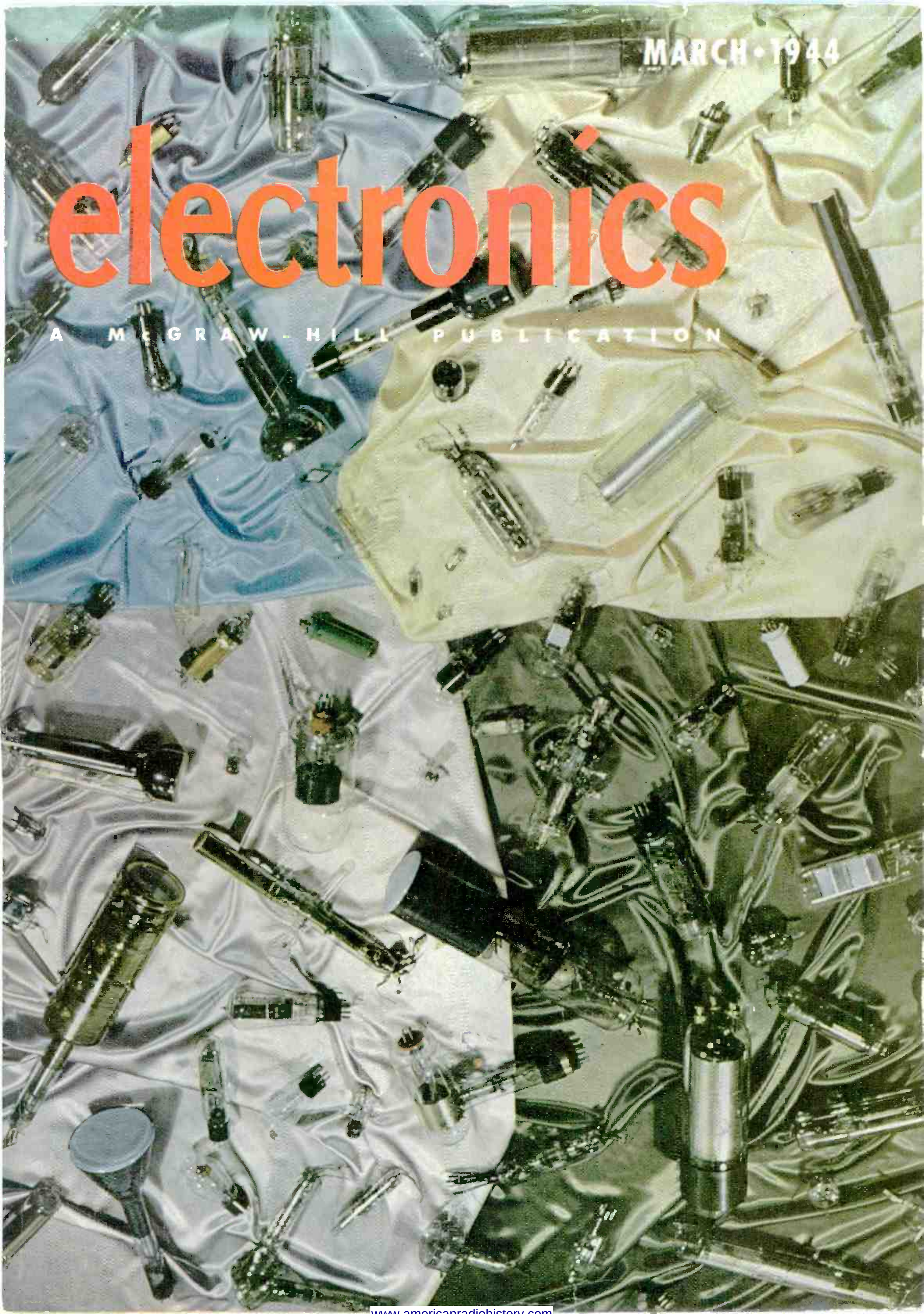

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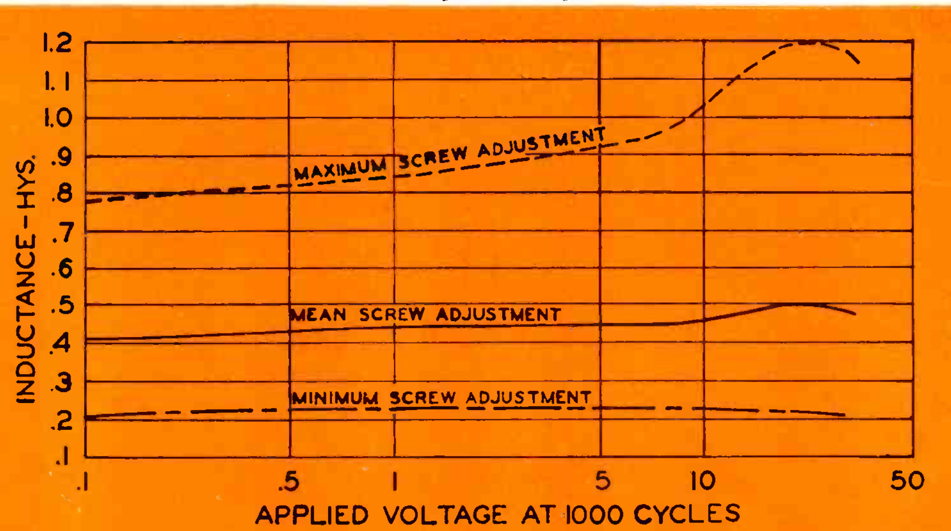

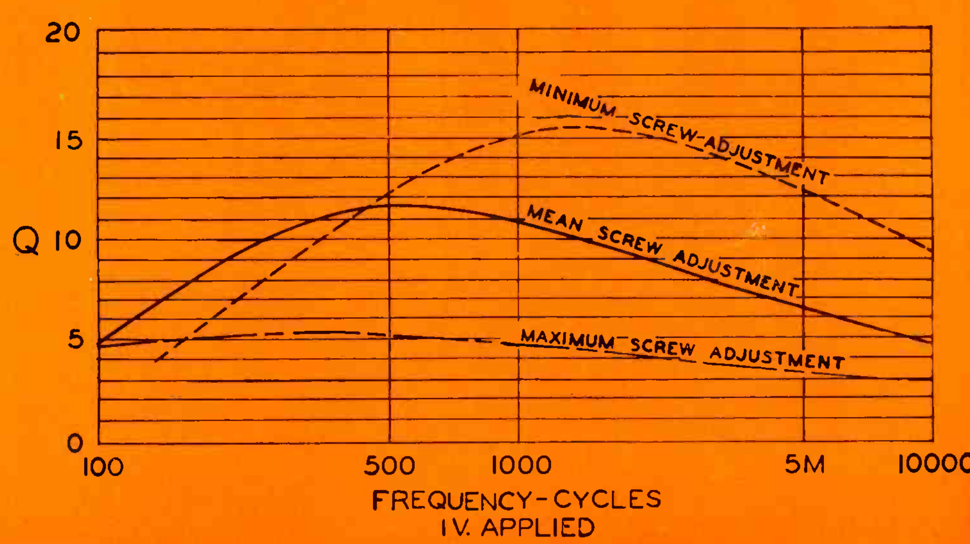

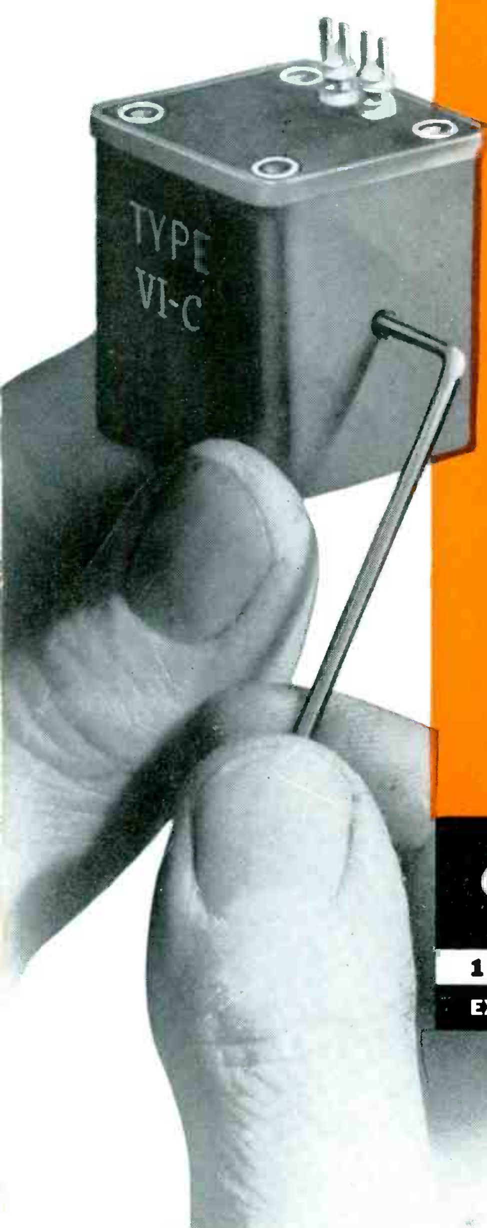

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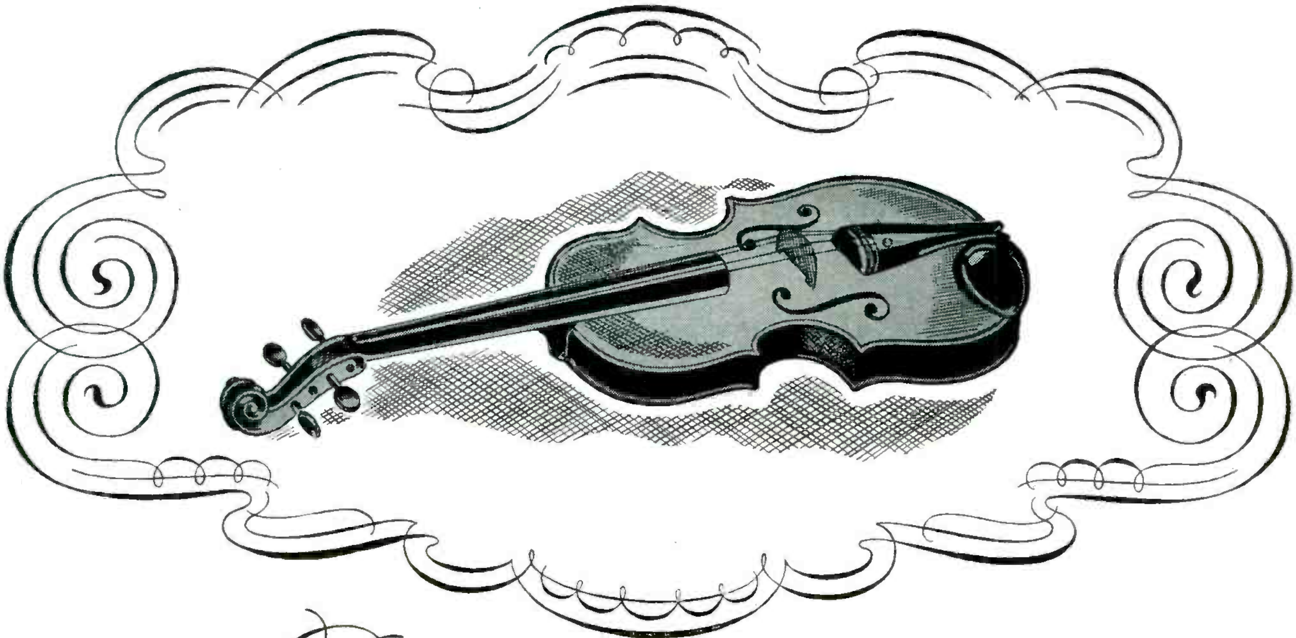

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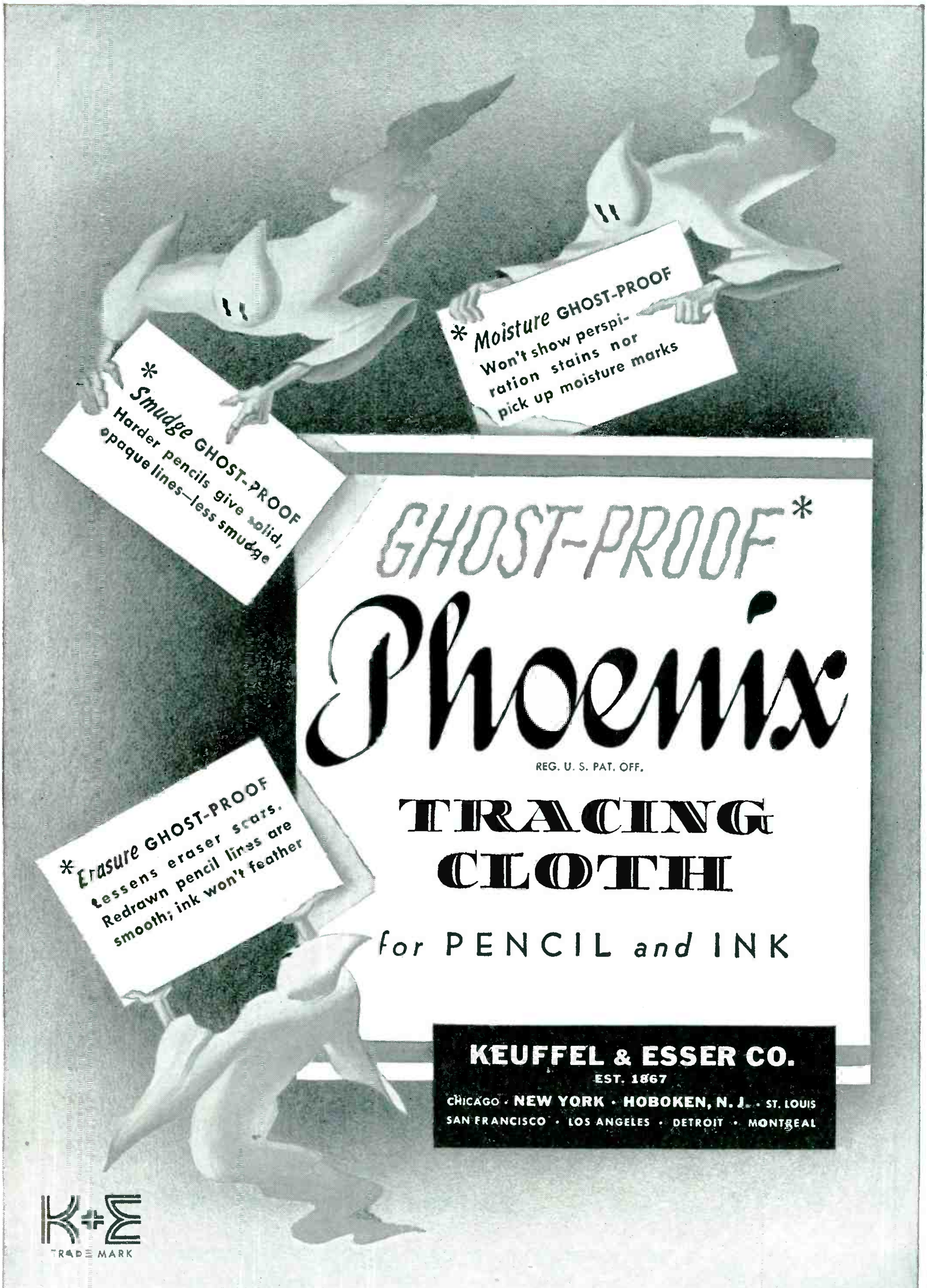
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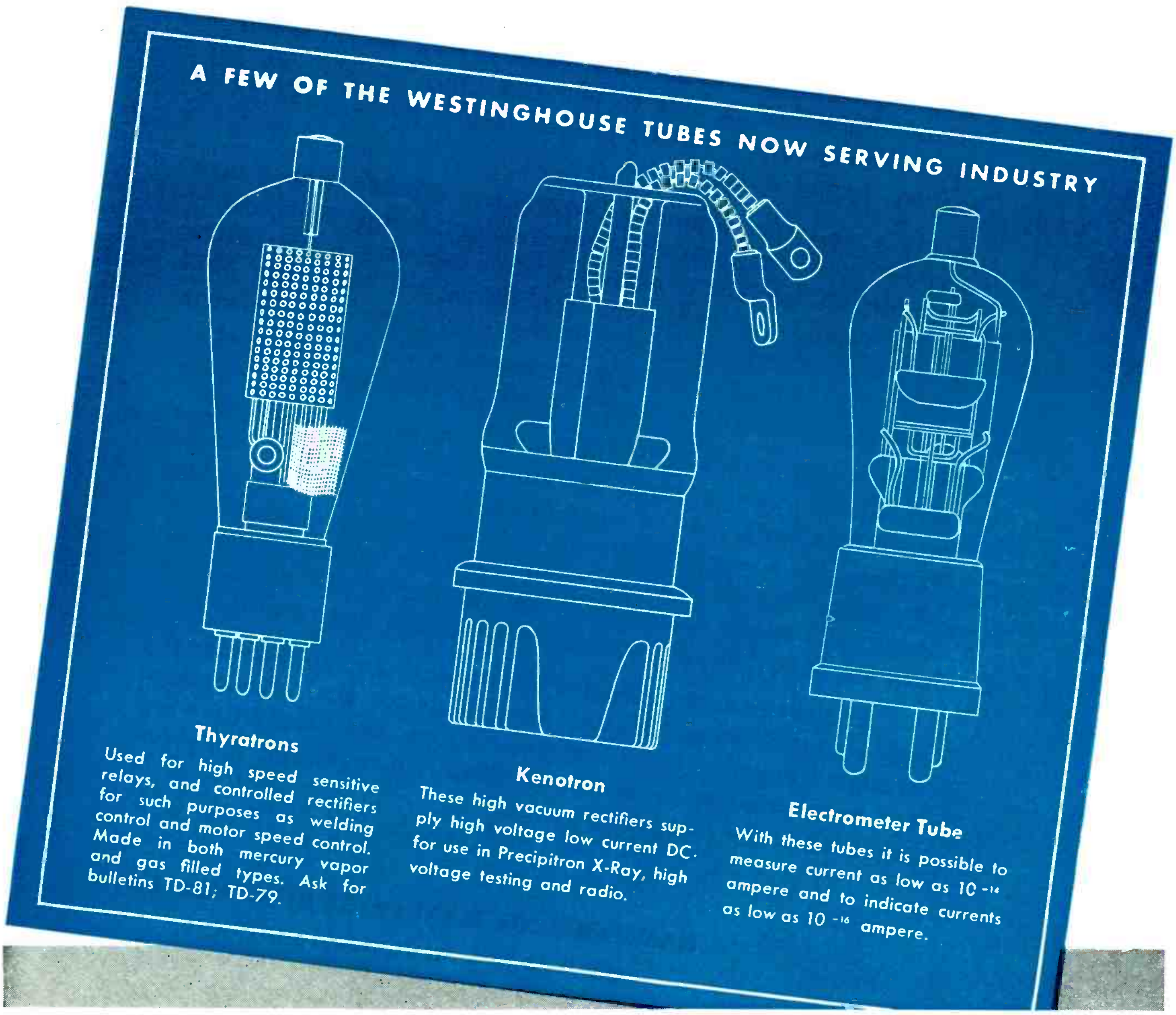

Who Said The "Ham" <u>Is</u> <u>Finished?</u>

THERE have been rumors to the effect that the radio Amateurs were going to be denied their old frequency bands, and given new bands of such high frequency as to be useless for medium and long distance communication.

Some rumors say "Remember the last War? We are going to get the same treatment this time!"

Now, we don't believe the "Hams" should be denied their rightful place on the air in bands suitable for communication beyond the horizon — — and further, we do not believe that our Government would want to see those privileges denied.

Are not the "Hams" fighting on many battlefronts, working in war factories and laboratories for a New World wherein the individual will be able to live and enjoy his hobbies, his church and other personal freedoms which go to make up a healthy, happy world?

It is well-known among Government officials whose task it was to build our great war-time communications system that from the rank and file of amateurs came executives, instructors and thousands of engineers and operators. Without this nucleus of experienced men, it would no doubt have taken a much longer time to reach the present high degree of perfection in the communications branch of our fighting forces.

In every emergency Amateurs have proved their ability and willingness to come to the aid of their Country — — who would be so unjust as to want to deny them their small place in the radio spectrum? We do not believe these rumors that the "Ham" will be denied his privileges, we believe rather that those who speak so much of justice coming out of this war will see to it that the Amateur receives his just reward.

The entire radio industry knows well, and appreciates the many contributions "Hams" have made for the advancement of high frequency radio communications, and surely they too can be counted on to assist the "Ham" in regaining his privileges *when the right time comes.*

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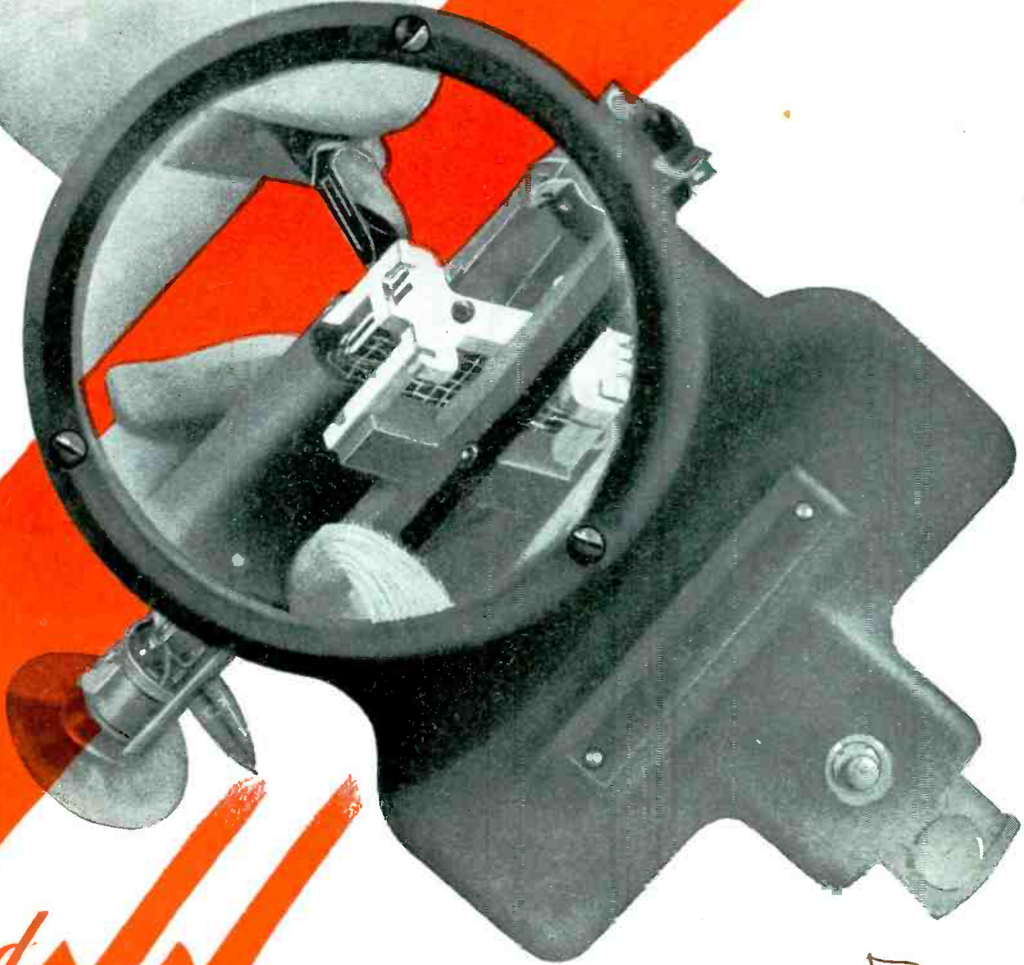
One of a series showing AMPEREX tubes in the making



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TRANSMITTING AND RECTIFYING TUBES

Checked and double checked. That's the ***all-the-way*** history of *Amperex* tubes through every stage of construction. No chances are taken. Even after tubes have been aged, seasoned and subjected to severe tests, each day's production must hurdle final examination in our x-ray rooms. Here, an exhaustive analysis is made to determine the presence of invisible defects. When we pronounce the tubes "bottled to perfection" — *they are!* More than 100 different types of *Amperex* tubes are available for broadcast, industrial and electro-medical applications. Each one with "Amperextras" which assure operating efficiency and longer life.

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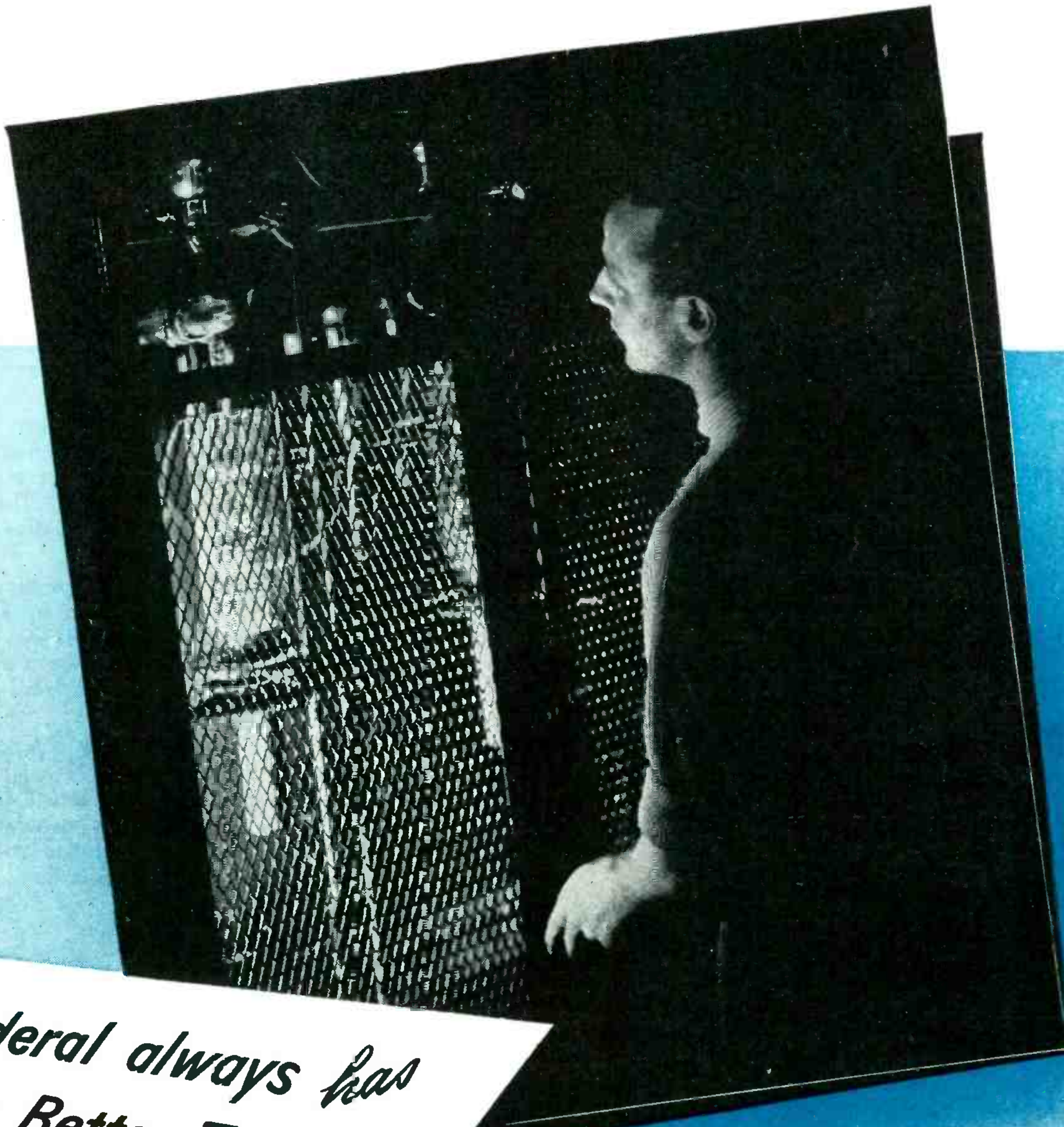

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For almost two decades Federal has made better tubes—tubes that surpass in design and construction, in quality of materials, in craftsmanship, in performance.

