analyzed mathematically by David B. Smith in a paper prepared in collaboration with W. E. Bradley, both of Philco. He considered the case when a mixture of noise and useful signal is applied to the input of an ideal receiver and showed that any given impulse noise that exceeds the carrier can produce either a click or a pop. The pops are larger and last longer and their pitch is determined by the time constant of the deemphasis circuit, 100 microseconds. At 100 percent signal modulation, the amplitude of the pops is about 13 percent. The pitch of the clicks is determined by the time constant of the audio system and they last about six microseconds. Their amplitude is never greater than 6.5 percent.

Balanced phase-shift types of f-m detectors were discussed by S. W. Seeley of RCA. He showed the vector relations of a typical discriminator circuit and traced the action during the change in the relative phase of the potentials across the primary and secondary windings. The vector relations of the secondary potentials become greater, as if enlarged photographically, but do not otherwise change when the primary voltage is increased by tuning the primary to resonance.

I-F, R-F, Magnetic Recording

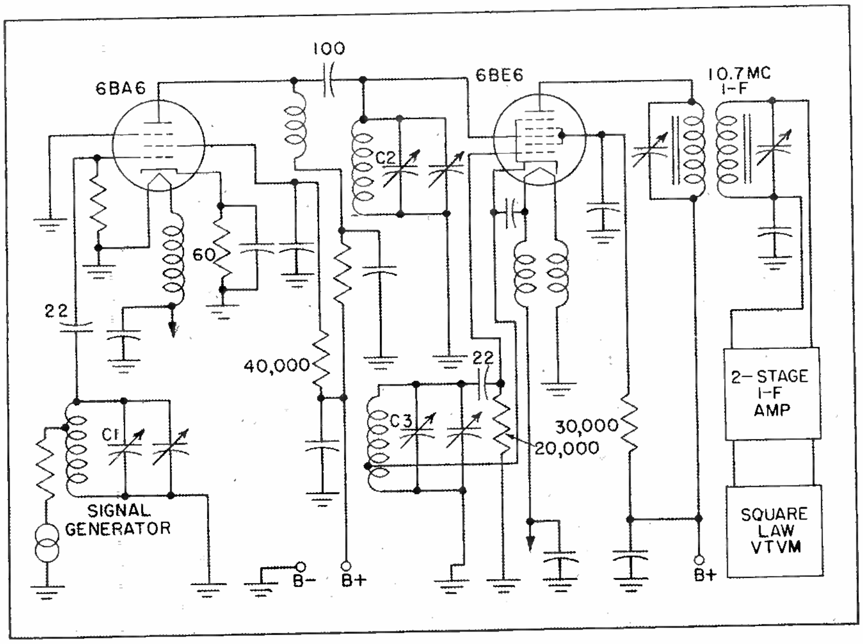
Design and performance of capacitance-coupled amplifiers were discussed by Merwin J. Larsen in a paper by himself and Lynn L. Merrill, both of Stromberg-Carlson. An i-f amplifier was built for the range of 21 to 28 mc for a television receiver. Attenuating traps were used for the sound signal. A mathematical analysis was made and experimentally obtained curves were presented as an aid in selecting circuit parameters for flat-top frequency response.

Two new miniature tubes designed for the r-f amplifier and converter stages for new f-m band receivers were described by R. M. Cohen, R. C. Fortin and C. M. Morris, all of RCA. One tube, type 6BA6, is an r-f pentode having characteristics like those of a 6SG7 but with a more remote cutoff characteristic. Its grid is formed to conform to the shape of the cathode, thus reducing the possibility of shorting under vibration. The other tube, type 6BE6, is a pentagrid converter similar to the 6SA7 but the g_m of the oscillator portion is double that of the 6SA7.

A recommended circuit for the tubes contains heater chokes that maintain the heater at the potential of the cathode to prevent varying heater capacitance from causing frequency modulation of the oscillator. No d-c resistance is used in the signal grid circuit because the oscillator develops an appreciable voltage on this grid. When used in circuits having a low value of capacitance the signal grid may be tapped down on the coil, but the usual receiver bandswitch generally has sufficient capacitance to obviate this need. One circuit shown has an overall gain to the grid of the i-f amplifier of 70. The image rejection ratio is 56 db.

A brief history of magnetic recording from the days of American Telegraphone at the turn of the century to the present day was given by S. J. Begun of Brush. He traced developments made during the war in recording on the various mediums such as tungsten steel, stainless steel, plated wire, and paper and plastic bases having suspended magnetic particles.

(*Continued on next page*)

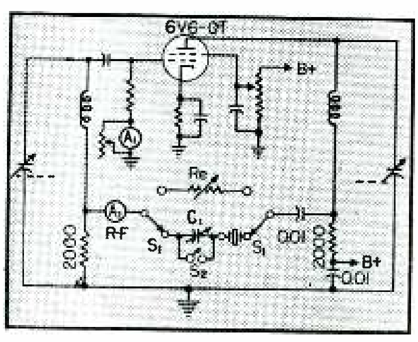


Typical self-excited converter and r-f amplifier circuits for the 6BE6 and 6BA6 tubes developed for the new f-m band

Quartz Crystals

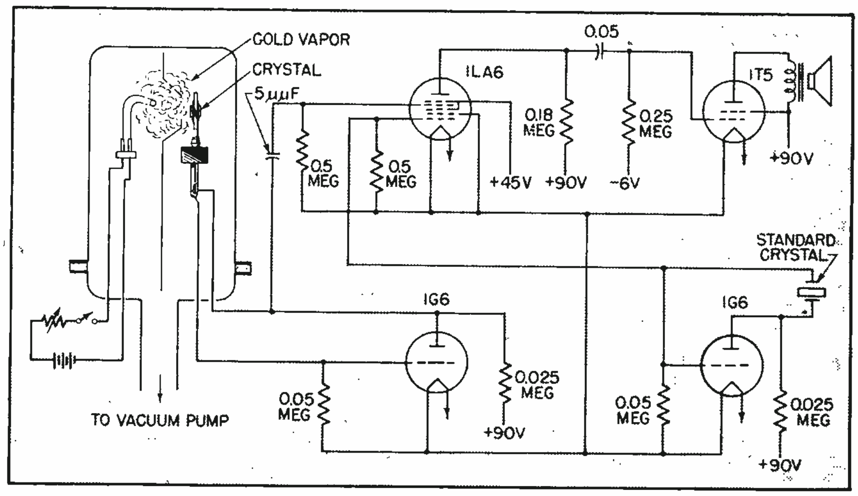
Techniques developed during the war for mass production of quartz crystals and humidity-proof holders in million-unit batches, with relatively unskilled help and to tolerance specifications considered impossible only a few years ago, were described publicly for the first time despite the inevitable cutting of some of the IRE papers for secrecy reasons.

After reviewing the fundamental properties of crystal units, Captain C. J. Miller, Jr. of Squier Signal Laboratory analyzed one by one the chances for standardizing these properties to permit drastic reduction in the number of different types of crystals now in use. A standard crystal unit was defined as one in which all of the characteristics except frequency are specified. Standard specifications for approved units are planned, with a format somewhat like that now used for vacuum tubes. One goal is elimination of the need for supplying standard test units to crystal manufacturers. An overall tolerance of 0.01 percent for frequency is recommended for standardization, along with universal use of the hermetically sealed holder. It is considered practical now to make crystals as thin as 0.003 inch. The laboratory has developed a crystal impedance meter that can operate a crystal either at series resonance or into a small capacitive reactance. The crystal and the capacitance are switched into the circuit alternately with a rheostat while the rheostat is adjusted until switching produces no change in rectified grid current, and the value of the rheostat is then the effective resistance of the crystal.



Simplified schematic circuit diagram of the crystal impedance meter

Techniques for measuring performance characteristics of crystal units with commercially available test equipment were outlined by W. D. George of the Bureau of Standards, and graphs of results were shown for 50-mc and 8.7-mc units. Relative merits and limitations of the various available methods were indicated, along with observations on behavior of crystal units.



Circuit arrangement for lowering quartz crystal frequency by plating with gold. Metal is deposited until the loudspeaker indicates zero beat between the crystal and a standard

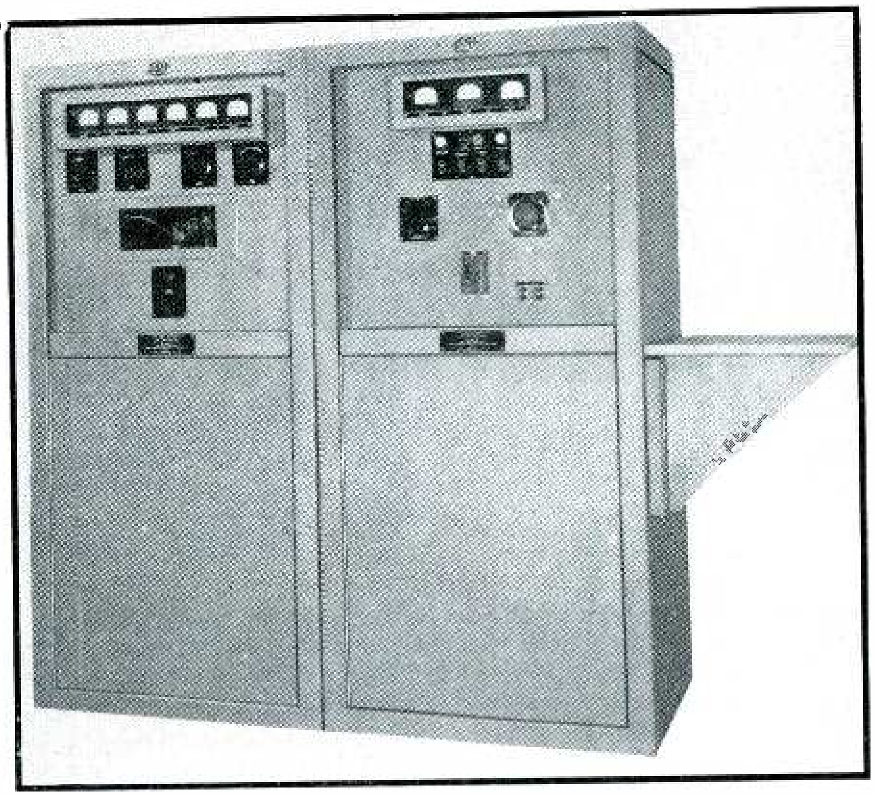
Hermetically Sealed Holders.

Stages in the development of hermetically sealed metal holders for quartz crystals were described by A. W. Zeigler of Bell Laboratories. Successful sealing of the crystal units in dry air at atmospheric pressure was achieved with the aid of induction soldering, using a multi-turn work coil and heavy current for a very short interval. Finished products were tested by immersion in water at 90 C, creating a pressure differential of about 3 lb, and watching for bubbles. Induction heating combined with mechanized fixtures and conveyor belts permitted production of 80,000 of the hermetically sealed units by relatively untrained operators before the end of the war.

With new mass-control techniques described and demonstrated by R. A. Sykes of Bell Laboratories, material is added rather than removed to bring crystals to their required critical frequency. In this new process, with which over 2,500,000 complete crystal units have already been produced, the crystal unit is ground to a frequency roughly up to 300 kc too high. It is then placed in a small evaporator housing and evacuated while connected to a circuit in which its frequency is compared with that of an oscillator working at the desired frequency, so that a beat note is heard. A filament switch is then turned on, causing gold to be evaporated and deposited onto the crystal unit. The filament button is held down as the beat frequency gradually lowers to a growl and finally stops at zero beat. The evacuation time is a matter of seconds, as also is the actual plating time, so that a crystal can be brought to the required frequency by relatively untrained workers in a minute or so, with every assurance of permanence and stability. In answer to a question, the author stated that harmonic crystals have been developed that operate satisfactorily in the range of 15 to 50 mc.

Loran Transmitting Stations

Circuits and operating functions of the transmitter, timer, and synchronizer, which generate the synchronous pulses of the system, are described in this concluding article on Loran

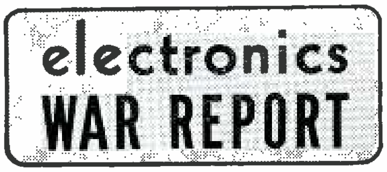


Front view of the transmitter, consisting of r-f unit and modulator; exciter, control circuits and power supply (right)

IN the first article of this series, it was pointed out that the Loran transmitting station produces a series of accurately spaced pulses which are rigidly synchronized with the pulses from another station. In this article the equipment which generates, times and synchronizes the pulses is described. The functions performed by this equipment are: (1) to generate and broadcast 40-microsecond pulses of r-f at 1,700 to 2,000 kc and at a peak power level of from 75 to 150 kw; (2) to repeat the pulses at 25 or 33⅓ pps so precisely that the accumulated error in timing the pulses does not amount to more than a microsecond over a period of several minutes; and (3) to synchronize the timing of the pulse sequence with that of a similar sequence to an accuracy of one microsecond. These rather formidable requirements are met by three basic units known as the transmitter, the timer and the synchronizer.

The layout of a Loran transmitting station comprises a vertically-polarized non-directional transmitting radiator, and a similar (usually directional) receiving antenna, appropriate radial-conductor ground systems for each, and buildings which house the equipment and the primary power supply. The transmitting and timing equipment are provided in duplicate to permit uninterrupted 24-hour service.

The pulses from the distant station, to which the transmitter is to be synchronized, are fed to a shielded room within the transmitting building, a precaution to insure that the local transmitted signal does not block the receiver. The received ("remote") signal is delayed and thereafter displayed on a cathode-ray indicator. The transmitted ("local") signal, properly attenuated, is displayed on the same screen, and the phase of the transmitted keying system is adjusted until the remote and local signals appear superimposed on the indicator. As originally set up, this synchronized relationship was maintained by manual adjustment of the local pulse rate; later automatic synchronizing equipment was developed which performs this function without human aid, and which warns the operator by ringing a buzzer if the synchronization fails. The primary power source is 60-cps 115-volt single phase, derived from utility lines when available, or generated by gasoline-driven power units.



The Transmitter

The transmitter proper is a self-excited tuned-grid tuned-plate push-pull oscillator, pulse modulated in the cathode circuit. The modulator is driven by two exciters which derive their timing from respective timers. Two exciters are necessary because certain Loran stations are required to generate two sequences of pulses simultaneously, at slightly different rates. This is the case when a double master station (defined in Part I of

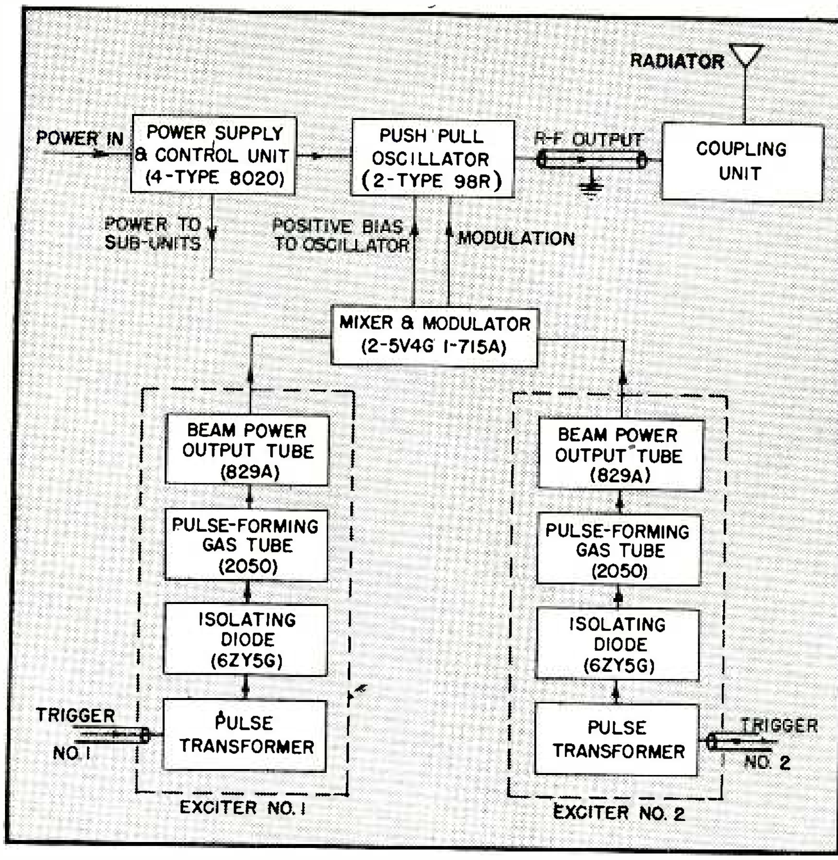


FIG. 1—Block diagram of the Loran transmitter. The modulator can be driven by two sets of pulses simultaneously, thus permitting synchronization with two adjacent stations

this series) is paired with two slave stations, the two pairs operating at different pulse rates. Occasionally the slave stations are operated with two rates.

The transmitter must be so designed that there is a minimum of interaction between the two sequences. An important interaction occurs due to the beating effect between the two rates. Suppose, for example, that one rate is 25 pps and the other $25\frac{1}{16}$ pps. The two pulses occur simultaneously at some instant and thereafter are separated in time until 400 (16 x 25) pulses have passed (16 seconds later) when they again coincide. Since this interaction occurs on only one pulse in 400 no serious consequence arises.

Pulse-forming Circuits

The block diagram of the Loran transmitter is shown in Fig. 1. The trigger input fed to the transmitter from the timer enters the exciter unit, the simplified schematic of which is shown in Fig. 2. The trigger has a sharp leading edge and an exponential decay. The trigger voltage is first increased by passage through a pulse transformer and then drives a gas tetrode (type 2050) through a diode which inhibits gas-ion bombardment. In the plate circuit of the gas tetrode is a 40-millihenry inductor and an 0.008 μf capacitor. This series-resonant circuit is shocked into oscillation by the pulse and produces a positive half-sine wave between the gas-tetrode plate and ground. The duration of this half sine wave is about 40 microseconds at half amplitude. This is the basic pulse width of the transmitter output; it can be adjusted by changing the L and C values. The negative half of the sine wave is not formed since the gas tetrode is by that time cut off. The positive wave thus formed is passed to the grids of a double beam tetrode (type 829A) which are normally biased well below cutoff. The beam tubes are connected in a cathode-coupled circuit known as a "bootstrap" circuit. This circuit resembles a cathode follower except that the grid circuit is returned to the cathode rather than to ground. Hence the output voltage developed across the cathode resistor is not fed back to the grid, there is no degeneration, and the circuit has normal gain. The tube and all connected elements, including the grid driving circuit, rise in potential during the pulse, which appears in positive polarity across the beam-tube cathode resistor. The bootstrap circuit has the advantage of operating with zero plate current between pulses but at the same time delivering positive output pulses which permit the following modulator tube likewise to be cut off between pulses. The half sine-wave pulse is distorted to more nearly

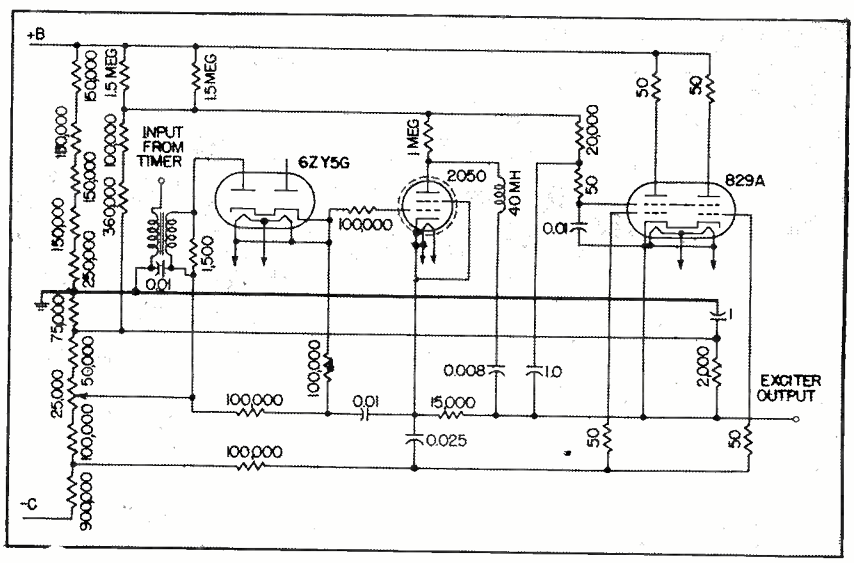


FIG. 2—Schematic diagram of the exciter unit, which produces 40-microsecond pulses to drive the modulator. The type 829A tube is connected as a "bootstrap" cathode-coupled stage which does not reverse polarity

rectangular shape in passing through the beam tubes, but retains its width at about 40 microseconds.

The output pulse of the exciter is then mixed with a similar pulse sequence produced by the other exciter at the other pulse rate. The two pulse sequences are combined in two diodes as shown in the simplified schematic of the modulator (Fig. 3). The diodes permit passage of each pulse sequence to the modulator grid but prohibit passage of the pulse sequence from one exciter output to the other.

Modulator-Keyer

The modulator proper is a beam power tube (type 715A) capable of operation with very high voltage on its plate (up to 5 kv). The grid of the modulator is biased well beyond cutoff and hence the modulator does not normally conduct. When a pulse is delivered to it through the mixer from either exciter, the modulator is driven to full conduction, acting as a virtual short-circuit between the r-f oscillator cathode and ground. The cathode bias is thereby removed from the oscillator and oscillations

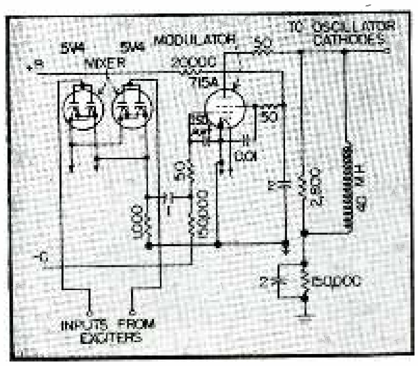


FIG. 3—The modulator, connected in the cathode circuit of the oscillator. Two exciter outputs are combined in a diode mixer and drive the 715A beam tube which shorts the oscillator cathode to ground

begin, reaching full amplitude in about 20 cycles of the carrier. Forty microseconds later, at the conclusion of the modulator pulse, the modulator is cut off.

The cessation of modulator current reintroduces the cathode bias of the oscillator and shuts off the oscillations. To aid in this action, a 40-millihenry inductor shunted by 2,800 ohms resistance, is included in the modulator circuit between modulator plate and ground. During the pulse, a current builds up in this inductor, flowing through the modulator. When the modulator is shut off at the end of the pulse, the current in the inductor cannot be shut off instantaneously so a high voltage is induced across its terminals. The polarity of this induced voltage is such as to make the modulator plate more positive, and this is the proper polarity to drive the oscillator cathodes, connected to the modulator plate, to cutoff. Hence the inductor serves the impress a higher than normal cathode bias on the oscillator at the conclusion of the pulse and the r-f oscillations are thereby abruptly terminated.

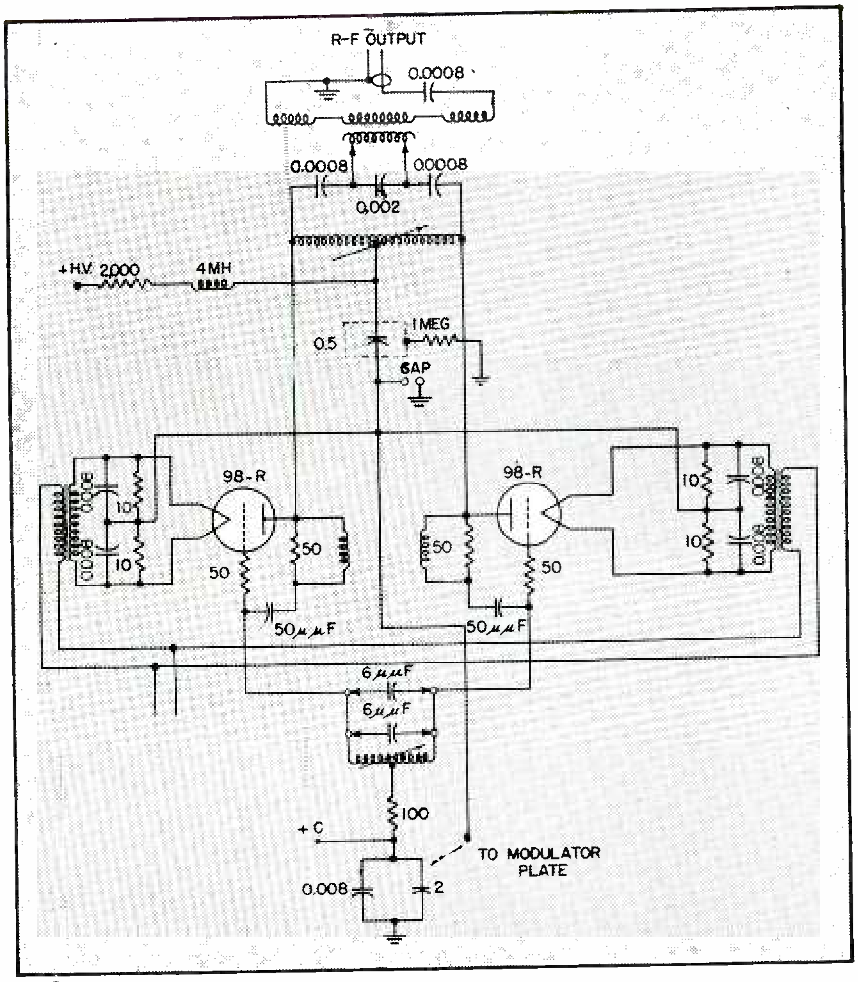


FIG. 4—Simplified schematic of the push-pull oscillator. This self-excited unit produces peak power of 75 to 150 kw

R-F Generator

The oscillator itself (Fig. 4) is remarkable in the fact that a self-excited oscillator can be made to have high stability, not only in frequency but also in the starting phase of the r-f cycles at the beginning of each pulse. This stability is achieved by careful elimination of incipient parasitic oscillations, good electrical symmetry between the two halves of the oscillator, and the absence of excessive heating. The oscillator tubes (type 98-R) are air-cooled external-anode tubes rated at 1,000 watts average plate dissipation. The actual average power fed to these tubes is from 150 to 300 watts, of which less than 100 watts is plate dissipation.

The duty cycle of the system, when double pulse sequences are carried, is two 40-microsecond pulses every 40,000 microseconds (at 25 pps), or about 0.2 percent. When 100 kw peak power output is delivered at 60 percent efficiency, the peak input power is 133 kw, and the average input power is 133 x 0.002 = 0.26 kw. The oscillator tubes are considerably oversize from the plate dissipation standpoint, but not when the peak power requirements are considered. The 98-R tubes have thoriated filaments which can deliver 10 amperes peak emission current, and which can be operated with up to 25 kv on the plates. Normal operating plate potential is about 17.5 kv, derived from a bridge rectifier (four type 8020 diodes).

Circuitwise the oscillator is a conventional tuned-grid tuned-plate arrangement, the grid circuit assuming control of the frequency. Positive bias is applied to the grids to assure rapid starting at the beginning of each pulse. Coarse adjustment of frequency is introduced by taps on the grid and plate coils, fine adjustment by rotating a shorted turn within each coil. Figure 5 shows the construction of the transmitter and its components.

The Timer

The timer is the central feature of the Loran station, since it establishes the pulse rate and maintains the pulse intervals on which the operation of the system is based. Essentially the timer is a 50-kc quartz-crystal clock of the highest attainable accuracy, with auxiliary divider circuits which generate the trigger pulses at 25 or $33\frac{1}{3}$ pps. The frequency of the quartz-crystal clock is adjustable over a limited range and this adjustment is employed to keep the transmitted pulses precisely in synchronism with Loran signals received from the other station of the Loran pair. The local and remote signals are received over the same channel and presented on the same indicators, in a manner similar to that of the Loran receiver (see part II of this series). The quartz-crystal oscillator frequency divider and selector circuits, receiver and indicators are contained within the timer assembly, as shown in Figs. 6 and 7. External to the timer, but closely associated with it functionally, are the local signal attentuator, the automatic synchronizer and switching gear for interchanging duplicate equipment in case of failure.

Time-Frequency Standard

Figure 8 shows the block diagram of the timer and related equipment. The action of the timer, and of the entire system for that matter, starts with the 50-kc quartz-crystal oscillator. The quartz bar is designed to have the most stable frequency possible and is carefully mounted and temperature controlled. The operating specifications require an accumulated timing error less than 1 microsecond over a period of 3 minutes and the design specifications are considerably more stringent than this. One microsecond stability is attained for periods as long as 20 minutes, which corresponds to a frequency stability of 1 part in 10^9. If this error were maintained for a period of 30 years, the accumulated error of this clock would amount to less than a second. The Meacham bridge circuit, used in the oscillator, provides the requisite high stability.

The oscillator output in sinusoidal form is split into four phases and passed through a capacitive phase

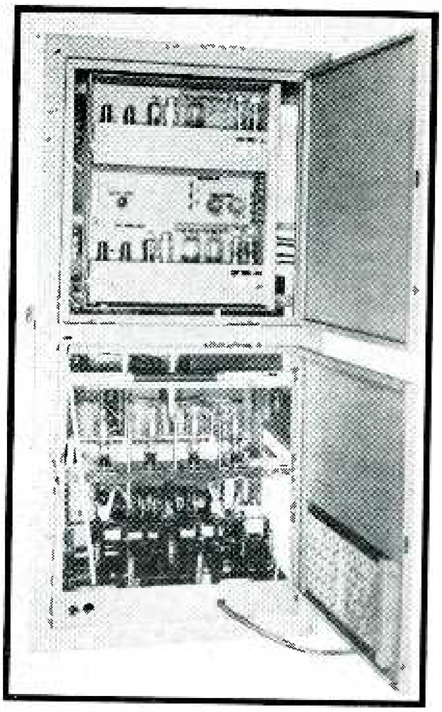


FIG. 5—Rear view of Loran transmitter showing two exciter units (top) and 25-kv bridge rectifier (bottom)

shifter. Rotation of the phase shifter dial adds or subtracts any desired fraction or whole number of cycles to the oscillator output thus shifting the time of occurrence of the output trigger pulses. Attached to the phase-shifter shaft is, in addition, an auxiliary frequency control which changes the constants of the oscillator circuit by a small amount in a direction to reduce the required amount of phase shift. Thus as the operator adjusts the phase shifter to keep the remote and local pulses in synchronism, he automatically corrects the oscillator frequency to bring the pulse rates, as well as the phases, into synchronism. After a few adjustments of this type (which may be likened to the "aided-tracking" mechanism in gunfire control radars) the synchronous position is reached, and the only adjustment required thereafter is that to correct for the minute casual variations in the crystal frequency.

Frequency Dividers

Returning to the block diagram (Fig. 8), the phase shifted oscillator output is passed to a frequency doubler and blocking oscillator which produces sharp pulses at 100 kc, i.e. at 10 microsecond separation. These pulses are used as markers on the indicator screens and also to drive the ensuing frequency-divider chain. This chain consists of six counter circuits, dividing by factors of 5, 2, 5, 2, 5 and 4 respectively to achieve a frequency of 50 cps. For operation at $33\frac{1}{3}$ cps, the last counter divides by 3, producing an output frequency of $66\frac{2}{3}$ cps.

At intervals along the divider chain, as shown, 100 and 1,000-microsecond marker pulses are led off, mixed and applied to the vertical deflection plates of the indicators. These markers are also used to synchronize the delay circuits as hereinafter described.

Each divider circuit is a combination of a blocking oscillator and two diodes, through which a capacitor is charged in steps until its voltage reaches a sufficient level to trigger the following blocking oscillator. A detailed description of the counter circuit is contained in part II of this series.

The output of the divider chain is fed to a square-wave generator (Eccles-Jordan circuit) which introduces the final division by a factor of 2 and produces two rectangular waves of opposite polarity at 25 or $33\frac{1}{3}$ pps. These are the basic pulse rates of the system. Feedback is provided, as in the Loran receiver-indicator, to introduce slight variations in the basic pulse rates (in steps of $\frac{1}{16}$ cps at 25 cps).

Master-Slave Operation

The leading edges of the rectangular waves are used to coordinate the remaining functions of the timer. Before describing these functions, a distinction must be made between

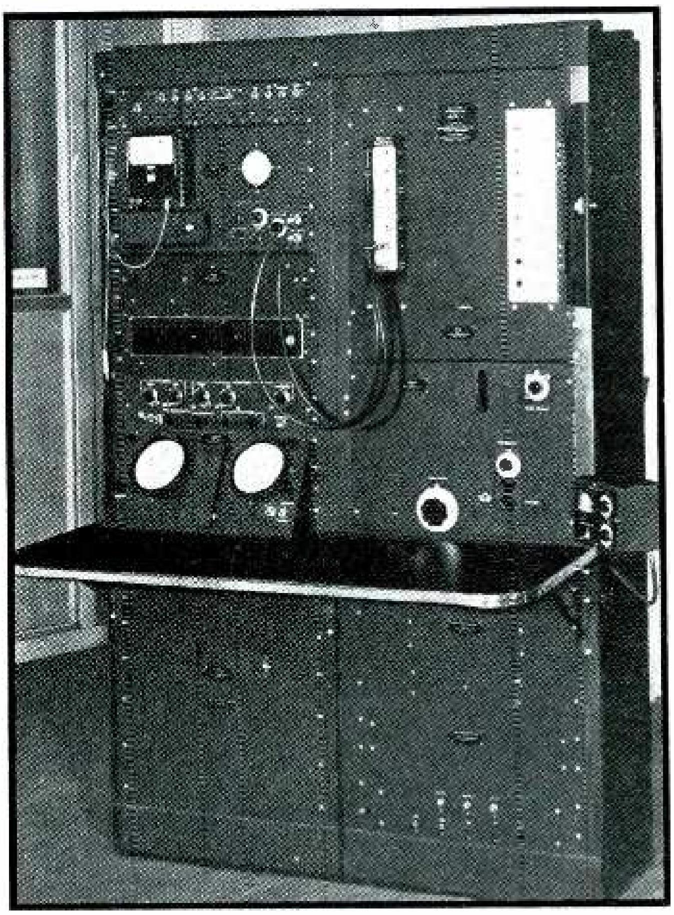


FIG. 6—Model C-1 Loran timer, which synchronizes the signals with the adjacent station

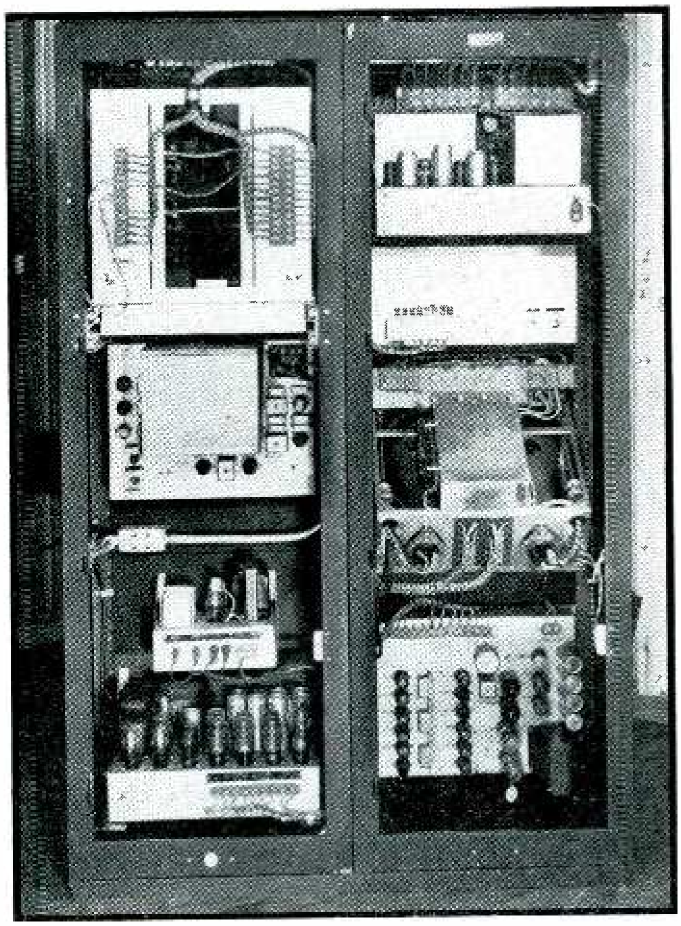


FIG. 7—Rear view of timer. Balsa-wood box at center of unit at left houses 50-kc quartz bar which maintains frequency constant

operation of the timer in a master station and in a slave station. In a master station (type A operation), the timer is adjusted initially to have a value within a few thousands of a percent of the correct value and then thereafter operates without adjustment. In the slave station (type B operation) the time of occurrence of the slave pulses is adjusted from time to time to maintain the proper relationship with the master pulses.

The same timer equipment is used in either case, but the manner of connection and operation differs. The primary difference arises in the sequence of the master and slave pulses. In the slave station the master pulse arrives, and after a delay of approximately 1,000 microseconds the slave pulse is transmitted. In the master station, on the other hand, the master pulse is transmitted at will and the slave pulse is received after 1,000 microseconds plus twice the time required for the pulse to traverse the distance between master and slave stations. Evidently different delays are required in the two cases to bring the master and slave pulses into coincidence on the indicator screen.

Consider, first, operation in a slave station, and refer to Fig. 8. As shown at the right in the diagram, the remote signal (from the master or "A" station) arrives at the receiving antenna, is passed through a coupling unit and through an attenuator (which is inactive when the remote signal arrives and hence introduces no attenuation) and thence to a superheterodyne receiver. This receiver is similar in all essential respects to the receiver of the Loran receiving equipment used by the navigator. The remote signal after detection and amplification by the receiver is passed to a mixer amplifier where the marker pulses from the divider chain are mixed with it. The combined signal is applied to the vertical deflection plates of the two indicator tubes. Thus the remote signal is presented to the operator.

Local Signal Attenuation

After a delay introduced by the timer, the trigger signal is passed from the timer to the transmitter which thereupon emits the slave pulse. This pulse is very strong and would tend to block the receiver were it not for several precautions. In the receiving coupling unit, two gas tubes (type VR-105) are inserted which break down during the transmission of the local pulse and thus prevent more than a few volts being impressed on the receiver transmission line. Moreover, the attenuator previously mentioned is active during the reception of the local pulse and further attenuates the signal (down to a few microvolts amplitude). This attenuator consists of two mutually isolated amplifier stages (type 6AC7) whose grids are biased beyond cutoff during the transmission of the local pulse, by a rectangular wave derived from the selector circuits of the timer. Careful shielding and arrangement of circuits are required to minimize unwanted pickup of the local signal from undesired sources. Installation of the timer and attentuator equipment in a shielded room is standard practice.

The local signal must be viewed on the indicator for matching with the remote signal. For this purpose, the local signal is picked up directly at the transmitting antenna coupling unit, passed through a network which introduces a known delay and thence to the receiver. By this means both remote and local signals are caused to suffer the same delay between pick-up antenna and indicator deflection plates. The amount of pick-up from the local antenna is adjusted by a potentiometer at the input to the receiver, so that both local and remote signals have the same amplitude on the indicator screen. If either the local or distant signals should change amplitude for any reason, adjustment of this potentiometer will equalize the signal amplitudes.

Selector Circuits

The remaining function of the timer equipment is the generation of the trigger pulses which drive the transmitter. This is accomplished in selector circuits, two groups of which are provided; one for the slave pulse (B selector) the other for the master pulse (A selector). The initial circuit of each selector is a delay multivibrator, actuated by the rectangular-wave output of the Eccles-Jordan circuit. After a delay determined by the constants of this multivibrator, a gate pulse, less than 1,000 microseconds long, is formed and mixed with the 1,000-microsecond markers from the fourth divider. In this manner a particular 1,000-microsecond marker is selected from the sequence. This pulse is passed on to another delay multivibrator ("fine delay") which reacts after an adjustable time and selects a particular 50-microsecond pulse from the sequence generated by the second divider. In the case of the A selector, this latter pulse is used, after suitable shaping and amplification, to form the output trigger which drives the transmitter. In the case of the B selector, the pulse is passed through an additional delay multivibrator which permits a continuous adjustment within any selected 50-microsecond interval. Thereafter the delayed pulse is used as the trigger. As shown in the diagram, a two-way link is provided which connects the trigger circuit to the A selector when the timer is used in a master station, or to the B selector when used in a slave station.

The output of the selector circuits is thus seen to depend on the markers for the precision of timing rather than on the constants of the delay multivibrators. Since the markers are directly generated from the stable quartz-crystal oscillator, rigid synchronization at the desired rate and interval is assured.

Another two-way link is provided between the selector circuits and the attenuator previously mentioned. The attenuator is driven by the A selector (which initiates a 1,800-microsecond wave to bias the attenuating amplifier) in the case of master operation, or by the B selector for slave operation.

Indicator Oscilloscopes

The indicators are similar in function to the receiver indicators described in Part II of this series. Two indicators are used so that the slow sweeps (showing the full repetition interval of the system) and the fast sweep (showing the expanded pulses superimposed) may be monitored simultaneously. The slow sweep is driven by the output of the Eccles-Jordan circuit at 50 (or 66⅔) pps, and a trace separation voltage is imposed from the same source in the

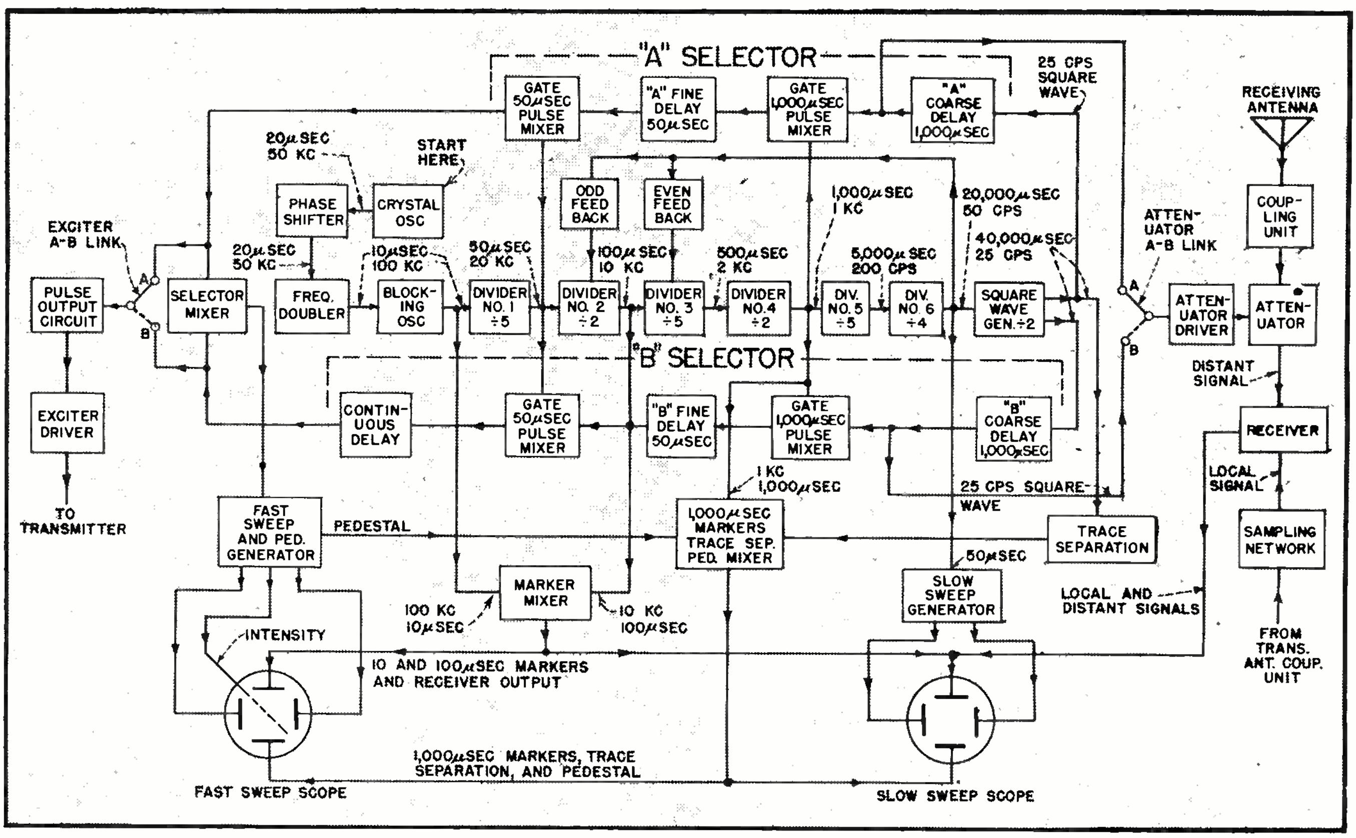


FIG. 8—Block diagram of timing unit. This equipment performs functions similar to the Loran receiver indicator but with greater precision and stability. Two indicators show slow and fast sweeps simultaneously

vertical dimension. Thus two parallel traces, each 20,000 (or 15,000) microseconds long, are formed with pedestals, markers and received signals superimposed on them. The pedestals are formed by the output triggers of the A and B selectors, and the time difference between the pedestals is determined by the settings of the coarse and fine delay controls in the selectors.

Operation as a Master

In the case of master station operation, the A pedestal is placed at a convenient position to the left of the top trace, and the B pedestal to the right on the lower trace by an amount equal to the slave station delay (usually 950 or 1,000 microseconds) plus twice the time of traverse between master and slave stations. Since the same trigger forms the A pedestal and the local (master) pulse, the master pulse appears at the beginning of the master pedestal. When the remote slave station is maintaining proper sync, the slave pulse appears at the beginning of the slave pedestal. Adjustment of the continuous delay in the B selector permits placing the two pulses directly one under the other on the expanded (fast) sweep. The operator of the master station is thus enabled to monitor the synchronization performed by the slave station and to give warning if the synchronization fails. In this way, two checks are provided on the synchronization (in addition to monitor stations set up for the purpose).

Operation as a Slave

When the timer is used in a slave station, the two-way links are connected in the B positions, and the local (slave) transmitter is triggered by the B selector, so the slave pulse must appear at the beginning of the slave pedestal. The remote master pulse appears to the left on the master pedestal by an amount determined by the settings of the A selector. This amount is set at a particular value (950 or 1,000 microseconds), known as the slave station delay. Provision is made for changing this delay in accordance with a prearranged code, for use in wartime to confuse the enemy should he attempt to use the transmissions.

The slave station operator views

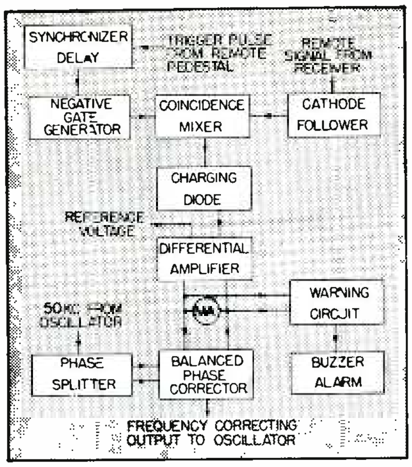


FIG. 9—Block diagram of the automatic synchronizer which keeps slave and master pulses in step without manual control

master and slave pulses on the fast sweep and adjusts the oscillator phase shifter as required to keep the two pulses superimposed. In this manner the slave station is triggered in rigid synchronization with the reception of the remote master pulses.

Automatic synchronization

A device which performs slave station synchronization automatically has been introduced to relieve the burden of manual operation of the slave timer. This device, known as the synchronizer, is used normally only for type B operation. The block diagram of the synchronizer is shown in Fig. 9. The synchronizer compares the time of occurence of the remote (master) signal with that of the remote (A) pedestal in the timer. The comparison is carried out in a so-called coincidence mixer, an amplifier fed from two sources. To the control grid of this amplifier the remote signal is fed directly from the receiver. The cathode of the same tube receives a narrow rectangular wave, about 5 microseconds long, which is derived from the A selector of the timer. The pulse which forms the A pedestal in the timer is passed through a synchronizer delay multivibrator which introduces a delay equal to the cumulative delay experienced by the local signal. The delay pulse generates the gate pulse.

Coincidence Mixer

The coincidence mixer with remote signal and gate applied to grid and cathode respectively, passes plate current only when both signals are present simultaneously, and the magnitude of the current passed depends on the time relationship between them, increasing as the gate more nearly approaches the center of the remote pulse.

Differential Amplifier and Alarm

The output of the coincidence mixer thus consists of pulses, the peak value of which depends on the degree of coincidence between remote signal and the pedestal on which it is displayed. These pulses are passed through a diode detector and charge a capacitor to the peak value of the pulses. The voltage across the capacitor is thus a measure of the degree of synchronization. The capacitor voltage is compared with a steady reference voltage in a differential amplifier which develops an output proportional to the difference between them. If this difference voltage exceeds a certain limit it actuates a relay and a warning buzzer operates, indicating departure from the established limits of synchronization (plus or minus one microsecond).

Time-Frequency Corrector

Variation in the difference voltage actuates a balanced phase corrector, consisting of two tubes fed voltage from the 50-kc oscillator in the timer. The latter voltage is split into two phases, 180 degrees apart, which are fed to the control grids of the phase corrector tubes. The screen grids of the same tubes receive the difference voltage from the differential amplifier. Consequently the voltage appearing across the common plate connection of the two tubes and ground, shifts in phase as the difference voltage varies. This 50-kc signal, with phase shifting in accordance with the relative displacement of the remote signal and the gate signal, is fed back to the 50-kc oscillator in such polarity that it "pulls" the oscillator frequency in the proper direction to overcome the departure from synchronization.

Readers interested in more complete descriptions of Loran equipment will be interested to know that the Radiation Laboratory is preparing a book on the Loran System which will be issued as one of the 28 volumes in the Radiation Laboratory Technical Series, to be published in 1946.—D.G.F.

SENSORY

By LAWRENCE CRANBERG
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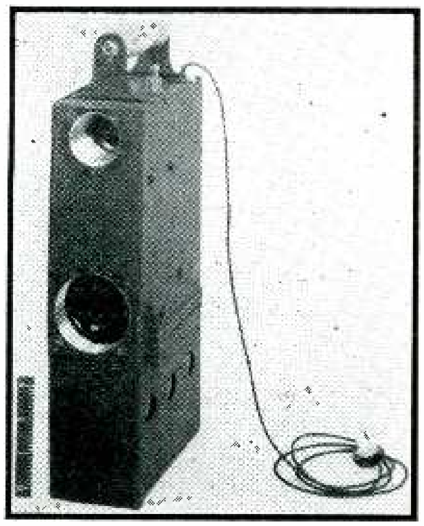
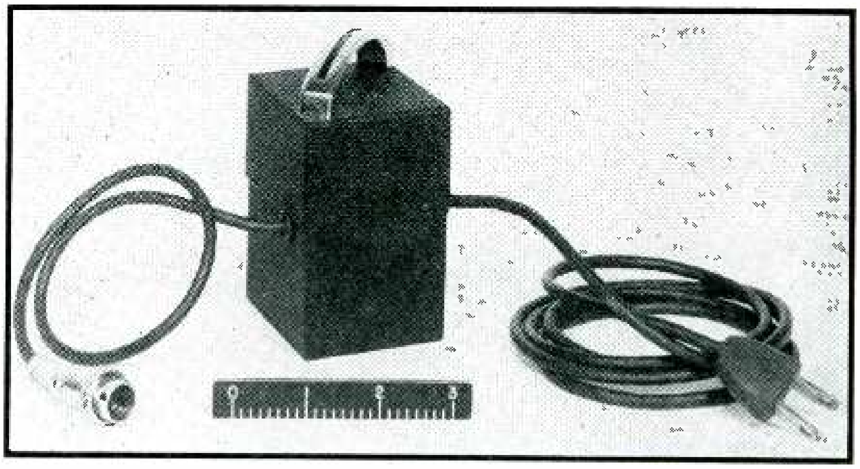


Sensory aid developed by Signal Corps Engineering Laboratories. The air-conduction headphone is shown at the right. The complete unit weighs about nine pounds



Miniature battery charger for the sensory aid unit. This is operated from ordinary 115 v a-c mains

THE NEED for a means which would indicate to a blind person the presence of obstacles in his path, or irregularities in the ground surface such as steps and holes, and the distance to them, has been long and keenly felt. Everyone is familiar to some extent with the role played in this connection by the Seeing Eye dog. However, numerous factors limit the proportion of sightless people who can use the dog, and indicate the need for a device which might perform at least some of the same functions.

Very little, if any, work aimed at the development of such a device had been done prior to the war. However, World War II, with its blinded veterans and its dramatic demonstration of the powers of the electronic art, has provided real impetus toward such a development. Activity was initiated at the Signal Corps Engineering Laboratories at Bradley Beach, New Jersey, in April 1945, at the request of the Surgeon General. Earlier activity was started under OSRD auspices.

This article in no sense reports a finished work. It is intended as an interim report only, to record the results of progress at this laboratory to date and to stimulate ideas for other methods of attack on this humanely important problem.

Specific performance requirements for a practical device agreeable to all are not easily defined. Tentatively, the following objectives have been set up: (1) to detect steps up and steps down; (2) to provide information sufficient to enable a person to follow a straight line such as that indicated by curbing or a wall; (3) to detect objects between 3 and 6 feet away with which a person may collide; (4) to provide information sufficient to enable a person to get a rough plan-position picture of his environment; (5) to accomplish the above with reasonable speed and reliability with a minimum of training and equipment, and a minimum of interference with the user's hearing.

It would appear in principle that a ranging device of suitable resolution in azimuth and elevation—in effect on extended cane—would provide the kinds of information required. Thus far virtually all the systems considered had as their objective the furnishing of information about the range of objects up to distances of about 30 feet, within a cone of a few degrees.

Choice of Techniques

A number of methods of attack were initiated simultaneously, using radio, supersonic, and photoelectric techniques. A photoelectric method has yielded the most promising results thus far, and the remainder of this article will be devoted to a description of a system whose first embodiment is now suitable for practical evaluation, and is undergoing test by blinded veteran personnel under technical supervision. This unit weighs nine pounds, and is the size of a large book. It is intended to be carried in the hand at the operator's side for convenience of aiming. Fundamentally, the device is a one-point-at-a-time, short-range range finder with a small earphone by means of which the user receives coded information about what the device sees.

Optical Triangulation Principle

The principle of operation may be understood by reference to Fig. 1. An incandescent tungsten lamp at the focus of a lens L_1 causes a narrow beam of light to be projected along the axis of the system (an image of the source being formed at infinity). If the beam is intercepted, the illuminated spot on the object serves as a secondary source which is imaged in the plane of lens L_2, and then illuminates the phototube. If the axes of lenses L_1 and L_2 are parallel, the locus

AID For The BLIND

An experimental photoelectric ranging device gives aural indication of the angle between a projected beam of light and the reflected beam from an obstacle. The angle depends upon distance to the object, which can be interpreted from a coded tone signal by the operator

of image-points corresponding to the range of object-points from infinity to some near point, *P*, will be along a line *Q-Q'*. For practical purposes this line may be satisfactorily approximated by a straight line nearly perpendicular to the axis of the receiver lens. The problem of ranging, then, is one of determining the position of the received image along the line *Q-Q'*.

The scheme adopted for accomplishing this is mechanically to interrupt the rays reflected from the object before these rays are received by the phototube. For the purpose of this interruption, a flat cone-shaped code disc of perforated metal, or a film of varying density, is rotated at a constant rate in front of the cell. The generatrix of the cone-shaped disc coincides with *Q-Q'*, and the cone is mounted with its axis parallel to the receiver lens. The signals created by the cell due to these interruptions form a code understandable to the trained operator of the device, and are transmitted to him by means of an earphone. By these means a wide variety of codes is possible. For purposes of illustration, Fig. 2A shows one which gives dot-dash signals, and Fig. 2B shows one which depends upon a rate of interruption. Thus, in the first case, the rays from a near object causes three closely spaced signals followed by a long pause for each revolution of the disc. As the object recedes, the image overlaps the next code signal, which is a dot and a dash, and the signal is three dots and a dot-dash. The relative amplitude of the two signals would depend upon whether the range corresponded more closely to the three dots or the dot-dash. With further increase in distance of the object, the signal would become just dot-dash, and so on.

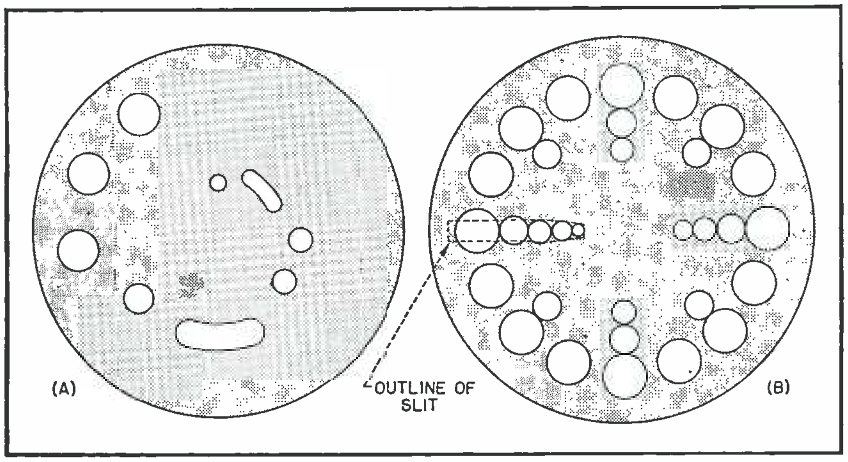


FIG. 2—Two experimental types of coding cone. That at (A) gives dot-dash signals, while that at (B) gives a low-frequency tone whose pitch depends upon distance to an obstruction

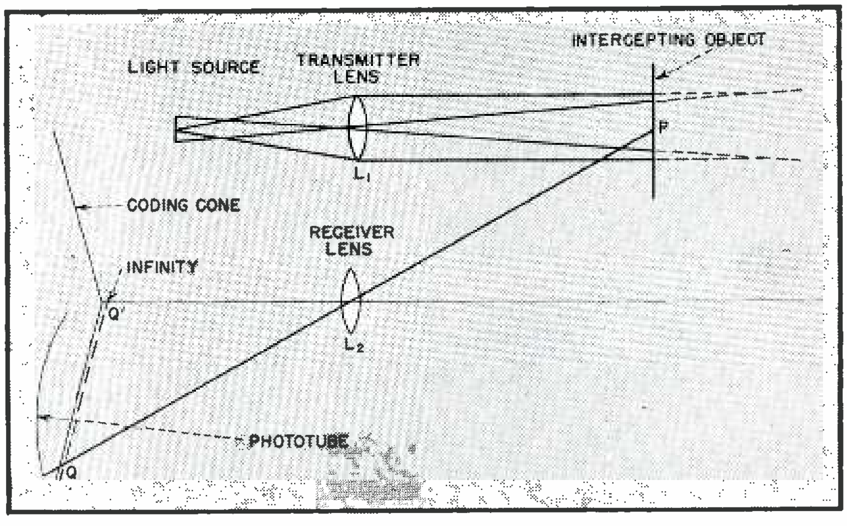


FIG. 1—Schematic diagram illustrating triangulation ranging principle. As the distance to the intercepting object becomes great, the reflected beam passes nearly straight through the axis of the receiver lens. A series of holes in the coding cone allows interpretation of the angle of intercepted light on the photocell

In the arrangement shown by Fig. 2B, the received rays would be interrupted at rates which increase in geometric steps as one progresses from the center of the cone to the edge (corresponding to large and small distances, respectively). When the image overlaps two rates, the higher rate will be effective, with alternate interruptions accented. In all cases the coding apertures increase in size with decreasing distance because of the increase in image size as the distance decreases.

Modulated Light Source

It is apparent that to distinguish the projected light from the ambient, it is necessary to modulate the former in some way. This is accom-

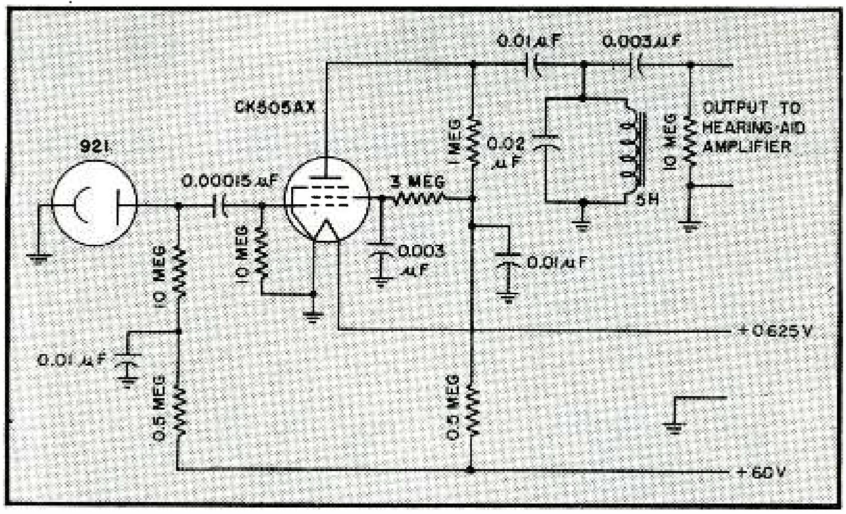


FIG. 3—Schematic wiring diagram of the phototube stage and the first stage of the amplifier. The output is fed into a slightly modified, conventional hearing-aid unit

plished by mechanically interrupting the light output of the transmitter by means of a rotating perforated disc, at the rate of 500 cps. The motor used to drive this disc is also used to drive the coding cone through a train of speed-reducing gears.

The received intelligence-bearing signal thus consists of 500-cps modulated light coded with dots or other characteristic indications. This is detected by a conventional photoemissive gas-filled phototube, and by an amplifier tuned to 500 cps. Presentation of the information is aural, using a standard air-conduction type hearing-aid receiver.

Design Considerations

In formulating a practical design, the principal considerations involved are the geometry of a device which will provide suitable minimum range and range increments, and the signal-noise ratio considerations, which determine such things as the maximum range and the weight of the power supply. With the arrangement provided in the first model of the device, using standard components, the minimum range is three feet. The specifications of transmitter and receiver optical systems follow. Transmitter lens: focal length, 1.5 in.; diameter, 1.0 in.; achromat. Receiver lens: focal length, 3 in.; diameter, 2.0 in.; achromat. Separation of axes: 5 in.

The light source is a 3-watt flashlight lamp with prefocused base. With this arrangement the distances corresponding to those for which the received images just fail to overlap are 3.5, 5, 7, 10, and 20 feet. Thus, pure signals would be produced from obstacle at these distances.

Signal-noise Calculations

The signal-noise ratio provided by the system may be calculated for the general case, if we assume a conventional emission-type phototube, and if we assume that in bright sunlight shot-noise due to steady background light illuminating the phototube is the limiting noise.

Thus, for an object at infinity

$$\frac{e_S}{e_N} = \frac{S_S\, W\, P_S\, D_R}{4d^2 \sin\theta}\sqrt{\frac{1}{e\,\Delta\, S_B\, B}} \times \left(1 - \frac{1}{\sqrt{1+(1/4f^2)}}\right) \qquad (1)$$

where e_S = rms signal voltage
e_N = rms shot-noise voltage
S_S = phototube light-to-current conversion factor for signal
W = candle power of source
D_R = diameter of receiver lens
ρ_S = reflectance of object for transmitted light
ρ_B = reflectance of object for background light
d = distance of object
θ = semi-angle of acceptance of receiver of objects at infinity
e = electron charge
Δ = amplifier bandwidth
S_B = Phototube light-to-current conversion factor for background
B = background brightness
f = f-value of transmitter lens

In deriving the above it has been assumed that optical losses are negligible, the projected light is chopped sinusoidally with no loss, and the obstacle intercepts the whole beam.

The values of the various parameters for the model are approximately as follows: f, 1.5; θ, 0.75 deg; W, 3 candles; Δ, 100 cps; D_R, 2 in.; S_S, 150 x 10^{-6} amp per lumen.

Assuming $S_S = S_B$, and $d = 30$ feet, we have

$$\frac{e_S}{e_N} = 2\,\rho_S/\sqrt{B} \times 10^3 \qquad (2)$$

From the definition of the various photometric quantities we have

$$B = I\,\rho_B/\pi \qquad (3)$$

where I is the ambient illumination. Combining Eq. 2 and 3 and assuming $\rho_S = \rho_B = \rho$ gives

$$e_S/e_N = 2\sqrt{\pi\rho/I} \times 10^3 \qquad (4)$$

For temperate latitudes at noon, I = 10,000 foot-candles, giving

$$e_S/e_N = 35\sqrt{\rho} \qquad (5)$$

A system with the design parameters given should then be capable of providing an intelligible signal over a reasonably wide variety of conditions of distance, ambient illumination, and reflectivity.

Interference from External Light Sources

In the foregoing only fundamental statistical noise has been considered. There are in addition extraneous light signals which may be picked up that mar intelligibility, most important among these being 120-cps signals due to artificial light sources, and noise due to modulation of ambient light by the coding cone.

Both of these may be dealt with satisfactorily by choosing a sufficiently high modulating frequency for the transmitter and tuning the receiver amplifier sharply about that frequency, with special attention to keeping the low-frequency gain as small as possible. Despite these measures, 120-cps signals are audible if a source of a-c light is imaged on the coding cone. But this is relatively improbable chance, and in any case provides useful information. Signals of this frequency due to indirect illumination are effectively filtered out, however.

The coding has been designed so that signals generated by the coding cone shall have a minimum of high-frequency components. In the present model this is accomplished by having the minimum number of code symbols at relatively slow speed of rotation (1 to 2 per second), and by shaping the cone apertures so that there are no abrupt changes in phototube illumination as the disc rotates. Low-frequency noises, audible as "plop-plop", due to modulation of light from backgrounds of high brightness by the coding cone, can be heard from the sky under certain conditions. It should be possible to reduce or eliminate these by more effective low-frequency filtering, or by placing the receiver above the transmitter, so that the former will almost always be illuminated by points below the horizon.

To keep the d-c illumination on the phototube to a minimum, the coding cone is backed by a slit which lies along the line Q-Q'. To provide the maximum signal, the width of the slit should be the same as the diameter of the received image. This would make it closely a triangle, whose vertex corresponded to infinity. However, troublesome modulation of ambient light is due primarily to the code signals corresponding to the closer range, because of the large size of the corresponding apertures. Since signals at the close ranges are usually of more than adequate amplitude, the slit has, in fact, been made of constant width for about half its length, as shown in Fig. 2B.

Circuit Characteristics

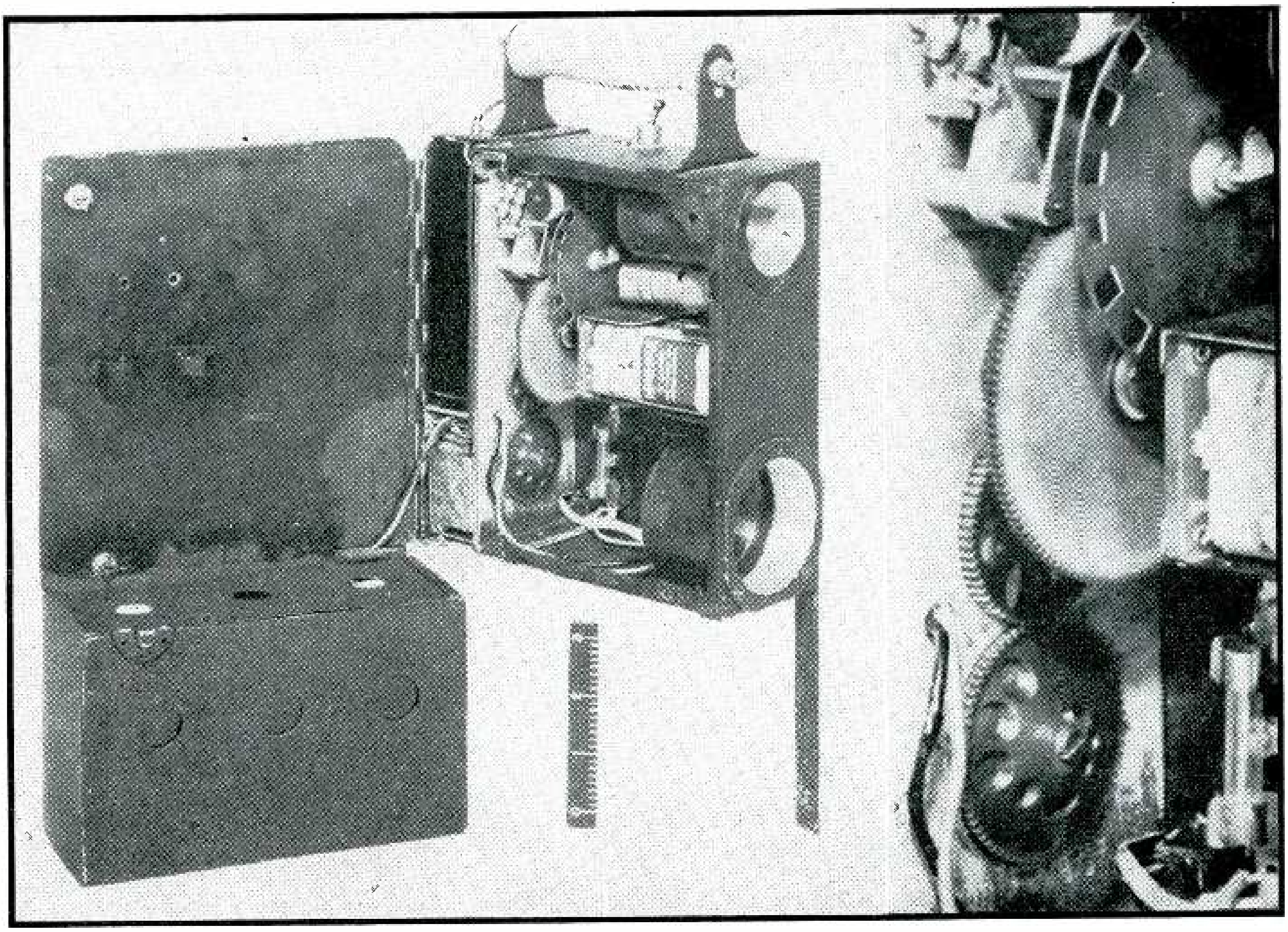
The amplifier in the first model consists of four stages in cascade, with an overall voltage gain of 95 db. Hearing-aid tubes and components are used throughout. The schematic wiring diagram of the phototube and first amplifier stage is given in Fig. 3. Most of the frequency discrimination is provided by the tuned circuit in the plate of the first stage to prevent early overloading by low-frequency ambient signals. The inductor used has a Q of approximately 9 at 500 cps. This part of the circuit alone provides a 6-db drop in gain at approximately 50 cps plus or minus the frequency of maximum gain. The remainder of the amplifier is a commercial hearing-aid unit modified to peak at 500 cps. It uses RC filtering only, and provides relatively little useful frequency discrimination except at the lowest frequencies.

Mechanical Problems

Close attention must be paid in design of the electronic parts to minimize mechanical, electrical, and magnetic coupling between them and the motor. A motor having good speed stability is also essential if maximum advantage is to be obtained from the narrow band width of the receiver. A completely satisfactory motor has not yet been obtained.

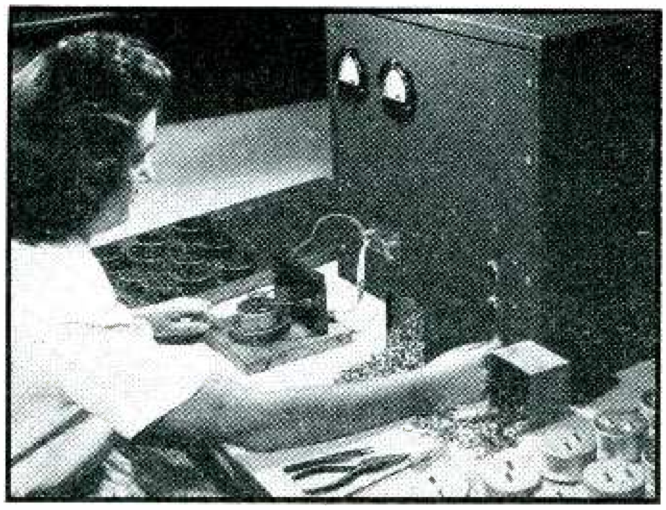
Acknowledgments

Invaluable assistance in the design and construction of the first test model has been provided by Messrs. N. L. Heikes, E. Blutman, A. Gray, and E. Wiler of the Signal Corps Engineering Laboratories.

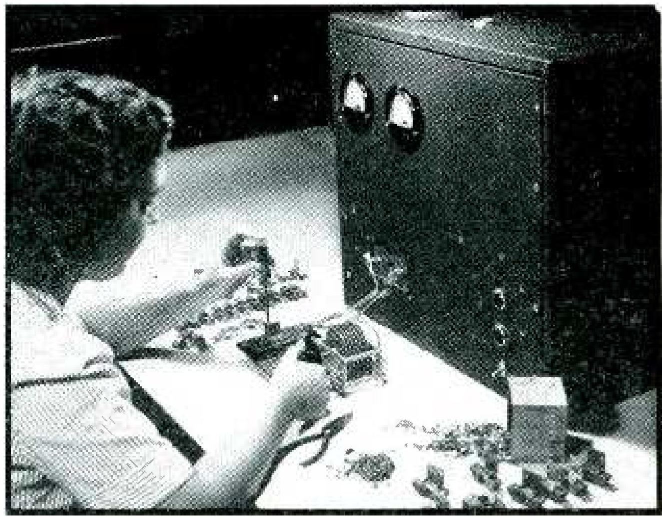


Interior view of the sensory aid. The battery which runs the driving motor is contained in the compartment at the lower left. The enlarged detail to the right shows the gear train driving the coding cone (lowest toothed wheel) and the 500-cps chopper modulator (at top with square apertures)

R-F Soldering of



R-f soldering of feed-through insulators to back of meter case



R-f soldering of pole faces to Alnico magnets of meter movements

THE PRODUCTION of solder-sealed meters capable of withstanding 25-inch vacuum tests involves a number of critical soldering operations. The edge-metallized glass window and the glass-insulated feed-through terminals must be uniformly and cleanly soldered to the steel case of the instrument, with no pinholes or flux inclusions. Ordinary techniques involving soldering irons or torches did not heat the entire required area at a uniform rate, left a rough, unfinished appearance, and required a long time-cycle for each operation.

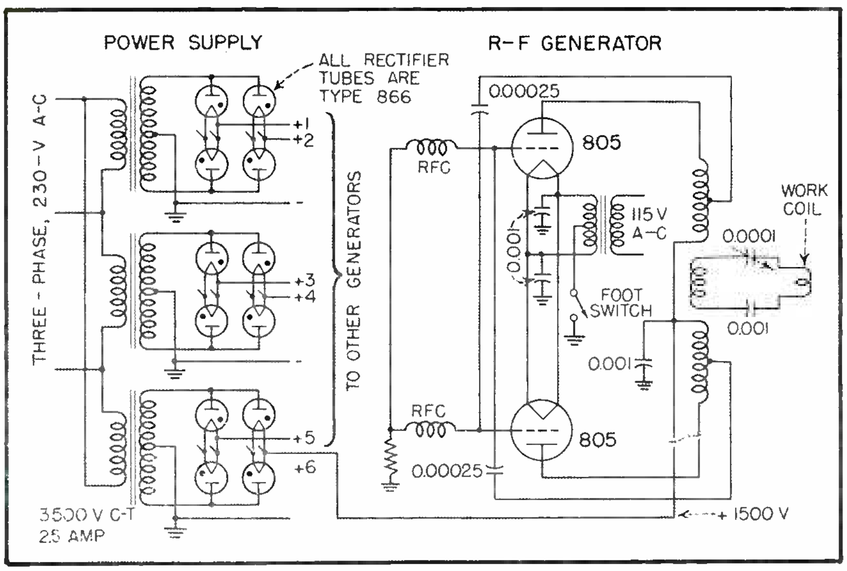
Bearing in mind that a number of stations or fixtures were required to handle the different operations, and considering the safety factors involved, it was decided to build a number of low-power r-f generators that could be plugged into high-voltage d-c outlets scattered throughout the plant and fed from a master d-c power supply.

Placing the power equipment in a remote section of the plant, on a shelf near the ceiling where a ladder was required for access, minimized the danger of accidents to personnel operating the units and prevented unauthorized persons from tampering with the power supply.

Design of R-F Generators

The r-f generators were mounted on the benches in standard table rack cabinets, with a heavy cable running from each to a foot switch that is mounted on the floor and used to turn the generator on and off. The foot switch is connected in the filament center-tap lead of the generator and provides effective keying, as the plates are continually energized.

The generator itself is a simple push-pull oscillator using type 805 tubes operated somewhat below their maximum rating to insure stability. In most applications the generator is



Circuit of remotely located 1,500-volt d-c power supply and one of the r-f generators used at bench locations. No filtering is required in the power pack, which has six independent output lines. Generators having small loads may be paralleled on one line, so that the power pack can handle ten or more units simultaneously under some operating conditions. Automatic timers prevent closing of power pack plate circuits until the rectifier filaments are heated

Metal-to-Glass Seals

High-voltage d-c power from a remotely located bank of full-wave rectifiers is run to outlets throughout the plant, for energizing up to ten r-f generators used in soldering glass windows and feed-through terminals to cases of hermetically sealed meters by electronic heating

By R. A. AMMON

General Manager
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Manchester, New Hampshire

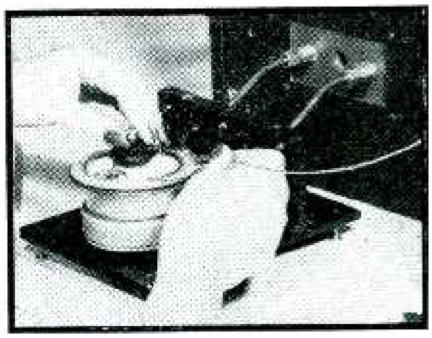
tuned to about 30 mc. The output circuits are designed to resonate the work coil and keep the r-f voltage on the coil at a minimum. In the standard r-f soldering unit, it is possible for the operator to place her hand directly on the work coil while an instrument is being sealed, without receiving an r-f burn. This electronic soldering system is actually safer than an ordinary soldering iron from the standpoint of burns.

By shunting work coils with high-voltage mica capacitors that bring them all to the same resonant frequency when the load is in place, all fixtures can be interchanged by the operator or foreman without disturbing the generator or affecting tuning.

Soldering Pole Pieces

Previously, the mounting of pole pieces on Alnico magnets for meters by a resistance soldering method left the parts badly oxidized at the points of contact, and left solder runs and excess flux scattered over the work. This method also required a multiplicity of fixtures for locking the work while the solder joint cooled.

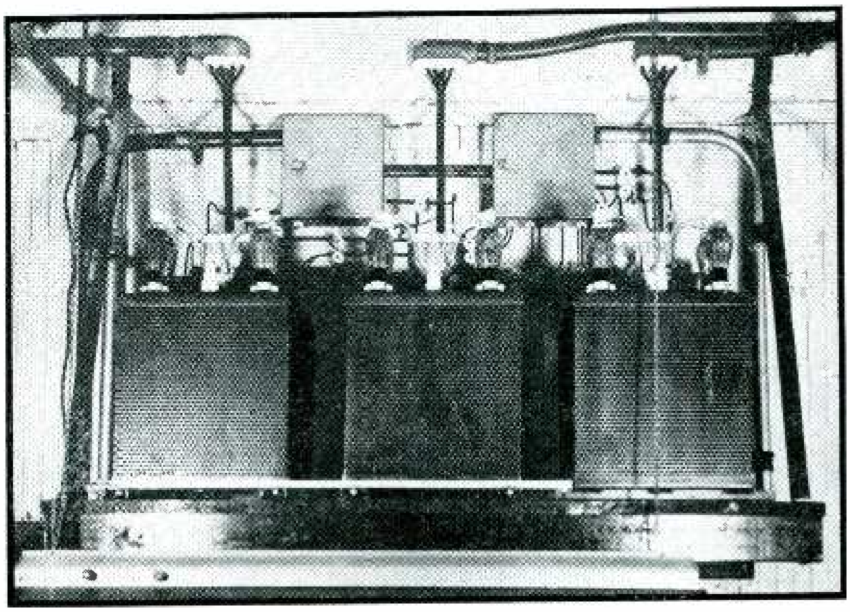
By adapting a special fixture to one of the standard r-f generators, it was possible to eliminate these troubles. Holding fixtures were no longer needed, and the finished piece cooled quickly enough to permit almost instant ejection. The r-f method thus reduced fabricating cost on magnet assemblies considerably and permitted sending them directly from the induction soldering machine to the electroplating department without further finishing or cleaning. Production capacity was doubled for this particular operation, and the appearance of the finished product considerably improved.



R-f soldering of metallized edge of glass window to case of meter, using a single-turn flattened work coil

Each new application of r-f soldering seems to suggest another use. As one example, special fixtures for soldering metallized glass jewel bearings in position on the frame of the meter are now being set up. Only a small part of the available power will be used for this operation.

With appropriately designed fixtures, heating at high frequencies can be localized to such a definite degree that solder-flow patterns can be predicted and damage to adjacent parts eliminated. Thus, in soldering glass windows to meter cases the r-f soldering equipment heats only the rim of the case in the immediate vicinity of the metallized edge of the glass, leaving the glass, the rest of the case, and the instrument inside quite cool.



Master power supply, using twelve type 866 mercury-vapor rectifier tubes to supply 1,500 volts d-c to as many as ten r-f generators scattered throughout the plant

Gaseous Discharge Tubes

AND APPLICATIONS

Details and operating circuits of a new crater-type modulator glow lamp for facsimile service, of the basic strobotron tube for stroboscopic applications, and of new high-intensity strobotrons used as light sources in high-speed photography

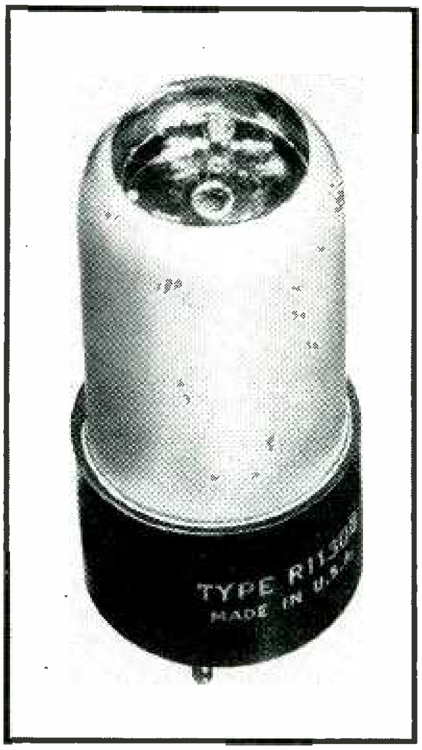


FIG. 1—New modulator glow lamp for facsimile equipment

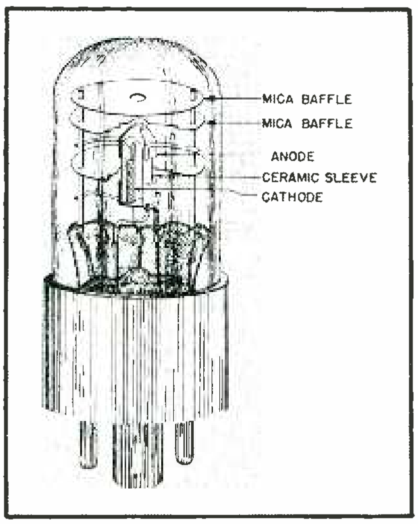


FIG. 2—Construction of modulator glow lamp. Crater forms inside hollow cathode

By R. C. HILLIARD

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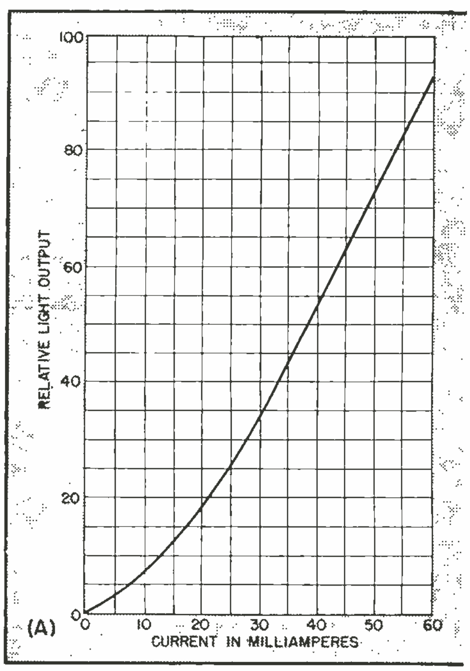
WARTIME EXIGENCIES, while in some cases forcing the standardization of electron tube production to basic types, stimulated design and development of new types to meet tactical and strategic requirements. As one example, facsimile transmission was recognized by military agencies as highly desirable. Existing equipment, however, though capable of high-quality results, lacked the ruggedness and portability required in field equipment. One of the most serious difficulties was the lack of a facsimile recording element for service applications. The extreme severity of the military requirements finally led to the development of the modulator glow lamp, a sturdy crater-type lamp having a long service life.

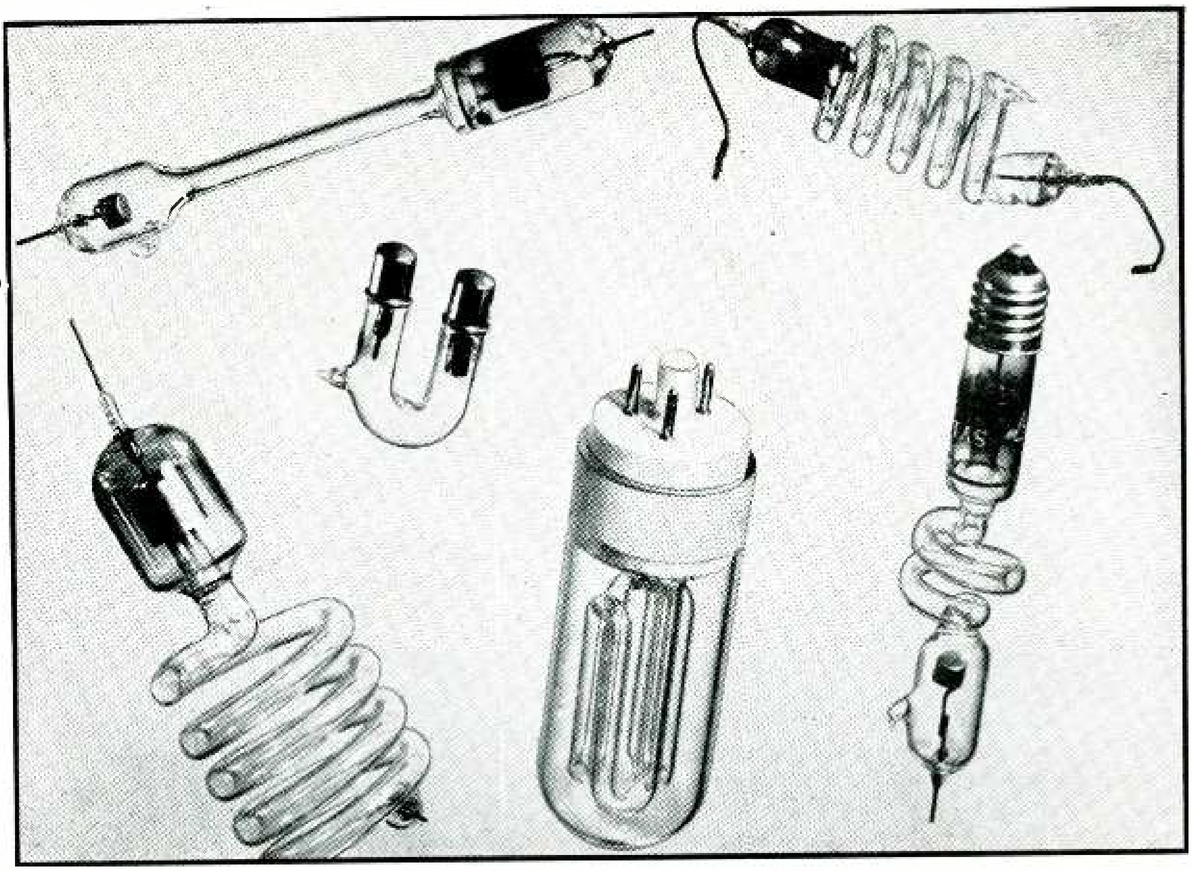
Other military requirements similarly led to the development of new high-intensity strobotrons for flash photography. All add to the complement of gaseous discharge tubes now available for industrial and communications applications.