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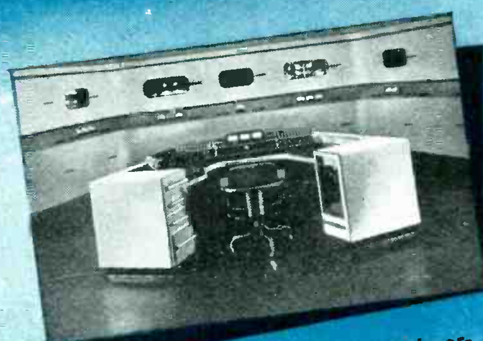
And in support of Federal tube quality and performance is Federal customer service, always ready and prepared to handle the problems of broadcast stations in meeting any requirement or emergency.

That is why Federal's established reputation for building better transmitting and rectifying tubes rests on an enduring foundation; why Federal tubes doubly ensure customer satisfaction.

This customer satisfaction, now enjoyed by many leading broadcast stations, is available to you. Whether you require tubes of standard types or whether you have a particular tube problem to solve, Federal service will prove profitable to your interests.



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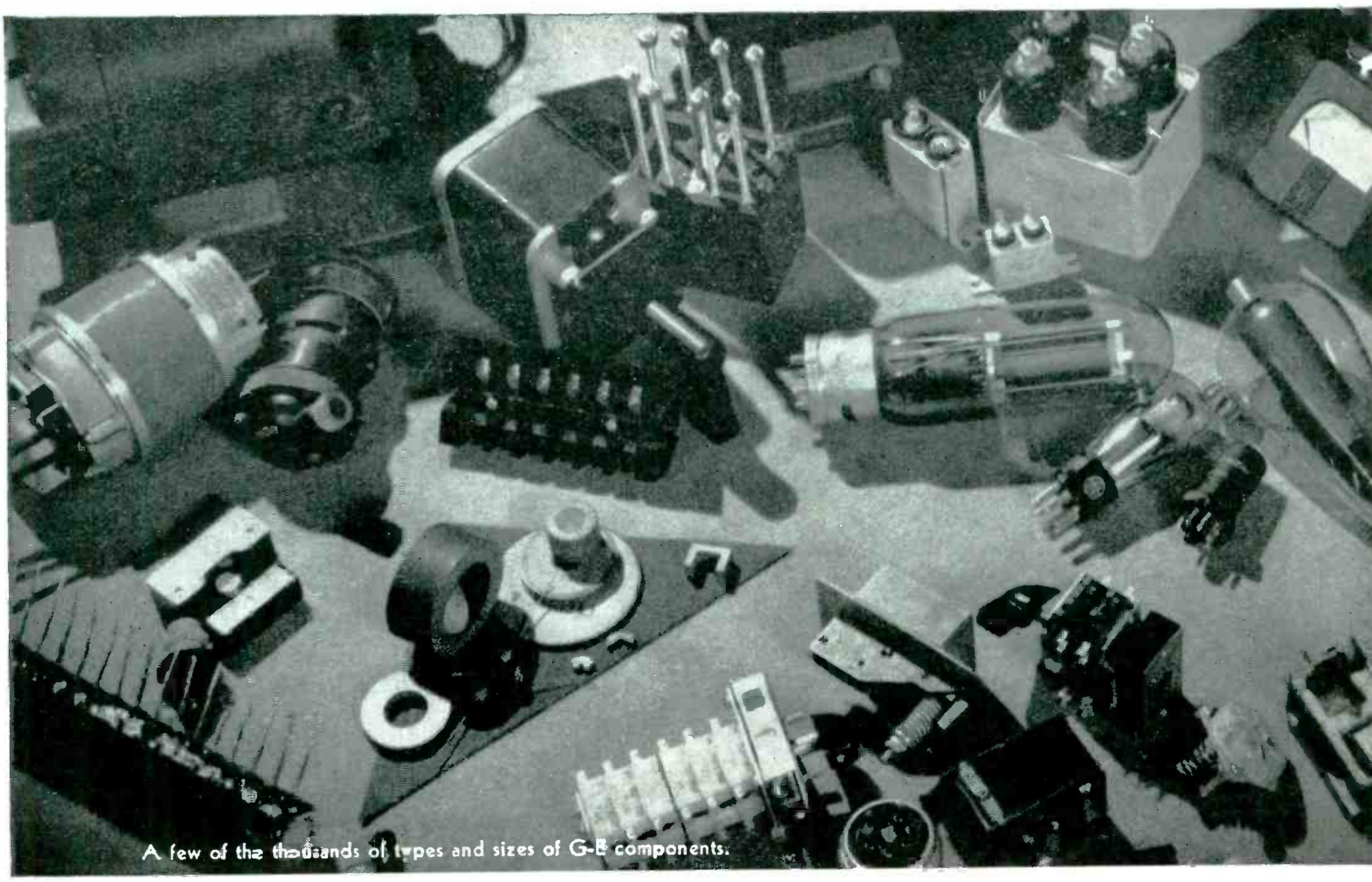
The majority of these new G-E electronic components are available only for military use or for war production. Though little can be published about their design, and less about actual applications, full information can be furnished in confidence to manufacturers of electronic equipment. For such data please get in touch with the nearest G-E office. ***General Electric Company, Schenectady, N. Y.***



A few of the thousands of types and sizes of G-E components.

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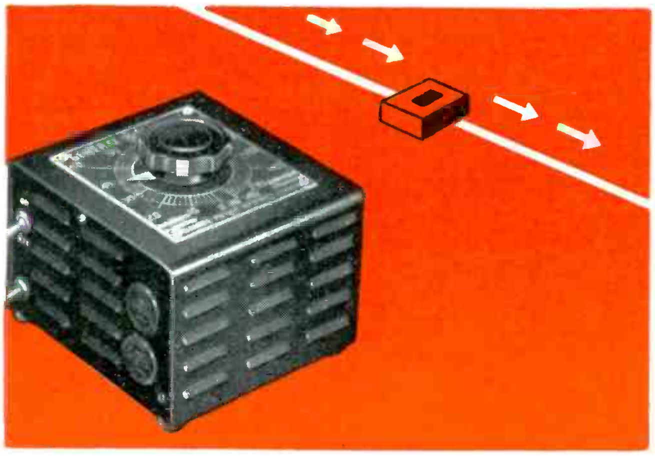

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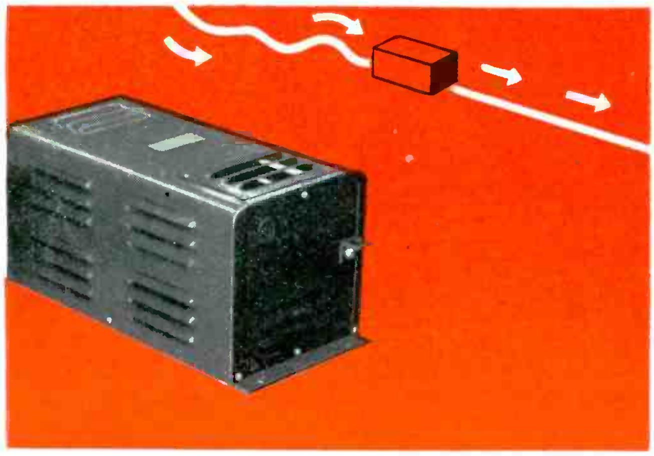

AUTOMATIC VOLTAGE STABILIZER used in conjunction with equipment requiring closely regulated input voltage. Provides practically instantaneous correction of voltage changes caused by either a changing input voltage or variation in magnitude of the load. Has no moving parts, requires no adjustments. Bulletin GEA-3634A.

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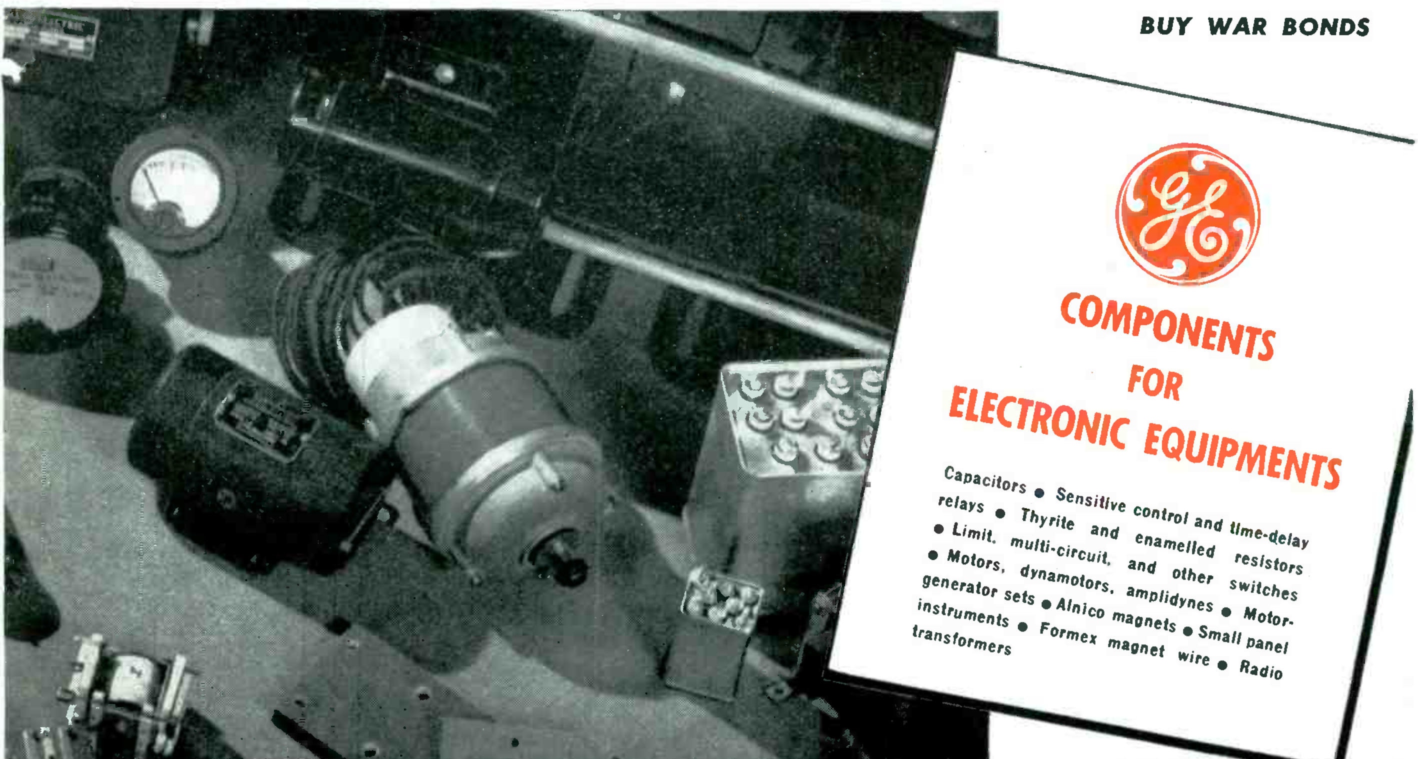

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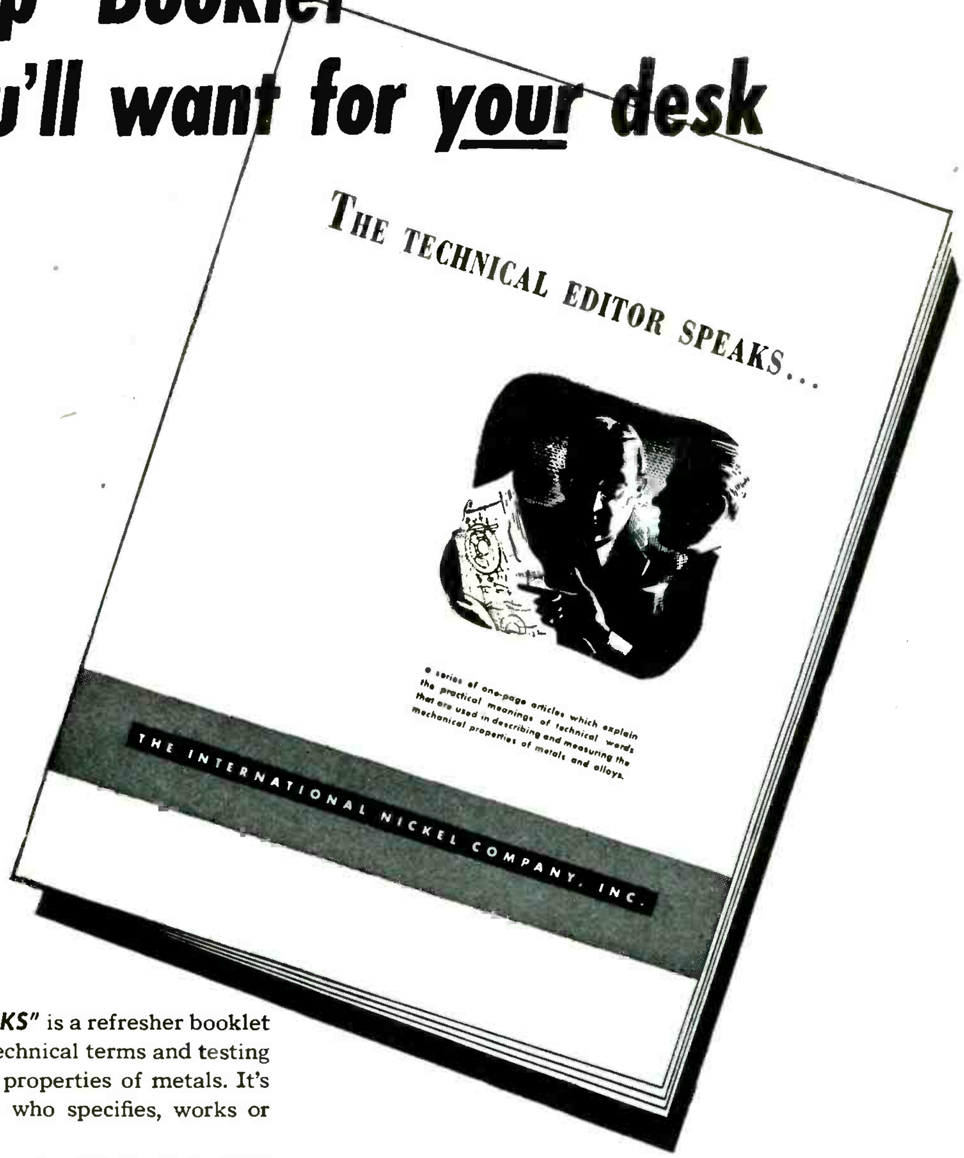

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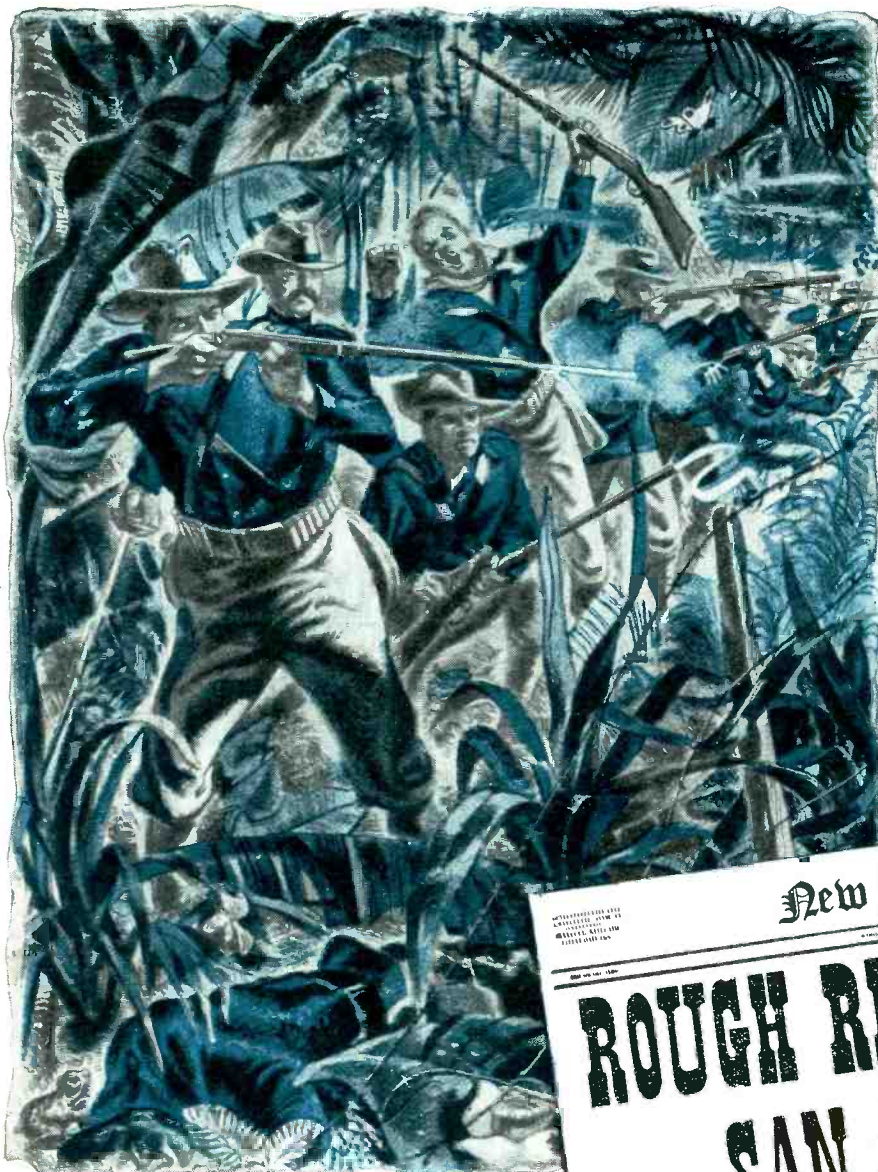
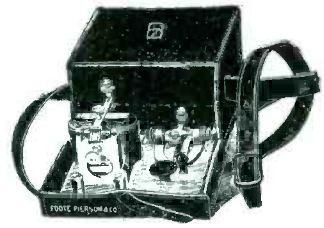
INCO NICKEL ALLOYS

MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • "Z" NICKEL • NICKEL
Sheet . . . Strip . . . Rod . . . Tubing . . . Wire . . . Castings





Main line telegraph combination set as supplied to the Signal Corps in 1898

In 1898

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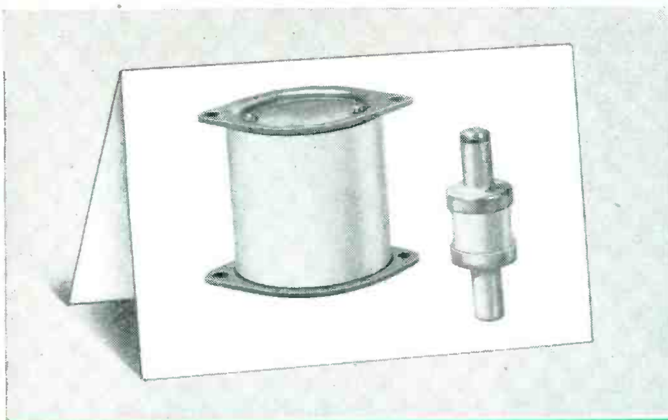
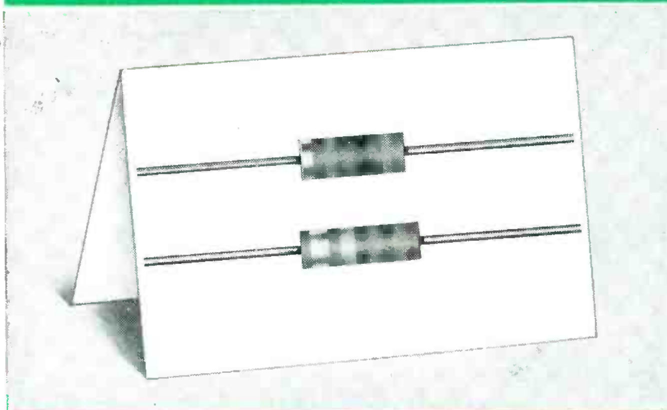


HIGH VOLTAGE TRANSMITTING CERAMICON — DOUBLE CUP CERAMICON



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CERAMICON TRIMMERS

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ELECTRONIC *by Erie*

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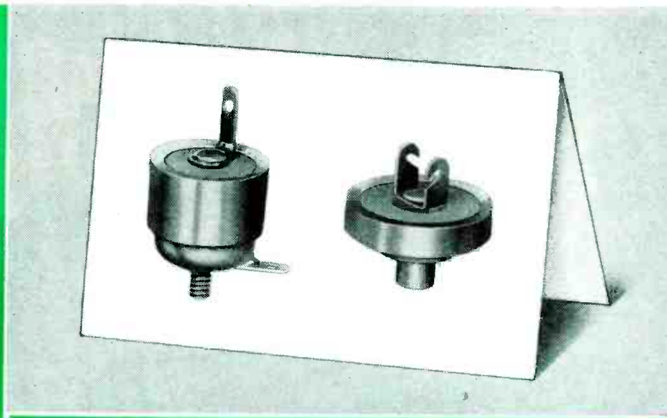
Engineering . . .

Production . . .

ERIE RESISTOR CORPORATION

COMPONENTS
Erie Resistor



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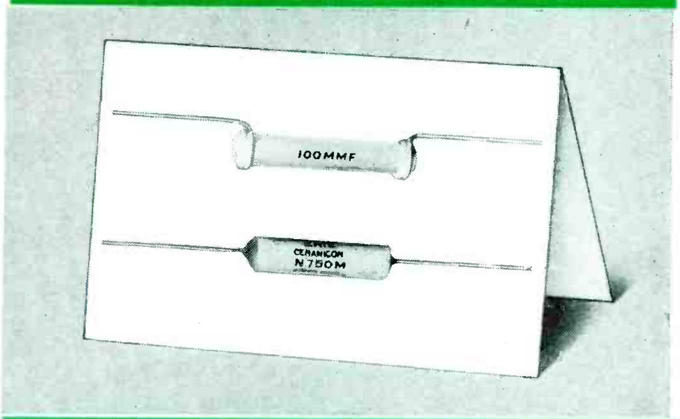
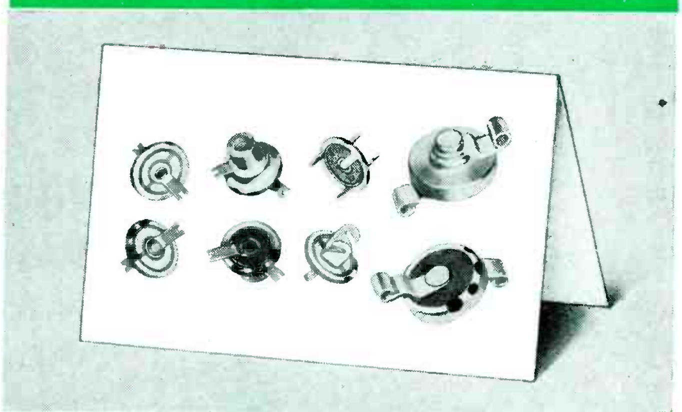
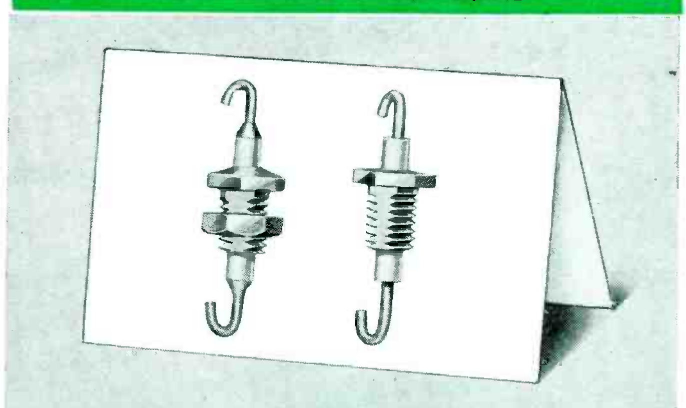


CERAMICONS



ERIE BUTTON SILVER MICAS



FEED-THRU CERAMICONS

Erie Resistor has made many contributions to the progress of the Electronic Industry through the development of accurate, dependable components. In 1933, Erie Resistor introduced the first insulated ½ and 1 watt carbon resistors. Three years later, Erie Ceramicons, a new type of silvered ceramic condenser, with definite reproducable temperature characteristics, were made available for American radios. The continued development of this basic principal of construction has kept pace with industry's requirements, with Ceramicon Trimmers and high-voltage transmitting Ceramicons. For V.H.F. and U.H.F. applications, where low series inductance is essential, Erie Resistor developed Button Silver Mica Condensers and Disc Ceramicons.

Behind these developments are the Erie Resistor Engineers who have also designed most of the automatic machinery and other production equipment necessary for the economical manufacture of Erie components. These men have the theoretical knowledge and practical experience necessary for the design of new types of components for F M. and Television. Electric equipment manufacturers are invited to consult with the Erie Resistor engineering department on their condenser and resistor design problems.

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Let's All Back The Attack
BUY WAR BONDS

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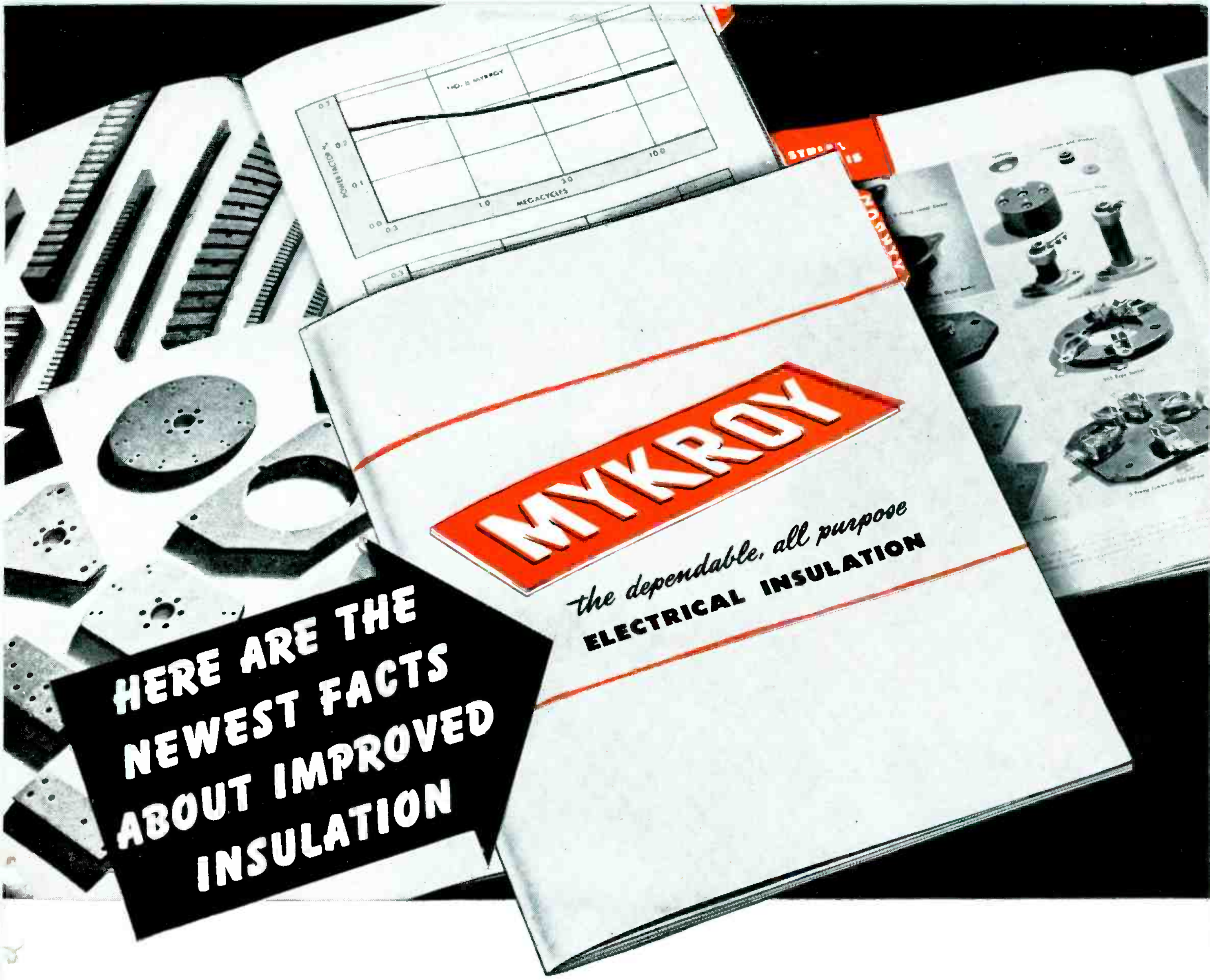

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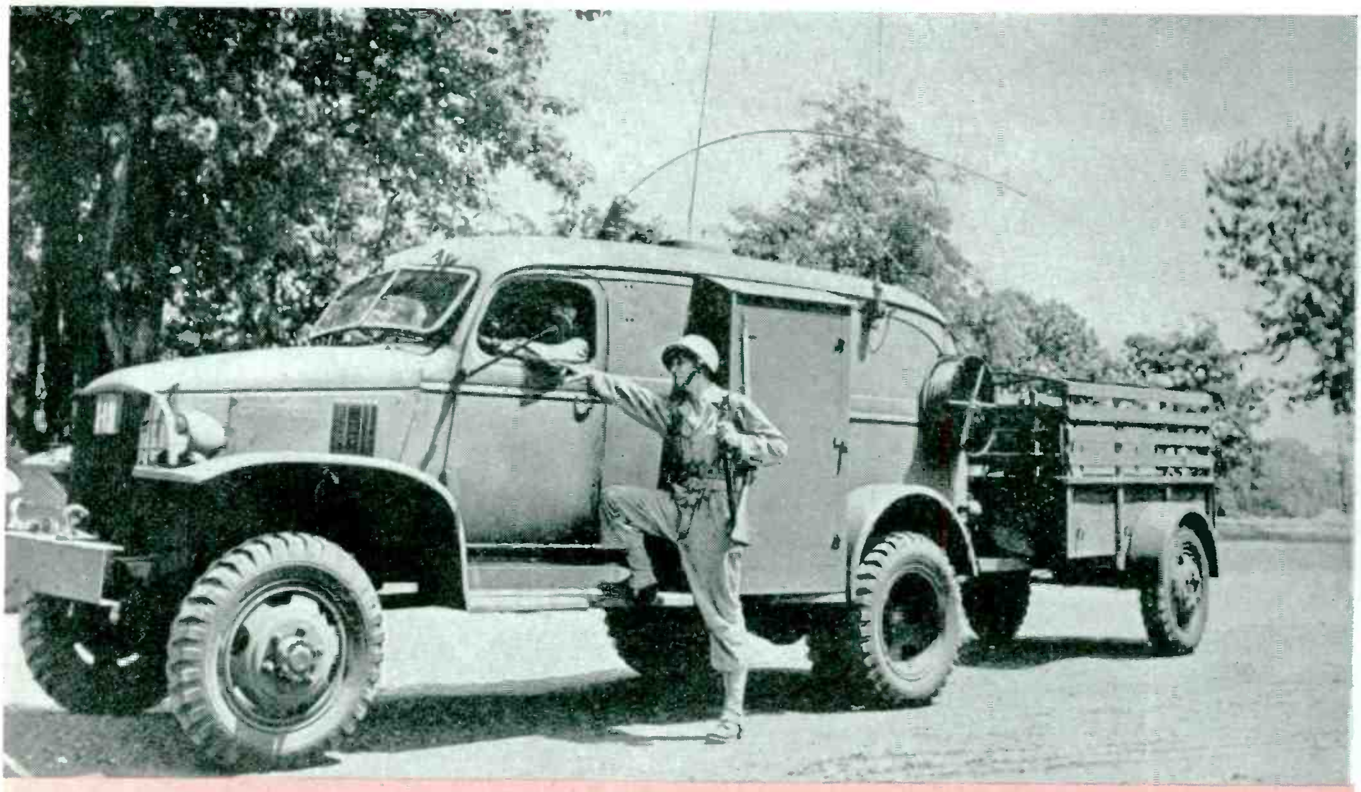

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Compact, powerful equipment in the SCR-299—permits two-way communication while scout car is traveling at high speeds.

American ingenuity and skill have given the Allied Forces another powerful war weapon—the Hallicrafters-built SCR-299, a sturdy, versatile mobile communications unit. In this fast-moving war, with speed and coordination all important, dependable communication plays a vital part.

In the SCR-299 unit, and in many other types of Signal Corps equipment, there are hundreds of feet of Belden wire.

Belden Manufacturing Company
4625 W. Van Buren Street
Chicago 44, Illinois

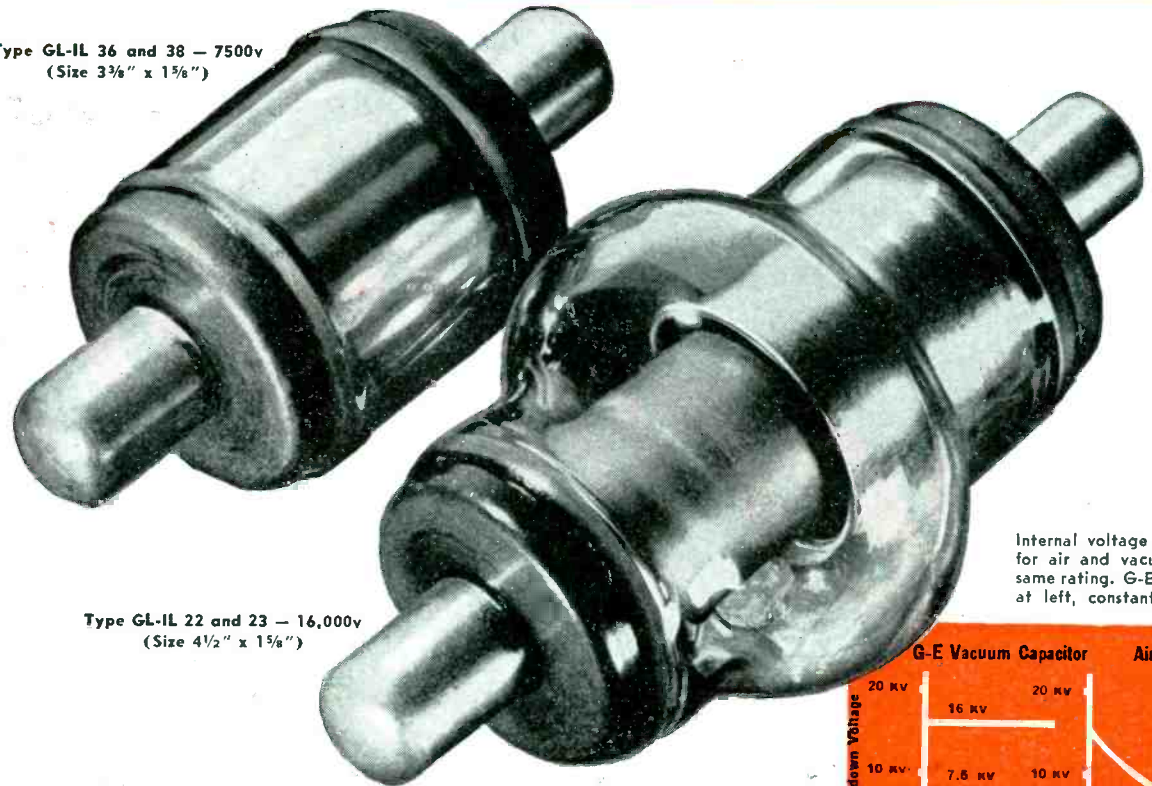
Awarded the U. S. Treasury Special Citation of Merit for initiating the War Bond-or-Cash Dividend Plan

Belden WIRE

FOR RADIO AND COMMUNICATIONS EQUIPMENT

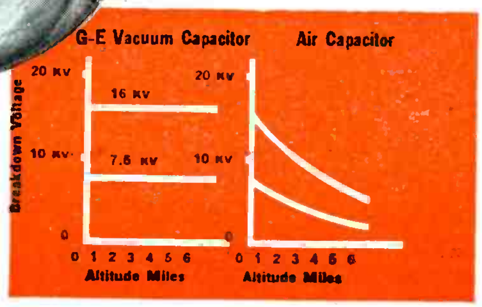
G-E VACUUM CAPACITORS ARE
ONLY ONE-TENTH THE SIZE
OF SIMILARLY RATED AIR CAPACITORS

Type GL-IL 36 and 38 — 7500v
(Size 3⅜" x 1⅝")



Type GL-IL 22 and 23 — 16,000v
(Size 4½" x 1⅝")

Internal voltage breakdown curves for air and vacuum capacitors of same rating. G-E vacuum capacitor at left, constant at all altitudes.



SMALL HIGH-CAPACITANCE UNITS

another G·E electronic FIRST!

Maintaining a long and constantly growing record of electronic "firsts," General Electric has pioneered and developed a new, unique line of vacuum capacitors having high capacitance heretofore considered impractical.

G-E vacuum capacitors are made respectively for peak voltages of 7500 and 16,000 in capacitances of 12, 25, 50 and 100 mmfd.

The remarkably small size of these G-E capacitors permits the compactness of design which is so important in circuits (especially high-frequency) common in military, aircraft, and amateur radio equipment.

Other advantages: Since there is no heating in the vacuum dielectric, and the total capacitance is lumped into a volume of about 1 cu. in., G-E vacuum capacitors are virtually loss-free. Internal voltage breakdown is constant, and is independent of altitude, temperature, humidity. Dust and other foreign matter have no effect on them. Stemless, electronically welded construction gives great rigidity. Savings in critical materials are reflected in lower costs.

A G-E "first" in industry, too! G-E vacuum capacitors are ideal in electronic heating apparatus where high voltages and heavy currents are present. No mica to deteriorate under heavy stresses; no dielectric losses due to dirt, moisture, and other factors! No large, cumbersome capacitor device is necessary—since these capacitors may be used in parallel with each carrying its share of the heavy current.

Write Today for Bulletin ET-2—"G-E Vacuum Capacitors." It includes nomographs to help you select the right capacitor for the job. Address *Electronics Department, General Electric, Schenectady, N. Y.*

• Tune in "The World Today" every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday listen to the G-E "All Girl Orchestra" at 10 P. M. E.W.T. over NBC.

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

GENERAL ELECTRIC

161-C3

COMPLETE G-E EQUIPMENT

for wide-range, high-fidelity FM broadcasting

1. *FM Broadcast Transmitter.* G-E two-section 1000-watt transmitter, consisting of basic 250-watt exciter and 1000-watt radio frequency amplifier. Others from 250-watt to 50-kw ratings.

2. *FM Broadcast Antenna.* Circular type — an exclusive G-E development. Easy to tune and adjust — increased power gain.

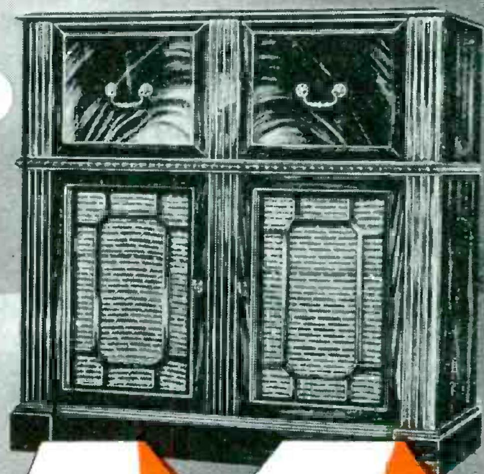
3. *FM S-T Relay Transmitter* (25 watts) for relaying, *without* wires, local studio programs to remotely located broadcast transmitter station.

4. *FM Station Monitor* for checking center frequency, percentage modulation, and fidelity.

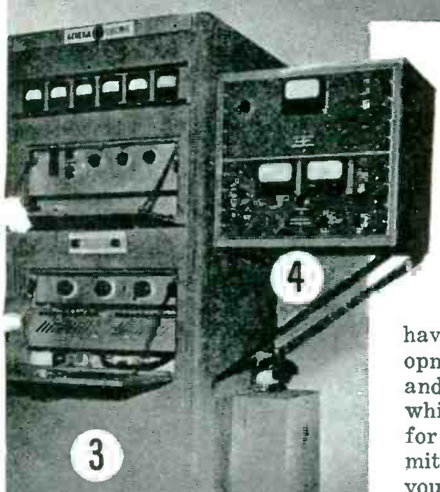
5. *FM S-T (studio-to-transmitter) Directional Relay Antenna* that provides a 100-fold power gain when used at both the studio and station transmitters.

6. *FM Receiver.* Full fidelity FM with noise levels as low as the circuits themselves and less than 2% distortion.

7. *Transmitter Tubes.* Developed from a long list of G-E basic electronic-tube "firsts," G-E transmitter tubes carry the definite assurance of maximum economy, efficiency and service life.



for FM



WHEN you start planning your post-war FM station, make full use of General Electric's broad FM experience and "know how."

You can have the full benefit of the background and knowledge of the *only* manufacturer with experience in building the *complete* FM system . . . from transmitter right through to home receiver. You can have the full benefit of exclusive G-E developments such as the FM circular antenna, and the studio-to-transmitter relay system which enables you to establish your studio for maximum convenience and your transmitter for maximum coverage. And, when you install your G-E equipment, we will put on an aggressive FM receiver sales campaign in your area to help you establish your station and to broaden your listening audience.

General Electric's own FM broadcasting experience, which includes more than 3 years of programming through its own proving-ground station WGFM, will give you valuable programming information.

General Electric equipment is installed in more than a third of all the commercial FM broadcast stations now in operation; and six exclusive G-E *S-T* relays, with thousands of hours of continuous broadcast operation, are now serving their stations. These provide examples where practical operating and maintenance costs are a matter of record.

Thus does widespread *proof of performance* supplement the years of development and engineering that have made G. E. unquestionably the leader in FM radio equipment.

50 FM STATIONS ON THE AIR
80 APPLICATIONS PENDING

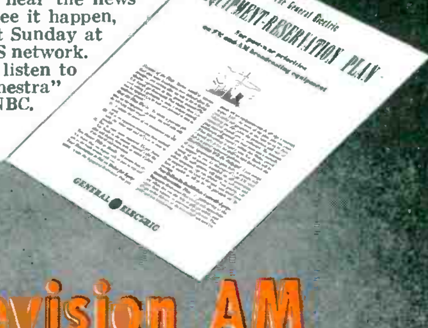
NOW IS THE TIME TO PLAN YOUR POST-WAR FM STATION

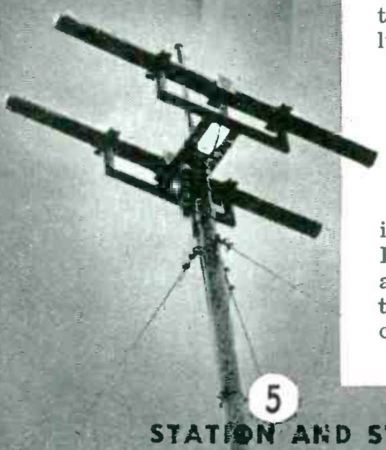
Write for "How to Plan an FM Station," along with other helpful booklets and bulletins on how other broadcasters established themselves; on FM transmitters, antennas, and associated equipment.

Reserve your post-war FM equipment now

General Electric offers you "The G-E Equipment-Reservation Plan." This plan will help you secure your place in radio broadcasting post-war. It will enable you to establish a *post-war priority* on a broadcast transmitter and associated equipment. It will enable us to plan definitely for quick post-war deliveries. Write for "The G-E Equipment-Reservation Plan"—address *Electronics Department, General Electric, Schenectady, N. Y.*

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





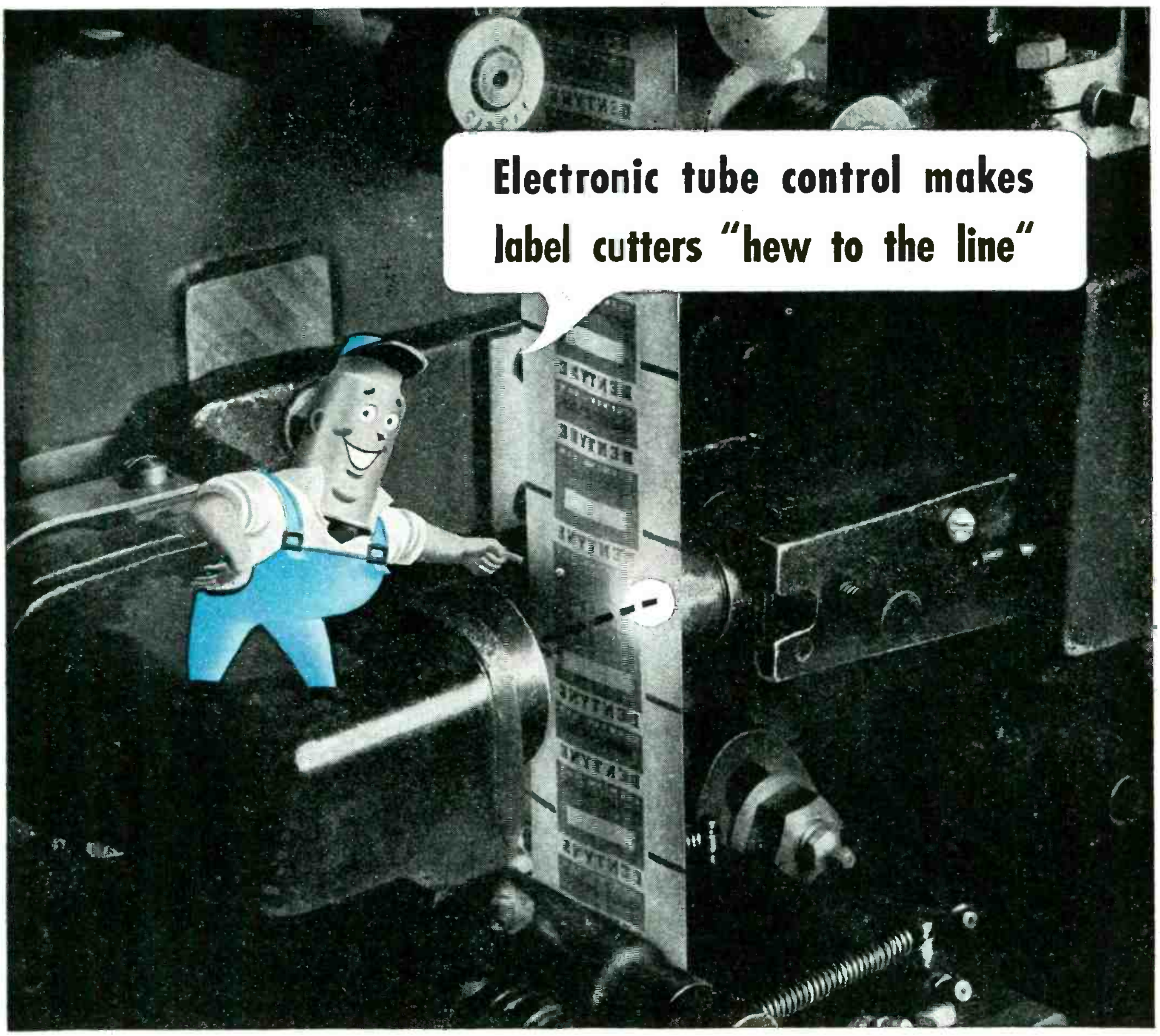
STATION AND STUDIO EQUIPMENT • TRANSMITTERS
ANTENNAS • ELECTRONIC TUBES • HOME RECEIVERS

GENERAL ELECTRIC **FM television AM**

160-C6

See G.E. for all three!

No. 11 IN A SERIES EXPLAINING THE USES OF ELECTRONIC TUBES IN INDUSTRY



The G-E phototube and G-E thyratron are the electronic tubes used in synchronizing the operation of this packaging machine.

Here the G-E phototube is being used in a photo-electric relay control—to eliminate cumulative errors in label-cutting register caused by slippage, shrinkage or stretching of paper. It makes possible the use of a continuous web of paper (instead of individual precut sheets) with complete accuracy.

As the web rolls through the processing machine, the phototube scans the margin for the register marks, and—in co-operation with the thyratron tube—gives the command to "CUT" at precisely the right instant. (Subsequent operations of the machine wrap and package the individual sticks of gum.)

The G-E phototube is exceptionally versatile. It can operate with transmitted or reflected light; on transparent, opaque, dull, glossy, shiny, or colored material. . . . Its applications in counting, sorting, and inspection jobs are unlimited.

The phototube is only one of a complete line of G-E electronic tubes now working for industry on innumerable jobs and many kinds of machinery. It is the purpose of G-E electronic tube engineers to aid any manufacturer of electronic devices in the application of tubes. Through its nation-wide distributing system, General Electric is also prepared to supply users of electronic devices with replacement tubes.

"HOW ELECTRONIC TUBES WORK"

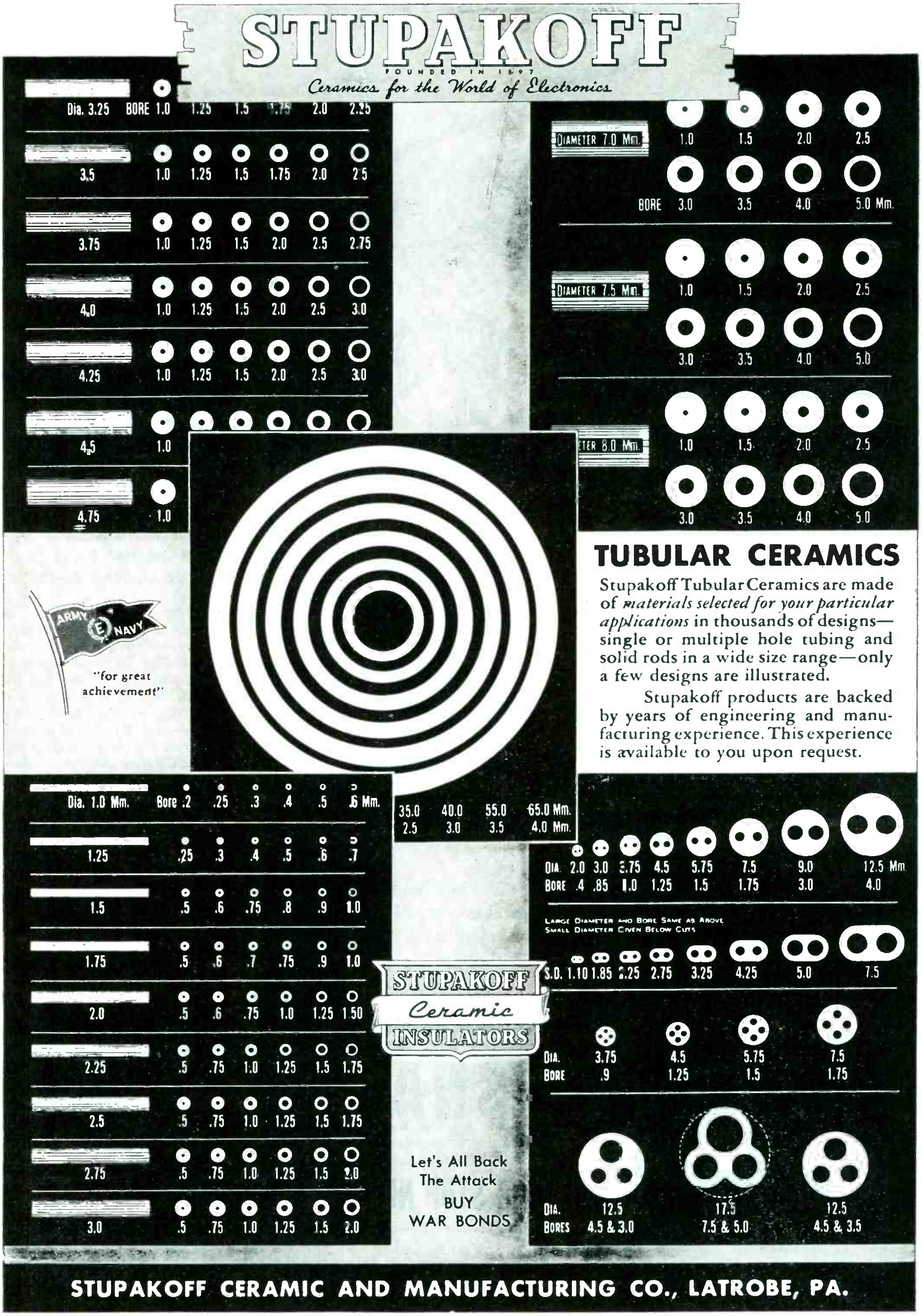
This booklet will be mailed to you *without charge*. Its 24 pages are interestingly illustrated and written in easily understood language. Shows typical electronic tubes and their applications. Address *Electronics Department, General Electric, Schenectady, N. Y.*

• *Tune in* "The World Today" *and hear the news direct from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday listen to the G-E* "All Girl Orchestra" *at 10 P.M. E.W.T. over NBC.*

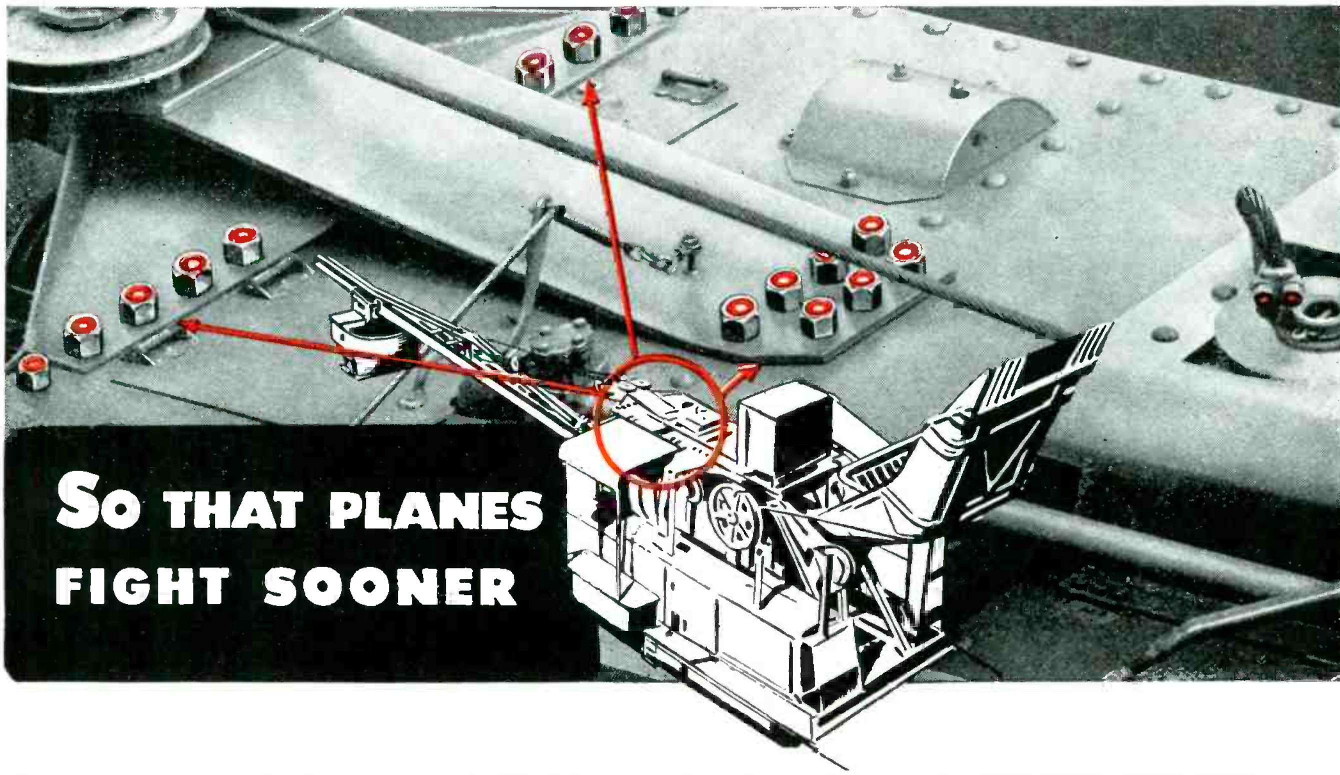
G.E. HAS MADE MORE BASIC ELECTRONIC TUBE DEVELOPMENTS THAN ANY OTHER MANUFACTURER

GENERAL ELECTRIC

162-C3



STUPAKOFF
FOUNDED IN 1897
Ceramics for the World of Electronics
Dia. 3.25 BORE 1.0 1.25 1.5 1.75 2.0 2.25
3.5 1.0 1.25 1.5 1.75 2.0 2.5
3.75 1.0 1.25 1.5 2.0 2.5 2.75
4.0 1.0 1.25 1.5 2.0 2.5 3.0
4.25 1.0 1.25 1.5 2.0 2.5 3.0
4.5 1.0
4.75 1.0
DIAMETER 7.0 Mm. 1.0 1.5 2.0 2.5
BORE 3.0 3.5 4.0 5.0 Mm.
DIAMETER 7.5 Mm. 1.0 1.5 2.0 2.5
3.0 3.5 4.0 5.0
ETER 8.0 Mm. 1.0 1.5 2.0 2.5
3.0 3.5 4.0 5.0
TUBULAR CERAMICS
Stupakoff Tubular Ceramics are made of materials selected for your particular applications in thousands of designs—single or multiple hole tubing and solid rods in a wide size range—only a few designs are illustrated.
Stupakoff products are backed by years of engineering and manufacturing experience. This experience is available to you upon request.
ARMY E NAVY
"for great achievement"
35.0 40.0 55.0 65.0 Mm.
2.5 3.0 3.5 4.0 Mm.
Dia. 1.0 Mm. Bore .2 .25 .3 .4 .5 .6 Mm.
1.25 .25 .3 .4 .5 .6 .7
1.5 .5 .6 .75 .8 .9 1.0
1.75 .5 .6 .7 .75 .9 1.0
2.0 .5 .6 .75 1.0 1.25 1.50
2.25 .5 .75 1.0 1.25 1.5 1.75
2.5 .5 .75 1.0 1.25 1.5 1.75
2.75 .5 .75 1.0 1.25 1.5 2.0
3.0 .5 .75 1.0 1.25 1.5 2.0
DIA. 2.0 3.0 3.75 4.5 5.75 7.5 9.0 12.5 Mm.
BORE .4 .85 1.0 1.25 1.5 1.75 3.0 4.0
Large Diameter and Bore Same as Above
Small Diameter Given Below Cuts
S.D. 1.10 1.85 2.25 2.75 3.25 4.25 5.0 7.5
STUPAKOFF
Ceramic
INSULATORS
DIA. 3.75 4.5 5.75 7.5
BORE .9 1.25 1.5 1.75
Let's All Back
The Attack
BUY
WAR BONDS
DIA. 12.5 17.5 12.5
BORES 4.5 & 3.0 7.5 & 5.0 4.5 & 3.5
STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.