Modulator Glow Lamp

A crater lamp in its simplest form is a glow discharge tube with a hollow cathode. By virtue of high ionization density and the fact that the discharge is viewed in depth, a high effective intensity is obtained. Previous types, which had been applied to sound-on-film recording and elementary mechanical television systems, were lacking in the required intensity, stability and useful life.

A new attack on the problem from a fresh viewpoint was necessary. The resulting lamp, unlike the usual glow lamps, depends upon a two-fold effect wherein the ionization of the gas results in the excitation of the cathode material. This lamp is shown in Fig. 1 and the construction in Fig. 2. The base is of the standard octal type. The bulb is selected for mini-





Examples of externally-excited gaseous discharge tubes

mum distortion at the end as this portion of the bulb lies in the optical path. The mica baffles effectively reduce blackening of the lamp end due to sputtering.

In a typical facsimile receiving system the lamp crater is focused through a baffle with a sharp rectangular opening. The image of this opening is focused by the optical system so as to give a spot at the sensitized surface 0.0072 inch high and 0.0104 inch wide on a 2.75-inch diameter drum carrying the sensitized material. In practice, the drum rotation is 90 rpm and the horizontal scanning movement is 0.0104 inch per revolution.

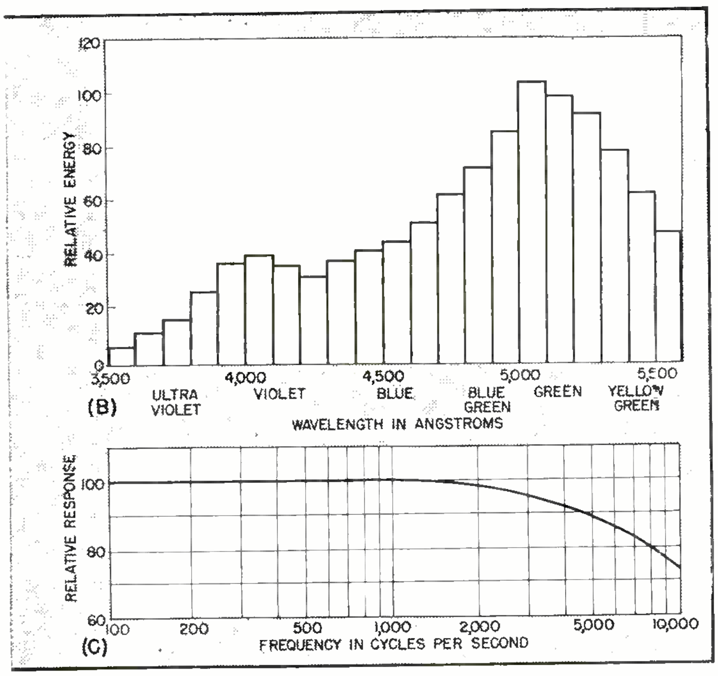


FIG. 3—Performance curves of new modulator glow lamp, showing (A) the average light response, (B) typical wavelength spectrum, and (C) average frequency response

The curves in Fig. 3 give an overall idea of the performance to be expected. Thus, Fig. 3A shows how the light output varies with the tube current, Fig. 3B shows the spectrum of the output, and Fig. 3C shows how the modulating frequency affects the output for a constant tube current. The spectral response is reasonably peaked for recording purposes, insofar as is compatible with other design considerations.

Elementary single-ended and push-pull output circuits are shown in Fig. 4. The degenerative action of the amplifier tube provides a circuit in which the current through the lamp varies linearly with signal voltage regardless of variations in lamp impedance.

Characteristics of the modulator glow lamp are such that its adaption to portable sound-on-film recording systems naturally follows where ruggedness must accompany high-quality performance. Applications considered cover oscillograph timing markers, stroboscopic devices, seismic recorders, photoelectric counters, and other instruments where a high-intensity modulated point source of light is required.

Strobotrons

Although the strobotron is not a tube in the strictest sense, the implications of its special properties merit a brief review of its characteristics. The type 1D21/631P1 neon-filled strobotron shown in Fig. 5 was designed principally as a medium-intensity light source for stroboscopic applications.[1, 2] This type of tube and the high-intensity strobotrons described later were developed by Edgerton, Germeshausen, and Grier at the Massachusetts Institute of Technology. The ability of the tube to pass extremely high peak anode currents of short duration led to its use as a control device in connection with many special electronic circuit applications.[3]

Figure 6 gives the basic circuit of a commercial stroboscopic test device developed by the General Radio Company, employing a strobotron light source driven by a multivibrator. The oscillation frequency is varied by changing the grid bias voltage of the 6N7 by means of potentiometer *R*. The output signal of the multivibrator at the grid of the strobotron is in the form of a sharp negative pulse. This insures that the time interval between strobotron flashes will be substantially independent of variations which may occur in circuit or tube constants.

The 1D21/631P1 is essentially a double-grid cold-cathode gaseous discharge tube capable of peak anode currents as high as 300 to 400 amperes under favorable duty cycle conditions. The components are a cathode, an inner grid, an outer grid and an anode. All leads are brought out to the terminals of a standard 4-pin base. The cathode, which is composed of powered metal and a compound of caesium, is shielded from the discharge by a ceramic disc.

The inner grid is a wire probe and the outer grid is a graphite ring to which a wire probe is also attached. Graphite is used because the breakdown voltage between the outer grid and the anode will be less affected should some of the caesium from the cathode be deposited on the outer grid. The use of caesium for the active cathode material is dictated by the necessity for a rapid breakdown of the cathode surface under bombardment to form a cathode spot facilitating the formation of an intense arc rather than a glow discharge.

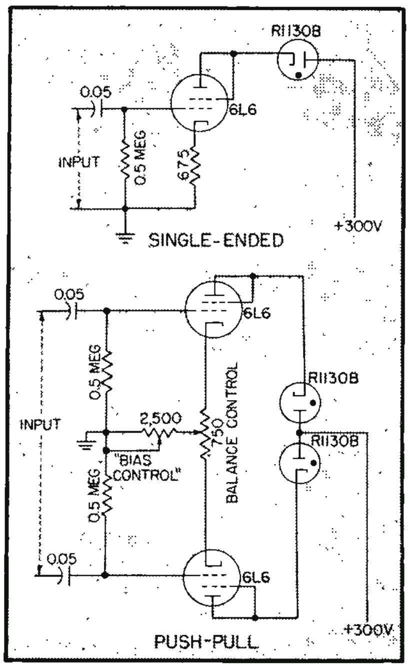


FIG. 4—Typical output circuits for driving the new type R1130B modulator glow lamps

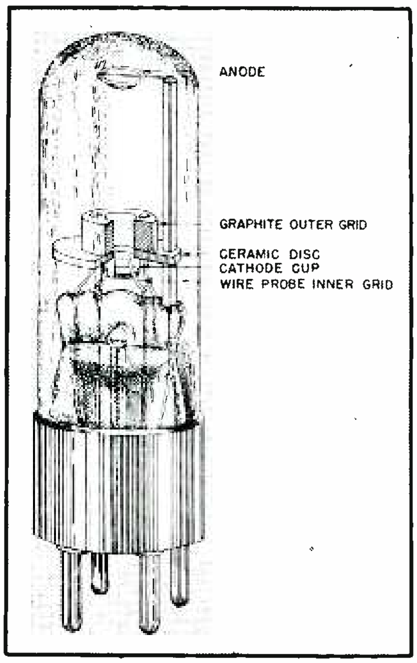


FIG. 5—Construction of type 1D21/631P1 neon-filled strobotron

Control Characteristics

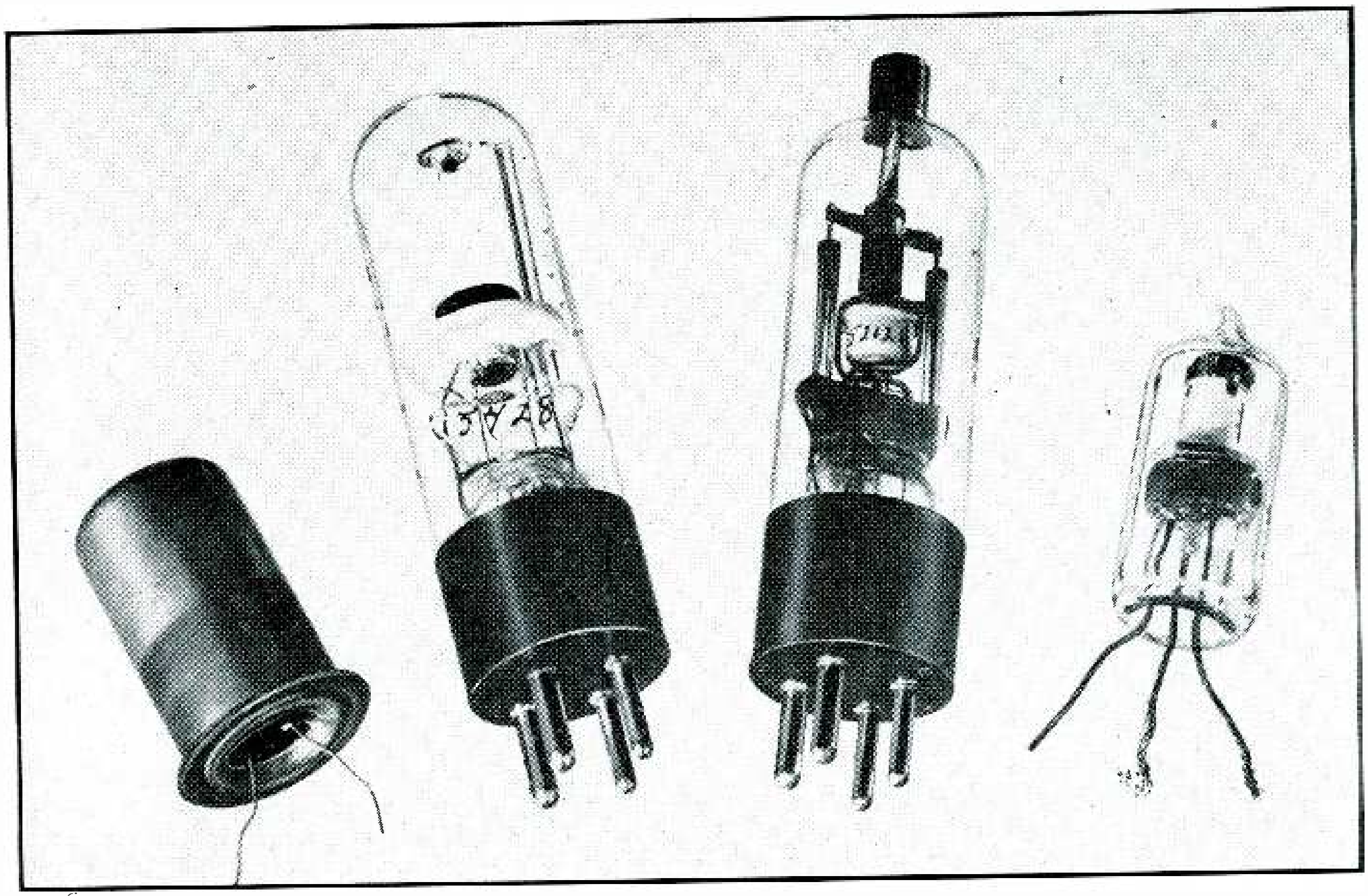
In Fig. 7, the control characteristics of the 1D21/631P1 are given for three values of anode voltage. For a given anode voltage, as long as the vector sum of the two grid voltages falls within the closed loop, the tube will not fire. Any increase or decrease in one or both of the grid voltages which causes their vector sum to fall outside the closed loop will result in breakdown of the tube. It has been found that such control curves vary during the life of the tube and hence are not included as characteristic curves. This is due to the fact that during discharge a portion of the cathode material may be evaporated and deposited on either or both of the control grids, thus altering the control characteristics for subsequent operation. If extreme stability of operation is required, the tube may be fired by means of subsidiary apparatus which provides a steep pulse of sufficient amplitude (about 150 volts peak), as in the circuit of Fig. 6.

Effect of Reverse Current

The impedance and, in consequence, the voltage drop through the tube are low and care should be taken in design of operating circuits to avoid any tendency toward reverse current, causing the anode to assume the role of cathode during a part of the discharge cycle. This can result in anode sputtering with attendant blackening of the envelope and some cleanup of gas. The inductance of long leads from the discharge capacitor might be sufficiently high to result in voltage backswing and inversion. Shortening the leads and introducing sufficient resistance to provide critical damping of the circuit will usually avoid complications.

Cathode Spot Formation

A peak cathode current of approximately five amperes is necessary for formation of the cathode spot and the resulting brilliant arc-type discharge. Best results for high-current operation are to be expected when the circuit constants are proportioned to give peak cathode currents of from 10 to 200 amperes, at an average anode current of 50 ma or



Special types of gaseous discharge tubes, used in various applications for generating short-duration pulses having extremely high peak current

less. The plate voltage should not exceed 350 volts d-c. Repetition rates up to 250 pulses per second may be reached with some deterioration in life at the higher values.

The tube can also be operated under conditions of glow discharge without the formation of the characteristic cathode spot. Under these conditions the tube can be used as a control device when high peak currents are not required.

Other tubes of this type have been developed for special features of operation, such as high hold-off voltage (2 kv), higher repetition rate (to 1000 pps), low time-jitter, and high light output. These include tubes for the newly publicized electronic ignition systems[4], welding control[3], ignitron control, and rectifier circuits—in fact, wherever a device for generating short-duration pulses of extremely high peak current is required.

The 1D21/631P1 strobotron has a light output sufficient only for visual observations close to the subject. For photographic analysis of motion and for single photographs of extremely short exposure, special types of discharge tubes have been developed with high light output and short flash-duration. The 1B61, developed for use as a high-intensity stroboscopic source of light, is typical of a series of externally-excited discharge tubes, operated in a circuit arrangement as shown in Fig. 8.

With proper choice of circuit components, this tube may be operated for short periods at flash rates up to 100 pps. By inserting an ignition transformer between the cathode of the 1D21/631P1 and ground in the circuit of Fig. 6, a convenient means of triggering is provided. Note that the 1D21 is here being employed as an electronic switch rather than as a light source. The capacitor in this circuit is discharged through the 1D21 and the primary of a small ignition coil transformer. The secondary high-voltage terminal is connected to an external electrode which may consist of a single turn of wire

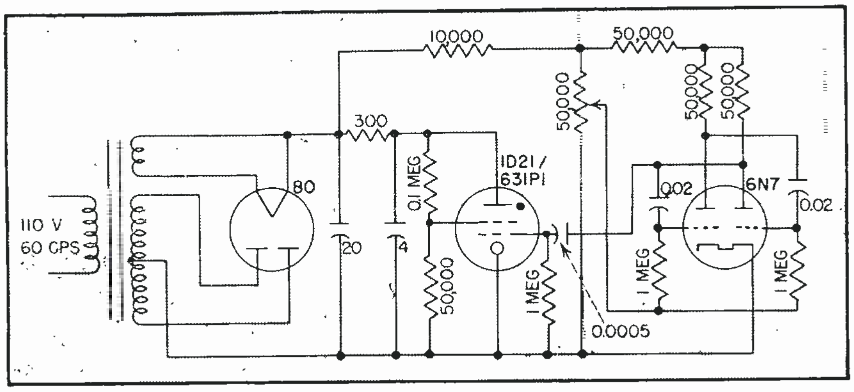


FIG. 6—Stroboscope circuit employing type 1D21/631P1 strobotron

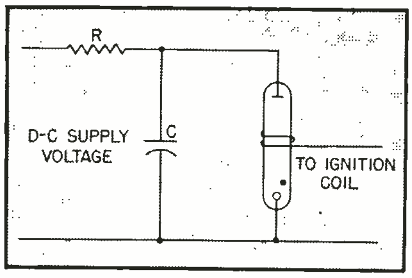
wrapped around the 1B61. When the trigger tube fires, the high-voltage field of the secondary initiates the discharge and an intense arc then results in the discharge tube.

These tubes are characterized by low-impedance conduction paths, ranging from one to three ohms depending on the circuit, nature of the gas used, the pressure filling, the geometry of the tube, and the cathode structure. The cathode structure is similar to that of the strobotron, permitting rapid transfer from a glow to an arc type of discharge. The cathodes of these tubes are formed from mixtures or alloys of metals, one or several of which have a low work function. Upon the initiation of the gas discharge a hot-spot, similar to that formed on the mercury pool in ignitrons and mercury pool rectifiers, results, with a corresponding decrease in the cathode drop. A larger proportion of the capacitor energy appears in the arc or positive column discharge and higher efficiency results. A wide variety of types is possible because the kind and pressure of gas used determine such factors as the equivalent color temperature and voltage hold-off. A tube designed for stroboscopic purposes has entirely different characteristics from one designed for high-speed color photography or for the photography of projectiles in flight.

High-Speed Photography

There seems to be some misconception as to the time-intensity characteristics of high-speed flash circuits for photographic purposes. The figure 1/30,000th second has recurred in the popular photographic press, but there is nothing inherent in the discharge itself which fixes the duration at that particular value. For a given tube the actual time of discharge varies almost in direct proportion to the value of capacitance used. Oscillographic measurements show, however, that for ordinary equipment the flash duration is of the order of 300 microseconds or 1/3,000th second. With a careful choice of components and circuit layout, a 1/10,000th-second exposure is readily obtainable. With tubes designed for the purpose and with extremely careful attention paid to details of construction and design, exposures of one microsecond are obtainable, and durations of from three to five microseconds are obtained with standard production tubes designed for short-duration characteristics.

FIG. 8—Circuit arrangement used with externally-excited discharge tubes



Discharge Circuit Design

It may be well to consider here the energy absorbed by a gaseous discharge tube under various conditions of design. As an elementary approximation the equivalent circuit of the discharge tube may be represented as in Fig. 9, where R_L *is* the dynamic arc resistance in the operating range and E_c is the extinction voltage. The value of R_L will in general vary during the discharge.[1]

As the following development shows, even a small amount of effective dynamic arc resistance can, in normal circuits, greatly increase the energy appearing in the tube. In general, under the gaseous discharge conditions for maximum illumination, the more energy that is expended in the tube, the greater will be the luminous output.

If the tube has no dynamic or effective resistance during the discharge, the energy dissipated in the tube is accurately expressed as the product of the tube drop and the total charge which has passed through it.

From the fundamental relations between capacitance, voltage, charge, and energy it can readily be shown that in a nonoscillatory circuit the percentage of energy appearing in the tube with respect to the energy liberated by the capacitor during the discharge can be expressed conveniently as

$$100\left(\frac{2E_2}{E_1+E_2}\right) \qquad (1)$$

where E_1 is the initial and E_2 the final capacitor voltage. In the case of a tube used for illumination purposes this expression can be considered as its electrical efficiency.

If the experimentally justified assumption is made that the dynamic arc resistance of the tube can be replaced by an effective linear resistance R_L, then the percentage of

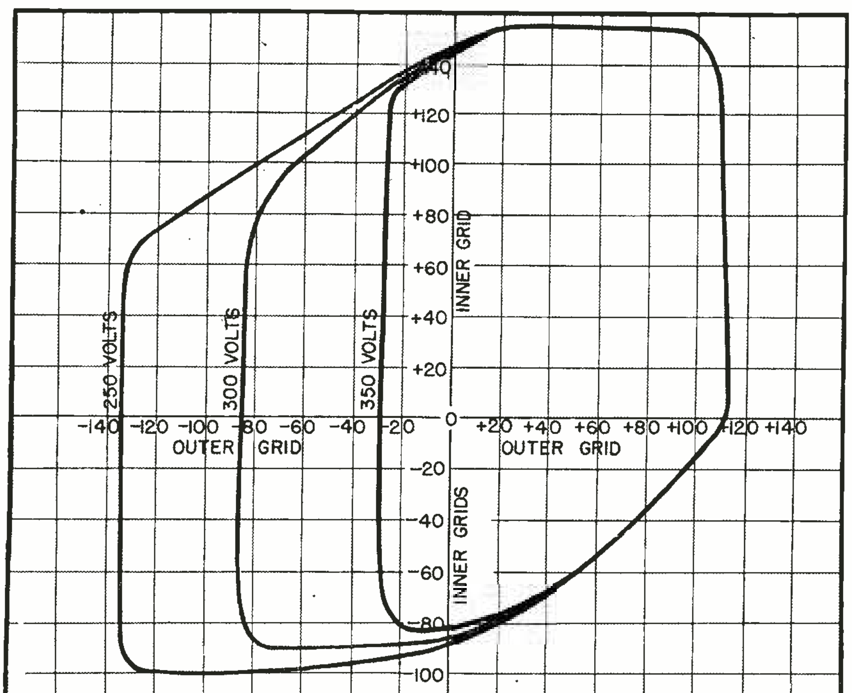


FIG. 7—Control characteristics of 1D21/631P1 strobotron

energy appearing in the tube is found to be

$$EFF = 100\left[1 - \left(\frac{R_C}{R_L + R_C}\right)\left(\frac{E_1 - E_2}{E_1 + E_2}\right)\right] \quad (2)$$

where R_L is the effective arc resistance and R_C is the external resistance.

A substitution of the nominal values of 20 volts for E_2, 300 volts for E_1, and 0 ohms for R_L yields an efficiency of 12.5 percent. If, however, a nominal value of 0.1 ohm is substituted for arc resistance, with a typical circuit resistance of 0.01 ohm the electrical efficiency becomes 92.1 percent.

Unlike a power transfer problem where the impedance of the load is preferably matched to the generator, the case of efficient energy transfer calls for a definite mismatch. With favorable circuit conditions and tube design, an arc resistance of several ohms may result in high efficiency from a lamp standpoint. A tube for electronic switching purposes would of course be designed for minimum internal impedance.

So far nothing has been said about the method of charging the discharge capacitor, but Fig. 8 includes a conventional arrangement. The choice of charging resistor is ultimately determined by either the deionization time of the discharge tube, its minimum arc-sustaining current, or the maximum drain that the power supply is capable of handling.

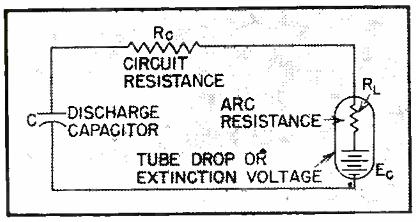


FIG. 9—Equivalent circuit of a gaseous discharge tube

It is usually sufficient, however, to set the time constant of the charging resistor and discharge capacitor at one-fourth of the time interval between discharges (switching period) for the maximum repetition rate. Under that condition the capacitor will recharge to within two percent of the supply voltage if the supply is sufficiently well regulated, and the maximum theoretical charging efficiency of 50 percent will be closely approximated by the circuit.

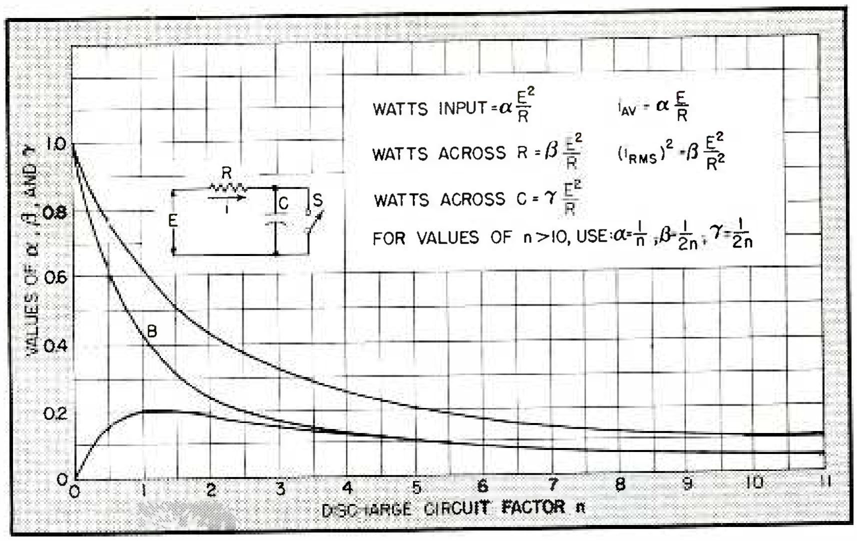


FIG. 10—Chart for determining power ratings of charging circuit components used in connection with a gaseous discharge tube

The power ratings of the charging circuit components are calculated without much difficulty, but because such calculations are made repeatedly and involve the evaluation of exponentials, a reduction to the graphical form of Fig. 10 is more convenient. To use this graph, we first incorporate the circuit data in the formula $n = 1/PRC$, where P is repetition rate in pps, R is charging resistance in ohms, and C is discharge capacitance in farads. The circuit data figure n is the abscissa of the plot. We then pick off the corresponding values of the auxiliary calculation functions α, β, and γ from the graph. The total power drain on the power supply is then simply $\alpha E^2/R$, where E is the supply voltage and R the charging resistance in ohms as before. The power dissipated in the resistor is $\beta E^2/R$, and that supplied to the capacitor and then dissipated in the discharge circuit is $\gamma E^2/R$.

Thus, to show an example, if we have a 350-volt power supply, a 2-μf capacitor, a 5,000-ohm charging resistor, and a 40-pps repetition rate, the circuit data figure is $n = 1/PRC = 1/40 \times 5 \times 10^3 \times 2 \times 10^{-6} = 2.5$. From the graph we find $\alpha = 0.38$, $\beta = 0.20$, and $\gamma = 0.18$. The total power taken from the supply is 9.3 watts, the power lost in the charging resistor is 4.9 watts, and that utilized in the discharge circuit is 4.4 watts. The last two values add to give that of the total power, as they should. The supply will have to furnish 27 milliamperes current.

In applications where power or energy are at a premium, it is practical to substitute a choke in series with a diode in lieu of the charging resistor. In that case, the capacitor voltage reaches a value approximately twice that of the supply voltage on the second discharge and remains at that voltage provided there is no leakage present.

If discharges are to take place at a fixed or slowly varying repetition rate it is possible to eliminate the diode and adjust the LC combination for a resonant frequency one half that of the lowest repetition rate desired.

For any of the above circuits, power supply regulation will affect the behavior of charging characteristics but is seldom a serious problem.

In place of a simple discharge capacitor a wide variety of RLC combinations can be used to develop pulses of an equally wide variety of shapes. The field of application of cold-cathode gas discharge tubes is expected to expand due to the simplicity and flexibility of the associated circuits.

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ELECTRONIC RUBBER PREHEATER

Wartime tank-tread manufacturing equipment is converted to peacetime job preheating wringer rolls and automotive products, saving as much as 60 percent curing time

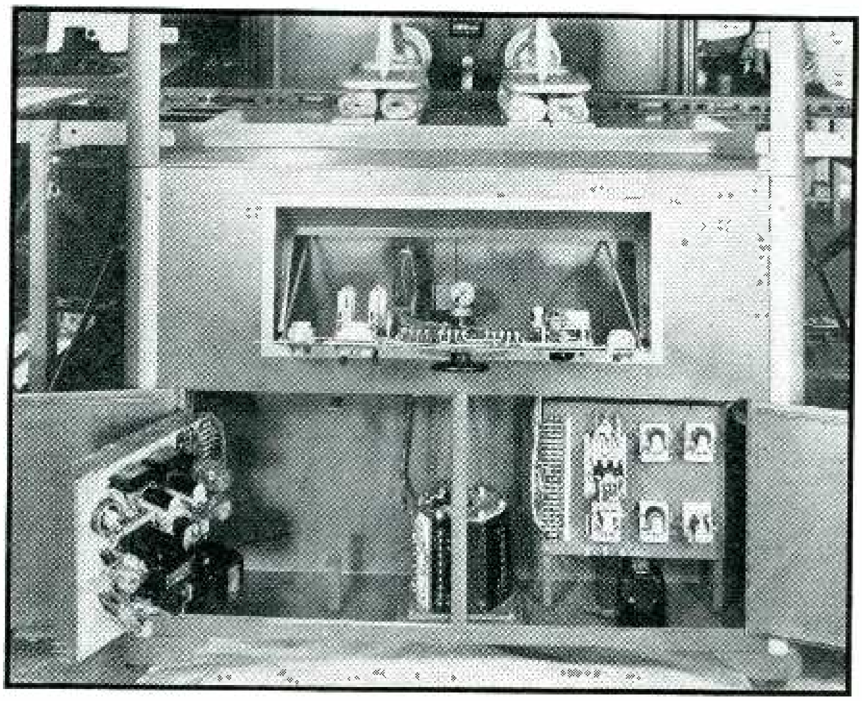

FIG. 1—Relays and controls of the rubber preheater are accessible from the front by dropping the hinged panels as shown

HIGH-FREQUENCY HEATING of plastic and rubber compounds received great impetus during the war under the unprecedented demands for production. For example, a typical problem involved the use of specialized high-frequency heating equipment to make more effective use of molding presses used in producing treads for the medium and heavy tanks of the U. S. Army. This problem was solved satisfactorily by making a complete generator for producing the heat and a conveyor system for bringing the work to the heating unit.

Upon cessation of hostilities it became equally important to convert existing equipment to civilian manufacture and to supply new machines for preheating the large quantities of molded plastic and rubber materials required for peacetime consumption.

Dielectric heating equipment for either war or peace was required to meet the following specifications:

(1) The equipment had to be fully automatic for operation by unskilled labor, with a minimum training period.

(2) The generator was to have a 20-kw high-frequency (27 mc) output, which would process 34 pounds of material during a 1½-minute heating cycle.

(3) The generator had to adjust itself automatically to compensate for various changes in the load, regardless of whether they were due to changes in physical properties as a function of temperature, or to changes in the dimensions of the load. It was necessary that constant power be supplied to the work under all conditions.

(4) The generator had to be completely self-contained together with a suitable conveyor which would bring the material to the heater electrodes and, after heating, deliver the work to the molding presses. The operation of the conveyor system had to be synchronized with the heating cycle of the generator.

(5) The entire unit was required to be absolutely fool-proof and the operator fully protected against electrical hazards.

(6) All parts had to be readily accessible, as shown in Fig. 1, so that in case of trouble the unit could be quickly and easily serviced.

(7) As would be expected, the production requirement called for a continuous operation of three eight-hour shifts daily, six days per week, or a total work week of 144 hours.

Design

A 20-kw high-frequency heating unit was selected for the project and, with a few changes, adapted to work with the conveyor. Figure 2 shows a view of the installation, with the generator unit in the back center, the work table with the electrodes and controls in the front center, and the conveyor system running through the work table.

The tank-track preforms were placed on the conveyor and, supported by guides of non-metallic material, were conveyed to the generator electrodes. When the work came to the correct position under the electrodes for preheating, a sensitive switch stopped the conveyor. Power was then applied automatically and within 1½ minutes the 34 pounds of

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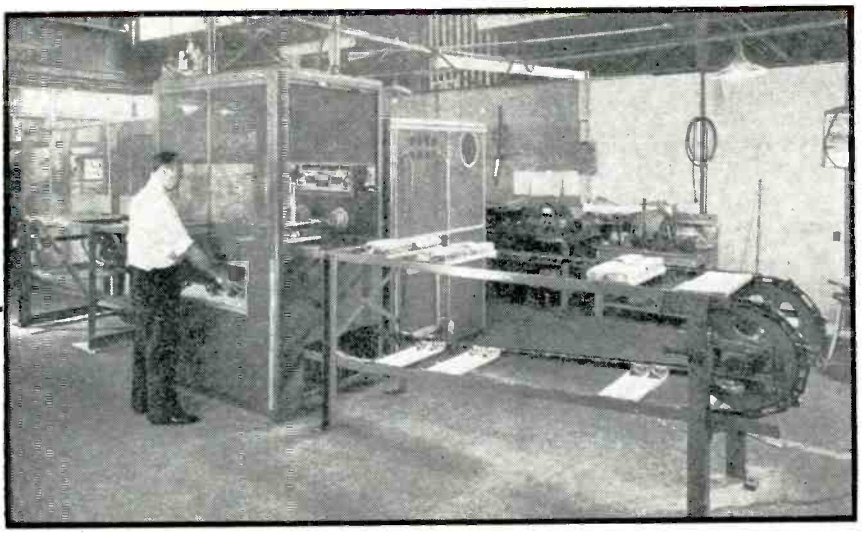

Various safety precautions and automatic operation, except for starting and stopping, made it possible to use unskilled labor

rubber was preheated throughout to nearly curing temperature. After being heated the material continued on to the press operator where metal inserts were placed in the hot preforms. Finally, the assembly was cured in the steam platen presses, the total time being a fraction of that normally required to process the pieces without the aid of high-frequency dielectric preheating.

Electronic preheating combined with the automatic conveying system not only increased the production of tank treads but, as was expected from the preliminary tests on samples, gave a product of considerably better wearing quality.

Rematching

A contributing factor to the good performance was a rematching feature described previously.[1] In this case the principle was used to provide a constant 20-kw power output. In view of the detailed description contained in the reference, it will be sufficient merely to recall in brief the essentials of the method.

In practically all applications of dielectric heating one is confronted with the fact that the dielectric properties of treated material, namely, power factor and dielectric constant, are a definite function of temperature. During the heating cycle, when the material is raised from room temperature to possibly 270F or higher, the power factor and dielectric constant increase. These changes in the electrical properties of the material cause the impedance of the generator load to decrease from a relatively high to a much lower value.

Therefore, unless the generator is designed with a considerably higher output capacity than is required at the beginning of the heating cycle, toward the end of the heating period the oscillator tubes will either be overloaded or, worse still, the generator will cease to oscillate. The actual load impedance reflected on the generator will depend entirely upon the degree of coupling between the load and the generator.

Now, if by some means the

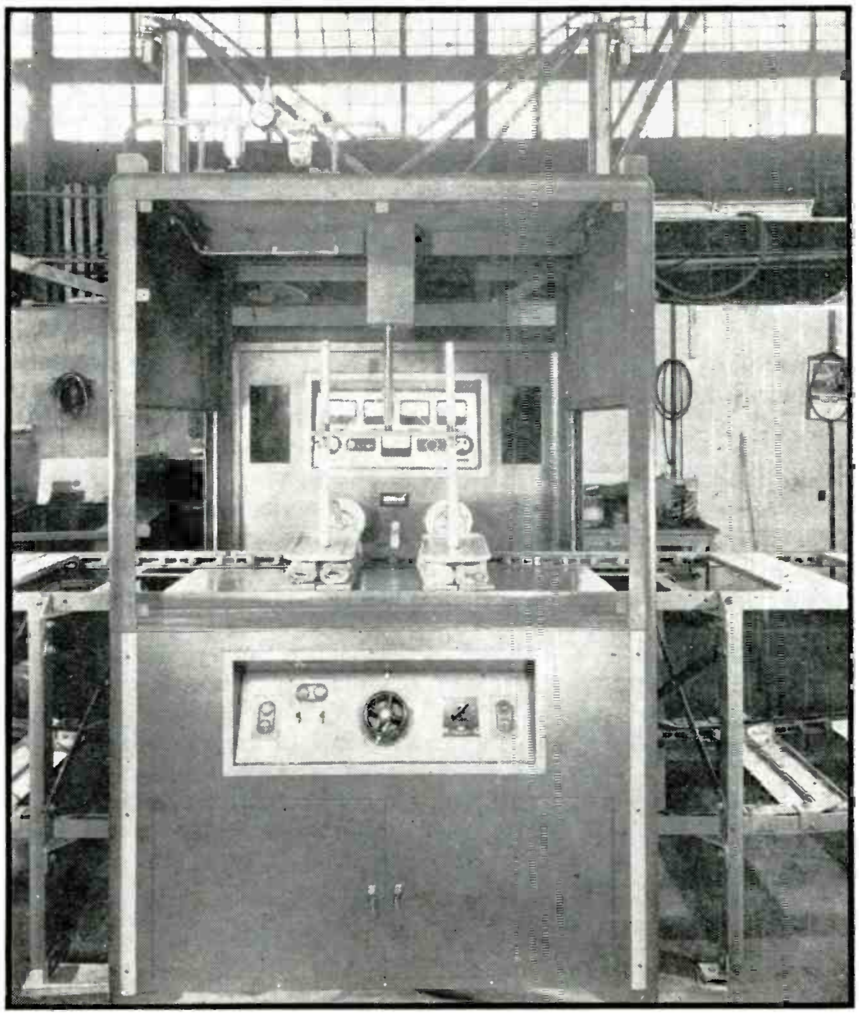

FIG. 2—Adaptation of the equipment, used here for preheating tank treads, to different types of work is possible by modifying the heating electrodes. The work and indicating meters are visible to the operator through a protecting screen not shown here

coupling between the load and generator can be varied automatically so that changes in the value of load impedance will be compensated by corresponding changes in the coupling between the load and generator, then a constant value of reflected load impedance will be obtained and constant power will be delivered to the load throughout the heating cycle.

In the equipment under discussion, the automatic control of coupling between the load and generator is accomplished by an electronically operated motor mechanism which automatically adjusts the spacing between the material to be heated and the heater electrodes. The rematching system makes possible an immediate change in production from one type of preform to another, within reasonable limits of volume and shape. If the mass changes and the same final temperature is desired, then it becomes only necessary to change the heating cycle.

Details

The heater electrodes are raised or lowered by a motor and gear reduction drive. A grounded copper plate forms the common electrode for the movable heater plates.

The oscillator circuit is shown in Figure 3. The high voltage B + is grounded to afford maximum safety to the operator. Another feature is an output power meter by which the power absorption of the load can be calculated.

A separate bias supply provides the grids with the proper voltage for maximum operating efficiency without loss in plate potential. In applications where the dielectric qualities are especially poor due to the presence of conducting particles such as the carbon black used to increase wear resistance in tank treads, a very high power loss occurs in the oscillator power output circuit.

A novel method was developed to maintain low tank temperature by forcing air through the tubing used in the tank coil and load leads.

Figure 4 shows the conveyor carrier plates as originally set up for tank tread production. Twelve tank treads were handled simultaneously. The arrangement permitted the preloading of the carrier plates so that the individual preforms could be spaced equally and would not fall off the conveyor if the chain was suddenly stopped.

Modifications of the r-f generator and conveyor permit preheating of wringer rolls as well as automotive parts. The wringer rolls with their metallic shafts are placed in a horizontal position on the conveyor, in the same manner as the tank track preforms were handled. The wringer rolls are preheated and then press-cured with an approximate 60 percent saving in press curing time.

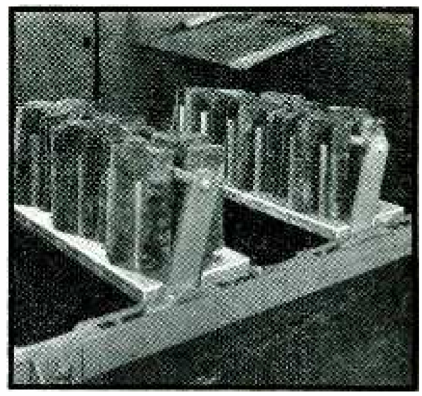

FIG. 4—Tank treads, heated twelve at a time, required special racks to hold them in place when the conveyor belt was stopped or started suddenly

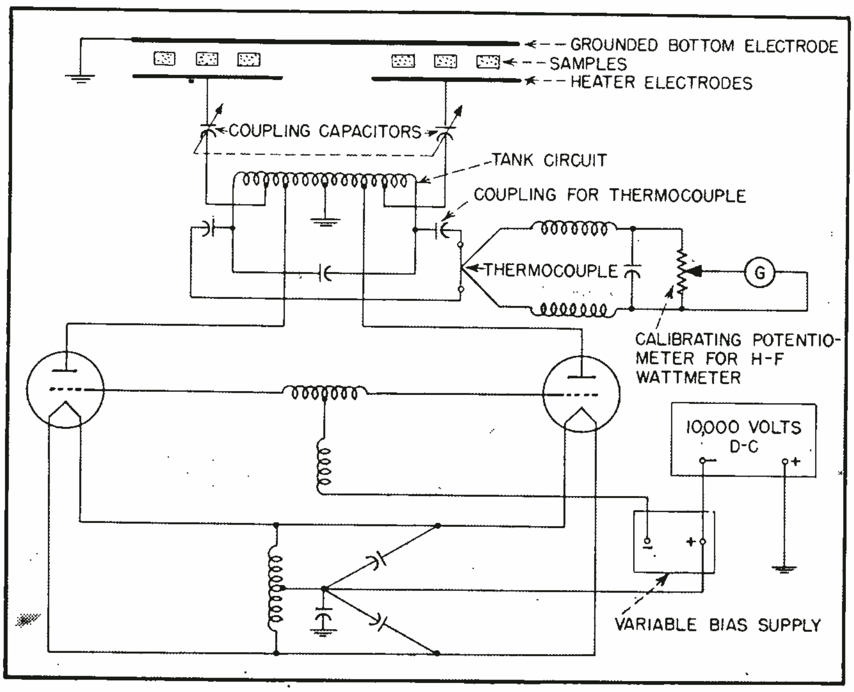

FIG. 3—Schematic diagram of the r-f heating unit showing oscillator, electrode arrangement, method of coupling the load to the tank coil and the thermal arrangement for measuring load power. The galvanometer is the central instrument shown in Fig. 2 and is calibrated to read watts directly

Operation

To start the machine, the operator pushes left- and right-hand start buttons on the control panel. As a safety measure both buttons must be pressed simultaneously and held until both side gates are locked in the final down position. The gates will go up if either of the push buttons is released while the gates are in motion.

Once the gates reach their final down position they become self-holding and an interlocking relay arrangement connects the high voltage power supply and starts the timer circuit. The timer circuit is preset for a heating cycle of any desired length of time. After the timer reaches the end of the preheating cycle, the holding relays of the automatic high-voltage contactors and the solenoids on the air cylinders are released, raising the gates. When the gates reach the top position, the conveyor begins to move, bringing a new load into the heating position, and carrying the heated preforms to the vulcanizers.

The entire cycle may be repeated every 1½ minutes, supplying approximately 1200 pounds of heated preforms per hour to the presses, 24 hours daily.

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Facsimile Synchronizing Methods

Techniques involving a quartz crystal, tuning-fork oscillators, and vibrators for automatic synchronizing of a facsimile receiver to a transmitter are described. Simple methods such as the use of a common power line and manual correction by a trained operator are also covered

By DANIEL SCHULMAN*

ONE OF THE PROBLEMS encountered in the design of equipment for facsimile reception is that the building up of the elemental areas must be accomplished in a uniform geometric relation. The skew, or deviation from a straight line, must come within very close tolerances to avoid distortions in transmissions.

As a typical example of the high degree of speed control required, assume a system in which a tuning fork is used as a frequency control and feeds an amplifier which drives a synchronous motor. The drum is coupled to the motor through gears and mechanical clutches. To achieve compactness an 1800-cycle fork is often used. The speed of the drum is established at 90 revolutions per minute.

A synchronous motor using 120 poles will revolve at 1800 rpm according to the formula:

$$rpm = 120f/P$$

where rpm = revolutions per minute
f = applied frequency
P = number of poles

Using a 20-to-1 gear ratio, the required drum speed is obtained. A typical drum traverses the lead screw at approximately 100 revolutions to the inch. The circumference of the drum is 9.4 inches. A picture eight inches long will require 800 revolutions and will traverse the drum in 800 divided by 1.5 or 533 seconds.

Analyzing the skew for 1801 cycles applied to the synchronous motor:

$$\text{rpm} = \frac{120 \times 1801}{120} = 1801$$

$$\text{drum speed} = \frac{1801}{20} = 90.05 \text{ rpm}$$

drum speed revolutions per second

$$= \frac{90.05}{60} = 1.5008$$

The distance scanned per second will equal 1.5008×9.4 inches or 14.10752 inches. The distance scanned with an applied frequency of 1800 cycles is computed at 14.1 inches and this figure multiplied by 533, the time in seconds for a complete transmission, will give a total skew of 4.008 inches. Interpreting in degrees, $\tan 4.008/8 = 30$ degrees.

It has been proposed that for photographic recordings a maximum skew of 0.08 degree be tolerable. Such a condition could be obtained with a frequency of 1800.0056, which will give a total deviation of 0.023 inches. The frequency of the fork must be maintained to 1 part in 323,000. For direct recording systems the tolerance may be lowered and a frequency stability of 1 part in 10,000 would be acceptable.

Synchronous Systems

In early models there existed a system in which manual control of the speed of a d-c motor was accomplished by a rheostat. Variations were observed stroboscopically with a 60-cycle tuning fork. The shaft of the motor mechanically interrupted a light source which could be observed through a vibrating tuning fork that was carefully calibrated to the desired frequency. Observation throughout the entire transmission was necessary since supply voltage variations and also a dynamically unbalanced drum traversing the lead screw would affect the speed.

Phasing the transmission was also accomplished by a trained operator. At a certain point on the drum at the start of the transmission an audio

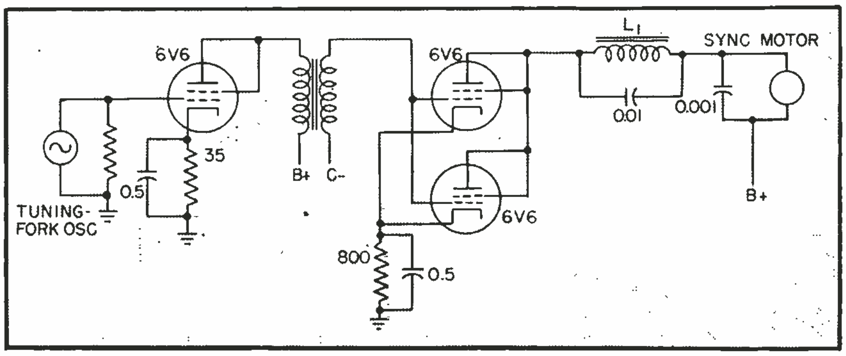

FIG. 1—Tuning-fork oscillator and class C amplifier supply high voltage to a synchronous motor. An additional motor brings the synchronous motor up to speed

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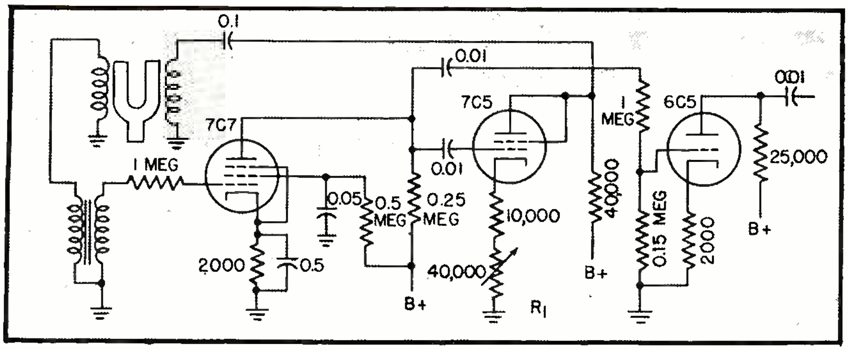


FIG. 2—(Above) Circuit of a tuning-fork oscillator using a multivibrator

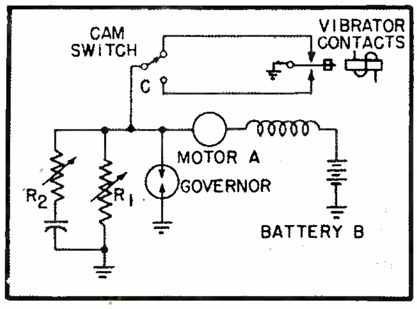


FIG. 3—(Right) In this circuit, a balance is sought between the action of the motor-driven cam switch and that of the vibrator

tone or pulse would be sent. A loudspeaker at the receiving end would respond and the operator would manually slow the drum until the pulse would coincide with the correct phasing position. In this manner a fairly reliable source of synchronism and phasing could be obtained.

Another scheme that was used principally on home recordings employed a 60-cycle synchronous motor. Good results are obtained if both the transmitter and receiver are connected to the same power source. For long-distance transmission the system becomes impractical. For telegraphic transmission with direct-recording devices this arrangement is practical within the confines of one city.

Present Synchronous Systems

The mechanisms in common use today have been developed to a high degree of speed control and automatic phasing. The general schemes adopted depend on the establishment of a stable frequency source and the application of this power to a motor to regulate or determine the speed.

In lieu of the visual tuning fork and stroboscopic method outlined previously, an automatic arrangement has been devised that uses a magnetic brake in conjunction with a d-c motor to control the speed. This motor is designed for a higher speed than is required. Application of a control frequency through an amplifier provides a braking action when the armature attains the desired speed. Due to the inherent wow of this type of motor, it is necessary to employ a flywheel to counteract hunting and reduce effects of gear ripples and voltage fluctuations.

Tuning Fork and Motor

Figure 1 illustrates a modern system in common use. A stable tuning-fork oscillator supplies a 30-volt input to a power amplifier tube, which is transformer-coupled to a pair of parallel power amplifier tubes. These are operated in class C to produce maximum efficiency. The resonance characteristics of L_1 and the shunt 0.01-μf capacitor serve to produce a high voltage for the synchronous motor windings. Reactor L_1 should have a value of 0.9 henry. This is the incremental inductance with 80 ma of d-c plate current through its windings.

The plate circuit has a low-Q resonant characteristic and considerable harmonics are generated. The voltage rises to the extent that corona effects are noticeable and insulation must be considered in wiring the plate circuit. Approximately 1000 volts exists across the four series-coil windings of the synchronous motor.

This type of motor will not start by itself and requires an additional motive source to bring it up to speed. The characteristics are such that it will lock into synchronism from a higher speed but will stall completely at lower speeds.

Phasing of the drum is accomplished at the start of transmissions by use of a pushbutton. Both transmitter and receiver drums are rotating synchronously and, at the start of transmission, a white dot causes a pulse or audio tone to be transmitted. The receiver drum is coupled to the motor by a clutch that is designed to slip easily and grab hard. Pressing the button engages a solenoid that causes the drum to slip in relation to the motor. At the same time, a pulse demodulator amplifier is connected to the output of the main line amplifier. The solenoid releases upon reception of the transmitted pulse.

Tuning Fork and Multivibrator

A tuning-fork oscillator is illustrated in Fig. 2. The circuit is that of a conventional multivibrator with a feedback network including the elements of the tuning-fork coils and capacitances. The frequency of the oscillator is determined by the vibrating tuning fork.

The multivibrator oscillates at the injected frequency and minute variations of a fraction of a cycle are possible with the adjustment of R_1. A "hard" drive will cause the fork to vibrate at a greater amplitude, thus slowing its speed. Stability for the amplitude of the drive is maintained by a regulated B supply. Either a VR105-30 tube or an electronic regulator may be used.

The fork is constructed of bimetallic materials to stabilize against temperature variations. Frequency stability of one part in five million is common. This system serves as an excellent arrangement for the frequency control in electric drive systems.

Submultiple-Frequency Generator

As a variation of Fig. 2, a crystal is being used commercially in place of a tuning fork with excellent results. One scheme is to use a 300-kc crystal-controlled oscillator, feeding it into a multivibrator to generate submultiple frequencies. A 60-cycle wave is generated in two multivibrator circuits. The first division occurs at 30 kc. The 300-kc crystal was chosen because of its ability to phase easily with a variable capacitance in the circuit.

In developing these frequency controls, an accurate check may be obtained by a scheme in which the crystal or tuning fork locks a multivibrator circuit in at 60 cycles, which is then amplified to drive a synchronous clock.

Signal Synchronization

For economy, it is desirable to eliminate a self-contained frequency control. Various methods have been tried, such as signal synchronism and mechanical start-stop systems.

Signal synchronizing systems transmit an audio-frequency tone that drives the motor at both the transmitter and the receiver. It then becomes necessary to confine the picture modulation signal to levels higher than the synchronizing signals. In black and white transmissions, a modified scheme works out well. A multivibrator circuit is normally employed. During zero modulation levels, the synchronizing signal locks the multivibrator in at the correct frequency. Television circuits employ similar arrangements for locking the horizontal and vertical sweeps.

Mechanical start-stop systems are employed in direct recording devices. A synchronous motor is employed so that error in scanning a complete line is tolerable. The motor is connected to a cam through a clutch. The cam is arranged to drive a stylus across a recording blank in a reciprocating motion. Terminating each line, the clutch disengages and the stylus resumes its motion on a pulse from the transmitter. A high degree of mechanical precision is required so that the sweeps will align correctly.

Vibrator-Controlled Motor

Figure 3 illustrates a system in which the action of cam contacts on the shaft of a motor is balanced against the frequency of a vibrator.

Current from battery B goes through the series motor, through R_1 and to ground. At the correct speed of 3600 rpm, R_1 allows the minimum amount of current to flow through the motor when the cam switch and the vibrator contacts are open to ground. The governor opens at 3500 rpm. Cam C is mechanically connected to the shaft and makes and breaks the spdt switch 60 times a second. The vibrator is stabilized at 60 cycles a second and its contacts are arranged as a spdt switch.

There are four possible positions of the cam switch and vibrator contacts. At normal speed, the cam contacts lead the vibrator contacts. The time element in which R_1 is shorted depends on the amount of lead of the cam contacts. Such an arrangement hunts a balance between cam and vibrator.

If greater voltage is applied to the motor, the cam switch contacts lead the vibrator contacts by a greater amount. Resistor R_1 is then in the circuit a longer time and the speed is reduced. The opposite conditions prevail when the voltage is lower than normal.

The inherent wow of the motor is smoothed by the effects of a heavy flywheel. With this arrangement, no apparent variations of speed are noticeable.

Vibrator Speed Control

Since the speed of the motor is dependent upon the speed of the vibrator, means must be taken to stabilize the frequency of the vibrator. A safe tolerance factor would be to have the frequency of the vibrator vary from 59.5 to 60.5 cps on a battery voltage variation from 9 to 13.

Figure 4 illustrates a system in use. A constant current is maintained in the vibrator coil by means of a type of ballast tube designed for the purpose. Current variations in the vibrator coil cause frequency variations in the vibrator. Variation of frequency is accomplished by R_3. Resistor R_2 should be a temperature-compensated resistor to react inversely to the tendency of the vibrator to accelerate as it heats.

Figure 5 shows a variation of Fig. 4 in which a VR 105-30 is employed for regulating current in the vibrator coil. Since one power supply is used for the main signal amplifier, modulation troubles may occur due to radiation characteristics of the vibrator.

Tape equipment is employed solely for black and white message communication. Recordings are made on narrow tape by means of a spiral helix rotating at about 60 rpm. Drive rollers move the tape across a printer knife edge that is properly oriented to the helix. Signal modulation actuates the knife edge and scanning of 60 to 100 lines per inch is accomplished. Since these lines are short and the rate of motion so high, larger tolerances of speed control are acceptable.

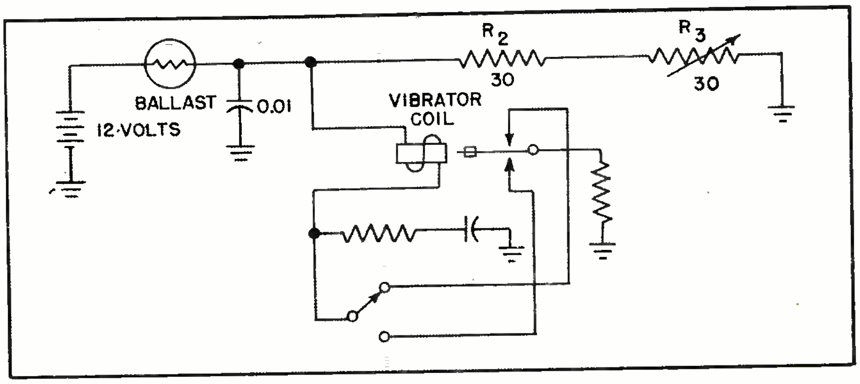


FIG. 4—Use of a special ballast permits regulation of the vibrator frequency

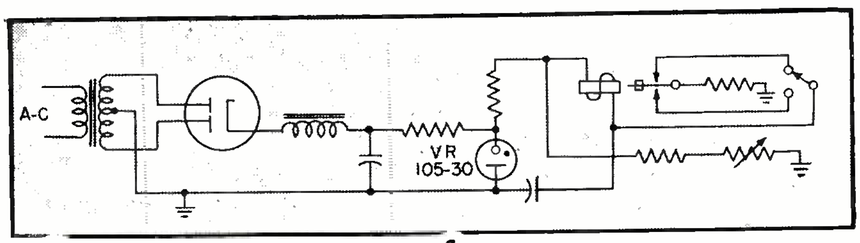
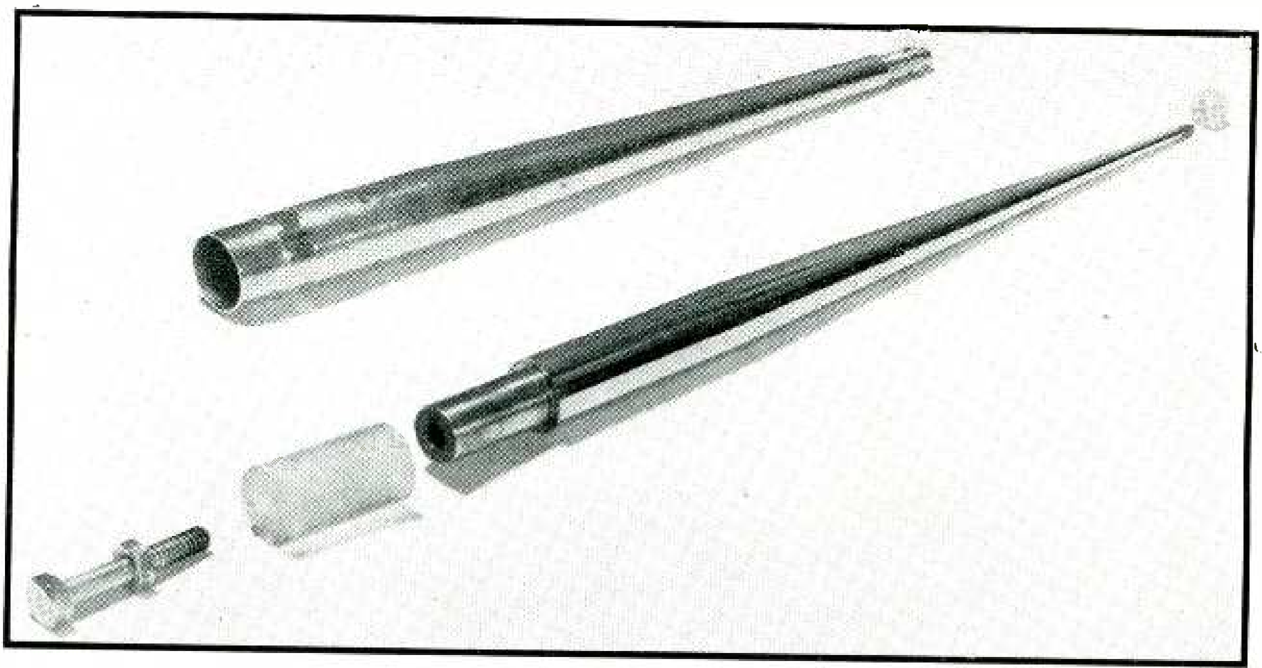
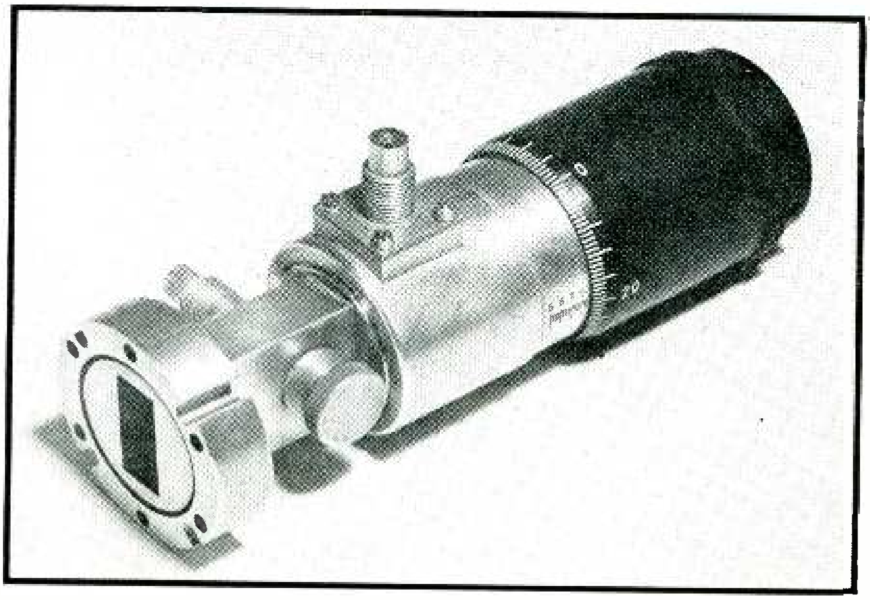


FIG. 5—Current through the vibrator is controlled by the voltage-regulator tube



Separating-medium mandrel made of cold drawn steel, stress-relieved before machining, and finish ground to close tolerances to produce round tubing with a tapered section in the middle, the straight portions being parallel to within a fraction of a thousandth of an inch. End caps, supporting bolt and finished tubing also shown

Electroforming



Wavemeter using waveguide feed in which the precision resonator is electroformed

By F. HASSELL and F. JENKS

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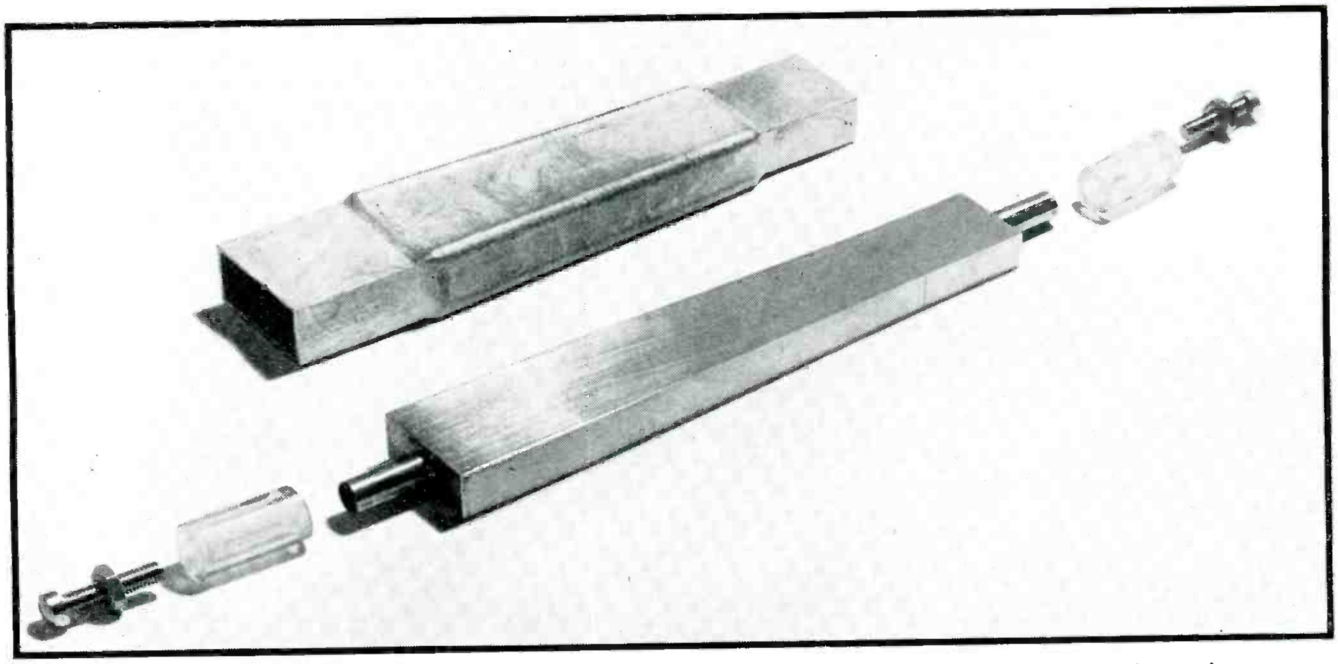
THE WELL KNOWN ART of electrodeposition of metals is a manufacturing technique with which all microwave engineers and designers should become familiar. Good design practice requires that surfaces of microwave instruments and transmission line components carrying r-f currents be smooth and held to close tolerances. To prevent reflections and excessive absorption of energy in the skin-depth layer, a polished surface of gold, silver or copper free from minute variations is desirable. Microwave components have their conducting surfaces on the inside of the apparatus, thereby tremendously increasing the problem of accurate machining. By using electroforming techniques, however, the precision machining is done on the outside of a mandrel whose finish determines the surface condition inside the completed piece.

Such techniques have simplified the problem of holding precision tolerances on such components as telescopic tubing, round and rectangular waveguide, tee sections, tapered and twisted sections, resonators, and pieces of irregular shape. Electroformed metals possess metallurgical characteristics similar to metals formed by rolling, drawing, forging, or casting with the exception that the crystal growth is radial instead of longitudinal. The process of electrodeposition of metal on the mandrel builds up a heavy coating of the material which is essentially free from stress. Such a condition helps to maintain the dimensional accuracy of the piece over long periods of time, as well as to allow machining without producing distortion.

The designer has a large selection of materials to choose from since nearly all metals are readily available in commercial electroplating es-



Tapered rectangular waveguide section and its mandrel, an example of the precision tubing made possible by electroforming methods

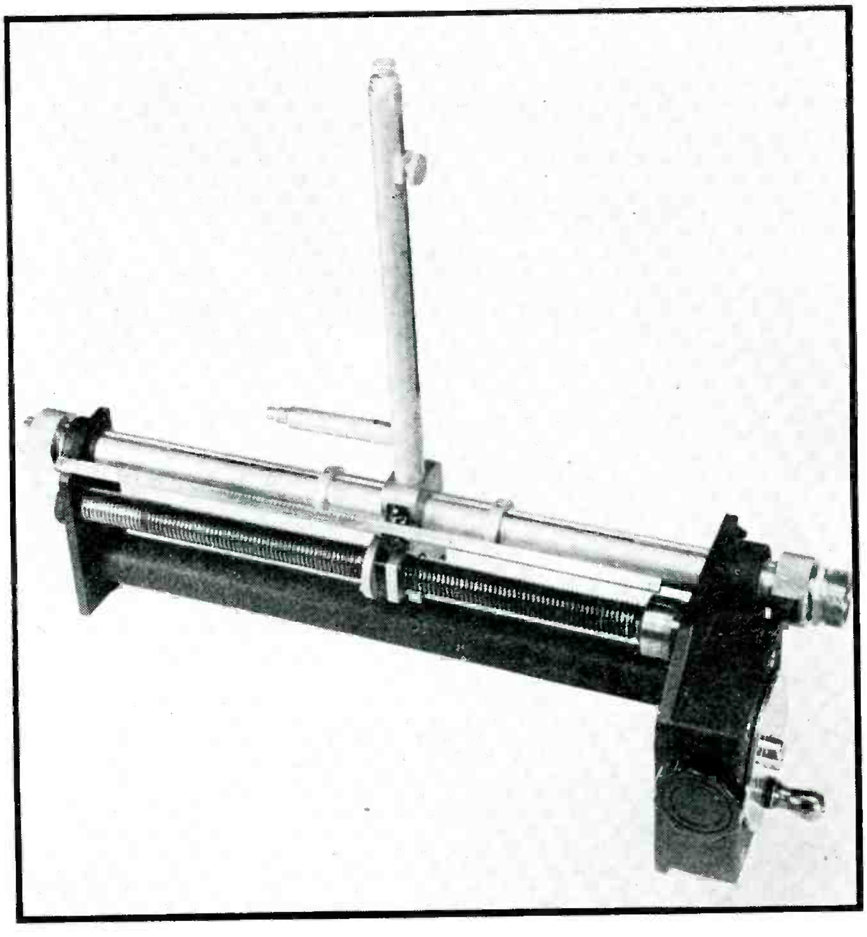
Microwave Components

Fabrication of high-precision waveguides and other parts for microwave apparatus simplified by electroforming techniques, processes noted for precision if not for economy

tablishments. It is possible to plate layers of different materials to produce special characteristics in the finished product, such as copper on the inside for good conductivity and chromium on the outside for durability. Another important use of electroforming is to make separate layers of concentric tubing which slide smoothly over one another. Two or more layers of such telescopic tubing can be built up on the same mandrel during the manufacturing process. Electroforming is not an economical method of fabrication, but in many cases it is less expensive than conventional machining of the part to precision tolerances.

Mandrels

There are two distinct classes of work involved in fabricating microwave components. One deals with pieces of uniform cross-section or pieces having a taper in one direction only. In such cases it is possible to withdraw the mandrel from the finished work and use it again. On the



Impedance meter whose coaxial line and travelling carriage are non-rotatable precision telescopic tubing other hand pieces with irregular shapes, or in general, with any geometry which does not permit withdrawing the mandrel when finished necessitate an expendable mandrel.

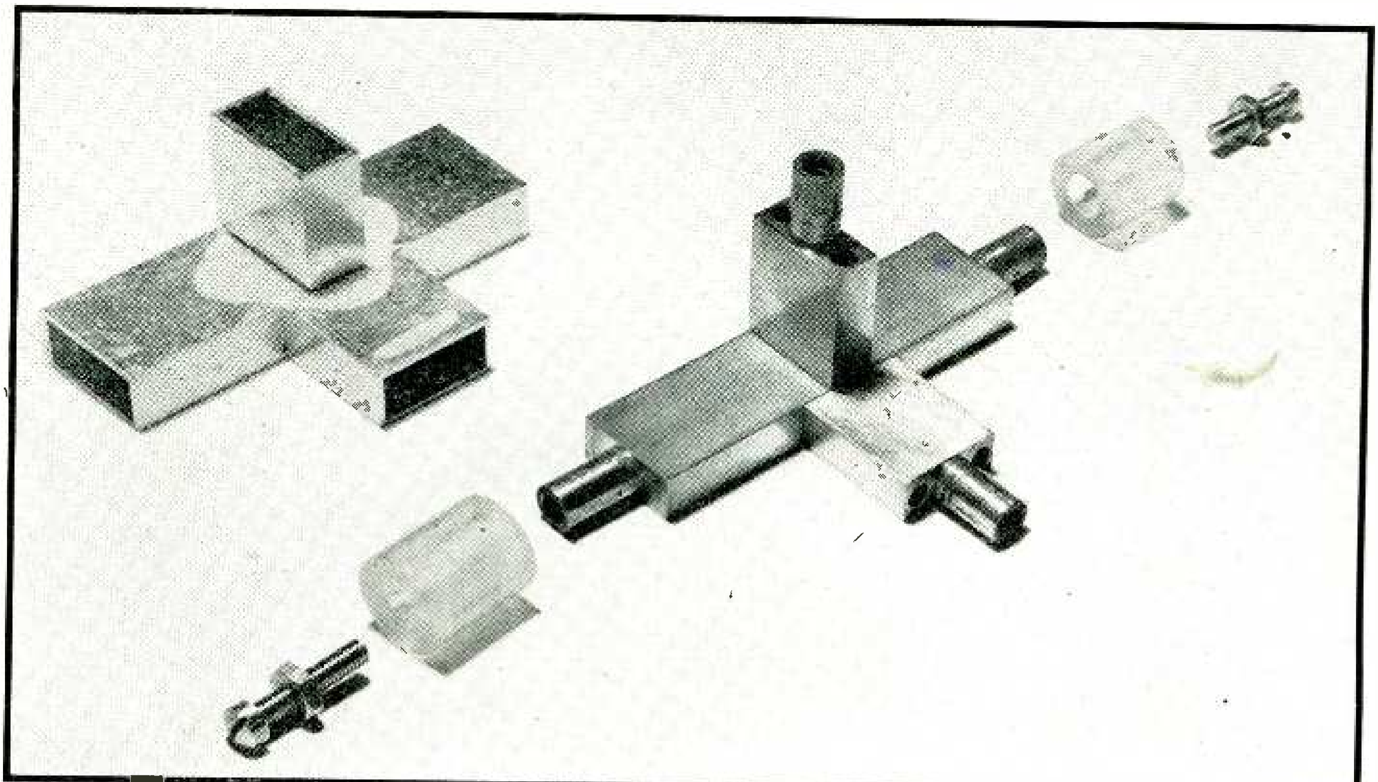
The reusable mandrels can be divided into two classifications: (1) those using a separating medium and (2) those relying on the poor adherence of a conductive coating. These two types are constructed alike, and differ mainly in the material of the mandrel and the method of separating it from the work. In each case machining centers are provided in the ends for machining both the mandrel and the outside of the electroformed work. Threaded holes may also be put in the ends to accommodate bolts or hooks used to support the mandrel in the plating tank. To prevent the plating solution from etching the machining centers, plastic masking caps are made to fit tightly over the mandrel ends. A nut and washer on the threaded bolt tighten against the cap to complete the seal. Usually the ends of the mandrel are turned down for a short distance to provide a shoulder for the masking caps and for attaching a machining dog.

The mandrel diameter is usually made undersize by about 0.001 inch and then uniformly plated with tin to the correct dimensions by proper handling in the tank. Copper may then be heavily electrodeposited on the tin to build up the material for the tubing. When the outside of the copper tubing has been machined to size, the mandrel can easily be withdrawn from the work by heating the assembly to slightly above the melting point of tin. To avoid oxidation of the tin which would prevent separation of the mandrel from the work, the heating is best done in either an oil, wax, or lead bath, but it can be accomplished in air under controlled conditions.

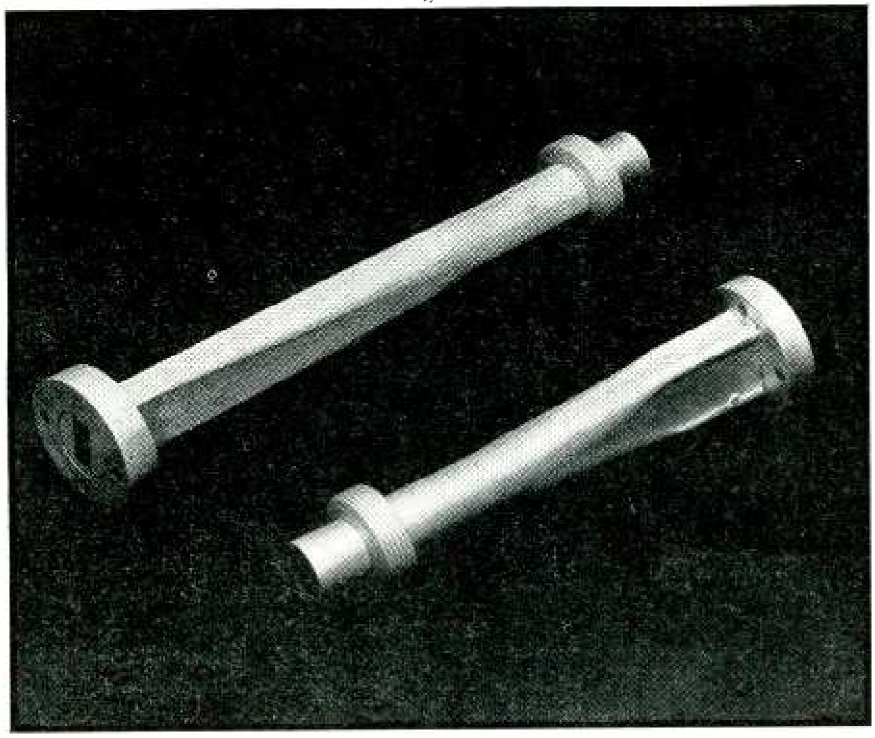
The poor adherence type of mandrel is made of glass, Kovar, or any other material having a relatively low coefficient of thermal expansion. The glass mandrels in this classification, are interesting because their finish can be obtained by optical grinding and polishing methods if necessary to meet the stringent tolerance requirements. The surface of the mandrel is made conducting by coating it with silver either by a spraying or dipping process. This extremely thin coating becomes an integral part of the electroformed work when finished. A sprayed coating is also required for the low expansion metallic mandrels to provide a poor adherence film in order to remove the electroformed unit from the mandrel. Copper or any other suitable metal can then be plated on the silver to the desired thickness for the walls of the tubing. Sometimes chromium is added over the copper to provide a hard, wear resisting surface for sliding or rotating parts. After the outside of the work has been machined to dimensions, the mandrel may be removed by heating the assembly to about 600 F. Since the silver-copper-chromium shell expands about twice as fast as the glass mandrel, the work becomes larger than the mandrel and can easily be removed. Also, since the layer of silver was deposited on the polished mandrel by a spraying process, it does not adhere very tenaciously to the glass, thereby allowing separation of the expanded work from the mandrel.

Expendable Mandrels

The expendable mandrels can also be divided into two groups: (1) dissolvable metals and (2) fusible metals and waxes. Both groups are used in applications where the mandrel must change form to permit its removal from the work. The dissolv-



Waveguide tee section and the multiple mandrel used in its fabrication



Round-to-rectangular waveguide sections made on expendable materials

able mandrels can be made of commercially pure aluminum (dissolves in NaOH) or zinc (dissolves in HCl), or ordinary cold rolled steel which is dissolvable in HCl. Applications for this type of mandrel would be in work having thin walls where excessive heat might cause distortion, or where a mandrel harder than the fusible metals and waxes was required. When using expendable mandrels, it may be necessary to provide several reference points for machining purposes.

The fusible metals and waxes are useful as mandrels in making intricate shapes where the finished piece is obtained by melting out the mandrel. The waxes are made conducting by either spraying with a metallic or graphite coating, or by any of the other accepted techniques. Commercial fusible metals can be had in a wide variety of melting temperatures. Since these metals and waxes can be cast easily into precision mandrels, fabrication of irregular shaped components by electroforming can be put on a production basis.

Precision Tubing

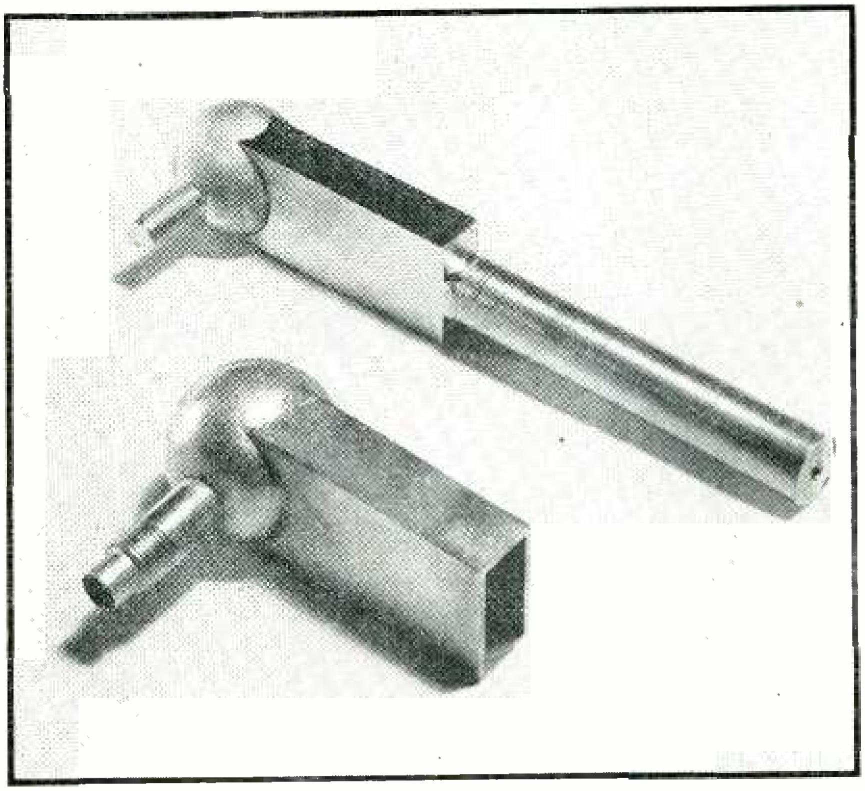
In many cases tubing of uniform cross-section is required for coaxial line or waveguide precision instruments. When going from one diameter coaxial line to another, a long tapered section is needed to provide a good match between the two lines to maintain a low standing-wave ratio. At times a waveguide is tapered to meet geometry requirements of a special application. All of these unusual conditions can be adequately met by using electroforming techniques on reusable mandrels. The internal dimensions of the pieces are as precise as the outside surface of the mandrels, and may be held to a few tenths of a thousandth of an inch.

To fabricate any of the pieces illustrated by ordinary machining methods would be rather difficult.

Telescopic Tubing

One of the most difficult problems in designing a coaxial line impedance meter is maintaining extreme accuracy in the sliding probe mechanism, and yet having the instrument easy to machine and assemble. The travelling probe must remain at a constant depth inside the coaxial line as it moves along through the longitudinal slot. It must also maintain a fixed relationship with respect to the sides of the slot, a condition which necessitates no wobble or slop in the carriage. Electro-magnetic energy can be prevented from leaking out of the slot by providing a close fitting cover which slides with the carriage.

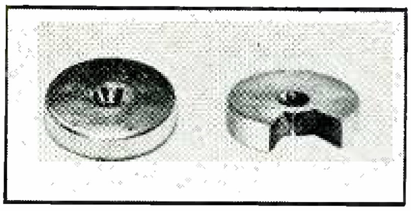
All of the above requirements can



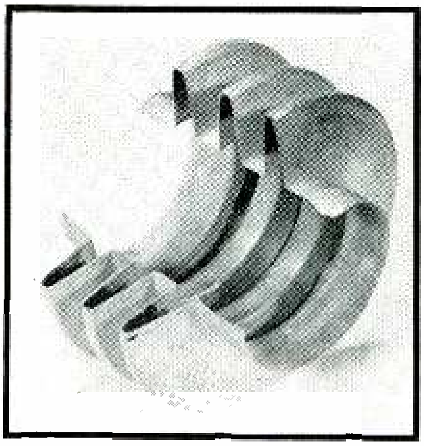
Dissolvable metal mandrel and experimental waveguide starting section using a special antenna housing, a typical use of the techniques for experimental models be met by electroforming non-rotating telescopic tubing on a re-usable mandrel. The procedure is to use a steel mandrel slightly under the size required for the inside diameter of the coaxial line. After tin plating to dimensions, copper is heavily deposited over the tin in the usual manner. The outside surfaces are then machined to provide the desired wall thickness. At this time the groove in a slotted line is ground or milled the entire length of the piece. The outside surface of the coaxial line conductor is now tin plated to allow it to be used as the mandrel for forming the piece of tubing which is to slide over it. When this second tubing has been electroformed, it is machined to size and the work is ready for separation from the steel mandrel. The assembly is heated to slightly above the melting point of tin in either an oil, wax, or lead bath, the work is separated from the mandrel, and the pieces of tubing separated from each other. The tin is wiped off the hot mandrel with a clean cloth, the mandrel is ready for use again. The tin remaining on the tubing sections is etched away in boiling hydrochloric acid for two to three hours. Any further machining required on the tubing after removing the mandrel necessitates careful handling of the work to preserve the precision already attained.

Telescopic tubing made by this process accomplishes the following things for the impedance meter designer. The inside diameter of the coaxial line is maintained accurately throughout its length and has a smooth surface finish. Since electroformed metals are relatively stress free, no measurable distortion of the tubing will occur when the probe slot is milled in the inner section. The longitudinal groove and key prevent any tendency of the carriage to rotate or wobble around the coaxial line, and the outer tubing can be used as the carriage. The spacing between the inner and the outer tubes is a minimum, being only the thickness of the tin plating used as the separating medium. This condition is desirable when using a slot cover to prevent electromagnetic energy leaking out through the probe slot.

Telescopic rectangular tubing is just as feasible as round tubing, and the dimensions of the inner piece can be held to far closer tolerances than commercial rectangular tubing.



Dissolvable mandrel made of aluminum, and the reentrant resonator made from it. After electroforming the wall to the required thickness the mandrel was dissolved by NaOH



Bellows constructed by the electroforming process

Other uses for telescopic tubing in microwave components are in adjustable lengths of coaxial line or line stretchers, multi-stub transformers, precision matching sections, and rotating joints. The possibility of easy fabrication of precision telescopic tubing makes adjustable line-section problems much simpler than heretofore. This is especially true where added wear resistance is available by using tubing with a copper core and a hard chromium outer shell.

Multiple Mandrels

Tee sections for precision waveguide applications are difficult to make from standard rectangular tubing. Electroformed tee sections have accurate dimensions both at the junctions and in the waveguide itself. It is most important that a good electrical contact be made across the butt joints where the mandrel sections come together, otherwise a flaw will result in the finished electroformed piece at the point of poor contact.

Bolts hold the mandrel assembly together during plating, and are removed when ready to withdraw the sections from the work. To prevent the solution from plating on the heads of the bolts, insulating plugs are forced into the counter-bored holes. Separating the mandrel from the work is accomplished by heating the assembly to melt the tin. The mandrel sections are withdrawn and the remaining tin is etched away in HCl.

Glass mandrels can be used in making precision tubing. Instead of using tin for the separating medium, a metallic layer can be deposited upon the surface of the glass to make it conducting, and separation of the work from the mandrel is accomplished as explained earlier. In all other respects, glass and metal mandrels produce similar results.

Irregular Shapes

Certain applications require a section of waveguide which goes smoothly from a rectangular to a circular cross-section. This is an ideal example for the expendable mandrel technique. Probably the simplest method would be to use a fusible metal of low melting point, shape it to size, electroform, machine the outside surface where necessary, and then melt out the mandrel.

A slightly different type of waveguide problem is one using rectangular cross-section with a smooth 90-deg twist along the axis to the guide. To maintain a low standing-wave ratio, the internal dimensions should be kept accurate and the wall faces parallel throughout the twisted section. Either type of expendable mandrel could be used in this case with good results.

Sometimes it is necessary to make special bellows whose depth of convolution or whose length is such as to prevent it from being manufactured by conventional methods. For example, the depth of convolution might be some fraction of a wavelength to produce certain electrical results in a flexible transmission line section. The mandrel for such a bellows could be aluminum. It would be necessary, however, to provide a special anode structure between the convolutions to obtain sufficient "throwing power" from the plating bath. Otherwise the wall thickness will be non-uniform and the bellows will not operate smoothly.

TELEPHONE AMPLIFIER

Privately serviced telephone lines used by broadcasters are often unsatisfactory because of high attenuation owing to great length. A simple two-way amplifier for ordinary handsets facilitates communication without danger of crossstalk

By HOWARD K. VAN JEPMOND
Engineer
Radio Station WJJD
Chicago, Ill.

RADIO broadcast transmitters are usually located many miles from their studios. They are customarily linked by two or more leased wires, one carrying the program to the transmitter and another used for nearly continuous communication between studio and transmitter engineers. The chief restriction placed by the telephone companies upon their use is that the maximum transmitted voltage shall not exceed 1.73 volts.

Avoiding Feedback

The carbon-button microphone with which the ordinary local-battery telephone handset is equipped generates about the maximum voltage allowed. This indicates, therefore, that amplification should be confined to the receiving end of the line. Difficulty will be experienced if the input of a receiver amplifier is connected directly across the telephone line because both transmitted and received signals are present at this point and the transmitted signal is much more intense. With the ordinary handset, this connection would cause the receiver to talk back, at a volume depending on the gain of the amplifier. All telephones talk back to some extent (the phenomenon is called side tone) and the effect is not annoying. However, when an amplifier is used at the receiver, the side tone becomes intolerably loud and may even result in audio feedback which renders the equipment useless.

To avoid excessively loud side tone, the transmitted signal must be kept out of the receiving amplifier by means of a bridge circuit such as that shown in the right-hand side of Fig. 1. Here, the impedance of the artificial line Z must match that of the telephone line so that the bridge circuit formed by L_2, L_3, Z, and the line will be in balance for signals transmitted from L_1, resulting in minimum signal at L_4. Signals from the other end of the telephone line will be induced in L_4 because of the effective shunt connection for reception. Since half the transmitted power is dissipated in the artificial line, it is necessary to provide amplification for the microphone as well.

The complete schematic circuit diagram of the amplifier used at WJJD is shown. One triode receiving-type tube was found to give sufficient gain in each amplifier. A control is necessary in the transmitting amplifier to adjust the transmitted voltage to its limit of 1.73 volts.

Without recourse to test equipment, the major problem in getting the amplifier to function properly is finding the correct value of Z. This was determined in practice by connecting an audio oscillator to the input of the transmitting amplifier and a volume indicator meter at the output of the receiving amplifier. Variable resistors, capacitors, and small inductors were then connected until a combination was found that resulted in a minimum reading on the VI meter for all frequencies between 100 and 4,000 cps. A typical network for Z is shown in the dashed box. Although the balancing network design is necessarily different for each line, this information is often available from the telephone company leasing the circuit.

Useful for Nemo

The equipment can be used at either or both ends of a studio-transmitter line, but the balancing network is not the same at both ends, and in any case must be adjusted separately. Side tone resulting from a slight unbalance is not unpleasant, giving a simulation of ordinary telephone conditions. This technique lends itself to other uses such as long nemo (remote pickup) lines.

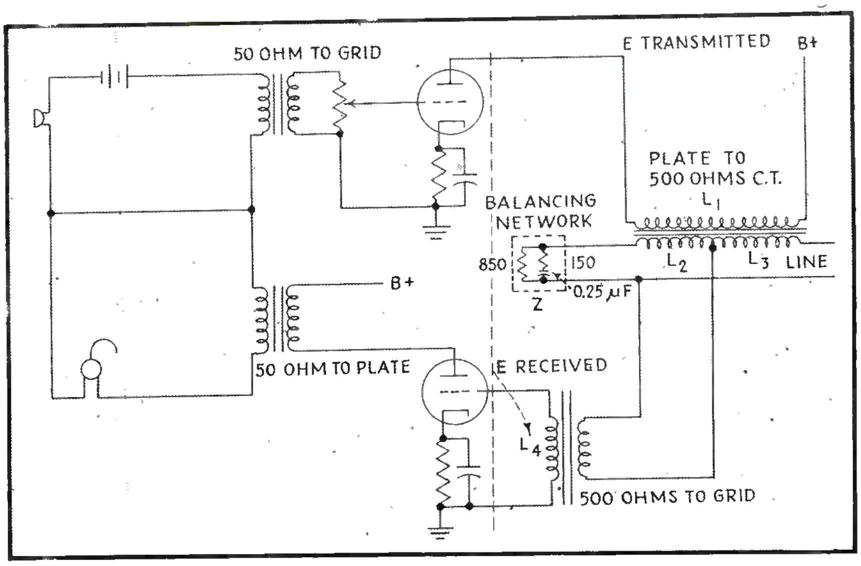


FIG. 1—Complete terminal equipment showing the handset and amplifiers, bridge circuit for reducing side tone, and detail of a typical balancing network. A conventional power supply is used

The MPG-1 Radar

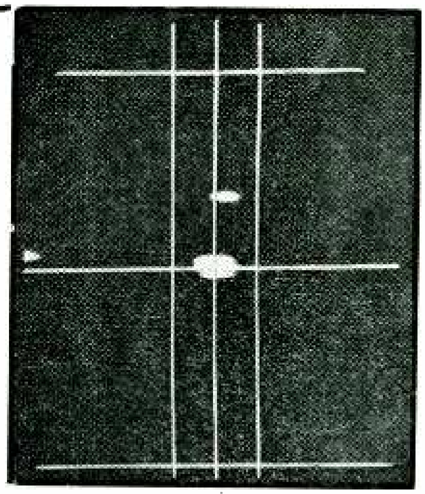
Concluding a series on the 3-cm coastal fire-control radar, the details of the timing and indicating systems are presented. Crystal controlled sweeps determine range of marine targets to a static precision of ±3 yards

By H. A. STRAUS, L. J. RUEGER, C. A. WERT

Radiation Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.

and S. J. REISMAN, M. TAYLOR, R. J. DAVIS, J. H. TAYLOR

Radio Division, Bendix Aviation Corp., Towson, Md.



Type-B indicator presentation of shell splashes and marine target, taken on the MPG-1 by the Coast Artillery Board. The target (a corner reflector on a float) appears just above the intersection of the centerlines. A 155-mm shell has landed just short of the target (immediately below) while another shell splash can be seen above and 0.3 degrees to the right. The echo at the left is a tug towing the target. The range coordinate is 2000 yards from bottom to top of picture

IN THE PRECEDING ARTICLES of this series, a general introduction to the AN/MPG-1 radar and a brief description of the transmitting, r-f, receiving and antenna-positioning systems were presented. The timing, ppi, b-indicator, and remote-B indicator systems are described in this article.

Timing System

Since pulse transit time (time between transmission and reception) and target range are measured on oscilloscopes, the oscilloscope sweeps must be accurately synchronized to the transmitted pulse. Further, since the expanded B-scope presents only a 2000-yard segment of range, with the range sweep starting at the bottom of the scope and the target located in the center, a delay is necessary in the B-scope trigger so that the range sweep will not start until a period of time has elapsed equal to the pulse transit time minus 6.1 microseconds (1000 yards). On short-range ppi, the transmitted pulse must be delayed 6.1 microseconds to give the movable range marker a chance to form at zero range. Since the B-scope range-sweep trigger is synchronized to the ppi movable-marker trigger (a design feature which is necessary to enable the operators to select on the 30,000-yard ppi the targets which are to be tracked on the B-scope) an additional delay of 6.1 microseconds is needed in the transmitted pulse to ensure that the selected target will be near the center of the B-scope when the mode of presentation is switched from short-range ppi to type B. It is the function of the timing system to supply the triggers and delays necessary for the measurement of target range, and to provide range accuracy of about ±20 yards. A timing diagram of the modulator, ppi, and B-scope triggers is given in Fig. 1.

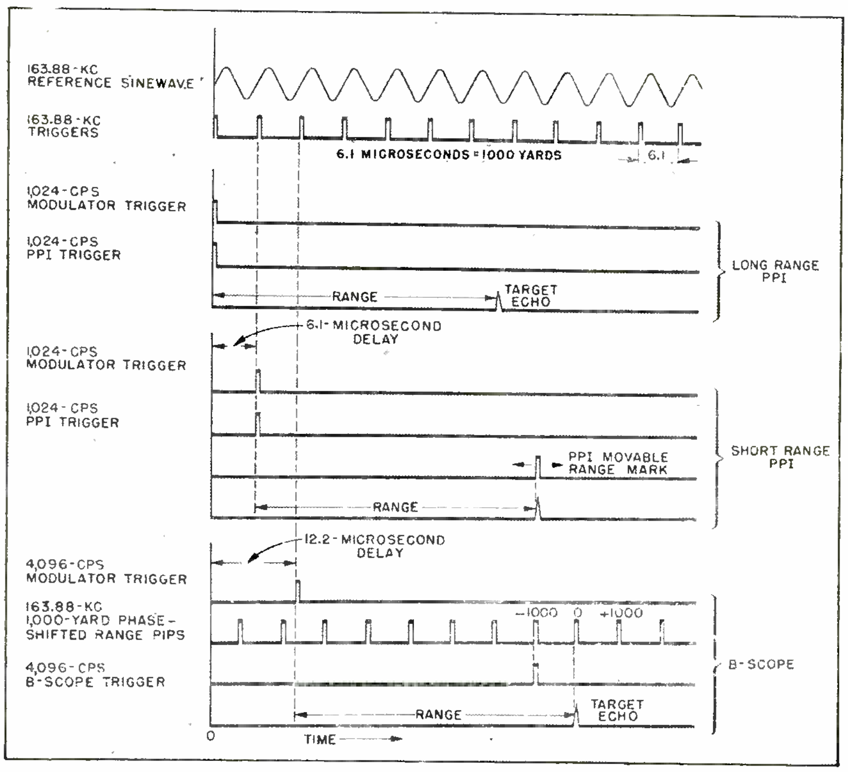


FIG. 1—Time coordination between sinewave reference voltage and various triggers which initiate modulator, B-scope and ppi

Basically, target range is meas-

Chesapeake Bay from Fort Smallwood, as presented by plan position indicator on 30,000-yard scale

ured by counting the number of oscillations completed by a 163.88-kc crystal during the pulse transit time. This frequency is chosen because its period is 6.1 microseconds, which is equal to the transit time of a pulse which travels from the antenna to a target 1000 yards away, then back to the antenna. Thus a linear relationship exists between the range of a target in thousands of yards, and the number of crystal oscillations.

Figure 2 is a block diagram of the timing system. The crystal oscillator generates a reference sinewave which is transmitted to a frequency-divider circuit and a phase-shifter circuit. This sinewave establishes the zero-time reference point for the entire system.

In the frequency-dividing circuit the reference sinewave is formed into pips of the desired frequency as shown in Fig. 3. The trigger circuit forms the incoming pips into sharp trigger pulses for the ppi range-sweep and modulator and introduces the necessary delays required for formation of the movable range marker at zero range and the triggering of the B-scope range sweep at range minus 1000 yards.

The phase-shifter circuit receives a fraction of the reference sinewave and produces a phase-shifted output which is a sinewave of constant amplitude having the same frequency as the reference sinewave. By means of mechanical linkage between the range tracking unit and a specially-designed capacitor, the phase-shift is made proportional to the range indicated on the tracking-unit dials. Pips derived from the phase-shifted 163.88-kc sinewave are fed to the B-indicating system where they are formed into 1000-yard range markers. These same pips are also fed to the coincidence circuit where they take part in the formation of the B-scope range-sweep trigger.

The coincidence circuit also receives a 6-microsecond gate from the range-delay circuit. This gate is triggered by the trailing edge of a sawtooth voltage waveform the width of which is roughly proportional to target range. The width of the sawtooth, which is obtained by mechan-

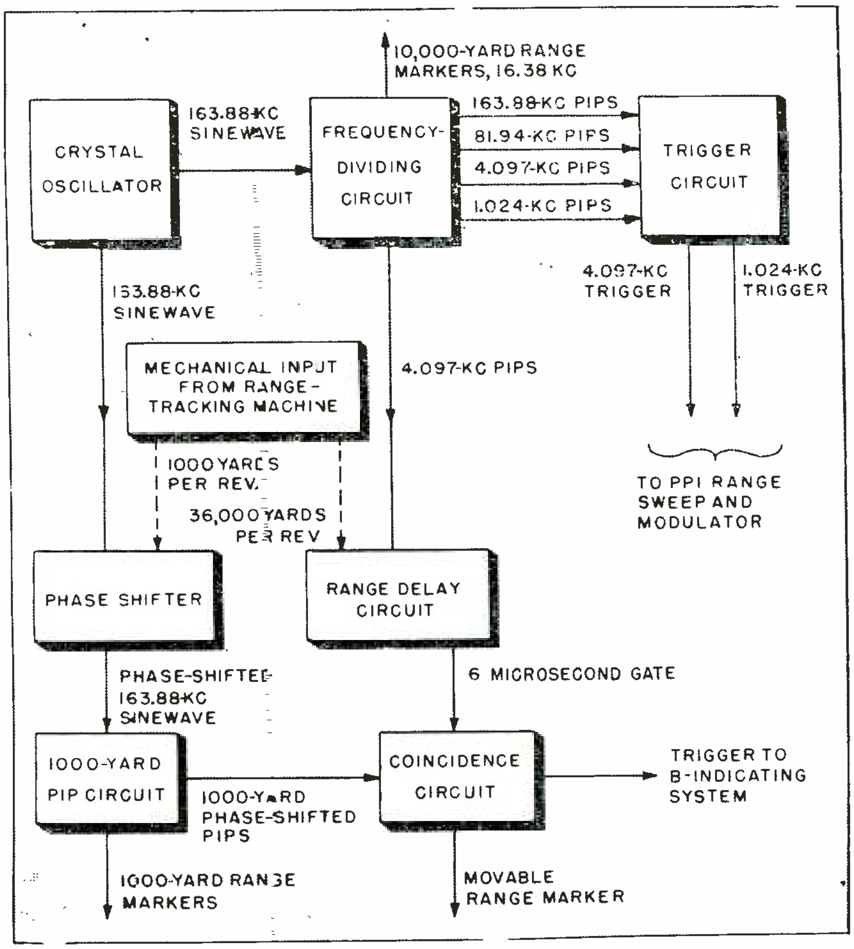


FIG. 2—Block diagram of the timing system

electronics WAR REPORT

ical linkage of a potentiometer to the range tracking unit, is a coarse measure of range. The coincidence tube can conduct only one phase-shifted pip while the 6-microsecond gate is on, because the interval between pips is at least 6 microseconds. The pips formed from the phase-shifted sinewave are a fine measure of target range.

Timing Circuit Details

In the frequency-dividing circuits the reference sinewave is rectified, squared, differentiated and formed into 163.88 kc pips. All of the frequency dividers used are of the blocking oscillator type, an example of which is shown in Fig. 4. The blocking oscillator employs cathode feedback and an *R-C* time-constant network in the grid circuit which determines the free-running frequency. To make this stage operate as a 2:1 divider, the values of C_g and R_g are so chosen that the grid-voltage recovery time is long enough to prevent triggering of the blocking oscillator except by alternate applied trigger pulses. For one out of every two input pulses, the grid voltage is so near the cut-off point that the additional voltage of the input trigger raises the grid voltage above cutoff and initiates the cycle. Thus every other input pulse acts as a synchronizing trigger and the output pips generated by the blocking oscillator recur at one-half the frequency of the input pips. Reliable division is usually limited to a ratio of approximately 5:1 to prevent instability.

The trigger circuit employs a delay gate generator (multivibrator) and coincidence tube to introduce delays in the modulator and ppi triggers. On long-range ppi no delays are needed so the coincidence suppressor grid is grounded while the 1.024 kc modulator and ppi triggers are applied to the control grid and amplified by the stage. On short-range ppi the suppressor is connected to —130 volts so that the stage is non-conducting unless a positive voltage of more than +130 volts, in the form of a delay gate, is applied to the suppressor. By using a 9-microsecond delay gate on the suppressor and applying 6.1-microsecond pulses to the grid, a pulse is selected for amplification which is delayed by 6.1 microseconds with respect to zero time. This delay in the modulator and short-range ppi triggers is needed to allow the movable marker to appear at zero range. On type-B presentation, an additional 6.1 microsecond delay is required in the modulator trigger because the B-scope range sweep is triggered by the same pip which triggers the ppi movable mark, and if the modulator trigger were not delayed by 12.2 microseconds the target pip would appear at the bottom of the B-scope. An 18-microsecond delay gate applied to the coincidence suppressor and 12.2-microsecond pips applied to the grid give the desired results.

Special Capacitor

For accurate range measurement, it is necessary to obtain a constant-amplitude 163.88-kc phase-shifted sinewave whose phase differs from that of the reference sinewave by an amount which is continuously proportional to the setting of the range tracking unit dials. The reference sinewave is applied to an *R-C* phase-splitting circuit, R_1C_1 and R_2C_2. In the circuit shown in Fig. 5 the capacitive reactance of C_1 is made equal to the resistance of R_1 and likewise for R_2 and C_2, resulting in the appearance at points *A*, *B*, *C*, and *D* of four voltages in phase quadrature, having the same frequency and amplitude. Thus plates 1, 2, 3 and 4 of the special capacitor shown have equal impressed voltages, but the voltage on plate 1 is in phase with the reference sinewave, the voltage on plate 2 is 90 deg out of phase, the voltage on plate 3 is 180 deg out of phase, etc. The special capacitor is so designed that it combines these four voltages into a resultant sinewave of constant amplitude (0.5v rms), frequency (163.88 kc) and phase shift (with reference to the input) which is proportional to the rangetracking dial setting.

An exploded view of the phase-shift capacitor is given in Fig. 6. One half of the capacitor is a circular common plate, the other half consists of four quadrant-shaped plates which are insulated from one another. On the shaft, which is driven by the range tracking unit, is a circular, eccentrically-mounted disc of mycalex dielectric which rotates between the two halves of the capacitor. Since the capacity between the

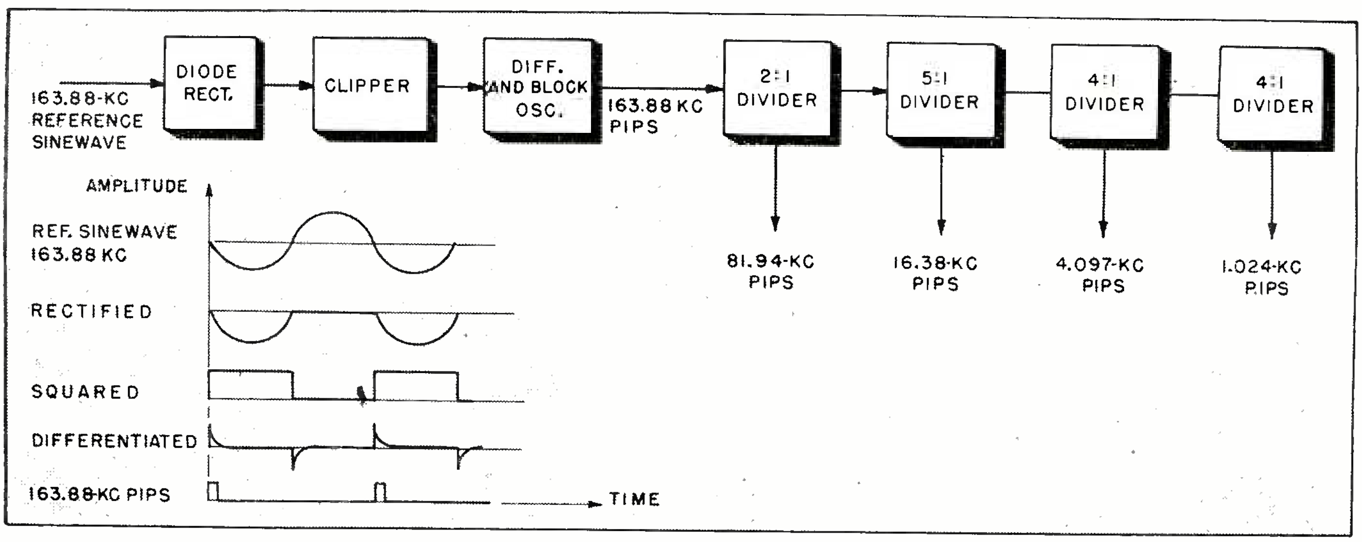


FIG. 3—Block diagram of frequency-dividing chain which reduces 163.88-kc reference voltage to pulse and indicator timing pulses

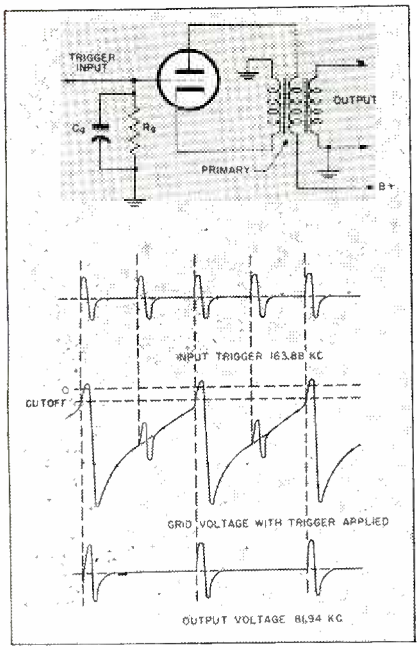


FIG. 4—Circuit and waveforms of a two-to-one blocking oscillator frequency-divider

circular plate and any one of the quadrant plates depends on the amount of dielectric between them, the capacitance of each quadrant depends on the position of the dielectric disc. The resultant output appears across resistor R_1 (Fig. 5) and is a combination of the voltages appearing across each quadrant and the common plate.

The capacitor shaft is revolved until the disc is opposite quadrant 1. The output is then in phase with the reference sinewave. If the range tracking dials indicate zero range and it is desired to bring the capacitor to zero, this may be done without uncoupling the capacitor shaft from the tracking unit. A control permits rotation of the capacitor housing while the dielectric disc remains stationary, until quadrant 1 is opposite the disc. Range errors up to approximately ±50 yards, which are due to circuit delays in the B-indicator system and the modulator, may be eliminated by this method. If the tracking handwheel is now turned, the disc moves away from quadrant 1 and covers an ever-increasing portion of quadrant 2. The output is shifted in phase until, when the disc is opposite quadrant 2, the phase shift amounts to 90 deg. As the disc moves toward quadrant 3, the amount of phase shift increases toward 180 deg. For one complete rotation of the capacitor shaft, the phase shift amounts to 360 deg, or 1000 yards of target range. The phase-shifted output is formed into 163.88-kc pips by a circuit which is similar to the pip-forming circuit previously described. It remains up to the range delay circuit to determine the number of rotations made by the phase-shift capacitor in tracking from zero range out to the target.

The range delay circuit shown in Fig. 7 selects one of the phase-shifted pips derived from the phase-shifted sinewave and moves that pip from zero range out to the range of the target as the tracking output is increased from zero. The range delay circuit is a coarse measure and the phase shift capacitor is a fine measure of range. A range potentiometer, the shaft of which is coupled mechanically to the range tracking unit, sets a d-c voltage level which is approximately proportional to range.

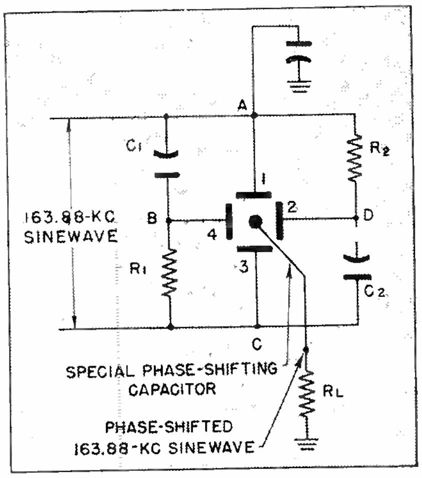


FIG. 5—Simplified schematic of capacitive phase-shifter which employs a quadrant stator and rotating dielectric element

When a linear sawtooth is built up to the d-c level established by the range potentiometer, a gate voltage about 6-microseconds wide is developed. The 6-microsecond gate and the desired phase-shifted pip are both applied to a coincidence tube, the output of which is a pulse which is shifted in time by an amount equivalent to the range tracking dial indication on short-range ppi and less than this by 1000 yards on B-type presentation.

A 4.097-kc trigger is amplified and used to drive a multivibrator. The multivibrator output is a negative gate which cuts off the clamper tube V_2 for the duration of the gate. When the sawtooth has reached the d-c level established by the range potentiometer the negative gate is no longer required and the multivibrator is returned to its original condition by a negative pip from the shut-off amplifier.

The linear sawtooth circuit includes the clamper, isolation diode, cathode follower and discharge diode. With no trigger applied to the trigger amplifier, clamper V_2 conducts heavily and current flows through R_2 and the isolation diode. The V_2 plate is held at +2 volts. Point A is slightly less than 300 volts and C_3 charges almost to the B+ supply voltage. When the circuit is triggered the clamper is cut off and its plate voltage rises. This voltage increase is applied to the R-C circuit. A voltage drop across R_1 occurs as the result of charging current surging through this resistor, and a sawtooth voltage begins to build up from the level established across R_1, resulting in a trapezoidal waveform. Without feedback, C_1 and C_2 would charge toward +300 volts and the output voltage would be exponential in form. However, a linear voltage is required for accurate range measurement and hence feedback circuits are provided to make the output linear. Feedback through R_2 is applied to both C_1 and C_2 and through R_3 to C_2 only.

Cathode follower V_3 is normally conducting. As the charge builds up on C_1 and C_2, the V_3 grid becomes more positive, causing the plate current to rise, thus increasing the

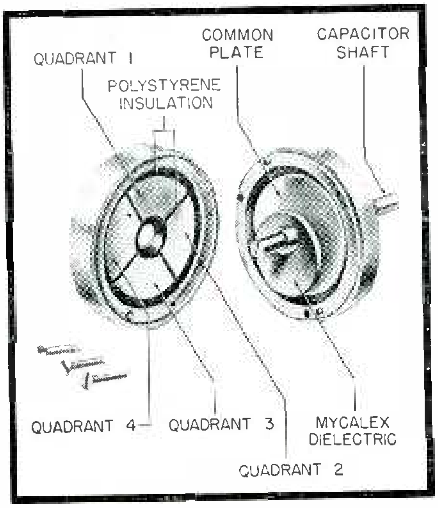


FIG. 6—Internal construction of quadrant-type capacitive phase-shifter

cathode potential, which increases the voltage at point A. Because of the long time constant of C_3 and R_2, C_3 loses very little charge. The isolation diode stops conducting when point A reaches +300 volts. Capacitors C_1 and C_2 charge toward the rising voltage at point A. At long range this voltage may exceed 300v. A constant current flow is thus maintained and a linear charging curve is produced. When the V_3 cathode potential is raised, the voltage increase is applied through R_3 to C_2 only, thus providing an additional linearizing action.

The pick-off diode begins to con-

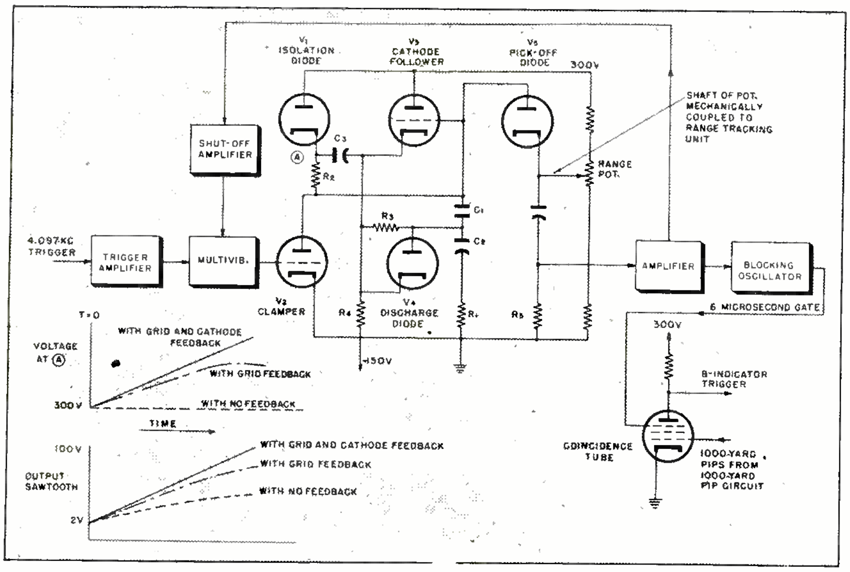


FIG. 7—Block diagram and simplified schematic of range delay circuit

duct when the sawtooth voltage reaches the d-c level set by the range potentiometer. A pulse having the required time delay for the B-sweep is developed across R_5, then amplified and applied to the shut-off amplifier which cuts off the multivibrator. When the multivibrator is cut off, V_2 conducts and C_1 and C_2 are discharged, aided by the discharge diode which shorts R_3. The circuit is thus returned to its original condition. The pulse from the pick-off diode also triggers a blocking oscillator which generates a 6-microsecond gate. Both the 6-microsecond gate and the phase-shifted 1000-yard pips are applied to a coincidence tube which conducts only when the gate and a pip coincide. The gate is wide enough to pass only one pip. The coincidence output is a negative pulse which triggers the B-sweep circuit. If the slope of the linear sawtooth is properly chosen, the 6-microsecond gate and a particular phase-shifted pip will move in range at the same rate when the tracking output increases mechanically, thus making it possible to select one pip and follow it from zero to maximum range.

When the system is calibrated on a target of known range by adjustment of the phase shifter capacitor, the indicated range to any other target is a function of the linearity of the capacitor. Careful operators can obtain accuracy in the order of ±3 yards. If no known target is available, the system may be calibrated on the signal due to transmitted pulse but the resultant range accuracy is not better than ±20 yards. Note that the range errors are absolute and not a percentage of range.

PPI System

Surveillance of targets is provided on a conventional 7-inch magnetic deflection plan position indicator, a general description of which is given in the first installment of this series of articles. Figure 8 is a block diagram of the system. Since a persistent screen is used, range markers appear as circles when the antenna rotates, and a polar map of the area of interest is generated when the antenna scans back and forth. The range sweep starts from the center of the scope and proceeds to the edge at a uniform linear velocity. The deflection coil, which is mounted in a mechanically-driven slip-ring and bearing assembly, is rotated by servo control so that the range sweep always indicates the direction of the emitted pulse. A rotatable azimuth scale with an engraved line is provided over the scope face. When a control knob is turned to position the engraved line over a target signal, the target azimuth may be read on an index.

When tracking, a different type of sector scan is used and hence ppi data cannot be presented simultaneously with B-scope data unless video signals, servo data and range-sweep triggers are obtained from a separate surveillance set located in the neighborhood. Figure 9 shows the waveforms applied to the cathode-ray tube.

B-Indicator and Remote-B Systems

An area 10-deg wide by 2000-yards deep, located anywhere within 28,000 yards of the antenna, may be presented on the B-scope. Range is measured vertically, azimuth horizontally. Range markers representing range minus 1000 yards, target range, and range plus 1000 yards appear as horizontal lines across the scope face. Vertical markers indicate azimuth minus 1 deg, target azimuth, and azimuth plus 1 deg.

Approximately sixteen pictures of the B-scope area are made each second, depending on the drive motor speed, and each picture is composed of approximately 225 vertical scan lines. The range markers are generated by momentary intensity modulation of the tube at 1000-yard intervals during each range-sweep. Azimuth markers are generated by intensifying the tube during an entire range sweep. The range sweeps begin at the bottom of the scope, at a range corresponding to the tracking unit dial-reading minus 1000 yards. The center of the scope represents the dial readings of both the azimuth and the range tracking unit. Since the azimuth sweep starts at the left of the vertical centerline of the tube, the first range sweep for each picture is at the left of this center line, the next range sweep a little to the right of the first, etc. One range sweep is generated for each transmitted pulse.

The horizontal displacement of any range sweep depends on the displacement of the antenna beam at the moment the corresponding pulse is

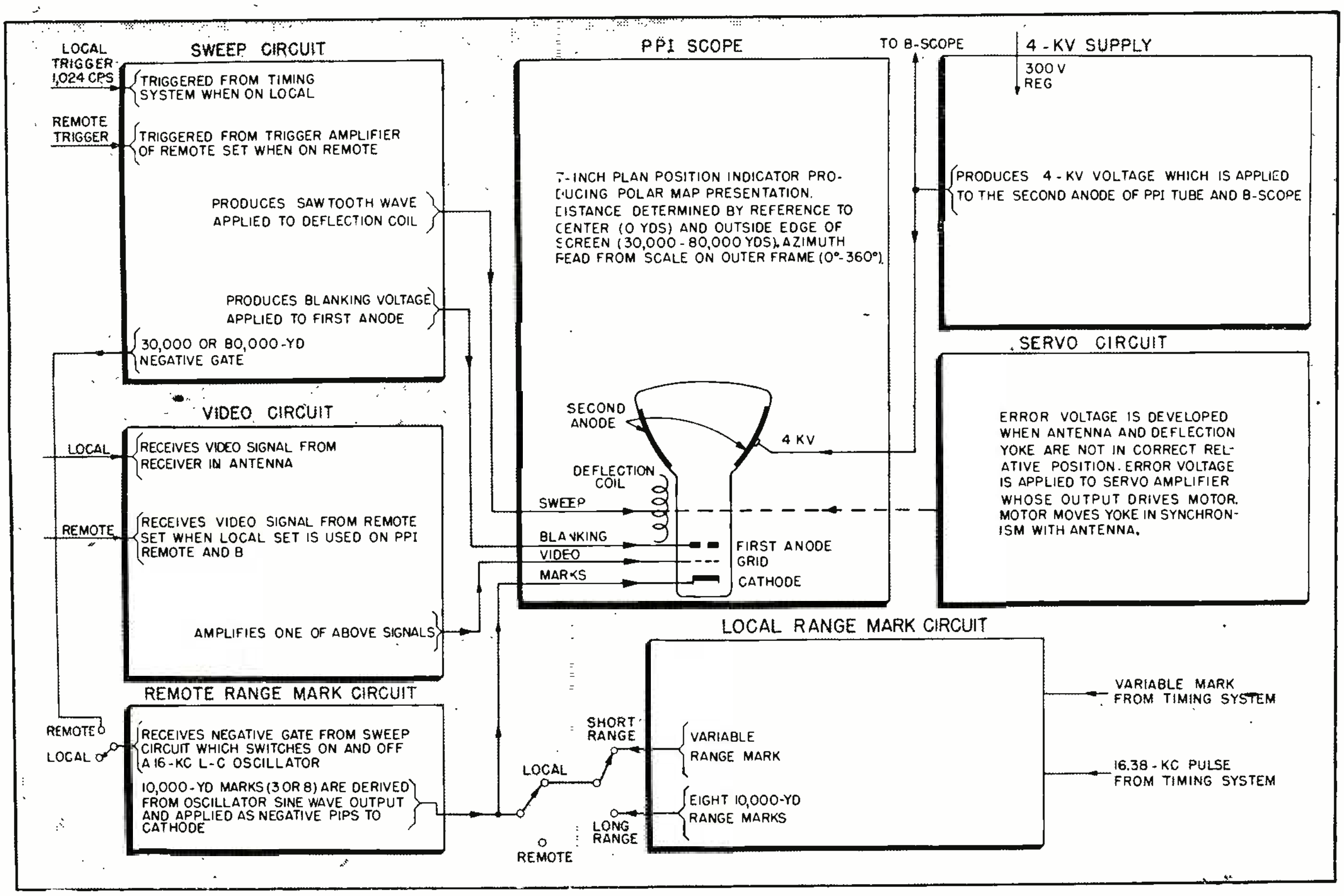


FIG. 8—Block diagram of ppi system. The deflection yoke is rotated mechanically about the neck of the cathode-ray tube, while intensity modulation imposes echo signals and range markers

transmitted. Maximum horizontal displacement is equivalent to 10 deg across the tube face, since this is the extent of the electrical scan as determined by the optics of the antenna. A tracking motion of the whole antenna assembly may take place independently of the antenna scan so that the 10 deg B-scope area may be moved in azimuth to follow a target.

To obtain an approximately distortionless map of the B-scope area, the horizontal and vertical scale factors are made equal to 400 yards per inch of scope face. This means that as the 2000-yard by 10-deg B-scope area is moved out in range, the horizontal linear distance across the tube face which represents 10 deg in azimuth must be expanded, since a chord subtended by a 10-deg central angle becomes longer as the radius is increased. Since the useful length of tube face is 5 inches, the full 10 deg in azimuth cannot be presented on expanded operation at ranges in excess of 12000 yards. It is possible to switch to normal B-presentation, in which 10 deg of azimuth just covers the tube face regardless of the range of the B-scope area. This type of operation is very useful when tracking close-in targets, since, on the "expanded" scope, the azimuth presentation would steadily approach zero width as the tracking unit dial reading approached zero yards. For close-in targets the normal scope aids considerably in identifying important features of vessels such as superstructure, fore and aft decks, etc.

A separate video channel capable of passing pulses having a rise time of less than 0.05 microsecond is provided in the B-scope circuits. Range and azimuth markers are mixed with echo signals in the early stages of the video channel and the limiting action is performed by the last stage. This arrangement prevents blooming

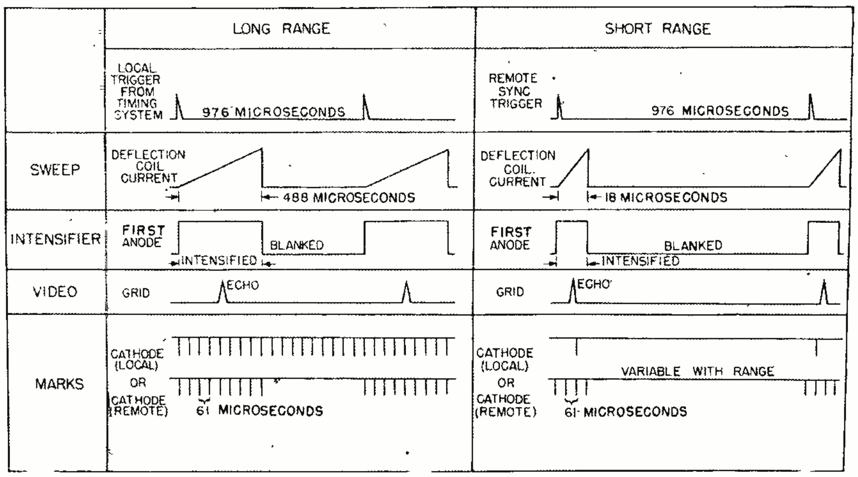


FIG. 9—Waveforms applied to the various electrodes of the ppi tube, for short-range and long-range indication

of the scope when markers cross or when targets fall on markers. The indicator tube cathode receives the negative mixed marker and signal voltages. Horizontal and vertical blanking information is applied to the control grid through a gated amplifier. The horizontal and vertical sweeps are applied to the common magnetic deflection yoke. Details of the indicator circuits are shown in Fig. 10.

The rotating feed drive, in addition to operating the antenna scan mechanism, also drives the azimuth blanking disc and azimuth mark disc as shown in Fig. 11. Both discs are interposed between a phototube and a source of light so that the phototube receives light only when the slotted portions of the discs are in the proper position. The azimuth mark disc has three slots cut in it. The object is to have the center slot in front of the light source when one of the antenna feed arms is at the center of the horn throat and to have one of the other slots in front of the light source when the feed arm is 8 deg to either side of the horn-throat center. Since the feed-arm displacement bears a ratio of 8:1 to the antenna-beam displacement, 1-deg azimuth marks can be generated by this arrangement. This 8:1 ratio, together with the fact that the discs are geared to rotate four times as fast as the feed-arm unit, necessitates a spacing of 32 deg between slots in the azimuth mark disc. The azimuth-mark generating circuits are triggered each time one of these slots is in front of the light source, and synchronization between the position of the slots and the displacement of the beam is effected mechanically through a gear train.

The azimuth sweep is generated by a circuit employing a variable capacitor the shaft of which is also geared to the rotating feed drive. This capacitor modulates the output of a 1-mc oscillator and the resulting waveform is rectified to produce a linear azimuth sweep voltage, the amplitude of which is proportional to the displacement of the antenna beam. See Fig. 12.

During the azimuth-sweep fly-back interval, the B-scope must be blanked

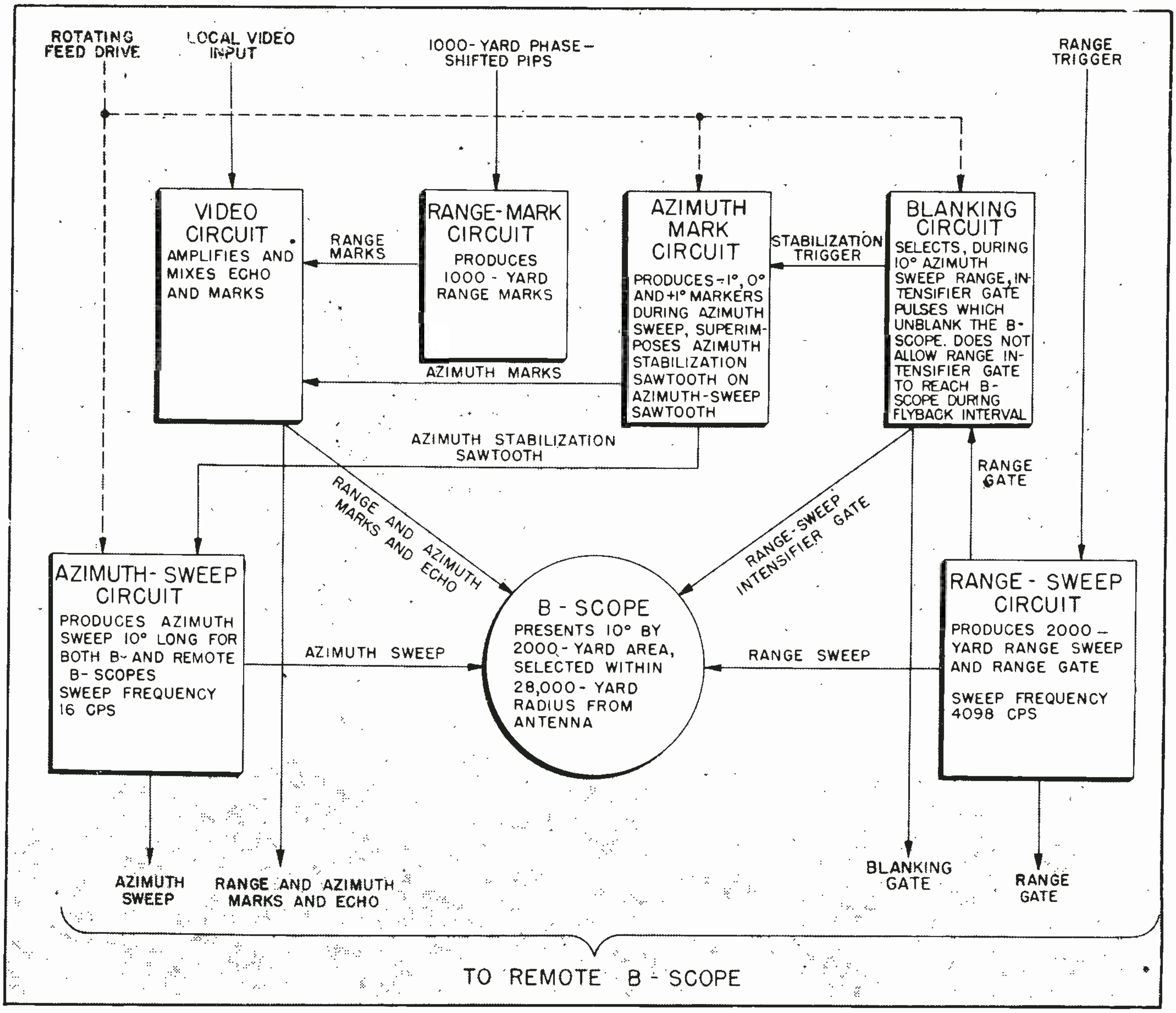


FIG. 10—Block diagram of elements of the B-scope system

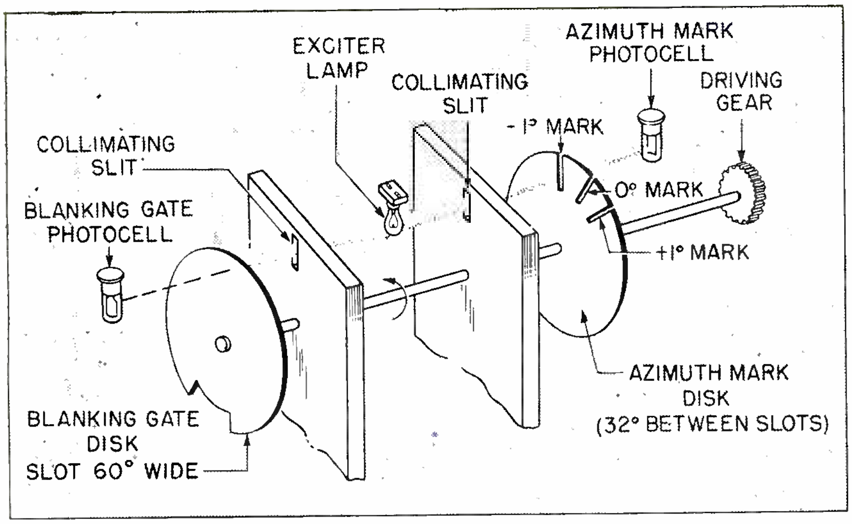


FIG. 11—Photo-mechanical system for producing azimuth marks and blanking pulses as antenna rotates

out to prevent a return trace from being seen. A blanking voltage is generated when the 60-deg slot in the blanking disc is in front of the light source. The 60-deg slot is sufficiently wide to cover the switching interval between adjacent antenna feed arms. When the blanking gate is off, intensifier gates synchronized with the range sweeps are applied to the B-scope grid. The intensifier gate raises the intensity level of the electron beam to a point at which the additional intensity due to a mark or video signal will result in modulation of the sweep. Between range sweeps the intensifier gate is off and the tube is blanked out. When the blanking gate is on, however, intensifier gates are prevented from being formed altogether, assuring that no signal will intensify the electron beam sufficiently to cause the azimuth-sweep return-trace to be seen.

Note that the azimuth marks are generated by a mechanical relation whereas the range sweeps are derived from a crystal-controlled sinewave. No synchronization exists here, and it is not certain that each mark will confine itself to the width of a range sweep and appear at the same point on the scope each time an azimuth sweep takes place. This would result in jittery marks. Therefore a circuit is provided which halts the left-to-right progression of the electron beam each time an azimuth mark appears. The electron beam is held stationary just long enough for a range sweep to arrive; then this range sweep is intensified and forms the azimuth marker on the scope.

From the B-indicating system the remote-B system receives azimuth sweep combined with stabilization, video information (marks and signal), azimuth blanking and range gate voltages. The remaining circuits of the remote-B system are similar to corresponding circuits in the B-system. A mechanism is provided in the remote-B system so that an operator who places cursors over the center of impact of shell-splash signals can read range and azimuth deviations on dials and telephone firing corrections which will assist in placing the center of impact of succeeding rounds over the target. An auxiliary attachment computes range corrections in terms of percentage of present target range.

A long range version of the AN/MPG-1 is now developed which makes use of the same major components including aided tracking machines for range and azimuth, but is intended for fixed harbor defense installations. The tracking range is extended to 50,000 yards and the pulse recurrence rate is reduced to allow for a longer pulse transit time. There is no change in range or azimuth accuracy. Tower and trailer are not provided. The number of vacuum tubes used in this system (approximately 210) is the same as the AN/MPG-1. The weight of the operating components, including the power plant, is approximately 8200 pounds. It is expected that a version of this set will find considerable peace-time use as a traffic-control radar for harbors. Ships which have no radar of their own can be "talked up the channel" during bad visibility.

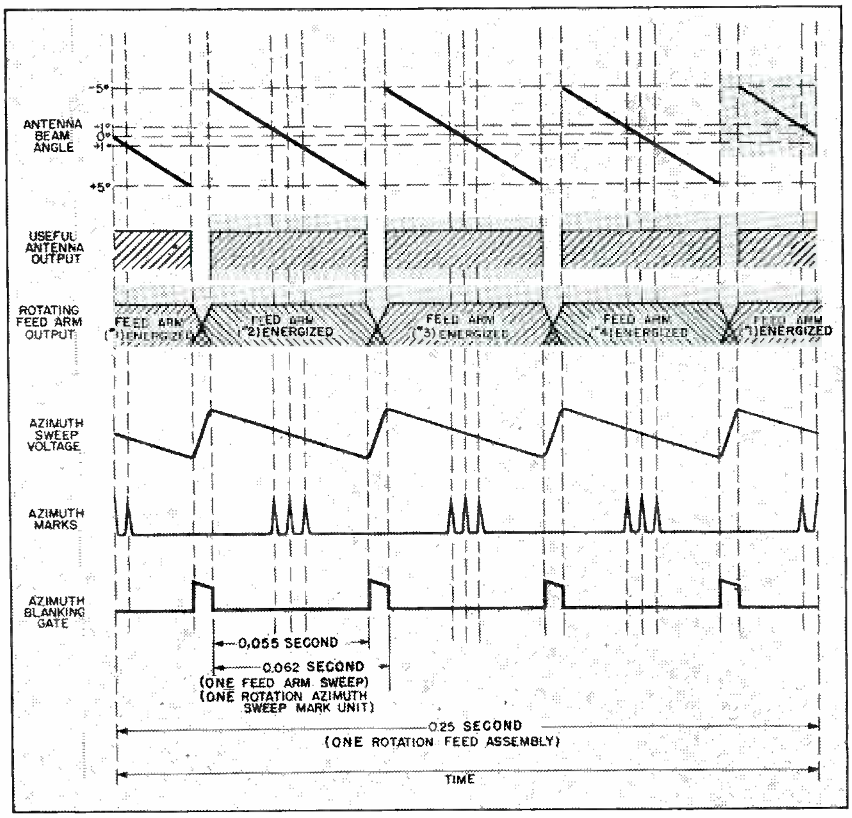
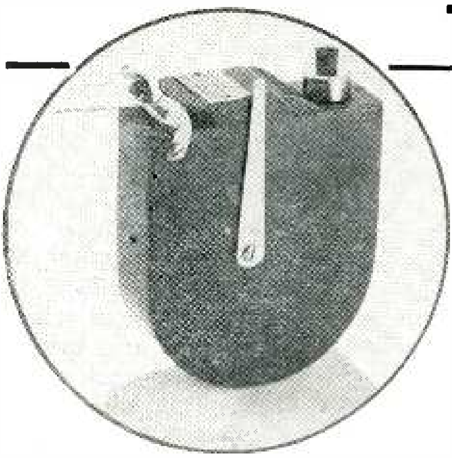


FIG. 12—Timing coordination between antenna rotation and azimuth-marking and blanking waveforms

Electrodynamic DIRECT-INKING PEN



Single direct-inking pen unit employing the design features described in this article

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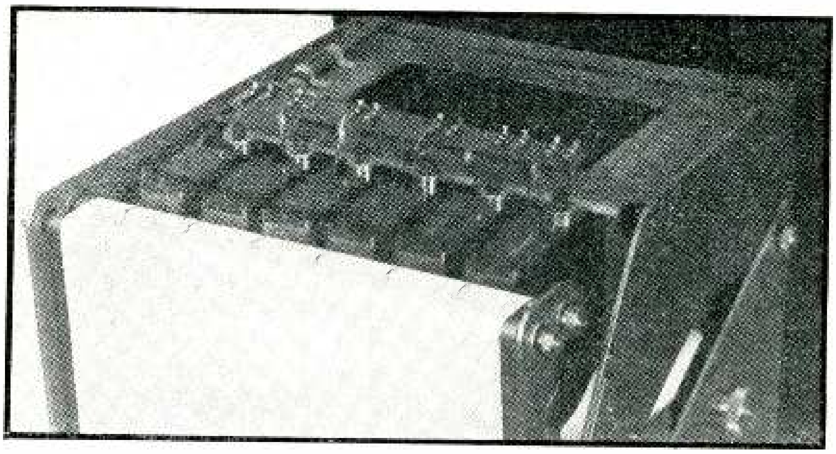

Six-channel recorder employing the new pen units, all energized here with identical voltages for demonstration purposes

THE moving-coil pen to be discussed gives high-speed records of transients directly inked on a moving paper chart. The final pen design will write with good fidelity from d-c up to more than 100 cps, as indicated by the frequency response curve in Fig. 1. It is compact enough to permit placing several units side by side with 1.75-inch spacing so that multichannel recorders can easily be constructed.

Design Criterions

The design goals for producing a practical recorder that combines the ultimate in speed, accuracy, and sensitivity are:

(1) High speed for wide frequency response.

(2) Linear phase shift for good reproduction of wave shapes.

(3) Critical damping (no overshoot) for sudden changes in wave shape.

(4) Optimum housing dimensions for multichannel use.

(5) High sensitivity.

(6) Light weight.

At first glance, it would appear that a mirror galvanometer recording on film would satisfy the above requirements; and it does. However, it is frequently necessary to observe phenomena at the time of occurrence. With the added disadvantage of film processing, the light beam on film is barred from use in a great many applications.

It is often necessary to record continuous records for long periods of time. This also would bar the use of film unless complex automatic film development schemes are used.

For the immediate reproduction of signals, we are then committed to the direct recorder. Direct recording can be done in any one of three ways: (1) direct inking; (2) wax paper; (3) chemical paper. All three methods are usable, but for simplicity, permanence, and low cost, the direct-inking scheme still appears as the most feasible.

Lightweight recorders can be built using electromagnetic driving means. In this case, the flux in the air gap is varied and the force is developed between the iron vane and the pole pieces. For good linearity, however, only small angular rotations can be obtained and lever step-up systems are required. The coupling between the electrical and mechanical side in these systems is usually so small that mechanical damping must be used. The dual drawbacks of using the lever and mechanical damping have proved to be a strong obstacle in the practical design of electromagnetic direct-inking pens.

Choice of Drive for Pen

The dynamic drive, i.e., a moving coil in a uniform magnetic field, appears to be a more suitable approach. With high flux density in the field, it has been possible to design the pen so that no mechanical damping is required and good linearity with good transient response is obtained.

Use of a doubly resonant system

Mathematical analysis, choice of drive, constructional details, and performance curves of a high-speed unit capable of inking wave forms of transients directly on a moving paper chart. Response is essentially flat from zero up to 100 cps

allows extension of the high-frequency range. An analysis will first be made of a simple resonant system, followed by the calculations of the more complex system, with a comparison of the theoretically computed response and the one actually obtained.

Construction of Pen

In order to obtain optimum results, the writing pen obviously should be as long and lightweight as possible, with sufficient rigidity to produce linear deflections at the highest accelerations required. The pen used in this unit, shown in Fig. 2, is designed for the best compromise between light weight and stiffness. It is this pen that determines the parameters of the system.

A given force is required to drive the pen at a given amplitude at a given frequency. By way of example, suppose it is necessary to reproduce a sine wave at 100 cps with a peak amplitude of 0.5 inch. The acceleration at the pen tip then is $(2\pi f)^2 A = 4\pi^2 \times 10^4 \times 0.5 \times 1/12 = 16{,}500$ ft per sec², or approximately 510 G's.

The strength of the pen is thus a limiting factor for the reproduction of the high frequencies. It is this pen, then, which limited the goal of the present design to approximately 100 cps.

Singly Resonant System

Let us examine a simple system in order to estimate properly the limiting parameters. Assume that the pen is rigidly clamped to the moving coil (C_2 in Fig. 2 has zero compliance) and the whole system is suspended in the magnetic field on a straight length of music wire C_1. The equations of motion can be derived for this system.

Although all the motions are rotary around a pivot, the equations will be written with all the forces and impedances acting at the radius of the coil, 0.3 inches from the pivot. Thus, the equation will be written to represent the pen M_2 as if all its mass were acting at the rotary circumference of the driving coil.

If a voltage E from a zero-impedance source is placed across the electrical terminals of the coil in the magnetic field, then in the steady state case

$$E = Ri + Blv \qquad (1)$$

where R = electrical resistance of coil (ohms)
i = current (amperes)
B = flux density of gap (webers)
l = effective length of coiled wire (meters)
v = velocity of coil along circumference of pivoted coil (meters per sec)

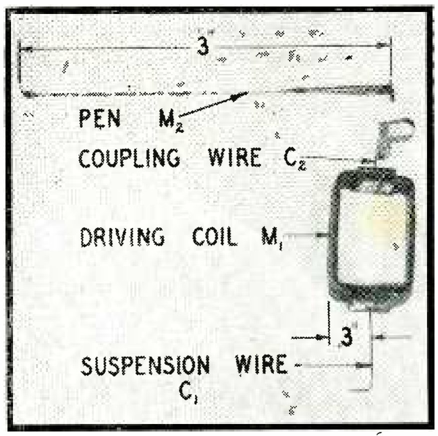

FIG. 2—Final design of writing pen and moving coil

This equation defines the relationship whereby the voltage must equal the iR drop plus the back emf (Blv) of the moving coil.

On the mechanical side, the generated force due to the current i must equal the mechanical reactance multiplied by the velocity, or

$$Bli = Z_m v \qquad (2)$$

where Z_m = mechanical impedance of coil, pen, and wire.

These two equations, for a given set of parameters, define the complex current in the coil and its complex velocity when a voltage is applied at the terminals of the coil. The frictional resistance at the pen tip is small, hence

$$Z_m = j\omega (M_1 + M_2) + 1/j\omega C_1 \qquad (3)$$

where $M_t = M_1 + M_2$ = effective mass of pen and coil at circumference of coil (kilograms)
C_1 = compliance of wire suspension in meters per newton (1 newton = 10^5 dynes)

Substituting Eq. 3 in Eq. 2,

$$Bli = \left(j\omega M_t + \frac{1}{j\omega C_1}\right) v \qquad (4)$$

Eliminating i from Eq. 1 and 4 and

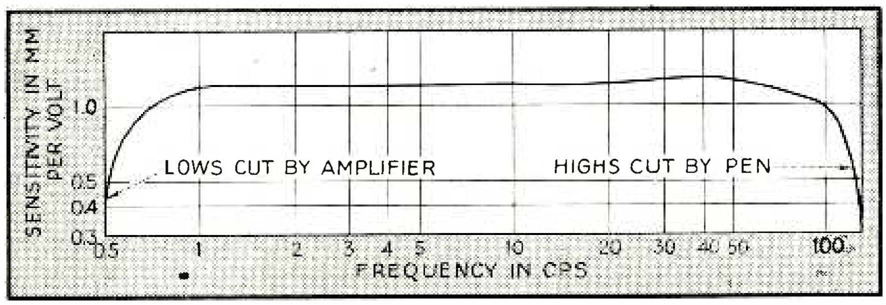

FIG. 1—Frequency response of high-speed direct-inking pen and amplifier

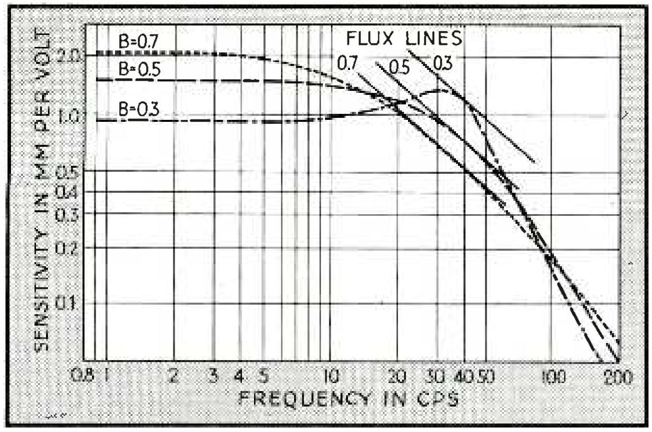

FIG. 3—Calculated response of the singly resonant system for constant mechanical impedance and varying flux density

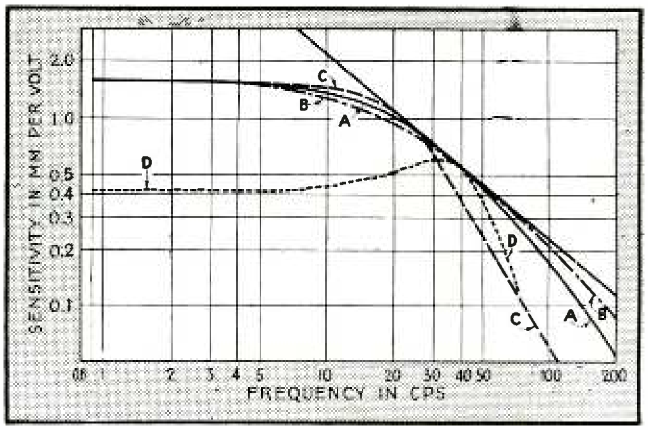

FIG. 4—Effect of varying mechanical impedances on sensitivity for a constant flux density of 0.6 weber

solving for the velocity of the coil gives

$$v = \frac{E\,Bl}{R\left(j\omega M_t + \frac{1}{j\omega C_1}\right) + B^2l^2} \qquad (5)$$

Because $v = dA/dt$, where A is the displacement, then $v = j\omega A$ for sinusoidal motions, or

$$A = -jE\left(\frac{Bl}{\frac{R}{jC_1} + j\omega^2 RM_t + \omega B^2l^2}\right) \qquad (6)$$

Thus, the amplitude of motion is described as a function of the parameters of the system.

Figure 3 shows the predicted performance when M_t, C_1, E, and l are kept constant and only the flux density B is varied.

At low frequencies (ω approaches 0), Eq. 6 becomes

$$A = E\,C_1Bl/R \qquad (7)$$

Sensitivity at low frequencies is thus proportional to flux density B and compliance C_1, and is flat with frequency down to zero or d-c. This is clearly shown in Fig. 3.

At the mechanical resonance of the system, ($\omega^2 = 1/M_tC_1$), Eq. 6 simplifies to

$$A = -jE/\omega Bl \qquad (8)$$

Thus, the amplitude at resonance is determined solely by the frequency and the flux density. Therefore, if the mechanical resonant frequency is kept constant, the amplitude at resonance is actually inversely proportional to the flux density. In the curves drawn in Fig. 3, the mechanical resonance occurs at 38 cycles. Note that for the higher flux density the amplitude of response is actually decreased.

This limiting effect of the locus line defined by Eq. 8 is demonstrated in Fig. 4. The mechanical impedances are varied but the flux density is kept constant at 0.6 weber (1 weber = 10^4 gauss). Curve A, obtained for pen motion when M_t and C_1 are kept at the normal values, is tangent to the slope line at 38 cps. Curve B is obtained by arbitrarily cutting the value of M_t in half. The resonant frequency is now 53 cps but the curve is still tangent to the slope line. Curve C is obtained by doubling the mass M_t. Resonance now occurs at 27 cps, but is again limited by the slope line. Curve D is for M_t doubled and C_1 cut to one-fourth its normal value. The four curves thus show that despite violent changes in mechanical impedances, the amplitude at resonance is always limited by the locus line. This is logical because at resonance the mechanical impedance approaches zero, and it is only this flux density which can limit the motion by its generated back emf.

Doubly Resonant System

It can be seen from Fig. 3 that a decrease in flux density allows an extension of the flat frequency response at the expense of obtaining an underdamped system. It is possible to break across this locus line boundary by using a doubly resonant system. The compliance C_2 is inserted between the pen M_2 and the coil M_1, as shown in Fig. 2. The equations of motion now become

$$E = Ri + Blv_1 + (0)v_2 \qquad (9)$$

$$0 = -Bli + \left(j\omega M_t + \frac{1}{j\omega C_1}\right)v_1 - j\omega M_2v_2 \qquad (10)$$

$$0 = (0)i - j\omega M_2v_1 + \left(j\omega M_2 + \frac{1}{j\omega C_2}\right)v_2 \qquad (11)$$

where v_1 = circumferential velocity of coil
v_2 = velocity of pen referred to coil radius

Equation 9 is the same as Eq. 1 and is derived in the same manner. Equation 10 states that the force generated in the coil, Bli, must equal the mechanical force required by the moving coil plus the force required to move the pen M_2. The pen velocity v_2, depending on its phase, will either add to or subtract from the mechanical force. Equation 11 defines the mechanical equilibrium conditions if no current flowed in the coil. The two masses at their respective relative velocities must be in balance.

Solving for v_2, which is the velocity of the pen and of main interest, and resolving v_2 to A_2, the amplitude of the pen is

$$A_2 = \frac{-jE\,Bl}{\left[jR\omega^2(M_1+M_2) + \frac{R}{jC_1}\right](1-\omega^2M_2C_2) + \omega B^2l^2(1-\omega^2M_2C_2) + jR\omega^4M_2^2C_2} \qquad (12)$$

At low frequencies (ω approaches 0), Eq. 12 yields

$$A_2 = E\,BlC_1/R \qquad (13)$$

Thus, there is no change in low-frequency amplitude sensitivity.

At the resonant frequency between C_2 and $M_1 + M_2 = M_t$,

$$A_2 = \frac{-jEBl}{\omega B^2l^2(1-\omega^2M_2C_2) + jR\omega^4M_2^2C_2} \qquad (14)$$

Here it is seen that the response can break across the boundary line of the flux locus. In the denominator, the parameters M_2 and C_2 can be adjusted independently so that the amplitude at resonance is essentially the same as that for the low frequency. This gives an extension of the flatness of response.

At the resonant frequency of M_2 and C_2 (where $1 - \omega^2 M_2 C_2 = 0$),

$$A_2 = \frac{-EBl}{R\omega^4 M_2^2 C_2} \qquad (15)$$

Since $\omega^4 = 1/M_2^2 C_2^2$

$$A_2 = -EBlC_2/R \qquad (16)$$

By selecting M_2 and C_2 in correct proportions, a system can be designed to give the most desirable response.

For the actual design of the moving-coil pen, the following values (arbitrarily referred to 0.3-inch radius) were selected:

M_1	= 2.25 grams	= 0.00225 kg
M_2	= 2.25 grams	= 0.00225 kg
C_1	= 4×10^{-6} cm/dyne	= 4×10^{-3} meters/newton
C_2	= 1.5×10^{-6} cm/dyne	= 1.5×10^{-3} meters/newton
B	= 6000 gauss	= 0.6 weber
l	= 10,700 cm	= 107 meters
R	= 1,450 ohms	= 1,450 ohms

When the mks values (right-hand column) are inserted in Eq. 12, the frequency response shown in Fig. 5 is obtained. The theoretical curve is in excellent agreement with the actual curve obtained.

Note that the response at 100 cps is not brought to the full sensitivity of the low frequencies. The reasons for designing the pen motor this way are threefold:

(1) A careful examination of Eq. 12 and a few trial calculations show that as C_2 is made softer and the amplitude of the second resonance (90 cycles) is brought up, the amplitude at the first resonance is increased in accordance with Eq. 14. This can be carried to the point where an undesirable peak in the displacement occurs at the first resonance.

(2) By requiring amplifier compensation at high frequencies, it is possible to limit the voltages applied at high frequencies to such values that no pen breakage occurs. Thus the amplitudes and consequent accelerations of the pen are limited to safe values by the automatic overload of the amplifier at high frequencies.

(3) The values selected yield a more linear relation between phase shift and frequency. This is an important consideration for reproduction of transient wave shapes.

Power Requirements

The power requirement is low. Thus, for 2-inch peak-to-peak displacement at the pen tip, the voltage required at low frequencies is, from Eq. 7

$$E = A_2 R/BlC_1 \qquad (17)$$

Remembering that 2 inches (for a 3-inch pen) reflected at the coil is 0.2-inch displacement and converting to mks units

$$E = \frac{(0.2/2.8) \times 0.025 \times 1{,}450}{0.6 \times 107 \times 4 \times 10^{-3}} = 14.5 \text{ volts rms}$$

$$\text{Power} = (E^2/R) = (14.5^2/1450) = 0.145 \text{ watt}$$

Transient Response

For reproduction of transients, it is necessary to have linear phase shift and critical damping at cutoff in addition to flat frequency response. Figure 6 shows the variation of phase shift with frequency for four of the singly resonant systems and for the finally designed doubly resonant system.

The singly resonant systems are severely limited in phase shift linearity to about 50 cps. An optimum flux density for linear phase shift for the singly resonant system occurs for curve C, for which B is 0.4 weber.

Curve E is the phase shift for the doubly resonant system with the design values as given above. Here the improvement in linearity of phase shift is marked and extends up to 150 cps. The S-shaped curve indicates a slightly overdamped condition. This selection is made to correct for the internal impedance of the driving amplifier. In Eq. 12, R is defined as the resistance of the coil. Actually the value of R should be increased to include the resistance component of the internal impedance of the amplifier. This effectively results in a decrease of the damping effect of the flux.

In actual practice it was found that the amplifier could have an internal impedance of 250 ohms (compared with 1,450 ohms for the coil) without materially affecting the critical damping and linear phase shift requirement. Figure 7 shows the performance of the pen when square-wave signals are applied.

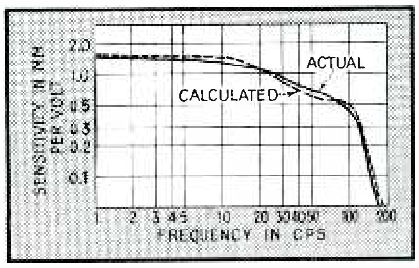

FIG. 5—Comparison of calculated and actual frequency response of the doubly resonant system

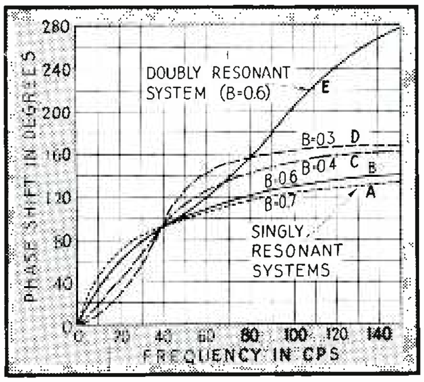

FIG. 6—Variation of phase shift with frequency for singly and doubly resonant systems

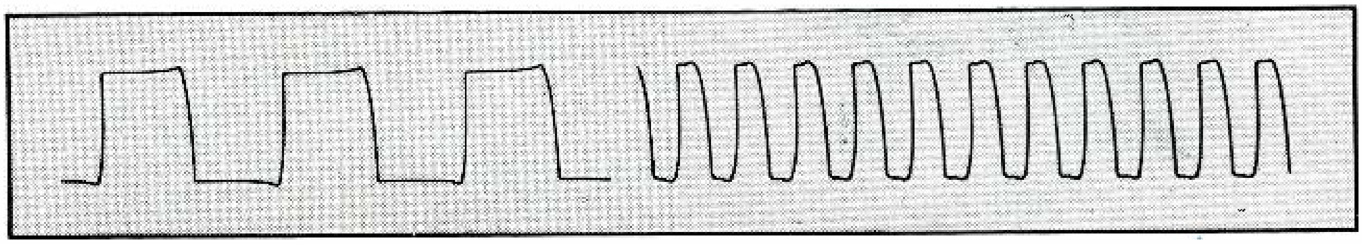

FIG. 7—Actual-size reproductions of tracings made with the new pen for 5 and 15 cps square-wave input voltages and a paper speed of 10 cm per sec

FUEL CONSUMPTION

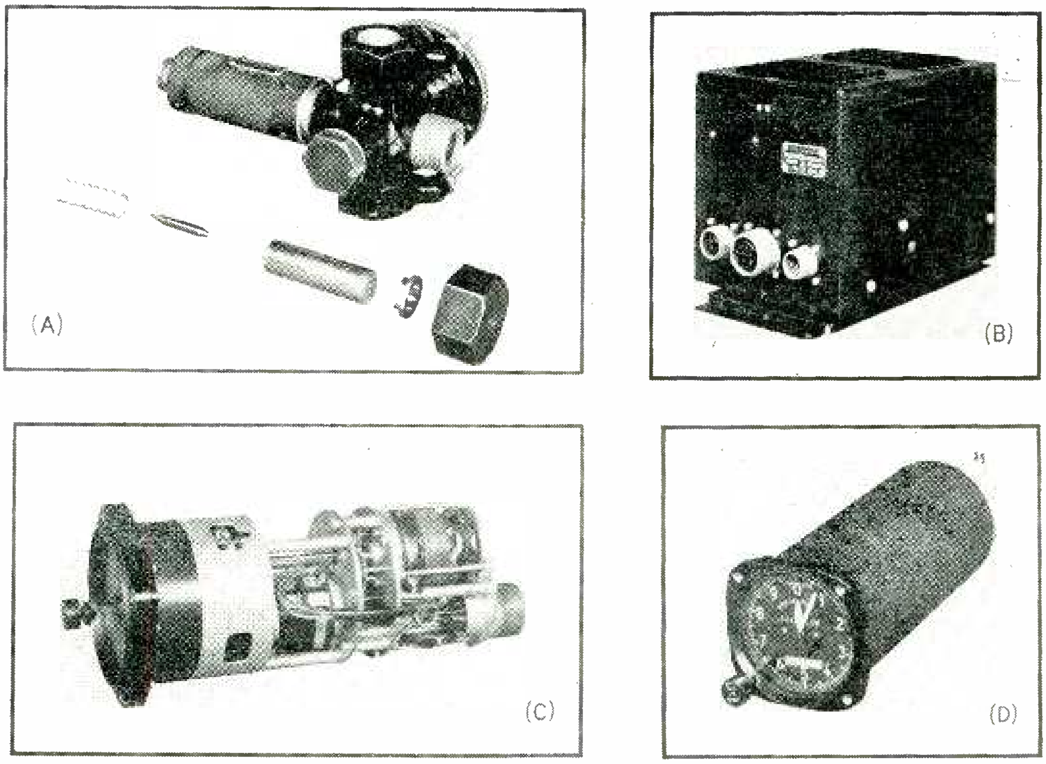

FIG. 1—Parts comprising the fuel-flow indicator and integrator. (A) The mechanical flow-valve with position transmitter at left. (B) Shock-mounted chassis containing vacuum tubes and other electronic components. (C) Interior of indicator-integrator instrument, showing one of the small motors and the precision potentiometer. (D) Aircraft-type indicator shows fuel flow up to 2,000 pounds per hour in easily read increments of ten pounds. Total consumed is displayed on the inset counter mechanism

ACCURATE MEASUREMENT of fuel consumption on large aircraft is important because of the great amount used. Small percentage errors mean substantial losses in pay load. For military operations, it is desirable to integrate over the period of flight the amount of fuel consumed so that the remainder may be accurately estimated from a knowledge of the initial amount before takeoff, neglecting leakage.

The instrument parts shown in Fig. 1 comprise an electronic fuel-flow meter and integrator designed for the Air Forces to fill a vital need in the B-29 program. The instrument consists of a transmitter (A) which measures the flow of fuel and converts this into a mechanical position, an indicator (C and D) which remotely displays this mechanical position in a manner most convenient to the pilot, and an integrator, which is also a part of the indicator, to sum up the amount of fuel consumed. An electronic chassis (B) contains the necessary tubes and other remaining components.

Necessity for an Electronic System

The accuracy of position transmission must be at least two percent of the actual position at one-tenth of the maximum motion. In the instrument, the maximum mechanical motion corresponds to a fuel flow of two thousand pounds per hour. The requirements, then, call for an accuracy of forty pounds an hour at full scale (two thousand pounds), and an accuracy of four pounds at two hundred pounds per hour, or one-tenth of full scale. As no mechanical or electrical position-transmission system was known which possessed these requirements, an electronically powered servo was utilized.

The mechanical motion of the fuel-flow transmitter is used to operate an inductance element of a resistance-balanced inductance bridge. The electrical output of the bridge excites an electronic amplifier which supplies power to a small two-phase induction motor which balances the bridge by varying the resistance elements. The indicating hands are geared to this resistance element, the position of which is a function of the inductance position, and therefore of the flow of fuel through the transmitter. The use of electronic means here provided satisfactory sensitivities.

100-cps Time Standard for Integration

A constant-speed time standard was necessary, however, to drive this mechanical integrator. Here the accuracy requirement was again rather stringent, the time base having to be true within at least one percent. The size of the indicator precluded the use of any type of mechanical governor known, so once

INDICATOR

Electronic servo transmits the position of an aircraft fuel-flow valve to a remote indicator. A mechanical integrator combines this information with impulses from a 100-cps time standard to totalize the liquid flow. Device is applicable to industrial telemetering problems

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again electronics was called to the rescue.

A stabilized one-hundred-cycle oscillator is employed to power a small synchronous motor which in turn acts as the constant speed drive for the mechanical integrator. This oscillator is easily maintained within one percent throughout the normal aircraft temperature variations, and has proved to be most satisfactory as a solution to this problem.

Mechanical Device Operates Counter

Figure 1C shows the interior of the indicator, including one of the two motors which drive the potentiometer used to balance the inductance bridge and the integrator.

The mechanical integrator is in the space just to the rear of the dial and is the conventional picker type which is easy to manufacture and keep in operation. In this type of integrator a ratchet pawl is driven at constant speed by the synchronous motor around a ratchet wheel which has a suitable number of teeth for the accuracy required. The number of teeth that the pawl picks up on each rotation is a function of the fuel flow, so that the resulting rotation of the ratchet wheel may be geared to a suitable counter to indicate the total fuel consumed. This counter may be seen on the dial of the indicator in Fig. 1D.

Conventional Circuits Insure Accuracy

Figure 2 is a schematic circuit drawing of the whole system. Special care is taken to insure that the bridge is balanced for the fundamental at all portions of the scale to insure freedom from errors due to fundamental phase shifts arising from temperature changes. The bridge shown is used because it permits three-wire connection to the transmitter mounted on the engines. It also uses as the balancing element a precision potentiometer which can be wound to any desired curve to provide the exactly linear scale which is required when a sweep pointer and integrator are used.

The calibration accuracy of this instrument is within ten pounds of fuel flow per hour everywhere on the scale, all points of which are within one dial graduation. The totalizer performs well, being adjusted to compensate partially for the small errors of the meter itself. Overall errors throughout the cruising range are thus much less than one percent.

Commercial Applications

This instrument has been a most interesting development because the arts of mechanics, hydraulics, electricity, and electronics were all brought into play. It is a typical application of electronic techniques to industrial problems and indicates a probable trend in meeting certain commercial telemetering requirements.

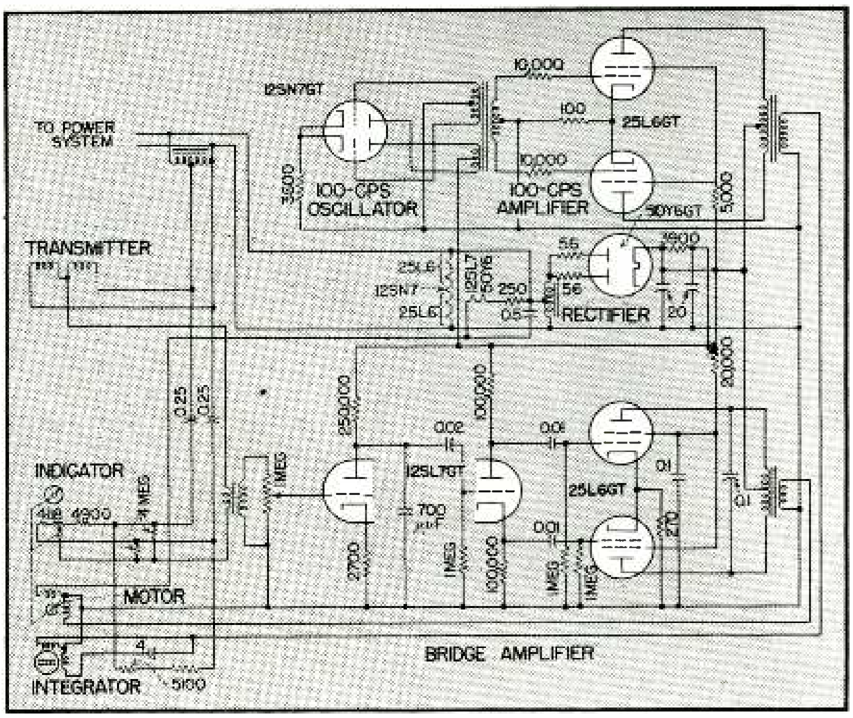


FIG. 2—Schematic circuit diagram of the electronic components and their connections to the servo mechanisms. The 100-cps oscillator and amplifier at the top furnish a time standard for the integrator. Three tubes below form part of the indicator bridge circuit. The transmitter is mounted on the aircraft engine and the indicator convenient to the pilot

Superregenerative

Experimental determination of characteristics of a superregenerative detector indicates that selectivity and sensitivity increase and noise decreases with decreasing quench frequency. Selectivity decreases with increasing quench amplitude

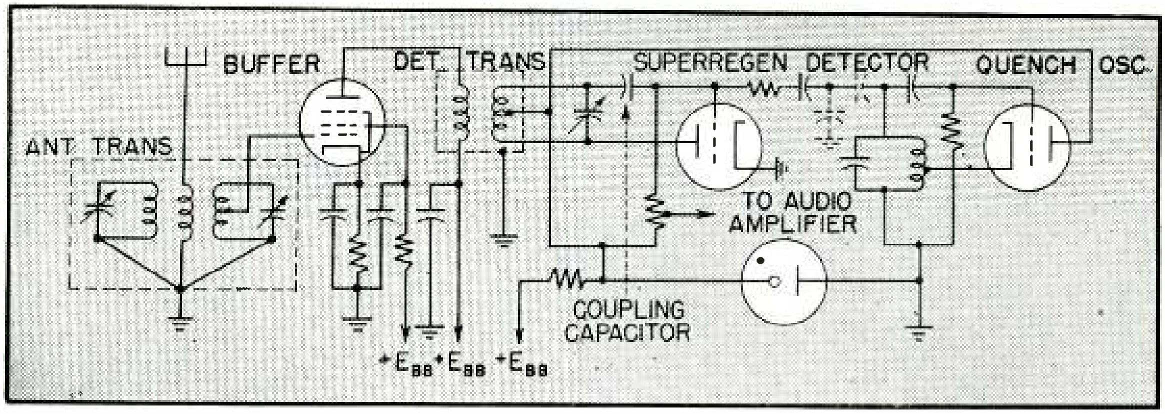


FIG. 1—Circuit of superregenerative receiver upon which tests were made. Dotted capacitors were added later to decrease bandwidth by reducing quench amplitude to the detector tube

By ALLAN EASTON

Special Products Division
Emerson Radio and Phonograph Corp.

THIS PAPER describes an experiment dealing with the effect of some circuit parameters on the selectivity characteristic of a superregenerative detector. Data is presented and some conclusions discussed, along with a brief qualitative explanation of the reasons underlying the observed phenomena.

The author was confronted with the problem that on a superregenerative receiver, designed and placed in production, it was found necessary to tighten the selectivity specification.

Receiver Circuit

The circuit diagram of the receiver is shown as Fig. 1. Components essential to the discussion are shown in detail. The receiver consisted of five basic parts: (1) selective antenna transformer; (2) buffer amplifier tube for reduction of reradiation; (3) superregenerative detector; (4) external sinusoidal quench oscillator; (5) audio amplifier.

The oscillator circuit which performs the superregenerative function is a conventional Hartley oscillator, with the tank connected between grid and plate of the tube. The frequency of operation is in the one hundred megacycle range. The sinusoidal quench voltage is impressed on the grid of the detector through a large resistance. The audio output voltage is taken from the grid circuit.

Selectivity Measurements

Several samples of the production receiver were carefully aligned and the selectivity measured. The curve of Fig. 2 labeled Typical Set represents this measured selectivity. The required selectivity dictated by the revised specification, and the selectivity obtained as a result of this investigation are also shown. Study of the obtained selectivity curve indicates plenty of leeway for production variations.

It was first necessary to ascertain the individual contribution of each stage to the total selectivity characteristic. The bandwidth of the detector alone was determined in the usual manner. A standard signal generator was connected to the grid of the r-f amplifier and the changes in frequency required to restore standard output for input voltage ratios of 2, 10, 100, and 1000 times the resonant value were observed. Figure 3 shows a plot of the overall selectivity of the typical set as shown on Fig. 2. The selectivity characteristic of the detector alone, and the bandwidth of the antenna transformer alone are also shown. The data for the antenna transformer curve was obtained by impressing a signal voltage, whose frequency was varied, across the antenna terminals and measuring the voltage appearing at the grid of the r-f buffer.

With this selectivity information, the following requirements were recognized as essential to improving the selectivity: (1) antenna coil selectivity might be sharpened; (2) leakage, if any, around the antenna coil could be reduced to obtain full benefit of the antenna coil selectivity; (3) the superregenerative detector selectivity might be increased to carry the entire selectivity specification by itself.

Several attempts were made to sharpen the antenna transformer selectivity. The grid tap of the antenna transformer was shifted to obtain the optimum position, higher-*Q*

Detector Selectivity

coils were tried, and the coupling was altered. Some improvements were realized in the transformer characteristic but the overall selectivity was not appreciably changed.

Experiment indicated definitely that while leakage broadened the selectivity curve slightly it was not a controlling factor.

Detector Selectivity

Next, factors affecting detector selectivity were studied. The design of the detector transformer was changed. The plate coupling coil was moved away from the grid winding. This change seemed to reduce loading on the grid winding, thereby increasing the Q. Selectivity improved somewhat, but the sensitivity declined. Oscillator excitation was decreased by changing the tap on the detector coil. This, in effect, reduced the negative resistance, resulting in increased Q. The selectivity at an input voltage ratio of 100 was 3.0 percent, compared with 3.5 percent previously observed. Again, however, sensitivity was decreased, this time by a factor of 10.

In order to study the effects of quench frequency and quench amplitude upon selectivity, apparatus was connected as indicated in the block diagram of Fig. 4. The quench frequency was varied over wide limits for several values of quench amplitude, and the bandwidth of the detector stage alone was measured. The results are shown in Fig. 5A. These curves are convincing evidence that selectivity is greatly influenced by both quench frequency and quench amplitude. The selectivity may be controlled over a five to one range by these parameters.

Figure 5B indicates a definite reduction in noise output as quench frequency is lowered. The usable sensitivity is much improved, and the signal to noise ratio, under these conditions, is higher. Figure 5C shows how detector sensitivity depends on quench frequency.

Figure 6 is a plot of detector bandwidth versus quench amplitude. The quench frequency was 60 kc. The data was taken at both ends of the carrier frequency band, that is at 50 and at 100 mc. The optimum value of quench frequency is roughly proportional to the carrier frequency. Bandwidth was measured where the required input signal was 100 times that at resonance for the same signal output in all bandwidth measurements.

Study of the various curves shows that best bandwidth is obtained with about a 50-kc quench frequency and two to three volts quench amplitude.

The production receiver was altered to accomplish the recommended changes. The original receivers used a quench frequency of 150 kc at 9.5 volts amplitude. These values had been chosen because the sensitivity and selectivity were least affected by small changes in quench constants. The change consisted of increasing the size of the quench oscillator tank capacitor, inserting an iron core to increase the quench oscillator coil inductance, and reducing the quench amplitude by using a capacitance divider across the tank.