RANSOME pavers built American highways. Now they are rushing airports along our battle fronts.

Every hour of construction time they can save gives that much advantage to our fighting airmen.

Paving is a shattering job. And it used to be accepted that frequent take-ups and tightening were part of paver maintenance.

But no more! Not since Ransome began using Elastic Stop Nuts—the nuts that stay put.

Now the paver keeps on the go longer, and our planes fight sooner.

The reason Elastic Stop Nuts hold tight in spite of wracking vibration lies in the elastic collar in their tops. This snuggles close around the bolt threads, grips them and prevents the nut from turning and loosening.

Countless fastening problems lie ahead in the coming days of peace. Many of them will be solved successfully with Elastic Stop Nuts. Products will be safer, and longer-lasting. Production equipment will stay at work with less maintenance.

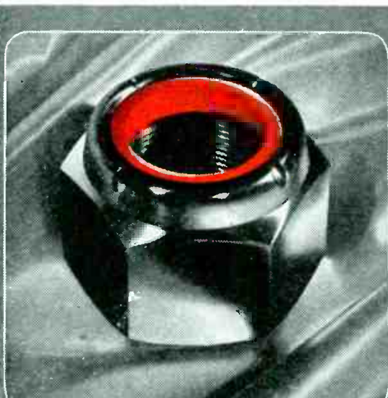
If you are faced with a fastening problem, feel free to call upon us. Our engineers will gladly help you solve it and suggest the proper Elastic Stop Nut.

ELASTIC STOP NUTS HELP BIG, BUSY RANSOME PAVERS DO MANY VITAL WAR JOBS

"Concrete road pavers are subjected to tough, grueling work, especially on twenty-four-hours-a-day service, for which many Ransome Pavers have been called upon in the construction of airport runways since the war started. All told, there are about 1,200 Elastic Stop Nuts used on every Ransome Paver we build. By substituting Elastic Stop Nuts for the ordinary kind, we are helping the Ransome Paver owner minimize his maintenance job because the nuts are self-locking and vibrationproof. No time out for tightening—no extra hours of labor to take up slack. Elastic Stop Nuts also simplify our shop assembly job. They are a further contribution to the improvement of our paver, which is our constant goal."

J. B. Faber Chief Engineer

RANSOME MACHINERY CO., DUNELLEN, N. J.
Subsidiary of Worthington Pump and Machinery Co.

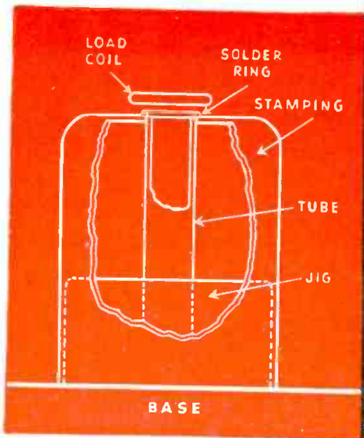


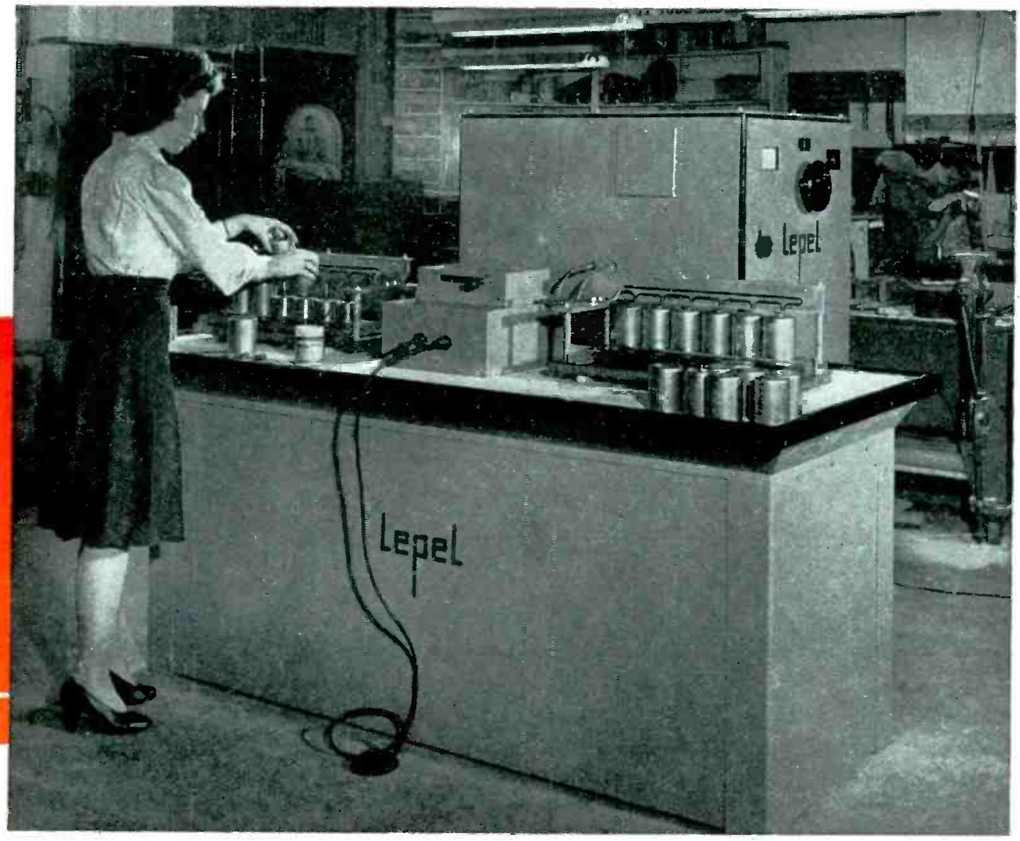
ESNA
TRADE MARK OF
ELASTIC STOP NUT CORPORATION
OF AMERICA

ELASTIC STOP NUTS

Lock fast to make things last

UNION, NEW JERSEY AND
LINCOLN, NEBRASKA





Lepel Induction Heating performs the most intricate soldering jobs-FASTER, BETTER, and at LOWER COST

Here is a set-up designed by Lepel engineers, to cut the time and cost of silver-soldering a 5/8″ tube 3¾″ long inside a cup-shaped stamping 3″ diameter by 3¾″ deep.

Jigs hold the parts in position for soldering. After they are fluxed, pre-formed rings of silver solder are placed in position and heat is applied by the specially-designed high frequency load coils.

As the heating cycle is automatically controlled, six assemblies can be soldered at one time, the operator placing the parts, fluxing and positioning the solder rings on six assemblies while another group of six assemblies is being heated. Thus, almost continuous production is attained and costs minimized.

Since the heat is generated within the metal itself, the solder penetrates throughout the seam. Accurate temperature control and concentration of the heat in the seam minimize discoloration.

Lepel Induction Heating solders or brazes all ferrous and non-ferrous metals, using alloys of any melting point. Manual or automatic operation is possible and the work can be synchronized with other operations to provide continuous-flow production.

The same compact, portable Lepel Unit, with simple changes of the load coils, can be used for other soldering and brazing operations or for hardening, annealing, stress-relieving or melting.

Lepel field engineers will gladly study your soldering, brazing or hardening operations and offer suggestions for performing them more efficiently by the Lepel method.

Lepel High Frequency Laboratories, Inc.
Pioneers in Induction Heating
39 West 60th Street New York 23, N. Y.

Lepel

HIGH FREQUENCY INDUCTION HEATING UNITS

Blueprinting

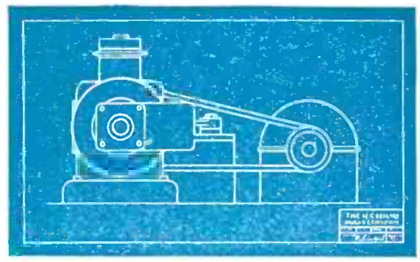
PROVIDES THE BEST OF ALL TRACING REPRODUCTION METHODS

FASTEST . . .

30 feet per minute actual production speed with Pease "22" Continuous Blueprinting and Finishing Machine (not shown) provides quality Blueprints in staggering quantities . . . ON TIME . . . NO WAITING.

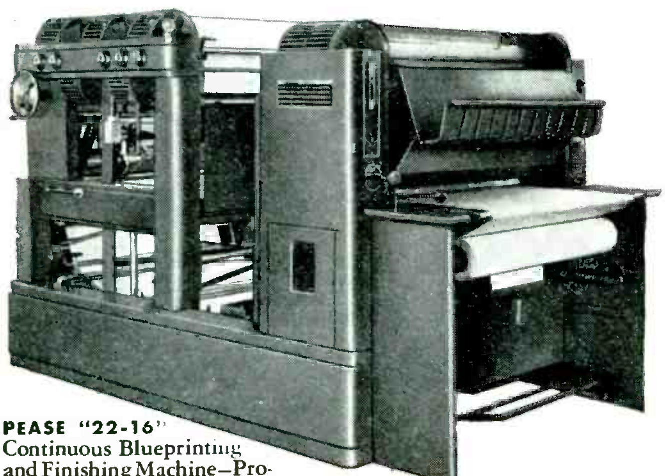
LOWEST COST . . .

As low as a cent (and even less) per square foot of finished Blueprints with Pease Continuous Blueprinting and Finishing Machines . . . much higher with other tracing reproduction methods.



FINEST . . .

Blueprints – sharp white lines on deep blue backgrounds, virtually impervious to dirty finger marks. Blueline prints – sharp blue lines on clear white . . . Both easy to handle, lie flat, conserve filing space. Good Blueprints can be made from old, soiled, worn or torn tracings . . . impossible with other tracing reproduction methods.



PEASE "22-16"
Continuous Blueprinting and Finishing Machine—Production Speed, 20 feet per minute. (Model "22," not shown, has a Production Speed of 30 feet per minute.)

EXCLUSIVE PEASE FEATURES . . .

- **Sliding "Vacuum-like" Contact** smooths out tracings, prevents errors in printing.
- **Three Speed Lamp Control** provides operation at 10, 15, or 20 amperes, minimizes running speed and dryer heat changes.
- **Actinic "No-Break" Arc Lamps** burn for 45 minutes without breaking arc, resume instantaneously.
- **Horizontal "Floating" Water Wash** floats prints free from tension and prevents wrinkles, stains, bleeding.
- **Quick Change Chemical Applicator System** very economically allows change from Blueprints to Negatives in 20 seconds.
- **Eight-inch Diameter Drying Drums,** thermostatically controlled, heated by gas or electricity, dry the prints "flat as hung wallpaper."

VERSATILITY . . .

Pease Continuous Blueprinting and Finishing Machines are not limited to making Blueprints alone. They also produce excellent Blueline prints, Brownprints and Brownline prints . . . together with a Wet Direct Process Developing Attachment they provide a splendid method of making Black and White prints continuously . . . Moreover, when used in conjunction with a dry direct process developing machine they afford a first rate system for making Whiteprints (dry direct process prints).

Ask for a Pease Tracing Reproduction Specialist to help you with your problems. No obligation of course.

THE C. F. PEASE COMPANY

2639 WEST IRVING PARK ROAD • CHICAGO 18

Pease Blueprinting Machines A TYPE AND SIZE FOR EVERY REQUIREMENT INCLUDING DIRECT PROCESS PRINTING AND DEVELOPING MACHINES

TOO GOOD — JUST RIGHT — *NOT SO GOOD*

Admit it. Like any enlightened gentleman, you too are a connoisseur when it comes to women. You can pick 'em; and no fooling. Feminine desirability we leave to you, but we do pride ourselves upon fashioning tubes "just right" for your electronic equipment.

As you know, ideal production would yield only tubes with the exact characteristics required. In practice, Hytron sets close tolerances for all characteristics, and then painstakingly controls production to hit uniformly the centers of those tolerances.

Does it seem strange that Hytron rejects not only tubes "not so good" but also "too good"? Consider a simple example. Mutual conductance is a figure of merit normally desired high. Once your circuit constants have been fixed for a standard tube, however, too great transconductance may give unstable performance.

Hytron strives, therefore, to produce for you tubes which are standardized; uniform tubes which — as originals or spares — will always be *just right* for the wartime radio and electronic applications you design.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON CORPORATION ELECTRONIC AND RADIO TUBES

SALEM AND NEWBURYPORT, MASS.

HYTRON RADIO TUBES

BUY ANOTHER WAR BOND

AAC Quartz CRYSTALS

help keep the communications

BRANIFF AIRWAYS
GREAT LAKES TO THE GULF

CANADIAN PACIFIC
AIR LINES

CHICAGO AND SOUTHERN AIR LINES
C&S
VALLEY LEVEL ROUTE
AIRLINER SERVICE

COLONIAL AIRLINES

CONTINENTAL AIR LINES

DELTA AIR LINES

INLAND AIR LINES

MID-CONTINENT AIRLINES

NATIONAL AIRLINES

NORTHEAST AIRLINES

NORTHWEST AIRLINES

PAA

Panagra

TCA

TWA
GOES ALL THE WAY

WESTERN AIR LINES

ARMY NAVY

Today..and Tomorrow

Illustrated at right is a typical crystal manufactured by Aircraft Accessories Corporation and used in both ground and plane radio installations by America's commercial airlines. Many other types of AAC crystal units are being supplied various branches of the armed service and other government agencies.

Today, practically all AAC facilities are devoted to war production. Tomorrow, advanced AAC electronic developments will be available for the post-war world.

AAC Products

AIRCRAFT

Manufacturers of PRECISION

Burbank, Calif. Kansas

Systems of the World's Greatest Airlines Working Efficiently!

REALIZING the extreme importance placed by the airlines upon the proper maintenance of their communications facilities, Aircraft Accessories Corporation has set aside a special division of its crystal laboratories to provide rapid delivery to airlines and associated communications services of a variety of standard crystals. *Deliveries in limited quantities can be made within a few days* after receipt of purchase order with adequate priority.

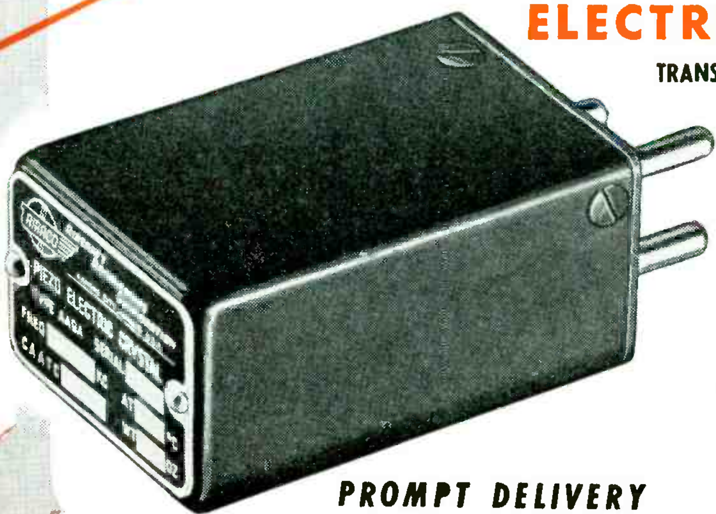
In the manufacture of quartz crystals, AAC development and production engineers employ the experience gained as one of America's largest producers of transmitters and other precision radio equipment. AAC crystal units will meet the most exacting requirements under severe operating conditions. Address all crystal orders and inquiries to Electronics Division, Kansas City, Kansas.

The services of our Engineering Department in designing special equipment are available to you without obligation.

Products of

ELECTRONICS DIVISION

TRANSMITTERS • AIRCRAFT AND TANK ANTENNAS
QUARTZ CRYSTALS • RADIO
TEST EQUIPMENT



Type AA9 Crystal, 2.5 parts/million temperature coefficient, accuracy of carrier frequency .01%. Made in three models—A, G and E, covering total fundamental frequency range of 200 to 10,000 kc. Internal adjustment screw permits small amount of frequency control in the single crystal units, AA9A and AA9G.

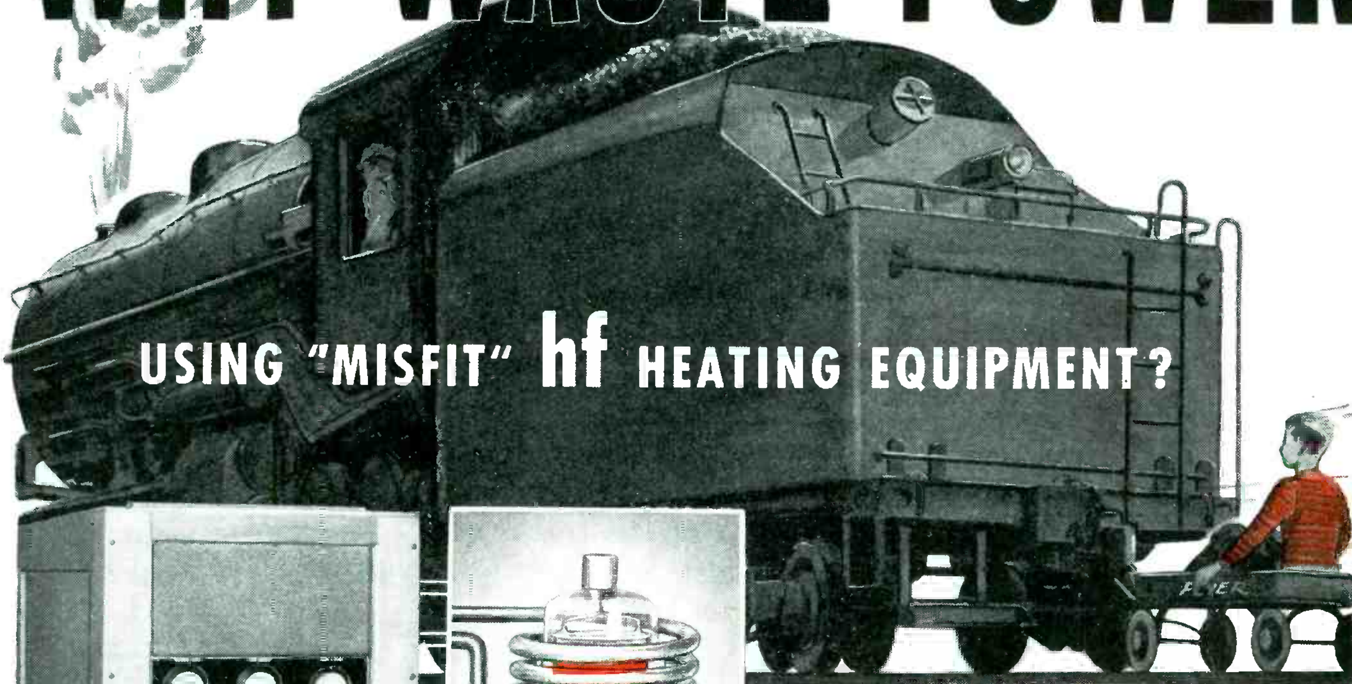
PROMPT DELIVERY

Accessories Corporation

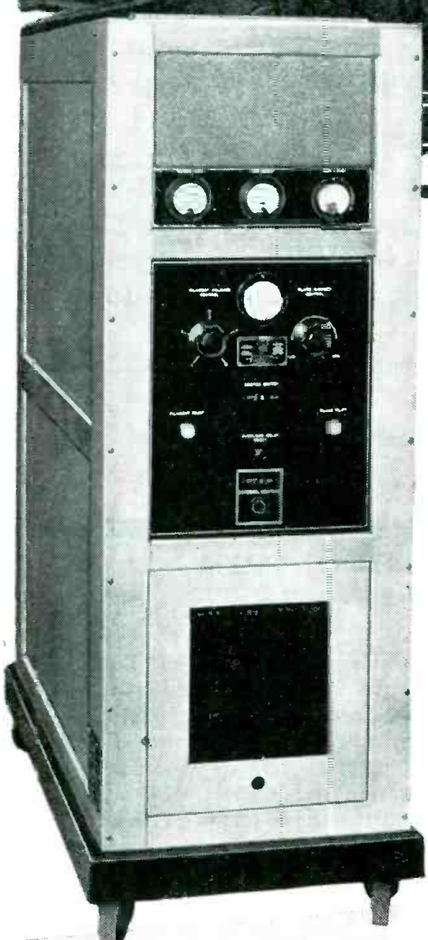
AIRCRAFT EQUIPMENT • HYDRAULICS • ELECTRONICS

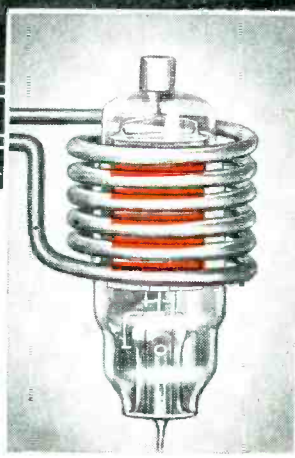
City, Kans. New York, N. Y. Cable Address: AACPRO

WHY WASTE POWER



USING "MISFIT" hf HEATING EQUIPMENT?





IT PAYS TO SELECT A UNIT OF CORRECT FREQUENCY AND POWER FOR *YOUR* APPLICATIONS

Your hf heating unit may bear the name of the most famous maker. But it's a costly white elephant if it can't give you the right FREQUENCY AND POWER combination to do *your* specific heating jobs with maximum electrical efficiency and economy.

For example: when a heating operation can best be done at 5 kw and 22 megacycles, it doesn't make sense to be using 20 kw and a frequency of 500 kc. Why accept a misfit, when you can get a unit tailor-made to *your* specific needs?

Our designs offer wide ranges of power and frequency. We can give you the unit you need, permitting your larger equipment to be released for work more suited to it. Our installations usually pay for themselves many times over during the first year.

Write for detailed information

Our equipment offers you a selection of frequencies up to 300 mc—and the following power range, with stepless control from zero to full load:

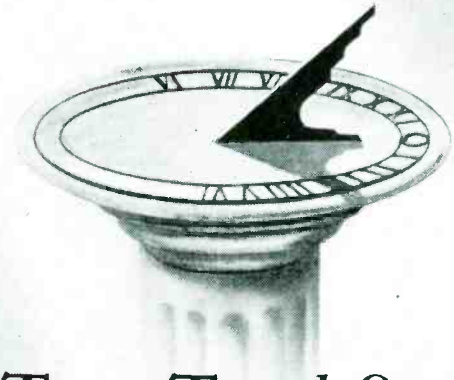
- 5 Kw
- 7½ Kw
- 10 Kw
- 12½ Kw
- 15 Kw
- 18 Kw
- 25 Kw
- 40 Kw
- 100 Kw

Scientific Electric

DIVISION OF "S" CORRUGATED QUENCHED GAP COMPANY

119 Monroe Street Garfield, New Jersey

Designers and Builders of high frequency converters since 1921



The Time-Tested Standard of **QUALITY**

in Resistance Alloys is

Nichrome*

. . . made ONLY by

Driver-Harris

Just as the jeweler's yardstick of quality in gold is "24 karat", the engineer's criterion for judging resistance alloys is "how does it compare with NICHROME*?"

Although there are several excellent nickel and chromium combinations, there is only one NICHROME*. . . and it is made ONLY by Driver-Harris Company.

NICHROME* contains more than a balanced union of nickel and chromium. The extra ingredient is a composite of such quality components as: exclusive agencies or additions to basic formulas . . . expert and precise control of highly technical processes during all manufacturing operations . . . and, of course, our 45 years of specialized knowledge.

To insure dependable performance, long service and the "stamp of quality" in your postwar products, specify NICHROME* and other D-H resistance alloys.

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

D H

SPECIAL PURPOSE ALLOYS SINCE 1899

Driver-Harris
COMPANY

HARRISON, N. J.

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

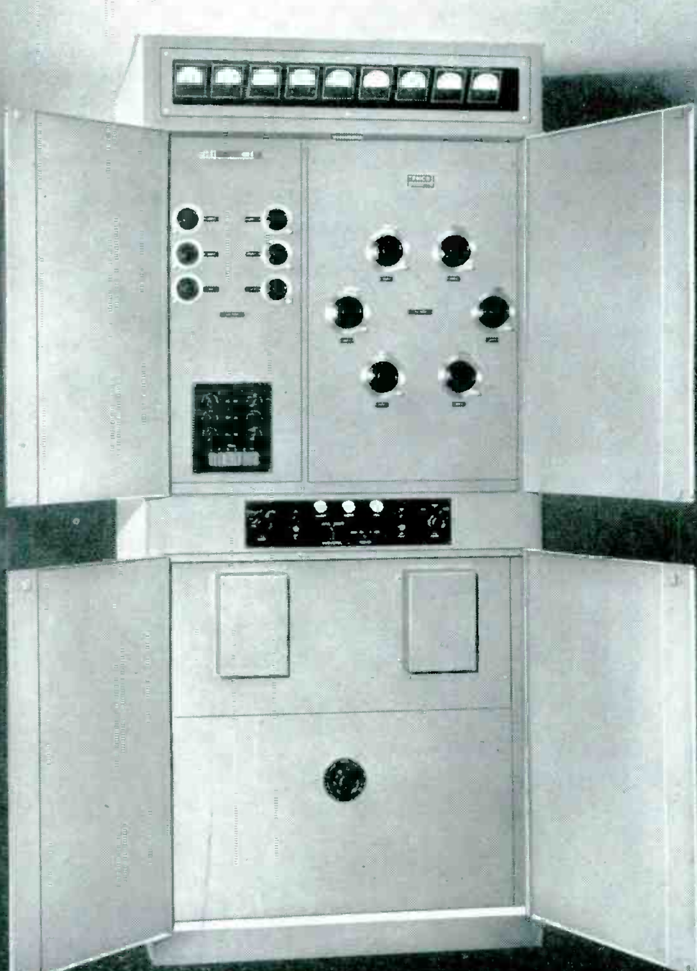
Tested and Proved in War

TO SERVE YOU EFFICIENTLY IN PEACE

Communication equipment by TEMCO has long been outstanding and widely used where utmost dependability is required. Underlying this preference is the fact that TEMCO equipment is engineered and built with the perfectionist's greater investment of time, materials and wiring skill.

TEMCO equipment is proving its better-built qualities in every branch of military and governmental service . . . under the most rigorous wartime conditions.

Fresh from these exacting tests will come new and advanced transmitting equipment by TEMCO, to serve your civilian broadcasting needs with maximum efficiency.



TEMCO Model 250-GSC, 200 watts output, A1, A2, A3 emission; frequency range 2 to 16 megacycles, with provision for 4 crystal controlled frequencies and electron coupled master oscillator.

TEMCO Model 1000-AG-CW—6 frequency motor-driven band changing radio telegraph transmitter. Power output 1000-1200 watts.