Effect of Strong Signals

Further tests on the production receiver indicated that detuning occurred when the input voltage was increased. This phenomenon is characteristic of oscillators with intermittent or pulsed modulation. When the duty cycle of the modulating pulse voltage is changed, there is a corresponding frequency shift in the

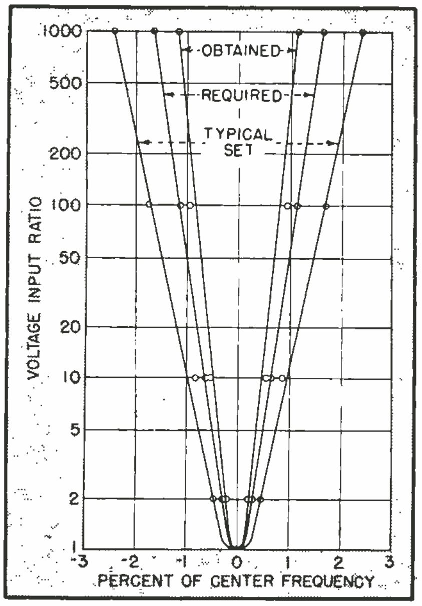


FIG. 2—Measured selectivities of superregenerative receiver

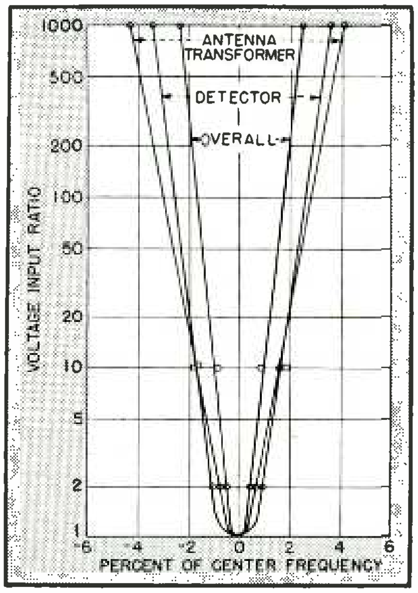


FIG. 3—Circuit contributions to receiver selectivity

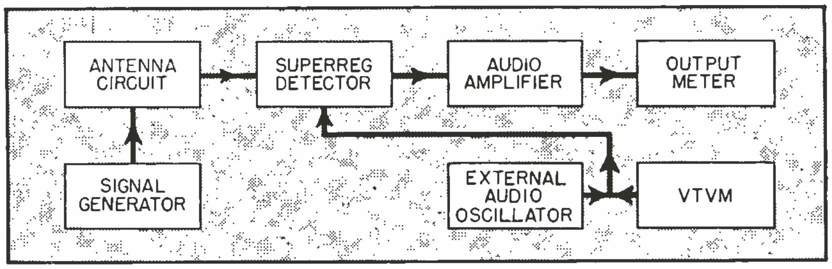


FIG. 4—Basic laboratory circuit used to study the effects on superregenerative detector of quench frequency and amplitude, and signal strength

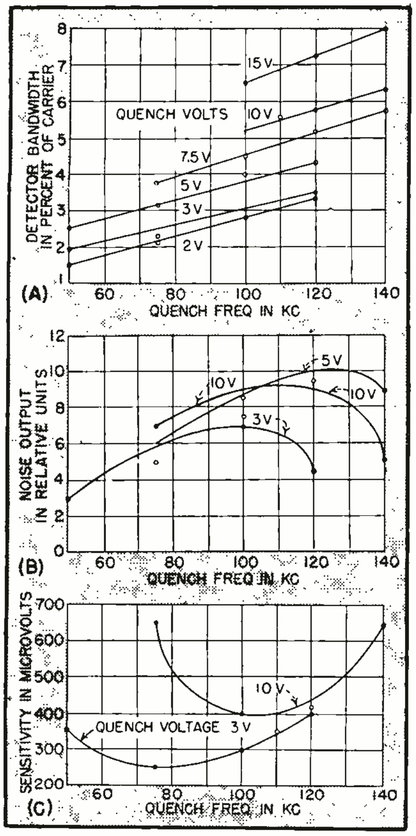


FIG. 5—Quench frequency affects detector bandwidth (A), detector noise output (B), and detector sensitivity (C)

oscillator. This shift, in effect, reduces the selectivity as measured by the interfering signal method. The percentage detuning was as much as 1.25 percent of carrier frequency as the input was increased from 50 to 20,000 microvolts, meaning that a receiver which passed a static selectivity test would probably fail when given a dynamic selectivity test.

A simplified equivalent circuit is shown in Fig. 7 along with some other tabulated data. Several sizes of coupling capacitor were installed in order to study the effect of decoupling the variable resistance presented by the oscillator tube from the tank circuit. For each size of coupling capacitor indicated, the following steps were taken.

The receiver was tuned to resonance with about 50 microvolts input and the carrier frequency for maximum audio output observed. The input was raised to 20,000 microvolts and the audio output measured without retuning. The first column shows the capacitance used. The second column shows the audio output variation versus coupling capacitor size to be as much as 4.5 to 1. The signal generator was retuned to obtain maximum audio output and again the audio measured. The third column shows this data. Observe that the audio output was nearly doubled by retuning.

The increment of frequency required to retune was recorded in column four. The detuning varied from 0.43 percent to 1.25 percent depending upon the size of the capacitor. The bandwidth was measured for each size of capacitor; results are tabulated in the last column. The bandwidth changed almost 2 to 1. Our conclusion is that the smaller the capacitor, the lighter the loading, and thus the higher the Q of the tuned circuit. Values of capacitance smaller than 10 $\mu\mu$f resulted in oscillator failure.

Theory of Operation

Precise, quantitative analysis of superregeneration is a risky procedure because of the difficulty in completely describing the phenomenon. The contradictory conclusions resulting from the several methods of analysis found in the literature (see bibliography) reflect this difficulty. The brief discussion which follows will, therefore, be qualitative in nature. The conclusions reached were deduced from the experimental work and were tested on the same equipment. Thus the conclusions are valid when applied to similar circuits, but should be examined carefully before being applied to other types of superregenerative detectors.

Refer to the detector circuit in Fig. 1. Assume the signal voltage and the quench voltage to be disconnected. When the plate potential is turned on, oscillations will build up exponentially. The equation describing the phenomenon is given by Frink[1] as

$$I_0 = \frac{e_S\,\omega_R}{\beta R}\,\epsilon^{-Rt/2L} \qquad (1)$$

where

I_0: amplitude of the oscillatory current
e_S: random noise amplitude (signal absent) or signal amplitude
ω_R: $2\pi \times$ resonant frequency
t: time
L: inductance in tuned circuits
C: capacitance in tuned circuits
R: total effective resistance in tuned circuits
$\beta = [(1/LC) - (R/2L)^2]^{1/2}$

The amplitude of the oscillatory current is proportional to the signal strength, e_S. In the initial conditions just postulated, e_S is random noise.

The rate at which oscillations grow, dI_0/dt, is also proportional to e_S; thus

$$\frac{dI_0}{dt} = \frac{e_S\,\omega_R}{2L\beta}\,\epsilon^{-Rt/2L} \qquad (2)$$

In the case of growth, R is negative. In the case of decay, R is positive.

These equations were derived assuming linear elements. The oscillations will actually reach saturation at a time somewhat different from that indicated by the equations, because of the nonlinearity of the detector grid circuit.

Instead of turning the plate voltage on and off, the grid bias can be varied periodically to produce a similar effect. In this case, the quench voltage will interrupt the oscillations. In Fig. 8 there is shown a plot of a square wave of quench voltage. Square-wave quench voltage is used on the figure for the sake of clarity. Immediately below this plot is the

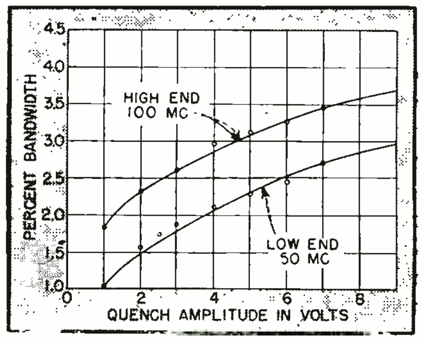


FIG. 6—Bandwidth is affected by quench amplitude

growth and the decay envelope of the oscillations for zero input signal. In this case, random noise triggers the oscillations. The detector output will consist of noise, the characteristic hiss usually associated with the superregenerative detector. Lower lines indicate the growth, with signal introduced. The rate of rise of the oscillations is greater the larger the incoming signal. The shaded areas indicate the contribution of the signal amplitude to the rise time.

The voltage appearing across the detector grid resistor, which constitutes the detector output to the audio amplifier, depends upon the average grid current, i_G, and is proportional to the area under the lower curves of Fig. 8. In addition

$$i_G = K\,(2L/R)\,\log_e\,(e_{S1}/e_{S2}) \qquad (3)$$

where i_G: change in detector current, K: constant for detector, e_{S1}/e_{S2}: applied signal voltage ratio.

The change in detector current varies as the logarithm of the applied signal ratio, which accounts for the desirable limiting action on strong signals and the comparative freedom from noise interference. If the superregenerative detector is to be operated on strong signals, the use of high transmitter modulation percentages is recommended. Equation 3 predicts that the output from the detector will drop as signal input is increased when low modulation levels are employed. Kalmus[2] has used the superregenerative detector in f-m receivers to obtain both amplification and limiting action.

The sensitivity of the superregenerative detector is a function of the i_G of Eq. 3. The sensitivity obtainable at high frequencies is considerably greater and could be obtained by other comparatively simple means. Noise muting sensitivities of 10 to 20 microvolts were realized with the receiver shown.

Choice of Quench Constants

The data presented indicates that it is possible to control the selectivity over wide limits by relatively simple changes in circuit constants. This possibility lends itself particularly well to production receivers. Quench frequency and quench amplitude are the parameters which have considerable effect on selectivity and are the easiest to control. Some changes in sensitivity occur simultaneously and are sometimes difficult to predict, as was illustrated in Fig. 5C. However, it is possible in most instances to arrive at a compromise which will result in good selectivity, sensitivity, and signal to noise ratio.

The most important factor in determining the quench magnitude and frequency is the decrement of the tuned circuit. The oscillations should have time to decay to below the level of the weakest signal to be detected. If this is not done, a coherent state of oscillation results, in which the oscillations are continuous and do not decay completely. Consequently, the oscillator will beat with the incoming signal. Multiple responses, one for each sideband of the coherent oscillator, will result. This condition of multiple responses is brought about by excessive quench frequency or insufficient quench amplitude. The quench frequency should be low enough to permit the oscillations to reach maximum amplitude. The data taken in the performance of the experiments described above seems to indicate that a greater on period of oscillation, brought about by either lowered quench frequency and/or amplitude, will result in improved selectivity.

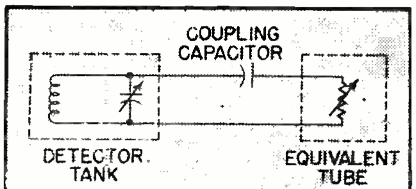
If the quench frequency is too high, the superregenerative detector will operate in the linear mode rather than the logarithmic mode. The linear mode of operation does not have the advantage of noise quieting and limiting on strong signals.

The quench frequency should be high enough so that no combination of quench frequencies and modulation frequencies can result in audible interference.

At high frequencies selectivities far greater than those possible with two and perhaps more tuned circuits alone can be obtained. The practical limit on selectivity comes from the problem of oscillator drift. An excessively sharp receiver is adversely affected by temperature, humidity, or voltage changes, which may result in complete loss of signal, whereas a less selective receiver will only lose sensitivity.

The superrengenerative detector is a very high gain device, consequently it does not seem advisable to rely on preselector stages for selectivity. Preselector stages are essential, however, for the reduction of oscillator reradiation.

When it is important to maintain constant percentage bandwidth over a large frequency range, it will be necessary to change the quench constants simultaneously with the frequency setting. If several bands are employed, switching of quench constants is desirable.



COUPLING CAPACITOR	AUDIO OUTPUT BEFORE RETUNING	AUDIO OUTPUT AFTER TUNING	FREQUENCY CHANGE IN %	TOTAL BAND-WIDTH IN %
10	45.0	64	0.43	1.42
15	19.0	37	0.90	1.90
20	20.0	29	0.85	2.08
25	13.0	23	1.03	2.15
35	12.5	19	1.19	2.49
50	10.0	14	1.25	2.75

FIG. 7—Detuning of the superregenerative detector by strong signals can be minimized by using a small coupling capacitor between detector tank and superregenerative tube

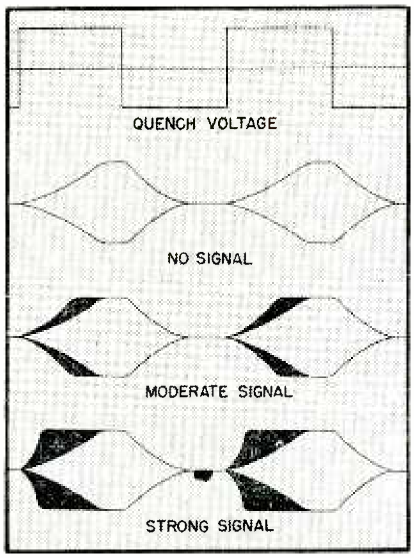


FIG. 8—Strength of the signal determines the rate at which detector oscillations grow

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High-Resistance

A d-c vacuum-tube voltmeter with a very high input resistance was developed and found to be quite useful in general electronics laboratory work. The resulting instrument has a linear scale substantially independent of tube characteristics; it possesses over-voltage protection; it has a very high input impedance; and it is particularly unique in that an electrical zero adjustment is not used.

The circuit is that of a reflex voltmeter[1,2] and has found application lately in a commercial vacuum-tube voltmeter[3]. The voltmeter to be described differs from this one mainly in that over-voltage protection is furnished and no electrical zero adjustment is used.

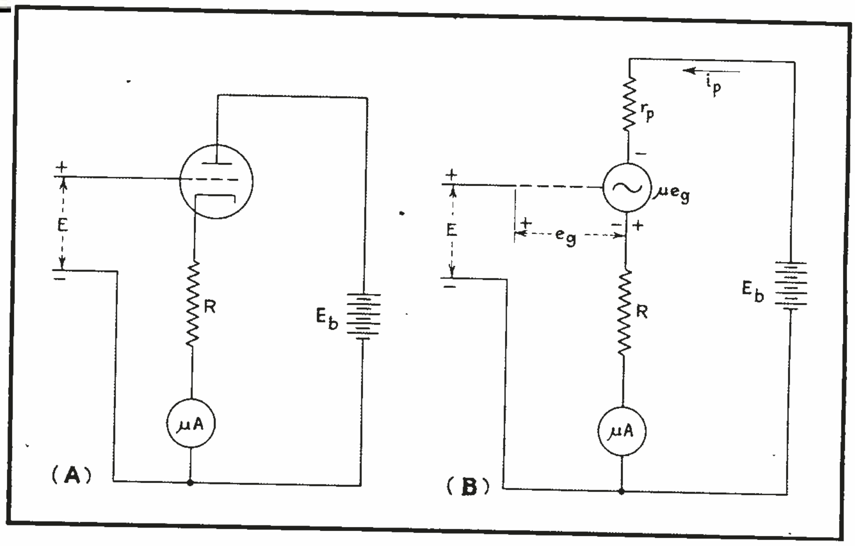

FIG. 1—(A) Basic circuit diagram of the d-c voltmeter. (B) Basic equivalent circuit arranged for analysis

TABLE I—EXPERIMENTAL RANGE DESIGN

Voltage Range	Resistor R, Megohms	Plate Voltage	Residual Current, μa	Saturation Current, μa	Open-Circuit Current, μa
0–50	0.5	162	5.7	285	135
0–100	1.0	278	4.3	275	195
0–250	2.5	370	2.3	155	125

Linearity

The abbreviated circuit of the voltmeter is shown in Fig. 1A. The voltage to be measured is E, and the negative feedback introduced by the resistance R makes the voltmeter linear over a large range of voltages. The simplified equivalent circuit of the voltmeter is given in Fig. 1B if the assumption of linear tube characteristics is made. By solving the circuit equations, the current through the meter is

$$i_p = \frac{E + (1/\mu)\,E_b}{R\,(1 + 1/\mu) + 1/g_m} \qquad (1)$$

where $g_m = \mu/r_p$.

If the tube used has both a high amplification factor μ and a high mutual conductance g_m, the current i_p becomes

$$i_p = E/R \qquad (2)$$

This indicates that for large values of applied voltage E, the meter current i_p is substantially independent of the characteristics of the tube and of the plate voltage supply and depends only on cathode resistance R. This property of the circuit will largely eliminate the problem of tube replacements, because no recalibration will be necessary when the tube is replaced.

Residual Current

When applied voltage E is zero, the meter current i_p becomes

$$i_{pr} = \frac{(1/\mu)\,E_b}{R\,(1 + 1/\mu) + 1/g_m} \qquad (3)$$

which might be called the residual current. In most cases $R \gg 1/g_m$ and $\mu \gg 1$, and hence

$$i_{pr} = \frac{(1/\mu)\,E_b}{R} \qquad (4)$$

This residual courrent can be balanced out by means of a circuit involving a zero adjustment, or the current can be kept as low as possible by making the plate voltage E_b small and making the amplification factor large. This latter method is the one adopted for this voltmeter in that it completely eliminates any zero adjustment, but it does mean that a small residual current is always present with the input terminals of the voltmeter shorted. The current through the meter given by Eq. 1 will be proportional to applied voltage E except for the residual current of Eq. 3.

If the residual current is made small, the maximum error should occur at the lower end of the meter scale, and the error should be smallest at the top end. To make R large means that the current meter used must have a full scale current that is as low as possible. A compromise in the interests of ruggedness was a panel-type microammeter.

Saturation for Safety

The voltmeter circuit will start to saturate when the grid voltage e_g is zero. When the circuit equations are solved under these conditions, it is found that the applied voltage E is

$$E = \frac{R}{R + r_p} E_b \qquad (5)$$

and, because $r_p \ll R$,

$$E = E_b \qquad (6)$$

The voltmeter thus starts to saturate when the applied voltage becomes equal to the plate voltage of the tube.

Grid current actually flows before the point $e_g = 0$ is reached, and hence to prevent the grid current from making the voltmeter non-linear and from reducing the input impedance, the plate voltage E_b is made some-

D-C VOLTMETER

Design of a reflex vtvm for measuring voltages of sources having an internal resistance as high as 1,000 megohms. The maximum error on any scale is less than eight percent and, for the upper sixty percent of scale, less than five percent. At 100 megohms internal resistance, the errors are five and two percent respectively

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what larger than the full applied voltage E. When E is made larger than E_b, the voltmeter starts to draw grid current, saturation sets in, and the meter current stops increasing. Hence, this property of saturation can be used to prevent meter overloads.

In all cases, E_b was adjusted so that the meter current with overloads did not become more than three times the full-scale current. The meters withstand this amount of overload current without injury. The full scale deflection of the meter used should occur when

$$E = E_b \tag{7}$$

If the grid current of the tube is neglected, the input resistance R_i of the circuit can be calculated from Fig. 2A in which R_c is the paralleled resistance of the measuring cable of the tube and tube socket to ground, and of any resistance that may be added for reasons to be given later. The resistance between the grid and the cathode terminals of the tube and the tube socket is shown as R_g, while that between grid and plate is R_p. Both the resistances of the cable and of the tube are usually several thousand megohms.

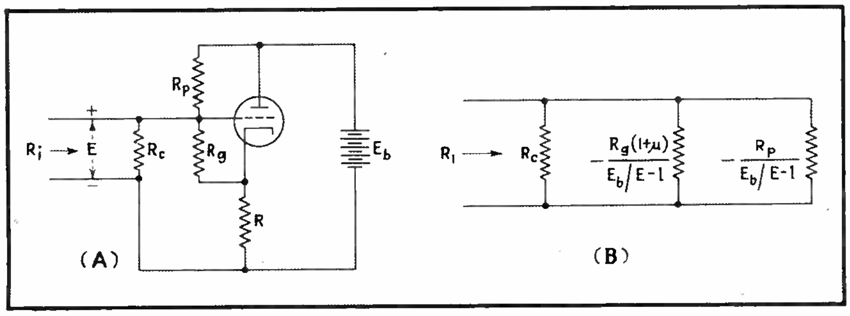

FIG. 2—(A) Circuit for calculation of the input resistance of the d-c voltmeter. (B) Equivalent input circuit composed of two negative resistances and one positive resistance

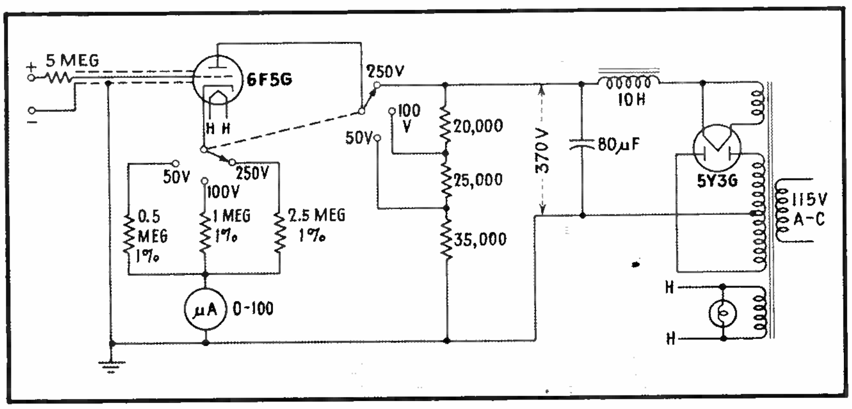

FIG. 3—Complete circuit of the high input resistance d-c voltmeter

Varying Input Resistance

The solution of the circuit equations along with the use of the approximation $V_p \ll R$ shows that the input impedance of the voltmeter appears to be composed of three resistances in parallel as given in Fig. 2B. Two of the resistances are negative, while the third is positive. Because the positive resistance R_c is usually smaller than the two negative resistances in parallel, the input resistance R_i is positive and slightly greater than R_c. It should be noticed that R_i varies with the voltage E to be measured, and increases in magnitude as E decreases. Grid current flow which becomes large as E approaches E_b will reduce the input resistance R_i. Positive ion flow to the grid also becomes important as E approaches E_b.

If the input terminals of the voltmeter are open-circuited, no current can flow into the meter, and an equilibrium point must be reached such that the negative resistances must be equal to the positive resistance. Neglecting grid current, this equilibrium point occurs when

$$\frac{E}{E_b} = \frac{\dfrac{1}{R_g(1+\mu)} + \dfrac{1}{R_p}}{\dfrac{1}{R_c} + \dfrac{1}{R_g(1+\mu)} + \dfrac{1}{R_p}}. \tag{8}$$

Equilibrium will occur when E approaches E_b if R_c is very large, and as E approaches zero if R_c is very small. This indicates that on open-circuit the meter may indicate full scale or even more, but the pointer will not go past the saturation point in any case. The open-circuit reading can be reduced by decreasing R_c, but this will also reduce the input resistance of the voltmeter. Equation 8 also indicates that as the internal resistance of the voltage to be measured approaches the parallel resistance of R_c,

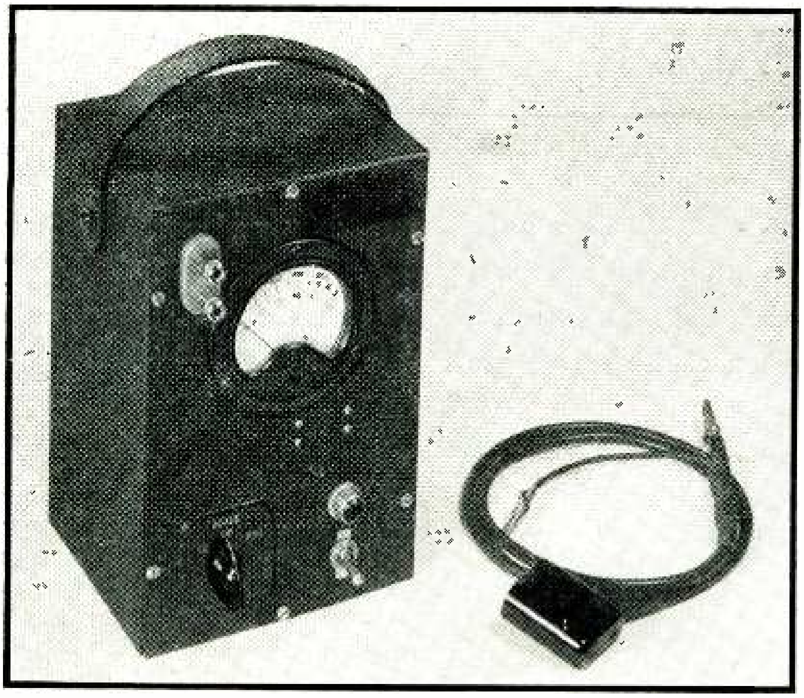

FIG. 4—The voltage range switch is the only control in the final instrument

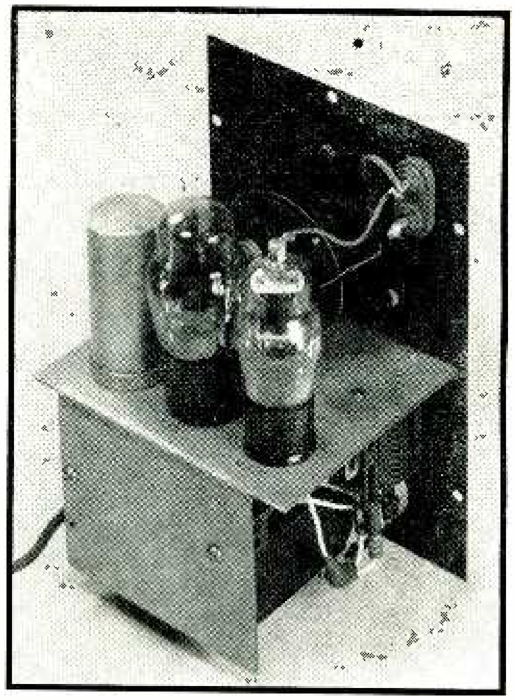

FIG. 5—Wiring of components is below chassis

$R_g(1 + \mu)$, and R_p, the accuracy of measurement will become poor.

Final Design

An experimental circuit was constructed using a 6F5G tube because this had a high amplification factor and a fairly high mutual conductance. A 0-100 microampere, d-c instrument was chosen to indicate the applied voltage, and three scales of 50, 100, and 250 volts were decided upon. Table I indicates the design and experimental results for each of these ranges.

The cathode resistor R is determined by dividing the range in volts by the full-scale current in amperes of the meter used. The plate voltage used must be large enough so that no appreciable grid current flows over the useful range of the meter but small enough so that neither the residual current, nor the saturation current, is too large.

The open-circuit current was found always to be somewhat smaller than the saturation current except for the 50-volt range, where it is much smaller than the saturation current. The reason for this is that grid current flows in larger quantities just above full scale, and this has the effect of reducing R_c.

A twenty-volt full-scale was found successful, but was not used. Any range below this could not be used, because the conditions for linearity, residual current, and saturation current could not be met adequately. Ranges above 250 volts are very successful and are limited only by what plate voltages the tube must withstand.

It was found that for voltage sources whose internal resistance was 100 megohms or below, the maximum error on any scale was less than 5 percent, while for the upper sixty percent of the scale the error was less than two percent. When the voltage sources had a resistance of 1000 megohms, the errors became eight and five percent respectively.

To keep the open-circuit reading of the voltmeter below full-scale, a 10,000-megohm resistor from the grid of the 6F5G tube to ground was successful.

Any alternating voltage superimposed on the direct voltage to be measured is kept out of the meter by the use of a simple low-pass filter consisting of a high resistance in the probe and the shunt capacitance of the cable to the voltmeter. An additional mica capacitor may be necessary in some cases.

The circuit diagram of the voltmeter constructed is shown in Fig. 3. No voltage regulator is needed in the power supply because the reading of the voltmeter is not affected by small changes in the plate voltage. Precision resistors are used in the cathode circuit in series with the microammeter, because on these resistors to a large extent depends the accuracy of the instrument. The heater of the 6F5G tube was left floating. Changing tubes had no effect on the calibration.

The external view of the completed instrument is shown in Fig. 4, the internal view is given in Fig. 5. These illustrations indicate that the design is generous and the voltmeter could be built much smaller.

In addition to the advantage of high input resistance, the vacuum-tube voltmeter described can have its tubes changed without affecting calibration and poor regulation of supply voltages does not affect operation. It was found to be simple to build and to operate and also features a linear scale and over-voltage protection.

Its disadvantages are that it measures positive direct voltages only; is not suitable for use on low voltages; has a residual current indication; and indicates a reading with the input open-circuited.

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Wire Length of UNIVERSAL COILS

Procedure for calculating outside diameter and total wire length when number of turns, form diameter, gear ratio and wire size are supplied, for estimation and manufacture

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As is well known, if the inner diameter, the outer diameter, and the total number of turns T of a universal-wound coil are given, the length l in feet of wire in the coil can be calculated very closely by means of the formula

$$l = \pi D_m T/12 \qquad (1)$$

where D_m is the mean diameter in inches of the coil. For the purpose of computation, this formula can be written in the more convenient form

$$l = 0.262 D_m T \qquad (2)$$

where the symbols have the same meaning as before.

Unfortunately, in most universal coil specifications the outer diameter is not given, but only the inner diameter, the number of turns, the gear ratio, and the size and kind of wire. However, this data is sufficient to determine the outer diameter, and consequently the length of wire in the coil.

A universal-wound coil has the inherent property that the number of turns per layer is the same for every layer and, furthermore, is a simple function of the gear ratio employed in winding the coil.

In particular, the number of turns t per layer of a universal-wound coil is given by the formula

$$t = nN_c/q(2N_D - nN_c) \qquad (3)$$

where n is the approximate or integral number of crossovers per turn, q is the number of crossovers per winding cycle, N_c is the number of teeth in the cam gear, and N_D is the number of teeth in the drive gear used in winding the coil.

If the number of crossovers per turn is not given, it can be determined easily from the respective gears used by dividing twice the number of teeth in the drive gear by the number of teeth in the cam gear, and taking for n the integer nearest the quotient, or that integer plus a simple fraction, usually either $\frac{1}{3}$ or $\frac{1}{2}$.

The number of crossovers per winding cycle, on the other hand, can be determined by writing the number of crossovers per turn in the form of a fraction i_1/i_2 reduced to lowest terms. If i_1 is an even integer $q = i_1$; if it is an odd integer, $q = 2i_1$.

The q values corresponding to values of n most commonly used are given in Table I.

Having found the number of turns per layer, the actual number of layers can be found by dividing the total number of turns by the number of turns per layer; the height of the coil above the form can be found next by multiplying this result by the overall diameter of the wire used (found from wire tables). Expressed mathematically,

$$h = Tw/t \qquad (4)$$

where h is the height of the coil expressed in inches and w is the overall diameter of the wire, also expressed in inches.

Having the height of the coil, the mean diameter is easily found from the formula

$$D_m = d + h \qquad (5)$$

where d is the diameter of the dowel or form on which the coil is wound. The value of the mean diameter thus found can be substituted in the formula for l previously given to find the length of wire.

TABLE I. CORRESPONDING VALUES OF n AND q

n	q	n	q
1	2	4	4
1.33	4	5	10
1.50	6	6	6
2	2	7	14
3	6	8	8

Practical Example

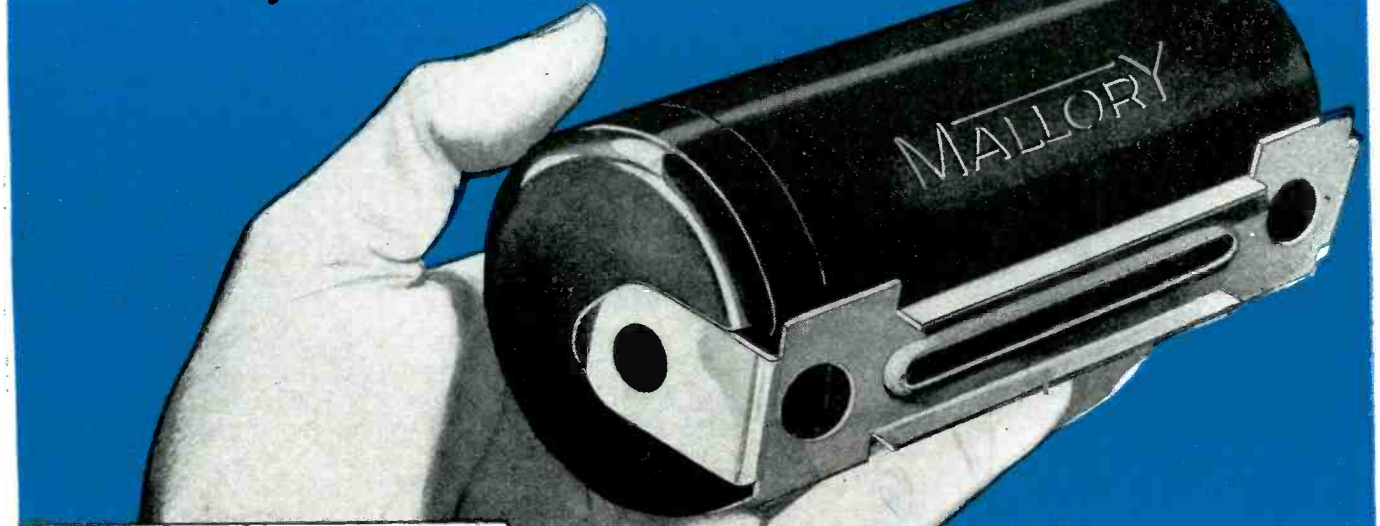
Let it be required to find the length of wire in a universal-wound coil consisting of 440 turns of 3/41 S. Cel. E. Litz wire ($w = 0.0092$) wound on a ceramic dowel 0.375 inch in diameter using a gear ratio of 41/80 ($N_D = 41$, $N_c = 80$).

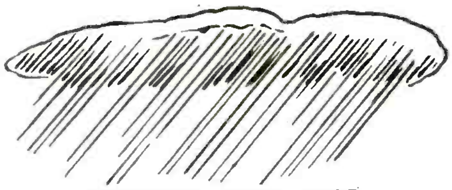
In order to find the number of crossovers per turn we form the ratio $2 \times 41/80 = 81/80$ and select the nearest integer to the result, namely 1. Hence, the coil is wound with one crossover per turn.

Next, in order to find the corresponding number of crossovers per winding cycle, we write the number of crossovers per turn in the form of a fraction reduced to lowest terms, namely 1/1. The numerator of this fraction is an odd number, hence the number of crossovers per winding cycle is equal to 2×1 or 2. (Compare also Table I.)

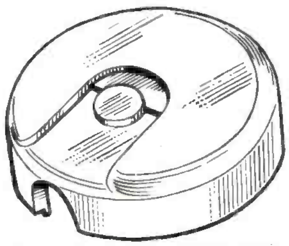
Hence for the coil under consideration we have $n = 1$ and $q = 2$. Substituting in the formula for the number of turns per layer, we have $t = 1 \times 80/[2(2 \times 41 - 1 \times 80)] = 20$, so the coil has 20 turns per layer. The actual number of layers is therefore 440/20 or 22, and the height of the coil is 22×0.0092 or 0.202 inch. Because the diameter of the form is 0.375 inch, the mean diameter of the coil is 0.577 inch, and the length of wire in the coil is $0.262 \times 440 \times 0.577$ or 66.5 feet.

You've Got To Hand It To This Mallory Motor-Starting Capacitor

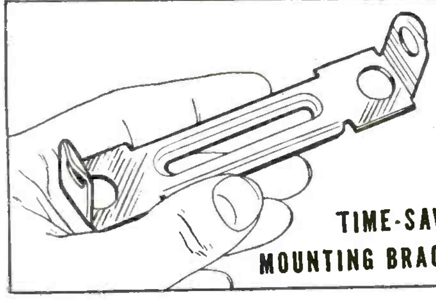




MOISTURE-PROOF CASE



SPLASH-PROOF END CAP



TIME-SAVING MOUNTING BRACKET

ONE trouble with ordinary motor-starting capacitors is that they're not too well insulated—the cardboard sleeves get soggy in time. *Not so with this plastic encased Mallory Type P capacitor!*

Then, too, many manufacturers have trouble with tight fitting end caps — or with padding expedients that are intended to stop rattling. *Not true of this Mallory Type P AC capacitor with its lock-in end cap!*

Finally, most AC capacitors are troublesome to mount — they need all kinds of expensive and extraneous gadgets. But Mallory Type P has its own mounting bracket. *Only two screws are needed to put it in place!*

For eliminating replacement headaches, improving appearance, speeding up assembly time—you've got to hand it to this Mallory Motor-Starting Capacitor. We'll be glad to send you specification sheets — write for form #746-C.

P. R. MALLORY & CO Inc

MALLORY CAPACITORS

(ELECTROLYTIC, FILM and PAPER)

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

INDUSTRIAL CONTROL

Tubes Warn of Dull Drills

AN AUTOMATIC ELECTRONIC control has been developed for drilling machines that produce deep holes. It reduces drill breakage and decreases the time of drilling. The control automatically withdraws the drill when torque exceeds a certain amount.

Although ten percent is the usual operating allowance, the device can be set to operate with as low as one percent increase in torque load on the drill spindle. The pulling-out action warns the operator that the drill should be replaced with a sharpened tool. This control is being used at Ford Motor Co., with an automatic unit for drilling the radial oil holes of the Pratt & Whitney engine and by H. E. Farmer Engineering Co. in the design of a tapping unit which is driven through a reversible motor.

Other types of machine tools may find application of this type of torque control to measure tool dullness. When danger of breakage is negligible and retraction unnecessary, the equipment could be set up to operate a signal light to inform the operator when tools must be replaced.

Electronic Control of Fish Fence

AN ELECTRONIC fish fence keeps the fish in the state hatcheries at Pennsylvania's famed Pymatuning Lake reservation in waters where they are protected, thereby saving millions of them for later planting in the streams and lakes of the state. The screen or fence consists of one or more rows of metal rods or strips that serve as electrodes through which electrical impulses are sent to set up an electric field in the water.

The electric impulse gives the fish an effective but harmless shock and sends them scurrying back to a safe area. The impulses are produced at a relatively rapid rate from an electronic generator, resulting in a special wave form of current that turns back both large and small fish simultaneously, an impossible feat with ordinary current. The proper wave form was the result of several years of research by engineers of Westinghouse and Henry T. Burkey of the Electric Fish Screen Company of Hollywood, Calif.

At Pymatuning, the electric fence prevents the fish from migrating to open water where they would be caught by fishermen or eaten by larger fish. The fence has other extremely practical applications in preventing fish from being destroyed in the water intakes of irrigation projects, hydro-electric plants, and industrial works. A number of similar fences have been installed in California with marked success.

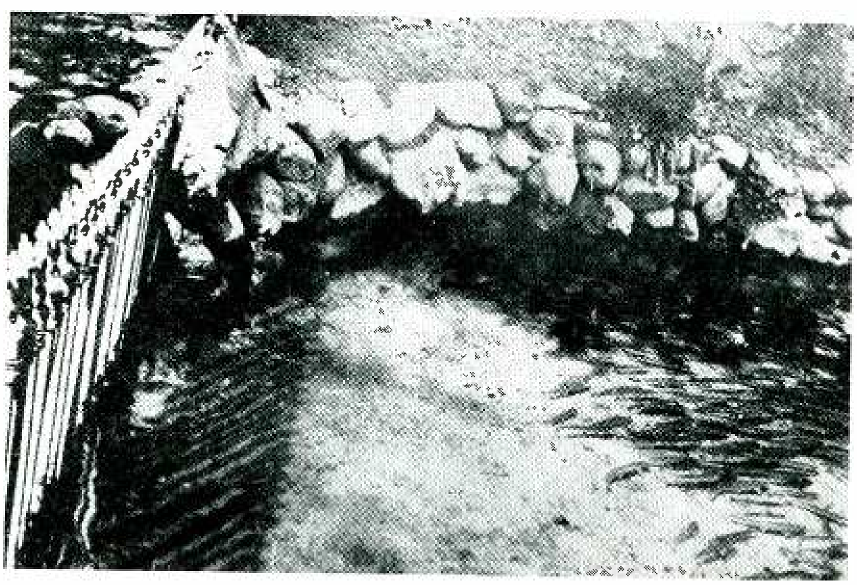


Fig. 1—Young rainbow trout in an irrigation canal swim away when they come within the zone of influence of the electric fish fence at left. The rod-type fence is controlled by a special electronic generator and emits electrical charges that repel the fish without harm

Electronic Cooking in Slot Machine

HOT DOGS, hamburgers or grilled cheese sandwiches will soon be available from an automatic canteen that engineers of the General Electric Company and the Automatic Canteen Company of America have developed for serving hot sandwiches at the drop of a dime and the push of a button. The specialty division of the G.E. electronics department in Syracuse is building several thousands of the units for the canteen company.

As shown in the photograph, the machine looks something like a soft drink or cigaret machine. It connects to the 110-volt line, has push-button selectors for choice of food; a glass window behind which is the electronic heating unit, and below this a glass door and compartment into which the hot dog or sandwich drops ready for the customer.

Individual trays inside the machine hold the frankfurters, cheese and hamburgers, wrapped in buns and enclosed in sanitary containers. The frankfurters and hamburgers are previously cooked in a special sanitary kitchen.

Many frequencies were tried before the problem of heating rolls and meat uniformly, without burning,

Hot sandwiches are delivered from this canteen after the food is electronically heated

was overcome. Some frequencies would heat the roll but not the frankfurter. Other frequencies would heat the frankfurter but burn the roll. Then when it looked as though both bun and meat would heat uniformly, one end of the bun would burn. Finally a frequency was found at which the right amount of heat was developed uniformly in the packaged item. To cut down radiated heat the oscillator unit is cooled by a blower.

G.E. engineers warn that it should not be construed from this development that the electronic stove is just around the corner and that the canteen grill does not solve the problems yet to be overcome in the field of electronic cooking. Further experimental work is necessary.

Supersonic Inspection of Strip Materials

PRODUCTION TESTING of materials for minute flaws can now be done by a supersonic method that was developed during the war to examine rocket powder grains for voids. The supersonic equipment replaced x-ray units that were used to radiograph each grain. Since the grains varied in size from five inches to five feet in length, considerable amounts of film were required and in March, 1944 it became apparent that there would not be enough x-ray film produced in this country to supply the demand when production hit its peak.

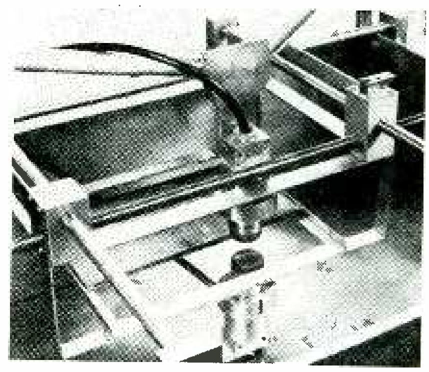
Frequencies between 50 and 1000 kc are used in the supersonic equipment built by Brush Development Co. Choice of the proper frequency is determined by the material to be tested and the type of flaw encountered. An electronic generator feeds a piezoelectric transducer that transmits the supersonic beam through the material. The properties of the material under test modify the beam and the resulting energy pattern is picked up on the other side of the material by another crystal transducer unit that operates as a microphone.

Use on Continuous Strip

The method is particularly applicable to materials having a constant cross-section such as those obtained by rolling and extruding. Such material can be examined continuously as it passes between a pair of transducers. Changes from its normal homogeneous condition, or flaws, change the energy level in the microphone. This in turn operates a relay that controls other equipment which either marks or rejects the flaw or section of material. If the relay action is fast, the material can flow through at high speed.

The supersonic method detects flaws associated with an apparent change in density and/or an apparent change in the modulus of elasticity. Since a single indication is obtained, the method does not distinguish which property is changed but indicates that either one or both have changed.

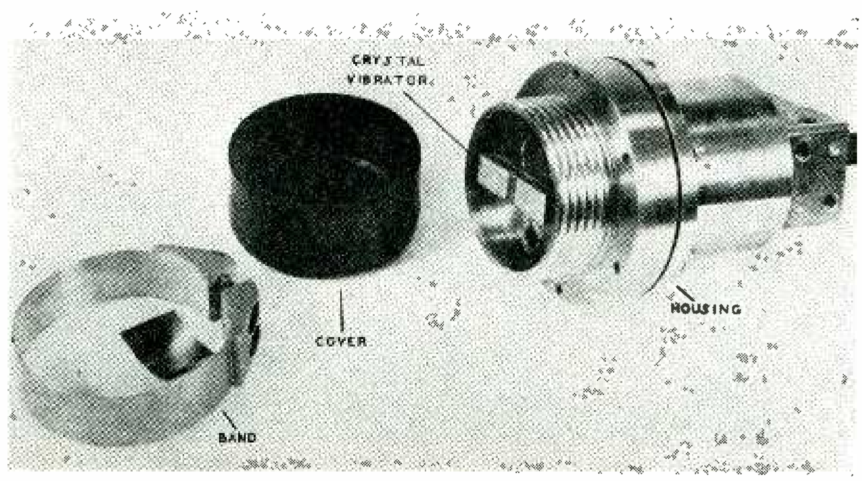
X-rays essentially inspect for the changes in density or total mass in the field of the beam. The fact that the Brush Hypersonic method is sensitive to the changes in modulus of elasticity also gives an advantage over x-ray when it is necessary to examine flaws that are thin slits or cracks in the material. In such flaws, the change in total mass is negligible, but at the separation junction the effective modulus is small since the material is already separated. Since the sonic method is sensitive to changes in the modulus, it gives



Continuous strip materials pass through a liquid-filled tank in which the piezoelectric transducers are mounted to face both sides of the strip

sensitivity detections of this type of flaw even though the thickness of the slit or crack may be only 0.001 inch.

Such flaws occur frequently in materials that are rolled in sheets to a given thickness. The stock contains long thin laminations rolled flat and the trapped gases are rolled into long pipes. The change in total mass is exceedingly small, but the change in stiffness is very great and better de-



Elements of the Brush piezoelectric transducer for supersonic inspection of materials

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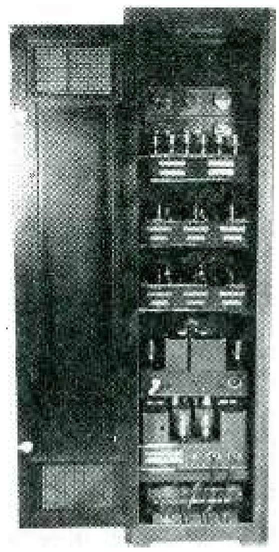
tection for these flaws is provided by the sonic method than by x-ray.

Other Applications

In separations in tires, the rubber jacket blisters away from the cotton fabric and a thin air pocket lies in between. X-rays will not detect this type of flaw. Poor cement joints that occur in processes like cycle-welding are detectable by sound beams. In this case, the actual effectual adhesion is a measure of the modulus or strength of the joint.

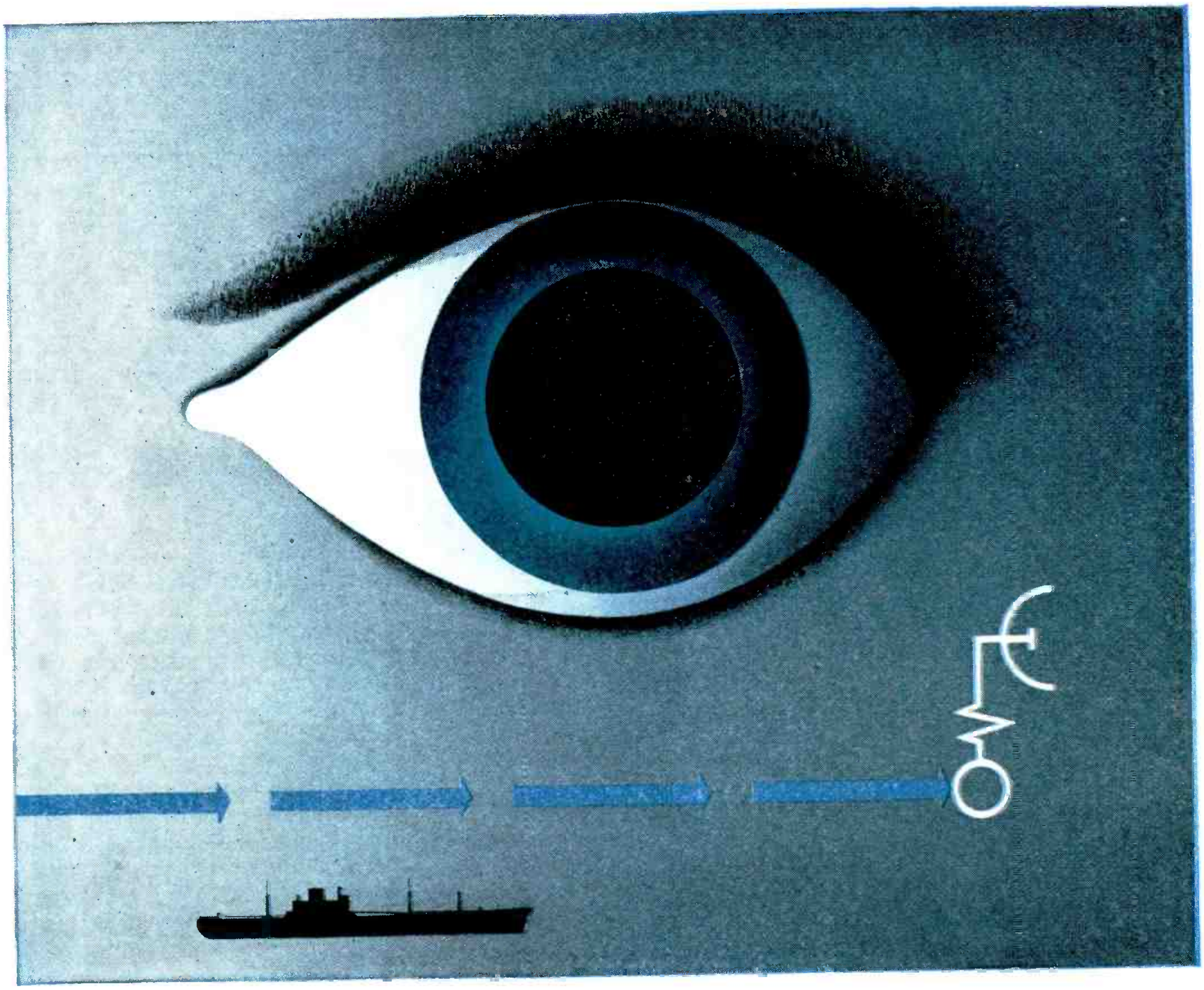
In 1944 the United States government embarked upon a heavy schedule of rocket projectile production. Uniformity in the composition of the rocket sticks and absence of voids, flaws, and foreign material, was imperative. The presence of any flaws in the powder sticks would result in



Electronic equipment of the Brush supersonic flaw detector. Six channels are used for operation with a series of transducer units spaced across the sheet of material

a premature explosion, rather than a uniform propelling action. At the start of the rocket projectile program, x-ray was used for inspection of the rocket powder sticks. In seeking a more practical and expedient method of inspection, the Hercules Powder Co. began to consult various electronics manufacturers.

The hypersonic Analyzer developed by Brush replaced x-ray equipment and was used in the entire U. S. rocket projectile program, saving tremendous quantities of x-ray film for other uses. It also eliminated the



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Sperry *Radar* has been conceived to function better in this fundamental service: *To enable ships to operate on schedule regardless of visibility*...through thick fog, heavy rain, dense smoke, darkness.

As an aid to navigation it picks up channel markers and buoys; assists in making landfalls with assurance; spots icebergs, floating derelicts and other hazards projecting above surface. It also permits vessels to enter harbors and proceed with all due safety and caution through fog. Another important feature: Sperry *Radar* provides a Gyro-Compass-controlled image and can be operated by bridge personnel without extensive technical background.

In design and construction, Sperry *Radar* reflects this company's many years of experience in precision manufacture of marine equipment—as well as its outstanding achievements in the field of electronics. In simplicity and dependability, this new *Radar* exemplifies again Sperry's ability to build superior products for merchant ship service.

Sperry Radar Features:

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- Gives accurate ranges read from indicator instead of estimated from scope.
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GYROSCOPICS • ELECTRONICS • RADAR • AUTOMATIC COMPUTATION • SERVO-MECHANISMS necessity of building a projected \$2,000,000 plant for the production of x-ray film. Since the end of the war, experiments have proceeded involving the application of the analyzer to inspection and flaw detection in various industrial fields.

Indicators

The flaw or defect may be indicated in any of several desired ways —on a meter, by signal light or a bell, or a relay hook-up may be used to make whatever physical markings may be desired such as paint spray, inspectors' rejection stamp, continuous ink-on-paper chart record, or an ejector mechanism.

The supersonic analyzer offers the same inspection possibilities for many metals and satisfactory tests have been made on aluminum, phosphor bronze, beryllium copper, brass and other metals and alloys. It is also highly sensitive to flaws in plastics and other extruded materials.

A wide variety of possible applications exist in many industries where the bonding of materials is employed in the manufacturing process. Since any separation between two bonded surfaces, such as tire plies, safety glass, and bonded metal strips, results in a change of density, these can be easily and accurately detected by this positive and non-destructive technique.

• • •

High-Frequency Heating Developments

TO ADAPT basic electronic heating units more specifically to problems of factory production, Westinghouse engineers expect to include automatic frequency control, automatic load control, and automatic cycling or production controls. These features were incorporated in the most spectacular high-frequency set of the year, the 125-kw, 13.6-mc unit developed by Westinghouse engineers for the Firestone Tire and Rubber Company for production curing and drying of Foamex, a new ultra-soft type of sponge-rubber used for cushions and mattresses. The set is fitted into the production line so that one side can be loaded or unloaded while energy is applied

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Overall length	17.5"	max.
Heater voltage	6.3	volts
Grid No. 1	45	volts*
Grid No. 2	250	volts
Anode	5000-11000	volts

P4 Screen—7 pin duodecal base

*cut-off voltage

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An engineer checks one of the rectifier tubes in the electronizer vulcanizer developed by Westinghouse for the Firestone Fall River, Mass. plant

to the other. This provides a high use factor on the h-f generator.

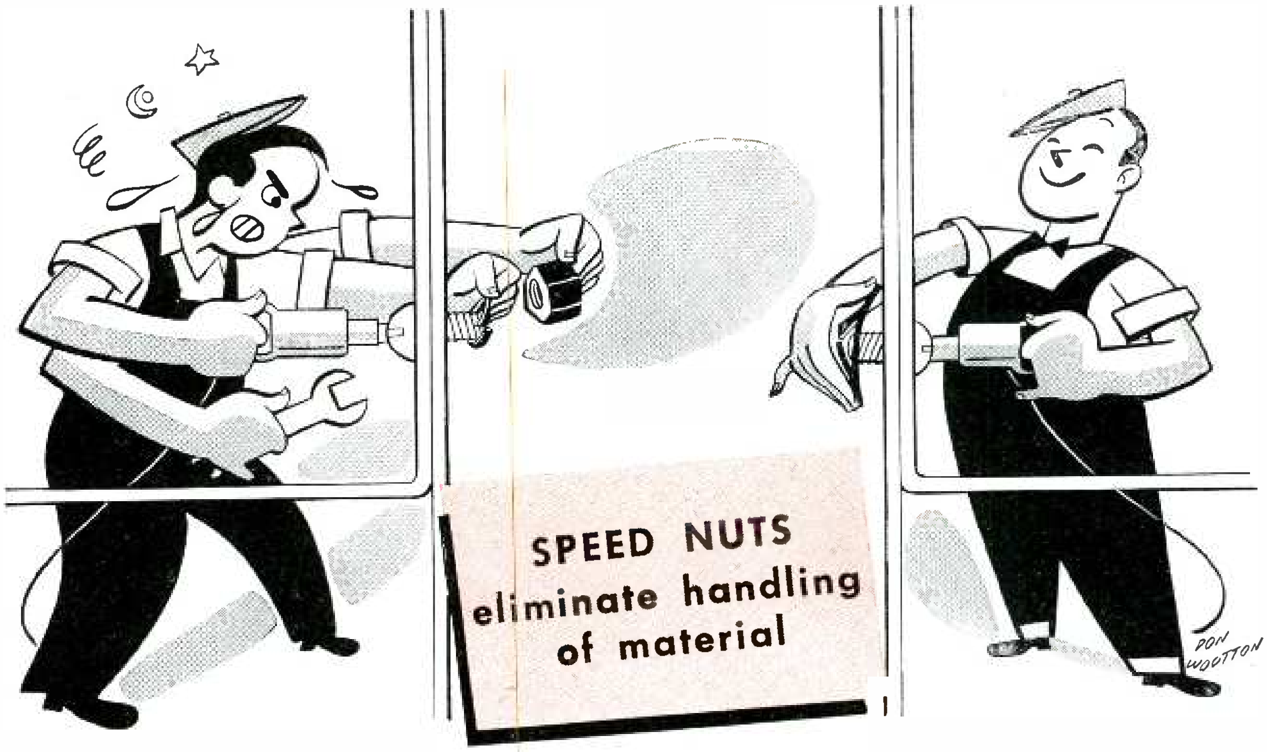
Control Circuits

Automatic frequency control is provided by using a quartz crystal to furnish a standard or reference frequency, and a circuit whose output is proportional to deviation of the actual from that of the standard frequency. The output actuates a motor-driven vernier capacitor which is a part of the frequency-determining circuit. The system holds the frequency within plus or minus 0.05 percent.

Automatic control of heating, regardless of variations in the work circuit as the heating progresses, is achieved by automatically varying the coupling of power from the r-f generator and by automatically maintaining resonance in the electrode circuit. Such automatic controls provide flexibility of process control and can be expected to appear in other standard r-f heating generators in the future.

At and above 30 megacycles, the elements of capacitance and inductance become electrically and physically small and current through coils and capacitors becomes high with resultant high component loss. Capacitors of the mica type normally used for this purpose may fail because of excessive internal loss. One

It takes a 4-arm man to keep up with a SPEED NUT Assembler



And even with 4 arms, we'll wager he couldn't keep up. For it stands to reason a man just can't handle a lock washer, threaded nut and a wrench as fast as he could handle a Speed Nut alone.

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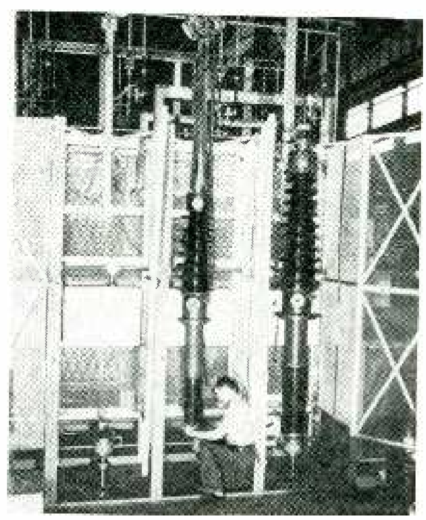
solution is a device called a Capacidductor, which in effect combines capacitance and inductance in one unit. It is built like a capacitor of four or five fixed plates, but is some 20 to 25 inches long to give it the inductive reactance necessary for operation at 30 megacycles. Electrically, it combines the features of a conventional transmission line-type circuit and associated fixed capacitors. It eliminates complicated and expensive mica capacitors, and is simple to manufacture.

Other Applications

Some interesting applications of electronic equipment for induction and dielectric heating have been made in recent months. For example, a 10-kw r-f generator is being used by Firestone Tire and Rubber Co. to preheat rubber preforms for solid rubber wheels and other thick section rubber products. By bringing the temperature of the raw material uniformly up almost to the curing temperature before going into the molds, more uniform curing is obtained and production greatly increased by a large reduction in press time from five hours to eighteen minutes.

Dielectric heating has reduced the drying time of high-voltage capacitor-type transformer bushings by eight to ten hours at the Sharon Works of Westinghouse Electric



Capacitor bushings are completely assembled and placed in individual cells on a treating rack for dielectric heating. The workman is connecting an oil pressure line before placing the bushing on a small pedestal

Corporation. In this application of high-frequency heating the last trace of moisture in the bushing is driven off by heat generated directly within the insulation. The time formerly lost in bringing the bushing up to drying temperature has been saved as the entire insulation reaches the proper temperature within a short time after the power is turned on. In addition to the time saving, the bulky drying ovens or the network of steam piping previously required to apply heat to the bushing have been eliminated.

The essential portions of the system are shown in Fig. 1. High-frequency current supplied by the electronic generator at the extreme left is carried by a nitrogen-filled coaxial line to the tuning box where individual adjustments for each bushing are made. Moisture driven out of the bushing by heat is carried off through the vacuum line. The oil pressure line permits insulating oil

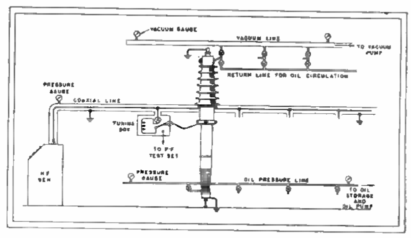


Fig. 1—Schematic diagram of the main elements used in processing capacitor bushings. Moisture driven from the bushing by dielectric heating is carried away through the vacuum line

to be forced into the insulation while heat is still being applied after it has been thoroughly dried.

For a chain-making operation, three 20-kw 450-kc r-f generators with special work-handling equipment were used last year to anneal the ends of 29 million steel pins. A dozen 2-kw, 30-mc units are being used by a plastic manufacturer to expedite production of plastic ignition-timing wheels.

An electronic blow torch, a dielectric heating unit that uses a waveguide to hurl ultra-short waves at an object to be polymerized, cured or bonded, was demonstrated recently by Dr. J. A. Hutcheson, associate director of Westinghouse Research Laboratories.

"This device," he explained, "pro-

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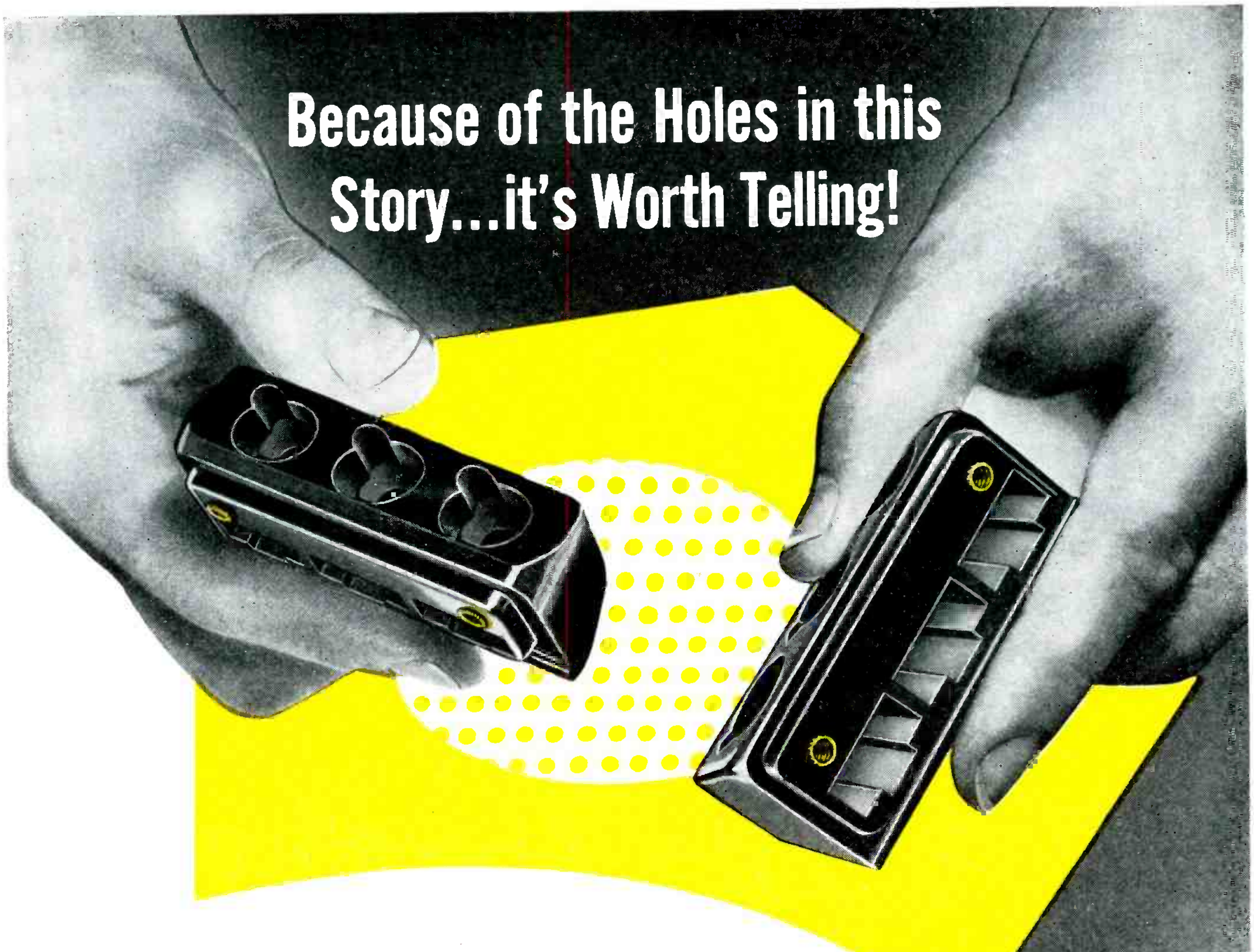

This is a Terminal Block. The two views of it reveal an alignment of three round, keyed holes molded into one side — and an opposing series of three rectangular, keyed holes molded into the adjacent face. Deep within the piece, these holes meet and form right-angle passages.

The part, of black Phenolic, compression molded with two metal inserts in place, comes out of the die six at a time — each a perfect counterpart — each an example of precision processing.

Much of the piece's success can be attributed directly to the care and accuracy given to the making of the mold. Designed and constructed by Consolidated, the die provides cam-operated, side-core mechanisms that automatically mold the shaped holes into the block.

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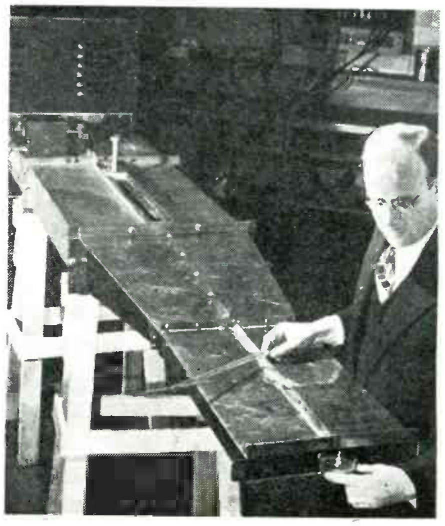


Use of a waveguide as an electronic blow torch to project high-frequency energy into materials is demonstrated at the Westinghouse Research Laboratory by Dr. J. A. Hutcheson, associate director. Liquid plastic in the dish can be solidified in three minutes

jects electronic waves on the material to be heated, wherever it may be, whereas previous devices required that the object be placed in an electrical field created between two stationary metal plates or electrodes.

"The advantages of this unit are that it can be used in restricted areas and effectively on irregularly-shaped pieces of material. Formerly, when a non-symmetrical piece was placed between the electrodes, the areas nearest the electrodes were in danger of being scorched or burned before the entire piece was uniformly heated."

Odd shapes of plywood forms, and T-joints formed by struts or spars could be easily cured or bonded by using waveguides. The work is still in the research stage and units are not available commercially.

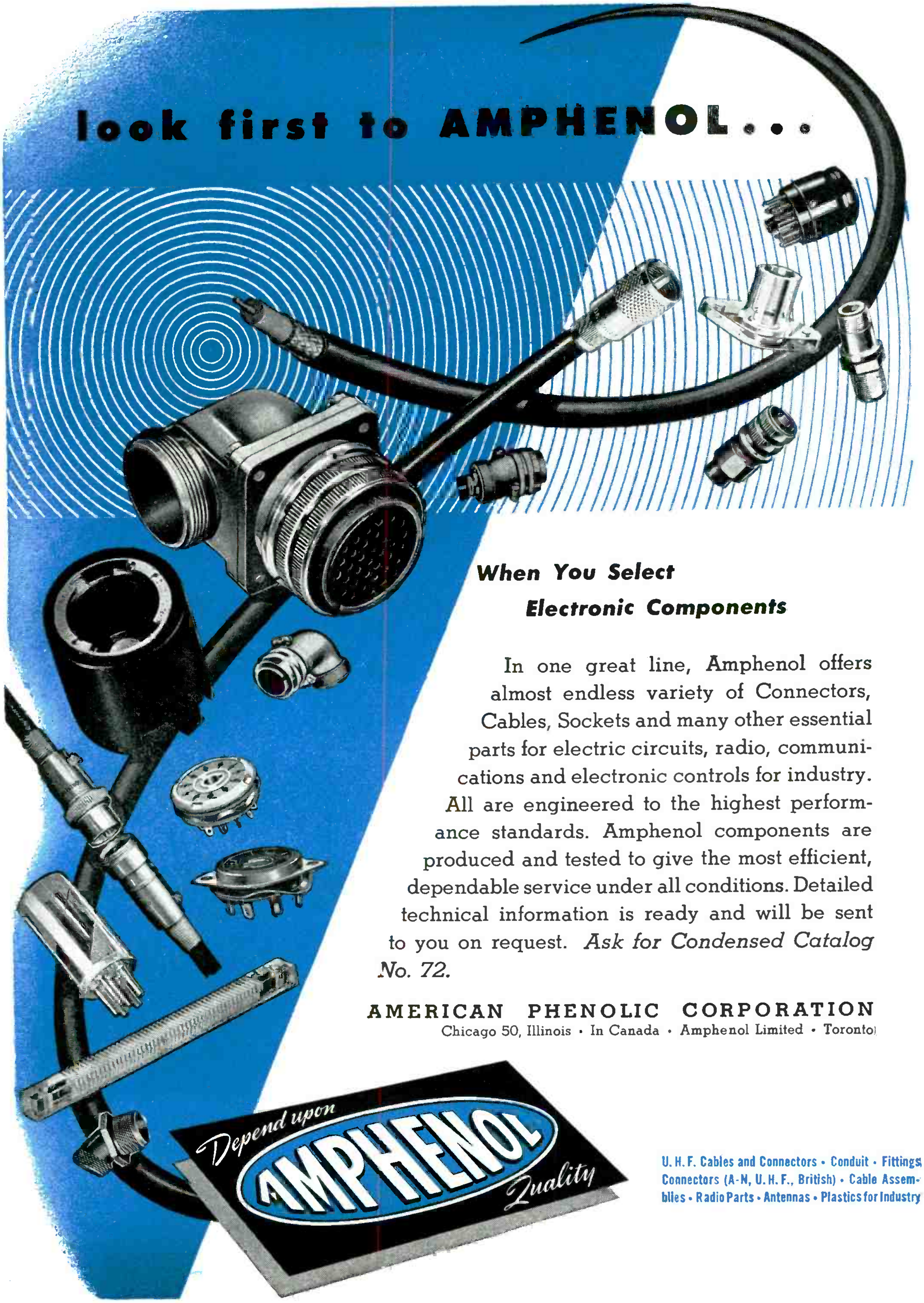
• • •

Photoelectric Fish Counter

By Lester V. Whitney
Department of Physics
Southwest Missouri State College
Springfield, Missouri

and Arthur D. Hasler
Zoological Laboratory
University of Wisconsin
Madison, Wisconsin

Commercial fishing fleets may find application of a fish detector or ichthyometer that has been used with success on studies of perch migra-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tion in Lake Mendota at Madison, Wisconsin.

In studying fish migration in a lake, it is often necessary to set nets to obtain data on numbers of fish present at different times and at different locations. Information of this sort can be obtained with the photoelectric ichthyometer.

The apparatus used under water was arranged as shown in Fig. 1. The light source was a six-volt automobile bulb in a water-tight housing,

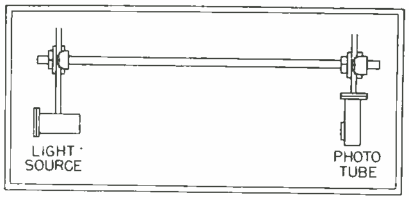

Fig. 1—The distance between the light source and the phototube was made as large as conveniently possible for use from a small boat

and the phototube was arranged so that it could be faced either upward for daylight intensity measurements, or toward the light source. The mechanism used to accomplish this motion was controlled by means of a cord reaching to the surface.

When the phototube was faced toward the light source, deflections of the pointer could be plainly observed on the microammeter as the fish swam through the beam. The intensity of the light source was kept low so as not to attract or repel the fish any more than could be avoided. The light was periodically turned off so as not to furnish a continuing attraction for fish which had already interrupted the beam. It was thought at first that it would be necessary to provide side nets to guide the fish into the beam, but good results were obtained without them.

A satisfactory correlation was found between pointer "kicks" registered per minute, and the numbers of fish caught either in nets over a definite period of time or by hand lines from the same, or nearby boats.

Circuit

A two-stage amplifier with the first stage under water was used at first, but a more simple circuit, shown in Fig. 2, has been built with sufficient sensitivity for fish detec-

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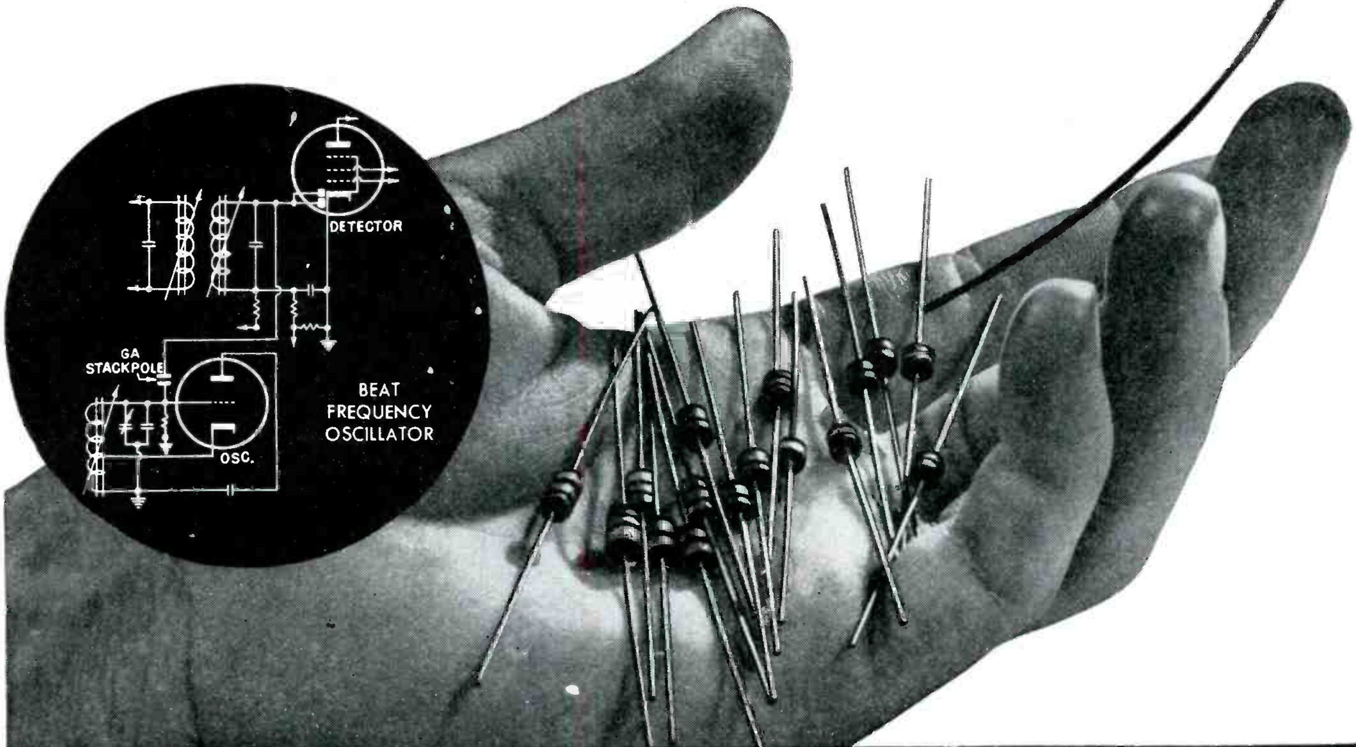

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tion. This circuit is not a true push-pull circuit since the phototube current affects only the grid potential of tube 1. A true push-pull circuit would require a separate phototube battery.

It was found by trial that when a separate phototube battery was used, unstable conditions resulted. This was because any contact with the battery or its case affected the grid

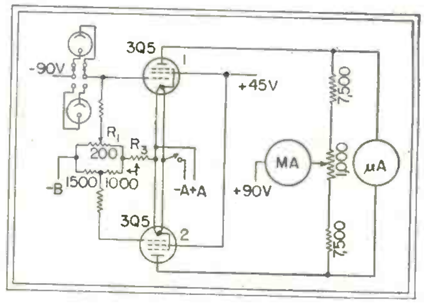
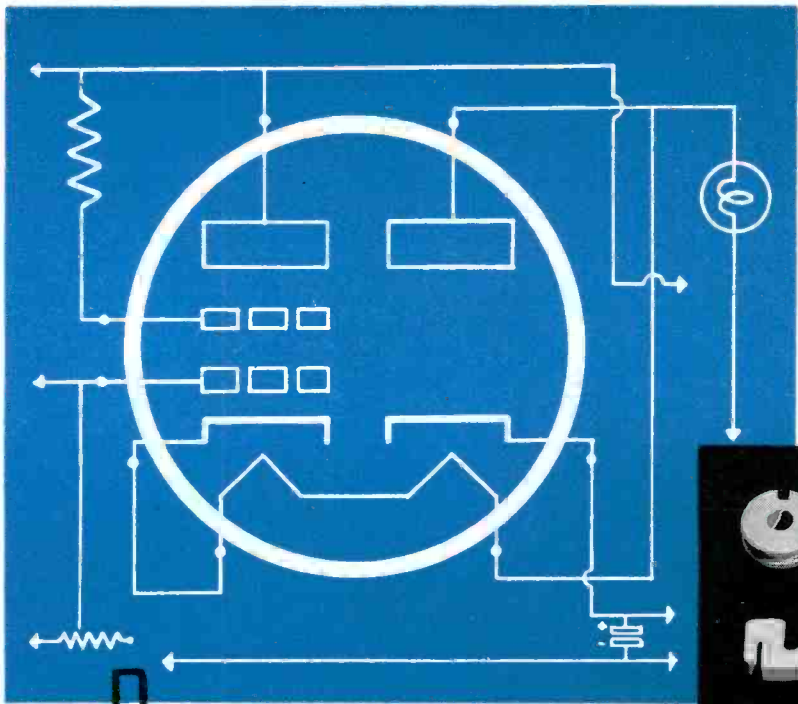


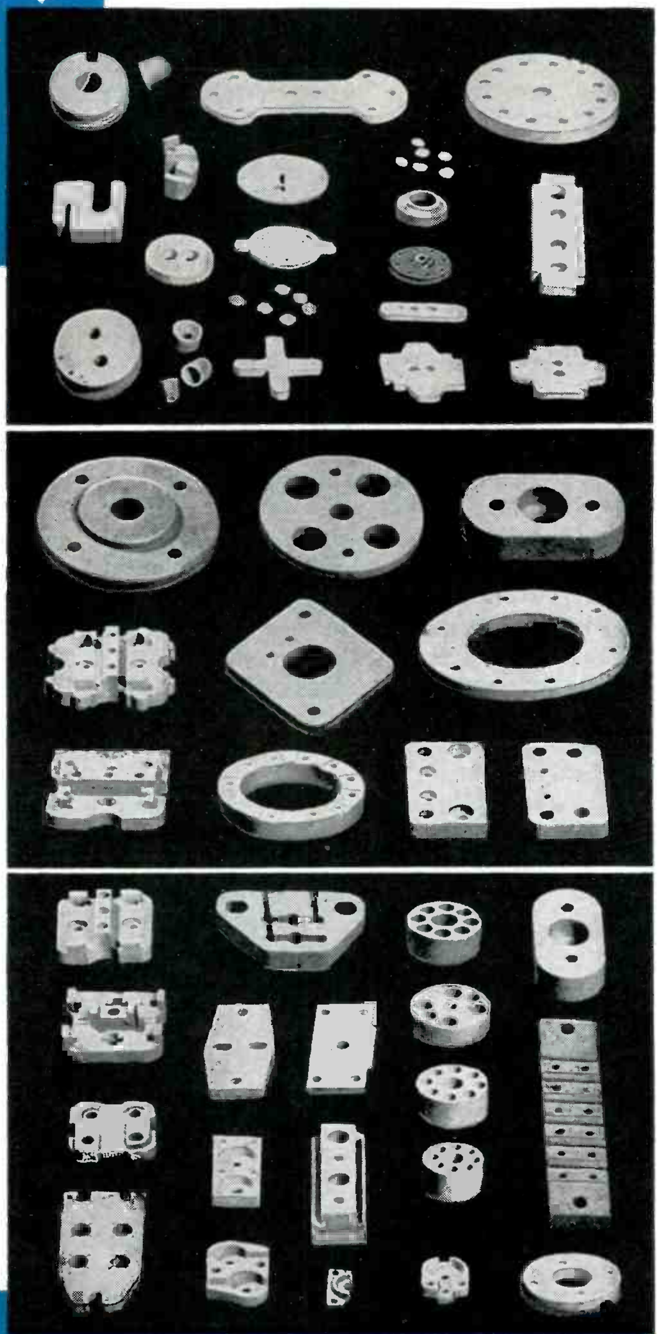
Fig. 2—Circuit of the photoelectric fish detector

of tube 2. Any contact with the water-tight housing of the phototube resulted in similar unstability. For these reasons the separate battery was omitted, the positive B terminal was grounded, and the positive phototube terminal was grounded to the water-tight housing.

In spite of the variation of total plate current, there is almost no degenerative effect because of grid bias so long as both tubes operate on the straight line portion of their characteristic curves. Any such effect could be further minimized by replacing resistance R_3 with a C battery of proper value.

To operate the fish-detector, the light source is first removed and the microammeter brought to zero set by means of adjustment R_1 and fine adjustment R_2. The light is then turned on and interruptions of the beam counted. A double-throw switch makes it possible to connect the amplifier to either of two phototubes. Both phototubes could be under water acting as fish detectors, or one could be below water and the other above water for daylight-intensity measurements. This arrangement makes possible a determination of the correlation, or lack of correlation, between daylight intensity measurements and fish movements. The instrument should be of value in the further study of fish migration and fish habits.





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TUBES AT WORK

Design of F-M Transmitter for 88-108 Mc

By Samuel L. Sack
Chief Engineer
Transmitter Equipment Mfg. Co., Inc.
New York, N. Y.

Use of a motor-driven capacitor for center-frequency control, balanced modulators, a push-pull oscillator, and linear circuit elements in plate tank circuits are interesting features of a new high-fidelity f-m transmitter having an output power of 250 watts in the new f-m band.

One of the major problems encountered in the use of direct frequency modulation of a primary oscillator is the attaining of consistent, stable center frequency control of that oscillator. The methods employed in this transmitter depart somewhat from those normally used.

The primary object in any center frequency stabilization control system is to make the reference crystal the sole frequency-determining element. It was therefore necessary to devise methods that would make all other circuit elements of the system non-critical.

When two carriers differ in frequency by a relatively small amount, one carrier can be considered as phase-modulating the other carrier. The amount of phase modulation of either carrier is determined by the relative amplitudes of the two carriers and the value of the beat difference between them. Advantage was taken of this fact in the Temco transmitter.

The output of the primary oscillator and the standard crystal oscillator are fed to two mixer stages. The a-m audio component is obtained from one mixer stage, while the other mixer stage is fed through limiters, then to a discriminator from which the f-m audio is recovered. The a-m and f-m audio is then fed to a phase detector as shown in Fig. 1.

Use of Thyratrons

The phase of the f-m audio in relation to the a-m audio is dependent upon the sine of the beat difference between the standard crystal oscillator carrier used as a reference and the primary oscillator carrier. The level of the d-c output voltage from the phase detector is a direct function of the beat difference between the two carriers and the sine of that voltage is a function of the sine of the beat between the carriers. The output voltage from the phase detector is then passed through a d-c amplifier, which in turn controls the grids of a pair of thyratron tubes. The output circuit of the thyratrons provides the a-c voltage of the proper phase to operate a two-phase motor which in turn is mechanically coupled to the primary oscillator tuning capacitor.

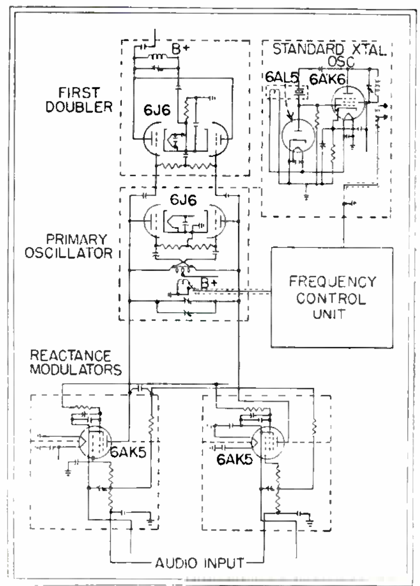


Fig. 2—Essential portions of the exciter unit of the Temco model 250 BCF f-m transmitter

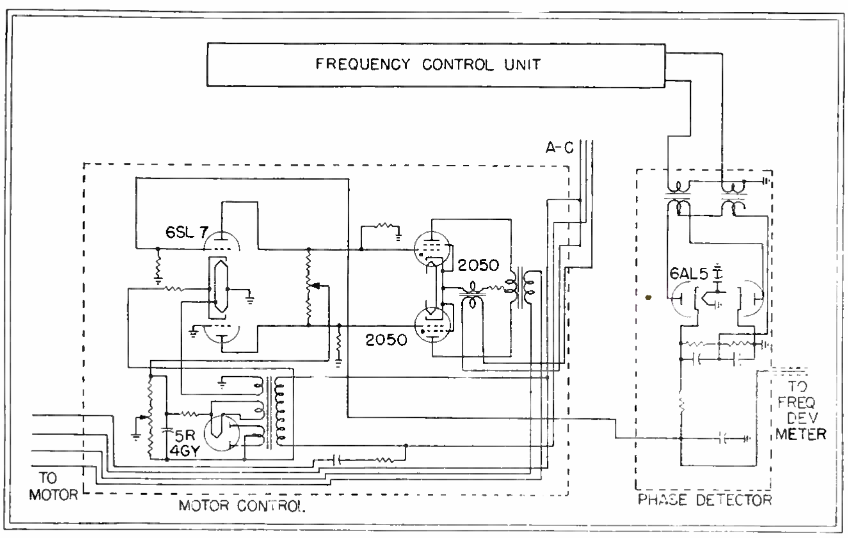
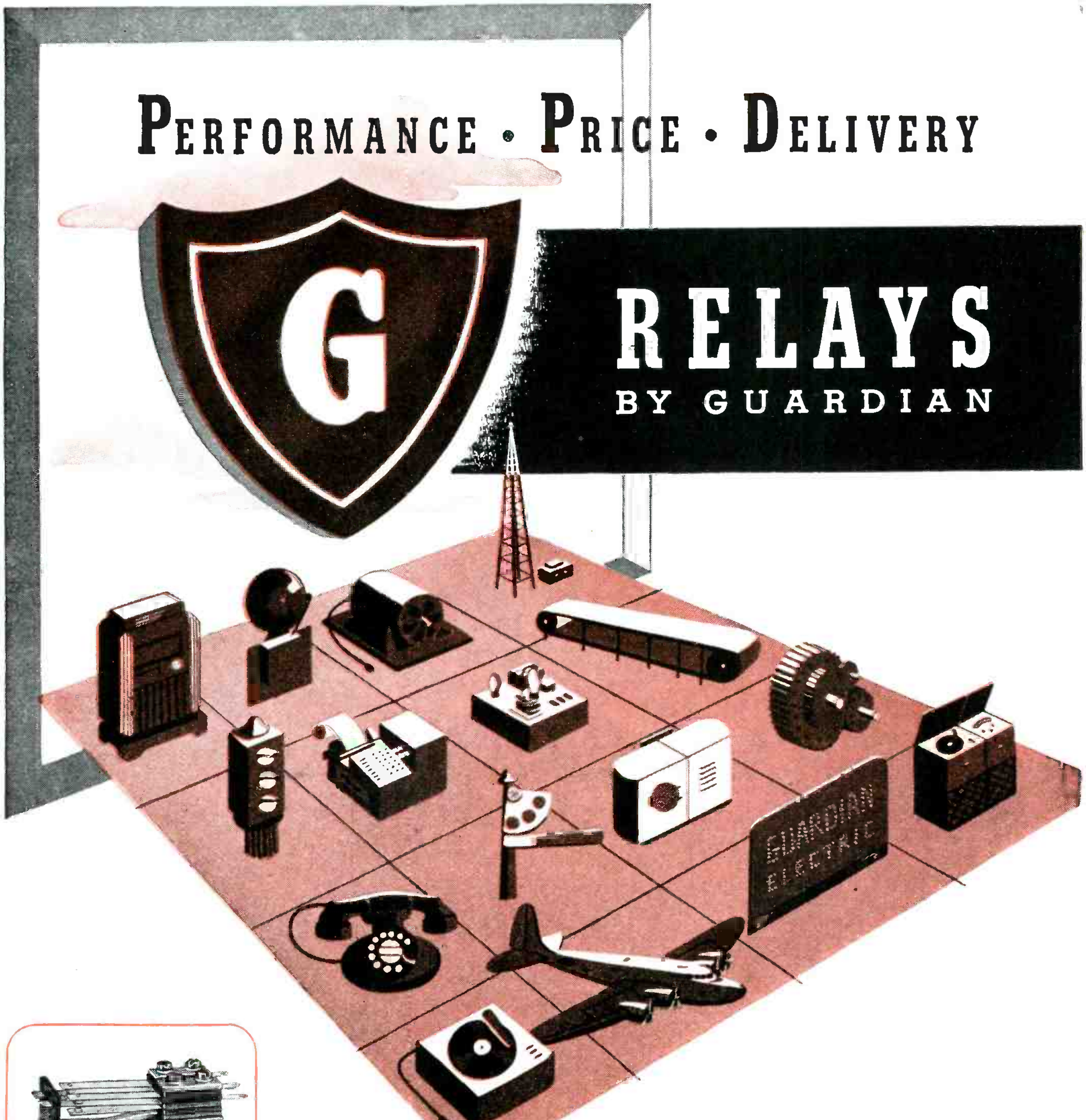
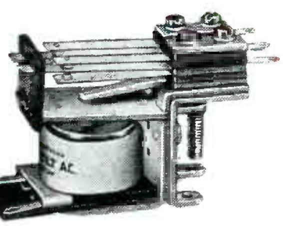


Fig. 1—Circuit arrangement for motor-driven correction of the center frequency of the primary oscillator

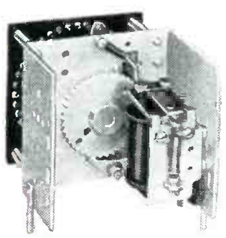
The d-c output voltage from the phase detector is used as a measure of the beat difference between the two carriers. Thus, placing a zero-center d-c voltmeter having a high internal resistance across the output of the phase detector provides a direct indication of the primary oscillator frequency in cycles with respect to the standard crystal oscillator frequency and indicates as well the sine of that difference.

Figure 2 is a schematic diagram of the exciter unit and shows the reactance-tube modulators, the push-pull oscillator, the first doubler and





Series 100 A. C. Relay



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A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY the control units for center frequency stabilization of the primary oscillator. The primary oscillator operates within the frequency range of 11-13.5 mc. A multiplication of eight times is used to obtain the desired carrier frequency. The use of balanced modulators and a push-pull oscillator provides twice the f-m swing of the oscillator frequency that would normally be obtained with a single modulator and thus permits the use of a multiplication factor of only eight. It has the further advantage of eliminating distortion due to second-order products.

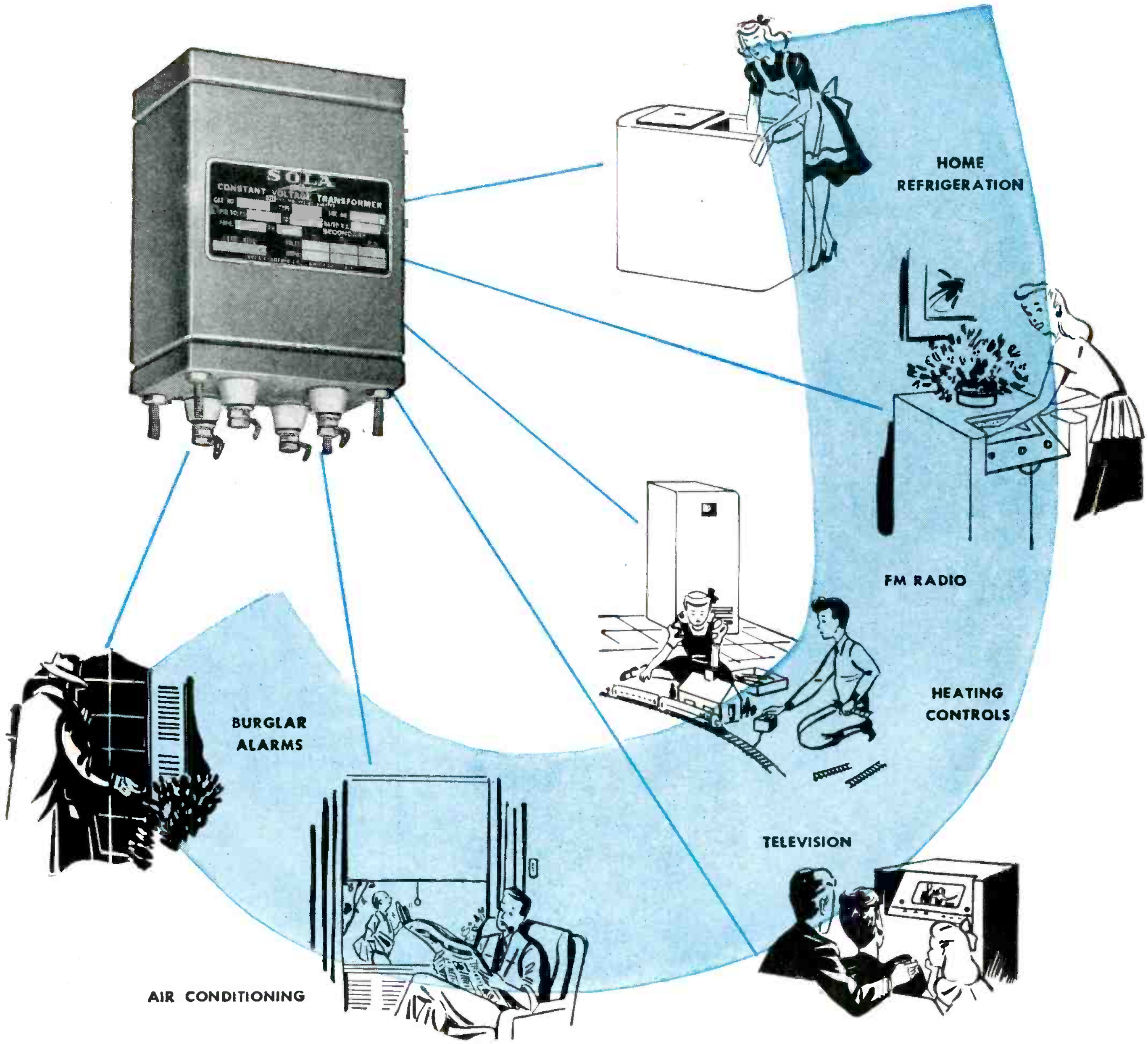
Balancing Action

Means are provided for balancing the cathode currents of the 6AK5 modulator tubes as well as providing controls for adjusting the value of the quadrature voltage fed back to each grid. The quadrature voltages fed to the grids of the modulator tubes are in phase and, if the grids are connected together and a modulating voltage of the same phase applied, the reactive currents, flowing through the push-pull oscillator tank coil as a result of the modulator plate currents, will be effectively zero. This provides a means of adjusting the cathode currents of the modulator and the values of the quadrature voltages fed to each grid so that no f-m modulation of the oscillator frequency takes place with a modulating voltage being applied to the grids of the modulators.

The balancing of the modulators can be carried on at various input levels of modulating voltage. This insures that the modulator tubes are both operating on the same portion of their G_m characteristic, which will result in symmetrical shift of the oscillator frequency around its center value.

With modulating voltages of opposite phase applied to the grids of each modulator tube, the reactive currents now flowing through the oscillator tank coil will be of the same sine and opposite phase so that the total net effect on the oscillator frequency will be effectively doubled.

The 6AK5 miniature pentode tubes were selected as modulators. To insure stable modulator operation and to prevent relaxation types of oscillation that can develop in the modulators, it was necessary to



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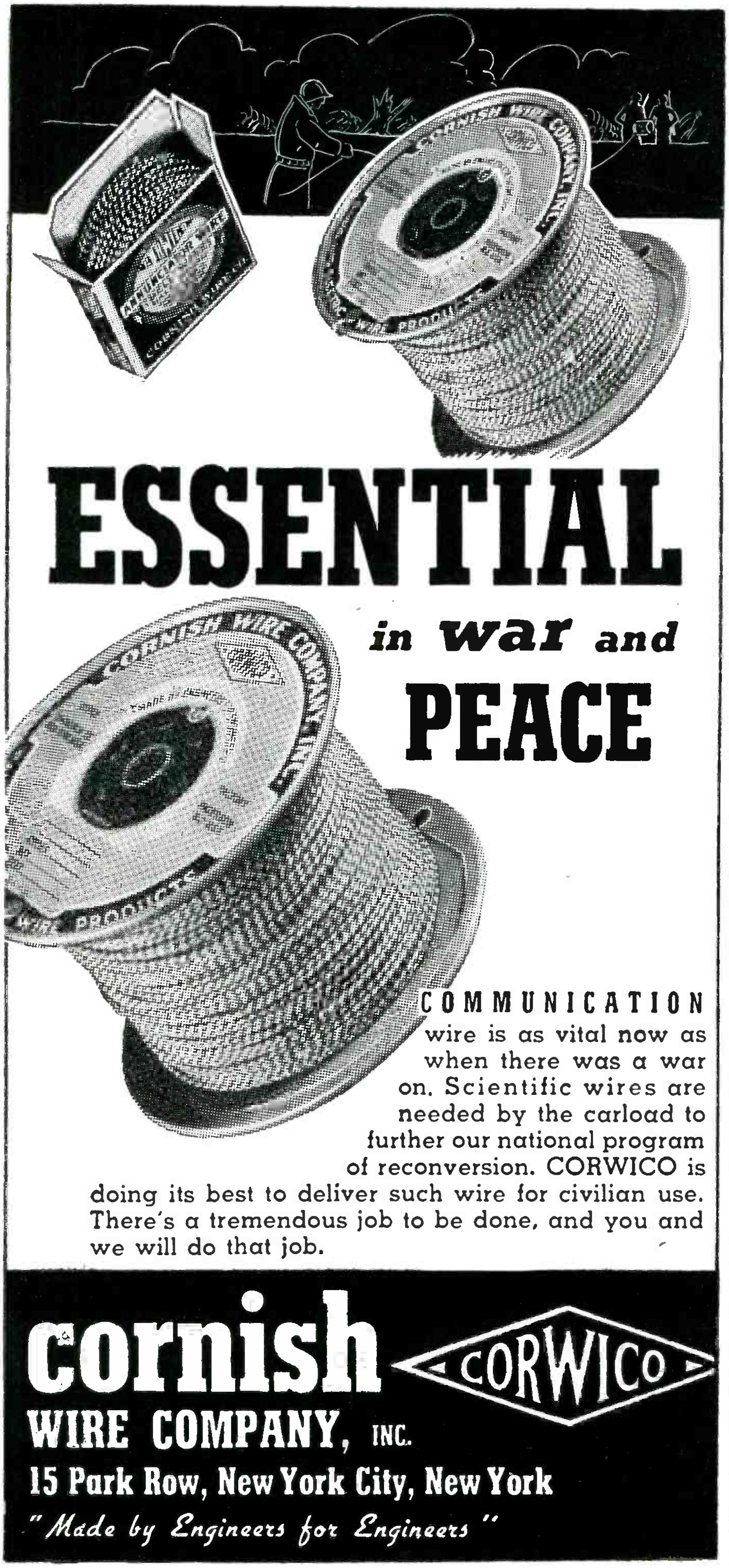

shield the grid and plate circuits of each tube carefully and to place each modulator in a separate can. As a result, the modulators are completely free from any tendency to oscillate and have excellent frequency response characteristics.

The audio modulating voltage fed to the grids of the modulator tubes is carried through a 500-ohm line across which is placed a series resistance-inductance network having a high-frequency pre-emphasis characteristic.

No correcting voltage, developed as a result of drift in the primary oscillator as compared to the standard crystal oscillator, is fed back to the grids of the modulator tubes for the purpose of center-frequency correction of the oscillator. Because of this fact, the modulators are always operating within the proper portion of their characteristics, which eliminates the possibility of distortion being introduced as a result of correcting voltages being fed to the modulators for the purpose of center-frequency correction.

Primary Oscillator

The plates of the modulator tubes are connected directly to the plates of the 6J6 dual miniature triode used in a push-pull Hartley oscillator that operates in the frequency range of 11-13.5 mc. It is necessary that the reactive currents developed by the modulator to obtain a minimum deviation of ± 10 kc of the oscillator frequency constitute a considerable portion of the total tank current. Thus, the constants of the tank circuit are so designed as to insure stable oscillator operation and, at the same time, permit ready modulation of the oscillator. It is likewise necessary that the oscillator be capable of developing sufficient output power to properly drive the first doubler stage.

A 6J6 miniature twin triode is used as a push-push doubler that develops approximately three watts of output power.

To develop considerable power from the second doubler to insure saturation of the grids of the third doubler, an 807 tube was selected. A split tank is employed in the plate circuit of this stage so that effectively only half of its output capaci-

tance appears across the tank coil. A push-pull beam power r-f amplifier tube is used as a third doubler so that ony half its input capacitance is placed across the 807 tank circuit. This circuit arrangement permits the use of lumped constants in the 807 plate tank, in spite of the fact that the tank circuit operates in the frequency range of 44-54 mc.

The 807 second doubler is capable of developing considerably more power than is required to drive the grids of the third doubler stage and a potentiometer in the screen circuit permits adjustment of the driving power. To insure stable operation of the 807 as a doubler in the region of 50 mc, it is necessary to isolate perfectly the grid and plate circuits and this is accomplished by placing each circuit in separate shields.

Concentric Tank

An 829B push-pull beam power amplifier was selected as the third doubler and driver for the final amplifier. To further assure fairly large amounts of reserve driving power, this tube is used as a push-push doubler. Inasmuch as the total output capacitance of the plates connected in parallel is approximately 14 $\mu\mu$f, a concentric transmission line is used as the tank element, with the outer conductor at both d-c and r-f ground potential. This method of construction effectively prevents any radiation from the tank circuit, and removes the possibility of accidental shock due to contact with this tank circuit. A 50-ohm con-

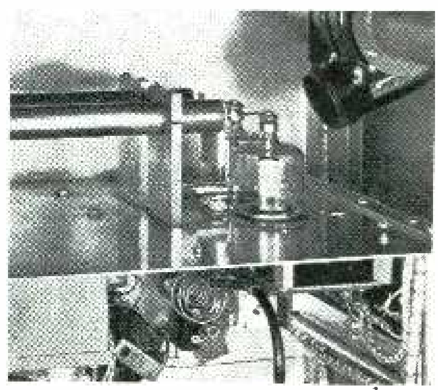

Fig. 3—Connections of the linear concentric lines to the anodes of the 4-125A tubes. The metal plates mounted on standoff insulators near the tubes are used for neutralization of the grid-to-plate capacitance

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centric line connected to the 50-ohm point on the 829B tank and terminating in a small coupling loop couples the tank circuit of the driver to the grid circuit of the final amplifier.

In the grid circuit of the final amplifier lumped constants are used since the tubes are in push-pull and place only half their input capacitances across the grid coil. The tubes in the final stage are Eimac type 4-125A. A potentiometer in the screens of the 829B's controls the drive to the final amplifier grids.

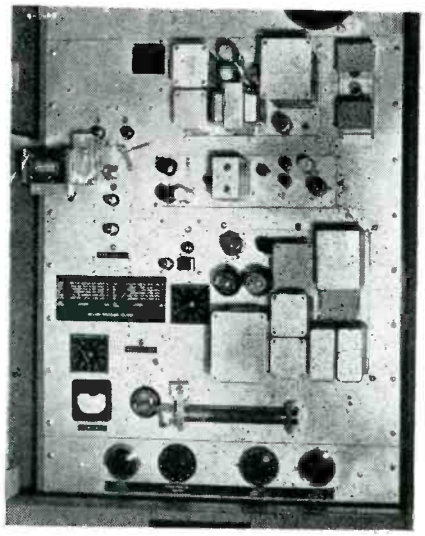

Fig. 4—Exciter unit of the f-m transmitter. The motor that controls the primary oscillator tuning capacitor appears at lower left above the modulator tubes

To obtain high efficiencies out of the plate circuit of the final amplifier, linear concentric line elements are employed. In spite of all precautions taken to prevent external coupling between plate and grid circuits, and in spite of the fact that special sockets were constructed which constituted the bypass capacitors for the screens and filaments of these tubes, it became necessary to neutralize the grid-to-plate capacitance. Because of the original socket construction, it was not feasible any longer to attempt to tune out the screen-grid lead inductance.

It was not possible to cross-neutralize in the conventional manner because the neutralizing leads themselves offered considerable inductance at these frequencies. It was necessary to use a neutralizing coil and metal plates placed in fairly close proximity to the anodes of the

Original Award July 27, 1942
Second Award February 13, 1943
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Fourth Award May 27, 1944
Fifth Award December 2 1944

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type 4-125A tubes to obtain satisfactory neutralization.

Tuning of the lines is accomplished by placing a small capacitor at a point of low impedance across the lines. It is possible to use a capacitor with fairly close spacing because no d-c potential exists across it and because the capacitor is placed at a point of low r-f potential. The output power from the final amplifier tank circuit is taken off by means of an adjustable coupling link terminating in a 50-ohm line.

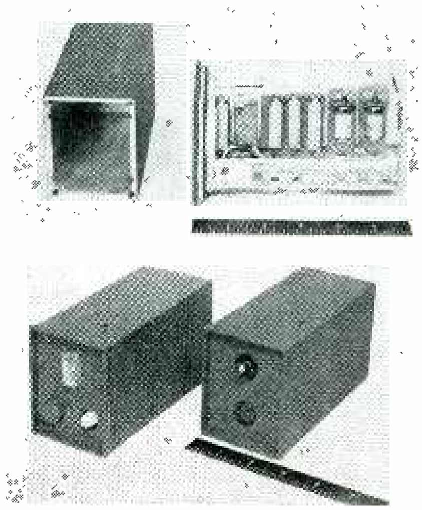
• • •

Twelve-Tube F-M Handie-Talkie

By J. M. Lee
Editors' Technical Associates
New York, N. Y.

DESIGNED TO TAKE the place of the famed a-m handie-talkie, a midget 12-tube f-m transmitter-receiver has been developed by the Signal Corps Engineering Laboratories. Called the AN/PRC-6, the set weighs eight pounds and is designed for use by foot troops in short distance communication on the front lines, either with other foot troops or with closely supporting armored vehicles. The frequency range of the set is from 47.0 to 55.4 mc and it is designed to operate with "B" sets of the Army's vehicular radio transmitters and receivers (AN/GRC-3 to 8).

The unit contains nine tubes in its receiver and three in its trans-



The small size of the 12-tube transmitter-receiver is illustrated by the view of the chassis at top. The complete unit in its case and a battery box are shown at bottom

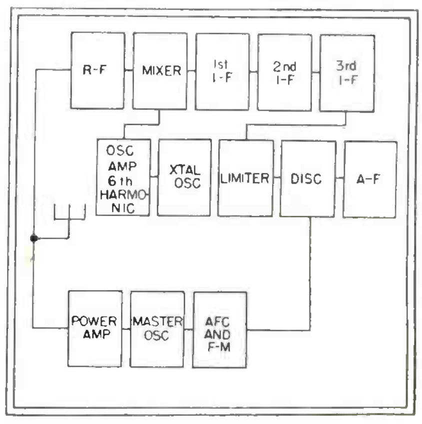
mitter. Eight of the tubes are type 2E31, a new r-f amplifier tube, about $1\frac{3}{8}$ inches long and not much bigger in diameter than a lead pencil.

Wider Application

The set was designed to take the place of the five-tube a-m handie-talkie SCR-536 because nearly all other radio sets used by the Army for short-range communication are f-m. Consequently, it is impossible for a soldier with the handie-talkie to communicate with anyone in a tank or in an airplane unless they too have a handie-talkie. Another obvious advantage of the PRC-6 for Army communications is its extremely low noise level under certain conditions, which makes comprehensible communication possible where a-m reception would be unsatisfactory.

Both the transmitter and the receiver of the PRC-6 are contained in a box 6 inches long, $3\frac{1}{2}$ inches wide, and $2\frac{3}{4}$ inches deep. As shown in the block diagram, the receiver consists of an r-f amplifier, mixer, a CK556AX in the crystal oscillator and oscillator amplifier stages, three i-f amplifiers, a limiter, a discriminator, and an audio amplifier. The transmitter has a master oscillator and power amplifier stages using 3A4's and an automatic frequency control and frequency modulator stage.

The comparative size of this set may be had by contrasting it with the 35-pound walkie-talkie (SCR-300) which troops dubbed the breaky-backy. The PRC-6 weighs



Stages of the new f-m handie-talkie. An amplifier is necessary to obtain sufficient power at the sixth harmonic of the receiver oscillator

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The demand for the 260 from men who first used it in the Armed Services (in laboratories of 300 government agencies and universities, and on the battlefields the world around) has now been added to its enormous popularity among radio servicemen. The Simpson 260 is easily the world's most popular high-sensitivity set tester for television and radio servicing.

The basic reason for this out-selling and out-performing by the Simpson 260 is this: It out-values every other similar instrument in the field. You cannot touch its precision, its useful ranges, or its sensitivity in any other instrument selling for the same price or even substantially more.

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10	10	10 V.
50	50	50 V.
250	250	250 V.
1000	1000	1000 V.
5000	5000	5000 V.

Milli-amperes D.C.	Micro-amperes	Ohms	
10	100	0-1000	(12 ohms center)
100		0-100,000	(1200 ohms center)
500		0-10 Megohms	(120,000 ohms center)

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about a fourth as much, and is so distributed on the soldier's person that it is virtually impossible for enemy snipers to identify him as a key communication man.

The power supply is housed in a case with a total capacity of about 60 cubic inches. Development is going forward on a new type dry battery which shows promise of being capable of operating the set for from four to six hours, when the set is worked on the usual ratio of two minutes receiving to one minute transmitting.

The sub-miniature 2E31 has roughly the same electrical characteristics as the prewar miniature pentode ILN5, but is about one-tenth the size. While it suffers by comparison from the standpoint of transconductance, having 500 μmhos instead of 700 for the ILN5, its ratio of gain over consumed battery power is better.

Receiver Oscillator Amplifier

The receiver local oscillator is controlled by a 10-mc crystal and since the set itself uses a frequency from 47.0 to 55.4 mc to produce an i-f of 4.3 mc, the sixth harmonic of the crystal is used rather than its fundamental frequency. This results in a relatively low oscillator output, hence the need for the amplifier stage between the crystal oscillator and the mixer.

The crystal used in the oscillator is typical of those developed for Army radio sets where pretuning at given frequencies is desirable for radios in a given tactical unit or area. They do away with the necessity of tuning by the operator, and insure immediate on-frequency communication. The frequency can be changed in such sets only by removing the crystal and inserting another of different frequency, usually at third or fourth echelon radio repair shops.

The crystal oscillator in the receiver is also used for indirect control of the transmitter frequency. This is accomplished by keeping the receiver turned on when the set is transmitting so it receives its own signal. When the signal produced by the transmitter self-excited oscillator varies from the pretuned crystal-controlled frequency of the receiver, the automatic frequency con-

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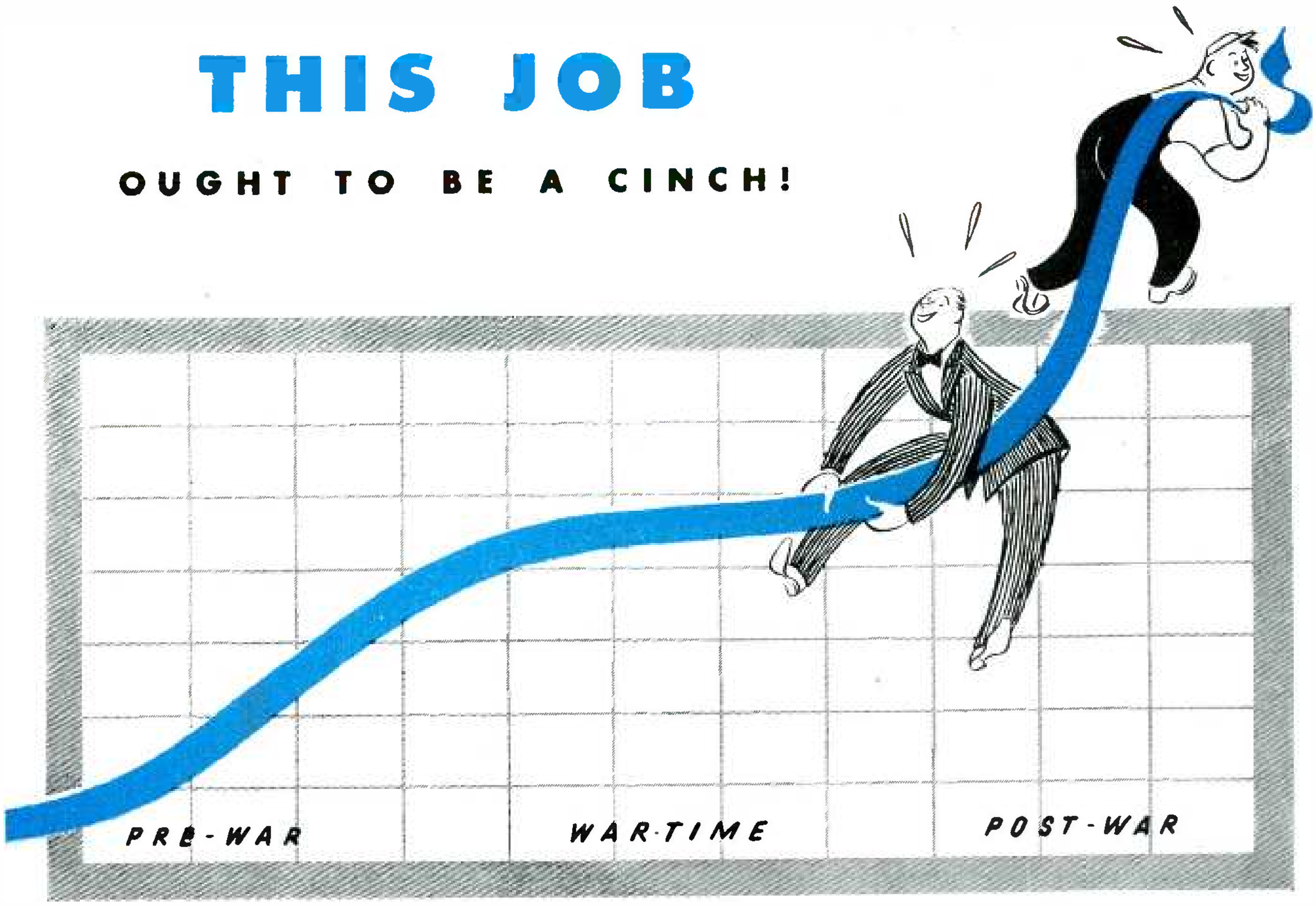

Who was it that scared the little Austrian paper hanger to death? Who was it that busted the Bulge? Who was it that brought the son of heaven down off his white horse? Who gets the credit for V-E Day?

Why, the brass hats and G. I. Joe. The financier behind his polished desk. The nation's industrialists who converted their plants into arsenals of war. Labor working three shifts, racing against time. The housewife wrestling with ration stamps. Junior and Little Sister collecting waste paper and tin cans.

It was all of them — all America working together for a common purpose. It took a war to show us what we could accomplish when we pooled our efforts. It surprised us, and astounded our enemies, the rate we could produce and the way we could fight.

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trol circuit pulls the master oscillator back on frequency.

Crystal Detector

The discriminator in the receiver employs a two-crystal detector. This type saves considerable space over what would be required for a traditional diode arrangement and the crystals are a refined version of the old cat-whisker detector. Experiments are going forward on such detectors using both germanium and selenium.

At present the set has a quarter-wave rod antenna about five feet long. Further experiments are being conducted with an antenna that is wholly or largely concealed. Among others, one consisting of a single loop around the GI helmet is being tried.

For military use, the set should be capable of sending or receiving for a distance of one mile in mildly rolling terrain and have a range of 300 yards in heavy jungle. Trees and shrubs absorb the radio waves to such an extent that satisfactory communication over greater distances is extremely difficult.

• • •

Portable Television Console

ALL CONTROL GEAR necessary for operation of two television cameras has been compressed into the unit which is shown in Fig. 1 with its designer, Klaus Landsberg, director of television, W6XYZ. It includes the synchronizing pulse generator, sweep signal generator, power supplies, and monitoring units.

Station W6XYZ is the Paramount Pictures' television subsidiary in Hollywood, Calif., and the equipment has resulted from practical operating experience by the engineering group there. Its basic inspiration is credited to the DuMont suitcase line of apparatus.

The front panels drop as shown in Fig. 2 to reveal the power supplies. Behind them can be seen the blades of cooling fans which circulate air throughout the entire assembly, discharging it from louvers at the rear of the top cover. Although there are more than 200 tubes in operation, the working

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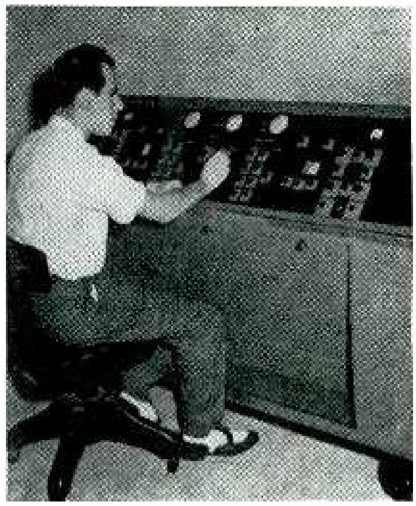

Fig. 1—Klaus Landsberg and the telemobile, portable television console, developed at W6XYZ, Paramount Pictures' station in Hollywood

temperature is kept well below a point of damage to the components.

Designed to combine a fatigue-free operator position and good visibility of the stage, the unit gives better accessibility for maintenance than rack and panel installations. Figure 3 shows the cover lifted back and two of the equipment bays hinged forward to bring both the tube side and the wiring side into convenient reach. The large access panel on the end covers the more-permanently-set blanking and sweep signal controls.

Shock mounts are used through-

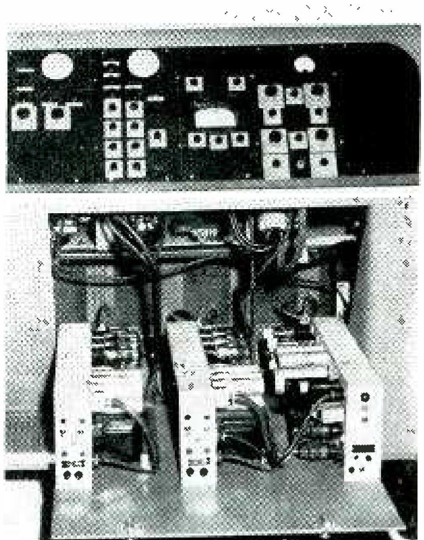

Fig. 2—Lower panels of the telemobile carry power-supply chassis in convenient position for service access. A small compartment contains tools

out against damage and microphonics. The small compartment to the right and above the right-hand power-supply chassis contains tools and servicing gear. Meters and cro are built-in and can be switched into any part of the circuits for testing.

In operation, the telemobile, as it has been named, requires no cabling between individual sections. The only connections are the 110-v power and two camera cables which can be attached in a few seconds. Coaxial cable connectors are provided on the left end for line patching. For field pickups, operation

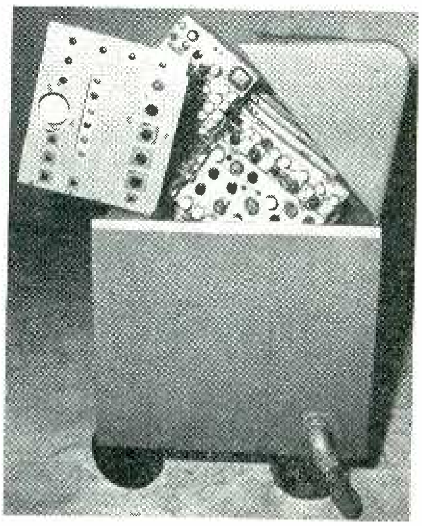

Fig. 3—Tent-shaped top lifts for maintenance and repair of operating units which hinge forward without being disconnected. Bottom, one of the two camera cables, the other being at the opposite end with the power plug and coaxial line-patching plugs

from a station wagon is possible because of the small size of the unit, while in stations involving a large number of studios, it is wheeled from studio to studio on its rubber-tired wheels and thus obviates the need for duplicate equipment. In a large studio, it can be placed behind the window in the wall nearest the action.

Where more than two cameras are required, any number of telemobiles can be combined. Additional units are smaller in size since they do not require synchronizing and sweep generators nor line amplifiers. The unit has proven its worth during actual operating conditions at W6XYZ.

THE ELECTRON ART

Massive Speaker Cabinet

By CHRISTIAN A. VOLF

Director of Research
Robinson-Houchin Optical Co.
Columbus, Ohio

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Helmholtz suggested that echoes and reverberations of musical sounds are as important to quality as are true vocal cords (instead of false ones) to the voice. He states that echoes and reverberations should not be absorbed. However, in contemporary acoustics, major attention has been given to the elimination by absorption of echoes and reverberations. Although architects and acoustical designers have formulated many fantastic shapes in order to produce good acoustical results in theaters, large enclosures, or outdoors, the best acoustic conditions are found in some of our older buildings. New architectural designs do not always produce as good results as we find in old brick structures.

Superiority of Old Carillons

In steel and concrete structures one should not look for good acoustics regardless of the plasters that may be used on the inner walls. It is not that the concrete mass is detrimental but that the steel girders, which form the skelton of the structure, conduct the sound away from where it is wanted.

Compare the sound effects and distribution from many famous carillons in the European countries; they can be heard from miles away. The same is true with relatively small bells in villages where churches are often of brick or wood structure. The chief reason for such good effects is the fact that the bells are not suspended from or anchored to steel girders but are suspended from heavy oak planks.

As a matter of illustration, one need only observe the carillons of the Riverside Church in New York or the Mellon Church in Pittsburgh. They are among our latest belfry towers and yet one has difficulty hearing them with reasonable fidelity a block away. The reason for this poor acoustical result has little to do with the openings in the belfry, its shape or its height. The poor acoustics rests chiefly upon the fact that more than 75 percent of the total output is carried through the steel girders and grounded directly into the foundation of the church proper. As evidence, those who are familiar with the famous carillons in European countries can best bear witness to the great difference represented in the beauty of the sounds coming from our famous cathedrals and those which came from the carillons in Mechlin, Ghent, Antwerp, Bruges, and Namur which far excelled the results obtained in any of our modern architectural church structures employing carillons.

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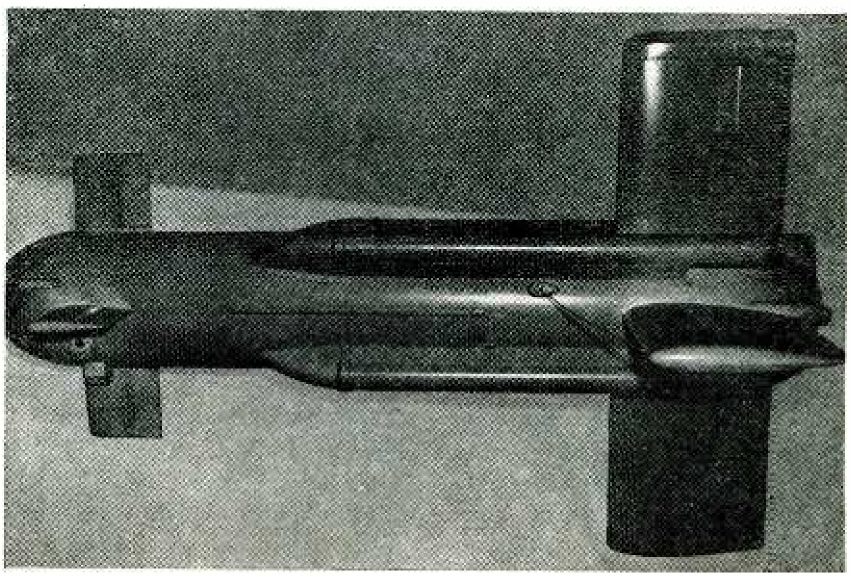

Radio controlled, rocket powered bomb being developed at the close of the war was to be launched from shipboard. It would race straight upward for 10,000 ft at 400 mph. A proximity fuse would detonate the 100-lb, general purpose charge if the bomb approached its target

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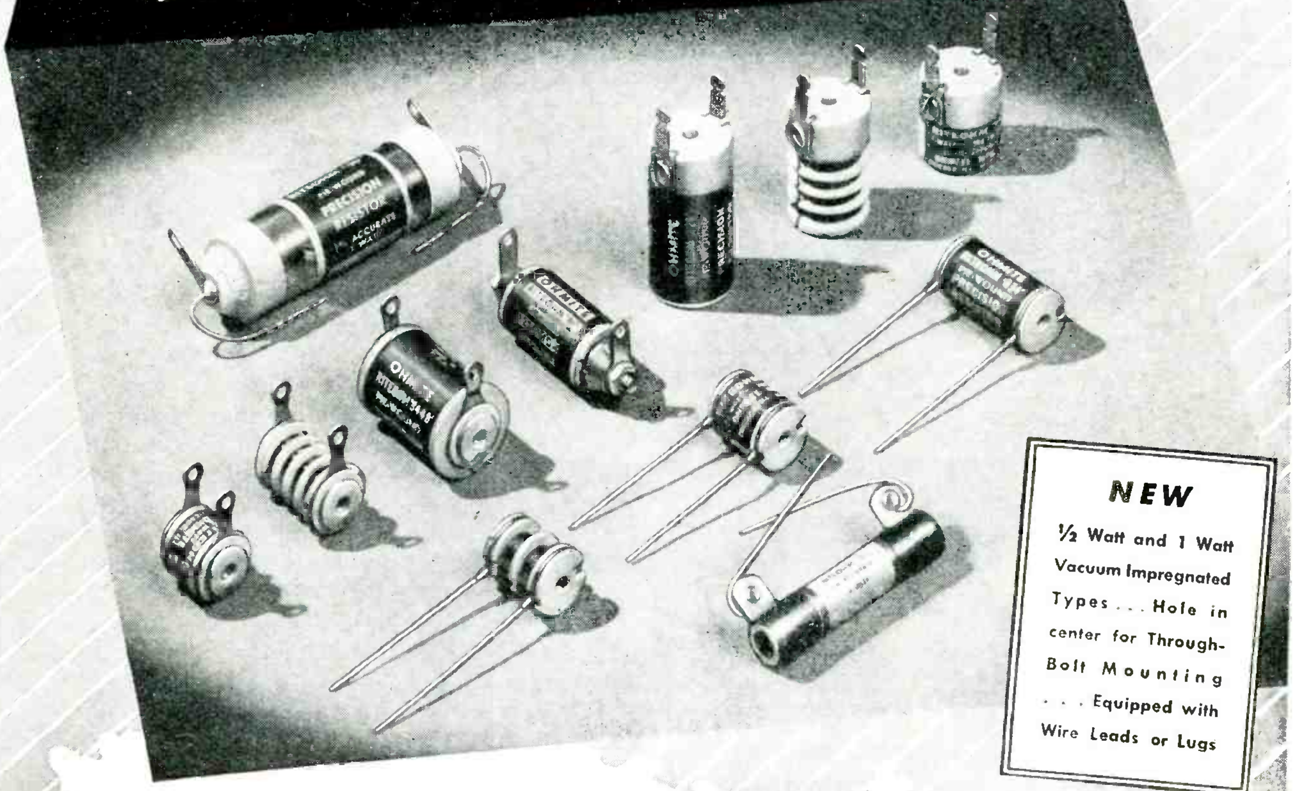

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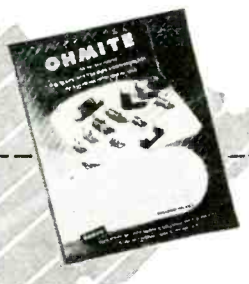

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plifying horns were developed to achieve natural hearing results in the many sizes and types of architectural enclosures but somehow the problem has never been satisfactorily solved. On the other hand, the theaters have been built to suit the sound equipment. One of the largest theaters to be built promised to be the last word in perfection in the acoustical arts. It was highly unsatisfactory. We are still designing theaters to suit the sound system and, when the theater has been completed, we often must then redesign our sound system to suit the new theater. And acceptable system must be worked out for each individual theater. This procedure is costly and could be avoided if we would return to well known acoustic principles which have proven to be excellent wherever they are employed.

The foregoing history has merely been cited to convince those interested in the acoustical arts that the selected building material and its mass is of greater importance than the shape within the theater as long as we do not totally disobey certain physical laws of shapes as was the case in the formula embodied in the ceiling of the Radio City Music Hall. The chief objection to that ceiling was that, instead of introducing an expansion factor, it introduced sharp reflective surfaces which resulted in too many echoes when it was first tried. It was tolerably corrected with sound absorbtion materials throughout, and then an abnormal increase of loudspeaker units became necessary to overcome the deadening effects on sound. The mistakes made in such outstanding structures are unnecessary if we use the knowledge available in the science of acoustics.

General Purpose Chamber

The illustrated resonator and sound distributor makes great progress toward perfection of good acoustics within large enclosures as well as out of doors sound amplification. Theoretically and in practice it represents well known acoustical principles and disobeys none of the acoustical laws. As has just been explained, it does not ground the sound as would a metal mount. The relationship of air column, mass, and quality of material, as well as form

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The two types of shipboard cable, TTRS *(above)* and TTRSA *(below)*, are identical in construction except for the armor braid covering the latter. Inside the sheath is a cabled assembly of twisted pairs; each twisted pair consists of tinned copper conductors insulated with Du Pont polythene, then twisted into duplex pairs, which are covered with tinned copper shielding braid and with color-coded cotton braid. The individual conductors are size AWG 20 and consist of 7 strands of 0.0126-inch tinned copper. The polythene insulation is extruded to a thickness of 20 mils.

Shipboard cable insulated with

Du Pont POLYTHENE

The shipboard cables here illustrated furnish another striking example in the growing list of difficult insulation jobs done capably by Du Pont's versatile plastic, polythene. These cables, manufactured by Rockbestos Products Corporation of New Haven, Conn., are used by the Navy for three functions: for transmission of synchronizing voltages in fire control equipment, for indicator sweep voltages, and for video frequency receiver output signals. In use they transmit signals from circuit to circuit as in a telephone circuit.

Polythene offers outstanding advantages as an electrical insulation. Because of its high dielectric strength, only a minimum thickness is needed. Polythene's low power factor makes it exceptionally effective for high-frequency wire, such as is used extensively in television. Polythene is chemically inert, light in weight (specific gravity 0.92) and retains its toughness and flexibility at temperatures ranging from −50° F. to 200° F.

For complete data sheet on polythene, write E. I. du Pont de Nemours & Co. (Inc.), Plastics Dept., Arlington, N. J.

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has been fully considered as illustrated in Fig. 1 from which all structural details can be observed. The dimension constitutes a 24-inch cubicle air column, the weight of this small chamber without any hardware or loudspeaker units installed is 90 pounds. In comparing this weight with any other empty reproducing chamber of similar size, it will be found three to four times heavier.

Five loudspeaker units of various dimensions may be installed within

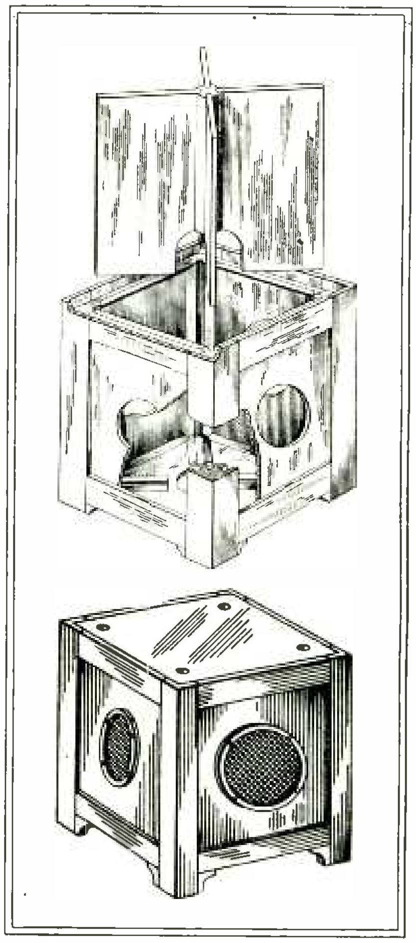
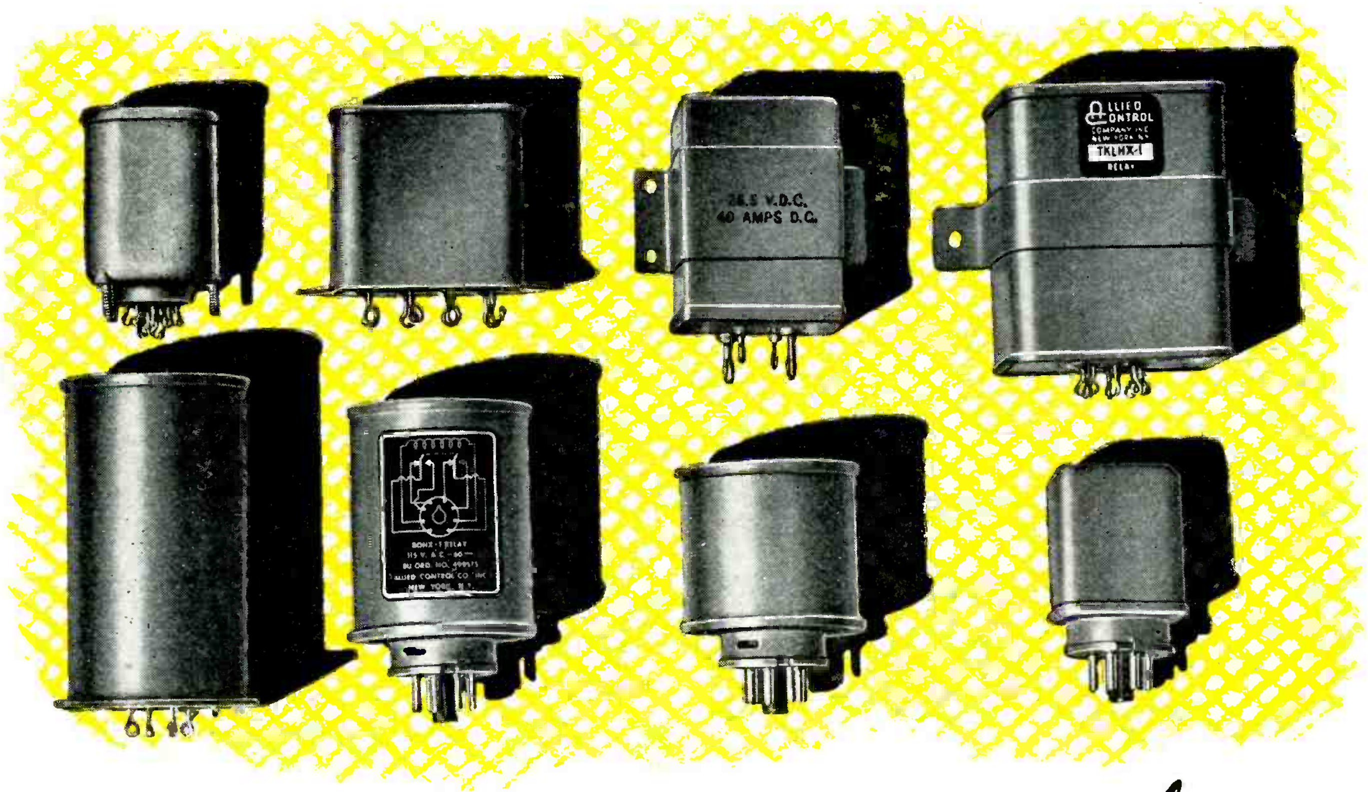
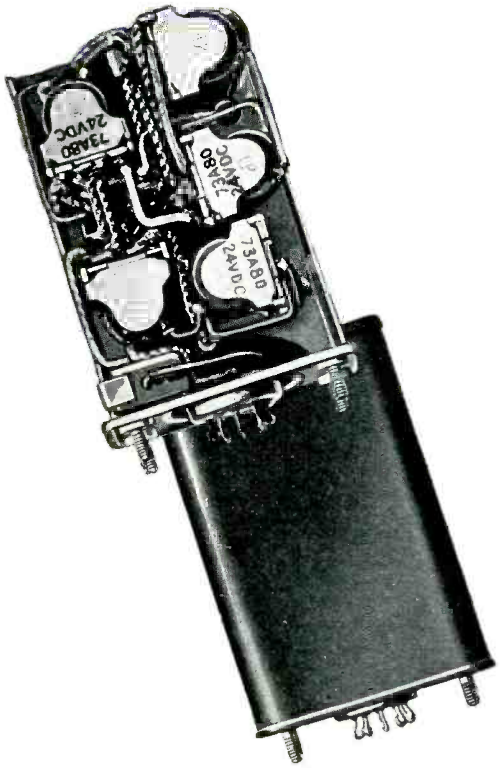


Fig. 1—The resonator cabinet is massively constructed of uniformly grained wood and houses five loudspeakers

the 24 inch cubicle space and a four sectional dividing section slid into the grooved segments, thereby separating the back of each unit from the other. The resonating box contains no other electrical equipment. The total unit is preferably suspended from the ceiling to a level most suitable and in proportion to the total ceiling height or, when employed in connection with motion pic-



DIVERSITY OF DESIGN *plus* IN ALLIED's HERMETICALLY-SEALED RELAYS



The photo above shows a cut-away view and completed assembly of Allied type TKHX-26 sealed relay with ten soldered terminals individually color marked.

These relays are designed to fit your specific applications and to fill your special requirements completely, but this is not all.

When you specify "Allied" you are sure to get a unit that is completely engineered as a sealed relay — not just equipment built around older types. Moreover these sealed relays are produced completely, from start to finish, in Allied plants, by one organization, under coordinated standards.

These products have back of them a wealth of pioneering experience in the sealing of relays to protect them from dirt, moisture and many foreign substances or to prevent tampering or accidental damage to the working parts. This experience is today expressed in a completely organized sealed-relay division, using the most modern techniques and equipment including a specially designed sealing room where air temperature, humidity and cleanliness are scientifically controlled.

There is wide diversity of design in Allied sealed relays. But of far greater importance are the benefits of experience, complete engineering, and modern manufacturing by one organization. Before you specify be sure to get all the facts about Allied relays.

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AL-102

GENERAL OFFICES: 2 East End Ave. (at 79th St.) New York 21, N. Y. *Factories:* New York City (2 East End Ave.) Plantsville, Conn. *Chicago*—4321 N. Knox Avenue, Chicago 41, Illinois. *In California:* Allied Control Co. of California, Inc. 1633 South Hope St., Los Angeles 15, Calif.

tures, is placed either directly above the screen or one unit on each side of the screen, depending on the size of the theater proper. As has been previously mentioned, a multiple installation of directional loudspeakers is unnecessary; this unit is all that is required.

The same unit may be employed as a console cabinet upon which may rest a radio or public address amplifying system as illustrated in Fig. 2. In this way it forms a complete professional sound unit of high quality.

A six-way switch is built into the amplifier section through which each speaker can be excited separately or all five jointly. In substance, it may

Fig. 2—The resonator can either be suspended from the ceiling in auditorium installations or placed on short legs above the floor as a base for the associated sound equipment

be defined as a five dimensional sound system because each loudspeaker is directional and yet, when all five are operating, the cabinet introduces no directional characteristic whatsoever. This fact is particularly true when the cabinet has been suspended from the ceiling.

One becomes aware of a totally new sound effect, namely that of mass sound, which theoretically would be the same as the fifth dimension. Helmholtz gave much consideration to the combinational tones in music and it is precisely these qualities that are brought out with as-

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tounding realization. Tests made of the sound values show that there is no predominance of either the higher or lower frequencies anywhere within the enclosure. There is a blending of the tonal response from the speaker units when measurements are taken beyond a reasonable distance from the sound source.

When listening to such recordings as the Sextet of Lucia, all of the voices stand out singularly and yet blend with the rest of the musical qualities. In the Hungarian Rhapsody No. 2 the magnificent chords and the massiveness is reproduced with brilliant results.

From the practical aspect, the resonator offers superior acoustical result and simplifies sound installations in large auditoriums or theaters because it requires only one outlet for each unit. Sound distribution from the cabinet is uniform, thus it can replace an installation where numerous directional loudspeaker units are employed toward the same end.

• • •

Infrasonic Switching

By ANGELO MONTANI
Woodhaven, N. Y.

SIMULTANEOUS, two-way communication over one channel is possible by infrasonic switching. By this switching technique two circuits are alternately interrupted, freeing the channel for use by one at a time for reoccurring intervals. Because of an auditory characteristic comparable to persistence of vision, the interruptions in the conversations are inaudable.

The purpose of this paper is to outline the functioning of this intercommunicating technique and at the same time to show how a development may be born from parallel thinking in two such apparently unrelated fields as physiology and electronics.

Auditory Measurements

Because the optic and acoustic nerves originate from the fourth cerebral ventricle, they should show analogies peculiar to nerves having the same embryologic history. In particular, is there a persistence of

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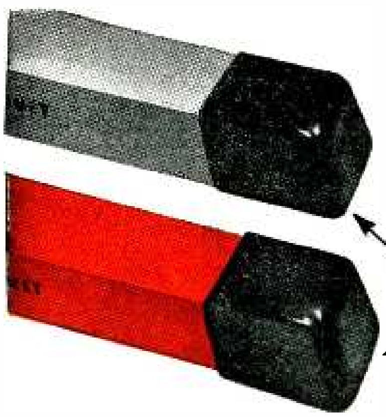

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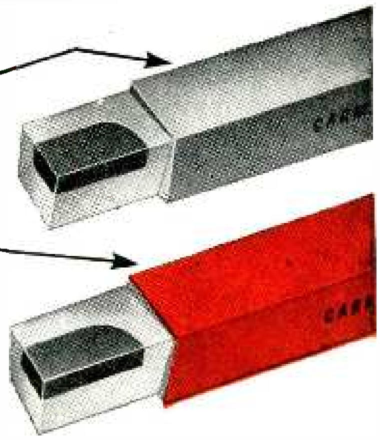

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the aural image just as there is a persistence of the visual image?

To answer this question the simple acoustic apparatus shown in Fig. 1 was devised. A single headphone earpiece was located at one opening of a nine-foot tube. A rotating shutter, coupled through a variable reduction drive to a motor, closed and opened the tube to the sounds from the earphone. The contraption was enclosed in a soundproof box

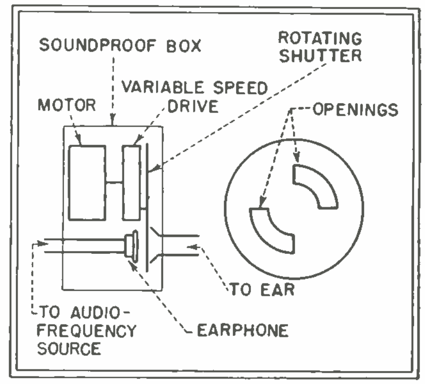

Fig. 1—Experimental equipment for measuring persistence of aural image

from which the tube protruded. Modulated currents from an audio amplifier or an audio signal generator were applied to the headphone. Because of the rotating shutter, the sound in the tube was intermittent, the periods of sound equaling the durations of silence.

With one's ear at the free end of the tube, one varies the shutter revolutions per second. When the sound is passed for one thirtieth of a second and interrupted for the same interval repeatedly, the emitted sounds are completely intelligible and the discontinuity is imperceivable. In other words, despite the fact that continuous sounds are chopped into time sequences lasting 0.033 seconds and separated by 0.033 second of silence, the sounds are still perceived as continuous.

Physiologically if an acoustical sound is interrupted and started again, the gap is not recorded provided the sound had previously lasted before the interruption and will continue to last after the interruption for a length of time sufficiently long to produce the sensation of pitch. The interval of 0.033 second is short enough not to be perceived between two acoustic stimula and long enough to produce a sensation of pitch.

The following table shows the

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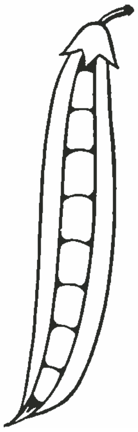

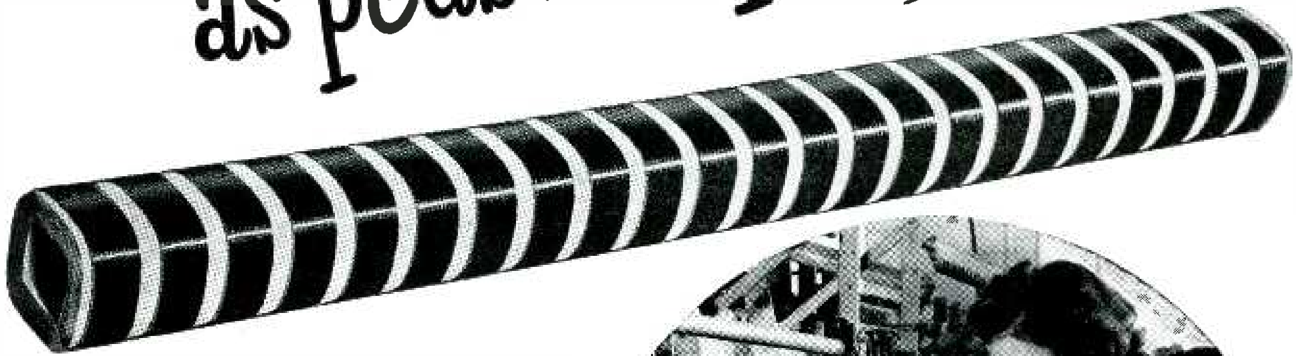

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minimum duration necessary for a tone of a given frequency to generate the physiological sensation of pitch.

Tone Freq in cps	Duration in seconds
50	0.060
200	0.022
300	0.014
1,000	0.012
2,000	0.012
5,000	0.015
10,000	0.025

This phenomenon of persistence of the aural image is the parallel of the persistence of the visual image which made possible motion pictures and television. This aural counterpart can similarly be used in the communication of speech.

Application to Telephony

Purposely leaving physiological considerations aside, let us examine the possible use of persistence of the aural image in speech communication. From the above experimental data we conclude that it is possible to use a single channel for 0.033 second, 15 times every second, leaving the line idle for about half the time. A second conversation can be sent over the line during the intervening 0.033-second intervals as illustrated in Fig. 2.

This practice finds an elegant application in the intercommunicating system used in offices and factories. The press to talk switch is unnecessary and the conversation is therefore more natural. One speaker can interrupt the other at will, which may or may not be an advantage, as in normal conversation.

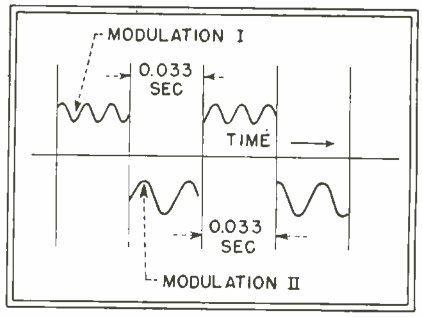
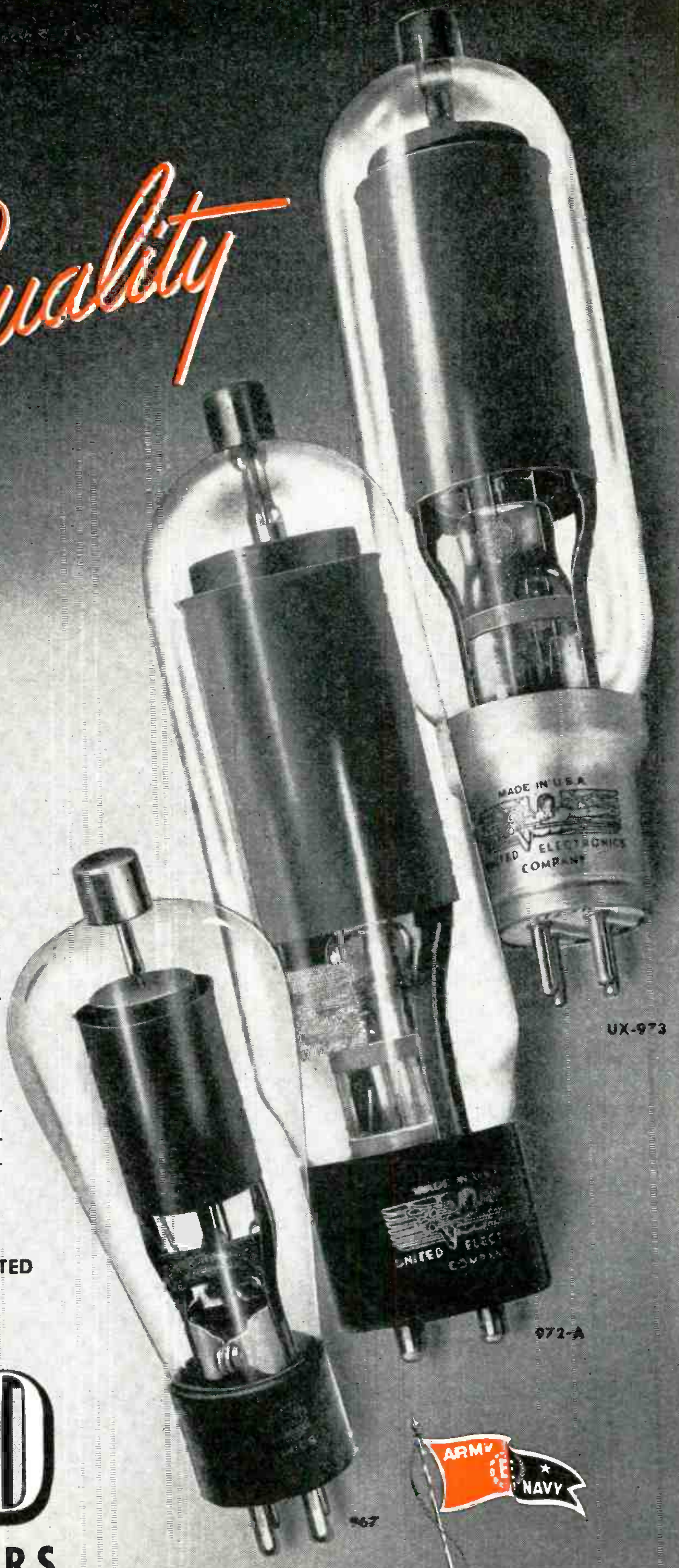


Fig. 2—Transmission of two signals by infrasonic switching. These signals can either be traveling in opposite directions as in two way communication or can be two simultaneous signals transmitted over a single electrical channel

An intercommunicating system using this principle is shown in Fig. 3. For about 0.033 second the line is used in one direction, then for the

Obvious Quality



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" " "	UX-973		--------
" " "	973 (Not illustrated)		873

next 0.033 second it is used in the opposite direction. As a consequence the feedback arising from connecting all microphones and speakers to the same line is eliminated. Because of the switching, the speaker at one station cannot feed back into the microphone at that station, therefore

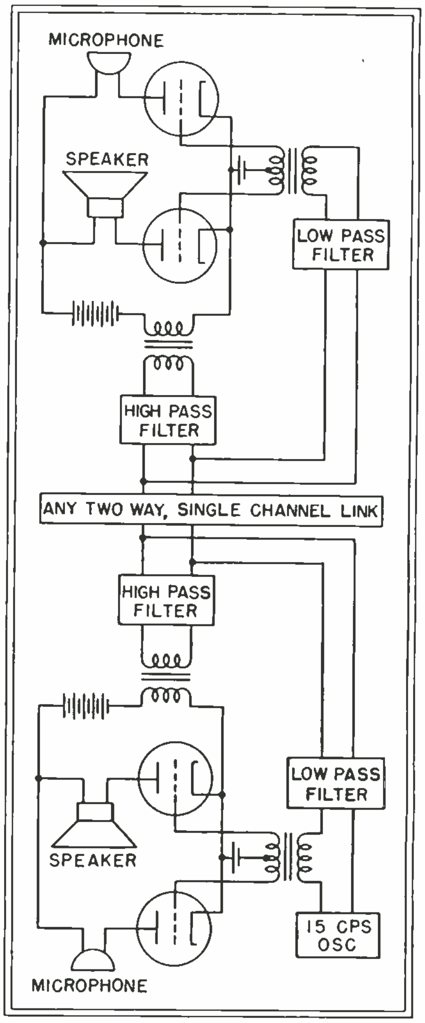

Fig. 3—Simple circuit illustrates the way in which simultaneous, two-way communication can be carried on over a single-channel link such as a two-wire line or a two-way radio

a dual-purpose unit having two coils and acting as speaker and microphone can be used.

The 15 cps of the switching oscillator is transmitted over the channel to maintain both (or several) stations in synchronism. It is suggested that the wave form of the switching be sinusoidal and of sufficient amplitude to transfer operation of the amplifiers within one millisecond. The 15 cps signal can be used to synchronize a multivi-

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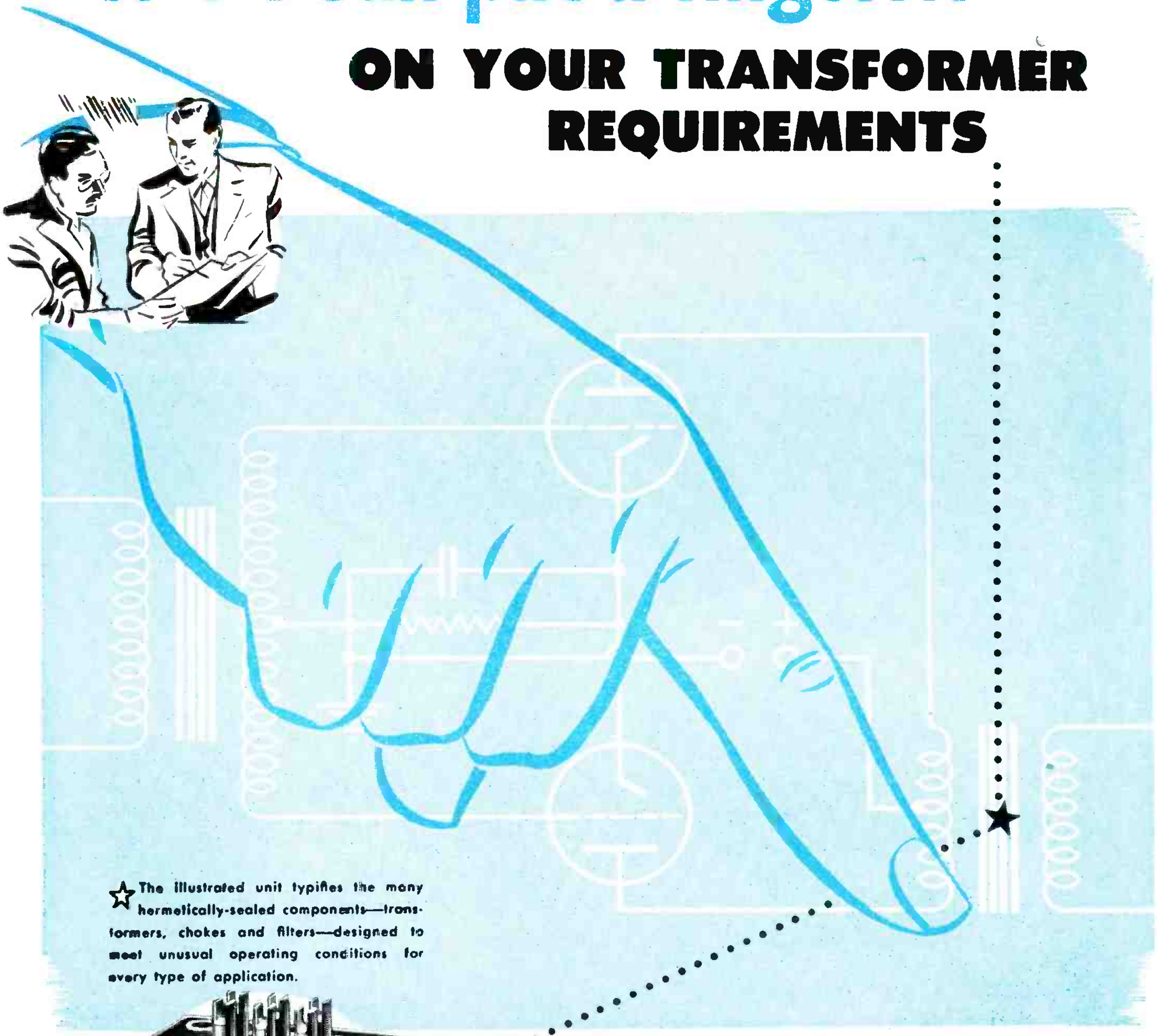

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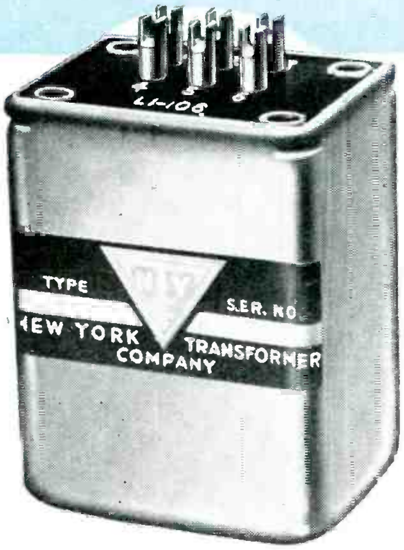

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brator in which case it can be of low amplitude. A phase shifter may be necessary for proper meshing of the switching with the intelligence signals.

• • •

Rectangular-Pulse Generator

By ROLLIN K. MCCOMBS AND FRANK C. WALZ

University of Colorado
From The Review of Scientific Inst.

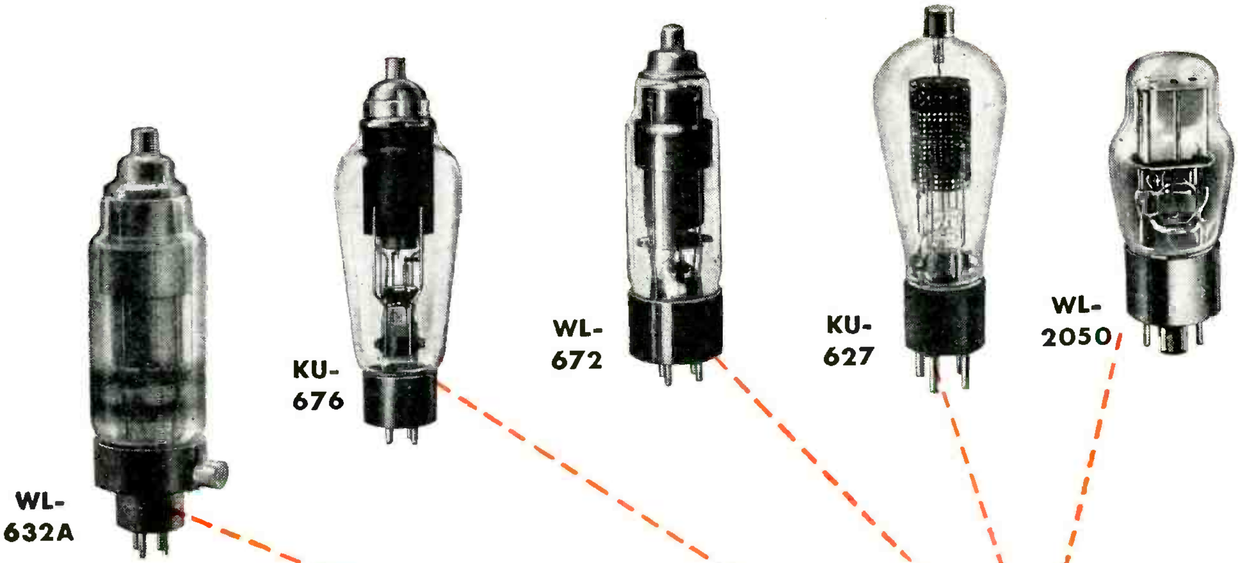
THE PULSE GENERATOR described in this paper, although designed specifically for shocking rats in studies of anoxia, has many applications. It supplies a unidirectional, rectangular current pulse of variable frequency, amplitude, and length. Each of these variables is independent of the others, and the amplitude is independent of load resistance.

Circuit

An essential feature of the circuit shown in Fig. 1, is the utilization of direct coupling thus giving operation to very low frequencies. Separate heater transformers must be used for each tube. Because of the small power requirements of the circuit, a voltage-doubler power supply is used. If electrolytic capacitors are used for C_2, C_3, C_4, and C_5, they should have working potentials of 600 volts and be shunted by 0.25 meg resistors to equalize their leakages. Oil-filled capacitors are more permanent but less compact.

The positive side of the power supply and the lower output terminal are grounded to the chassis as protection against accidental shock. A plug and jack for the output connection will further reduce the likelihood of accidental shock.

Voltage regulator tubes maintain all voltages sensibly constant for the direct coupling and assure independence of the controls. The tubes T_1 and T_2, together with their associated circuits, constitute a saw-tooth generator which can be used to supply the sweep voltage for cathode-ray tubes. A large capacitor of good quality for C_1 will permit frequencies as low as one cycle in several minutes to be



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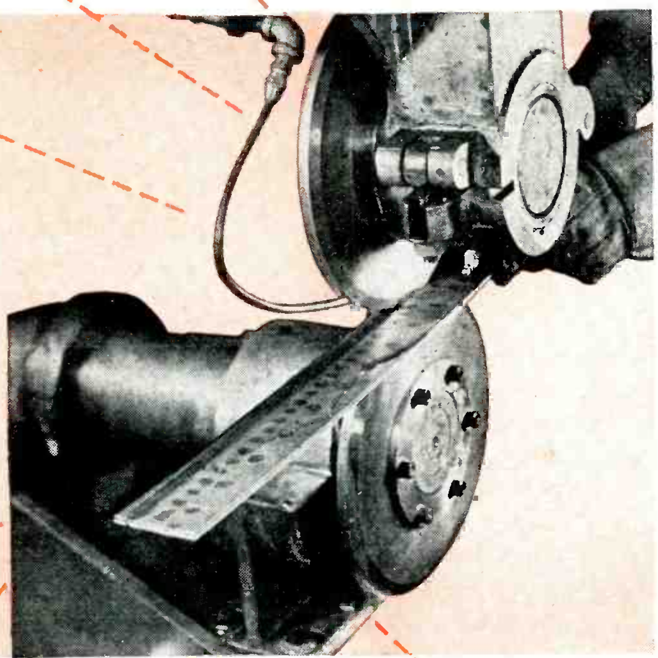
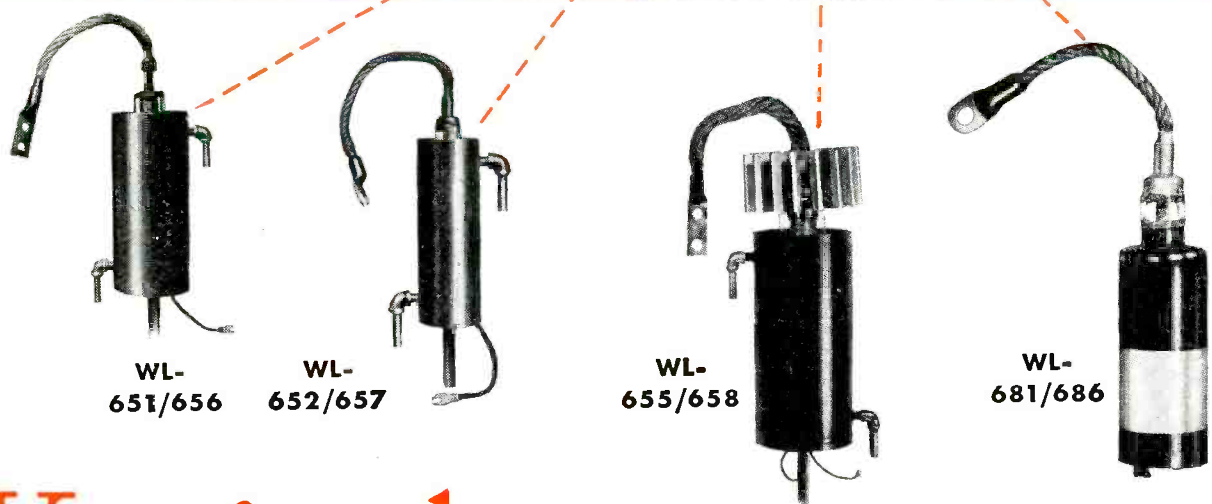


All of these standard Westinghouse tubes are carried in your local Westinghouse distributor's stock.

For descriptive data on any of these tubes, write your nearest Westinghouse office or Electronic Tube Sales Department, Westinghouse Electric Corporation, Bloomfield, N. J.



Westinghouse

Electronic Tubes at Work

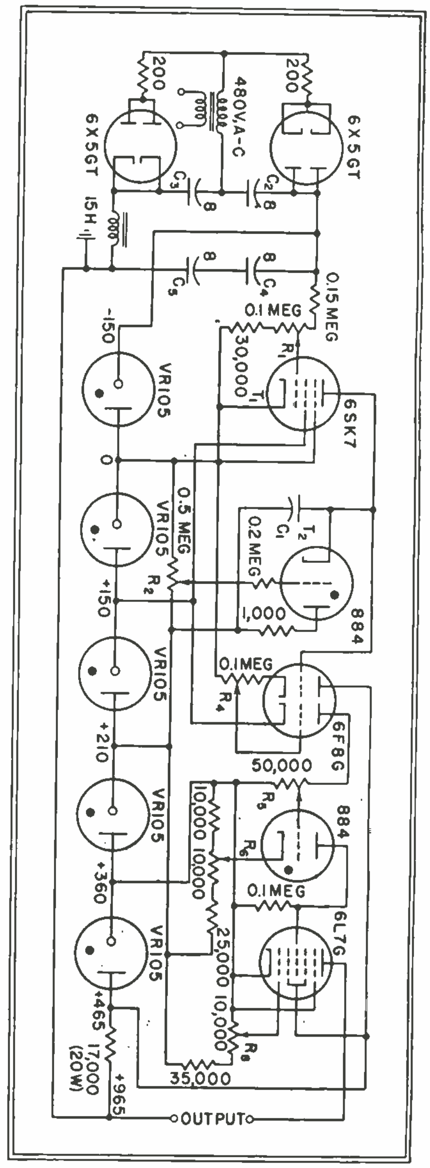


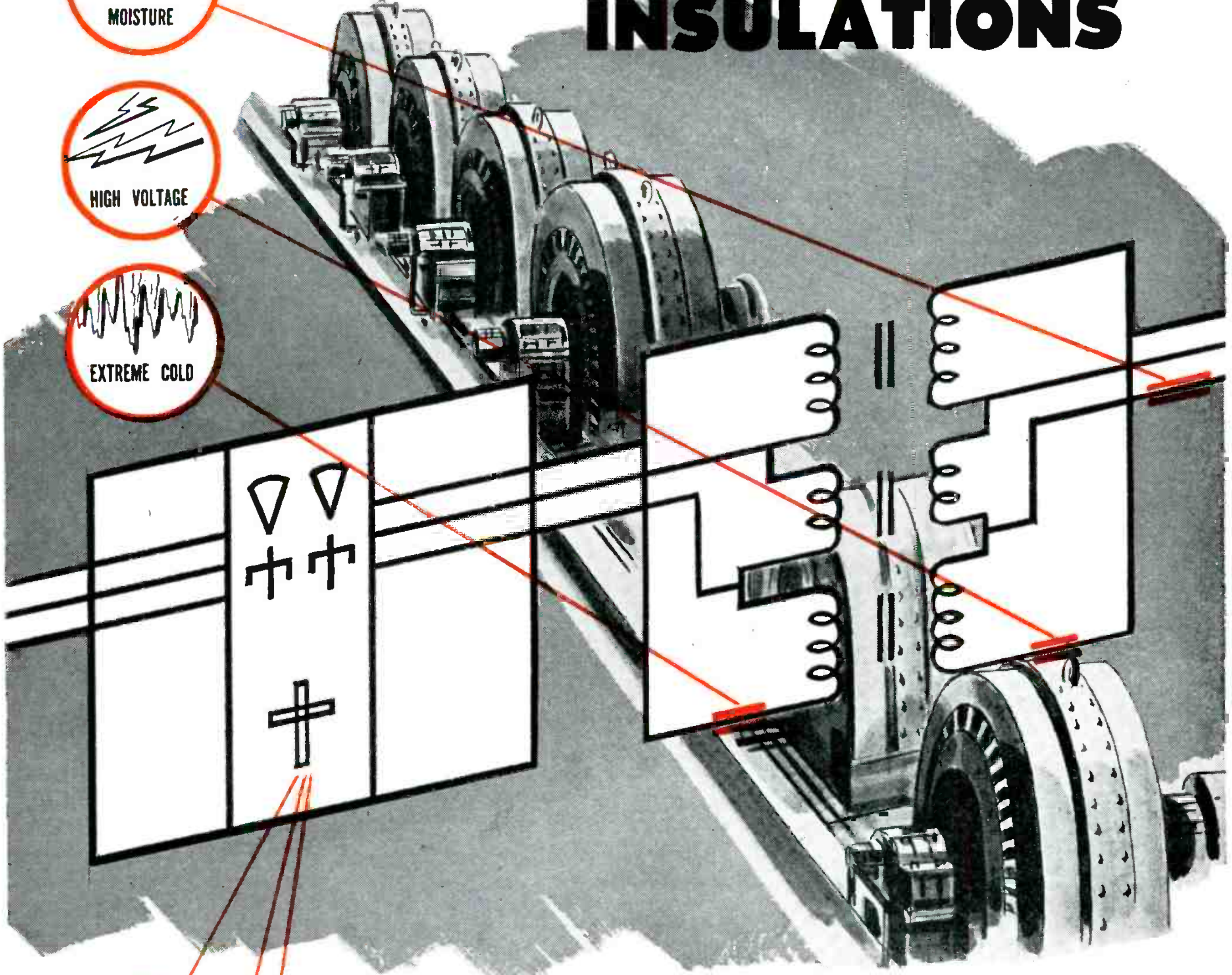
Fig. 1—A 65,000 ohm resistor in series with the thyratron grid lead from R_5 is not shown

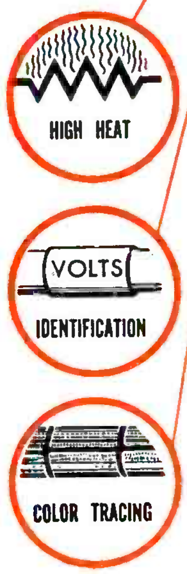
generated. The circuit will operate as high as 20,000 cps.

The 6F8G duotriode constitutes a cathode-coupling stage from the saw-tooth generator and an amplifier which triggers the 884 switching tube. The rectangular output of this tube is amplified by the 6L7G pentode which, because of its high plate resistance, provides a constant-current output for the pulse generator.

The pulse is controlled by the variable resistors. R_5 controls the length of the nonconducting portion of the cycle by varying both the bias and signal applied to the second 884. By varying R_8, the amplitude of the stimulus applied

turbo INSULATIONS





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OIL TUBING • PAPER AND TAPE • SATURATED SLEEVING • VARNISHED CAMBRIC • MICA AND MICA PRODUCTS to the subject can be varied from zero up. Pulse frequency is controlled by R_1; several values of C_1 can be used to change the range. Because cathode coupling is used from the saw-tooth generator, the frequency control can be reliably calibrated.

Calibration

Because the circuit is direct coupled, all constants are critical. The cathode-coupled amplifier must first be adjusted. With an oscilloscope across R_5, controls R_2 and R_4 are varied simultaneously until a saw-tooth wave of maximum undistorted amplitude is seen.

The setting of R_5 depends upon the required range of pulse length. The shortest pulse length obtainable with this circuit seems to be 1/10 of a cycle; there is no limit to maximum length.

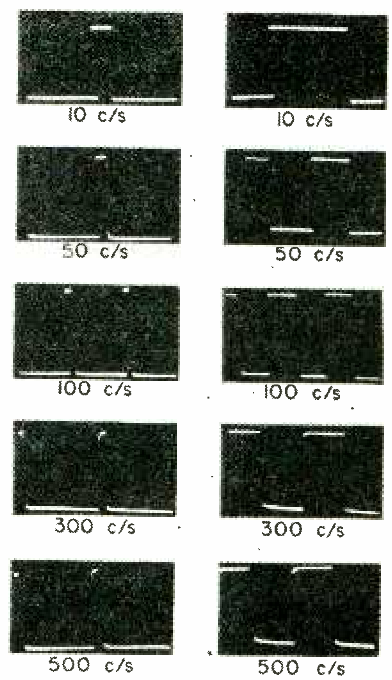

Fig. 2—Oscillograms of pulses, in the left-hand column, of one-tenth cycle duration, and, in the right-hand column, of one-half cycle duration for different frequencies

The frequency control may be calibrated using a low-frequency oscillator and an oscilloscope. The amplitude control is calibrated by putting a d-c milliammeter in series with a fixed resistor of the approximate impedance of the subject across the output. The

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cathode lead of T_5 is opened so that there is no potential drop in R_7. Output current now flows continuously and R_8 can be calibrated directly from the milliammeter reading. The series resistor is used to duplicate operating conditions. The pentode can be considered a constant-current source as long as its plate potential is greater than 100 volts.

The pulse-length control is calibrated after R_8 has been calibrated. With the pulse-generator operating normally and the milliammeter across the output as before, R_5 is varied. If, for example, R_8 is set at 2 ma, and the meter reads 0.2 ma, then current is flowing for 1/10 of a cycle. In this manner R_5 is calibrated.

Because R_4, R_5, and R_6 carry several milliampers of current, it is advisable to use wire-wound potentiometers.

At the higher frequencies the pulse rounds slightly at the corners because of the deionization time of the thyratron as Fig. 2 shows.

• • •

Source of High-Intensity X-Rays

A HIGH-INTENSITY X-RAY tube radiating 2,000,000 roentgens per minute in a 40-degree cone was described by Dr. G. L. Clark of the University of Illinois at the fifth annual national meeting of the American Industrial Radium and X-Ray Society held in November.

The intense radiation is obtained by using high beam current and water-cooling the anode. Absorption of x-ray energy by the tube window is minimized by making the window of a thin, vacuum-tight sheet of beryllium. The x-ray absorption of beryllium is a fraction of that of other materials. For efficient utilization of the radiation, the anode is positioned close to the window. This proximity to the window is possible because of the conductivity of beryllium. Other window material would become oveheated and electrically charged. Beryllium windows have been used previously but not in as large diameters as this one.