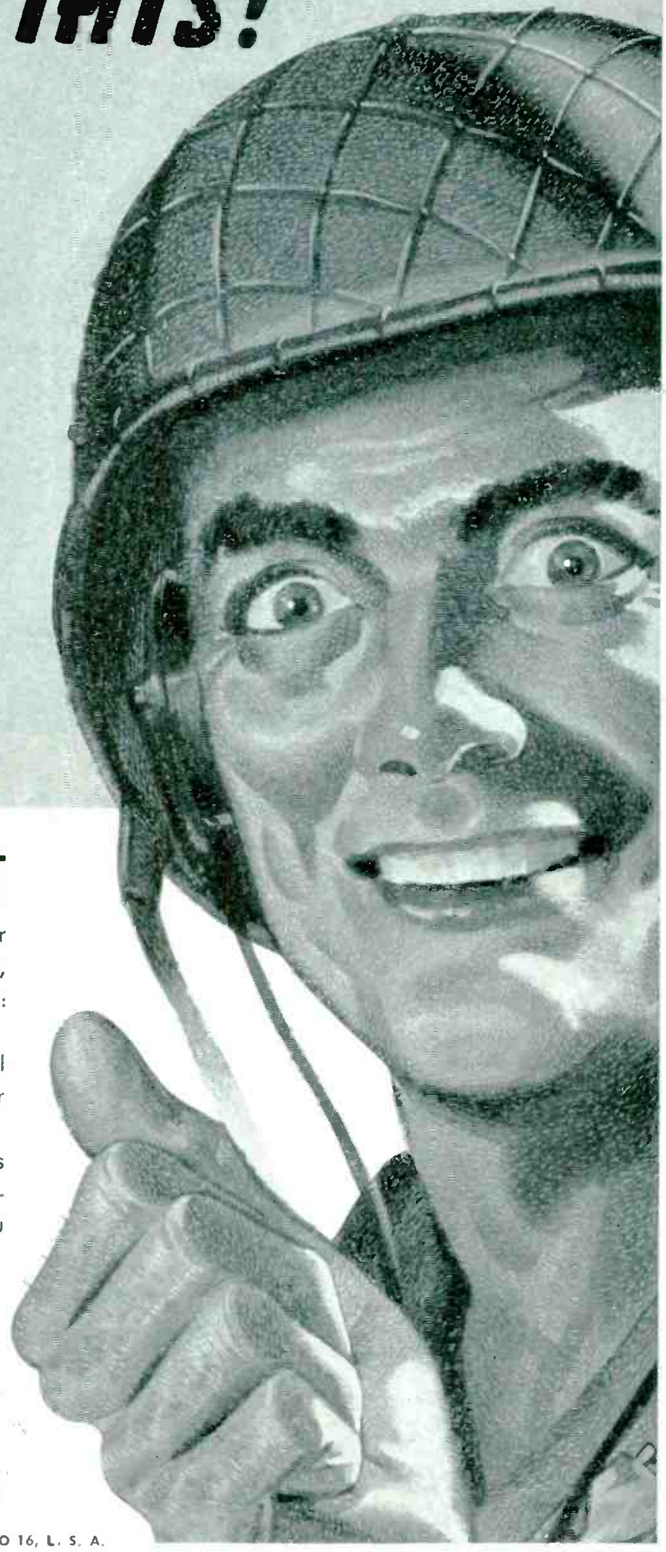
TEMCO

RADIO COMMUNICATION EQUIPMENT

TRANSMITTER EQUIPMENT MFG. CO., INC.

345 Hudson Street • New York 14, N. Y.

Hey Mac—
GET IN ON THIS!



SERVICE MEN...
KEEP SENDING THOSE LETTERS!

"Bill Halligan says that all the contest entries he's received so far have been *swell*—he wants *more* letters tellin' about actual experiences with *all* types of Radio Communications equipment built by Hallicrafters including the SCR-299!"

RULES FOR THE CONTEST

Hallicrafters will give $100.00 for the best letter received during each of the five months of November, December, January, February and March. (Deadline: Midnite, the last day of each month.)

For every serious letter received Hallicrafters will send $1.00 so even if you do not win a big prize your time will not be in vain.

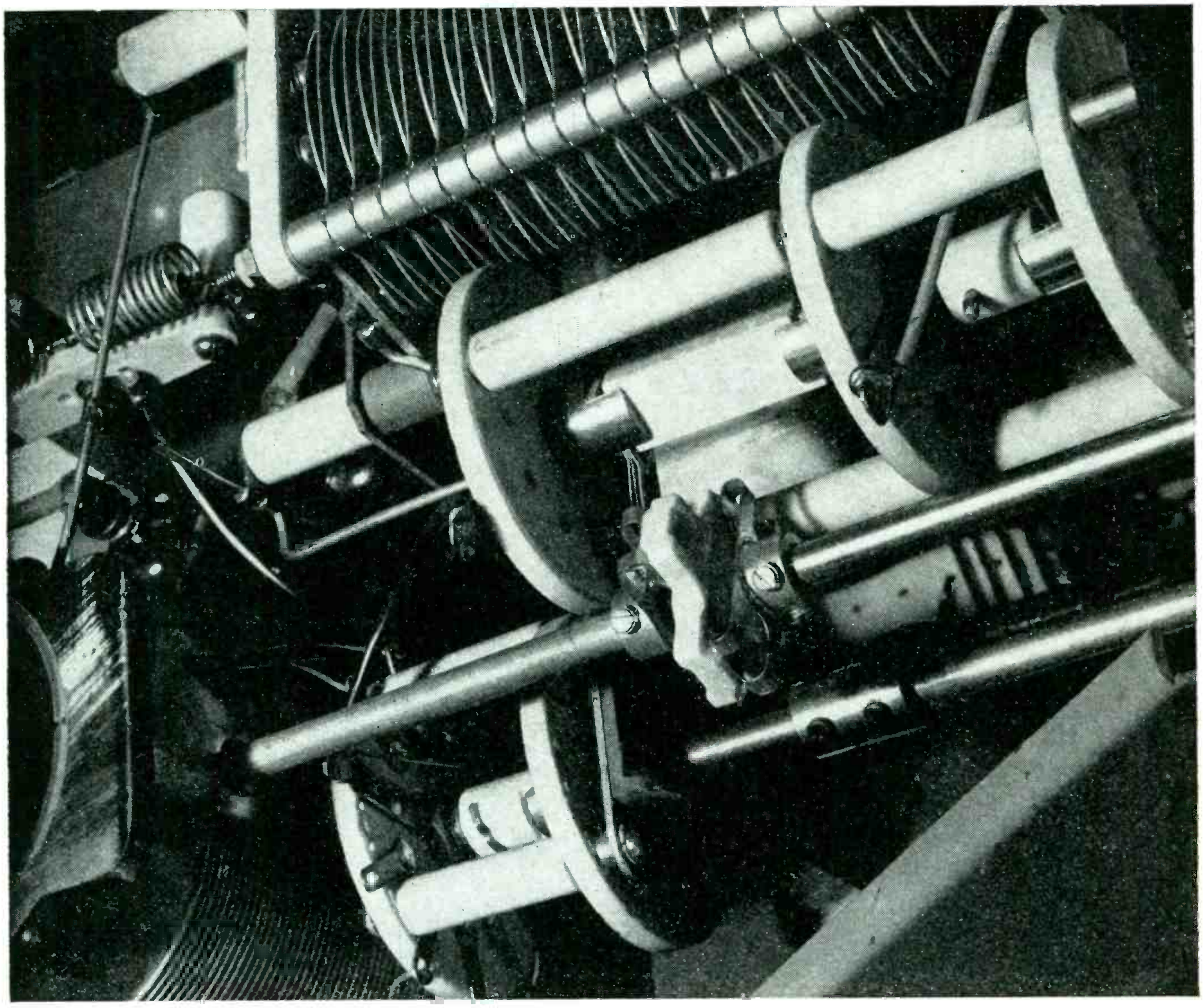
Your letter will become the property of Hallicrafters and they will have the right to reproduce it in a Hallicrafters advertisement. Write as many letters as you wish. V-Mail letters will do.

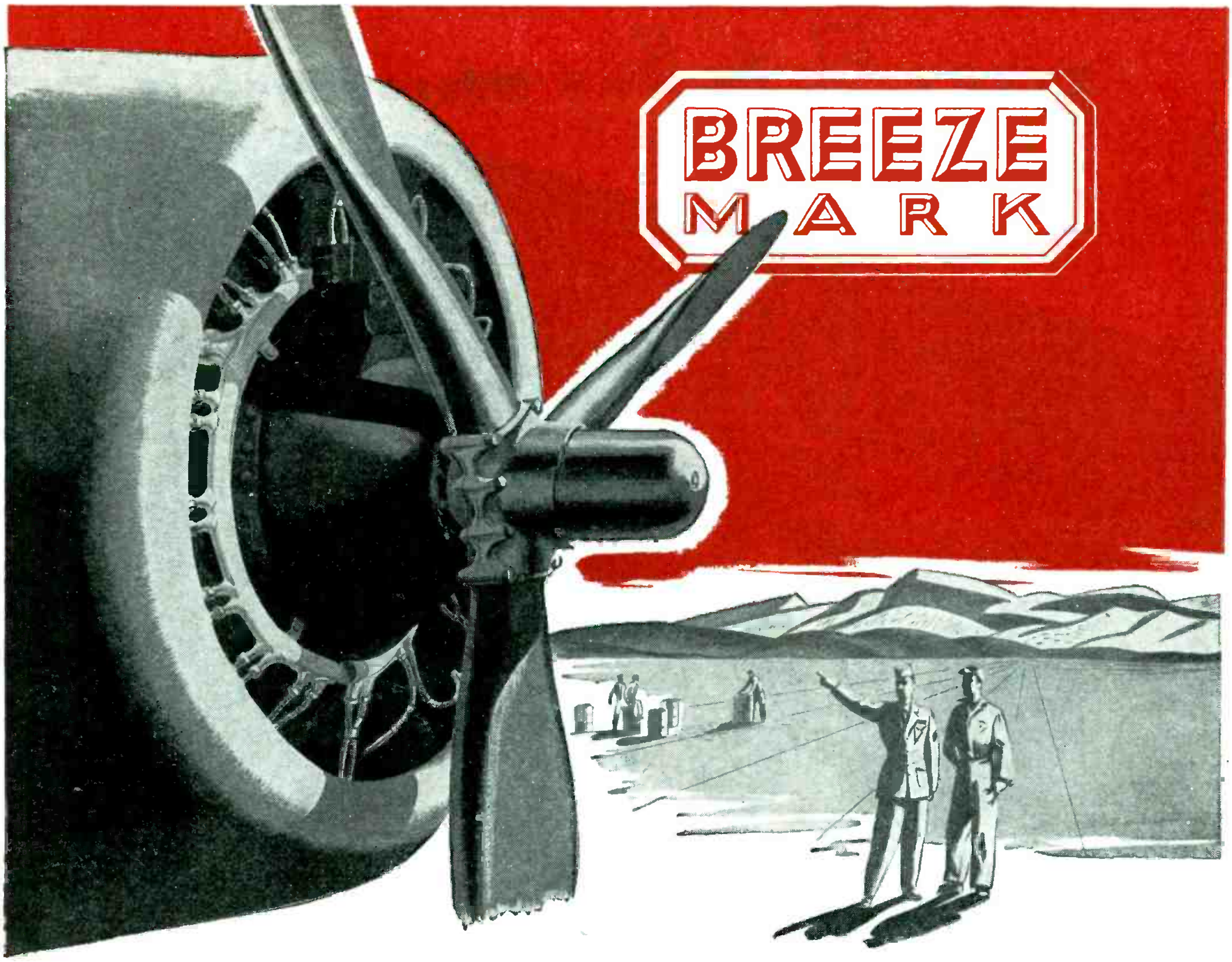
MILITARY REGULATIONS PROHIBIT THE PUBLICATION OF WINNERS' NAMES AND PHOTOS AT PRESENT... MONTHLY WINNERS WILL BE NOTIFIED IMMEDIATELY UPON JUDGING.

BUY MORE BONDS!

hallicrafters RADIO

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





Excerpt from a letter written by a former Breeze worker, now in our armed forces.

While our ship was on the ground, I spied a Breeze ignition shield and told the mech, 'I used to build 'em' He grinned and said, 'Best damn shield there is,' and with that my chest expanded to twice normal. A compliment like that from a motor doc reflects the swell job you folks are doing back home there on the production line. Keep it Up!

-what's in a *Name*

It All Depends on Past Associations and Present Circumstances

There's plenty in a name—when it's the familiar trademark of an old employer, and a man runs across it thousands of miles from home.

It means a lot to him then, because he knows first-hand of the skill and experience that went into the manufacture of the product, of the inspections that it went through before it was judged worthy to wear that trademark.

And then he realizes what that name represents—the pride of a manufacturer in a product, confidence in the future of the enterprise. The trademark becomes a symbol of opportunity for the day when men will resume their places once again in a peacetime world.

That's what's in a name—a reminder of the past and a promise for tomorrow.

Breeze BREEZE MARK
CORPORATIONS, INC.
NEWARK, NEW JERSEY

PRODUCTION FOR VICTORY • PRODUCTS FOR PEACE

EVERY *Electro-Voice* Microphone is

One outstanding Electro-Voice achievement is the Model 7-A, a desk mounting type communication microphone. Designed for and approved by the CAA, this microphone is extensively used for airport landing control in addition to a number of other sound pick-up applications. The smooth frequency curve, rising with frequency, gives extremely high intelligibility, even under the most difficult conditions.

Another . . . the now-famous Model T-45 "Lip Mike"... a noise-cancelling Differential Microphone . . . was designed by Electro-Voice in close collaboration with the Fort Monmouth Signal Corps.

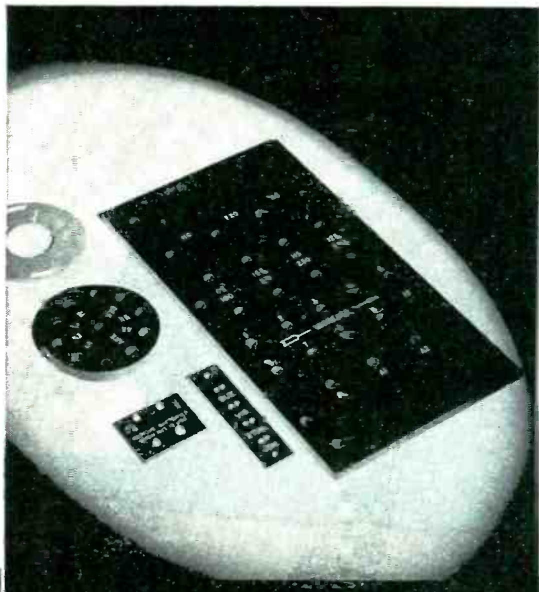
Every Dynamic, Carbon and Velocity Microphone in our complete line is DESIGNED by ELECTRO-VOICE.

We maintain a network of distributors throughout the country. If your limited quantity needs can be filled by any of our Standard Model Microphones, with or without minor modifications, we suggest that you contact your nearest radio parts distributor.

Electro-Voice MICROPHONES

ELECTRO-VOICE MANUFACTURING CO., INC.
1239 South Bend Ave. • South Bend 24, Indiana
EXPORT DIVISION: 13 EAST 40th ST., NEW YORK 16, N. Y.—U. S. A. CABLES: ARLAB

"H HOUR" ON "D DAY" STRIKES—



In instruments of communications of every description, parts of National Vulcanized Fibre and Phenolite, laminated Bakelite, have extensive and varied use. These possess great dielectric strength, lightness in weight and exceptional wearing qualities.

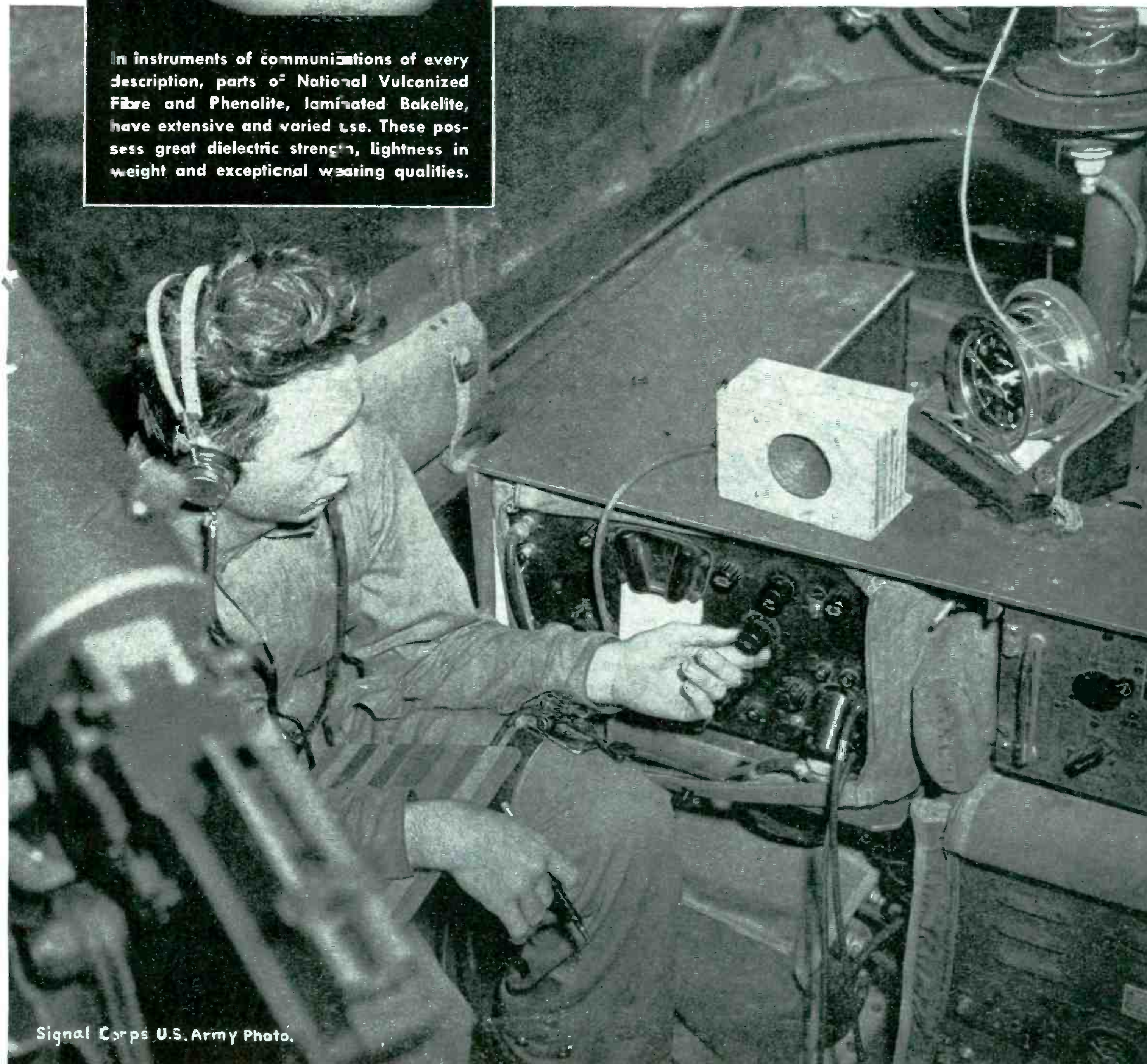
THE attack is on! The army's ears are working full blast! All the circuits are open! From the C.O. to the Ranger's Walkie Talkies, to the plane support, to the tanks, to the artillery, to all the combat teams, back and forth, a surge of communications fills the air. The very success of the advance depends greatly upon countless instruments of communications. Vital in turn, to their flawless performance, are plastics like National Vulcanized Fibre and Phenolite, laminated Bakelite.

We salute the electronic engineers of America who have given to our fighting men at the front the very best in communications.

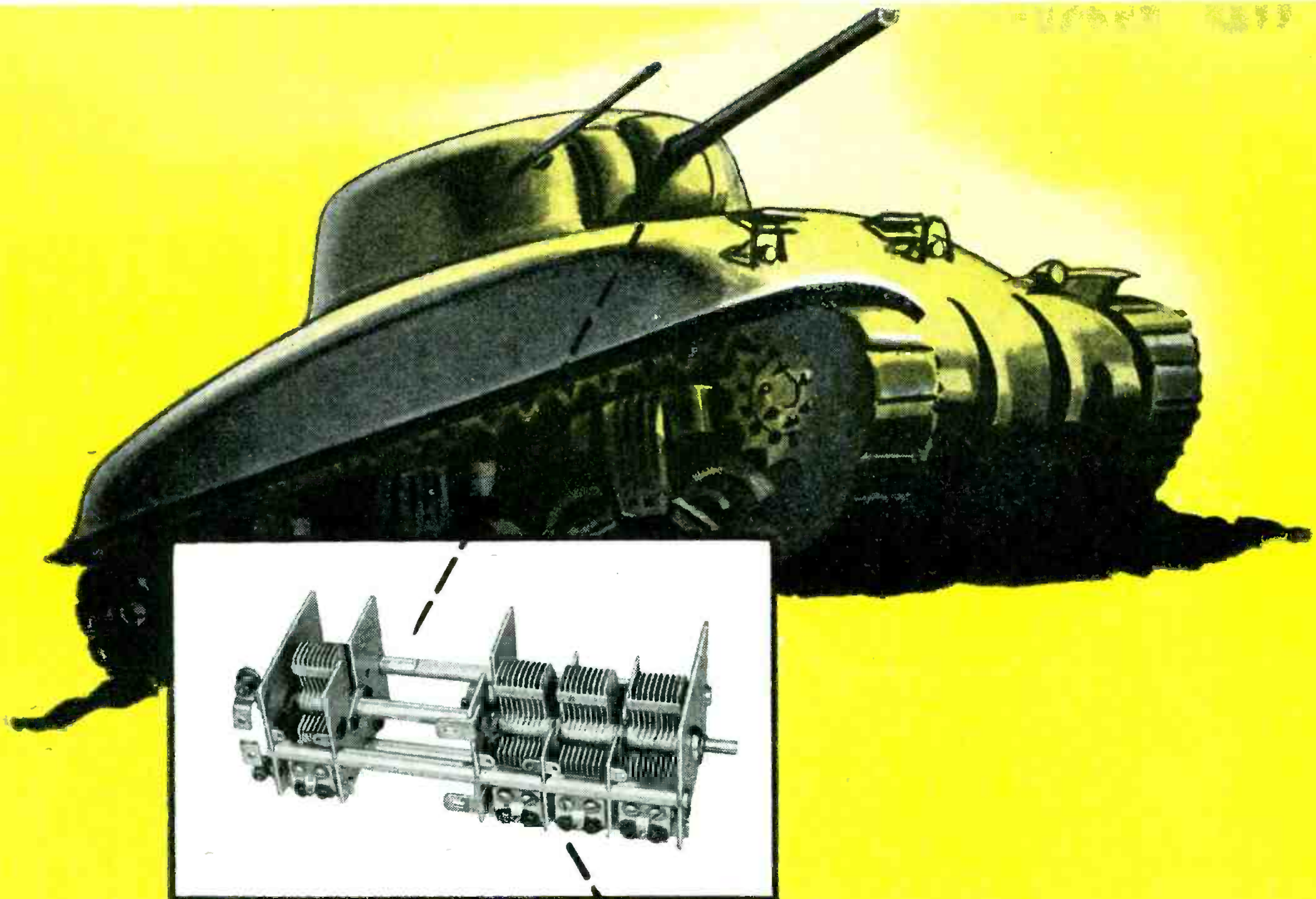
NATIONAL VULCANIZED FIBRE CO.

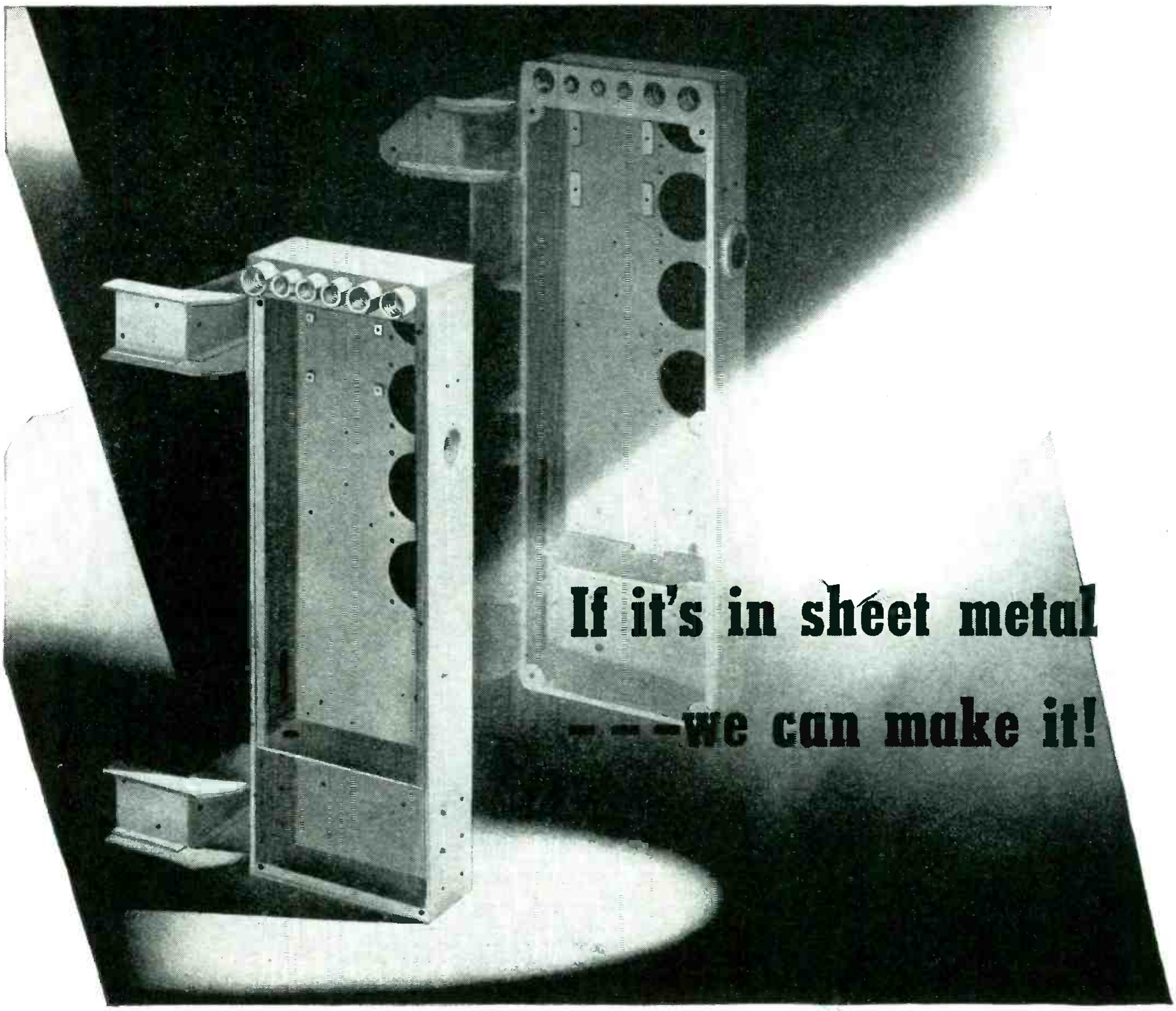
WILMINGTON DELAWARE

Offices in Principal Cities



Signal Corps U.S. Army Photo.





KARP activities

in sheet metal construction are as wide as the electronics field itself. Our facilities include hundreds of dies which may be utilized to cut your own die costs or, perhaps, eliminate them entirely.

An example of the Karp technique is this Junction Box in which are connected all wires operating an anti-aircraft searchlight unit. Originally, this Junction Box was made of cast aluminum. Material was scarce. Experienced machine shop mechanics and machine tools were difficult to obtain. It was our job to convert from cast aluminum to sheet steel. These are the results:

- The Karp-made sheet steel Junction Box is stronger, lighter weight, better looking.
- Critical material is saved, costs reduced, deliveries expedited.
- Since Karp technicians are trained to reduce the solution of an assignment to the simplest, most efficient and most economical form, man hours — and man-power—are saved.
- A sheet metal product is being produced with standard equipment without any special dies.