The high rate of radiation produced by this tube will facilitate

FREQUENCY SHIFT TRANSMITTER MONITORS

by PRESS WIRELESS

MODEL FSTM-1

Frequency Shift Transmitter Monitor Model FSTM-1 is a compact, precision unit designed by Press Wireless engineering laboratories to check the total frequency variations of the carrier of a radio transmitter operating on frequency shift circuits. Although transmitter tuning is not critical in FS circuits even with high-speed keying, the precise adjustments of the shifter unit controls for these carrier variations should be accomplished with rapid accuracy for top operating efficiency. In this single unit both visual meter and aural zero-beat indication facilitate quick determination of the frequency adjustments over a shift range of 400 to 1400 cycles-per-second on any r-f carrier between 2 and 26 megacycles without the necessity for gathering several separate equipments normally required for this frequency shift check. Despite its small size the FSTM-1 contains its own power supply and when rack mounted occupies only 10½ inches of panel space.

The outstanding advantages of r-f carrier frequency shift transmission for mechanized radio circuits are evidenced in the increasing number of FS installations in important telecommunication networks around the world.

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medical diagnosis and therapy. In industry, the intense x-rays will be useful in the plant, foundry, and control laboratories, and at the construction sites. Little-explored fields where intense radiations will be of value are controlling chemical reactions, and sterilizing packaged food by x-rays.

An x-ray tube, with a hemispherical window, that utilizes the entire 180-degree solid angle of radiation generated at the target has also been developed by Machlett Laboratories, Inc., the manufacturers of the previously described tube. By properly focusing the electron beam on the target, it is possible to mount the cathode outside the hemisphere subtended by the target face so that it does not eclipse any of the radiation.

• • •

Electronic Microphone

By JEROME ROTHSTEIN

Belmar, N. J.

Patented Nov. 27, 1945, No. 2,389,935

AN ELECTRONIC TUBE sensitive to mechanical vibrations is described in this patent. Figure 1 shows the principle of operation. A flexible diaphragm *D* is mechanically coupled to grid *G* of a parallel-plane electron tube. Motion of the diaphragm changes the relative position of the

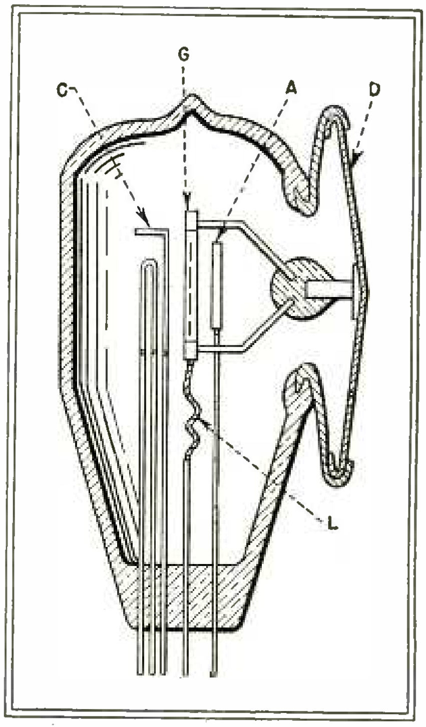

Fig. 1—Pressure-sensitive electron tube designed for use in pressure and motion measurements

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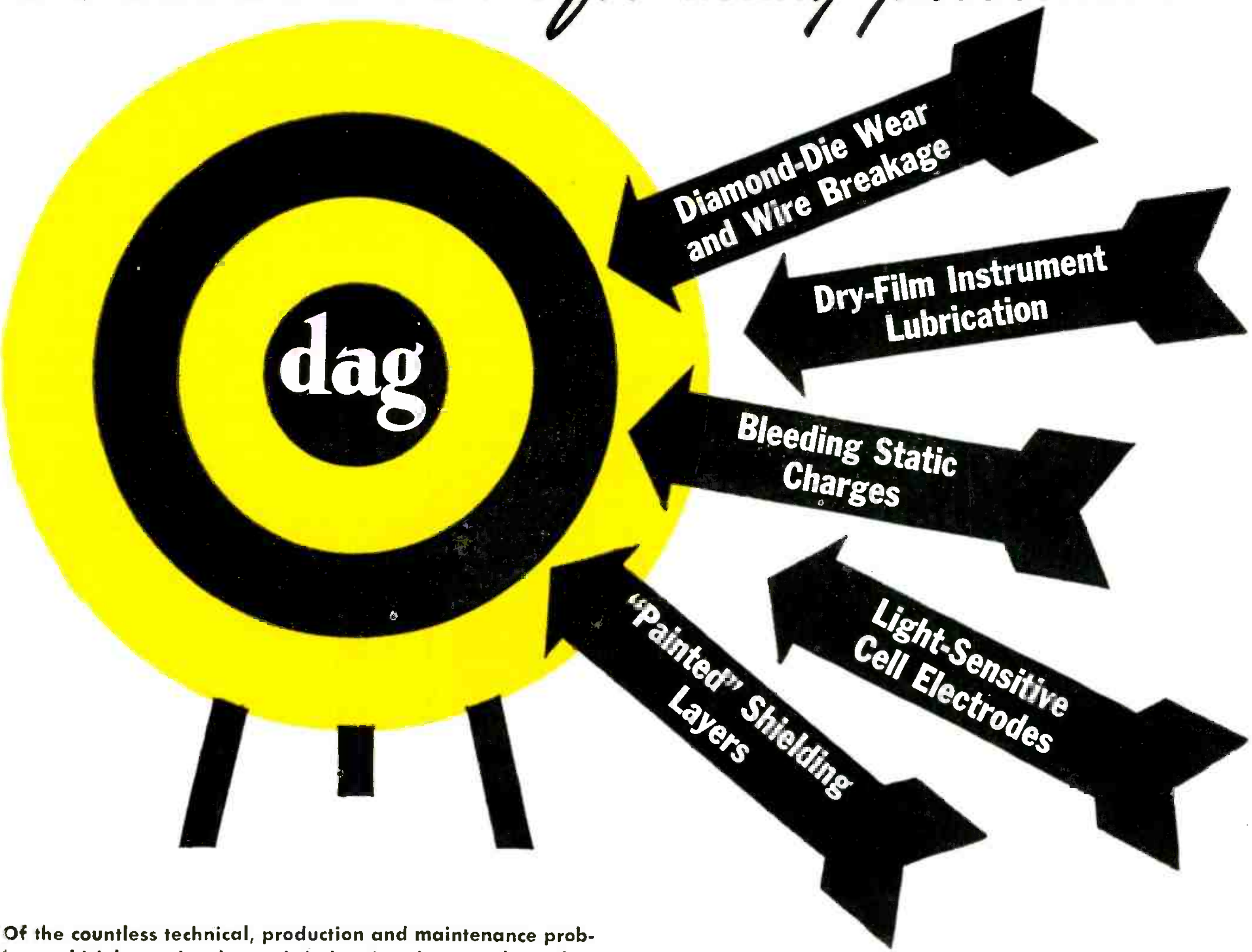

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To get into details of specification and application, send for the new literature listed below. And anytime our technical men can help by consultation—simply let us know.

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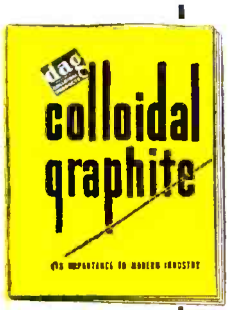

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(Lubricants containing **"dag"** colloidal graphite are available from major oil companies.)

grid between anode A and cathode C thereby altering the amplification factor of the tube which in turn varies the anode current.

The tube itself can be either a vacuum or gas tube constructed as a triode, as illustrated, or in any of the multigrid forms, and built into a glass or metal envelope. The diaphragm can either be electrically connected to or insulated from the control grid as circuit requirements dictate. If insulated, the grid can be connected to the external circuit by flexible lead L. The tube itself must be mounted so as to be free from vibration.

This purposely microphonic tube can be used in such applications as a microphone, barometer, altimeter, or strain gage. The end of a wire normally connected to a strain gage or optical lever can be connected to the diaphragm, thus converting the mechanical motion to be studied directly into electrical magnitude. The end of a temperature-sensitive strip can be connected to the diaphragm of this tube thereby forming a thermometer.

The electrical output from the tube can be used to actuate an indicating or recording instrument, either directly or through amplifiers and/or transmitting circuits. The anode current can either be direct or alternating. In the latter case, the motion of the grid serves to amplitude modulate the alternating anode current.

• • •

Compensating Amplifier

By CHARLES N. GILLESPIE
Radio Corp. of America
Patented June 26, 1945, No. 2,378,999

TO COMPENSATE for nonlinearities in the response of other system components, an equal but opposite nonlinearity is introduced into an amplifier. In the particular application considered, the amplifier corrects the distortion introduced by the nonlinearity of the recording method and paper of a facsimile system. The result is that there is a linear relation between the potential applied to the amplifier input and the half-tone produced on the facsimile paper.

Figure 1 illustrates the compensating portion of the facsimile amplifier. To aid in explaining the operation, a saw-tooth wave is assumed at the input. This wave is amplified by

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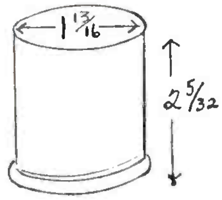

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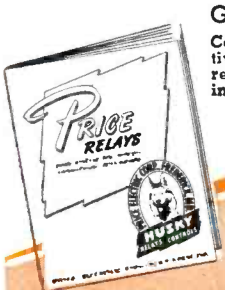

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FREDERICK, MARYLAND

tube 3. Tube 2 provides a reference bias for the grid of tube 3 in order to maintain the negative (white) pulses of the facsimile signal at the proper level.

If the grid potential of tube 3 is more positive than a predetermined level, the plate voltage of that tube will carry the cathode of tube 4 below its plate potential. Tube 4 will then conduct thereby shunting the output load resistor. Thus the load presented to the plate circuit of tube 3 will be reduced and likewise the amplification of the circuit will be reduced.

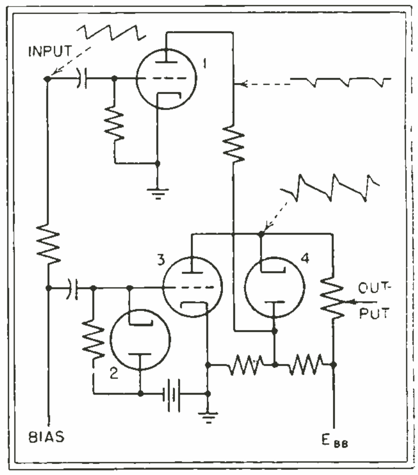

Fig. 1—Two different amplifications are obtained by electronically switching a shunt across the output load

As the input signal further increases tube 1 will conduct thereby making the plate of tube 4 more negative than its cathode with the result that tube 4 will cease conducting. The plate load of tube 3 will be returned to its original value and the circuit will give normal amplification. The output will be modified to a wave shape as shown, which, when reproduced on a nonlinear system for which the compensating amplifier has been designed, will give a saw tooth pattern.

METEORS passing through our atmosphere leave paths of ionized gas of sufficient volume and density to reflect microwave radar pulses. The ions shortly return to their electrically neutral state. Astronomers consider this use of radar more important than receiving reflections from the moon.

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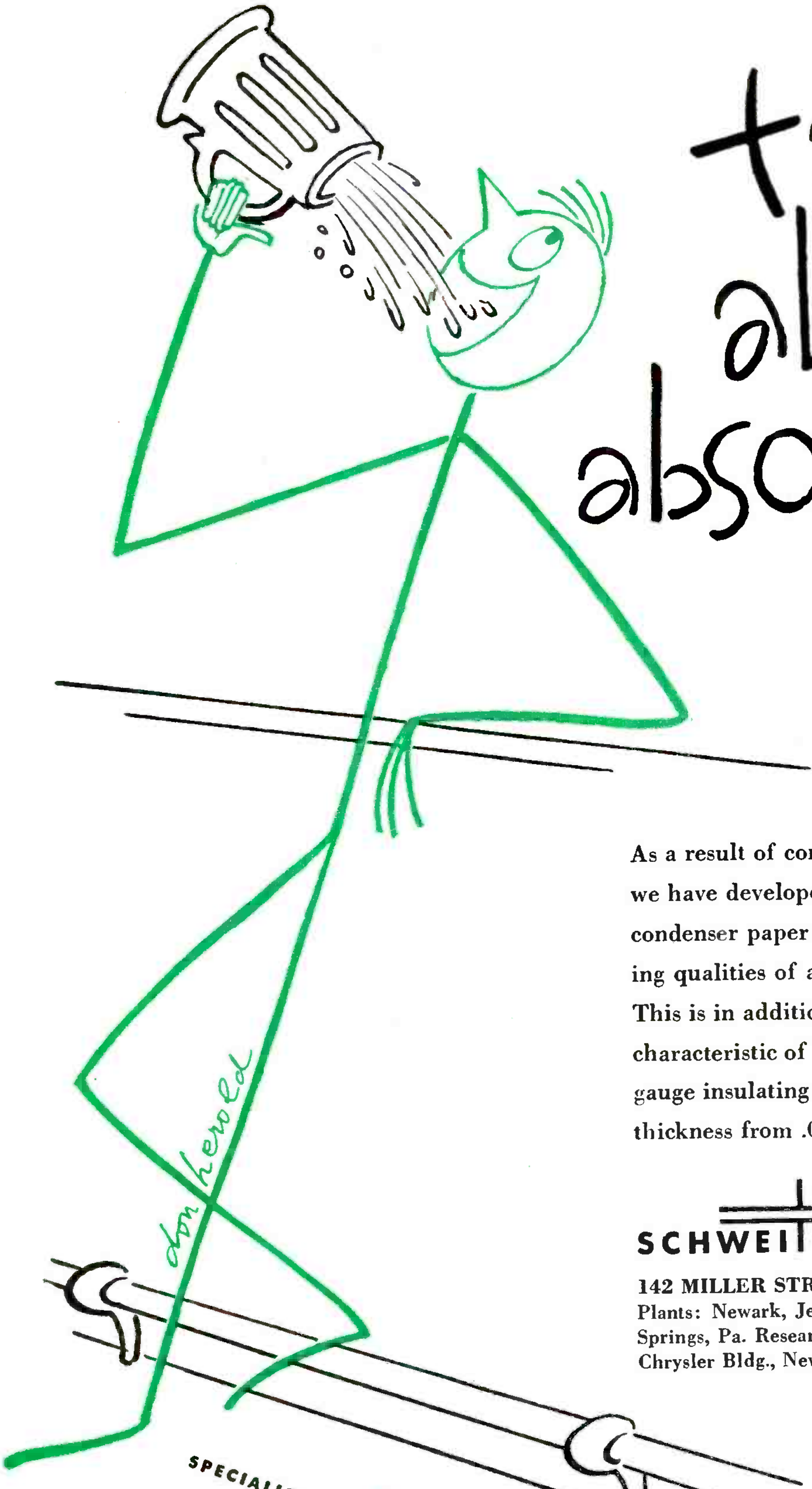

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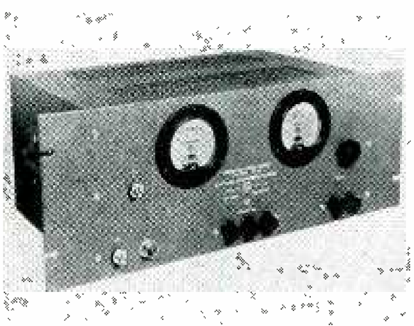
1

Regulated Power Supplies

ELECTRONIC MEASUREMENTS CO., Red Bank, N. J. The Model 200B regulated power supply delivers 125 ma in continuously variable increments from 0-325 v d-c and 6 amp at 6.3 v a-c, center-tapped, unregulated. Regulation is within 1 percent for voltages between 20-235, from no load to full load. Hum is within 10 mv at any voltage or load within ratings. Line input, 105 to 125 v a-c, 50/60 cps with a maximum power consumption of 220 w. The unit is equipped



with meters, controls, fuses and convenient output terminations, front and rear. It uses nine receiver-type tubes. Suitable for relay rack mounting or table, it has carrying handles. Overall dimensions are 7 x 11 x 19 in. and weight is about 40 lb.

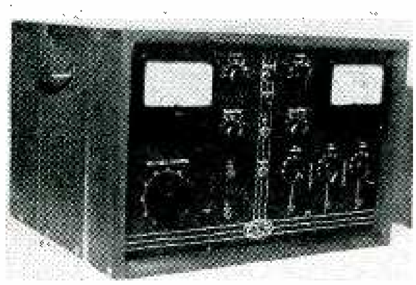
Similar in size, weight and line input voltage to the power supply above, the Model 205A will furnish 150 ma from 100-325 v d-c continuously and 5 ma maximum from 0-150 v d-c besides 6 amp at 6.3 v a-c, center-tapped, unregulated. The 100-325 v section regulates to within 1 percent. The 0-150 v output is regulated by a VR tube and is adjusted by a potentiometer. The no-load to full-load regulation at 150 v is within 1 percent, but will depend upon the potentiometer setting at lower voltages. Nine receiver-type tubes are used and the input power is about 250 w at full load.

The model 204A provides 300 ma up to 500 v d-c and 6 amp at 6.3 v a-c. Regulation is within 1 percent between 30-500 v. Fourteen receiver-type tubes are used. Full-load power consumption is 525 w. This unit is physically larger than the others, measuring 10½ x 15 x 19 in. and weighs about 70 lb. All three power supplies are little affected by moderate line voltage changes.

2

Multi-Power Supply

MOULIC SPECIALTIES CO., 1005 W. Washington St., Bloomington, Ill. The Model MS-1 power supply has three d-c outputs, regulated to better than 1 percent from 50 to 300 v. Voltages available are: −75 to +25 at 5 ma; 0-300 v, 100 ma; 0-300 v,



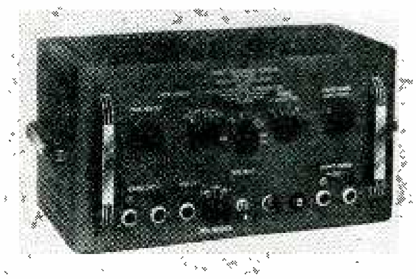
100 ma. There is also 0-20 v a-c, 3.5 amp, center-tapped. Selector switches permit reading the voltage of any output. Connections to the unit are by means of insulated banana plugs, color coded for identification.

3

Sweep Calibrator

UNITED CINEPHONE CORP., Torrington, Conn. Designed by Radiation Laboratory, the Model No. 8127 Sweep Calibrator is now available for civilian test work on radar and television. The instrument provides calibration marks for determining the sweep speed of a synchroscope or triggered sweep oscilloscope. The markers consist of short video pulses of less than a half microsecond duration, spaced by a known number of microseconds.

Time intervals of 2.5, 10, 50 and 100 microseconds can be chosen. These markers have an amplitude of 40 volts, positive or negative. An external trigger pulse of 66 v, positive or negative will operate the de-



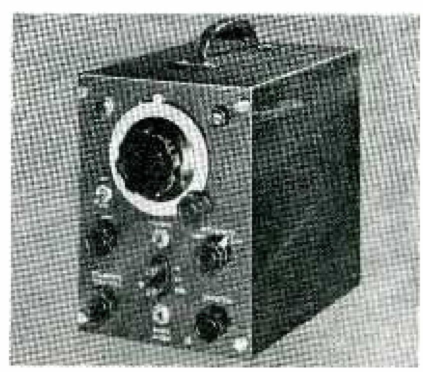
vice, or an internal generator can be used. The repetition rate is continuously variable from 2,000 to 3,000 cps by means of a calibrated control. The positive internal trigger has an amplitude of 120 v; the negative, 65 v. A gate is provided to select operation by the markers from 20 to 3,000 microseconds duration.

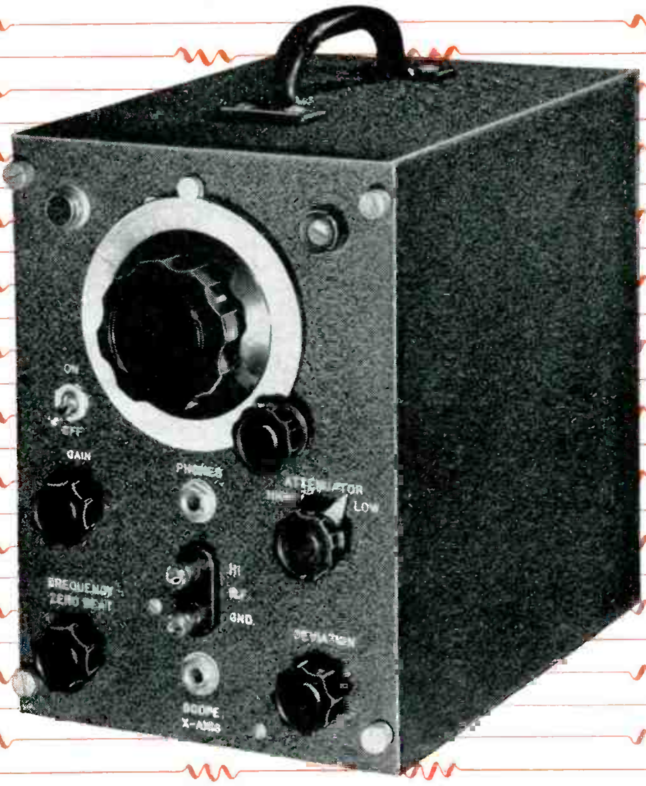
The unit operates on 110 to 120 v, 60 cps at a power of 85 w. Size of the equipment is 8 x 16 x 7¾ in., and weight is 23 lb.

4

Visual Signal Generator

HARVEY RADIO LABORATORIES, INC., 447 Concord Ave., Cambridge 38, Mass. Designed particularly for





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THE HAR-CAM *Visual Alignment* SIGNAL GENERATOR

This sturdy, compact HAR-CAM unit is designed for the visual alignment of the IF circuits in FM and AM receivers. The performance of the IF circuit is shown visually on an oscilloscope and accurate alignment is swiftly and easily accomplished.

The Model 205 TS HAR-CAM Visual Alignment SIGNAL GENERATOR has a frequency range from 100 kc to 20 mc . . . Its linear frequency sweep deviation is adjustable from zero to 900 kc peak to peak . . . Stable r-f gain control is independent of frequency . . . Output impedance, 1 ohm to 2500 ohms . . . It has a phone jack for aural monitoring of zero beat calibration of main tuning dial and a panel jack to feed linear sweep voltage to the x-axis amplifier of the oscilloscope . . . Size, 7″ wide, 9½″ high, 10½″ deep. Weight but 18 pounds.

The HAR-CAM 205 TS is designed and built with stable and proven circuit principles which insure fine, lasting performance. For complete specifications write for HAR-CAM Visual Alignment SIGNAL GENERATOR Bulletin No. H-40.

HARVEY RADIO LABORATORIES, INC.

439 CONCORD AVENUE • CAMBRIDGE 38, MASSACHUSETTS

HAR-CAM
HARVEY OF CAMBRIDGE

Typical HARVEY products: *Above left:* The HARVEY Marine Radio Telephone Model M-25; *center:* The HARVEY Regulated Power Supply 106 PA; *right:* The HAR-CAM Model MFT-25 FM Transmitter. Write for Bulletins.

aligning i-f circuits of f-m receivers by use of a cathode-ray oscilloscope, this equipment combines a direct-reading signal generator with range of 100 kc to 20 mc and a linear sweep adjustable from zero to 900 kc. A five-step attenuator gives an overall voltage range from 1 microvolt to 1 volt. Output impedance is 1 ohm to 2,500 ohms. Overall size is 7 x 9½ x 10½. Weight is 18 lb.

5

Mobile Communications

HARVEY RADIO LABORATORIES. The Har-Cam mobile transmitter is a narrow-band f-m type for voice frequencies between 500 and 3,000 cps. At a level of minus 15 db, a 1,000-cps tone produces a 15-kc deviation either side of the center frequency. Seven or eight receiver-type tubes are required for power outputs of 25, 40 or 70 w. The unit is 8½ x 9½ x 13 in. and weighs 29 lb.

The model MFR-15 receiver is available for mobile or fixed station operations in the frequency range 30 to 44 mc. Selection of either a-m or f-m detection is by means of a toggle switch. An adjustable squelch circuit is provided for quiet operation. In f-m operation, a carrier of 0.3 microvolts quiets the receiver. A-m sensitivity is high and selectivity is good with response 60 db down at 40 kc off resonance. Thirteen tubes are used. Over-all size is 8½ x 9½ x 13 and weight is 24 lb.

6

Film Thickness Measurement

AMERICAN INSTRUMENT CO., 8010-20 Georgia Ave., Silver Spring, Md. The Filmeter, NRL Model 1, is a new electronic instrument for measuring, rapidly and non-destructively, the thickness of paint, varnish, lacquer, ceramics, plastics, and other non-conducting coatings which may be deposited on non-magnetic base metals such as aluminum, brass, copper and bronze. The instrument measures coating thickness from zero to 0.005 inch, with an accuracy of 3 percent of full scale, and measurements may be made on any flat surface, or on convex or concave surfaces having a radius of curvature of not less than 6 in.

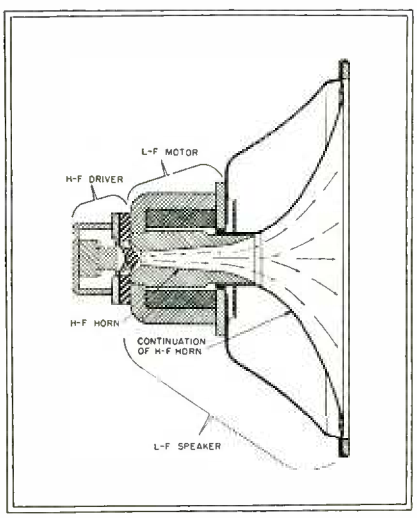
The unit consists of a battery-operated electronic beat-frequency oscillator contained in a 7 x 7 x 7 in. steel case. The inductance coil of one oscillator is mounted in the end of a tripod-mounted inductor, and is connected to the instrument by means of a shielded rubber-covered

cable. Earphones enable the operator to determine when the two oscillators are set to the same frequency. The entire instrument weighs approximately 11 lb, and may be used as a portable field instrument or on a laboratory bench.

7

Coaxial Speaker

JENSEN RADIO MANUFACTURING CO., Chicago, Ill. The Type H speaker consists of two units each reproducing a portion of the total frequency range. A compression-type high-frequency unit is attached to the back of a 15-inch direct-radiator low-frequency unit. The horn for the h-f unit is formed by a passage of expanding cross section through the



core of the l-f unit, the carefully shaped diaphragm of the l-f unit forming a continuation of the h-f horn. The l-f diaphragm is driven by a conventional voice coil assembly.

A center-tapped transformer of any desired impedance may be mounted on the speaker but is not furnished. Nominal input impedance is 16 ohms when no transformer is used. Power handling capacity is 25 watts maximum, in speech and music systems. The field is designed for a power dissipation of 20 watts, with 14 watts minimum.

8

Portable Wheatstone Bridge

THE WINSLOW CO., 9 Liberty St., Newark 5, N. J. A compact, lightweight bridge with an accuracy of 0.1 percent from 1 to 40,000 ohms is now available for resistance, Murray or Varley Loop and other tests. The range can be extended in excess of

100,000 ohms with great accuracy and below 1 ohm using ordinary precautions. The replaceable galvanometer has a coil resistance of 250 ohms and a sensitivity of 1 microamp per scale division. Overall dimensions are 8⅞ x 7⅜ x 5¾ in. and weight 8 lb.

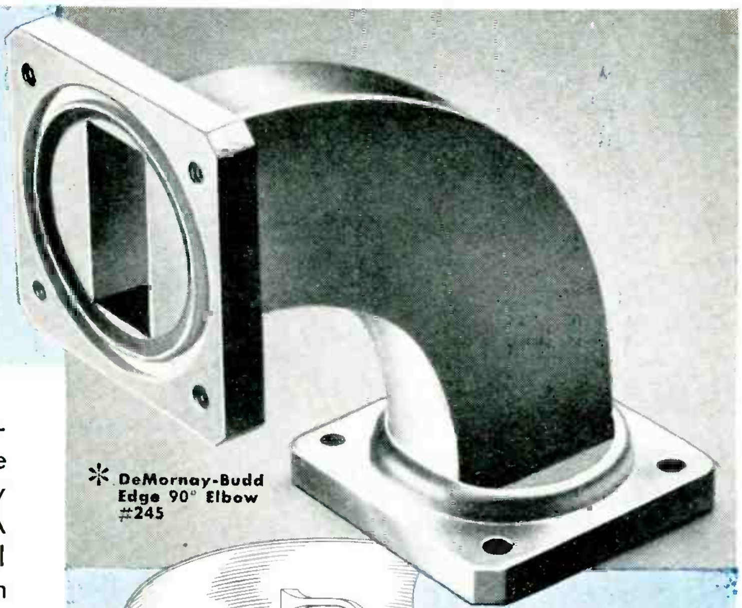
9

Multicellular Coaxial Speaker

STEPHENS MANUFACTURING CO., 10416 National Boulevard, Los Angeles 34, Calif. The new Tru-Sonic coaxial speaker utilizes a low-frequency paper cone and a high-frequency diaphragm operating into a

IMPORTANT FACTOR

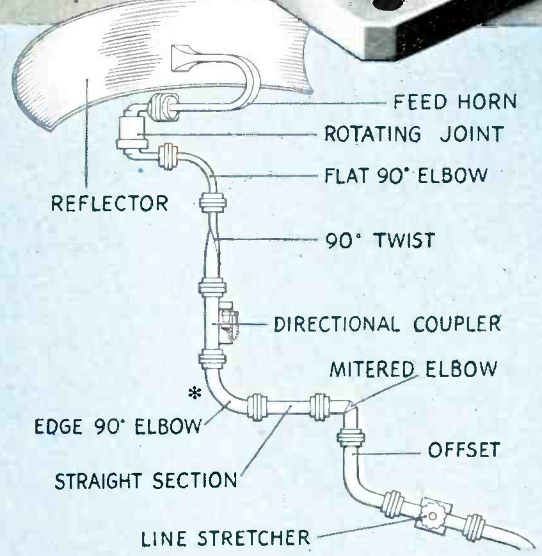
in maintaining low standing wave ratio



* DeMornay-Budd Edge 90° Elbow #245

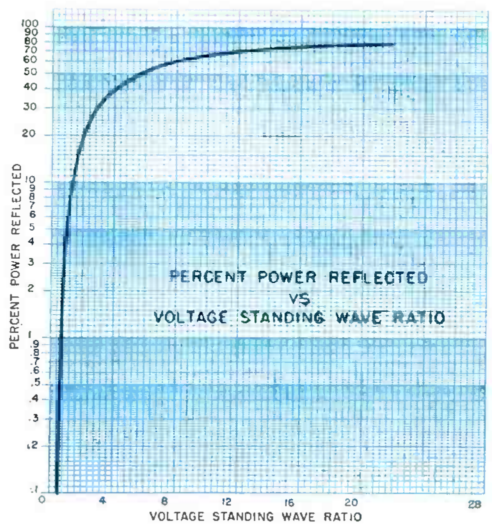
In all microwave transmission lines, it is important that the voltage standing wave ratio be kept as low as possible over the frequency range on which the equipment is operating. A high standing wave ratio means a loss of useful power because of the reflected power from the impedance mismatch. In addition, it causes a higher peak voltage in the transmission line thereby increasing the possibility of breakdown in the line.

The design and finish of an elbow have an important bearing on the voltage standing wave ratio. Impedance mismatches in an elbow can be caused by a change in the guide size due to improper bending or improper design. Discontinuities in elbows may be the result of improper bending techniques which cause indentations and other types of variations to appear on the inside wall of the wave guide. These irregularities change the impedance and result in a high standing wave ratio with its accompanying ills. Proper methods must be used in fabricating the elbow to prevent distortions which might result from bending the metal walls.



Asterisk indicates position of Edge 90° Elbow # 245 in above plumbing arrangement. In addition to this standard part, elbows can also be supplied for any specific application requirement.

The design and manufacture of transmission line equipment is a specialty on which we have had vast experience in connection with wartime radar. We invite your inquiries, without obligation, on any of your transmission line problems.



The curve shows the manner in which the reflected power increases with an increase in the voltage standing wave ratio. The curve is calculated from the following equation:

$$\%\ \text{Power Reflected} = \left(\frac{\left(\frac{V_{max}}{V_{min}}\right) - 1}{\left(\frac{V_{max}}{V_{min}}\right) + 1}\right)^2$$

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multicellular horn. Maximum power input is 20 w; vertical distribution angle is 40 deg and horizontal is 80 deg. Field excitation is either electromagnetic at 25 w or by means of a 6-lb Alnico V magnet. Field resistance can be made to specifications; is available at 1,800 or 2,500 ohms. Input impedance is 15 ohms. Frequency response is within ±5 db from 50 to 10,000 cps. The dividing network is the parallel half-section, constant-impedance type with an attenuation of 12 db per octave from the 1,200 cps crossover.

Overall diameter is 15¼ in., baffle opening 13¼ in., and depth behind panel, 9½ in. Weight is 31 lb.

10

Transconductance Meter

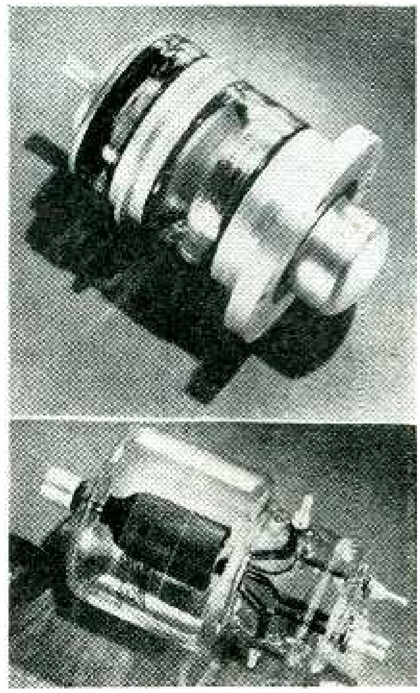
SENSITIVE RESEARCH INSTRUMENT Co., 9-11 Elm Ave., Mount Vernon, N. Y. This instrument is the newest in a line of laboratory standard, mutual conductance-plate impedance meters. Accuracy is enhanced both by the 12½ in. length scale and negligible impedance inserted in the plate circuit of the tube under test. The a-c signal applied to the grid need be only a fraction of a volt even on the lowest ranges. There is no discernible error from the d-c component of plate current up to values of 50 ma and the error at 100 ma is negligible; no bucking circuits are required.

The instrument covers values of g_m from 150 to 30,000 micromhos and R_p values from 250 to 2 megohms. Overall accuracy is 0.2 percent when used with accurately measured and regulated power supplies, competing successfully with other less facile methods.

Size of the meter is 24 x 14 x 6½ in.

11

VHF Transmitting Tubes



GENERAL ELECTRIC CO., Electronics Dept., Tube Div., Schenectady, N. Y. Maximum ratings of the new GL-592 (bottom) apply up to 110 mc. The tube has a maximum d-c plate voltage rating of 3,500 v and a maximum plate dissipation rating of 200 w under class C r-f amplifier and oscillator conditions. Under these conditions the maximum plate imput rating is 600 w. Fernico-seal design of the tube makes possible elimination of bases, soldered terminals and permits a reduction of lead length. This design provides greatly increased structural strength.

Full ratings on the new GL-9C24 triode (top) apply up to 220 megacycles. The tube has been tested under class B r-f power amplifier conditions with a bandwidth of 5 mc. The anode is water-cooled and capable of dissipating 5 kw.

As a class B r-f amplifier in a grounded-grid cavity the new tube has a maximum d-c plate voltage rating of 5,000 v. Actual 220 megacycle tests under broad-band and synchronizing peak conditions show a useful power output of 3.4 kw per tube at a d-c plate voltage of 4,000 v. The use of a grounded-grid cavity in this application minimizes the necessity for neutralization.

At the top f-m operating frequency of 110 mc, tests of the tube under class C r-f power amplifier conditions in a grounded-grid circuit at a d-c plate voltage of 6,000 v have shown a useful power output per tube of 6.4 kw. Here the maximum plate dissipation rating is 5 kw and the maximum d-c plate voltage rating is 6,500 v.

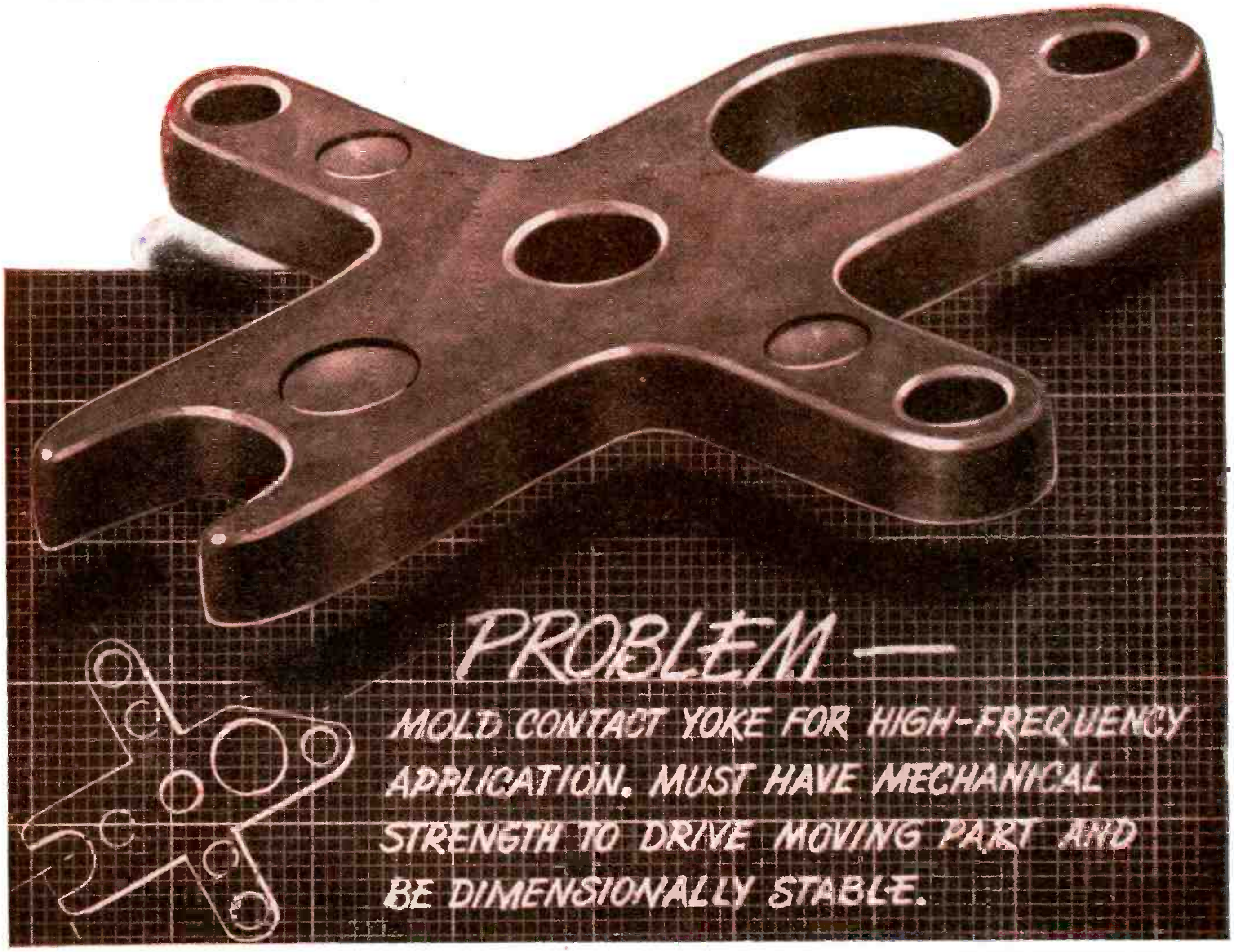
12

Photoelectric Flame Failure Alarm

COMBUSTION CONTROL CORP., 77 Broadway, Cambridge 42, Mass. has designed the Fireye Type F18T electronic flame-failure alarm and fuel cutoff. It provides explosion protection for all industrial and commercial oil and pulverized coal burners. Unlike thermal controls, it is actuated not by the effect of flame failure but by the flame itself.

The equipment consists of a phototube and amplifying system, housed in a dust-tight aluminum case. The entire control is mounted directly on the furnace wall and is aligned in a manner which permits the phototube to observe the flame through a 2-in.

DESIGNED AND ENGINEERED AT NO. 1 PLASTICS AVENUE



G-E MYCALEX . . . FOR PRECISION-MOLDED INSULATION

● This contact yoke was designed to drive a vital moving part in a high-frequency application. A flat and dimensionally stable part was required.

No. 1 Plastics Avenue was consulted. The problem was solved by specifying G-E mycalex—compound of glass and powdered mica with a unique combination of properties.

Molded in G-E mycalex by new techniques, this contact yoke has everything required of a high-frequency component—dielectric strength . . . low loss factor . . . stability . . . flatness . . . rigidity.

G-E mycalex is now available to all industry in standard rods and sheets, or molded to your own design. G-E designers and engineers will give you the benefit of their experience in molding hundreds of G-E mycalex parts. Write to Section S-8, Plastics Divisions, General Electric Company, 1 Plastics Avenue, Pittsfield, Massachusetts.

What is G-E Mycalex?

Fused glass and powdered mica produce a hard, gray-colored, stone-like material which is called mycalex.

G-E mycalex possesses a unique combination of properties for high-frequency insulation:

High dielectric strength; low power factor; prolonged resistance to electrical arcing; chemical stability—no deterioration with age; dimensional stability—freedom from warpage and shrinkage; imperviousness to water, oil, and gas; resistance to sudden temperature changes; low coefficient of thermal expansion; high heat resistance.

GENERAL ELECTRIC

CD46-MB

pipe connection which serves as both a sighting tube and a support for the equipment. A clear Pyrex filter keeps the equipment dust-tight and is mounted on a hinged shutter which permits it to be cleaned without shutdown. A heat-absorbing filter in the lens system as well as an efficient baffle system protects it from all radiated heat. The phototube operates at high ambient temperature.

Other features include a pilot light

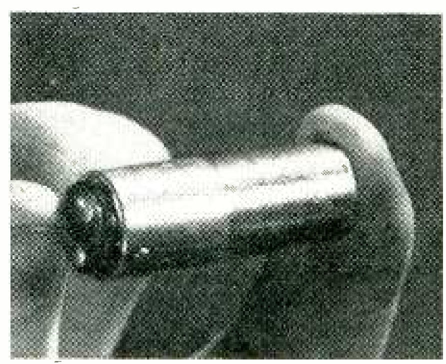
which can be viewed through an angle of 180 deg, and a time-delay element which prevents the relay from dropping out during purely transient flame disturbances.

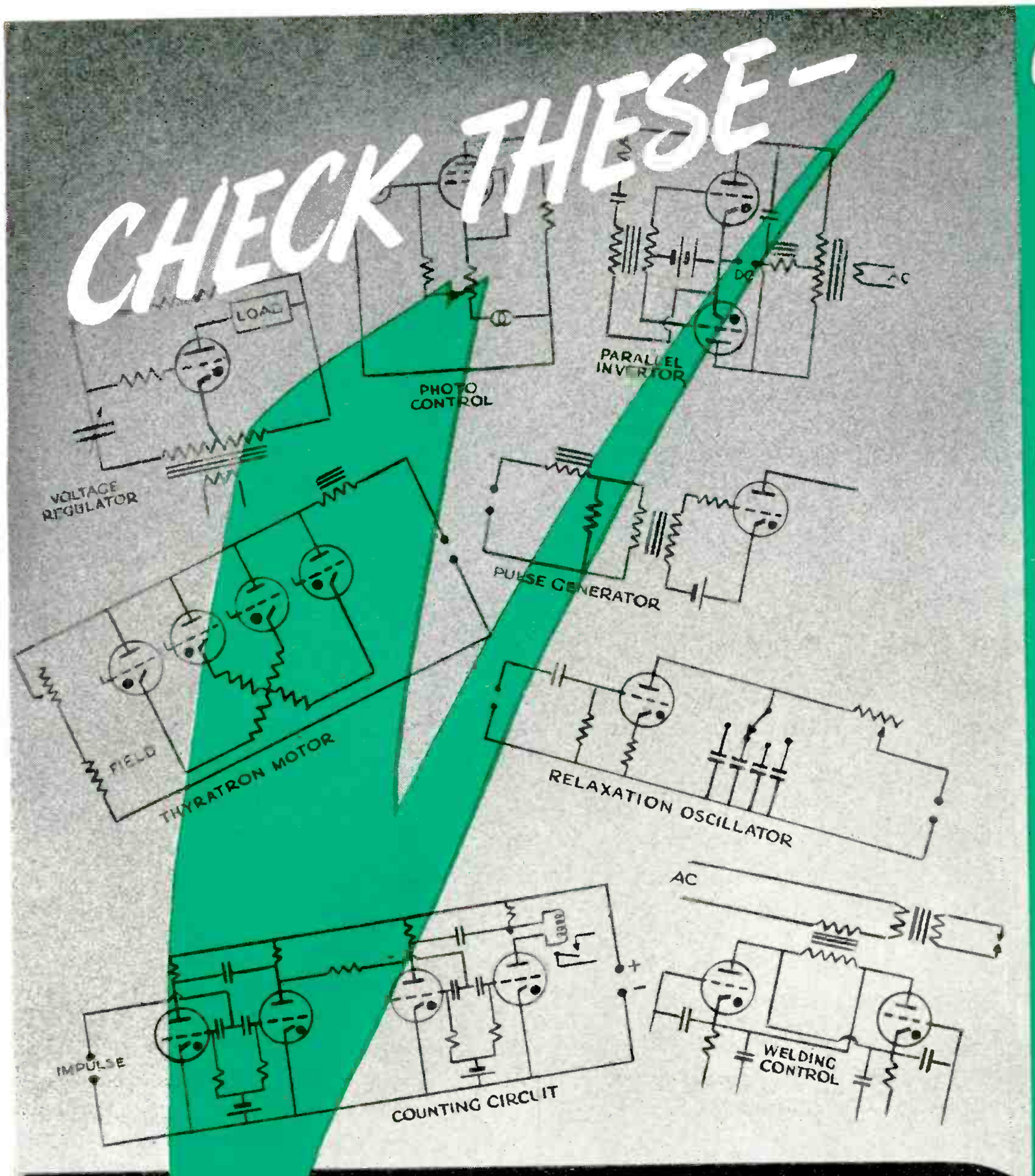
Power supply: 115-230 v 50/60 cps a-c 10 w. Output is a spst relay with 5 amp contact. The front of the control should be located within five feet of the flame which it is to monitor. Weight is 12½ lb. Ambient temperature range, 32 F to 150 F.

13

Cold-Cathode Regulators

SYLVANIA ELECTRIC PRODUCTS Inc., Industrial Electronics Division, Boston, Mass., has announced three miniature cold-cathode voltage regulators for 65 to 90 v operation where cur-





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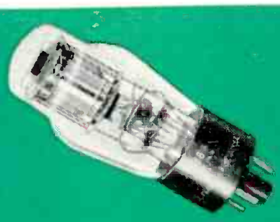
for control problem solutions

CHATHAM Thyratrons solve difficult control problems with a degree of accuracy and dependability unequalled by manual or ordinary mechanical control devices. Typically, the five CHATHAM Thyratrons illustrated provide precision performance in most industrial applications including counting, sorting, timing, measuring, pulsing, process control, voltage regulation, current conversion, etc. These tubes, and many other rectifiers currently in wide demand for industry and communications, can now be supplied by CHATHAM on short notice . . . in any quantity. For complete details—technical data, information, or collaboration in applying Thyratrons to your equipment or machinery—call or write today

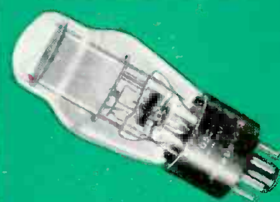
CHATHAM ELECTRONICS

475 WASHINGTON STREET, NEWARK 2, NEW JERSEY



884 GRID CONTROLLED ARGON RECTIFIER AND OSCILLATOR

Peak inverse and peak forward voltage	300 volts
Peak plate current	300 Ma
Average plate current	75 Ma
Average plate current (oscillator)	2 Ma
Filament voltage	6.3 volts



2050 GRID CONTROLLED XENON RECTIFIER

Peak inverse voltage	1300 volts
Peak plate current	500 Ma
Average plate current	100 Ma
Filament voltage	6.3 volts
Filament current	6 amps

17 GRID CONTROLLED MERCURY VAPOR RECTIFIER

Peak inverse voltage	5000 volts
Peak plate current	2.0 amps
Average plate current	5 amps
Filament voltage	2.5 volts
Filament current	5.0 amps

2021 GRID CONTROLLED XENON RECTIFIER

Peak inverse voltage	1300 volts
Peak plate current	500 Ma
Load current	100 Ma
Filament voltage	6.3 volts
Filament current	6 amps

2A4G GRID CONTROLLER ARGON RECTIFIER

Peak inverse voltage	200 volts
Peak plate current	1.25 amps
Average plate current	100 Ma
Filament voltage	2.5 volts
Filament current	2.5 amps

rents range between 2 and 3 ma and maximum voltage variation must not exceed 3 v. Mounted in miniature polarized bayonet bases, the bulbs of these tubes are enclosed in a metal shield which is color coded for visual identification. They are 1⅝ in. overall and ⅝ in. in diameter. Used in series with a current-limiting resistor of approximately 15,000 ohms on the load side of a 175 v d-c source, they may be operated in any position. Two or more tubes of the same type may be operated in series for better voltage regulation. Applications include cathode-ray oscilloscopes, synchroscopes and other electronic instruments.

14

Grid-Control Rectifier

EITEL-MCCULLOUGH, INC., San Bruno, Calif., presents a new grid-control mercury-vapor rectifier tube,

type KY21A/KY21. Filament voltage, 2.5 v; filament current, 10 amp; peak inverse voltage, 11,000 v; peak plate current, 3 amp.

15

Magnetic Wire Recorder

RADIOTECHNIC LABORATORY, 1328 Sherman Ave., Evanston, Ill., now have available their Model 55A magnetic wire recorder-reproducer and Model 22N recorder. Recordings made on the 22N are played back on the 55A. The recorder-reproducer is equipped with a 4-mil medium carbon steel wire 11,200 feet long which accommodates a 66-minute program. Frequency response is within 5 db from 300 to 3,500 cps. Either a crystal or dynamic mike can be used for recording and a built-in speaker or

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HEAT RESISTANT TO 1200°F!

If you need an electrical insulation that's not affected by temperatures up to 1200°F., yet is unusually flexible, workable and durable, you'll find it in BH Special Treated Fiberglas Sleeving. Even in direct contact with heat units this remarkable sleeving won't burn.

Reason? It's made of inorganic Fiberglas and treated by the exclusive BH process. No saturant is used, yet the sleeving won't fray when cut and it is *permanently* flexible. In addition to many other properties it is moisture, oil and grease resistant . . . works easier, simplifies assembly and lasts longer. Made in natural color only—all standard sizes. Get your free samples today and compare!

HERE'S ANOTHER NON-BURNING SLEEVING

BH *Extra Flexible* Fiberglas Sleeving won't burn because both yarns *and* impregnation are non-inflammable. This high quality sleeving has all the advantages of pure Fiberglas, is toughened against abrasion, is non-fraying and non-stiffening. It lasts indefinitely without rotting or cracking—the ideal all-purpose electrical insulation for all kinds of industrial equipment and home appliances. Available in all standard colors and sizes from No. 20 to 5/8″, inclusive. Put it to the toughest tests you know and watch the results!

ALL BH PRODUCTS AVAILABLE IN STANDARD 36″ LENGTHS AND 500-FT. COILS

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BENTLEY, HARRIS MANUFACTURING CO.

Dept. E Conshohocken, Penna.

headphones for play-back. Controls, timing indicator, and volume level are simple and accessible.

The equipment operates on 115 v a-c, 60 cps and consumes 130 w. It measures 11 x 8 x $12\frac{3}{4}$ in. and weighs $30\frac{1}{2}$ lb. The 22N was designed for airborne service and operates at 28 v d-c with a current drain of 2.5 amp. Signals from a carbon-button mike or a radio receiver can be recorded. The unit weighs $13\frac{1}{2}$ lb.

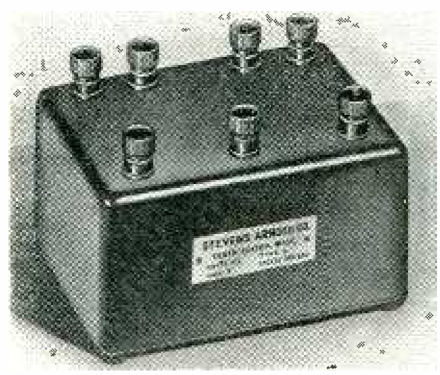
16

Frequency-Controlled Relays

STEVENS-ARNOLD CO., 22 Elkins St., South Boston, Mass., is manufacturing a line of tuned relays well suited for remote control applications. In the radio application, the switches are sufficiently sensitive so that when made on special order they can be controlled from either a crystal detector or vacuum-tube type receiver. Response time is only a small fraction of a second.

Each switch is adjusted at the factory to accept a selected band of frequencies in the range of 20 to 800 cps and to reject all others. In other words, one switch might be controlled by the band from 50 to 60 cps, another by the band from 65 to 75 cps, another by the band from 80 to 95 cps.

When more than one switch is connected together, the combination provides a means of selective switching by a choice of frequency bands. The range of 20 to 800 cps is adequate for the control of many separate switches on a single carrier circuit, and by combining the frequency bands in a coded sequence, any number of selective switching operations can be obtained.



Frequency selection and rejection

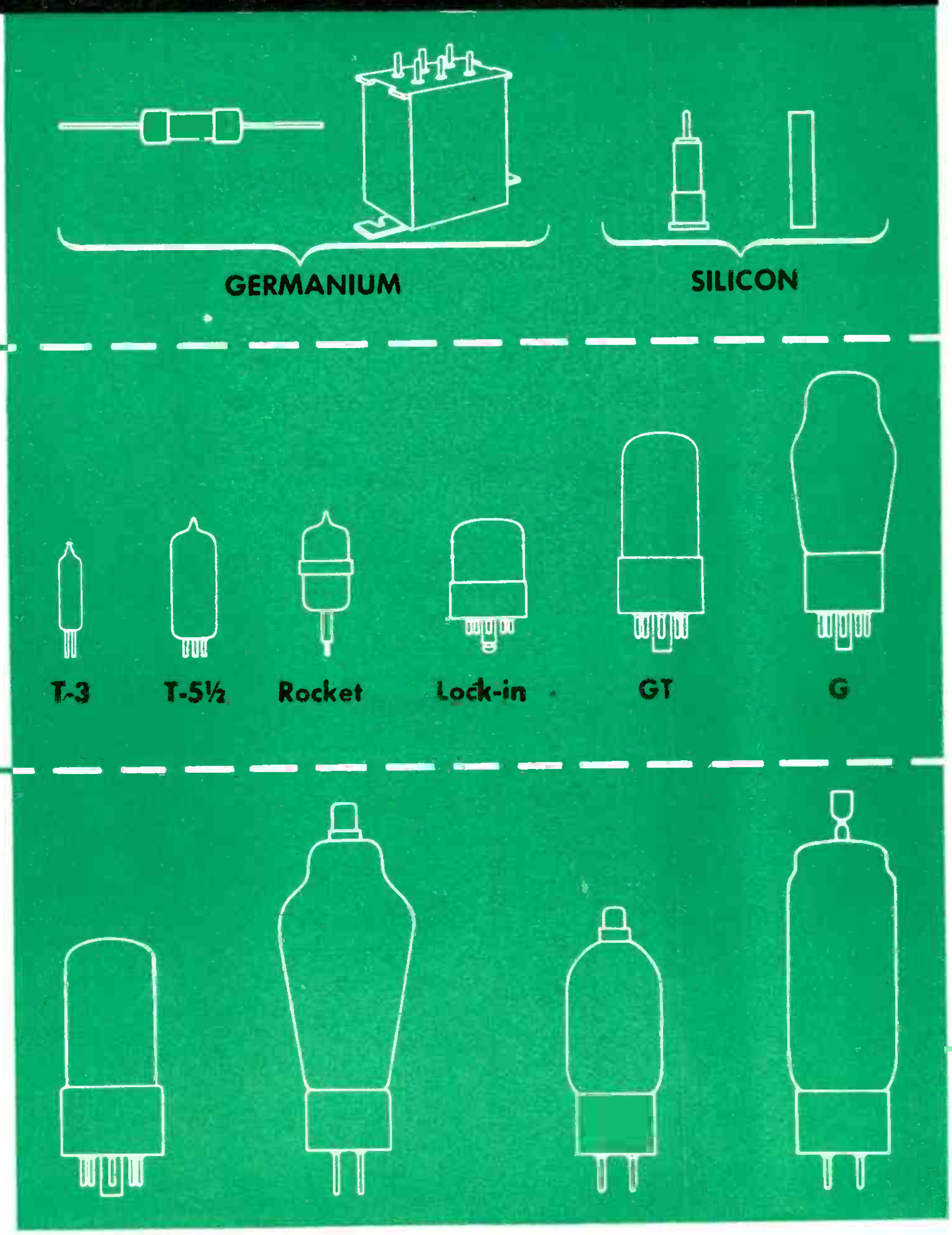
YES, Sylvania supplies ALL these rectifier types to equipment manufacturers

METAL

VACUUM

GAS

ARGON NEON
HELIUM HYDROGEN
XENON KRYPTON
MERCURY



Whatever type of rectifier you require, in standard sizes or built to specification, bring your problem to Sylvania Electric.

SYLVANIA ELECTRIC

Electronics Division . . . 500 Fifth Avenue, New York 18, N. Y.

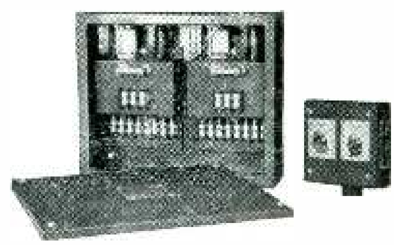
MAKERS OF ELECTRONIC DEVICES; RADIO TUBES; CATHODE RAY TUBES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES; ELECTRIC LIGHT BULBS is obtained by using the well-known vibrating-reed principle with hermetic sealing and other design features which make the switches maintenance-free.

Ratings of 1 to 10 amp, 115 v a-c are available. The size shown in the illustration measures 3 x 4 x 5 in. One set of binding posts is for the selected-frequency a-c, required to control the switch. Another set is for the auxiliary power, required to operate the switch. The remaining three are the switch terminals, this being a single-pole double-throw model.

17

Repeat-Cycle Timer

PHOTOSWITCH INC., 77 Broadway, Cambridge 42, Mass. has designed the Type 2T15U timer for machinery and process control for applications requiring two adjustable timing periods to run in a continuous cycle. This cycle is initiated by either momentary or sustained contacts, and provision for automatic recycling is provided. Each timing period is adjustable from 1/20th second to two minutes. Control is accomplished through specially de-



signed snap-action relays which result in extreme accuracy. Interval variations in repeat cycle timing are less than 2 percent. The unit provides six maximum time ranges from 1.5 seconds to two minutes for each period of the cycle. Each range is represented by a timing element which is snapped into a clip on the front of the control. The timer may be then set for any intervals up to these maximums by dials which are located either on the timer itself or in a small housing at a more convenient location.

Power supply: 115 v a-c or d-c. Output connections are those of a spdt switch for normally open and

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normally closed operational use.

Contacts: 1000 w, 115 to 600 v a-c and 500 w, 115 to 220 v d-c. The actuating control is designed so that either momentary or sustained contacts will control timing interval.

18

Television C-R Tube

ALLEN B. DUMONT LABS., Inc., Passaic, N. J., has the type 7EP4 cathode-ray tube in quantity production for use in low-priced television receivers. This 7 in. tube provides for a normal screen image 5¾ in. wide by 4¼ in. high, which is adequate for entertaining a group of several lookers-in. If desired, the screen size can be increased to 6⅛ in. wide, with

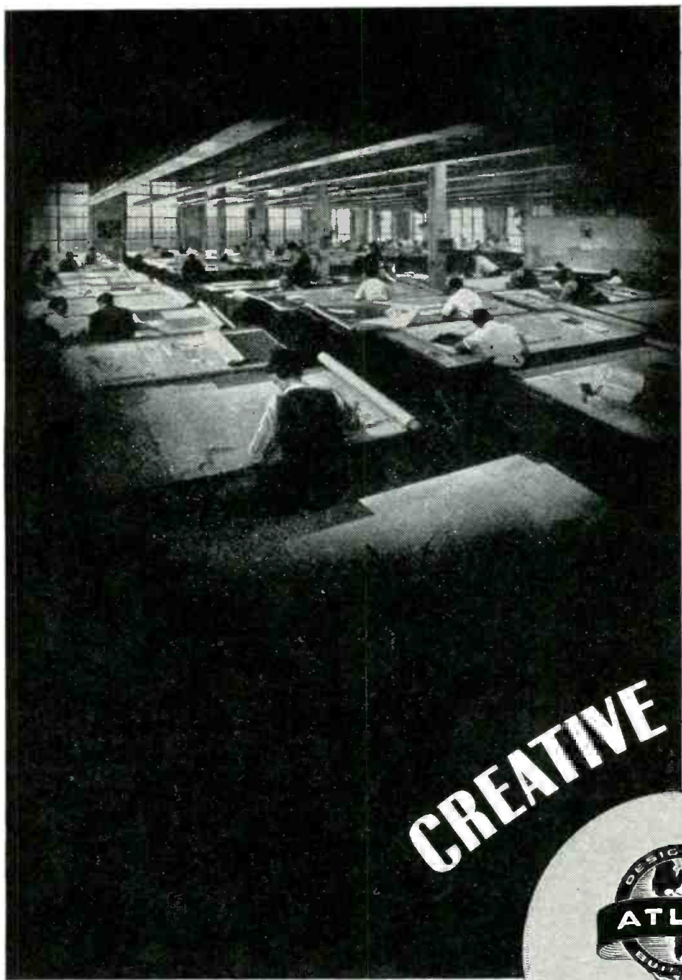
satisfactory results. The images are of high luminosity so that the room does not have to be darkened unless so desired for maximum concentration.

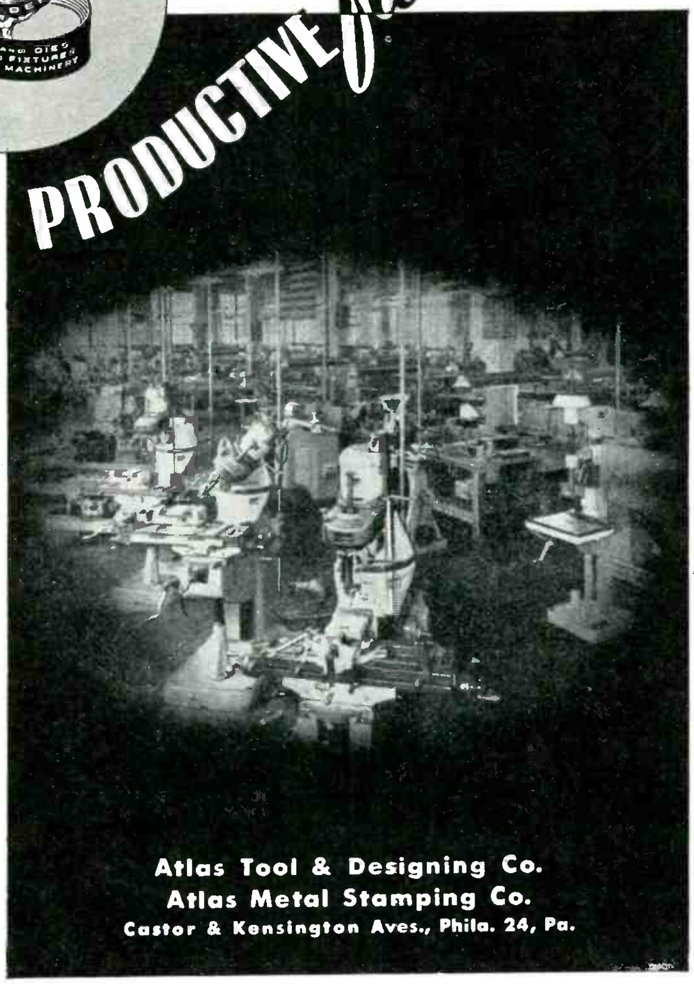
The 7EP4 tube fits easily into a cabinet of reasonable depth, being 15½ in. long. The accelerating potential is only 2,500 volts, therefore calling for a power supply that is relatively low in cost.

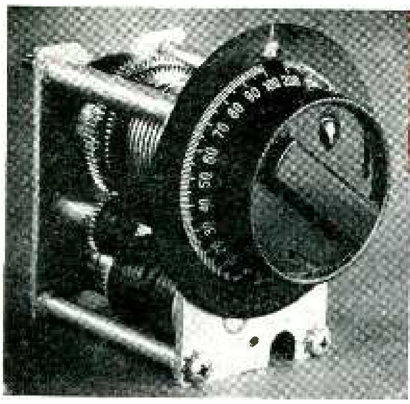
19

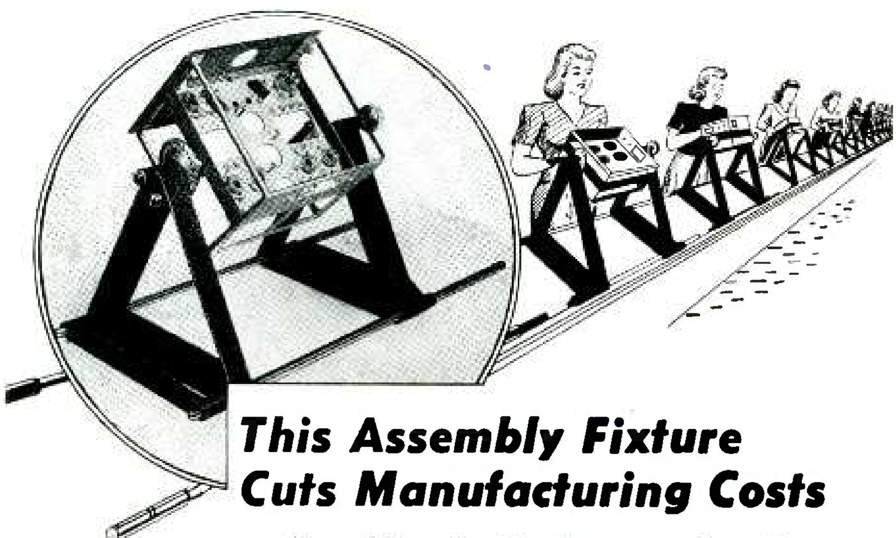
Transmitting Triode

EITEL-MCCULLOUGH, INC., San Bruno, Calif., announces the Eimac, 3×2500A3, a medium mu, forced-air cooled, external anode transmitting triode. It incorporates features which make it suitable for effective use at frequencies well into the vhf range, as well as at lower frequen-









cies. The grid terminates in a ring interposed between the plate and filament, to permit maximum convenience in the use of a tube as a grounded-grid amplifier at high frequencies with coaxial plate and filament tank circuits. The tube is also provided with a rugged, low-inductance cylindrical filament-stem structure, which allows a smooth transi-

tion between a linear filament tank circuit and the tube. As a result of the use of these unique grid and filament terminal arrangements, it is possible to install or remove the 3X2500A3 without the aid of tools.

The 3X2500A3 is capable of delivering relatively high-power output at low plate voltages. A single tube will deliver a radio-frequency output of 5000 watts at 3500 plate volts at low frequencies, and 3500 watts at 3000 plate volts at a frequency of 110 mc. The tube is of extremely compact design, having a diameter of less than 4½ inches.

20

Small Motor

TWO NEW FRACTIONAL hp, shaded-pole motors suitable for duties requiring moderate torques are available from Small Motors, Inc., 1308 Elston Ave., Chicago, Ill. The motors

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ELECTRONICS' fundamental policy has always been to supply its readers with all the pertinent and timely industry news. The ELECTRONICS' Reader Service supplements this policy by offering the reader an easy and effective means of obtaining complete, up to the minute data on new products and of maintaining at his fingertips comprehensive, practicable information on "who's doing what" in the industry.

There's complete coverage in every issue of ELECTRONICS of the month by month development by manufacturers of new materials, components and equipment, as well as brief mention of all the important, new, manufacturers' technical pamphlets and catalogs. Some of these items will be of particular interest to specific design and plant engineers, buyers, executives and others of our readers. They will want to make further inquiry concerning the new products described, or they will want to read and make a permanent part of their industrial library some of the manufacturers' literature and catalogs. ELECTRONICS' Reader Service makes it easy for them to obtain in readily accessible and usable form the information they desire.

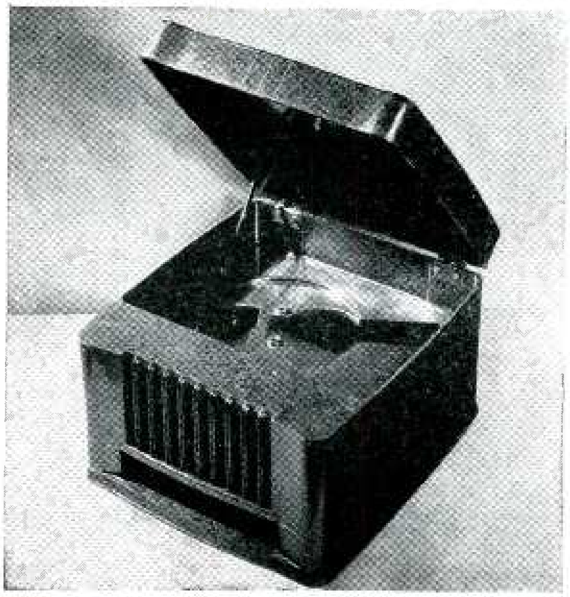
For the Manufacturer . . .

ELECTRONICS' Reader Service will also be welcomed by manufacturers who are desirous of placing the complete news of their product developments as well as their technical bulletins and catalogs in the hand of those members of the electronic industry . . . including design, electrical, and production engineers, researchers, physicists, executives, and buyers — who have a particular interest in, or represent a potential buying power, for their products.

•

SUGGESTIONS FOR THE IMPROVEMENT OF OUR READERS' SERVICE ARE INVITED

ELECTRONICS is constantly seeking new and improved ways of providing its readers with the news and information they want and need, and of assisting the manufacturer in effectively delivering his message to electronic markets. If you have any ideas for us, send them along. They'll receive prompt and grateful consideration.



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Dispelling the time-worn theory that large molded plastic pieces are impractical and uneconomical, these Admiral phonograph and radio-phonograph cabinets effectively demonstrate that large products as well as small can be molded of Durez phenolic plastics.

The bigger cabinet (right) when assembled contains a five-tube radio and automatic record player. The molded Durez body weighs 9½ pounds and the cover 3½ pounds. This makes a total cabinet weight of only 13 pounds.

Radio Frequency Preheat

Compression-molded in a 400-ton press, the special Durez compound used in this larger unit is preheated by radio frequency. This modern method of production facilitates the molding operation considerably and results in the strong, attractive cabinet shown.

The smaller unit, Admiral's automatic record player, is also molded of Durez but in a 300-ton press.

Why Plastics?

The progressive Admiral Corporation experimented and found that for top quality cabinets of this type—having light weight and an integral, lustrous finish, plastics were better suited than any other material.

Why Phenolic Plastics?

The excellent moldability, impact strength, eye-appealing finish, and the non-resonance of phenolic plastics proved the decisive factors in the choice of these most-versatile-of-all-plastics.

Why Durez Phenolic Plastics?

As specialists in the production of phenolic plastics for the past quarter century, the Durez staff have developed more than 300 multi-propertied Durez phenolic molding compounds from which to select the plastic that precisely fits the job.

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"Machining Data on Phenolic Plastics" is an informative manual which covers all the standard machining operations encountered in the average plant. Write for your free copy. No obligation, of course. Durez Plastics & Chemicals, Inc., 83 Walck Road, North Tonawanda, New York. *Export Agents: Omni Products Corporation 40 East 34th Street, New York 16, N. Y.*

DUREZ

PHENOLIC RESINS

MOLDING COMPOUNDS

INDUSTRIAL RESINS

OIL SOLUBLE RESINS

PLASTICS THAT FIT THE JOB

are of the four-pole type, wound for 115 v 60 cps, single phase, and may be had with either ball or oilless bearings. Field and rotor cores are laminated. Windings for special voltages or windings to stand locked rotor conditions are made to order.

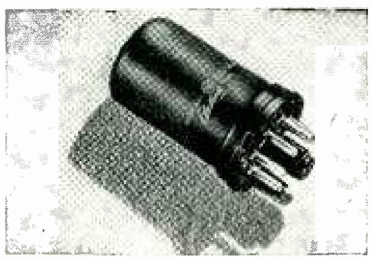
Four sizes are made: the SP-37 with ratings from 1/100 hp to 1/40 hp and speeds from 1,450 to 1,650 rpm; and the SP-38 with ratings from 1/35 hp to 1/10 hp and speeds from 1,400 to 1,650 rpm.

21

Midget Thyratron

GENERAL ELECTRIC CO., Schenectady, N. Y., announces the type GL-502 A all-metal midget thyratron with a net weight of two oz, height two and one-half inches and a diameter of one and five-eight inches. Because of its low grid-anode capacitance, the thyratron is relatively unaffected by line-voltage surges.

Specific applications for the tube include its use in controlling the



speed of fractional-horsepower motors, operation with phototubes, in sequence timers and electronic temperature control.

The GL-502 A is an inert-gas-filled, double-grid thyratron with negative control characteristics. The control characteristic of this tube is independent of ambient temperature over a wide range. It has high sensitivity characteristics because the grid current is low enough to permit the use of a high resistance in the grid circuit.

22

Cable and Pipe Locator

W. C. DILLON & CO., 5410 W. Harrison St., Chicago 44, Ill. produces the Stewart Cable Tester & Locator Combined. It finds old cable or pipe

The case for Dielectric Heating

making an end of a job ...*in wood gluing*

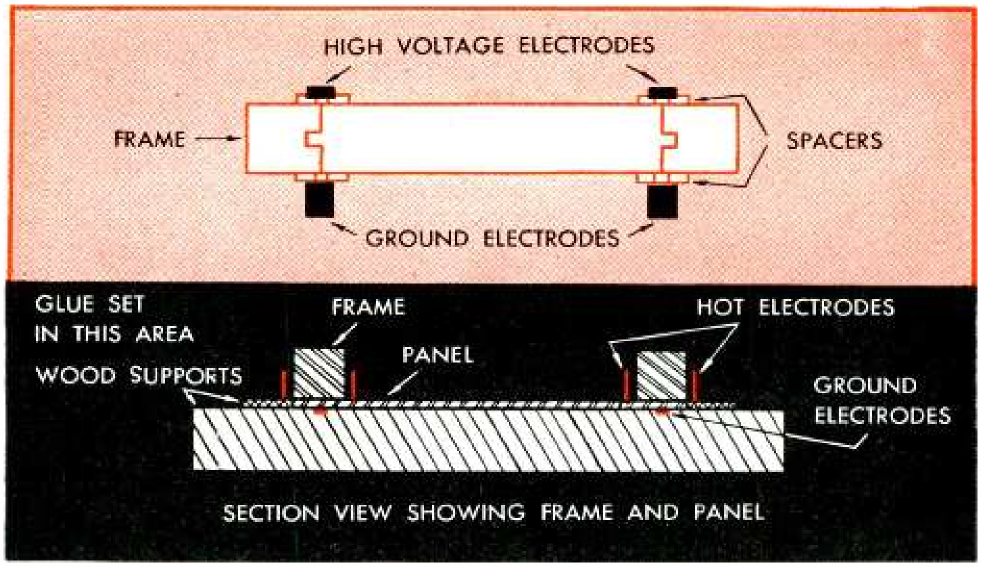
Speeding assembly operations is an important result of dielectric heating in modern wood processing. Here's an example.

The job was to glue four wood pieces into a frame, glue plywood to the frame and do both jobs in one operation at the rate of 125 units every hour! The complete assembly measured 12″ x 36″ and formed an end piece for a chest of drawers.

The solution found in the laboratory rested in the technique shown below . . . joints were heated by electrodes and glue set without pressure. The plywood was then glued to the frame at pressure of 110 to 170 psi with a cold-setting glue. Shrewd designing confined heating to regions near the glue line, permitted the use of a smaller-size generator.

Your benefits in using electronic heating apply to all types of heat-treating . . . hardening, sintering, annealing, brazing, soldering, curing and molding. Get the complete story from your nearest Westinghouse office today. Or, write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

J-08141



HERE'S FREE HELPFUL INFORMATION

on both induction and dielectric heating . . . their principles and theories; where to use them; how to select them; actual case histories of their use. Write for your copy today, on your business letterhead, please. Ask for B-3620.

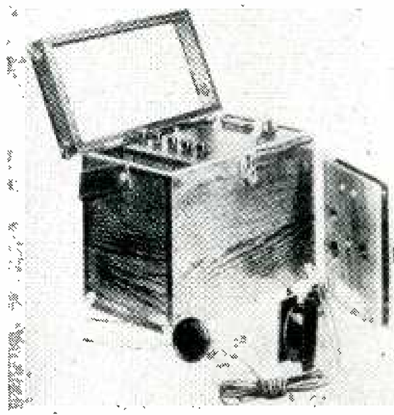
Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Electronics at Work

laid many years ago on which installation records have been lost or forgotten. It locates the exact path of cable or pipe to or from buildings; finds position of a water main in street or alley; has a lamp circuit for checking all connections after test has been set up.

It is especially valuable for checking depth of cable at river crossings. It determines whether or not a service pipe is below the frost line in



lowering or regrading thoroughfare. The unit is also used to rechart a town or district where records have been lost.

It is furnished with detector coil and neutral exploring coil. Built-in level in coil enables operator to maintain absolute accuracy.

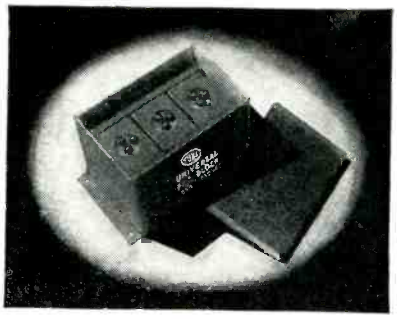
The uses of this instrument cover the needs of industrial concerns, public utilities, light and power fields, telephone service, forestry, and many others.

The unit is ruggedly built, easy portable, compactly encased for rough uses and weather. Size: 12½ x 7¼ x 11 in high. Weight: approximately 22 lb, including head phones, neutral exploring coil, and fish scale exploring coil.

23

Tapped Capacitor Block

TOBE DEUTSCHMANN CORP., Canton, Mass. produces a capacitor block which is applicable to power-factor correction in single- and polyphase circuits. The block is made up of dual 5 μf units which are oil-filled and hermetically sealed in metal cases. Assemblies are available in sizes from 600 va to 2 kva for operation at 230 v 50-60 cps. These capac-



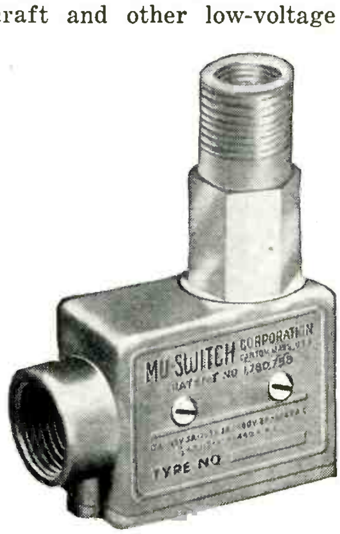
itors are capable of continuous operation at temperatures up to 75C and their normal heat rise at full voltage is less than 10C.

The capacitor block is contained in a housing of 16-gage steel with knockouts, at opposite ends, accommodating half-inch metal conduit. Circuit connection is made to soldering lugs that accommodate wires up to number 12. Flanges at the ends of the housing facilitate its mounting to a flat surface. The overall dimensions of the 600 va unit are $4\frac{13}{16}$ x $5\frac{5}{16}$ x $7\frac{1}{4}$ in.; the 1 kva unit is $11\frac{7}{8}$ in. long; the 2 kva unit is $23\frac{3}{4}$ in. long. Other ratings are available on special order.

24

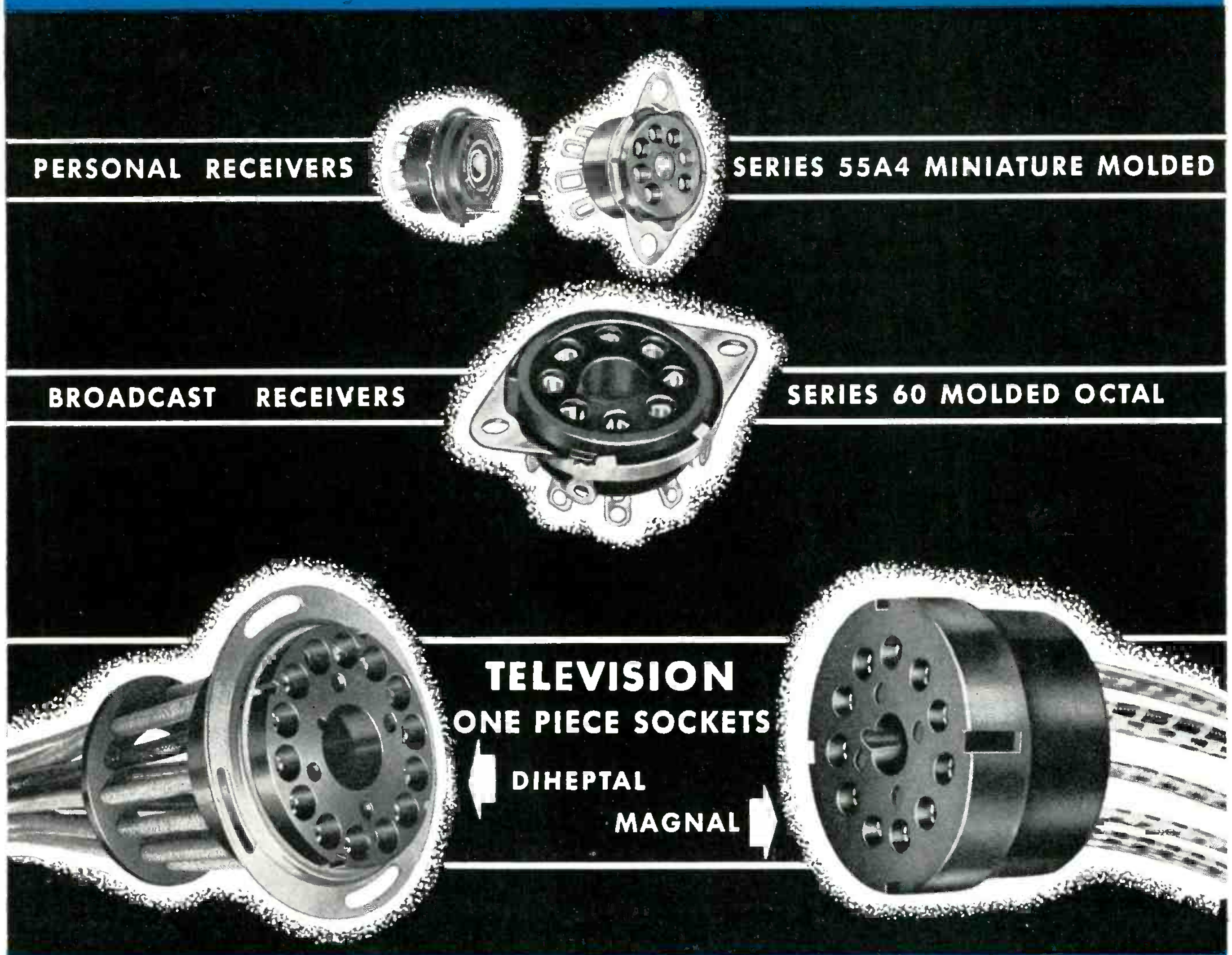
Fluid Pressure Switch

MU-SWITCH CORPORATION, Inc., 380 Pequit St., Canton, Mass., can furnish an electrical control initiated by changes in fluid pressure. The unit measures 1 x $2\frac{15}{16}$ x $3\frac{5}{8}$ in. The electric control element is a standard, spdt Mu-Switch. For industrial applications, the switch is rated at 15 amp 125 v a-c to 2 amp 600 v a-c or one half hp at voltages up to 460 a-c. For aircraft and other low-voltage d-c



Franklin QUALITY *Sockets*

for Personal . . . Broadcast . . . Television Receivers



. . . and for general purposes, the Series 39 Socket, with patented bow spring action contacts (with or without a soldering tab to eliminate wiring to ground) is the favorite of all time. Automatically machine made, tens of thousands are being delivered to the radio industry to enable peak production of standard receivers. The millions in use give testimony to its being the favorite socket of pre and post war receivers.

ELECTRONIC COMPONENTS

A. W. FRANKLIN MANUFACTURING CORP.
175 VARICK ST., NEW YORK 14, N. Y.

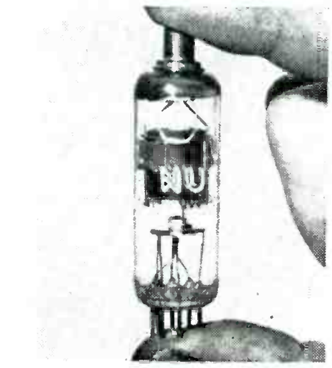
In California: A. W. FRANKLIN Mfg. Corp. of CALIFORNIA, 2216 West 11th St., Los Angeles 6, Calif.

SOCKETS • TERMINAL STRIPS • PLUGS • SWITCHES • PLASTIC FABRICATION • METAL STAMPINGS • ASSEMBLIES applications, the pressure switch has a maximum current rating of 25 amp at 28 v d-c. The hub for electrical conduit connection has an internal half-inch pipe thread. The pressure-sensitive portion of the switch assembly consists of a metal bellows soldered into a brass tube which is securely attached to the metal housing that contains the electric circuit element. The upper end of the pressure chamber has a standard half-inch pipe thread for attachment to the pressure line. This unit can be furnished for operation with a differential of 5 to 15 lb at nominal ratings of from 10 to 120 lb per sq in. The pressure chamber is made of a corrosion and heat-resisting material, and the unit can be safely operated at temperatures up to 300 F.

25

Miniature Rectifier

NATIONAL UNION RADIO CORP., 15 Washington St., Newark, N. J. The type 1Z2 tube which will handle 20,000 v within its 2$\frac{3}{8}$ in. bulb is de-



signed for use as a half-wave rectifier, but is also suited for use in fly-back pulse rectifiers and r-f supplies for television circuits.

26

Self-Timing Interrupter

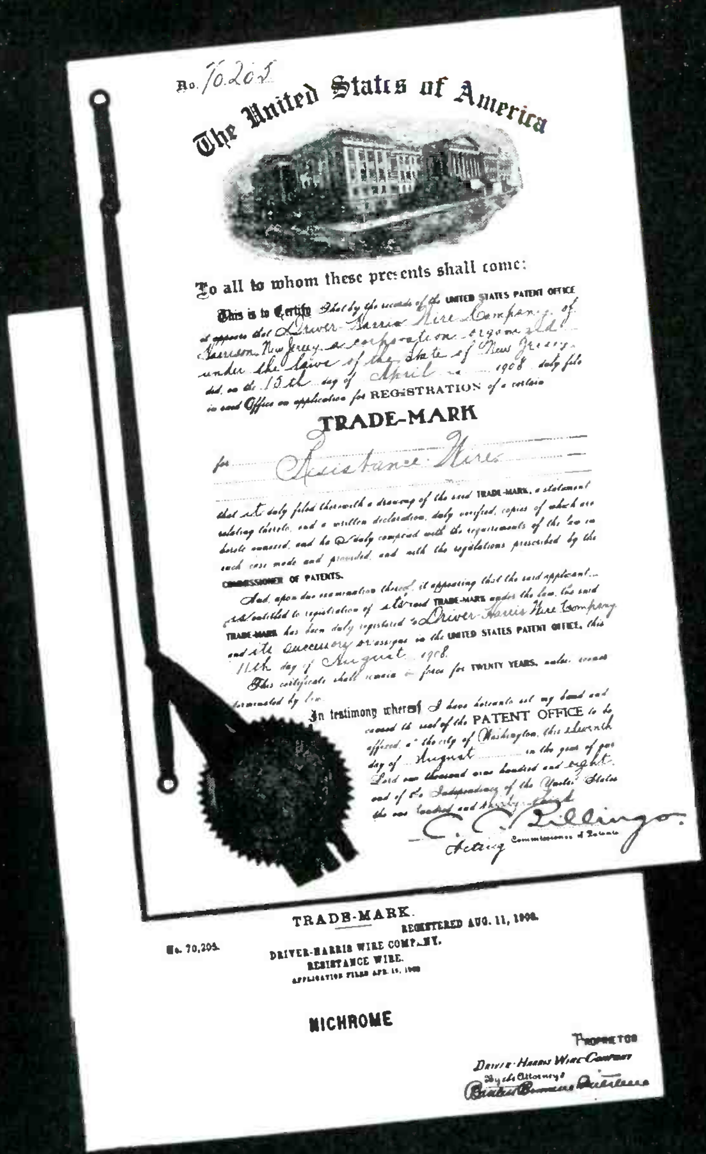
ELECTRONIC CONTROLS, INC., 44 Summer Ave., Newark 4, N. J. The new ECI interrupter unit is comprised of a glass-enclosed thermal element of the hot-wire type, a small power relay, and a resistor, when required. The device can be supplied with a fixed rate of interruption or with an external variable adjustment. The fixed unit can be supplied in

IT IS INDISPUTABLE!

.....that Da Vinci created Mona Lisa

.....that Driver-Harris created

Nichrome*


No. 70205

The United States of America

To all to whom these presents shall come:

This is to Certify That by the records of the UNITED STATES PATENT OFFICE it appears that Driver-Harris Wire Company, of Harrison, New Jersey, a corporation organized under the laws of the State of New Jersey, did, on the 15th day of April 1908, duly file in said Office an application for REGISTRATION of a certain

TRADE-MARK

for Resistance Wires

that it duly filed therewith a drawing of the said TRADE-MARK, a statement and a written declaration, duly verified, copies of which are hereto annexed, and has duly complied with the requirements of the law in such case made and provided, and with the regulations prescribed by the COMMISSIONER OF PATENTS.

And, upon due examination thereof, it appearing that the said applicant is entitled to registration of its said TRADE-MARK under the law, the said TRADE-MARK has been duly registered to Driver-Harris Wire Company and its successors or assigns in the UNITED STATES PATENT OFFICE, this 11th day of August 1908.

This certificate shall remain in force for TWENTY YEARS, unless sooner terminated by law.

In testimony whereof I have hereunto set my hand and caused the seal of the PATENT OFFICE to be affixed, at the city of Washington, this eleventh day of August in the year of our Lord one thousand nine hundred and eight, and of the Independence of the United States the one hundred and thirty-third.

C. C. Billings
Acting Commissioner of Patents

TRADE-MARK.
REGISTERED AUG. 11, 1908.

No. 70,205.

DRIVER-HARRIS WIRE COMPANY.
RESISTANCE WIRE.

NICHROME

Proprietor
Driver-Harris Wire Company

Down thru the ages the inscrutable countenance of Mona Lisa has been irrefutably attributed to and associated with Leonardo Da Vinci. Authenticated records prove conclusively that he was the creator of this masterpiece.

Likewise, the indisputable ownership of the trade-mark NICHROME for Resistance Wire was established by this duly authorized document granted to the Driver-Harris Company on August 11th, 1908. Subsequent registrations cover other product applications. Thus NICHROME is the registered trade-mark belonging solely and wholly to the Driver-Harris Company.

NICHROME is also the symbol of service that has for 38 years identified the *world's foremost heat and corrosion resistant alloy* – the time-tested standard by which other alloys are measured. Although there are other excellent nickel-chromium combinations there is only one NICHROME.....and it is made *only* by Driver-Harris.

**Nichrome is made only by*

D H — SPECIAL PURPOSE ALLOYS SINCE 1899

Driver-Harris
COMPANY

HARRISON • NEW JERSEY

BRANCHES: Chicago • Detroit • Cleveland • Los Angeles • San Francisco • Seattle

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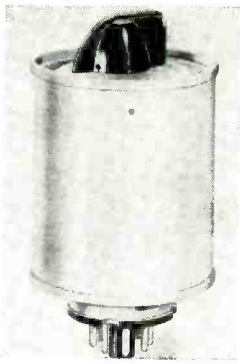
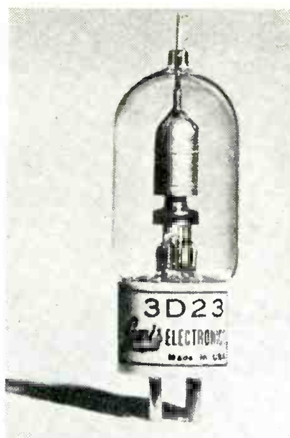


open-frame or plug-in metal enclosures; the adjustable unit in dust cover enclosure only. Timing range is from 1-12 pps; voltage, to 32 v d-c or to 125 v a-c, 60 cps. Contacts are spst normally open or closed, dpst normally open or closed and dpdt. Contacts carry 10 amp (non-inductive, at sea level).

27

New Tubes

LEWIS ELECTRONICS, Los Gatos, Calif., is releasing three new tubes for communications, medical and industrial use. The 3D23 is a high frequency tetrode. Operation is possible up to 250 mc wth full-power input and up to 400 with half-power input. Maximum power output is 130 w (35



w plate dissipation) making the tube suitable as a power amplifier, oscillator or amplifier-doubler.

It is made with a medium 4-pin ceramic bayonet base. Filament is thoriated tungsten, voltage 6.3 a-c or d-c, current 3 amp. The overall length of the tube including plate connection is 4.875 in. and maximum diameter of the bulb, 1.562 in. The

4C32 can be used as an unmodulated class C radio-frequency amplifier. Typical operating conditions are: d-c plate voltage, 2,000; power output 400 w. Maximum input is 900 watts, maximum plate dissipation 200 watts. Upper frequency limit of the tube with maximum power input is 60 mc, although higher frequencies are attainable if the plate voltage and power input are appropriately decreased.

The tube has a heavy graphite anode and an extra heavy thoriated tungsten filament.

Plate and grid connections are made at the top and side of the bulb respectively through heavy copper terminals which are welded directly to the glass. The tube has a 4-pin jumbo bayonet base (metal) with pins extending through a ceramic disc. Overall length is approximately 10½ in.; maximum dimension along the grid lead axis is approximately 4½ in.

Primarily a high frequency transmitting beam pentode, the 4E27 can be used as an oscillator, power amplifier (plate or suppressor modulated), modulator, or amplifier-doubler. By use of suppressor grid control it becomes possible to use this tube simultaneously as a power amplifier and electron switch for periodic or pulse time transmission. Output is rated as 200 w up to 75 mc, or to 80 percent of normal input as high as 150 mc, and requires small driving power for full output. The tube can be simultaneously or independently modulated on as many as three elements. The high screen dissipation is useful for electron-coupled circuits. It has an overall length of slightly under 6 in., bulb diameter of 2¾ in. Contacts are made through a jumbo 7-pin metal-sleeve bayonet base, plate connection being made at the top of the bulb. Filament is powered at 5 a-c or d-c, 7.5 amp.

28

Frequency Standard

GENERAL RADIO CO., 275 Massachusetts Ave., Cambridge 39, Mass. For standardization at low frequencies, the Type 816 vacuum-tube precision fork has applications in geophysical exploration, in rating clocks and watches, in synchronizing transmitting and receiving equipment in

the new electronics BUYERS' GUIDE

Contents were determined by questionnairing a cross-section of the many types of people who will use the Guide. They indicated the information they want, need and use, suggested important listing breakdowns and were enthusiastic about its vital usefulness. That's why we KNOW the Guide will be read . . . it's being "tailored to known needs"

Listings will provide authentic, easy-to-find buying reference. All items will be indexed with classifications broken down where necessary for complete clarification to quickly answer the question, "Who makes it and where can I buy it?" Advertisers' names and page numbers will be flagged in bold type as the source of necessary data on which to base purchases or make direct inquiry.

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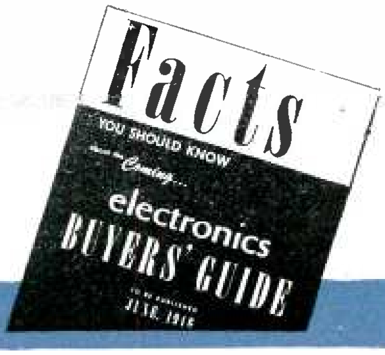
A SEPARATE ISSUE COMING JUNE 1946

A NEW PLAN has been adapted for the 1946 Buyers' Guide. For the Subscriber; it will be an additional, bonus issue of ELECTRONICS containing news and vital information of year-round value, plus the most authentic, comprehensive listing of products ever attempted. For the Advertiser; its twelve-month usefulness assures complete readership by the largest buying audience ever assembled.

CLOSING DATES

Copy to prepare: All details must be in our New York office not later than March 15th. *Copy to set:* April 1st, no proofs April 10th. *Complete Plates:* May 1st. Rates and detailed information can be obtained from the ELECTRONICS representative in your territory, or send for the 12 page descriptive folder illustrated below.



ABC **electronics** ABP

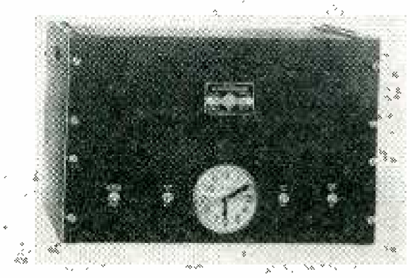
330 West 42nd St. • Established 1930 • New York 18, N. Y.

A McGRAW-HILL PUBLICATION

communication systems, in timekeeping and in chronographic work.

The tuning fork is fabricated from low-temperature-coefficient stainless steel and is housed in a temperature-controlled chamber. The mounting is designed to absorb a minimum of energy from the fork. Electromagnetic drive and pickup coils are symmetrically placed and are coupled through a vacuum-tube amplifier with automatic amplitude control.

A synchronous clock is driven from the fork and registers correct time



when the fork is vibrating at exactly its rated frequency. Comparison of the readings of this clock with radio time signals provides a means of checking the fork frequency. The frequency stability is one part in 100,000 (0.001 percent) which is approximately equivalent to one second per day.

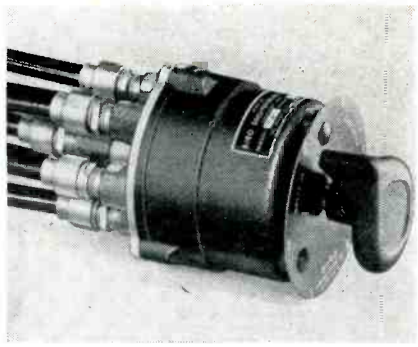
The fork frequency is available at output terminals with either sinusoidal or peaked waveform. Maximum output is 2 watts.

Power supply is a 115-volt d-c or a-c line. Two models are available, Type 816-A with a fork frequency of 50 cycles per second, and Type 816-B with a 60-cycle fork. Dimensions are 19 x 12¼ x 12½ in.; net weight is 49½ lb. The price is $385.

29

Coaxial Switches

BIRD ELECTRONIC CORP., 1800 East 38th St., Cleveland 14, Ohio. Models 74 and 72-2 Coaxwitch, developed for military use should find many communications applications, particularly for double-ended insertion devices. The switches are designed for use with 50/52-ohm cables such as RG-8/U and RG-9/U. When inserted ahead of a 52-ohm load previously matched for 1.0 standing-wave ratio,

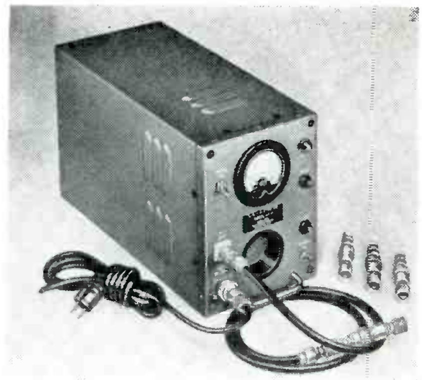


the resulting ratio for switch and load is not over 1.3 at 3,000 mc. Modifications of this type of switch are available on special order.

30

Vhf-uhf Wattmeter

BIRD ELECTRONIC CORP. The Model 63-A wattmeter can be used to facilitate alignment and power measurement of transmitters operating between 20 and 800 mc with power output up to 500 w. The equipment essentially comprises a blower-cooled

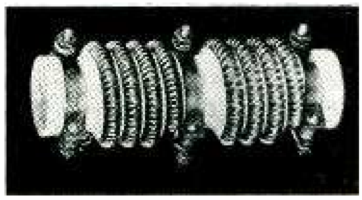


50-ohm load of wide-band constant-impedance design, series thermocouples near the transmitter end and a d-c millivoltmeter. The blower is powered by a 115-v, a-c or d-c 60 cps motor which need not be operated below 50 w r-f input.

31

Center-Tap Resistor

TECHTMANN INDUSTRIES, INC., 828 North Broadway, Milwaukee 2, Wisconsin, distributors for Regan Electrical Products announce the new Type CAM center-tap resistor. The

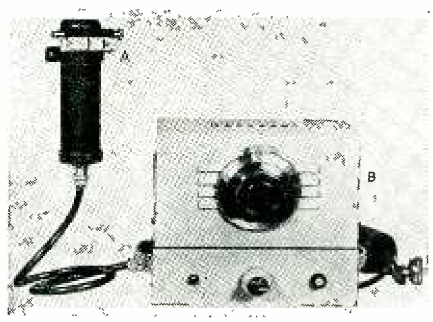


resistance element is helical wound upon a piece of solid steatite and clamped securely at both ends and in the middle. The element can be replaced without removing the assembly.

32

Exposure Control

ELECTRIC EYE EQUIPMENT CO., 16 West Fairchild St., Danville, Ill. The Hurletron meters accumulated exposure, thereby taking into account



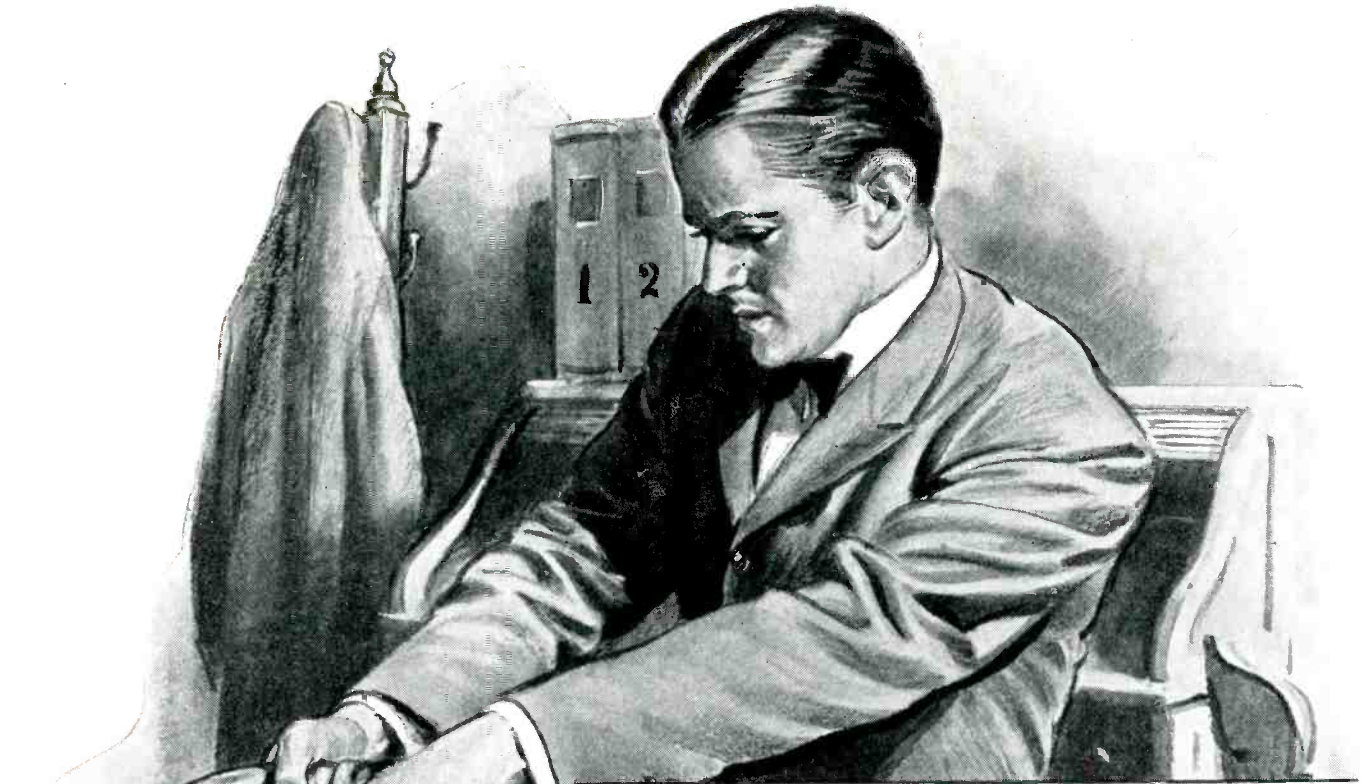
fluctuations of light intensity and compensating for them. By means of this device, identical prints may be obtained once optimum conditions have been determined.

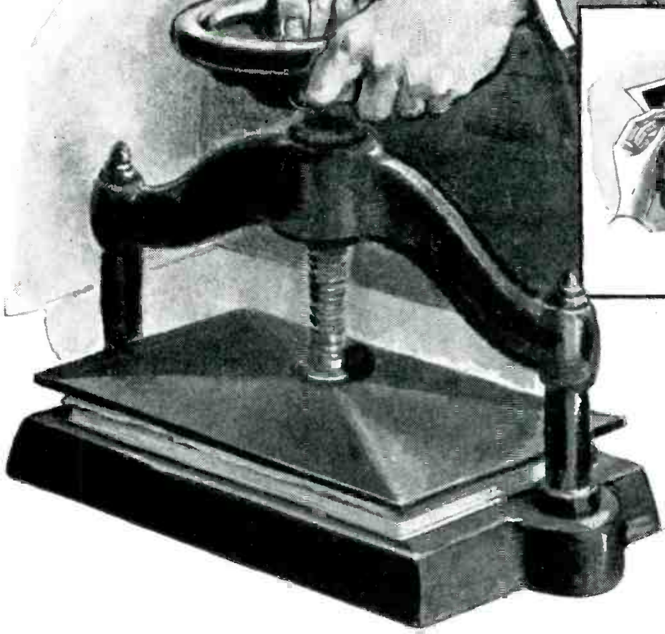
33

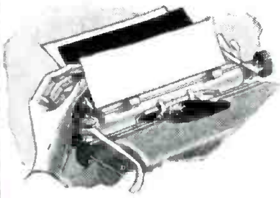
High Power Triode

TAYLOR TUBES INC., 2312 Wabansia Ave., Chicago, Ill. The zirconium coating sprayed on the 833A covers only that part of the plate which is most subject to heat during operation, thereby resulting in an improvement over the former tube bearing this designation.

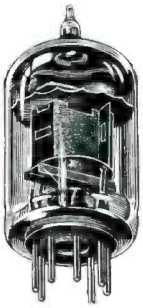
Maximum signal outputs are: as Class-B modulators (pair), 2,700 w; as r-f Class-B amplifier, telephone,







more efficient ...in miniature



ACTUAL SIZE

Many oldsters still remember the old letter copying press and long hours spent in dim light after other office workers had gone to their homes. While carbon paper was indeed an emancipator of office boys, it is but another example of the trend to greater efficiency in miniature.

And so it is with TUNG-SOL Miniature Electronic Tubes. The large type tube did do a job. But today, especially in high frequency circuits, TUNG-SOL Miniatures do a more efficient job. The shorter leads on the Miniature make for low lead inductance, low inter-element capacities, and high mutual conductance.

The smaller and lighter parts make possible a rigid construction that is more impervious to the effects of shock and vibration. The size of the Miniature makes it a factor in reducing the overall size of radio equipment.

The manufacturer who wants his equipment to be "modern" must consider the use of Miniatures. TUNG-SOL Engineers will gladly work with you in planning circuits and in selecting tubes with the sole objective of making your equipment as efficient as possible. Your confidences will be strictly respected.

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

TUNG-SOL LAMP WORKS, INC., NEWARK 4, NEW JERSEY

Sales Offices: Atlanta • Chicago • Dallas • Denver • Detroit • Los Angeles • New York

Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors

250 w; as r-f Class-C amplifier, plate-modulated, 1,500 w; and as r-f Class-C amplifier, telegraphy, 1,600 w.

Physical dimensions: diameter, 4$\frac{13}{32}$ in. max; height, 8$\frac{5}{8}$ in. Grid and plate caps at top: $\frac{5}{8}$ in. long by 0.567 in. diameter. Two filament caps at bottom: each 1$\frac{3}{32}$ in. long by $\frac{3}{8}$ in. diameter.

Electrical characteristics: filament (thoriated tungsten) 10 v (a-c or

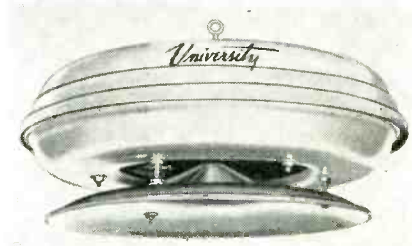
d-c) at 10 amp. Amplification factor: 10. Inter-electrode capacitances: g-f 12.3$\mu\mu$f; g-p 6.3$\mu\mu$f; p-f 8.5$\mu\mu$f.

Typical key-down conditions per tube: Class-C, r-f amplifier and oscillator: (ICAS ratings with forced air cooling) d-c plate volts, 4,000 v; d-c grid volts, minus 225 v; peak r-f grid voltage, 415 v; d-c plate current, 0.5 amp; d-c grid current, 95 ma; driving power, 35 w; power output, 1,600 w; highest frequency for maximum ratings, 20mc.

34

Radial Cone Loudspeaker Projectors

UNIVERSITY LABORATORIES, 225 Varick St., New York 14, N. Y. The Model RBP-12 and RBP-8 projectors are designed for good low-frequency response and 360-degree

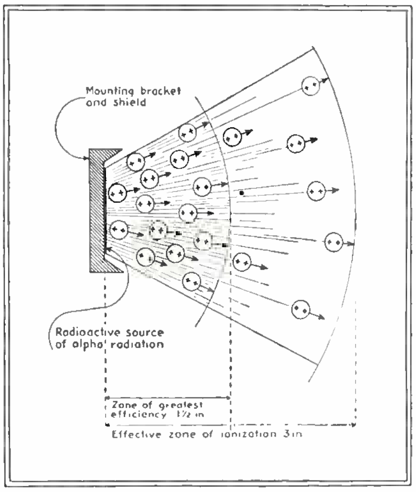


sound dispersion using only one speaker. These units can be used out of doors. For use with 12- and 8-in. speakers respectively, the larger unit measures 27 in. diam x 11 in. height, and weighs 19 lb.

35

Static Eliminator

UNITED STATES RADIUM CORP., 535 Pearl St., New York 7, N. Y. Static electricity occurs in the form of an electrical charge close to any fast-moving, non-conducting material near the point where it leaves an object with which it has been in close contact, such as a belt leaving a pulley or a sheet of paper leaving a roll. When sufficient charge is accumulated, a spark may ignite highly flammable materials nearby. Static-charged fibers or thin sheets often become unmanageable in manufacturing processes.



The Ionotron Static Eliminator emits alpha rays which disperse such a charge. Although it uses a salt of radium, safety precautions eliminate danger to operators of equipment. The radioactive source is beamed for greatest effectiveness.

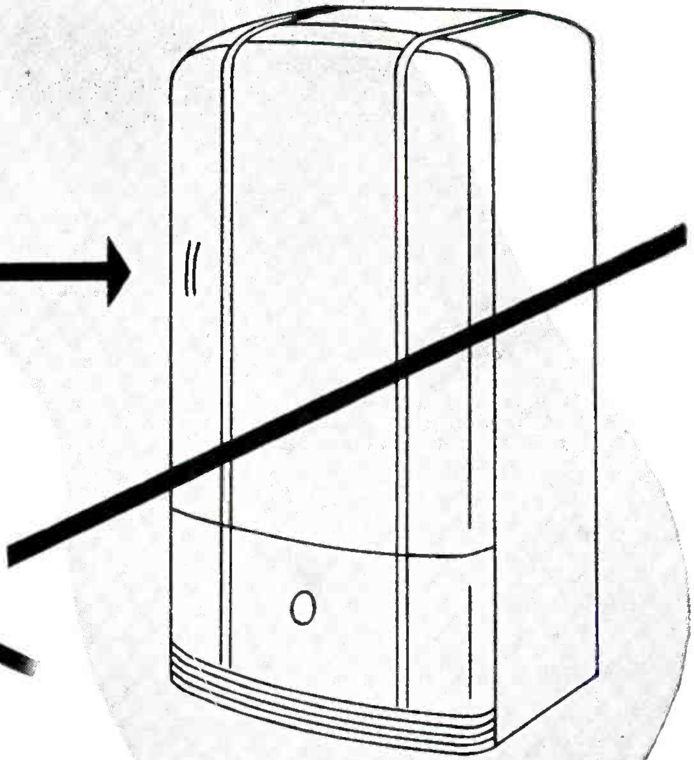
36

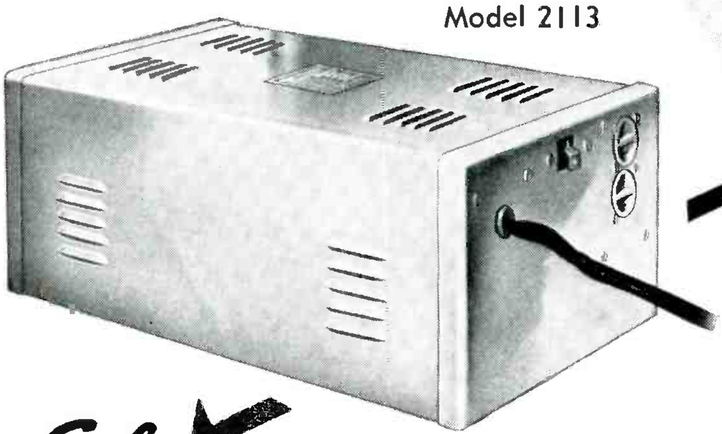
Uhf Beam Tetrode

TAYLOR TUBES, INC. have added the TB-35 which operates with full power input up to 250 mc and at half-power input to 400 mc.

The tube possesses a four-pin ceramic base and the plate connec-

TO OPERATE AN AC REFRIGERATOR ON DC





E·L ENGINEERED THIS INVERTER

If you're a retailer or distributor of appliances or radios, why waste storage and floor space on special DC models?

If you're an appliance or radio manufacturer, why waste time and money designing and building DC units?

E·L has eliminated the necessity for DC models by providing a complete line of Vibrator Inverters that convert AC products to DC with maximum efficiency. They give longer service and increased capacity at lower cost.

Both peacetime and wartime applications of E·L Vibrator Inverters have piled up an impressive record of performance and dependability. Extremely simple in design, they have only *one* moving part, and are precision-built throughout. No brushes, no armatures, no bearings, no lubrication or other routine maintenance!

It will pay you to get complete information on E·L Vibrator Inverters. And remember that E·L engineers are equipped and ready to design special power supplies for products with new or unusual requirements.

THERE IS AN

E·L VIBRATOR INVERTER

FOR EACH IMPORTANT APPLICATION

involving radios, appliances, communications equipment, electric motors, coin-operated equipment, public address systems, neon signs, electric razors and other products.

(Typical of 26 E·L Models available to meet your requirements)

Mod. No.	In-put Volts DC	Out-put Volts AC	Out-put Watts	Load P.F. (%)	Dimensions (in.)	Wt. (lbs.)	Principal Applications
302	6	115	75	80-100	9⅜x6⅜	15½	Radio Receivers. Appliances
507	12	115	150	80-100	10¾x7½x8¼	25	Radio Receivers, Transmitters, Appliances
146	32	115	350	80-100	16x10x8⅜	48	Receivers, Transmitters, Coin Phonographs
2113	115	115	⅛ hp	50-100	10¼x5¾x7	6¾	Refrigerators Water Coolers

Electronic LABORATORIES, INC.
INDIANAPOLIS

DC-AC INVERTERS

VIBRATORS AND VIBRATOR POWER EQUIPMENT FOR LIGHTING, COMMUNICATIONS, ELECTRIC AND ELECTRONIC APPLICATIONS tion is brought out at the top of the envelope. The overall size of the tube is 4⅞ in. and the maximum diameter is 1⅝ in.

Electrical characteristics: filament, thoriated tungsten, 6.3 v (a-c or d-c) at 3 amp; mu, 65; mutual conductance at I_b 80 ma, 2,750 micromhos. Interelectrode capacitances: input to plate, 0.2$\mu\mu$f; input, 6.5$\mu\mu$f; output, 1.8$\mu\mu$f.

Typical operation, Class-C telegraphy: d-c plate volts, 1,500; d-c grid no. 1 volts, 300; d-c grid no. 2 volts,

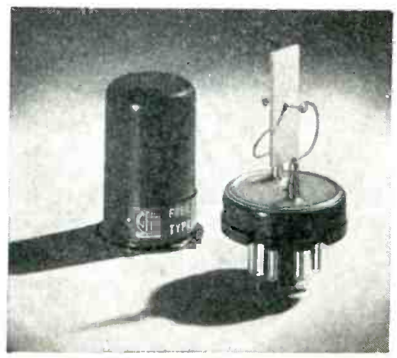
375; d-c plate current, 110 ma; d-c grid current, 15 ma; d-c screen current, 22 ma; plate dissipation, 35 w; peak r-f grid input volts, 350; driving power, 4.5 w; plate power output (to 250 mc), 130 w.

Typical operating conditions, Class C, plate modulated with a maximum modulation factor of 1.0: d-c plate volts, 1,000; d-c grid no. 1 volts, 200; d-c grid no. 2 volts, 300; d-c plate current, 85 ma; d-c grid current, 10 ma; peak r-f grid input voltage, 250; driving power, 2 watts; plate power output, 60 w.

37

Plug-in Crystal

JAMES KNIGHTS CO., Sandwich, Ill., is producing an octal-based crystal unit designated JK T9AD, which is



POLISHED POLYSTYRENE ROD AVAILABLE NOW

Plax polystyrene rod is now available in a new form: with a highly polished surface lustre. Thus designers may now readily work with crystal-clear rods of this unique material.

In this form, Plax polystyrene rod requires very little fabricating and it is easily polished after fabrication. A cutting-down wheel, using a compound held by a non-petroleum grease, will remove any surface imperfections caused by machining – and the final high lustre is restored by a soft cotton buff, free of compound.

The availability of crystal-clear polystyrene rod will suggest many new uses for this versatile material, which is light, hard, inexpensive, and easily fabricated. A few of the applications which immediately come to mind are push bars and racks, display and decorative fixtures, edge lighting effects, novelties, etc.

Plax polished polystyrene rod is available in standard 4′ lengths in all diameters up to 2″. Special lengths and colors are available on minimum order. Samples are available for testing purposes.

POLYSTYRENE LITERATURE AVAILABLE

Bulletins on how to machine, polish and cement polystyrene; on what to tell machinists about polystyrene; and on how to use coolants with polystyrene are available on your request.

While Plax has been the leader in development of uses for polystyrene, we also offer several other plastic materials in unique forms and shapes.

In fact, between the resources of Plax and the Shaw Insulator Company, Irvington 11, N. J., you can obtain help and counsel in the use of most plastic materials and processes. For the literature mentioned above . . . write Plax.

PLAX

FOR PLASTICS

NOT SUBSTITUTES···IMPROVEMENTS

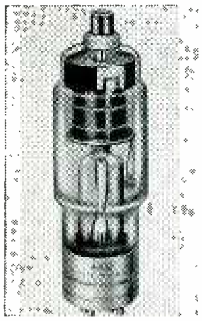
133 WALNUT STREET ★ HARTFORD 5, CONNECTICUT

dustproof and waterproof. Contact to the plated quartz is through shock-absorbing wire leads soldered to the plating. The quartz is processed to prevent aging. The unit is available for frequencies in the range 65-200 kc with a tolerance of better than 0.01 percent at temperatures between −50 to +70 C. It can be supplied with a nominal frequency tolerance of 0.005 percent at 25 C.

38

Xenon-filled Rectifier

CHATHAM ELECTRONICS, 475 Washington St., Newark 2, N. J. The new 4B32 rectifier operates perfectly from −75 to +90 C ambient temperature.

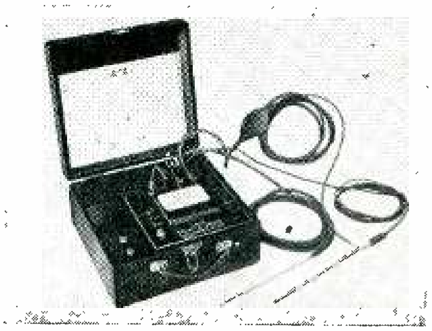


It is rated: peak inverse voltage, 10,000; average anode current, 1.25 amp; voltage drop, 10 v; filament voltage, 5 a-c; filament current 7.5 amp.

39

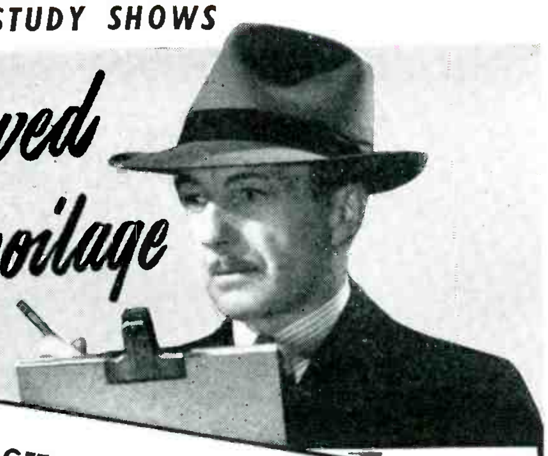
Stack Analysis Meter

DAVIS EMERGENCY EQUIPMENT CO., Inc., 45 Halleck St., Newark 4, N. J. The chief feature of the Stack-o-meter is the use of a single meter to read percentage of carbon dioxide, stack temperature and draft. Accuracy of the meter is based on the thermal conductivity principle of analyzing gases by means of an elec-



INDEPENDENT INVESTIGATOR'S STUDY SHOWS

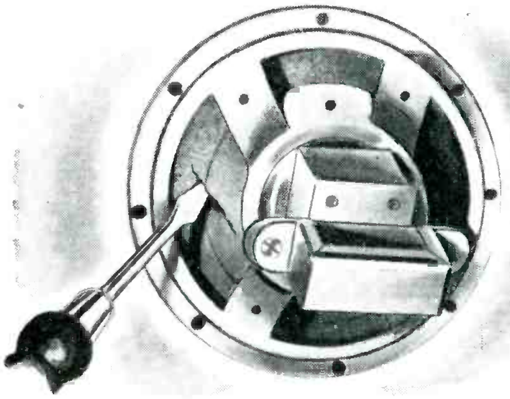
How Phillips Screws Saved Emerson Radio $40 Daily Spoilage



THIS INVESTIGATOR from James O. Peck Co., industrial research authorities, is visiting a number of representative plants to get authentic FACTS on assembly savings for you.

GET HIS UNBIASED REPORTS READ THE COMPLETE FACTS!

100 Driver Skids a day eliminated ... at 40¢ a skid!

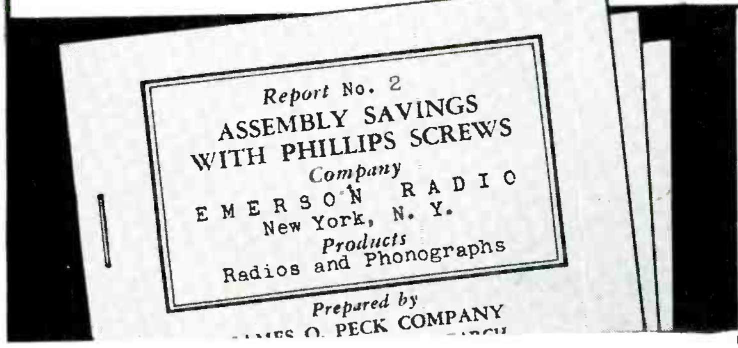


EMERSON RADIO & PHONOGRAPH CORP. use Phillips Screws for one good reason ... *they cut costs!* Good example is the daily saving of $40 formerly used up reclaiming loud speaker cones ruined by driver skids from slotted screws.

That's only one way Phillips Screws save. They can be driven faster – allow use of power in place of hand drivers. They drive tighter – fewer and smaller screws can often be used. Burrs and broken screw heads are eliminated, and the ornamental design improves product appearance.

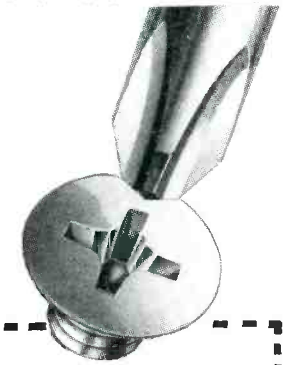
NOW, THESE UNBIASED REPORTS show how these advantages result in savings that add up *big* in yearly assembly records – savings you can't afford to miss with today's squeeze on profits.

THE ASSEMBLY STUDIES COVER ALL TYPES OF PRODUCTS – metal, plastics, wood. The report on Emerson – others now ready – and more to come – make up a practical manual of modern assembly methods, never-before-printed information, inside facts you'd pay good money to get, – and it's yours, now, FREE!



WHATEVER YOU MAKE, THERE ARE SAVINGS IDEAS HERE FOR YOU!

Find out how industry's best assembly experts cut costs! Get these reports, as they are issued. Don't wait ... mail the coupon TODAY!



PHILLIPS *Recessed Head* SCREWS

Wood Screws • Machine Screws • Self-tapping Screws • Stove Bolts

27 SOURCES

American Screw Co.
Atlantic Screw Works
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Corbin Screw Corp.
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Manufacturers Screw Products
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National Lock Co.
National Screw & Mfg. Co.
New England Screw Co.
Parker-Kalon Corp.
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The Southington Hardware Mfg. Co.
The Steel Company of Canada, Ltd.
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PHILLIPS SCREW MFRS.,
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2300 Industrial Trust Bldg., Providence, R. I.

Please send me the reports on Assembly Savings with Phillips Screws

Name ....

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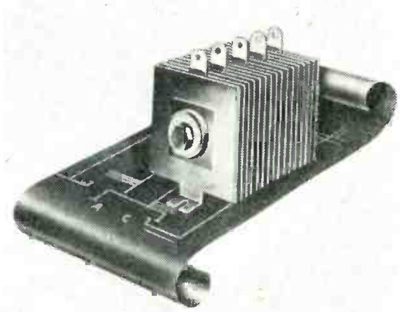
....

trical Wheatstone bridge circuit. Percentage of CO_2 is obtained from gas samples collected through a hand aspirator bulb. Stack temperatures are obtained from a thermocouple mounted in the gas sampling tube. Draft measurement is accomplished with a separate tube but read on the same meter as the other elements. The unit is completely portable, measuring 12 x 13 x 5 in. and weighing 11 lb.

40

Copper Sulphide Rectifier

BENWOOD-LINZE Co., St. Louis, Mo. has developed a dry-disk metallic rectifier rated at 50 amp without forced cooling for charging 6-volt



automotive batteries. Two rectifiers operated from separate transformer secondaries may be operated in parallel for 100 amp.

41

Marine Radiophone

JEFFERSON-TRAVIS CORP., 245 East 23rd St., New York 10, N. Y. One of the first models in a complete line of sea-going communication equipment is the Coastal Model 252 Radiotele-

"This A-B Adjustable Resistor can provide any resistance-rotation curve"

The Type JW Bradleyometer is a watertight unit with a resilient packing around the shaft to exclude moisture. Ideal for radio or radar equipment which may become immersed in water.

The resistor of the Type J Bradleyometer is a solid molded ring. During manufacture, the resistor material is varied throughout the circumference of the molded ring to provide the desired resistance-rotation characteristic.

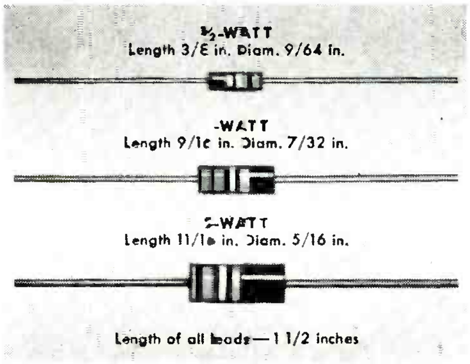
It is not a film or paint type resistor. Therefore, after molding, the resistance curve of the Bradleyometer is unaffected by heat, cold, moisture, or length of service.

The resistor unit is molded as a one-piece ring with terminals, face plate, and threaded bushing imbedded in the ring. The contact brush improves with age.

Type J Bradleyometers can be supplied in single, dual, triple unit construction for rheostat or potentiometer applications. A built-in line switch is optional. Complete specifications will be sent on application.

Allen-Bradley Company, 110 W. Greenfield Ave., Milwaukee 4, Wis.

ALLEN-BRADLEY FIXED RESISTORS



Bradleyunit Fixed Resistors are available in ½-watt, 1-watt, and 2-watt ratings in all RMA standard values from 10 ohms to 22.0 megohms.

ALLEN-BRADLEY
FIXED & ADJUSTABLE RADIO RESISTORS

QUALITY

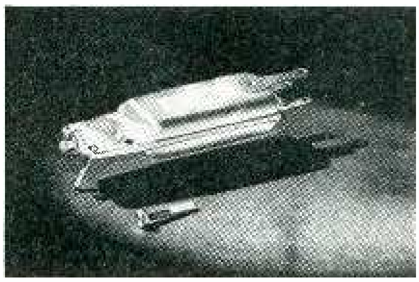
phone. It has a power output of 25 w on five channels, each crystal controlled. The use of mechanically interchangeable power supplies allows its use on 12, 32 or 110 v d-c or 115 v a-c power.

Other equipment now in production include four-channel, 10-watt, 10-channel, 75-watt marine communicators, direction finder, and marine antennas. Two-watt and 15-watt radiophone transmitters are becoming available for private flyers.

42

Pickup Cartridge

SHURE BROTHERS, 225 W. Huron St., Chicago 10, Ill. The crystal element of this new pickup cartridge is driven by a lever which improves the transmission of needle-chuck torque into the crystal. Lower needle-point impedance is obtained through this de-



sign, as well as greater immunity to shock. The lever arrangement absorbs the full impact of sudden jars. Minimum needle force of ¾ to 1¼ oz. results in an output voltage of from 1.6 to over 3. The cartridge is available in either aluminum or steel case, weighing 0.43 or 0.85 oz, respectively.

43

Tube Tester

HICKOK ELECTRICAL INSTRUMENT CO., 10527 Dupont Ave., Cleveland 8, Ohio. New all-purpose, radio tube and set testers designed with a dynamic mutual conductance circuit are now in production. Duplicating the method used by tube manufacturers, the Model 532C (counter model) and 532P (portable) accurately test and reject all bad tubes. The tester is fitted with easy-to-read scales having micromho ranges from 0-3,000, 0-6,000, 0-15,000 with legends indicating Replace, Doubtful and Good. This unit also provides for noise, gas, and

THESE SNC REPRESENTATIVES *offer you*

184 YEARS of RADIO EXPERIENCE

JACK BEEBE
General Sales Manager

We invite you to call on them and their long experience for assistance in solving any problems having to do with the transformer field. Because of the long experience of these men . . . the invaluable knowledge they have accumulated . . . their demonstrated integrity and sincerity, our sales and production policies will be coordinated with the advice and suggestions they bring from their field contacts.

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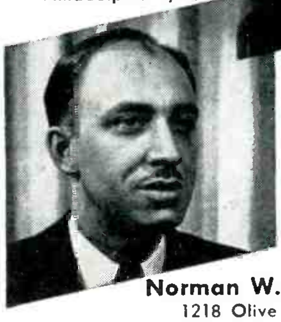
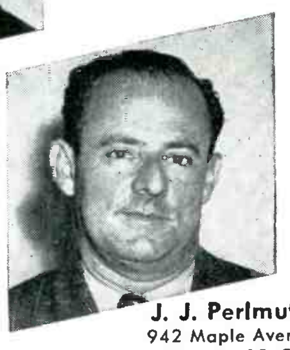
1531 Spruce Street
Philadelphia 2, Pa.

Bert Huvelman
Instrument Sales
325 W. Huron St.
Chicago, Ill.

Jack Cota
5 Ivy Street Bldg.
Atlanta 3, Georgia



Norman W. Kathrinus
1218 Olive Street
St. Louis 3, Mo.



J. J. Perlmuth
942 Maple Avenue
Los Angeles 15, Calif.

Joe Muniot
Southern Sellers . . 918 Union Street
New Orleans, La.

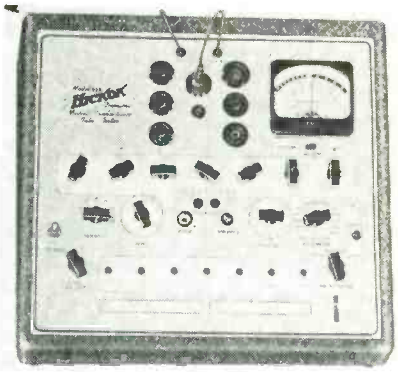
Fred B. Hill
256 First Avenue, N.
Minneapolis, Minn.

G. G. Willison
West Building . . Houston, Texas

SWAIN NELSON COMPANY

GLENVIEW ILLINOIS

hot and cold shorts tests. Diodes are tested separately with low voltage to prevent paralysis of the elements. Line voltage is indicated correctly on a large test meter, from 100 to 130 v. Rectified current is used to energize plates and grids using two rectifiers and tests can be made of grid-controlled rectifier tubes. Filament voltage is in steps to 117 v which affords a wide range of voltage checks. A roll chart in the panel helps locate

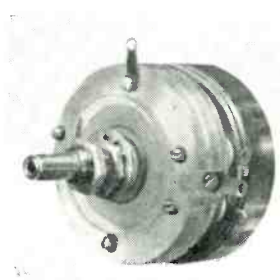


tube data. The tester is 17 x 18 x 8½ in. and operates on a power supply of 110-130 volts from 50-60 cps. Tube complement consists of one 83 and one 5Y3 GT. Tests of all present-day tubes, including octal, loktal, miniature, ballast and magic eye tubes, can be made and, in addition, provision for future tube designs has been taken care of.

14

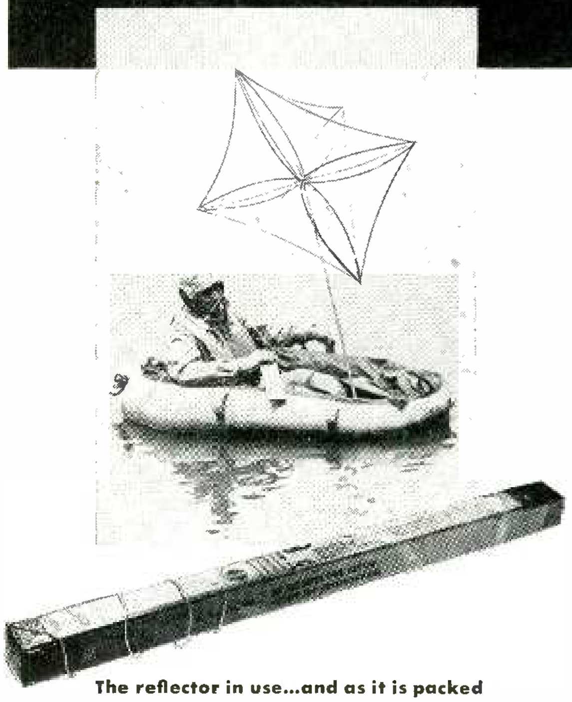
145-Mc Tuner

CALTRON CO., Los Angeles 34, Calif., announces a complete variable tuning unit in a compact assembly for single-hole mounting on receivers, wave meters, frequency meters, low



power transformers, and oscillators.

The unit has a tuning range of 140 mc to 160 mc with 3.5 $\mu\mu$f tube capacitance, (later models will be designed to cover any band of fre-



The reflector in use...and as it is packed

Eleven different "spider webs" of Monel mesh in the Vendo reflector catch radar beams approaching from any quarter. The mesh, knit from 0.0035-inch Monel wire, is furnished by Metal Textile Corp., Orange, N. J.

One of the problems was to make the reflector compact enough to fit in the smallest life raft pack. By using easily-folded Monel mesh, the unit can be stowed in a waxed cardboard carton, only 25" long and 1¾" square.

Peacetime possibilities include use as an aerial for home radios. One report cites tremendously improved reception.

In 1942, Eddie Rickenbacker and his companions crash-landed in the Pacific. For 22 days, airplanes combed the sky before sighting them.

Three years later, airmen forced down at sea were being found in a matter of hours . . . on blackest nights . . . in roughest weather.

. . . for radar was being used to locate friend as well as foe!

A metal reflector, developed by the National Defense Research Committee, turned the trick.

Known as the "Corner Reflector," it enabled life rafts to be easily detected by radar-equipped rescue craft.

To make the reflector, 4 ounces of wire mesh are formed into 11 triangular webs and stretched out on a collapsible framework. It is this mesh which reflects the radar waves and sends them back to appear as spots on the radar scopes of searching airplanes or ships.

Working with the Army and Navy, Vendo Company of Kansas City tested many metals for the mesh.

The metal had to offer just the right electrical and electronic characteristics. The metal had to be strong, so that the delicate mesh would not be ripped apart by winds. And *(of greatest importance)*, it had to resist corrosion by salt spray. For the slightest corrosion would set up high resistance at the thousands of mesh contacts, and seriously cut down over-all conductivity.

Of all the materials tested, only one was found to possess all the properties needed.

That was knit Monel mesh.

Remember Monel and other INCO Nickel Alloys whenever you need a "hard-to-find" combination of properties for electrical or electronic applications. For more information on metals that fight . . . corrosion . . . wear . . . fatigue . . . heat . . . stress . . . write for "Tremendous Trifles."

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street **New York 5, N. Y.**

NICKEL INCO ALLOYS
TRADE MARK

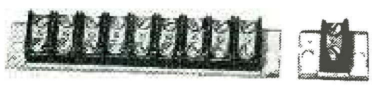
MONEL* • "K" MONEL* • "KR" MONEL* • "R" MONEL* • "S" MONEL* • INCONEL* • NICKEL • "L" NICKEL* • "Z" NICKEL*
*Reg. U. S. Pat. Off.

quencies between 50 and 1,000 mc), rotation 180 deg, diameter of body 2 in., shaft diameter ¼ in., mounting hole ⅜ in. The Q is many times greater than a conventional coil-capacitor combination. Close spacing of terminal lugs (approximately ½ in. between outside and ends of circuit), allows extremely short leads to tube connections.

45

Terminal Block

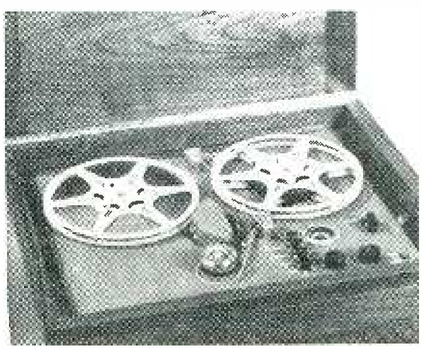
CURTIS DEVELOPMENT AND MFG. CO., One North Pulaski Road, Chicago 24, Ill. Any number of type M terminal blocks from one to 24 can be assembled and held rigid in the metal channel which is a feature of the new assembly. Terminal screw grounding is eliminated by tapping the holes only part of the way through the insulating material. The terminals can carry 10 amp up to 300 v. Marker strips are optional.



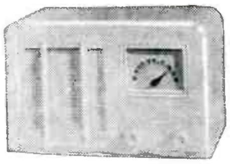
46

Paper Tape Recorder

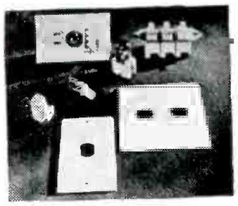
BRUSH DEVELOPMENT CO., 3405 Perkins Ave., Cleveland 14, Ohio. In development since 1929, and still being improved, an 8-mm strip of paper coated with a magnetic material on one side is being used as the medium for magnetic recording in a new equipment designed for inclusion in radio receivers or as a separate unit. The tape comes in 1,000-foot reels of the type used for movie film and will cost about $1.25. It plays for a half



There's a PLASKON ANSWER to your *Electrical needs!*



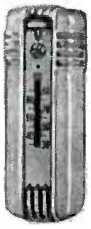
THE UNUSUAL properties inherent in Plaskon Materials make them especially suitable for the molding of parts, complete units, or assembly of, attractive and serviceable electrical products in wide variety. Plaskon Materials for molding are high in utility and decorative properties, giving products made from them impressive sales advantages.



Plaskon Urea-Formaldehyde Compound

1. Wide range of lightfast hues, from translucent natural and pure white to jet black. **2.** Smooth surface, eye-catching, warm to touch. **3.** Completely resistant to common organic solvents, impervious to oils and grease. **4.** Possesses extremely high flexural, impact and tensile strength. **5.** Highly resistant to arcing and tracking under high voltages and high frequencies.

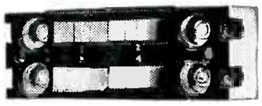
Plaskon Melamine Compound



1. Assures ample protection where water or high humidity prevent use of urea compounds. **2.** Exceptional resistance to acids, alkalies. Non-porous, non-corrodible. **3.** Under extreme conditions of heat and humidity, is non-tracking, highly resistant to arcing, and has high dielectric strength. **4.** Highest heat resistance of all light-colored plastics.

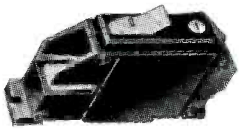
Plaskon Resin Glue

1. Materials bonded by Plaskon Resin Glue cannot be separated at glue line—the material fails first. **2.** Plaskon glue line is completely moisture-resistant, cannot be weakened by mold or fungi. **3.** Maintains its tenacious grip in heavy-duty service for years, under water, on land, in the air.



Experienced Plaskon technical men will be glad to help with your designing and manufacturing problems.

PLASKON DIVISION • LIBBEY • OWENS • FORD GLASS COMPANY
2136 Sylvan Avenue • Toledo 6, Ohio
Canadian Agent: Canadian Industries, Ltd. • Montreal, Quebec



PLASKON
TRADE MARK REGISTERED
MATERIALS

hour and can be rewound in about 20 seconds. When used in the present recorder it has a frequency range reasonably flat from 100 to 6,000 cps, is good for at least 1,000 playings. The recorder complete with microphone, magic eye level indicator and tubes will sell for about $150, available not earlier than the end of April. Phonograph or radio can also be recorded. The tape can be torn and spliced with any good adhesive. Magnetic erasing allows re-use of the tape many times during its lifetime.

47

Decade Voltage Supply

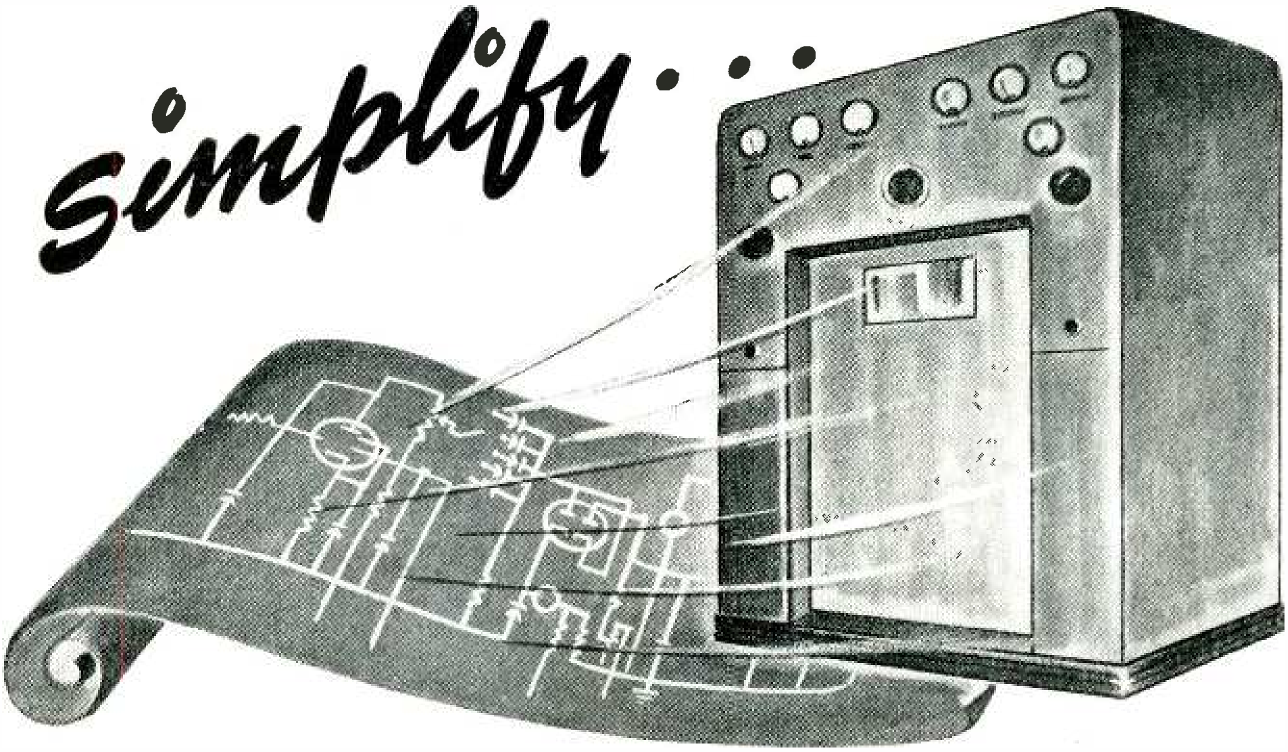
Clippard Instrument Laboratory has a new custom-built instrument Type DS-111 furnishing a-c potentials of laboratory accuracy in 1/10th-volt steps from 0 to 111 for laboratory or production line use in testing and calibration of a-c meters, vacuum tube voltmeters or other circuits where a known source of a-c voltage is required.

The instrument incorporates an isolation transformer with a primary tapped to adjust within one-tenth volt of line voltages from 100 to 132.

The secondary is tapped to provide the desired output voltages. A Weston meter, model 476, is placed in the secondary circuit and is calibrated with a single red line to indicate proper primary voltage adjustment. When the primary is adjusted to 100 volts the instrument may also be used as a variable-ratio transformer provided input voltages do not exceed calibration settings. One-thousand-to-one, to one-to-one values, in steps of 1/1,000 are furnished in ranges up to 10,000 cps.

Output is conservatively rated at

S.S.WHITE FLEXIBLE SHAFTS



ELECTRONIC "PACKAGING"

S.S.White Flexible Shafts have a definite function in simplifying electronic "packaging" — in other words, electronic equipment design. They provide remote control between any two points regardless of obstructions, congested conditions, or distance. Therefore, control knobs and dials may be grouped *anywhere* in relation to the controlled circuit elements. When properly applied, S.S.White remote control flexible shafts operate as smoothly and as sensitively as a direct connection.

S.S.White Flexible Shafts give the designer unrestricted freedom in placing circuit elements. He can get optimum circuit efficiency, economize on space, and plan on the easiest and most economical methods of wiring, servicing, and assembling. Flexible shafts eliminate in-line controls. Their adaptability leads to many improvements in cabinet design and simplifications in circuit plans.

In working out your own specific application, take advantage of the experienced cooperation of S.S.White engineers. Their specialized knowledge will assist you in making an effective application in less time.

FREE HANDBOOK TO ENGINEERS

The 256-page Flexible Shaft Handbook gives all details and data essential to working out actual applications. A free copy will be sent on request if you write for it on your business letterhead and state your position.

S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO.

DEPT. E, 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED RESISTORS • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

ARMY E NAVY

One of America's AAAA Industrial Enterprises

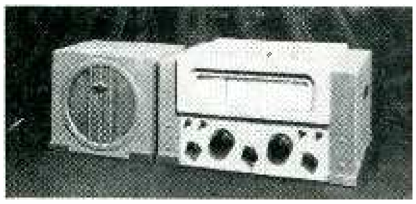
30 volt-amperes as follows: 0.1 to 1 volt, 5 amp permissible current; 0.01 to 11 volts, 2 amp; 0.1 to 31 volts, 1 amp; 0.1 to 111 volts, 0.3 amp. Accuracy of 1 percent is guaranteed for voltage output and 0.25 percent for the ratios.

The instrument is also supplied for 25 cps operation and in 1-to-1,110 v output models.

48

A-c—D-c Receiver

National Co., Inc., 61 Sherman St., Malden, Mass. The NC-46 is primarily an amateur or communications receiver replacing the NC-45. Besides continuous coverage from 540 kc to 30 mc, band spread tuning is provided for four amateur bands. The receiver operates on 120 v a-c or

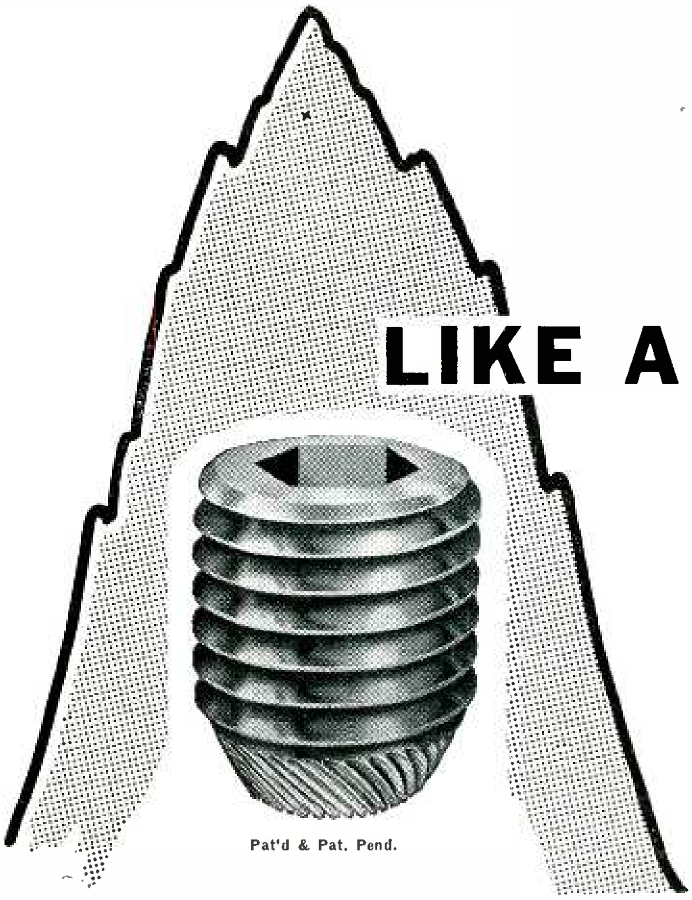


d-c, employs 10 tubes and has 4 watts audio output. An input of 5 microvolts gives 50 milliwatts output. Bandwidth is 4.5 kc at 6 db down with about 70 db at 10 kc off resonance. It is equipped with avc. The receiver is $9\frac{7}{16} \times 17\frac{3}{8} \times 12\frac{3}{8}$ in. and weighs 8 lb. The matching speaker is $8\frac{3}{8} \times 10\frac{7}{16} \times 7\frac{1}{2}$ in. and weighs 8 lb.

49

Dual F-m Antenna

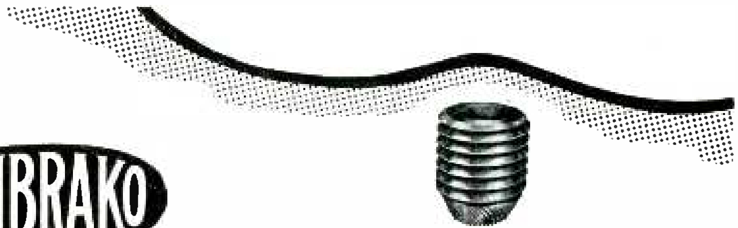
Workshop Associates, 66 Needham St., Newton Highlands 61, Mass. Good reception in the new f-m band will depend to a great extent on an adequate antenna. In some cases, omnidirectional reception will be desired, in others, a directive array with appreciable gain will be necessary. Kit No. 1 provides the basic materials for a non-directional antenna which can be mounted solidly, without guy wires, on the edge of



Pat'd & Pat. Pend.

LIKE A MOUNTAIN...

AND A MOLEHILL



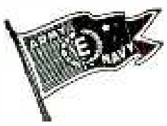
Pat'd & Pat. Pend.

UNBRAKO

Reg. U. S. Pat. Off.

That's just about how our regular "Unbrako" Self-Locking Socket Set Screws would appear, when placed beside one of our #0 size. But in spite of this almost unbelievable smallness, they are not only *Self-Lockers*, but are just as outstanding for accuracy, hardness and strength as their "big brothers."

"Unbrako" Socket Set Screws with the Knurled Cup Point (as shown), are *Self-Lockers* because the knurled points dig-in and hold firm against even the most stubborn vibration! Invaluable to the radio, electronics and smaller electrical manufacturing industries, because of their tiny size, these screws are available in sizes from #0 to 1" in diameter—all commercial lengths. Write today for our free "Unbrako" Catalog.



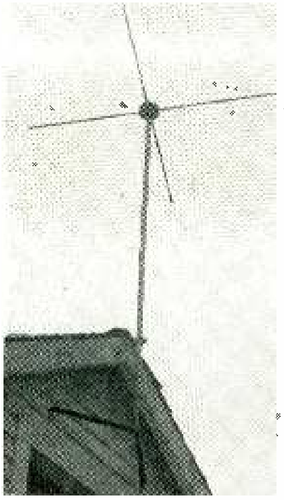
Knurling of Socket Screws originated with "Unbrako" years ago.

STANDARD PRESSED STEEL CO.

JENKINTOWN, PENNA. BOX 596

BOSTON CHICAGO DETROIT INDIANAPOLIS SAN FRANCISCO ST. LOUIS

OVER 40 YEARS IN BUSINESS



any roof. Sixty feet of low-loss transmission line are furnished to make connection to the receiver. Kit No. 2 comprises the necessary parts to convert the basic antenna into a high-gain array with parasitic director and reflector. The structures are designed to withstand 100 mph wind velocity when loaded with an inch of ice.

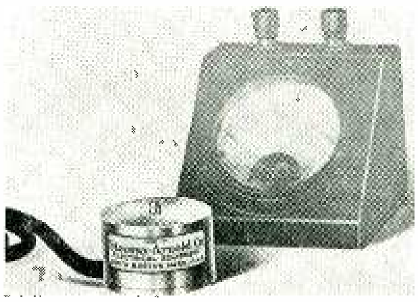
50

Deflection Pickup

STEVENS-ARNOLD CO., 22 Elkins St., South Boston, Mass. is producing an hermetically sealed electrical unit which translates minute deflections or pressure variations, applied to its plunger, into linear changes in its d-c output voltage.

Accurate readings are obtained in the range of 0.0005 to 0.1 in. movement of the plunger and reliable response up to 100 cycles per second can be expected. Output is 75 millivolts and internal resistance less than 1 ohm.

The combination of a pickup and an inexpensive indicating voltmeter gives the following results and remote indications are obtained at any distance: electric micrometer range 0.001 to 0.1 in.; electrical measure-



ments of force, acceleration and pressure; electric deflection gauge.

The pickup may be used under unfavorable operating conditions, including heavy vibration, at temperatures up to 300 deg F. and because it is hermetically sealed, it may be submerged in water. Power supply may be 115 v a-c or an 8, 12 or 24 v battery. Results may be recorded on a continuous strip chart.

Literature

51

Rectifier Bulletin. Richardson-Allen Corp., 15 W. 20th St., New York City, has just issued a bulletin called "Rectifiers", describing selenium or tube types.

52

Control Devices. Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y. is distributing a folder of sheets describing fractional hp motors, blowers and motor-operated controls.

53

Proximity Fuse Story. Cornell-Dubilier Electric Corp., South Plainfield, N. J. For those who have not tired of the proximity fuze story, this nine-page booklet will prove interesting, particularly the different pictures.

54

Process Timer. Photovolt Corp., 95 Madison Ave., New York 16, N. Y. Complete specifications and prices of electronic timers adjustable from 1/20 to 50 sec. They operate on 100-130 v a-c or d-c.

55

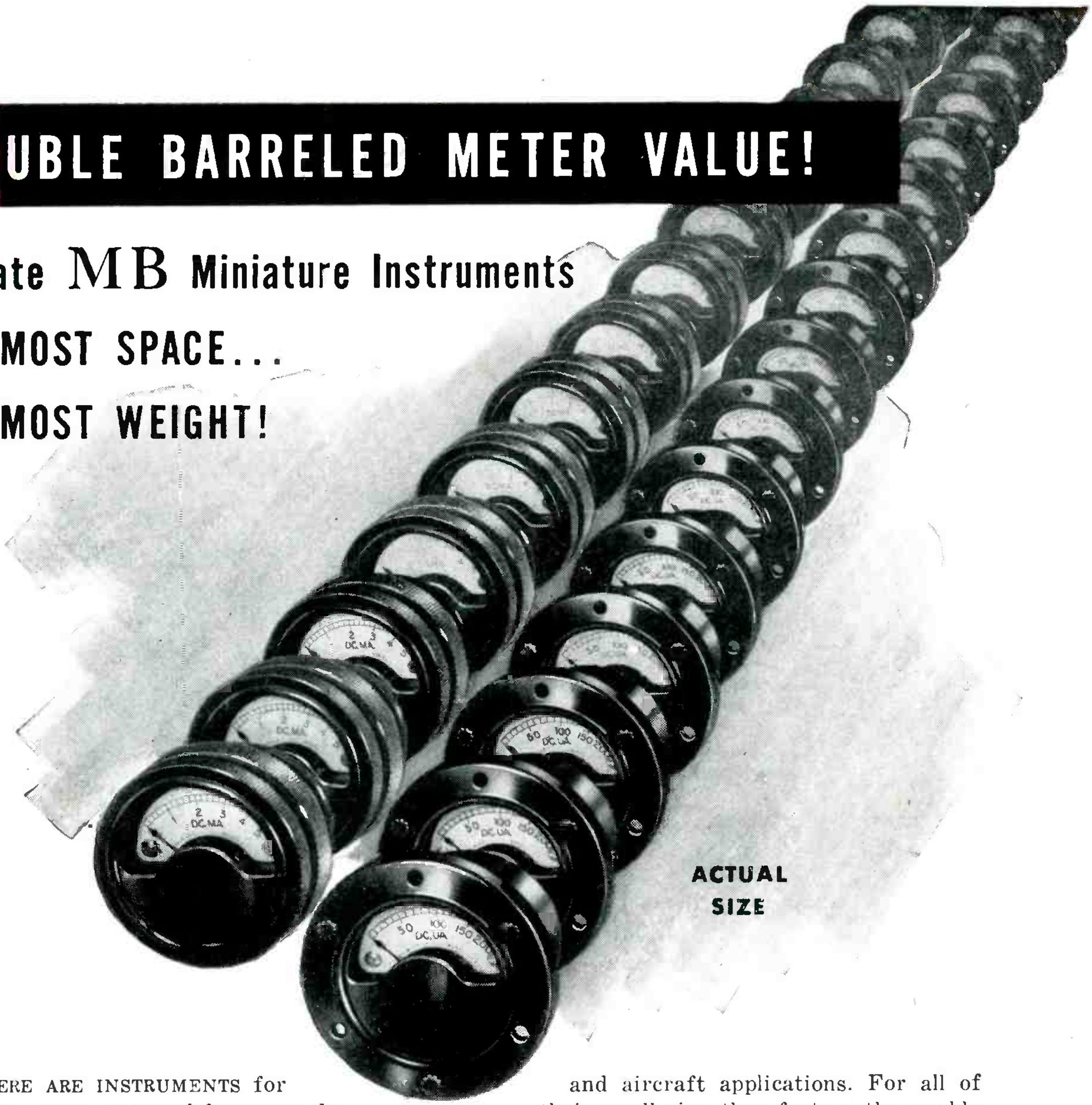
Industrial Research. Arthur D. Little, Inc., Cambridge 42, Mass. A 20-page booklet describing the facilities and projects undertaken by this firm for its clients in all fields of science.

56

Radar on Wings. Philco Corp., Philadelphia, Penna., reveals its war secrets in a 28-page, well-illustrated booklet. Engaged in a $250 million radar manufacturing program, Philco was the sole builder of the Mickey equipment. It also turned out

DOUBLE BARRELED METER VALUE!

Accurate MB Miniature Instruments SAVE MOST SPACE... MOST WEIGHT!



ACTUAL SIZE

HERE ARE INSTRUMENTS for your most cramped-for-space designs. *They mount through 1-inch openings!* Overall diameters are only slightly larger. Weights are a negligible 1¼ ounces.

Meeting the AWS in operational and constructional details, MB Meters have a place in your precision electronic and portable communication equipment, compact testers, and aircraft applications. For all of their small size, they feature thoroughly dependable and durable service.

Peak quality materials are used throughout . . . from those in the high-precision, responsive movement, to securely sealed, anodized aluminum cases.

Available in DC ranges from 0-100 microamperes through 0-10 milliamperes, and 0-50 millivolts, they're readily adapted to other ranges with external accessories. The MB companion 1½" series is supplied self-contained in standard DC, and rectifier and thermocouple-type AC instruments.

Think of MB when you're thinking of *multiple* meters. Several MB movements can be combined into one meter taking no more space than one of conventional size. An MB engineer will be glad to work on any practical adaptations for you. Write for details.

THE MB MANUFACTURING COMPANY, INC.
Instrument Division
331 East St., New Haven 11, Conn.

INSTRUMENT DIVISION

MINIATURE ELECTRICAL METERS FOR ANY PURPOSE

many Loran receiver-indicators which are used all over the world. Not a technical bulletin, it is still interesting reading.

57

Tachometers. Chicago Electric Tachometer Co., 800 North Clark St., Chicago 10, Ill. A four-page bulletin describes portable and permanently installed electric tachometers of all types, together with ranges, sizes and prices.

58

Graphic Recorders. Esterline-Angus Co., Inc., Indianapolis, Ind. A small, 16-page booklet describing a saving in consumption of high-priority electrodes by means of graphical-record study and suggesting uses in other sections of industry.

59

Metals and Alloys. Westinghouse Electric Corp., East Pittsburgh, Penna. A 47-page bulletin presenting physical and chemical properties and applications of various metallic materials all of which play a part in the electronic field.

60

C-r Tube Screens. Allen B. DuMont Laboratories, Inc., 2 Main Ave., Passaic, N. J. offer two new bulletins containing concise data and curves on the characteristics of the P5 and P11 cathode-ray tube screens.

61

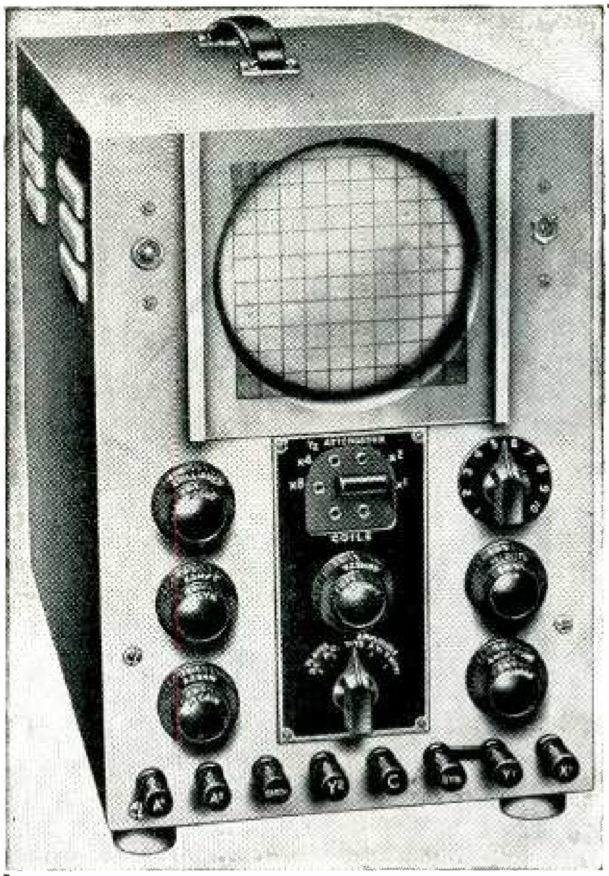
Vacuum Pumps. Kinney Manufacturing Co., Washington St., Boston 30, Mass. Bulletin V-45, 24 pages, describes a line of high-vacuum pumps, valves, oil separators and clutches.

62

Television Networks. American Telephone and Telegraph Co., 195 Broadway, New York 7, N. Y. Twenty pages cover the highlights of Bell System plans for expanding their communications facilities to provide adequate wire and radio links for new services like television.

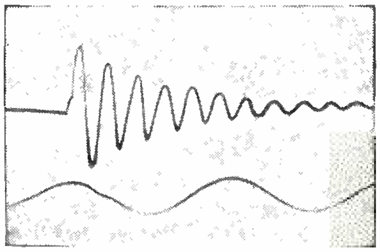
63

Catalog Supplement. General Radio Co., Cambridge 39, Mass. has turned out a supplement to its fourth edition of Catalog K, originally issued in 1939. All editions are brought up to date by means of the supplement un-



presenting the

DOUBLE



BEAM

OSCILLOGRAPH

Model 339 D. B. OSCILLOGRAPH. PRICE £40 Net F.O.B.

APPROXIMATE PERFORMANCE DATA

TIME BASE . . . 5 — 250,000 c.p.s.

AMPLIFIER	Gain	Frequency Band in c.p.s. — 3db.	Sensitivity mV.RMS/mm
1 stage	28	10 — 100,000	43.0
2 stage High Gain	900	10 — 100,000	1.3
Wide Band	106	10 — 2,000,000	10.0

Seven years after its appearance in 1938, the Cossor Double Beam Oscillograph is still unique. The intrinsic value of the technique introduced by this instrument, which provides true *simultaneous indication of any two effects* on a common time axis, has long been proved in all fields of research and production testing — both on recurrent and transient work. It is an understatement to say that practice has revealed no sphere of investigation where its use is not at least advantageous. Although of enhanced performance, the instrument is, in changeability of COSSOR single and double beam trapezium-corrected tubes, true double beam technique has been provided without inherent limitations or distortions. These fundamental qualities have been responsible for its selection as the standard Oscillograph for most of the Allied Nations' Armed Services. Thus precluded earlier from acquainting American users of the "double beamer", we are now able to make good this omission and satisfy also the friendly urging of A.E.F. Technicians who have all wanted "the folks back home" to know about it.

A. C. COSSOR Ltd

INSTRUMENT DIVISION

HIGHBURY LONDON N.5. ENGLAND

CABLE ADDRESS: Amplifiers London

CABLE CODES: Bentley's

til a new catalog can be compiled. There are 68 pages of descriptions, photographs and prices.

64

Ceramics. Stupakoff Ceramic and Mfg. Co., Latrobe, Pa. Bulletin 245 describes the complete line of ceramics, metallized ceramics, kovar and kovar-glass seals which find active use in the electronic industry.

65

Kovar-Glass Seals. Stupakoff has issued Bulletin 145 to describe the properties of kovar, a metal which expands or contracts exactly as does the glass into which it is sealed, thus providing a means of making connections to hermetically sealed electrical units. Stock sizes and specifications are in this 22-page book.

66

F-m Radiophone System. Federal Telephone and Radio Corp., Newark 1, N. J. Designed for police, fire and emergency service, this f-m mobile and fixed station system is interesting for its selective-signalling feature which allows several systems to operate in the same area with a minimum of confusion.

67

Indicator Lights. Gothard Manufacturing Co., 2110 Clear Lake Ave., Springfield, Ill. offers a reference book on indicator lights of all types, including assemblies with built-in resistors for neon lamps.

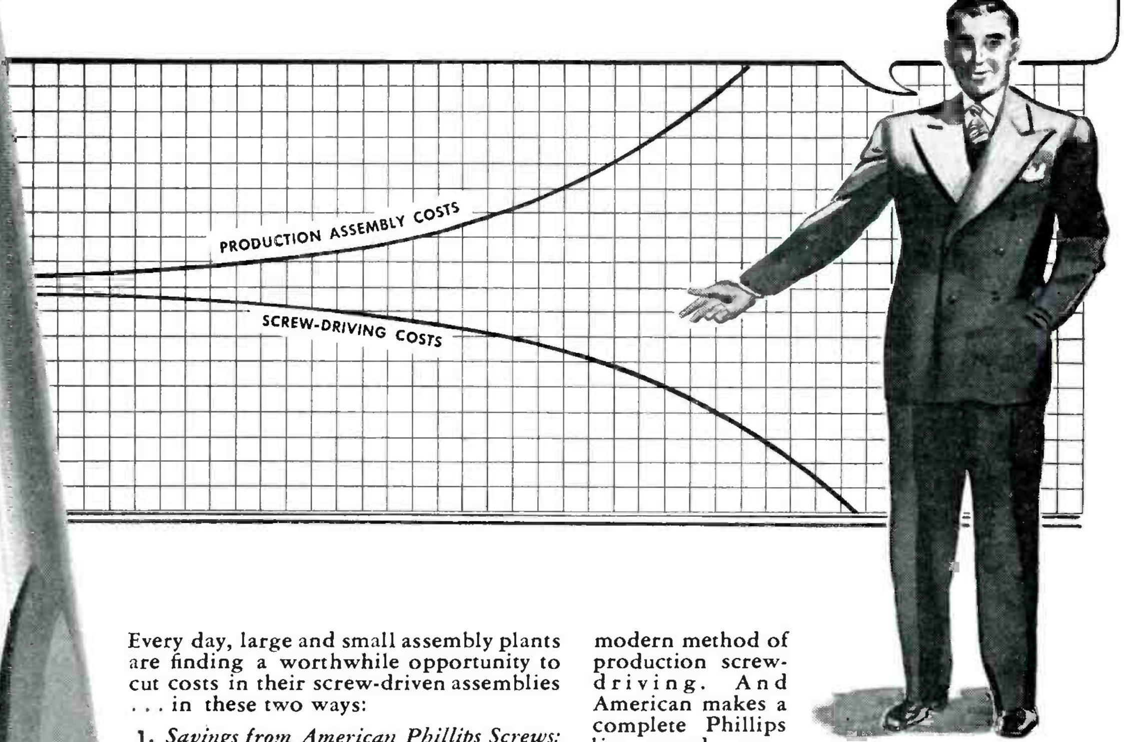
68

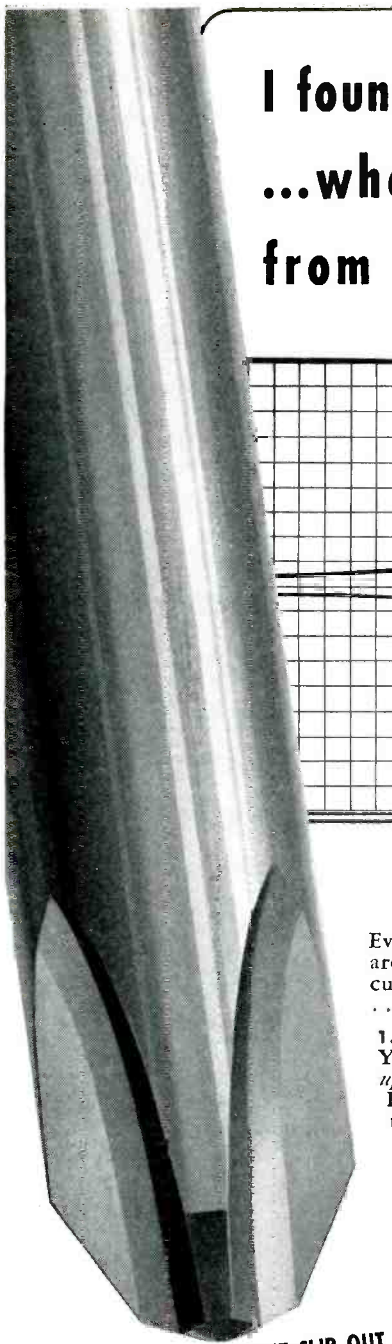
Constant Voltage Transformers. Sola Electric Co., 2525 Clybourn Ave., Chicago 14, Ill. A 33-page booklet titled "Electric Power Disciplined" describes equipment designed to overcome the inevitable line-voltage variations which are encountered when using voltage-sensitive devices on commercial lines.

69

Buyer's Guide. "The Representatives", 347 Fifth Avenue, New York 16, N. Y. have announced the compilation of a 130-page directory of all component manufacturers, their addresses, products they make and geographical list of representatives or regional sales offices.

I found the ONLY PLACE to Cut Assembly Costs ...when I found *All* the savings that come from using AMERICAN PHILLIPS SCREWS





Every day, large and small assembly plants are finding a worthwhile opportunity to cut costs in their screw-driven assemblies . . . in these two ways:

1. *Savings from American Phillips Screws:* You can discard hand drivers. And *speed up* with power drivers fitted with 4-winged Phillips bits that fit firm and straight into the recessed screwheads. This keeps workers from fumbling and dropping screws . . . enables them to drive every American Phillips Screw fast, straight and flush. No split or burred heads. No scarred and spoiled work. So output goes up. *And average assembly time-per-piece goes down as much as 50%.*

2. *Savings from American Screw Company's "Know-How" on All Types of Screws . . . And all Kinds of Metals:* Here are some facts you may be overlooking. Phillips Screws are *not* "specials." They're the standard, modern method of production screw-driving. And American makes a complete Phillips line...wood screws, machine screws, sheet metal screws, (3 types), and stove bolts . . . in all sizes, all types of heads, and in all practical metals.

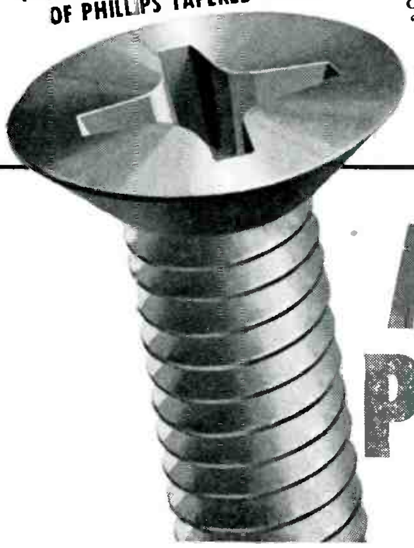
This means not only steel and brass, but also the *non-corrosive metals:* Stainless steel (in many different analyses, according to requirements), aluminum, monel and Everdur (silicon bronze). In particular, American specializes in Phillips Screws of stainless steels.