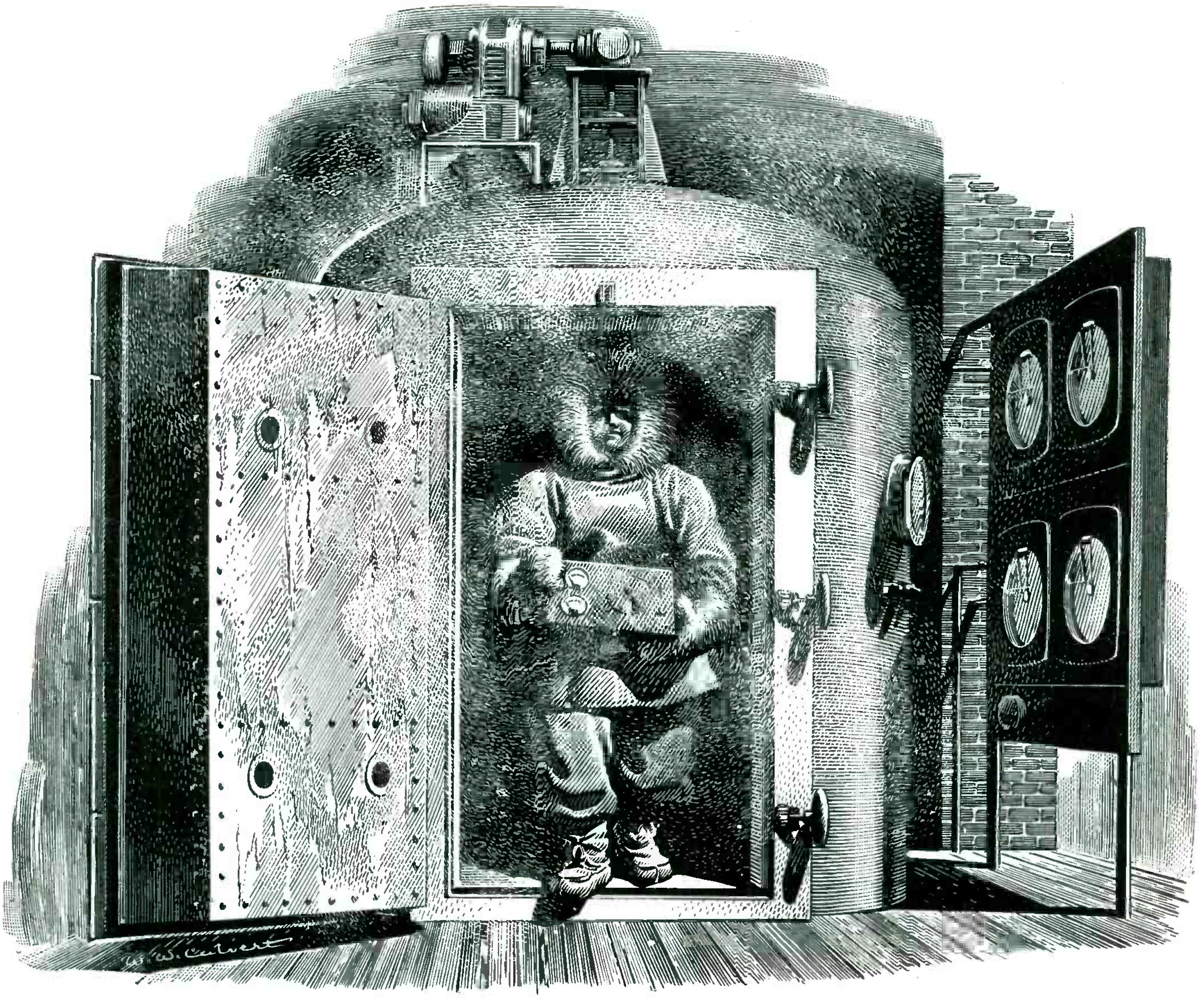
If it's in sheet metal . . . we can make it. The scope of our service can by no means be anticipated in printed literature. What we can do can only be told when we know your individual problem.

ARTISANS IN SHEET METAL

KARP METAL PRODUCTS CO., INC.
124 30th STREET • BROOKLYN 31, N. Y.

CABINETS
CHASSIS
RACKS
PANELS

HELP SHORTEN THE WAR . . . . KEEP BUYING MORE WAR BONDS



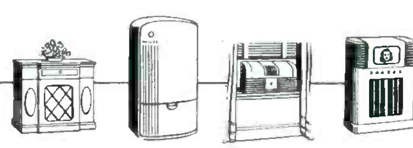
13 Miles above the ground . . .
in a Philco Refrigeration Laboratory!

Philco REFRIGERATION engineers solve a tough problem in the production of military equipment . . . another example of how Philco's vast facilities for research and production are serving our armed forces.

AT Philco, airborne electronic equipment and aircraft radios pass the stratosphere test—of thin air and sub-zero temperatures—*in the laboratory.*

This ingenious high altitude chamber faithfully duplicates every condition of temperature and pressure from sea level up to 70,000 feet! When aircraft equipment can maintain absolute accuracy and dependability at 70° below zero, with air pressure 1/20 of normal—it's *right!* And *only* when it's right does it leave the Philco plant.

The stratosphere chamber is just *one* of many instances in which the skill and experience of Philco refrigeration engineers have supplied the answer to the most difficult war production problems. It's an example, too, of the precision and quality which, after the war, will again make Philco refrigerators and air conditioners *first* in engineering, *first* in convenience, *first* in advanced design!



After Victory, Philco peacetime products will offer the highest advancements of modern science for the homes and industries of America.

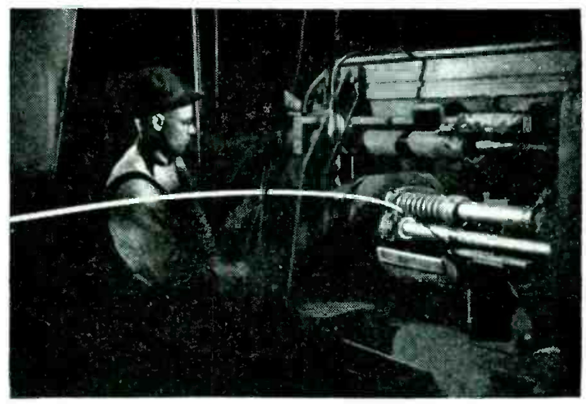
PHILCO
CORPORATION


The Chicago Telephone Supply Company has specialized in variable resistors for more than 15 years.
Today, all manufacturing facilities are devoted to winning the war.
Tomorrow, Chicago Telephone Supply will continue to serve the electronic industries with the quality workmanship and the service they have known during the years.
Manufacturers of Quality Electro Mechanical Components Since 1896
Plugs, Jacks, Switches, Variable Resistors
Telephone Generators and Ringers
CTS
Representatives
R. W. Farris
2600 Grand Avenue
Kansas City 8, Missouri
Phone: Victory 3070
Frank A. Emmet Co.
2837 West Pico Boulevard
Los Angeles 6, California
CHICAGO TELEPHONE SUPPLY
Company
Branch Offices
S. J. Hutchinson, Jr.
401 North Broad Street
Philadelphia 8, Pennsylvania
Phone: Walnut 5369
In Canada
C. C. Meredith & Co.
Streetsville, Ontario
ELKHART ★ INDIANA

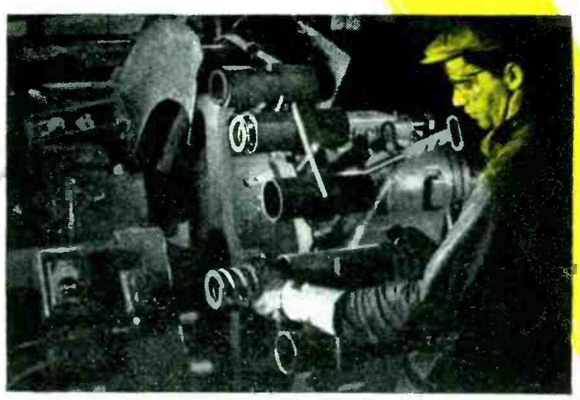
"HOW DOES MUEHLHAUSEN MAKE THOSE
SUPER-SIZE SPRINGS?"

Well—it's this way. Those big babies must be coiled hot, to extremely close tolerances . . . and produced in quantity at P-38 speed. It's specialized work that demands very specialized equipment. So—Muehlhausen has one huge plant totally devoted to hot forming. It is all conveyorized. Production is governed by a central laboratory. The quenching tanks are the size of swimming pools, and skyscraper-like shot blasters give springs clean, lustrous finish and added life.

Automatic tapering of bar ends prior to coiling



Precision hot-coiling springs on automatic equipment



Precision grinding squares both spring ends at once

Shipping finished springs in carload lots

To improve product performance, use

MUEHLHAUSEN
Designed
SPRINGS

To really appreciate how your production schedule and product can benefit by these extensive facilities, call Muehlhausen in on your next spring job. Write for new booklet on hot-coiling springs.

MUEHLHAUSEN SPRING CORPORATION
Division of Standard Steel Spring Company
760 Michigan Avenue, Logansport, Indiana

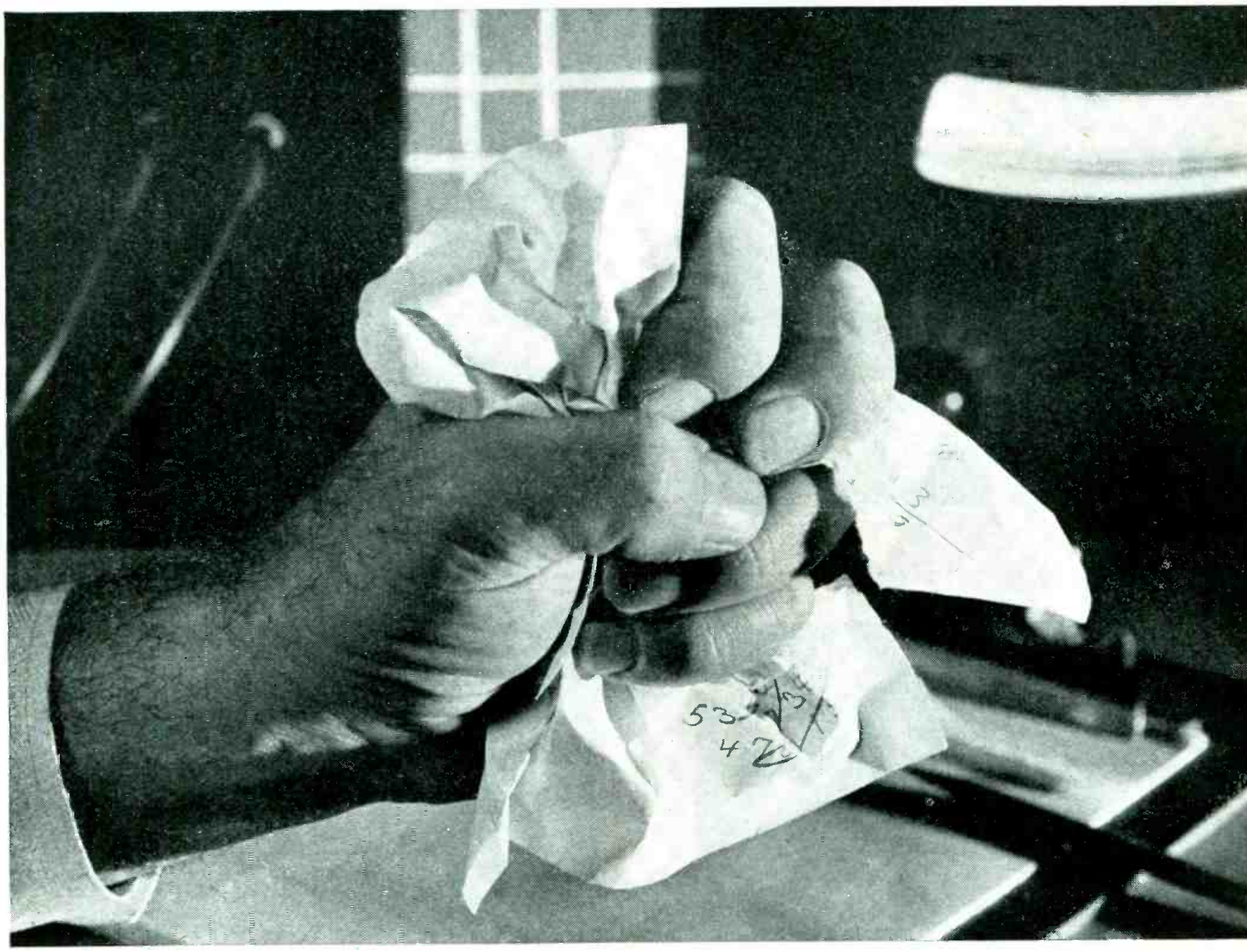
When something seems rotten in Denmark . . .

THERE is a strange quality in us all—even in fact-minded engineers. We tend to suspect ourselves first when we're face to face with failure. We forget that human beings have no corner on error.

Behind an apparent failure, for instance, may be the innocent face of a meter that failed to tell the truth. From there, calculations went hopeless awry and ended in a wad of paper held in an angry fist.

We do not suggest that you mistrust your tools. We do say—insist on *sustained accuracy** in your metering, measuring, and testing instruments. Use instruments that *through their lifetime* never waver from the truth.

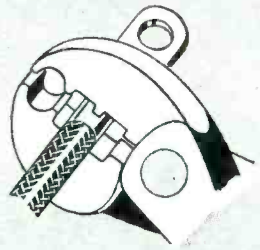
* **SUSTAINED ACCURACY** is not an easy quality to achieve. It must take into account all factors of use—must then employ the design, the alloys, the construction that infallibly protect an instrument against all threats to its reliable performance. Such instruments, obviously, must be built with performance—not price—in mind. We invite the inquiries of those who are interested in such standards.



Boes *instruments*

for Measuring, Metering & Testing Equipment ☆ *The W. W. Boes Co. Dayton, Ohio*

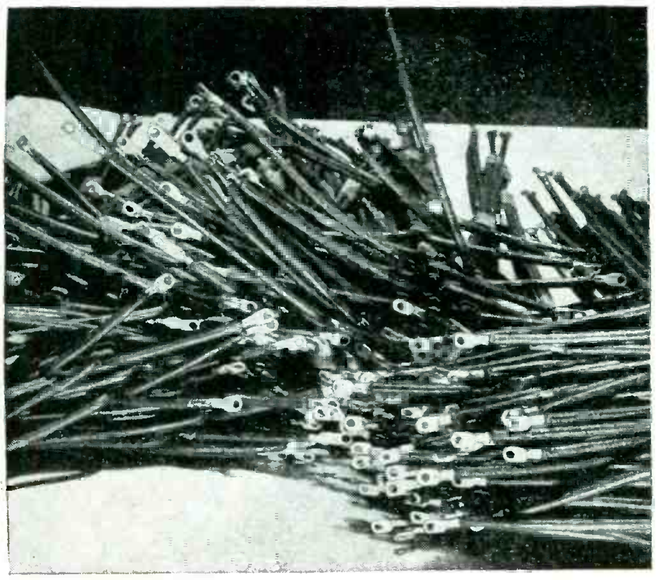
The stripped wire is merely inserted into the barrel of the Indent type connector.



The jaws of the Indenting pliers are then closed around the connector barrel.

This makes an Indent of controlled depth, which assures a connection of high strength and high conductivity.

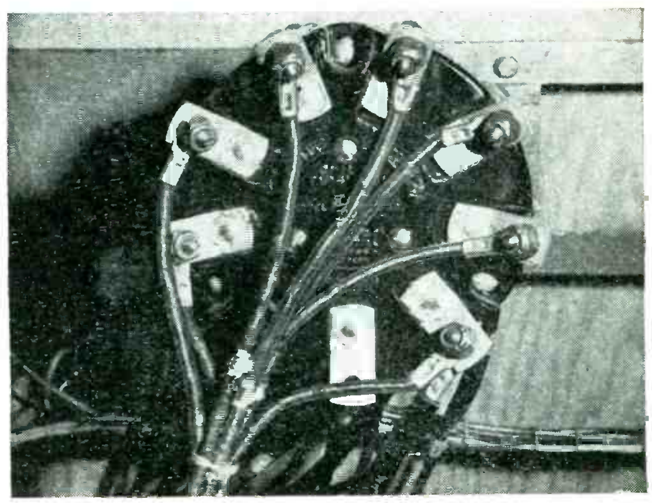
MECHANICAL INDENTING IS THE SPEEDY MODERN METHOD FOR MAKING ELECTRICAL CONNECTIONS



Hundreds of leads for electronic circuits are quickly Indent connected without a reject. Burndy Indent connectors are made in one-piece from pure copper; thus there can be no loosening of the connector, and there are no extra surfaces to cause increased contact resistance.

This automatic Burndy HYPRESS indents connectors as fast as the operator can press the trigger. Used extensively by aircraft and electrical manufacturers producing harnesses or leads in large quantities.

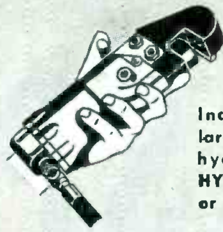
Inexperienced operators can make perfect Indent connections right from the start, and from three to ten times faster than by the older soldering methods. Absence of acid, which frequently causes finger burns, also makes job cleaner and faster.



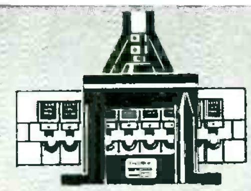
Indent connections are used on rotary switches of all sizes; Burndy Indent connectors being available for all wire sizes from #29 up through the larger cable sizes.

HEADQUARTERS FOR CONNECTORS

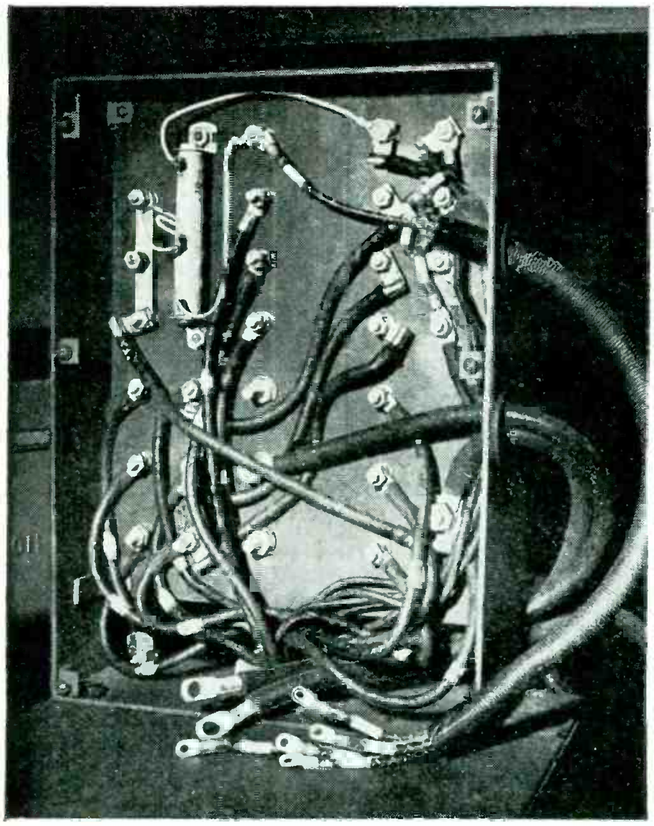
A cross sectional view of the Indent connection under the microscope looks like one continuous, solid conductor.



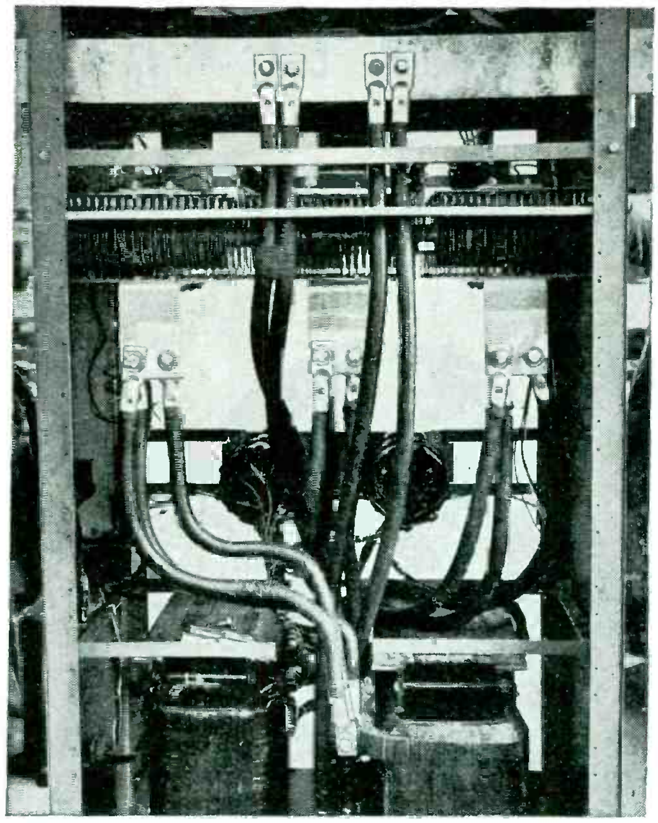
Indent connections on larger cable are made with hydraulic or pneumatic HYPRESSES, either portable or bench type.



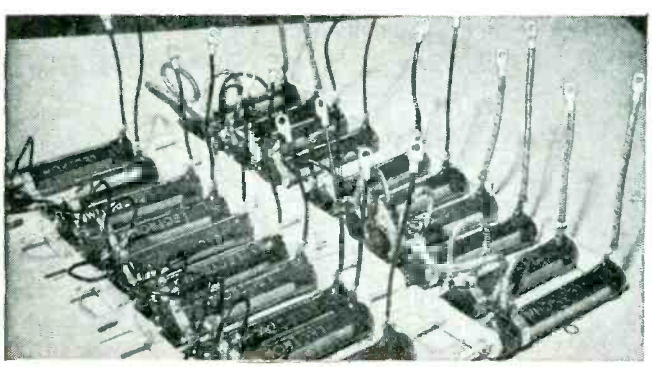
Where leads or harnasses are produced in quantity, speedy automatic bench type HYPRESSES are used for Indenting.



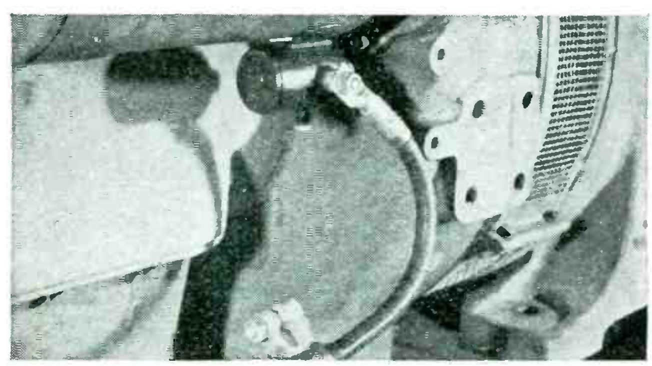
All connections in this panel on Diesel generating unit are made with Burndy Indent connectors, both the straight barrel and the right angle types being used.



On this large rectifier unit all connections are of the permanent indent type. View shows only terminals; but Indent connectors are also available for end-to-end as well as detachable connections.



Indent connectors are widely used on resistors and other small electrical components since they eliminate all troubles due to loose connections, and provide better circuit performance.



Indent Connectors are used on battery jumpers, too, because of their permanence, and their high conductivity . . . For complete information on Burndy Indent Connectors write to Connector Headquarters.

BURNDY

BURNDY Engineering Co., Inc.
107 EASTERN BOULEVARD, NEW YORK 54, N. Y.
In Canada: *Canadian Line Materials Limited, Toronto 13*

SAVE SPACE

WITH LEXEL INSULATED WIRE

When designs call for extra compactness and light weight of electrical installations, you'll find real help in **LEXEL**-insulated wire. **LEXEL** insulation tape provides maximum protection with minimum bulk and weight. It's especially useful for a wide variety of low-tension applications, such as instruments, controls, lead-in and hook-up wire and electronic circuits, where space is scarce.

But small bulk and weight aren't the only advantages offered by **LEXEL** insulating tape. The conductor is always CENTER-SEALED. **LEXEL** forms a continuous helical tube in which the conductor is automatically and permanently centered through every inch or mile of its length. It's heat sealed—and no extra material is needed for this extra insurance against off-centering.

The qualities of **LEXEL** (cellulose acetate butyrate) have earned approval for a wide variety of military installations. These same characteristics of high dielectric strength, high insulation resistance and low moisture absorption will make it equally valuable for the improved new products of peace time.

On your request, we'll gladly send test samples, specifications and names of manufacturers supplying **LEXEL** insulated wire and cable.

CUSTOM-MADE INSULATION

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

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

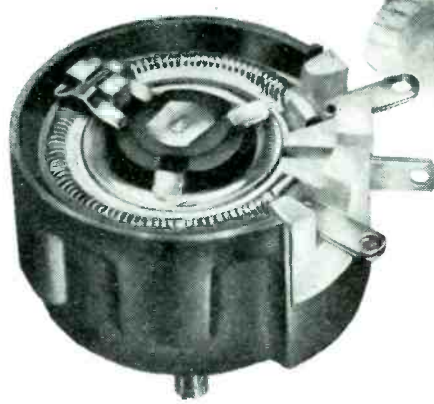
THE **DOBECKMUN** COMPANY

INDUSTRIAL PRODUCTS DIVISION • CLEVELAND, OHIO

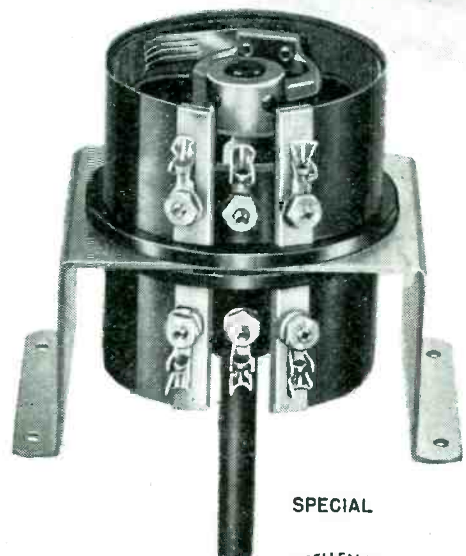
WESTERN SALES HEADQUARTERS • SAN FRANCISCO

UNDER *ANY* TRYING CONDITION

275



SPECIAL 25 AND 50 WATT



SPECIAL

UP A MOUNTAIN IN A TANK

HURTLING THROUGH SPACE IN A FORTRESS . . . . . .

WITHSTANDING THE GRUELLING PACE OF A WAR PLANT . . .

DeJur wire-wound potentiometers, in any assignment, fulfill their tasks capably and satisfactorily. The new line of these potentiometers covers a wide range of applications, for present and future use. Write for your copy of our "Special Bulletin", just off the press.

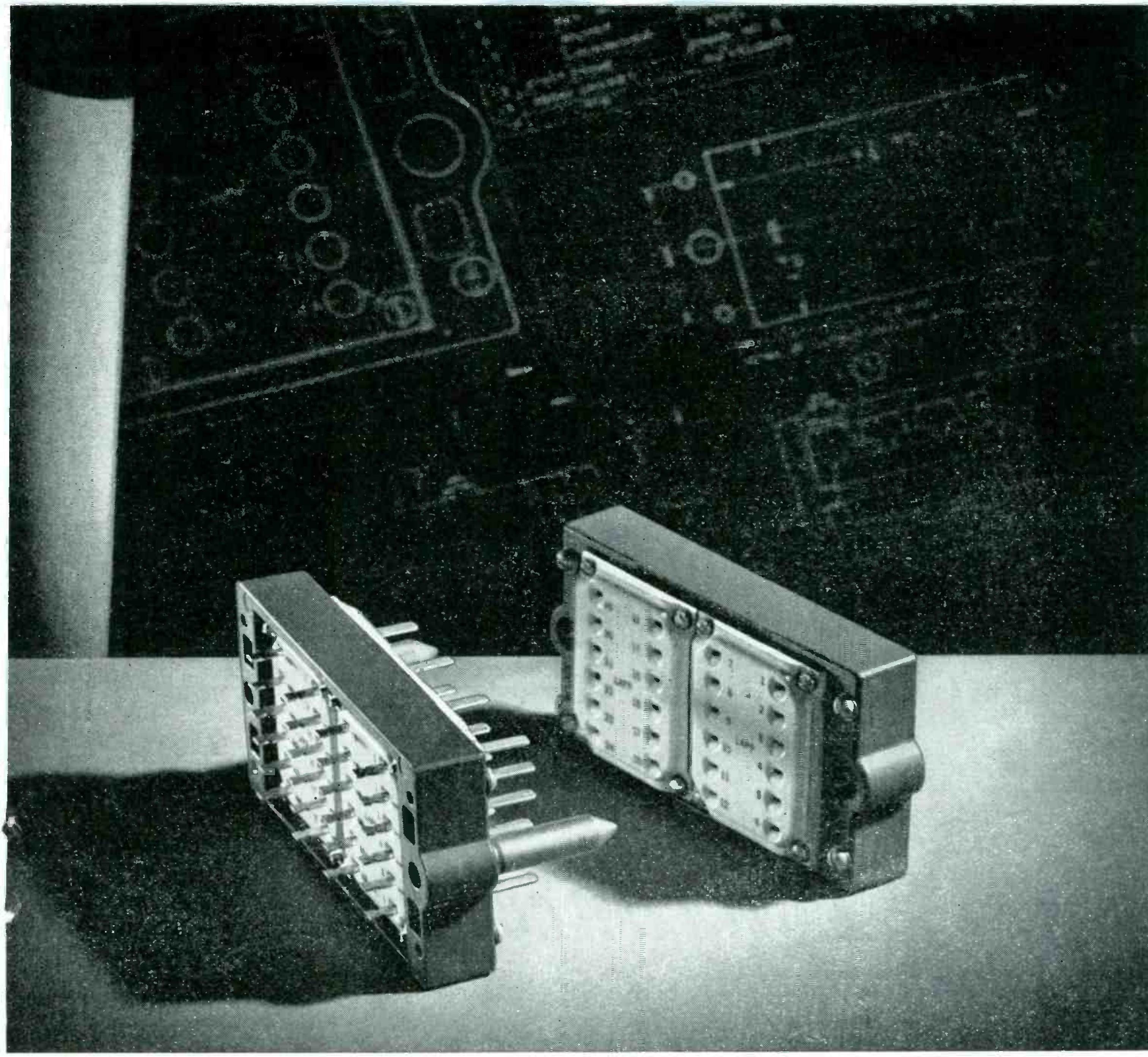
AWARDED FOR EXCELLENCE IN PRODUCTION AND QUALITY OF MATERIEL — ARMY E NAVY

HELP SHORTEN THE WAR . . . BUY MORE WAR BONDS

DeJur-Amsco Corporation

MANUFACTURERS OF DeJUR METERS, RHEOSTATS, POTENTIOMETERS AND OTHER PRECISION ELECTRONIC COMPONENTS
SHELTON, CONNECTICUT

NEW YORK PLANT: 99 Hudson Street, New York 13, N. Y. • **CANADIAN SALES OFFICE:** 560 King Street West, Toronto



An Electronic Part ... ENGINEERED TO A SPECIFIC NEED

This is a special-purpose electronic part. It is a plug-receptacle assembly for use with rack-panel type of mounting. Twenty-four silver-plated phospher-bronze contacts are provided, each male and female contact full floating between steatite plates. Heavy guide pins and matching holes in the frame assure perfect alignment.

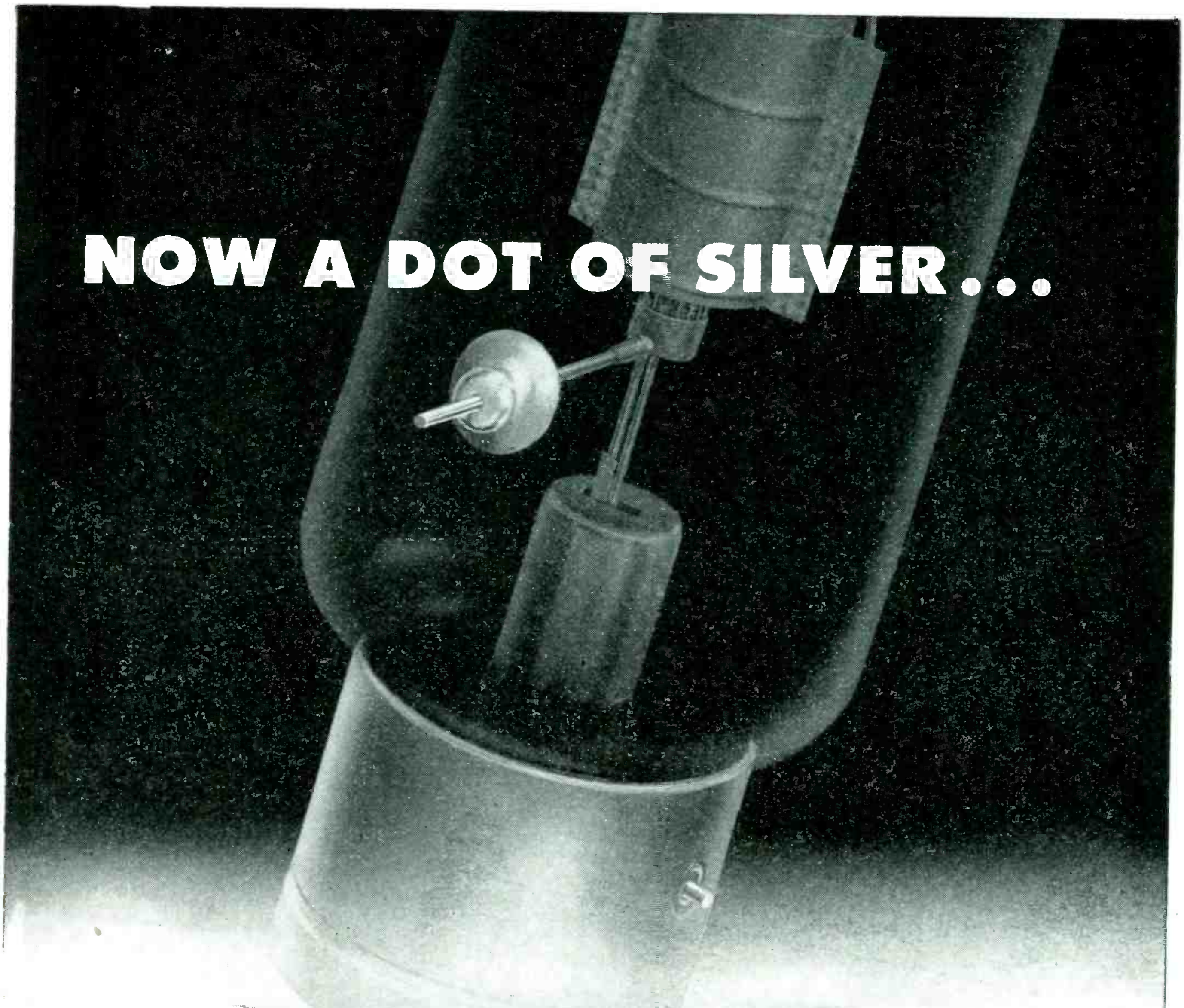
We don't know that your product has any need for such a part as this. We do know, however, that this part is most exactly suited to its special requirement, just as are hundreds upon hundreds of other parts which have been created through Lapp engineering and Lapp production facilities directed to the solution of specific problems.

With a broad basic knowledge of ceramics—their capabilities and their limitations—Lapp has been able to simplify and to improve many types of electronic equipment through engineering and production of sub-assemblies that make most efficient use of porcelain or steatite and associated metal parts.

There may be a way you can improve performance, cut costs and cut production time through use of Lapp-designed and Lapp-built sub-assemblies. We'd like to discuss your specific requirements with you. *Lapp Insulator Co., Inc., LeRoy, N. Y.*

Lapp

ARMY (E) NAVY



Increases tube capabilities at 125-mc by more than 20 times!

The new coating of silver around the grid leads of Gammatron tubes answers one of the most baffling problems in high-frequency communication.

Until W. G. Wagener, chief engineer of Heintz and Kaufman Ltd. hit upon this simple solution, the life of all transmitting tubes at high frequencies was relatively short. Even tubes such as the HK-254 lasted only a brief 50 to 100 hours at 125 megacycles when very heavily loaded. The trouble was always the same . . . the glass around the grid lead would crack, and the tube would be ruined.

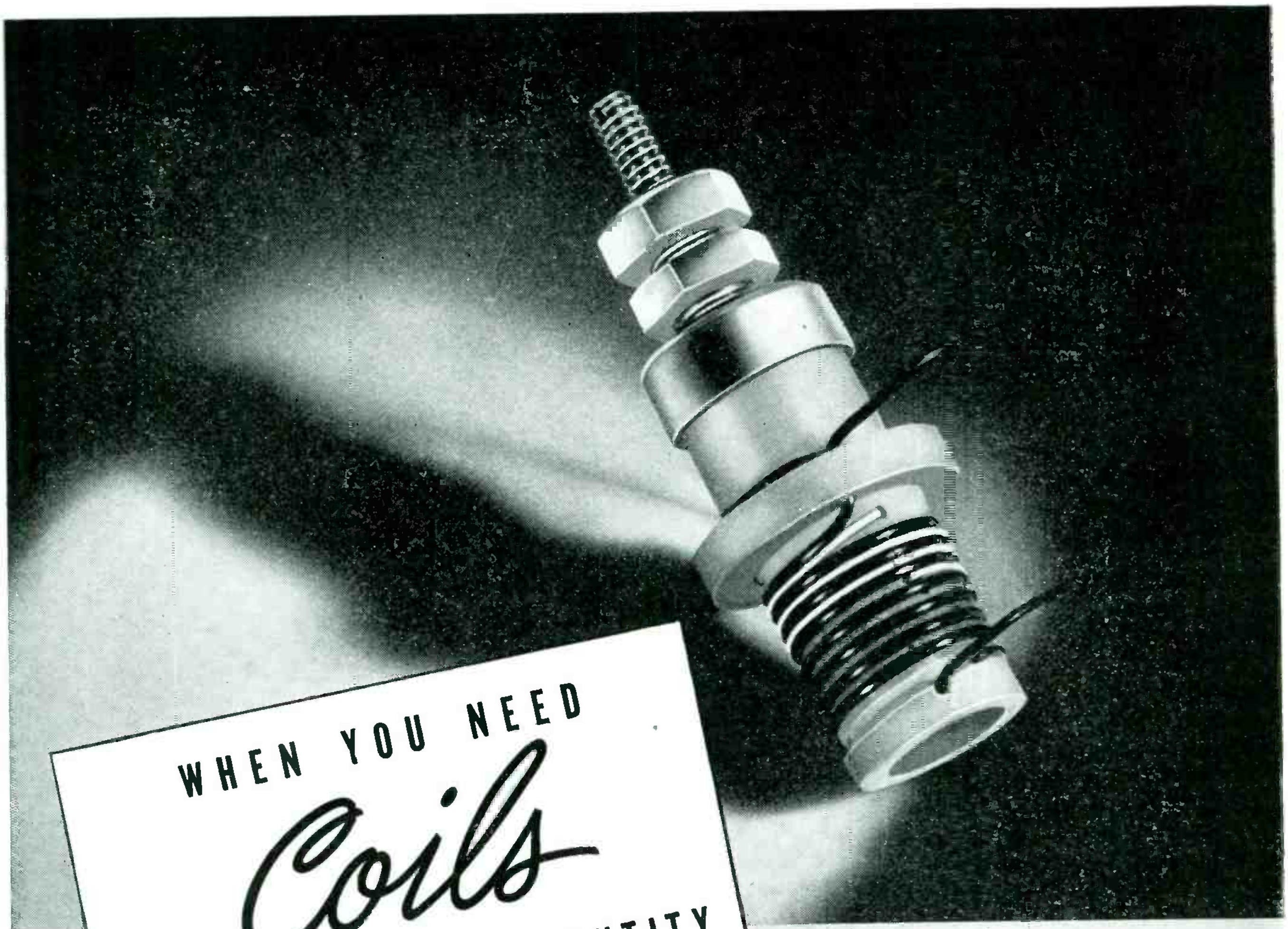
Heintz and Kaufman engineers found that the grid bead crack was caused by a change in composition of the glass adjacent to the tungsten. This change was due to a minute current flow resulting in electrolysis.

The silver coating now intercepts this current far enough away from the grid lead so that the glass immediately surrounding the lead retains its normal characteristics. Thus Heintz and Kaufman's patented coating enables such tubes as the HK-54, HK-254, and HK-454 to operate at high frequencies at higher powers for as long as 2000 hours—one Gammatron now outlasts 20 to 40 ordinary tubes without the silver dot!

HEINTZ AND KAUFMAN LTD.

SOUTH SAN FRANCISCO • CALIFORNIA, U. S. A.

Gammatron Tubes



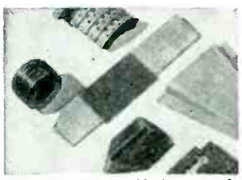
FACTS about
Molded – Formed – Laminated Plastics
FOR ELECTRONIC DEVICES

The developments and improvements in electronic and plastics applications, to meet war requirements, are two outstanding contributions of the engineering and research laboratories of both industries. Secrecy, time limitations and other restrictions have, thus far, prevented wide distribution of much of the data which has been obtained recently.

Richardson Plasticians *will, however, be glad to apply their years of experience and vast knowledge of recent developments in selecting the grade of Laminated or Molded INSUROK best suited for any Electronic application or post-war development.*

LAMINATED INSUROK

The high dielectric qualities of Laminated INSUROK have led to its use in a wide variety of electronic, radio and electrical applications. In addition, Laminated INSUROK has won the preference of engineers because of its light weight, strength, resiliency, durability, electrical insulation, resistance to corrosion, moisture and the destructive action of many chemicals, acids, oils, reagents, solvents, etc. The assistance of Richardson Plasticians in solving fabrication problems is available to users of INSUROK.



FABRICATED PARTS

The Richardson Company is well equipped to supply your needs for completed fabricated parts. Laminated INSUROK may be drilled, sawed, sheared, tapped, turned, planed, shaped or milled; or any combination of these operations will be performed to meet your product requirements.

PUNCHED PARTS

The characteristics of Laminated INSUROK and the uniformity, as well as economy, made possible by punching operations have resulted in the use of large quantities of punched Laminated INSUROK parts by the Electronic industry. Finished punched parts, made to your specifications, are available through The Richardson Company.

BEARINGS

Many concerns are utilizing the advantages of Laminated INSUROK bearings where wearability and low coefficient of friction are necessary. For such uses, bearings may be used with water as a shaft coolant or with oil or grease as a lubricant. In some instances, INSUROK bearings may be used with no lubrication or coolant. They are particularly adaptable where electrolytic action, corrosion and the effects of acids cause replacement or impair the efficiency of other types of bearings.

SHEETS—RODS and TUBES

The Richardson Company, in addition to supplying finished fabricated and punched parts, is well equipped to supply your needs with a wide variety of sheets, rods and tubes for fabrication in your own plant. Standard sizes of sheets are 36″ x 42″ and 36″ x 59″, but some grades can be supplied in larger sizes. Various colors are available. Rods and tubes are generally supplied in random lengths of 24″ to 36″, unless length is specified.

FORMED INSUROK

A thermosetting, fabric type sheet material which, under proper processing, permits simple and some compound bending—with a limited drawing characteristic.

MOLDED INSUROK

Strong, light weight, Molded INSUROK, made from any of the recognized plastic materials, requires no surface treatment or finish. Metal inserts may be securely and accurately molded in place to eliminate assembly operations.

In addition to compression and transfer molding, The Richardson Company produces products of thermo-plastic materials by injection molding of cellulose acetate, methyl methacylate, styrene and other compounds.

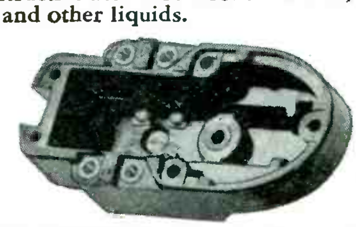
The characteristics of Molded INSUROK vary as to the individual requirements of each product. Be sure to get the Richardson Plasticians' recommendations before specifying.

ELECTRICAL PROPERTIES—INSUROK has superior insulating qualities and may be used in most electrical equipment even where high voltage conditions are encountered. Special grades of INSUROK are designed to give very low losses at radio frequencies.

WEATHER RESISTING—Heat and cold, sudden change in temperature have no adverse effects on INSUROK. It has a relatively low coefficient of expansion and contraction—its physical characteristics are permanent.

WORKABILITY—INSUROK can be handled like metal, without special tools. This is an important advantage where additional drilling or tapping might be required in assembly work within your own plant.

NON-HYGROSCOPIC—NON-CORROSIVE—INSUROK is resistant to moisture and the destructive action of most chemicals, solvents, acids, reagents, oils and other liquids.



DURABILITY—Great structural strength is an outstanding characteristic of Molded INSUROK. It is being successfully used where resistance to surface abrasion, impact, unusual strains and stresses is required.

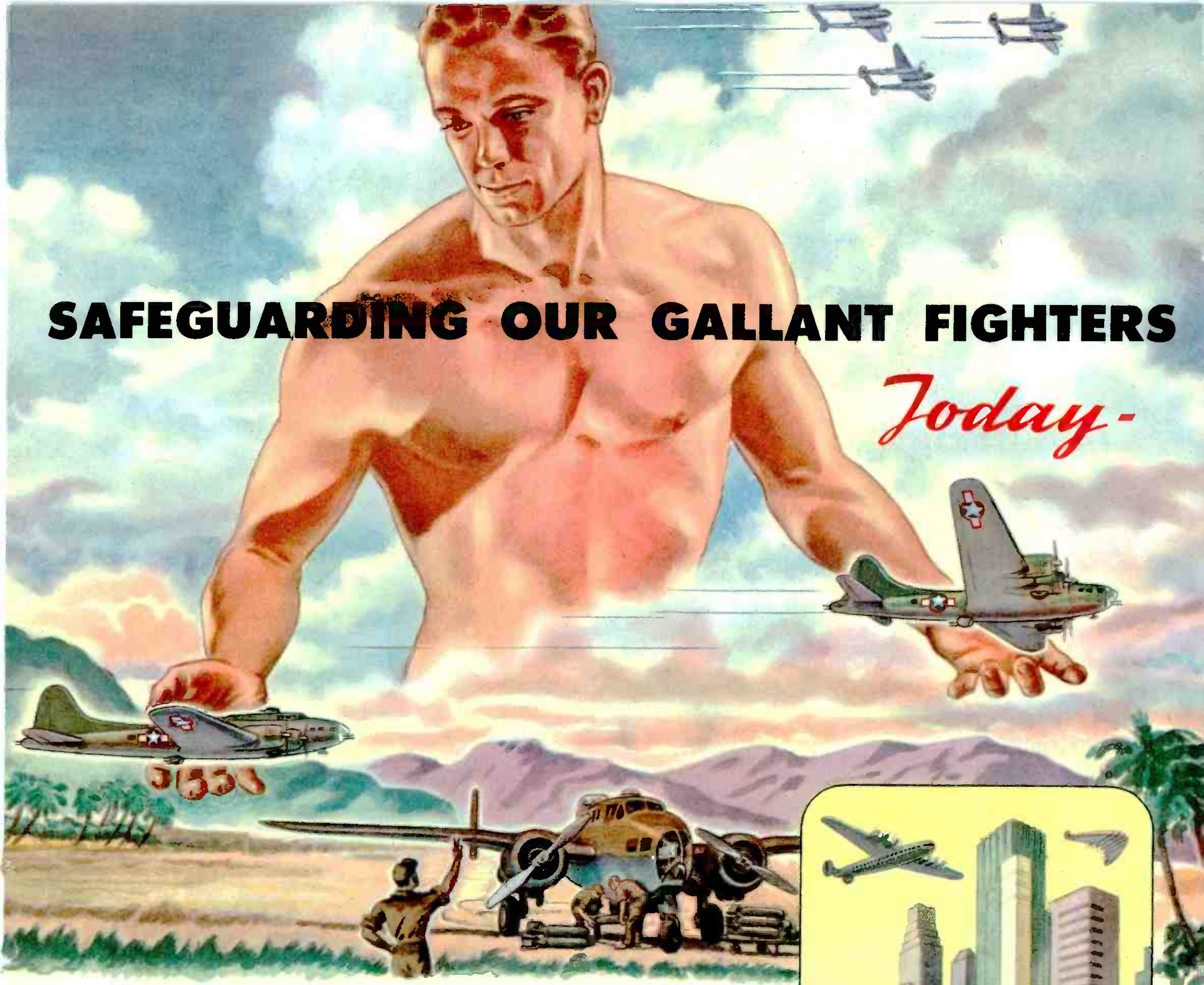
RICHARDSON TECHNICAL SERVICE—The facilities of Richardson Research, Design and Engineering Laboratories are available without cost or obligation. Richardson engineers will be glad to assist in the application of INSUROK and other plastics to present or contemplated products, or production machinery. Richardson plants are completely equipped for the volume production of all generally used types of plastics! Literature and catalogs will gladly be sent upon request.

INSUROK

Precision Plastics

The RICHARDSON COMPANY

MELROSE PARK, ILL. NEW BRUNSWICK, N. J. FOUNDED 1858 INDIANAPOLIS 1, IND. LOCKLAND, CINCINNATI 15, OHIO
DETROIT OFFICE: 6-252 G. M. BUILDING, DETROIT 2, MICHIGAN NEW YORK OFFICE: 75 WEST STREET, NEW YORK 6, N. Y.



SAFEGUARDING OUR GALLANT FIGHTERS *Today-*

...And Will Safeguard Commercial Flight-Tomorrow!

Today, amazing developments in electronic communications make possible new methods of aircraft control to aid our gallant Air Forces. Modern communications equipment is helping to coordinate fighting forces in the air... is helping to safeguard them on their vital missions. Air Communications is proud to help supply many precision-built products used in America's march to victory.

Tomorrow—when victory is won—Air Communications war-tested organization will devote its skill and experience to designing, engineering and building *everything for the safety, economy and convenience of peace-time flying.*

Air Communications engineers anticipate the great post-war "air age"... are busy now developing new and improved devices to smooth the path of flight for the giant air liners, cargo carriers and private planes that will fly the skyways of tomorrow.

Cooperative Engineering Available — let us help you solve your engineering problems of the future.

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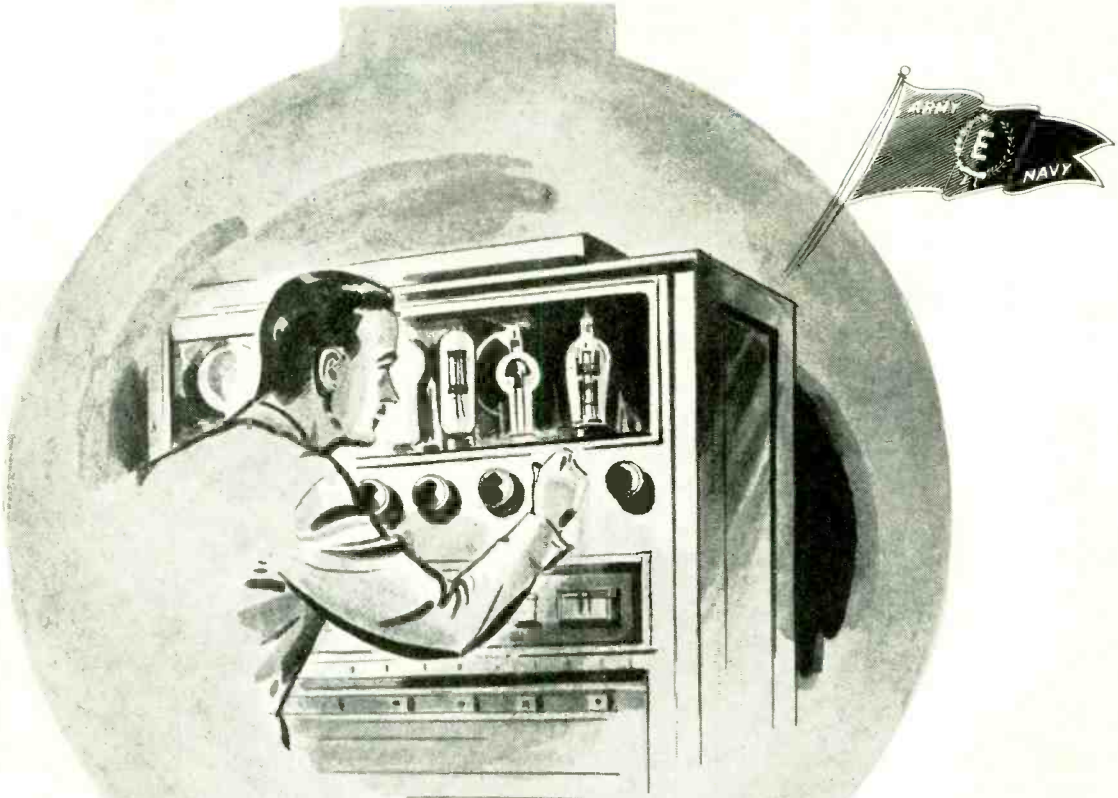
KANSAS CITY 8, MISSOURI

Keep Buying
WAR BONDS
For Victory

Designing, Engineering and Building for Victory... and the Future

Air Communications Products include: Radio Range Receivers, Glide Path Receivers, Marker Beacon Receivers, Aircraft Automatic Direction Finders, Aircraft Transmitters, Command Receivers, Command Transmitters, Small Transmitters up to 1 K.W., Interphone Equipment, Radio Telephone Equipment, Adaptors for Radio Compasses. Out of their achievements for war, Air Communications engineers will bring you new knowledge and experience of value in peacetime aviation.


ARMY
NAVY

CHECK THIS FASTER HF COIL ASSEMBLY METHOD . . .

WITH PRE-ASSEMBLED

Two-piece

HIPERSIL* CORES

Now you can eliminate the time-consuming operation of stacking hundreds of tissue-thin core laminations by hand for High-Frequency Communications Equipment. Pre-assembled Type C HIPERSIL cores are delivered to you in just TWO ready-to-assemble pieces per loop: Westinghouse winds a thin strip of HIPERSIL to form, bonds it, then cuts it in two.

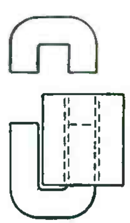
These split-type cores of HIPERSIL are available in a complete range of standard sizes, or they can be furnished uncut in rectangular or circular shapes if desired.

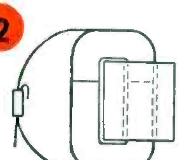
GET THE FACTS ABOUT HIPERSIL TYPE C CORES . . . write for **HIPERSIL BOOK, B-3223-A.** It contains performance facts and application data that will help speed production of vital communications equipment to the fighting forces. Address: Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N. J-70423

**Registered Trade-Mark, Westinghouse Elec. & Mfg. Co., for HIgh PERmeability SILicon steel.*

COMPARE THIS WITH YOUR PRESENT CORE ASSEMBLY METHODS

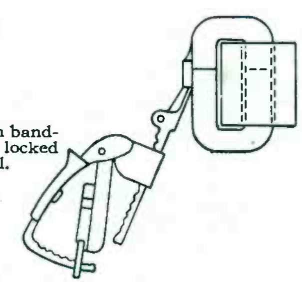
1 Core is placed around coil.



2 

Core parts are butted together. Strap is threaded through seal and . . .

3 . . . tightened with banding tool. Band is locked in place with seal.



Banding Straps, Seals and Tools available from Westinghouse. See Page 9 of booklet B-3223-A.

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

HIPERSIL CORES

KEEPING UP with DUCTILE ZIRCONIUM

Now that extremely pure Ductile Zirconium is a fact, and production is being stepped up, electronics engineers can plan more confidently for its wider use. Ductile Zirconium, produced by the Foote process (thermal decomposition of Zirconium tetraiodide), can be readily worked. Forms such as wire, sheets and rods are available combining structural advantages with the recognized properties of Zirconium.

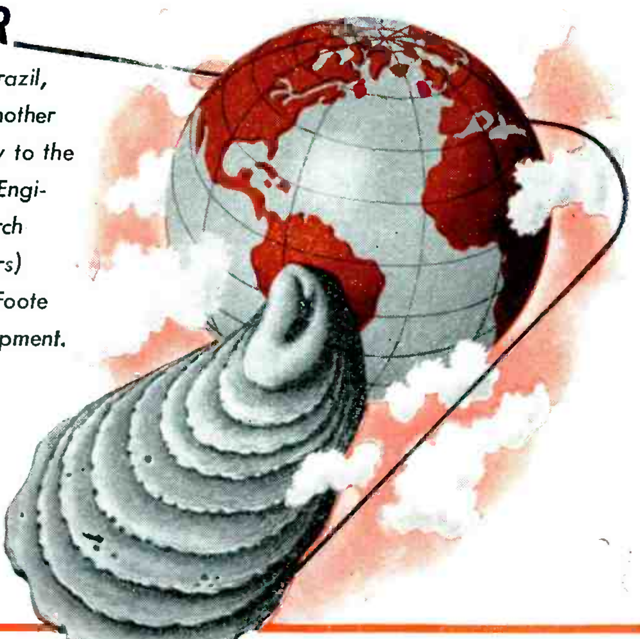
Chief among these properties of interest to you is, of course, Zirconium's value as a gas getter. Zirconium is a highly reactive metal and combines with all but the rare gases. However, large quantities of oxygen, nitrogen and hydrogen can be sorbed without forming a new phase . . . up to 40 atomic per cent of oxygen and 20 atomic per cent of nitrogen without X-Ray evidence of a compound. Except with hydrogen, the process is not reversible. Sorbed oxygen or nitrogen is not liberated even at temperatures exceeding 1500°C. A better vacuum is produced than is possible with the best pumps.