And *you* are invited to avail yourself of the screw industry's "Information Center" . . . to get American's recommendations for Phillips Screws of the type and metal best suited to your own assemblies . . . *and to cut your costs to lowest levels.*

4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS

AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND

Chicago 11: 589 E. Illinois Street   *Detroit 2:* 502 Stephenson Building



AMERICAN PHILLIPS *Screws*

ALL TYPES

ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

NEWS OF THE INDUSTRY

First details of h-f d-f; radar on transports; program of 1946 Broadcast Engineering Conference; Harvard's Electro-Acoustic Lab; scores of engineers change jobs

Program for Radio Parts Show in Chicago

THE 1946 RADIO PARTS and Electronic Equipment Conference and Trade Show will be held at the Stevens Hotel, Chicago, on May 13-16, 1946. Display of merchandise and participation in the show is limited to companies belonging to one of the three sponsoring manufacturers associations—Association of Electronic Parts and Equipment Manufacturers, Parts Division of RMA, and Sales Managers Clubs (Eastern Division).

Only radio parts, electronic equipment, service tools, and equipment regularly handled by distributors will be displayed; no manufacturer will be permitted to show, either in his booth or hotel room, any complete unit designed as a conventional home phonograph, home or auto receiver, hearing aid, diathermy unit, x-ray unit, or other such types of electronic equipment.

All committee and organization meetings are scheduled for May 13, along with registration. On the remaining three show days there are no meetings, and the Exhibition Hall will be open from 10 a.m. to 6 p.m. each day.

All hotel reservations must be cleared through the Housing Committee, Suite 2214, 221 No. LaSalle,

Preferred List of Army-Navy Electron Tubes as of Nov. 1, 1945

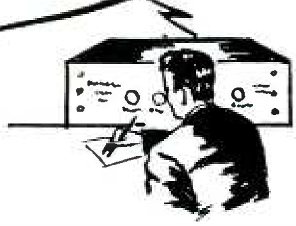
Filament Voltage	Diodes	Diode-Triodes	Triodes	Twin Triodes	Pentodes: Remote	Pentodes: Sharp	Converters	Klystrons	Power Output	Tuning Indicators	Rectifiers
1.4	1A3	1S5 (Diode-pentode)	1LE3	3A5	1T4	1L4 1LN5 1S5	1LC6 1R5		3A4 3Q4 3S4		
5.0											5U4G 5Y3GT/G
6.3	2B22 6AL5 6H6	6AQ6 6SQ7 6SR7	2C22 2C40 6C4 6F4 6J4 6J5 9002	6J6 6SL7W 6SN7W 7F8	6AB7 6SG7 6SK7 9003	6AC7W 6AG7 6AK5 6AN5 6AS6 6SH7 6SJ7 7W7 9001	6SA7	2K22 2K25 2K26 2K27 2K28 2K29 2K41 2K45 726A 726B 726C	6AK6 6AR6 6AS7G 6B4G 6L6WGA 6N7GT/G 6V6GT/G 6Y6G	6AF6G 6E5	6X5GT/G 1005
12.6	12H6	12SQ7 12SR7	12J5GT	12SL7GT 12SN7GT	12SG7 12SK7	12SH7 12SJ7 14W7	12SA7		12A6	1629	
25 or over									25L6GT/G 35L6GT/G		25Z6GT/G
Only types for 28 volts anode supply operation		26C6				6AJ5 26A6	26D6		26A5 26A7GT 28D7		

Miscellaneous: Cathode Ray	Miscellaneous: Crystals	Miscellaneous: Phototubes	Miscellaneous: Voltage Regulators
2AP1A 3DP1A 3JP1 3JP7 5CP1A 5CP7A 5FP7A 5FP14 5JP1 7BP7A 12DP7A	1N21B 1N23B 1N25 1N26 1N28 1N31 1N32	1P21 1P30 1P35 920 921 922 925 926 929 931A 935	0A2 0B2 0C2 0A3/VF75 0C3/VR105 0D3/VR150 991

Triodes		Tetrodes	Twin Tetrodes	Pentodes	Pulse Modulation	Magnetrons		Rectifiers: Vacuum	Rectifiers: Gas	Rectifiers: Grid Control	Clipper Tubes	Gas Switching: ATR	Gas Switching: TR	Pre-TR	Modulators
2C26A 2C39 2C43 3C28 CV92 (Br) 100TH 250TH 304TH	450TH 527 811 826 862A 880 889R-A 1626 8025A	807 813 814 827R 1625	815 829B 832A	2E22 2E25 4E27 803 837	3D21A 3C45 3E29 4C35 5C22 6C21 715C	2J30–34 2J41 2J42 2J48 2J49 2J50 2J51 2J53 2J55–56 2J58 2J60 2J61A–62A	4J31–35 4J36–42 4J43–44 4J50 4J51 4J52 5J26 5J29 5J30 5J31 5J32	1Z2 2X2A 3B24W 5R4GY 371B 836 1616 8016 8020	3B28 4B26 4B35 5B21 6C 83 857B 866A 869B 872A 1006	2D21 C5B 6D4 393A 394A 884 2050	3B26 4B31 719A	1B35 1B37 1B44 1B51 1B52 1B53 1B56 1B57	1B23 1B24 1B27 1B32 1B50 1B55 1B58	1B38 1B54	1B22 1B41 1B42

Receiving types are listed in the upper section, with transmitting types below. The purpose of this list is to effect an eventual reduction in the variety of tubes used in Service equipment. It is mandatory that all tubes to be used in all future design of new equipments under the jurisdiction of the Army laboratories or the Navy department be chosen from this list. Provisions are made for certain exceptions, however, and a procedure has been set up for obtaining permission to use other tubes; for Army equipment, the request should go to the Army Electronics Standads Agency, and for Navy equipment should go to Electronics Division, Bureau of Ships, Code 930-A, Navy Dept.

LAVOIE *Complete* AM or FM FIXED-FREQUENCY Communications Systems



Recommended for -

FIRE · POLICE · FORESTRY · TELEVISION RELAYS · INDUSTRIAL APPLICATIONS

TRANSMITTERS · RECEIVERS · ANTENNAS

UHF COMPLETE FIXED-FREQUENCY COMMUNICATIONS SYSTEMS—for any frequency between 100 and 3000 megacycles and for ANY type application: municipal, industrial or private use. We will specify equipment to assure adequate power for attenuation and other factors to provide clear, efficient operation consistent with economy.

LAVOIE Communications Systems are built with the same precision and care that won widespread use and reputation in the U. S. armed forces. If you will advise of the nature and scope of your requirements, full details and costs will be provided promptly.

OTHER LAVOIE PRODUCTS: Frequency Meters · Frequency Standards · Receivers · Transmitters · Antennas and Mounts.

UHF

Lavoie Laboratories

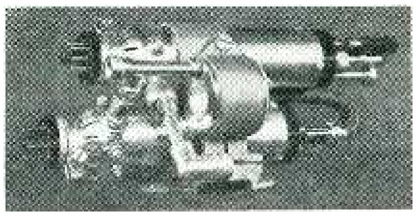
RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

Specialists in the Development and Manufacture of UHF Equipment

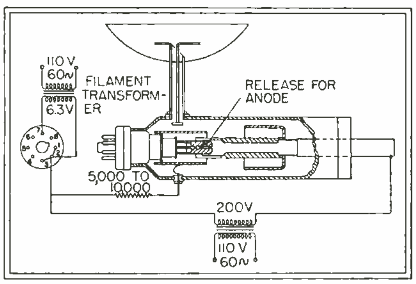
Chicago 1, Illinois, because of the very critical hotel and housing shortage. The committee has asked for and received committments from several Chicago hotels, allotting a definite and reserved number of rooms, and these will be allocated on the basis of not more than 2 rooms per member-exhibitor company and not more than 1 room per company for others.

Surplus 12-cm Radar Units Are Available to Schools

A NUMBER OF MICROWAVE re-entrant oscillator units using disk-seal tubes and originally manufactured for aircraft radar units have been purchased by the General Electric Educational Fund after having been declared scrap by the Army, and will be made available without charge to colleges and similar educational institutions. The circuits are designed for operation at a wavelength around 12 cm, tunable over approximately 20 percent of the range with a single control. The complete unit includes a local oscillator cavity using a 2C40 disk-seal tube, a pulsed transmitter



Microwave re-entrant oscillator unit, originally costing over $200, that is to be made available by General Electric Educational Fund to educational institutions without charge for demonstrations and experimentation



Two power transformers and a suitable dipole antenna with reflector must be connected to the oscillator as shown here. A detector consisting of a crystal detector and a microammeter or a-f amplifier can be used

cavity using a 2C43 disk-seal tube, and a T-R box, as pictured in the accompanying illustration. With it wave propagation, resonance, and other microwave phenomena can be demonstrated.

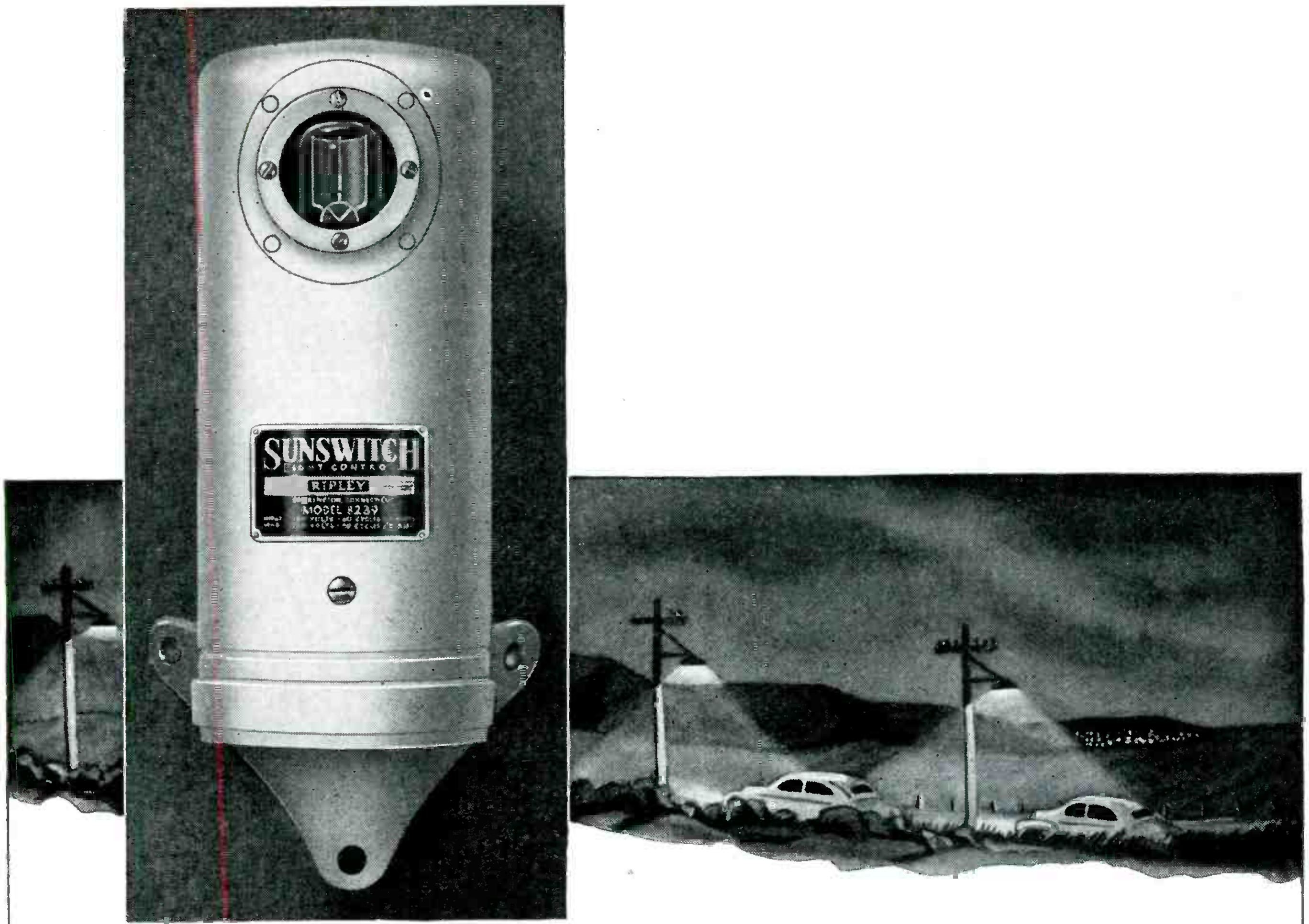
Two transformers operating from a 60-cps power line are sufficient to energize the local oscillator, as shown in the accompanying diagram. For c-w operation, however, a d-c source for the plate is generally preferable. Technical details and characteristics of re-entrant type oscillators of this type were given in "Cavity Oscillator Circuits", by A. M. Gurewitsch, on p 135, Feb. 1946 ELECTRONICS.

H-F Direction Finder

STILL ANOTHER WARTIME electronic device, the long-range high-frequency direction finder developed by the Federal Telephone and Radio Corporation, Newark, N. J., has emerged from curtains of secrecy, bringing to light a dramatic story of U-boat warfare. This d-f unit, capable of locating underseas craft even though they may be operating half way across the ocean, proved a worthy electronic teammate of radar in directing the Navy's escort ships and airplanes to victory over Axis submarines in the battle of the Atlantic, and now promises to be an invaluable postwar aid in increasing the safety of overseas passenger plane service.

The effectiveness of the new direction finder depended upon the use of radios by enemy U-boats. So successful was secrecy on this development that Nazi submarines continued to use their radios even while this was leading to their location and destruction in rapidly increasing numbers. Enemy submarines used Kurier or squirt transmission—a system of radio communication in split-second bursts—to their bases in occupied territory, to one another in organizing their wolf-pack attacks, and in conveying weather information from this side of the Atlantic to the German high command. These compressed messages were picked up at the enemy receiving station on high-speed recording devices which later stretched the recorded message by playing it back at reduced speed.

It was believed by the enemy that the brevity of these radio contacts forestalled detection by any devices



Tested for four Years . . . .

Back in 1941 our engineers had completed the design of a new street-lighting control which unfailingly insures adequate illumination regardless of changes and fluctuations in weather and the twilight hour.

Wartime obligations prevented production, but for four years the engineers' prototypes have been tested under actual street-lighting conditions . . . time-proven, it is now offered as our

SUNSWITCH
LIGHT CONTROL

A practical and rugged unit with 100 percent safety factor . . . its sturdy components assure a negligible maintenance cost. Tooling up for large scale production is now completed. Write for Bulletin No. 8239.

The SUNSWITCH can also be used to control illumination of public buildings, outdoor advertising, airport beacons, radio mast running lights, and ships' running lights.

The **RIPLEY** *Company*

13 NEW LITCHFIELD STREET TORRINGTON, CONNECTICUT

known to them. They were, of course, unaware of the new American direction finders on escort ships which revealed the location of the underseas craft the instant they started to transmit, no matter how briefly or how far away. The new direction finder responds with precise accuracy to radio waves from across the Atlantic, or farther.

Sub Plotted, Sighted, and Sunk

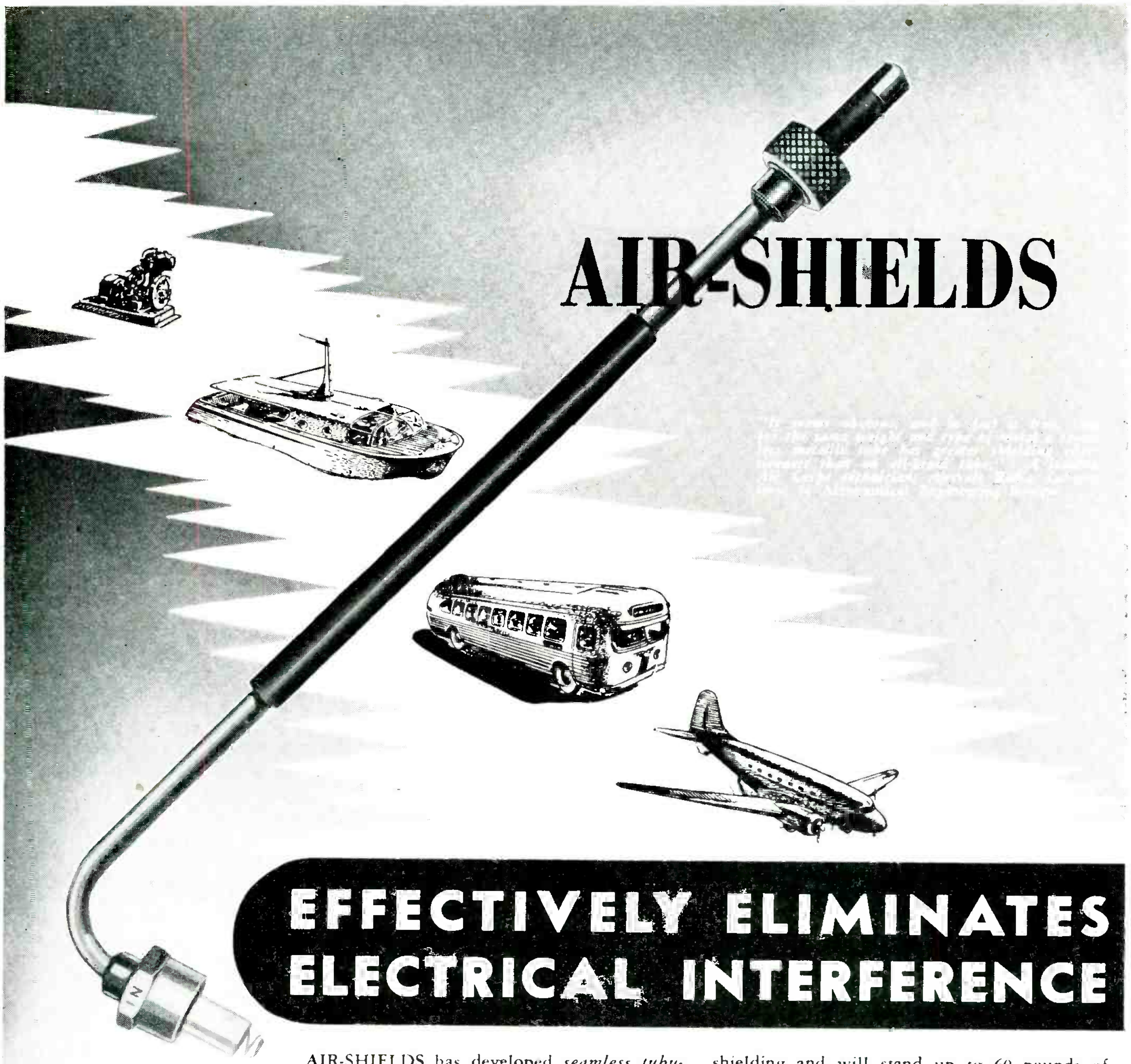
A typical result of d-f operation was the sinking of the German U-boat U-66 near the Cape Verde Islands in May, 1944. The U-66 in January, 1944, according to official Navy records, was operating off the West Coast of Africa. Her captain, wanting to refuel, sent a radio message lasting less than 15 seconds, but 26 Allied d-f stations obtained bearings on it. From these, the position of the U-66 was determined, and the USS BLOCK ISLAND and her escorts were dispatched to the scene. This group spotted the submarine by plane. The destroyer escort USS BUCKLEY, sent in for the kill, rammed and rode over the sub, but it managed to get into the clear. The BUCKLEY pursued and shot away the enemy's conning tower. The U-66, by then out of control, collided with the BUCKLEY and sank ten minutes later.

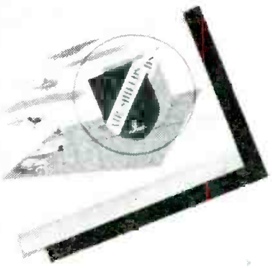
Historical Notes

The Bureau of Ships of the Navy made the first request for the development on March 21, 1941. In September, 1941, the ground direction finder was demonstrated to the Navy. Six weeks later it was ready for operational tests at sea. Early in 1942 some 500 high-frequency direction finders were operating on the Navy's new anti-submarine ships and 1,515 more were ordered. During this same period, sea-going radar achieved remarkable new capabilities, and the two became a deadly team in directing their ships to U-boat kills.

The new direction finder has almost no range limitation. Two bearings gave location mathematically with more than adequate accuracy to guide escort ships to within radar range if the sub remains surfaced, or put the sonic devices on a sound trail if it submerges.

Although most of the wartime use of the direction finder was against submarines, it was equally effective





in locating, at long range, airplanes in flight, and surface ships. These are the valuable peacetime applications. The location of an airplane crossing the ocean can be determined immediately by direction finders. Installations now being provided on both sides of the Atlantic will make available to a transoceanic pilot, who might be having navigational difficulty, a service which will give him his exact position at any time he requests it. Furthermore, these stations can immediately obtain a pinpoint location of any plane in trouble and relay it to the nearest ships and shore rescue stations.

The Navy officers reported that the high-frequency direction finder is now a vital instrument in the air-sea rescue system of the United States Coast Guard which is organized through its bases along U. S. coasts to dispatch immediately an airplane-rescue boat team to any scene of trouble at sea.

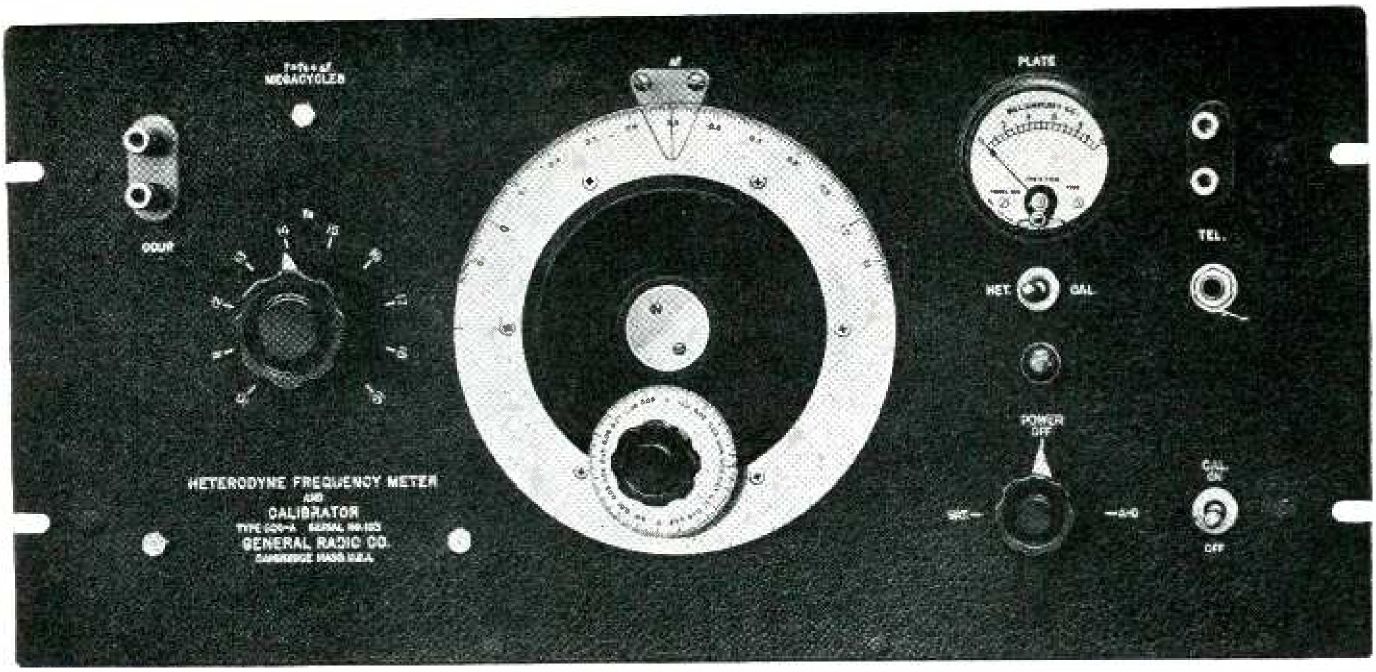
Personal Award Made

THE WAR DEPARTMENT has extended a unique personal honor to Dwight R. G. Palmer, president of General Cable Corporation, in a scroll of tribute for patriotic service, including production of 80 percent of the field wire procured by the Army Signal Corps in World War II.

The award, only one of its kind now contemplated, was presented in


Major General H. C. Ingles, Chief Signal Officer of the Army, presents unique War Department citation to Dwight R. G. Palmer

recognition of his personal achievements in breaking a serious bottleneck in war production; in developing substitutes for rubber insulation long before the need for them became generally apparent; in freely making these developments available to the rest of the industry, in extend-



from 300 Mc to 300 kc

ANOTHER G-R instrument again available for civilian use! At the moment, the popular Type 620-AR Heterodyne Frequency Meter and Monitor is available from stock. As a general-purpose frequency measuring instrument, this meter is very valuable for measuring the frequencies of a number of transmitters, for calibrating and servicing receivers and for checking the ranges of receivers and oscillators. Where the allowable frequency tolerance is 0.02% or greater, this meter can be used for monitoring radio transmitters.

FEATURES

- **VERY WIDE RANGE**—300 kilocycles to 300 megacycles
- **DIRECT READING**—no charts or curves to bother with
- **SELF-CALIBRATING**—calibration can be checked immediately from built-in piezo-electric oscillator
- **NO COILS TO CHANGE**—built-in coil system with 10-point panel selector switch
- **GOOD ACCURACY**—over-all accuracy is 0.01% or better
- **FLEXIBLE POWER SUPPLY**—built-in a-c supply or external d-c source, either selected by panel switch

TYPE 620-AR (Relay Rack Model) HETERODYNE FREQUENCY METER & CALIBRATOR $490

Order now; delivery probably can be made from stock

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

90 West St., New York 6 920 S. Michigan Ave., Chicago 5 1000 N. Seward St., Los Angeles 38

ing to the government freedom of use of all General Cable patents, and in taking extraordinary steps to maintain employee morale without discrimination as to race, color, or creed.

Radar on Transports

APPROXIMATELY 75.6 percent of U. S. troop-transport ships are now equipped with Raytheon model SO-1 and SO-8 radar, and it is expected that this figure will be increased to nearly 100 percent or 500 ships, early in 1946.

Radar eliminates the delays caused by bad weather or poor visibility. A pencil-sharp beam constantly searches the area all around the ship, giving a map-like presentation on the radar indicator of anything that falls within its range. Other ships, icebergs, buoys . . . even driftwood, are spotted with an accurate indication of their bearing and distance off.

With the defeat of Germany, our military leaders were faced with the problem of redeploying great numbers of troops to the Pacific and to the United States in the shortest possible time. Radar has to a great extent eliminated the necessity for reducing speed during periods of poor visibility and for waiting outside of harbors for fog to lift.

On several occasions, ships that normally carry 1,500 or more troops have spotted, on their radar indicators, floating mines that had broken loose during the storm, and were able to change course in time to prevent a collision and certain disaster.

Broadcast Engineering Conference

RESUMING AFTER a lapse of three war years, the sixth annual Broadcast Engineering Conference will be held in Campbell Hall, Ohio State University, Columbus, Ohio, during the week of March 18-23, 1946. The program places emphasis on new developments affecting broadcast engineering, including f-m and television, and will include an exhibition of new equipment by manufacturers.

The registration fee for the entire conference is $15 ($12 to those making payment before March 4). Special

GLOBAR TYPE BNR Resistors give instant protection

GLOBAR type BNR Resistors offer unusual advantages. Voltage sensitive, they respond instantly to load change. When a potential is applied, their resistance decreases. Release the potential and resistance increases. Note the curves illustrating this characteristic. Commonly referred to as Negative Resistance-Voltage, it can be practically applied to many uses.

For example, it acts as an ever-present sentinel...protecting meter coils...protecting coils in magnetic valves...protecting pilot lights on instrument panels. Perhaps one of its most popular uses is the absorption of the inductive kick produced by an oil burner ignition transformer.

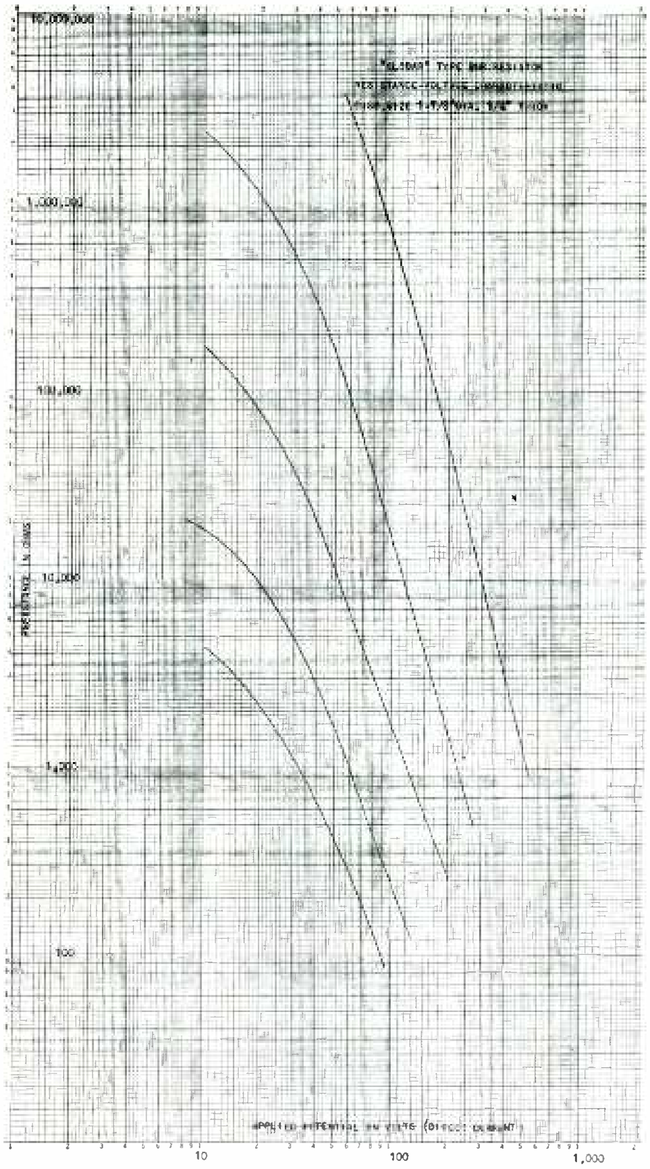
Fundamentally, GLOBAR type BNR Resistors dampen the effect of transient voltages in electrical circuits. Where conditions such as this are encountered, they can be used to advantage.

Because this type resistor must be made to meet exact needs of specific applications, it is not carried as a standard stock item. However, it can be readily manufactured to specifications. To save time and trouble...when resistors are being considered...the following information should be furnished.

1. Type of apparatus in which the resistors are to be used.
2. Method of mounting and space limitations.
3. Normal operating voltage and peak voltage if available.
4. Resistance and inductance of the circuit if available.
5. Ohmic resistance of the resistor and allowable plus and minus tolerance.
6. Maximum voltage applied continuously or intermittently.
7. Duration of load and elapse of time between its application.

Let us help you with your resistor problems. Write today. There is no obligation, of course.

Samples are available for engineering tests on short notice. The Carborundum Company, Globar Division, Niagara Falls, New York.



GLOBAR Ceramic Resistors

BY **CARBORUNDUM**

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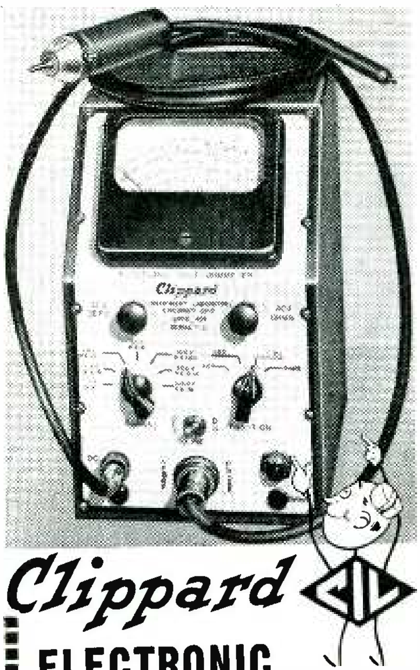


accommodations for the Conference are offered by the Fort Hayes Hotel.

Program

March 18: 9-11 a.m.—Contributions of War Developments to Broadcasting, by A. B. Chamberlain; 11-1 p.m.

Symposium on Broadcast Maintenance Problems, by A. J. Ebel; 2:30-4:30 p.m.—Design of Broadcast Studios with Irregular Boundary Surfaces.

March 19: 9-11 a.m.—Antenna Patterns and the Antennalyzer, by G. H. Brown; 11-1 p.m.—Symposium on Recording Techniques, by L. Smeby; 2:30-4:30 p.m.—General Acoustical Problems in Broadcasting, by E. J. Content.

March 20: 9-11 a.m.—Symposium on VHF Antenna and Coupling Circuits, by E. C. Jordan; 11-1 p.m.—Symposium on Television Station Operation, by R. E. Shelby; 2:30-4:30 p.m.—Radio Relays for F-M and Television.

March 21: 9-11 a.m.—Stratovision, by R. Harmon and others; 11-1 p.m.—Round Table and Question Box, by A. D. Ring, J. Willoughby, and others; 2:30-4:30 p.m.—Interconnecting Facilities for F-M and Television Broadcasting, by H. I. Romnes and W. E. Bloecker.

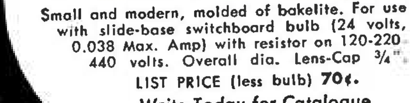
March 22: 9-11 a.m.—High-Powered Tubes for VHF Operation, by W. W. Salisbury; 11-1 p.m.—Symposium on F-M Operating Problems, by P. B. Laeser; 2:30-4:30—Symposium on F-M Monitors, by R. C. Higgy, D. B. Sinclair, F. Gunther, and H. R. Summerhayes, Jr.

March 23: 9-11 a.m.—Symposium on F-M Modulation Methods, by W. L. Everitt; 11-1 p.m.—Symposium on Field Experiences in VHF Propagation, by R. M. Wilmotte.

Achievements of Harvard's Electro-Acoustic Laboratory

AFTER FIVE YEARS of highly secretive and significant war work for the Army, Navy and Marine Corps, the Electro-Acoustic Laboratory in Cruft Building, Harvard University, has closed its doors.

Under the directorship of Dr. Leo L. Beranek, the Laboratory in November 1940 received its first commission from the Army Air Forces—to investigate means for quieting the noises inside long-range bombing planes so that the personnel could do



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Bring the Boys Home... with Victory Bonds!

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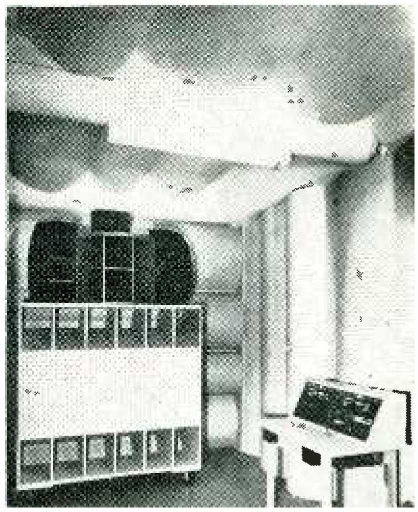
5323 WEST LAKE STREET • • • CHICAGO 44, ILLINOIS their job with less fatigue. A few months after that came its second and most important assignment, to make communication possible between the crews of aircraft flying at altitudes above 20,000 feet.

Sound-Treating Airplane Cabins

From the first project grew a new material sold under the trade name of Fiberglas AA, made from glass fibers a micron in diameter—only 1/100th the thickness of human hair. These glass fibers are coated with a plastic binder which holds them together in the form of a blanket that is ½ inch in thickness and weighs 1/20 pound per square foot.

In sound-treating an airplane, two ½ inch blankets of the Fiberglas are sewed on opposite sides of a sheet of asbestos paper, and the combination was mounted inside the plane about 3 inches away from the walls. Most



Diffuse sound room in the Electro-Acoustic Laboratory of Harvard, where noises heard in a plane during flight are realistically reproduced

long-range military planes manufactured after 1941 were treated in this manner. The Boeing Super-Fortress, one of the quietest military planes flying, was the laboratory's most outstanding example of successful quieting.

Talking at 40,000 Feet

Improvement of communications systems in aircraft involved determination of the way in which the human voice and the equipment varied as the atmospheric pressure was reduced to the very low values existing above 20,000 feet, and recommendation of new equipment designs

Two big NEWARK stores well stocked to serve your needs and staffed by people who know and can help solve your problems.

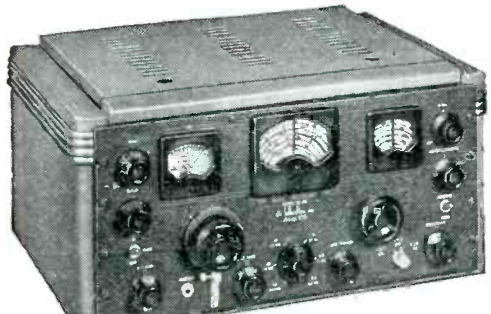
THIS MONTH'S FEATURES

THE FAMOUS NEWARK BARGAIN OIL-FILLED, OIL-IMPREGNATED

FILTER CONDENSERS

FULLY GUARANTEED AT RATED VOLTAGES

Capacity	Working Voltage	Height	Width	Depth	Wt.	Price
1 mfd.	1500 V.D.C.	2 3/16	1 3/4	1"	4 oz.	$ .79
4 mfd.	1000 V.D.C.	3 1/4	2 1/2	1 1/4	12 oz.	1.50
4 mfd.	3000 V.D.C.	3 3/4	1 3/4	3 5/16	1 1/4 lbs.	3.75
5 mfd.	2000 V.D.C.	4	3 3/4	1 1/4	1 lb. 4 oz.	2.15
8 mfd.	2000 V.D.C.	4 1/2	3 3/4	2 1/2	2 1/2 lbs.	2.75
.15 mfd.	4000 V.D.C.	2 7/8	1 3/4	1	8 oz.	.89
.25 mfd.*	2000 V.D.C.	3 3/4	1 3/4	1	6 oz.	.69
	*Special Porcelain Insulators					
1.5 mfd.	1000 V.D.C.	2 7/8	1 3/4	1	8 oz.	.59
10 mfd.	3000 V.D.C.	4 7/8	3 3/4	3 1/4	3 lbs. 8 oz.	4.75
13 mfd.	1000 V.D.C.	3 3/4	3 1/2	1 3/4	1 3/4 lbs.	2.25
15 mfd.	3000 V.D.C.	4 3/4	4 5/8	3 7/8	5 lbs.	5.25
8 mfd.	3000 V.D.C.	7 3/8	6 1/2	3 3/8	7 lbs. 4 oz.	3.95
2 mfd. & 4 mfd.	600 V. metal can	4 7/8	2 1/2	1 1/4	14 oz.	.80
5-5-15 mfd.	1000 V. in metal can	4 5/8	3 1/2	3 3/4	4 1/4 lbs.	1.75



HALLICRAFTERS

SX-28A	Super Skyrider with crystal, less speaker	$223.00
S-20R	Sky Champion with built-in speaker...	60.00
S-22R	Skyrider Marine with built-in speaker..	74.50
SX-25	Super Defiant with crystal, less speaker	94.50
S-39	Sky Ranger portable, AC/DC and battery	110.00
SX-36	FM/AM receiver	415.00
S-37	V.H.F. FM/AM receiver	591.75
PM-23	10" PM speaker in cabinet for use with SX-25, SX-28A	15.00

HAMMARLUND

HQ-129X (with tubes)...........	$129.00
ASPC-210X	318.00
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Available for rack mounting at same prices

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NC-2-40C and speaker........... $240.00

RME

RME-45 and speaker............ $166.00

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The DeLuxe—Model CP 810 .... **$9.75**

GENERAL ELECTRIC METERS

0-500 D.C. MA. 2" round Bakelite case.. **$3.50**

0-8 RF ammeter, 2" round Bakelite case.. **$4.00**

ABBOTT TR-4

Compact, efficient 2½ meter transmitter-receiver **$39.00**

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Many famous makes, popular types at ridiculously low prices! Write for list!

NEWARK TRANSFER BARGAINS

45556 778 V.C.T. at 200 MA. 115 V. 60 Cycle 6.3 V.C.T. at 5 A. 5 V. at 30 amp. 9 lbs. $3.95

45557 15 H. 150 MA. 200 ohm 2000 V. insulation 5½ lbs...$1.95

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CLOSE OUT ON METERS. $4.95 EACH

Western Electric Micro-ammeter. Bakelite case fits 3¾" hole.

Radium dial 150-0-150. Can be used with 0-200 micro and amp scale costing 15¢ additional. Excellent as a 5000 ohm-per-volt meter or null, sound level and galvanometer indicator.

Instruction included. No priority required.

4½" square 0-200 Micro-ammeter.

4½" square 100-0-100 Micro-ammeter.

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ALL PRICES SUBJECT TO CHANGE WITHOUT NOTICE to be adopted and manufactured for use at high altitudes.

To determine how the human voice varies with altitude, a complex machine called an audio spectrometer was developed to split up the sounds of speech into thirteen different bands. Eight men, wearing suitable oxygen masks and equipped with microphones and earphones, were placed in a large altitude tank and taken up to an altitude equivalent to 40,000 feet for two-hour stretches, where they read sentences, words and vowel sounds over the microphones. The audio spectrometer measured how loud they were talking in each of the different tonal bands.

Several very interesting things were learned. First, the human voice decreases in intensity at 35,000 feet to about 1/10 of its strength on the ground. No change in hearing was found. As a result of these discoveries, special amplifiers were built whose amplification automatically increased with altitude.

It was also found that the tonal quality of the voice changed with altitude. At 35,000 feet the consonants seemed unusually distinct, and there was a booming of the voice in the lower register. A lack of quality was added by the nasal passages. The talker experienced some difficulty—his nose felt stuffy and his throat cottony. There was an inability to speak more than two or three words without taking a breath. Also, the presence of the oxygen mask changed the tonal quality of the voice, amplifying the low notes. The microphones and the amplifier had to be built so that they amplified the higher notes more than the lower ones, thus removing the booming sound.

Design of Anechoic Chamber

One portion of the laboratory's work demanded the construction of a special room called an anechoic chamber (without echo) to simulate atmospheric conditions existing at one to three thousand feet above the earth. The walls are almost perfectly absorbing, with less than 1/1000 of the incident sound being reflected from the walls. This same situation exists above the earth where there are no buildings, walls or ground to reflect sound.

The walls of the chamber are lined with 20,000 wedge-shaped

CML

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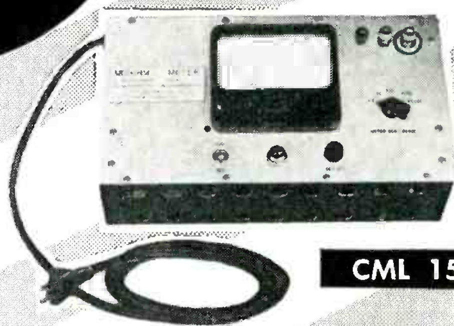
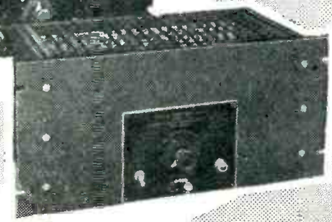
ROTOBRIDGE



CML 1500

CML 1100

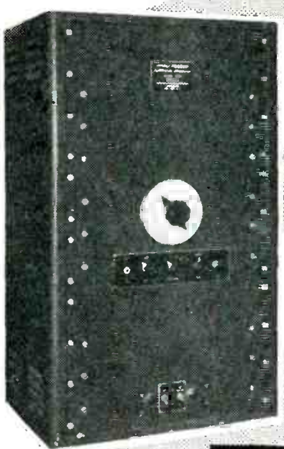


CML 1110

CML 1200

Each of the CML units shown has been designed to perform a vitally needed service for manufacturers in the electronic industry. As a result, they are to be found in a host of plants — in laboratory and on the production line—contributing importantly to the efficiency of electronics.

ROTOBRIDGE. . Mass Production Tester
CML 1100. . . . . Power Supply Units
CML 1420. . . . . Electronic Generator
CML 1200. . . . . Stroboscope
CML 1500. . . . . Megohm Meter



CML 1420

Write for Bulletins Today

COMMUNICATION MEASUREMENTS LABORATORY

120 GREENWICH STREET, NEW YORK 6, N. Y.

structures made from eight carloads of Fiberglas PF insulating board, sawed into wedges and covered with muslin.

The wedges, set snugly together and each turned at right angles to its neighbor, completely cover the walls, ceiling, floor, and doors. A four-foot track, held twelve feet above the concrete floor by cables, provides access to the chamber. Small cars carry apparatus into the

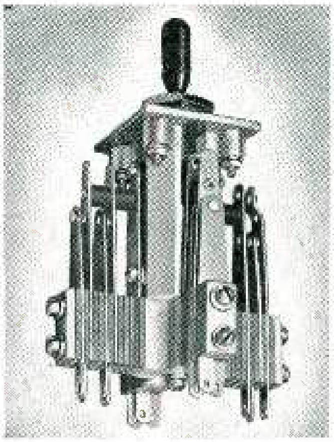
Interior of anechoic chamber has appearance of room lined with thousands of stalagmites and stalactites. Equipment-bearing cars travel on track in foreground

chamber on this track, and their covered tops provide a catwalk into the chamber. Cars usually are removed before experiments are run to avoid sound reflection from them, and the experiments are manipulated from control rooms which have electrical and telephone connection with the air-conditioned chamber.

This chamber is hailed by acoustical engineers as being the finest of its kind in the world, and will contribute to substantial advances in the field of acoustics in the post-war period. Already it has been used by the National Bureau of Standards to calibrate microphones for the precise measurement of sound.

The density of the Fiberglas board and the dimensions of the wedges are critically determined once the lowest frequency at which 99 percent or better absorption is decided on. If it is desired to sound-treat a small room, shorter wedges will be necessary, with a resulting decrease in the sound absorption at low frequencies. The lowest frequency at which 99.5 percent or better absorption can be obtained is that for which the wedge is equal in length to ¼ of the wavelength of the sound. When shorter wedges are used, the

NEW
MCF



5 POSITION CAM LEVER SWITCH by
GENERAL CONTROL COMPANY

Design features incorporated in the New MCF five position cam lever switch which are of particular interest to engineers and designers are:

- Single hole mounting for economy in assembly.
- Single bolt assembly of contact block to facilitate wiring
- Cast aluminum switch body and contact block for minimum weight.
- Straight line motion from centre to all switch positions for ease of operation.
- Rugged construction for long life and trouble free service.
- Locking or non-locking in all positions except centre position which is always locking.
- Fine silver contacts permanently riveted to nickle plated, phosphor bronze contact springs.
- Contacts rated at 10 amperes, 125 volt, AC (non-inductive load).

Further information furnished on request

Write for New Catalog No. 200

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TYPE Z-1
THE NEW STANDARD CRYSTAL UNIT FOR ALL HIGH FREQUENCY SERVICE

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TEMPERATURE COEFFICIENT LESS THAN 2 CYCLES PER MC. PER DEGREE CENTIGRADE

CALIBRATION ACCURATE TO WITHIN .005% OF SPECIFIED FREQUENCY

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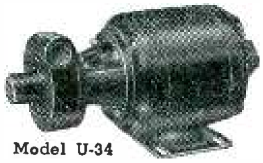
SMALL PUMPS CORRECTLY ENGINEERED FOR YOUR NEEDS

Eastern has designed and built pumps to meet manufacturers' specific needs for many years. Some of these needs have been complex, where the design of a completely new pump was necessary to solve a pumping problem never before encountered. Others were run-of the-mill, where one of Eastern's standard pumps from a line of over 600 different modifications was recommended with the knowledge that it would do the job required of it. Only a company with mechanical, electrical and chemical engineers on its staff could know the correct solution to so many and varied pumping problems. Eastern has such a diversified engineering staff. Thus your pumping problems, especially where small size and light weight combined with high performance and economy of operation are factors, are assured of quick solution. Special pumps when designed and approved, can be put into production when a reasonable quantity is involved.

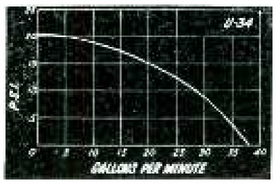
Illustrated here is a new Eastern Centrifugal Pump. Write for NEW catalog showing many other Eastern Pumps.

VOLUTE CENTRIFUGAL PUMP

Model U-34 illustrated, is designed for handling moderate volumes at relatively high heads, utilizing a minimum of space. It may be used for continuous duty operation. It is an excellent transfer pump. Close-coupled with open impeller mounted directly on motor shaft extension without use of an internal pump bearing. Available with mechanical rotary seal only. Standard models available in Monel Metal, Stainless Steel, Cast Iron, and rough or finished Bronze. Quotations on other alloys on request. Power: Heavy duty General Electric ball bearing motor in various frame enclosures and for almost all current requirements either 1/3 H.P. or ½ H.P. as the application demands. Weight: 36 lbs. Size: 12¼" x 6½" x 6½". Pump performance shown on chart illustrated here.



Model U-34



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Famous for years as COILS by DOYLE

LAYER-WOUND COIL

RELAY COIL

Be sure that the coil you buy bears the trademark name — "GRACOIL", for only then can you know that you have the best in electro-magnetic windings. Every "GRACOIL" is wound to the specified number of uniform turns from precision-gauged wire. Every "GRACOIL" is fully insulated, thoroughly impregnated, and properly laminated when supplied as a complete transformer. The most rigid inspections and tests make sure that each "GRACOIL" is worthy of the name it bears.

If your design calls for a special electro-magnetic application, let competent "GRACOIL" engineers make specific recommendations for you. Write today!

LOW VOLTAGE TRANSFORMER

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DOUBLE-CHECK SYSTEM

#JE-10—Miniature socket wiring plug for accurate alignment of miniature socket contacts during wiring. Precision cast of zinc base alloy — Pins of stainless steel.

#JE-12 — (Hardened tool steel insert) or JE-13 (Stainless steel insert) Miniature tube pin straightener to obtain a perfect fit when the tube is placed in the set.

For complete information and prices—write

RADIO ACCESSORY DIVISION

STAR EXPANSION PRODUCTS CO.

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AMERICAN CAPACITORS

DRY ELECTROLYTIC & PAPER DIELECTRIC

SPECIFICATION SHEETS ON REQUEST

ALL STANDARD TYPES • PRECISION ENGINEERED FOR DEPENDABILITY

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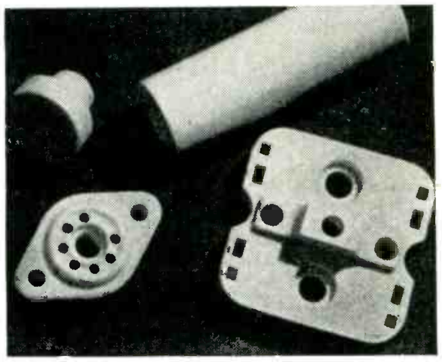


Lavite STEATITE CERAMIC

Properties and Characteristics of Our LAVITE S1-5 Steatite Ceramic Body

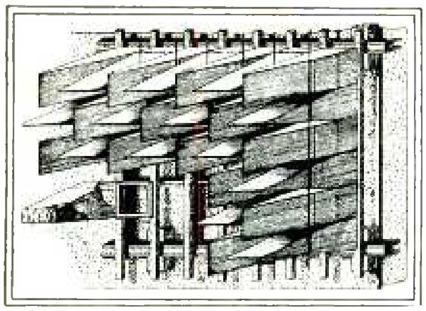
Compressive Strength	96,000 lbs. per square inch
Tensile Strength	7,200 lbs. per square inch
Flexural Strength	10,500 lbs. per square inch
Modulus of Rupture	20,000 lbs. per square inch
Dielectric Strength	235 volts per mil
Dielectric Constant	6.42 (Frequency of 1 megacycle)
Loss Factor	2.90 (Frequency of 1 megacycle)
Power Factor	.446 (Frequency of 1 megacycle)
Bulk Specific Gravity	2.664%
Density (from above gravity)	0.096 lbs. per cubic inch
Hardness (Mohr scale)	7.0
Softening Temperature	2,350°F.
Linear Coefficient of Expansion	8.13x10—6
Moisture Absorption (ASTM D-116-42-A)	0.009%

Design engineers and manufacturers in the radio, electrical and electronic fields are finding in LAVITE the precise qualities called for in their specifications . . . high compressive and dielectric strength, low moisture absorption and resistance to rot, fumes, acids, and high heat. The exceeding low loss-factor of LAVITE plus its excellent workability makes it ideal for all high frequency applications.

We will gladly supply samples for testing.

D. M. STEWARD MFG. COMPANY

Main Office & Works: Chattanooga, Tenn.
Needham, Mass. Chicago Los Angeles



Detail of Fiberglas wedges used in anechoic chamber. Each wedge is 45 inches long and 8 inches square at the base, and is braced by heavy wire running under its center and fastened to lengths of sash chain suspended from the ceiling

density of the Fiberglas board must be higher and the airspace behind the wedges must be decreased. Charts have been prepared by the Electro-Acoustic Laboratory from which the dimensions and densities of Fiberglas board can be determined.

Airplane Sound Effects

In another unusual room, the intense roar of airplane propellers was produced. Using electronic devices connected with amplifiers and loudspeakers, the noises heard in an airplane during flight could be faithfully reproduced. The walls of the room are lined with many sections of cylinders, each of a different diameter and running in a different direction on each wall. A battery of loudspeakers produced the sounds which were reflected randomly from the cylinders, thus producing an intense and diffuse sound field in the room. Microphones, amplifiers and headsets for use in airplanes and amphibious vehicles (which are often noisier than airplanes) were tested in this intense noise field before being sent to the Military Services for flight testing.

Better Hearing Aids

The most recent activity of the laboratory, undertaken when it became obvious that the war would be won by the Allied Nations, was the study of hearing aids for servicemen who had been deafened in battle. Results of this project have brought and will continue to bring relief to thousands of servicemen whose hearing was impaired by the German 88-mm shell and the Japanese equivalent. Almost all known makes of hearing aids have been submitted to rigid tests and their characteristics have been thoroughly described to

NEW SOLDERING GUN

THE SPEED IRON*

Patent Applied For

100 Watts 115 Volts 60 Cycles

Soldering Heat in 5 Seconds

Wherever you have a soldered joint in radio, electrical or electronic repair and service work, the Speed Iron will do the job faster and better.

The transformer principle gives high heat—in 5 seconds—after you press the trigger switch. Convenient to hold with a pistol grip handle, the compact dimensions of this new soldering tool permit you to get close to the joint. The copper loop soldering tip permits working in tight spots. The heat is produced by the high current flowing through the soldering tip—permitting direct and fast transfer to the soldered connection.

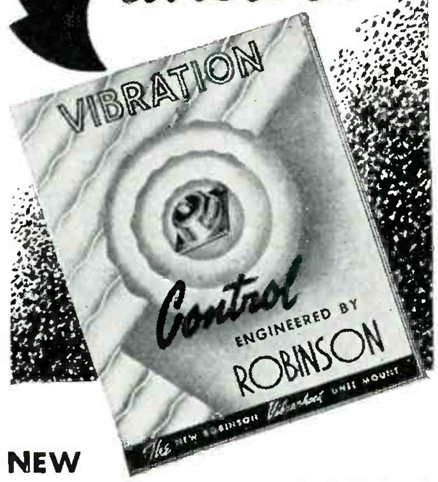
If you want to save time on soldering jobs with a tool that is ready to use in 5 seconds, get a Speed Iron today. See your radio parts distributor or write direct.

*T.M. Reg U. S. Pat. Off.

WELLER MFG. CO.

515 NORTHAMPTON STREET, EASTON, PA.

Here's the answer



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NO OTHER UNIT TYPE SHOCK MOUNT HAS THESE OUTSTANDING FEATURES

1. Stainless steel springs with three-way vibration absorption... 2. Built-in damping mechanism... 3. Built-in three-way shock assembly

Vibrashock is amazingly effective and surprisingly inexpensive. Send for new catalog shown here.

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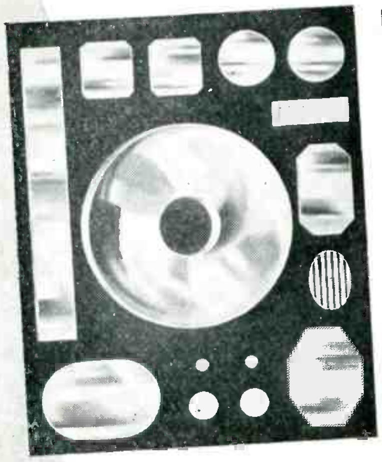
Front or Rear Surface

MIRRORS AND REFLECTORS



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Front or Rear Surface Mirrors and Reflectors made to your specifications.

Closest optical and dimensional tolerances observed.

- EXCEPTIONAL REFLECTIVITY
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SPECIALISTS IN VACUUM DEPOSITION

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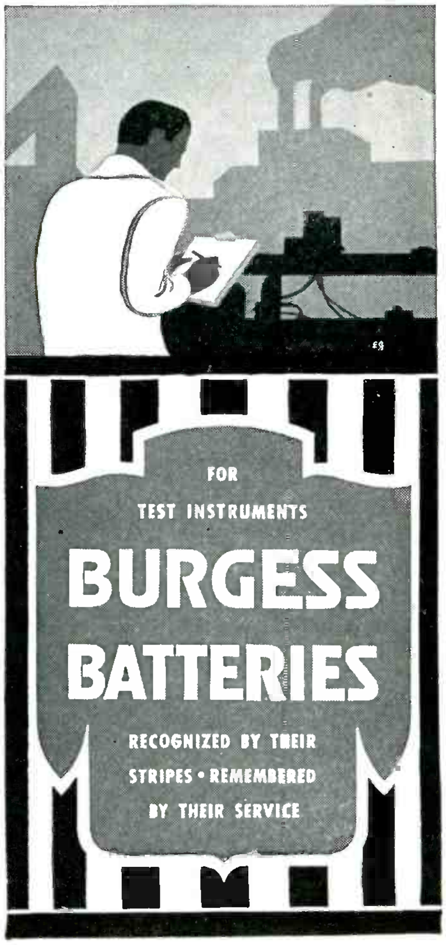


the military in classified reports.

In addition, the laboratory developed special headsets and handsets for use by Marines and Commandos. An entirely new communication system for use by divers was developed. Studies on wire recorders and on special units for use aboard ships of the U. S. Navy were completed. In due course of time, all of these developments will be made available for uses other than military.

MEETINGS TO COME

MARCH 7-9; OPTICAL SOCIETY OF AMERICA; Winter meeting; Hotel Statler, Cleveland, Ohio. For Program, write A. C. Hardy, Sec., Optical Society of America, Mass. Inst. of Technology, Cambridge 39, Mass.

MARCH 13; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Non-Linearity in Servomechanisms, by Dr. L. A. MacColl, Bell Telephone Laboratories; 301 Pupin Hall, Columbia University, 7 p.m.

MARCH 18-23; BROADCAST ENGINEERING CONFERENCE; developments since 1942 in broadcast engineering, including f-m and television; directed by Dr. W. L. Everitt, head, Department of Electrical Engineering, University of Illinois, Urbana, Ill., who requests addresses of those interested so they can be kept informed on the program details.

MARCH 27-30; AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE; Annual Meeting; St. Louis, Missouri. H. A. Meyerhoff, Exec. Secretary, Smithsonian Institution Bldg., Washington 25, D. C.

APRIL 10; AIEE; Applications of Servomechanisms, by S. J. Mikina, Westinghouse Electric Corp. Research Laboratories; 7 p.m. same place as March 13 meeting.

APRIL 25-30; INTERNATIONAL LIGHTING EXPOSITION; Stevens Hotel, Chicago.

MAY 13-16; RADIO PARTS AND ELECTRONIC EQUIPMENT TRADE SHOW; Stevens Hotel, Chicago. Inquiries to 221 N. LaSalle St., Chicago, Ill.

MAY 15-17; NEW ENGLAND ELECTRICAL TRADE SHOW; Exhibition Hall, Boston, Mass.

MAY 20-25; NATIONAL MARITIME EXPOSITION; Grand Central Palace, New

York City. Inquiries to headquarters at 17 Battery Place, New York, N. Y.

BUSINESS NEWS

Claude Neon Lights, Inc., New York City, has acquired Reeves-Ely Laboratories, Inc. and its subsidiaries—American Transformer Co., Hudson American Corp., Waring Products Corp., and The Winsted Hardware Mfg. Co.

General Electric Co. is planning a $10,000,000 administration building for its Electronics Park development outside Syracuse, N. Y., to house the main manufacturing units of the

Architects' sketch of proposed main manufacturing plant for Electronics Park

G-E Electronics Department. Floor area will be in excess of one million square feet. Completion in 1946 is dependent upon early improvement in materials and labor difficulties.

Sylvania Electric Products Inc. has acquired Wabash Appliance Corp., manufacturer of photoflash and incandescent lamps, and will operate the plant independently as a Sylvania subsidiary.

Press Wireless Mfg. Corp. has moved its engineering personnel into new quarters at 35th Ave. and 38th St., Long Island City.

Allied Control Co., Inc., New York City, has acquired B. F. Miller Co., Trenton, N. J. Plans call for continued enlargement and improvement of transformer manufacturing facilities, with B. F. Miller remaining as executive vice president and general manager.

Philco Products Incorporated is the new name of Philco Radio & Television Corp., wholly-owned distributing subsidiary of Philco Corp.

The Asco Corporation, Cleveland, Ohio, has been organized to manufacture radio, television, electronic, electrical, and mechanical components, with John Altmayer as president. A. R. Keskinen, formerly with Bendix Radio, has been employed as a project engineer.

WESTINGHOUSE ELECTRIC CORP. will concentrate the activities of its Industrial Electronics and X-Ray Divisions, now scattered among six locations in Baltimore and vicinity, in two plants. The X-Ray Division gets the entire Wilkens Ave. plant in Baltimore, and all Industrial Electronics work will be centered at Lansdowne.

CANADIAN RESEARCH INSTITUTE recently acquired new premises in Toronto that more than double its laboratory space. Production of a wide line of radio service equipment and laboratory apparatus is scheduled for the near future.

RCA has granted to RKO-Pathe, Inc. a license to record and distribute sound motion pictures for use in television broadcasting. The arrangement is expected to stimulate production of sound films for television.

COLONIAL RADIO CORP., Buffalo, N. Y., has obtained a building permit for a $225,000 assembly plant at Riverside, Calif. The main building is to be 190 by 280 ft and will house about 200 workers. Parts are to be fed to the unit from Buffalo while completed radio receivers will be merchandised on the Pacific Coast by Sears Roebuck outlets.

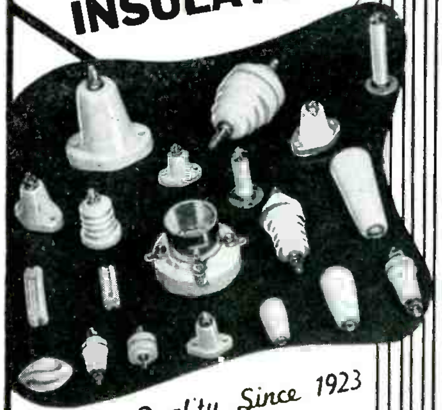
PHILLIPS CONTROL CO. of Chicago has acquired the design, manufacturing, and selling rights for relays formerly made by G-M Laboratories Inc., Chicago. In the future the line of relays will carry the trade name "Phil-trol".

PERSONNEL

RALPH A. POWERS, formerly with Bundy Tubing Co. of Detroit, has been named to succeed J. M. Cage as engineer in charge of electronic engineering at Allis-Chalmers Mfg. Co. Among his inventions are the electronically controlled camera used in making photo-finish pictures at race tracks, as well as many photoelectric measuring, sorting, and grading units.

CARL F. FRISCHE, chief research director of Sperry Gyroscope Co., has been elected vice-president for engineering. His wartime contributions to aviation at Sperry included de-

CERAMIC PORCELAIN & STEATITE
INSULATORS



Quality Since 1923

MANUFACTURERS OF RADIO HARDWARE *and* ANTENNAS

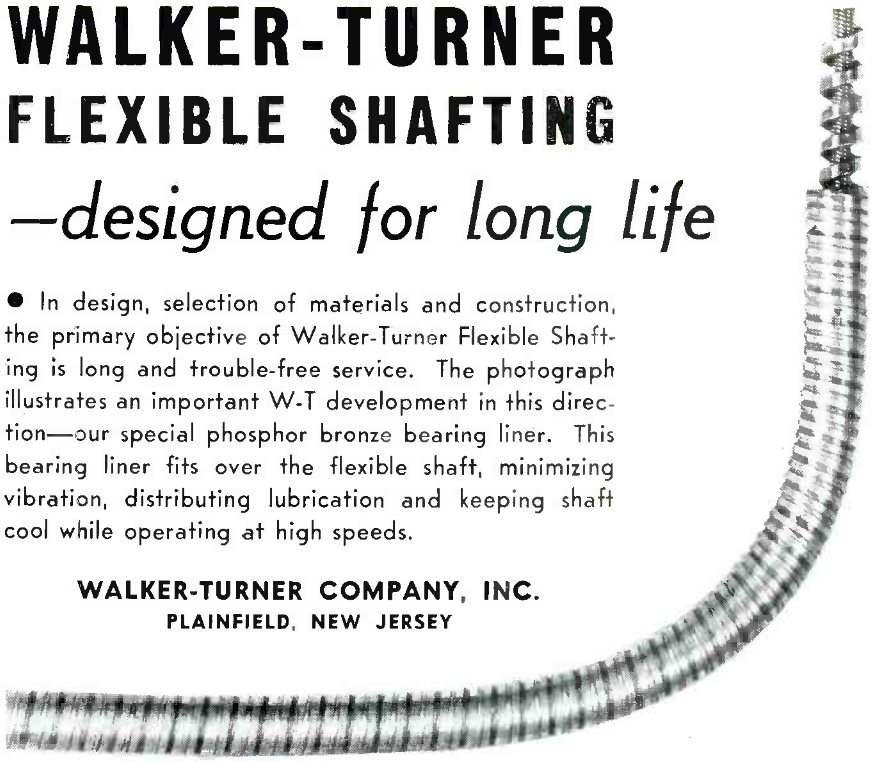
Also Carrying a COMPLETE LINE of WIRES, CABLES *and* HOOK-UP WIRES

Inquiries Invited!

BIRNBACH

BIRNBACH RADIO CO., Inc.
145 HUDSON ST. NEW YORK, 13, N. Y.

WALKER-TURNER FLEXIBLE SHAFTING
—designed for long life



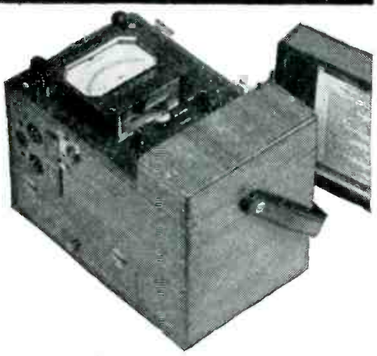
● In design, selection of materials and construction, the primary objective of Walker-Turner Flexible Shafting is long and trouble-free service. The photograph illustrates an important W-T development in this direction—our special phosphor bronze bearing liner. This bearing liner fits over the flexible shaft, minimizing vibration, distributing lubrication and keeping shaft cool while operating at high speeds.

WALKER-TURNER COMPANY, INC.
PLAINFIELD, NEW JERSEY

walker-Turner COMPANY, INC. PLAINFIELD, N.J. U.S.A.

FLEXIBLE SHAFTING
FOR REMOTE CONTROL AND POWER TRANSMISSION

New... CRANKLESS MODEL C-2 MEGOHMER INSULATION TESTER



Test Potential to 600 Volts DC. Ranges to 1000 megohms with two or three additional ohm ranges in each instrument. Long mirror scales, hand drawn, individually calibrated, with more scale divisions for superior readability and split hair accuracy. Automatically decreasing test potential protects equipment of low resistance value.

Truly a Precision Instrument
WRITE FOR BULLETIN 445

HERMAN H. **Sticht** COMPANY, INC.
27 PARK PLACE NEW YORK, N. Y.

Draftsman Wanted

Also

Designer, Detailer, Tracer and Engineer

We are one of the largest manufacturers of a wide variety of communication and electronic equipment in the world, fully prepared and ready to go ahead with a very ambitious, expansion program as quickly as we are permitted. There will be unlimited possibilities for creative, ambitious men to advance to key positions both in research development and production field.

Good Starting Salaries

Exceptionally fine working conditions

Apply: Personnel Office, 8 A. M. to 5 P. M.

Federal Telephone & Radio Corp.
the Mfg. unit of the International Tel. & Tel. Corp.
591 BROAD ST., NEWARK, N. J.

velopment of automatic pilots, bomb sights, and an instrument landing system.

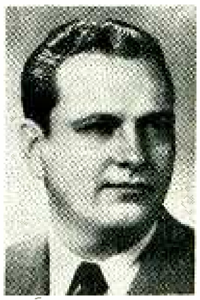
C. F. Frische

E. F. Carter

E. FINLEY CARTER becomes vice-president in charge of engineering at Sylvania Electric Products Inc. following the resignation of Roger M. Wise.

DAVID B. SMITH has been appointed vice-president in charge of engineering of Philco Corporation. As director of research since 1941 he supervised the fundamental microwave and uhf research that led to production of Philco airborne radar used by the Army and Navy.

D. B. Smith



L. F. Cramer

LEONARD F. CRAMER, vice-president and a director of Allen B. DuMont Laboratories, has been appointed director of the company's newly established Television Broadcasting Division.

FREDERICK R. LACK, vice president and manager of the Radio Division of Western Electric Co. Inc. was elected vice-president of the American Standards Association, having been nominated for this position by IRE.

MEADE BRUNET received a promotion from RCA Victor Division in Camden, to vice-president in charge of the Engineering Products Department.

PHILIP SPORN, executive vice-presi-

dent of American Gas & Electric Service Corp., was awarded the Edison Medal for 1945 by the AIEE "for his contributions to the art of economical and dependable power generation and transmission". Among his patents is one on high-speed carrier-current relaying for high-voltage transmission lines.

L. W. TEEGARDEN has been made vice-president in charge of the RCA Tube Department.

C. P. SWEENY has returned to the NBC Engineering Department and is now on the technical staff of the television transmitter in the Empire State Building, after four years with the Navy.

WALTER WIDLAR has been appointed general manager of the Mec-Rad Division of Black Industries, Cleveland, Ohio. For 10 years he was relay facilities engineer for The WGAR Broadcasting Co. in Cleveland, and since 1942 has been working on the sonobuoy and other wartime electronic developments at the Columbia University Division of War Research.

W. Widlar

H. V. Nielsen

HAROLD V. NIELSEN has been appointed chief engineer of United States Television Mfg. Corp., New York, in charge of all radio, television, and special product design and production. He was formerly with Sparks-Withington Co.

G. ROBT. MEZGER is back with Allen B. DuMont Laboratories, Inc. of Passaic, N. J. after 4½ years of active service in the U. S. Navy. He was assigned for a time to the Electronics Section of the David Taylor Model Basin in Washington.

JOHN M. CAGE has been appointed manager of the Industrial Electronics Division of Raytheon Mfg. Co., Waltham, Mass.

GEORGE D. RICE advances to become

acting assistant chief engineer of the Radio Division of Lear, Inc., Grand Rapids, Mich.

R. C. LONGFELLOW transferred from Schenectady to Syracuse to become engineer of the specialty division, Electronics Department, of General Electric Co., after over four years of radar engineering work in the Transmitter Division.

WALTER C. KIRK is now designing engineer of the Ken-Rad Division (Owensboro, Ky.) of General Electric Co., and will be responsible for design engineering of receiver tubes.


W. C. Kirk


W. E. Bradley

WILLIAM E. BRADLEY has been appointed director of research for Philco Corp., Philadelphia. Since joining Philco in 1936 he has contributed to engineering developments in f-m, television, and radar, including the new Philco advanced f-m system.

PAUL M. REYLING is now manager of production and engineering for Freeland & Olschner Products, Inc., New Orleans, La. He will manage their transmitting tube plant and supervise development projects. Previously he was senior engineer in charge of the vacuum-tube program for the Oak Ridge atomic bomb project.

HOWARD S. FRAZIER was made vice president of Freeland & Olschner Products, Inc., New Orleans. He was formerly director of engineering for NAB and vice chairman of RTPB. In addition to duties with F & O, he will conduct a radio management consulting practice for the broadcast industry.

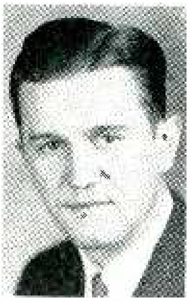
EDWARD M. SUMNER takes over as electronics laboratory research director for Ellinwood Industries, Los Angeles.

GEORGE KIS has joined Ellinwood industries as electronics laboratory

technician after two years of OSRD work at the University of California.

PAUL F. G. HOLST is now engineer in charge of audio and television development at The Crosley Corp., Cincinnati. For the past 16 years he was with RCA, working on audio, radio, and television circuit development.

P. F. G. Holst



J. B. Schaefer

J. B. SCHAEFER has been appointed plant manager at New York Transformer Co., and will direct engineering and manufacturing activities at the Alpha, N. J. plant. He was formerly with Sperry Gyroscope Co. as engineering manager.

CAROL M. VERONDA is now with Philips Laboratories, Inc., Irvington, N. Y. as assistant engineer in the Microwave Section, after work on radar at NRL. This recently organized laboratory is to be the research center for all interests of North American Philips Co., Inc. in the United States.

FRANK GRACE has joined Philips Laboratories, Inc. as assistant engineer, Microwave Section. He was previously with Reeves Sound Laboratories.

VICTOR WOUK recently joined the Engineering Laboratories staff of North American Philips Co., Inc., at Dobbs Ferry, N. Y., and will investigate circuit theory. He previously carried out research on mercury arc rectifiers and gaseous conduction at Westinghouse Electric Corp.

J. M. WHERRITT has joined Aireon Mfg. Corp. as manager of their new Emergency Communications Division in Kansas City, Kansas, after 14 years with the Missouri State Highway Patrol where he headed the communication division. For 7 of these years he was also editor of the monthly magazine, "Associated Police Communication Officers Bulletin".

MULFORD M. BRANDT has returned to

the Television Terminal Equipment Engineering group of RCA Victor after 4½ years in the Signal Corps, including work on secret guided missile projects of the Army Air Forces. He attained the rank of Colonel.

H. D. MORELAND has been named manager of the Westinghouse X-Ray Division in Baltimore.

THOMAS RYAN WARNER, recently released from the Army with the rank of lieutenant colonel, has been appointed assistant communications engineer of the Greyhound Corp., and will direct training of personnel and supervise procedures in connection with the system of two-way communication to be installed in more than 100 buses of Greyhound and two other lines operating into Chicago.

JAMES R. DOWNING is director of research at Cook Electric Co., Chicago. Since 1942 his major work has been on the atomic bomb project and in development of high-vacuum equipment for industry.

EDMUND S. WINLUND goes to the West Coast as industrial electronics engineer for RCA's Pacific region, with headquarters in Los Angeles. His work will include application engineering for electronic heating equipment.

IVAN G. EASTON has been placed in charge of the New York engineering office of General Radio Co.

J. KELLY JOHNSON has opened his own office as radio and electronic consultant in New York City.

HOWARD K. MORGAN, formerly director of engineering for TWA, Inc., is now on the engineering staff of Bendix Radio Division, Baltimore, Md.

PRESTON ROBINSON and JULIAN K. SPRAGUE have been appointed vice presidents of the Sprague Electric Co., North Adams, Mass.

—⁘—

RECORDINGS of the mating "songs" of mosquitoes made by Drs. Kahn, Celestin, and Offenhauser of Cornell indicate a strange similarity in the behavior pattern of mosquito and man. Two mosquitoes of the same sex may lead quiet bachelor existence but addition of a member of the opposite sex inspires a competitive singing match. The power of the female's voice exceeds that of the male's.

NEW BOOKS

Electronic Equipment and Accessories

By R. C. WALKER. *Chemical Publishing Company, Inc., Brooklyn 31, New York, 393 pages, $6.00.*

THIS SIMPLE INTRODUCTION to the subject of industrial electronics has as its goal the presentation of basic principles, each backed by carefully selected applications. The use of British technical terminology, British styles in circuit diagrams, and the references to British electronic tubes and equipment lessen the practical value of the book to American readers, but since circuit principles are the same the world over this is not too serious a fault.

The introductory chapters set forth the fundamental characteristics common to all electronic tubes, with factors to be considered in choosing the best tubes and circuits for problems most likely to occur in industrial work.

Characteristics and uses of tubes are taken up in three groups: Hard tubes, gas-filled triodes, and cathode-ray tubes. Typical applications are presented, including amplifiers, measuring circuits, relay circuits, circuits for phase changing, speed control of motors, speed synchronizing, high-speed impulse recording, automatic switching, d-c voltage conversion, lamp dimming, scanning circuits, impulse recording, frequency-operated switches, constant current or voltage control, timing, phase-angle control, and intermittent switching control. Two chapters deal respectively with principles and uses of cathode-ray tubes.

Light-sensitve devices that find application in industry are described as to construction, characteristics and operation; these include the selenium resistance bridge, the alkali metal photoelectric cell, the electron multiplier types of cells, and rectifiers. Several industrial devices that use light-sensitive cells to measure light are also explained, with descriptions of follow-up mechanisms and galvanometer relays for temperature control.

The text dealing with small switchgear is detailed and comprehensive. This chapter comprises more than one-sixth of the book. It runs the gamut from simple action mechanical switches through to special forms of relay-operated types.

Delayed action devices are described for use where an electrical control is required to come into operation sometime after an impulse has been given, or has to be sustained for a specified period after the impulse has been removed. Examples are given that serve to indicate the general scope of timing circuits using thermionic valves.

Electrically actuated counters or impulse recorders are discussed in connection with typical circuits and salient features of associated apparatus. Small d-c, a-c, and universal motors, metal rectifiers, telemeters, selsyn control, and piezoelectric devices are also covered.—J.K.

• • •

When Foreman and Steward Bargain

By Glenn Gardiner, *Vice-President, Forstman Woolen Co., McGraw-Hill Book Co., New York* 18, *N. Y.*, 194 *pages*, $2.00.

A Program for Personnel Administration

By J. J. Evans, Jr., *General Personnel Manager, Armstrong Cork Co., McGraw-Hill Book Co.*, 100 *pages*, $1.50.

Building A Sales Training Plan

By Edward J. Hegarty. *McGraw-Hill Book Co.*, 198 *pages*, $2.00.

The more books an engineer reads on the human relations side of his job, the better become his chances for advancement into executive positions. Once a certain proficiency is attained engineeringwise, generally sometime within the first ten years after completion of formal schooling, further progress depends so much on an engineer's ability to supervise and work with others that self-improvement along these lines can pay dividends.

The three books listed above constitute a starter for any ambitious engineer. All are well written, easy to read, and a nice size to carry in an overcoat pocket for perusal in odd moments during travel. All empha-

size the importance of considering the feelings, the desires, the thoughts, and the humanness of the other fellow, and give practical and simple techniques for making others do willingly, cheerfully, and efficiently the jobs you assign them. All stress the value of diplomacy, of thinking before acting, of selling ideas before presenting them as orders. In these and the scores of similar books now available lie the solutions to a high percentage of the labor-management problems now confronting industry.
—J.M.

• • •

Electrical Circuits and Machines

By EUGENE C. LISTER, *Supervisor of Electrical Theory Instruction, Iowa State College*, 1942-1944. *McGraw-Hill Book Co., Inc., New York*, 1945. 355 *pages*, $3.50.

THIS BOOK IS intended to serve as an outline text covering the fundamentals of electric circuits and machines in sufficient detail for the student to gain a general understanding of the subject and at the same time allow opportunity for an instructor to enlarge upon any phase of the subject to meet the needs of his students. To this end, basic principles and the physical actions which take place have been emphasized rather than detailed theoretical analysis, and the treatment of the subject matter has been made as nonmathematical as possible.

Both direct and alternating currents and circuits, motors and generators, and associated control and metering equipment are discussed and many numerical examples have been worked out in detail. Extra problems of a practical nature are given in those chapters where the solution of problems will illustrate the application of the principles involved. At the close of each chapter, a comprehensive list of review questions is given to aid the student in evaluating his grasp of the subject matter.

An extended discussion of electron tubes is beyond the scope of this book. Therefore, the fact that the final chapter contains only a brief description and discussion of a few fundamental tube types, circuits and typical industrial applications should not detract from the value of the book as a whole.—RAYMOND H. SCHAAF.

CONTACTS
FOR THE FIELD OF ELECTRONICS

Your Inquiry Will Have Special Value

if you mention that it is in response to advertising in this publication. Advertisers value such acknowledgments highly; so does the publisher. You benefit—as a reader—in the enlarged future service such acknowledgments help to make possible.

Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

International Radar

Dear Sir:

WITH REFERENCE to the article on page 364 of December ELECTRONICS, I would like to point out that the headline "C.A.A. Radar for Airways Approved by British" is somewhat misleading. Insofar as international approval and agreement can be said to have been reached at such a conference it might be closer to the actual facts to phrase the statement "Empire Radar Plan for Airways Approved by C.A.A." It is true that paragraph (3) does not explicitly state that C.A.A. was recommending their particular distance indicator to the C.E.R.C.A. Conference, nor does paragraph (4) imply that C.A.A.'s ideas in particular were given approbation, but when these paragraphs are read under the headline "C.A.A. Radar for Airways Approved by British", the suggestion is unavoidable. . . .

The C.A.A. representatives at the London Conference, in August, did present a large amount of useful data on aircraft communications, and their two-course V.H.F. range was recommended for interim international use. The well-engineered C.A.A. omnidirectional range was demonstrated, discussed, and recommended for further investigation. Their proposals for blind landing were also well received. These points are covered correctly in paragraphs (1), (2), and (5).

However, in connection with paragraph (4), the C.A.A. did not enlarge greatly on the radar future, and the proposals in this field came chiefly from the British, the Canadians, the Australians, and the U.S. Services, in the order named. From our talks with C.A.A. members, we believe that they concur in principle with the general philosophy expressed in the Canadian paper pre-

(*Continued on page 344*)

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sented at the Conference, entitled "Interim and Long Term Proposals for Short Distance Navigational Systems and for Airport and Airways Control Systems", though naturally differing in detail. The large and competent U.S. delegation to the C.E.R.C.A. Conference, in addition to presenting many excellent ideas, gave their general approval to the radar plan presented by the U.K., Canadian and Australian delegations.

Paragraph (3), if it represents the agreed opinion of the London Conference, refers to the Canadian Distance Indicator. . . . At the Second C.E.R.C.A. Conference, . . . C.A.A. asked that one model of the system should be turned over to them. Accordingly, in May, 1945, one of the N.R.C. engineers took to Indianapolis, Indiana, a complete working unit, consisting of the airborne distance indicator and the ground beacon with auxiliary equipment. After a series of demonstrations in our own aircraft, this equipment was then installed in a C.A.A. plane. The C.A.A. has demonstrated this system to all comers, though their overworked staff have not been able to give it any maintenance, as a consequence of which it was operating at reduced efficiency. . . .

In July, 1945, the National Research Council took another unit to England to demonstrate at the Third C.E.R.C.A. Conference, where the Canadian system was recommended for international standardization. . . . Our own domestic plans for the distance indicator are to install a chain of ground stations, in cooperation with the Department of Transport, between Montreal and Windsor and to fit several of Trans-Canada Air Lines aircraft with airborne sets, so that a series of thorough operational trials can be made before recommending specific and detailed equipment to the manufacturers. In addition, we have a program on foot to assist in implementing the general proposals put forward at the London Conference, in collaboration with the U. K., Empire, and the U.S.A. These proposals will be outlined in the proceedings of the Conference, which can be obtained from the C.E.R.C.A. Central Office, Ariel House, Strand, London, England.

D. W. R. McKinley
Radio Branch
National Research Council
Ottawa, Canada

INDEX TO ADVERTISERS

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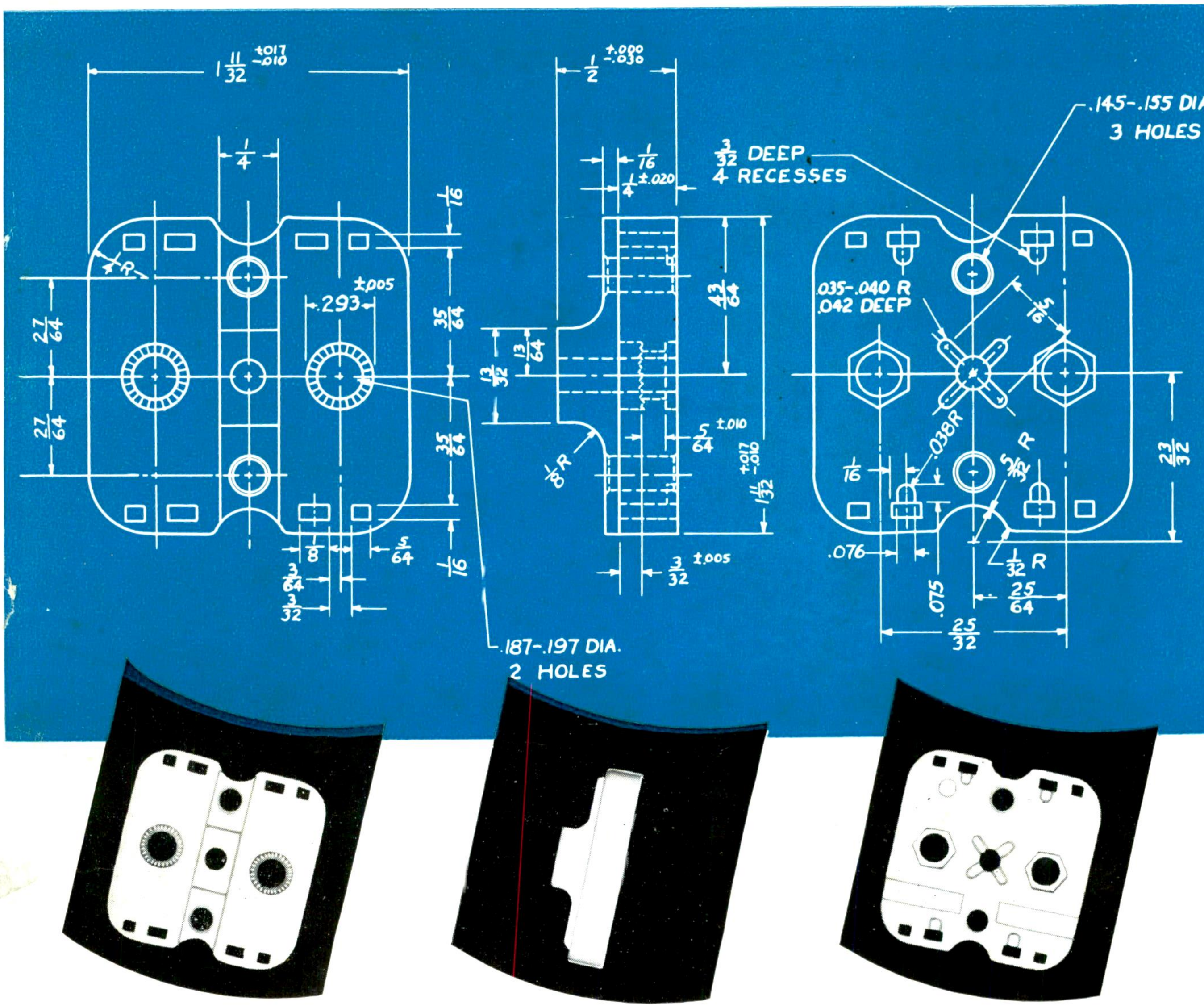

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