Ductile Zirconium is used to clean up practically all gases in vacuum tubes. Even when compounds form they diffuse with amazing velocity, renewing the surface and allowing the metal to fix more gas. Thus Ductile Zirconium is a continuous getter. Neither the metal nor the compounds volatilize so that the walls of the tubes remain clear. Inter-electrode leakage is less, and heat dissipation greater, tube life is increased.

Ductile Zirconium is used in transmitting tubes, rectifiers, and cathode ray tubes for anodes, grids, or glowing filaments. Some experimenters are welding pieces of Ductile Zirconium to the molybdenum anode for getter flags. More specific information will be supplied promptly at your request.

THE WORLD IS OUR OYSTER

Manganese from Cuba, Ilmenite from India, Rutile from Brazil, Celestite from Mexico . . . ores and minerals from many another Good Neighbor, from our Allies and from home find their way to the Foote Mineral Company on the heels of globe-trotting Foote Engineers. • Foote sees these products of the earth through research and processing, huddles with many industries (including yours) in their development. In addition to present definite uses of Foote products, there are probably many others now awaiting development. We urge you to let us work with you in your own research.



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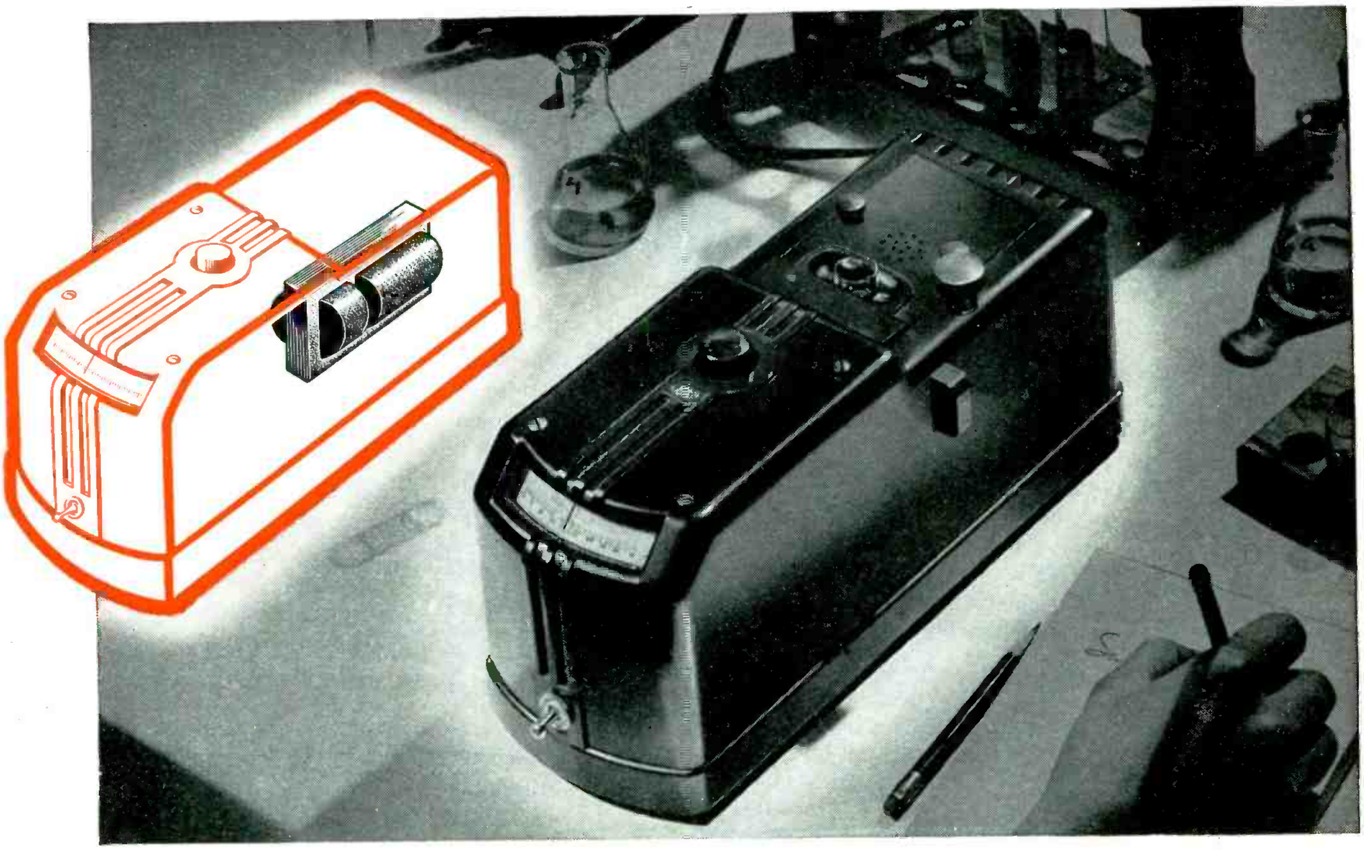
West Coast Repr.: Griffin Chemical Co., San Francisco, Calif. • English Repr.: Ernest B. Westman, Ltd., London, Eng.



The PHOTELOMETER insures the accuracy of its readings with built-in CONSTANT VOLTAGE

The "Photelometer" is a portable, photo-electric device, used to determine the concentration of substances in solution by the proportional transmission of incident light of *unvarying intensity*. For vital diagnoses and routine commercial decisions, it has supplanted the older systems of analysis by visual comparison, in many bio-chemical, industrial and hospital laboratories, due to its speed and accuracy.

The "Photelometer," so sensitive as to require voltage which does not vary more than ±1%, takes no chances with the uncertain voltages of commercial power lines. Its label specifies the voltage at which it should be operated and a built-in SOLA Constant Voltage Transformer maintains the voltage at this level by absorbing all sags and surges in the incoming power.

This is only one of the many electrically operated instruments and other types of equipment that now depend on built-in SOLA Constant Voltage Transformers for consistently accurate performance.

In designing any precision or electronic device, it is hazardous to assume that the voltage required for its successful operation will be available. Only where voltage control is incorporated as an integral part of the basic design can there be any guarantee of unvarying power. With this control, the performance of the device is automatically and instantaneously protected from voltage fluctuations.

SOLA Constant Voltage Transformers instantly and automatically absorb primary voltage variations up to 30% and deliver an unchanging, rated voltage. They require no supervision or manual adjustments and are self-protecting against short circuit. Custom-made units can be designed to exact specifications for built-in protection. Standard units are available in capacities from 10 VA to 15 KVA.

SOLA Constant Voltage Transformers

To Manufacturers:
Built-in voltage control guarantees the voltage called for on your label. Consult our engineers on details of design specifications.
Ask for Bulletin DCV-74

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

HIGH IN THE BLUE

—a *Ferranti* "*Laboratory*"

ON these ships, over the wide oceans or in combat zones, Ferranti Transformers have had their Quality tested and proven.

Now, thanks to increased production facilities, we can today take your orders for Ferranti Transformers, Chokes, Filters and allied products...*and make deliveries without delay.* We guarantee the most exacting Transformer performance for war or post-war equipment.

There is no "blue sky" about Ferranti Service and Quality. We will be pleased to work with you and give you the benefit of our many years of practical experience to help you solve your transformer problems.

Call or write us now

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FLEXIBLE VARNISHED OIL TUBING:

This TURBO insulation meets the diversity of requirements necessary to stand up against general break-downs, impairment through moisture absorption, and the general deteriorating influences caused by acids, alkalis, etc.

EXTRUDED TUBING:
resistant to sub-zero temperatures

Where the effects of extreme low temperatures are apt to induce insulation embrittlement, TURBO Extruded Tubing is especially suited. Sudden climatic changes, wide fluctuations in temperature, or refrigerant operating conditions will not effect the dependability

VARNISHED GLASS TUBING:
resistant to extremely high heat

The extensive use of this TURBO product is directly attributable to it's excellent characteristics under high heat conditions. Heavy duty operating conditions, confined areas where ventilation is minimized and other similar problems are solved

WIRE IDENTIFICATION MARKERS:

The facilitating of production and assembling operations, with corresponding increases in functional efficiency, are effected with this TURBO insulation product. Available in any size, length or color, these TURBO markers are strictly in accord with Army, Navy and Air Corps

TURBO

VARNISHED TUBING • SATURATED SLEEVING

New products, processes and equipment have already made their appearance as the result of the scientific advances induced by the intensified war demands; the picture is clear in requiring greater advances in functional efficiency.

TURBO engineers and technicians are abreast of the new developments, designs and improvements. For example, the "flash" point of TURBO Tubing, already high, is being forced to ever higher levels.

This means increased protection from combustion hazards—more essential even than "slow" burning. It means the fire never gets a chance to start. Conversely, embrittlement temperatures—the antidote to cracking—are being constantly lowered. TURBO looks ahead.

★ ★ ★

Write for sample board and list of standard sizes. It's a ready reference and handy gauge—free without obligation.

IF IT'S TURBO IT SAFE-GUARDS

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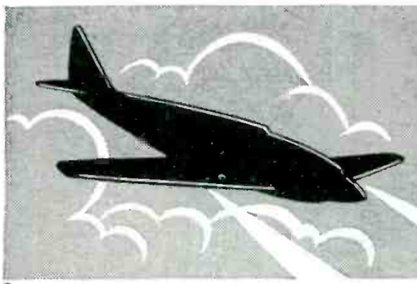
MANUFACTURERS OF MICA PLATE, BLOCK MICA, VARNISHED TUBING & CAMBRIC



Experience Spotlights the *Simplest* Fastening Method

...guides E. A. Laboratories to Savings with P-K Self-tapping Screws

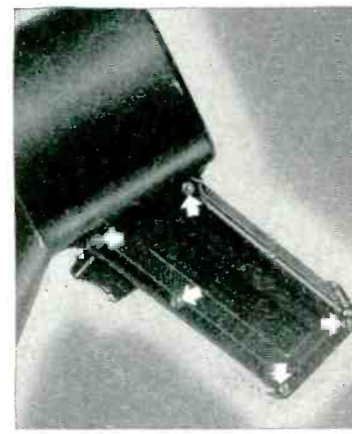
SPEED PLASTIC ASSEMBLIES

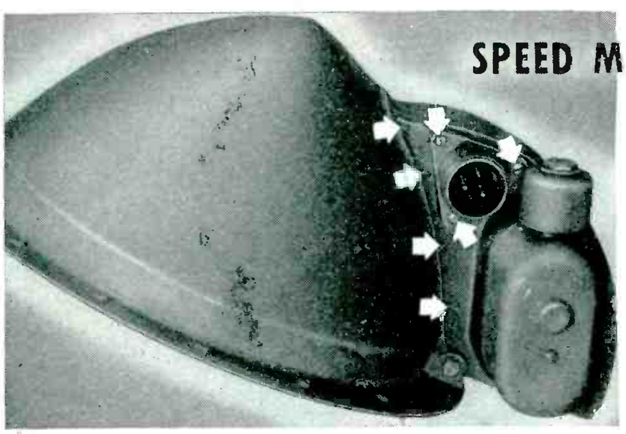
Inter-Aircraft Control Light

3 P-K Type "F" Screws used as locating pins for lamp unit.

4 P-K Type "F" Screws hold switch contactor and terminal lug in position.

5 P-K Type "F" Screws fasten Bakelite handle cover plate to Bakelite handle.





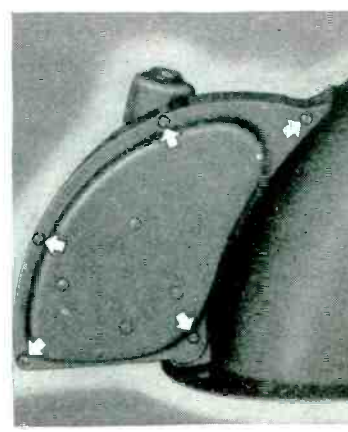
SPEED METAL ASSEMBLIES

Retractable Landing Lights

3 P-K Type "F" Screws driven through bakelite insulator, fasten electrical connector to lamp housing, both of die cast aluminum.

8 P-K Type "F" Screws fasten gear housing to lamp housing, both of die cast aluminum.

5 P-K Type "F" Screws fasten aluminum housing plate to die cast aluminum housing. Inside the lamp, P-K Type "F" Screws are used to fasten motor field to motor housing, and motor housing to gear housing.



E. A. Laboratories, Brooklyn, N. Y., having "questioned every fastening" on peacetime assemblies, were ready with the answer when heavy war orders made it necessary to pare production time and costs to the bone.

By designing their aircraft lighting specialties for assembly with P-K Self-tapping Screws, they eliminated tapping and tap maintenance, and the need for metal inserts in the plastic lamp. The P-K Type "F" Screws, cutting their own clean threads as they are driven, add to the strength and security so necessary in these products, and can be easily removed and replaced when required.

Take full advantage of Parker-Kalon's Assembly Engineering Service. Experience proves, in 7 out of 10 cases, P-K Self-tapping Screws will simplify plastic or metal fastening jobs . . . save vital man-hours . . . speed production . . . cut costs.

Question every fastening job . . . on the drafting board . . . in production. First see if it can be done with simple P-K Self-tapping Screws before putting up with slow, difficult fastening methods. Your request will bring a P-K Assembly Engineer to help you uncover opportunities to save time and money. Or, send details of your assembly for recommendations. Parker-Kalon Corp., 192-194 Varick Street, New York 14, N. Y.

SELF-TAPPING SCREWS FOR EVERY METAL AND PLASTIC ASSEMBLY

PARKER-KALON

Quality-Controlled

SELF-TAPPING SCREWS

what a great name means...

on a little package

TLA FEATURES

Insulated from chassis. Fire-proof—non-inflammable. Enclosed in cylindrical, aluminum container. Efficiently combines long life with small space. Ability to withstand high transient and peak voltages. Designed to operate under continuous full-load duty.

The meaning of the C-D insignia on a capacitor is strikingly illustrated in the performance of inverted filter Type TLA. This little wonder packs the highest insulation resistance, lowest power factor, longest life in the smallest space of any similar filter capacitor. Write for full description of TLA. Cornell-Dubilier Electric Corporation, South Plainfield, N.J.

In an independent inquiry just completed, 2,000 radio and electrical engineers were asked their first, second and third choice of capacitor make. When all the returns were in, Cornell-Dubilier was far in the lead — *receiving almost four times as many "firsts" as its nearest competitor.*

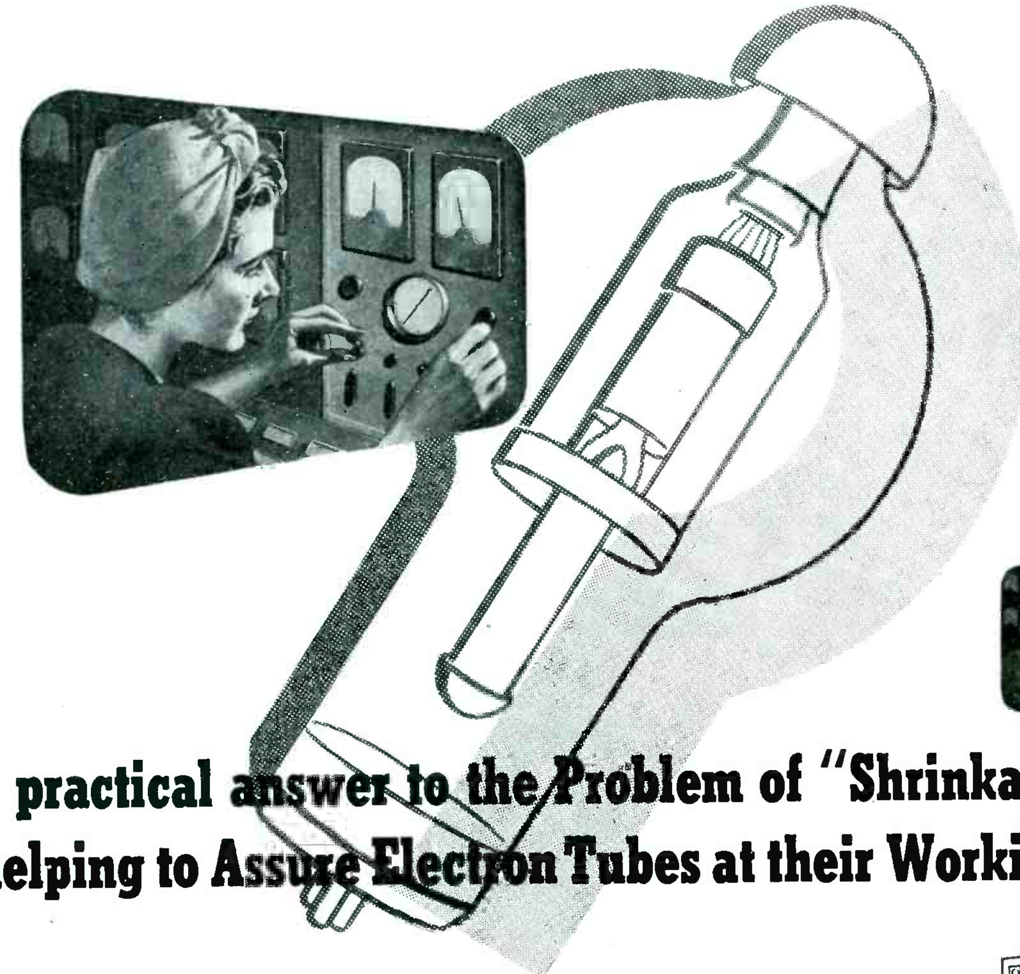
Cornell Dubilier capacitors

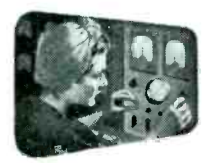
• more in use today than any other make

1910 CORNELL-DUBILIER CD CAPACITORS 1944

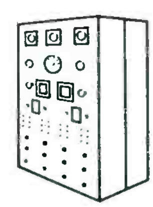
MICA • DYKANOL • PAPER
WET AND DRY
ELECTROLYTIC CAPACITORS

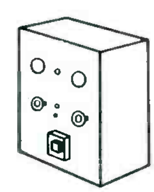
SHERRON TUBE TEST UNITS





...a practical answer to the Problem of "Shrinkage!"
...helping to Assure Electron Tubes at their Working Best.





Miracles are expected from electronics, and miracles are being performed—where the electron tube is at its working best. In short, the ideal must be the standard. Toward this end, Sherron test units are honored as indispensable equipment by many of the nation's most important makers of tubes . . . In its diversified electronic applications, Sherron test equipment is safeguarding production standards and maintaining positive quality controls. All equipment designed to meet specific manufacturing problems.

Sherron Electronics

Sherron Tube Test Units Measure:

Inter Electrode. Capacitance. Gas Current. Power Output. Trans-conductance. Amplification Factor. Oscillation and Frequency Cut-off. Power Rectifier. Peak Emission. Pulse Tests. Mechanical Impact or Sound Impact. Vibration.

MANUFACTURING PROCESSES:
Aging—Life—Pre-Heat.

CATHODE RAY:
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SHERRON METALLIC CORPORATION
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TIME NOW FOR THE PLANTING

"C-Day" is on the way... conversion to peace-time manufacture. Steel, copper, aluminum... many metals are becoming less critical... time now for the planting of your new product.

But with conversion will come cost consciousness instead of "cost-plus".

Manufacturers seeking cost-sensitive experience among war-born sub-contractors may have quite a search. Cost consciousness has become dulled during lush "cost-plus" years. It is a lost art to many... some never acquired it. It gets "drilled in" only through long years of peace-time practice.

Lewyt is *not* a war baby. Lewyt is a "manufacturer's manufacturer" with 56 years of cost-conscious "know-how". It returns to peace-time contract manufacturing with long experience in meeting the needs of production engineers who will have only costs and efficiency in mind.

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MANUFACTURING EXECUTIVES AND PRODUCT ENGINEERS

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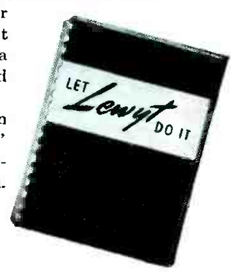
Lewyt's business is Contract Manufacturing. We specialize in electric and electronic instruments, chassis and housings; mechanical and electrical assemblies; highest precision machine work; sheet metal fabrications; all types of welding, product finishing, etc.

We also provide advanced engineering facilities as service assistance to our clients in connection with the design and re-design of products under development.

Why not get acquainted with our manufacturing experience, production and service facilities with our 48-page book, "Let Lewyt Do It"... the story of a unique organization told in pictures.



Write for it now as an aid to "transplanting" your product from drawing board to production.

Lewyt

LET LEWYT DO IT

When she drops her nickel in the juke box, she never thinks about the motor that turns the table or changes the records. All she wants is her money's worth, in music.

How dependably she gets it rests largely on the small motors that furnish the power. If they're "*Smooth Power*", neither she nor the maker of the juke box need worry.

"*Smooth Power*" motors start instantly, attain speed quickly and run as smooth as silk.

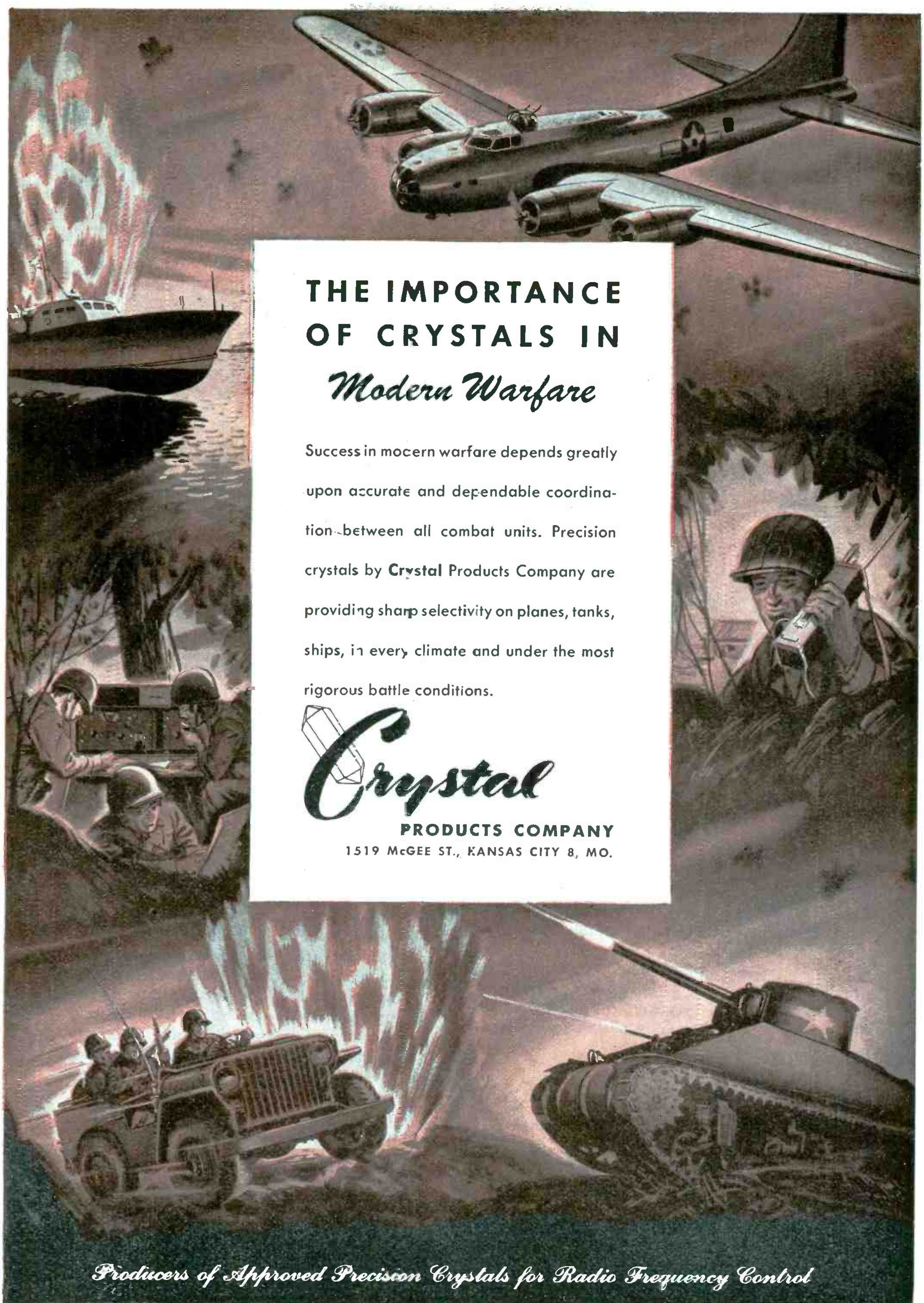
We've been making these powerful, compact motors for years. They're driving such varied devices as record changers, tape recorders and intricate control systems. Whatever type of service they're doing, you can be sure they answer promptly to every order.

Right now, War demands take all of our manufacturing capacity. But our engineers have time available to study your present or future needs, and make suggestions for the right "*Smooth Power*" motor for your particular job. Let's talk it over.

THE GENERAL INDUSTRIES COMPANY
COMPANY

Smooth Power

THE GENERAL INDUSTRIES COMPANY
Elyria Ohio


THE IMPORTANCE OF CRYSTALS IN
Modern Warfare
Success in modern warfare depends greatly upon accurate and dependable coordination between all combat units. Precision crystals by Crystal Products Company are providing sharp selectivity on planes, tanks, ships, in every climate and under the most rigorous battle conditions.
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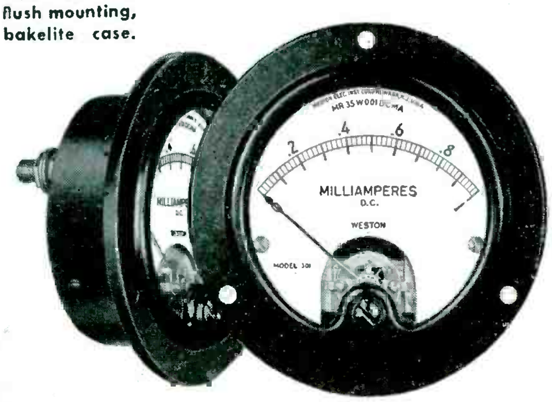
1519 McGEE ST., KANSAS CITY 8, MO.
Producers of Approved Precision Crystals for Radio Frequency Control

War Standard Instruments

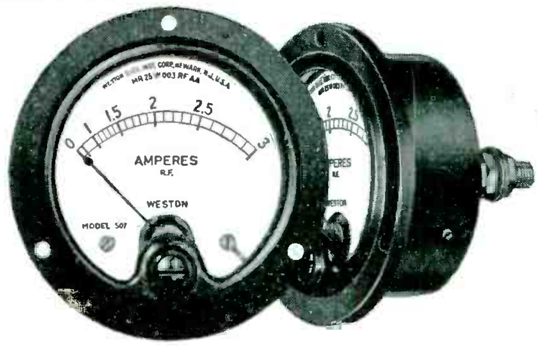
AND ACCESSORIES

3½" ROUND
flush mounting,
bakelite case.



Types **MR35-MR34**, in Weston Models 301-425-476, in all listed combinations in American War Standard C 39.2 — 1944

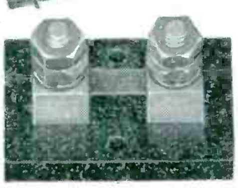
2½" ROUND
flush mounting,
bakelite case.



Types **MR25-MR24**, in Weston Models 506-507-517, in all listed combinations in American War Standard C 39.2 — 1944

THERMOCOUPLE CONVERTERS
per AWS C 39.4—1943 .. in all applicable ranges

RESISTORS
Types MFA—MFB—MFC... per AWS C 75.5 — 1943 . . . in all listed ranges.



SHUNTS
Types MSA—MSB—MSC... per AWS C 39.5 — 1943 . . . in all listed ranges.

A. W. S. instruments by Weston are the standard Weston instruments, with the required additional scale markings, and studs as specified. The instrument movements ... *therefore their long term dependability* . . . remains unchanged. Further, these panel meters still provide the thin movement and case . . . the original Weston design which, together with their enduring characteristics, *always* has distinguished instruments bearing this name. Inquiries invited. Approvals can be quoted. Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark 5, New Jersey.

Laboratory Standards . . Precision DC and AC Portables . . Instrument Transformers . . Sensitive Relays . . . DC, AC, and Thermo Switchboard and Panel Instruments.

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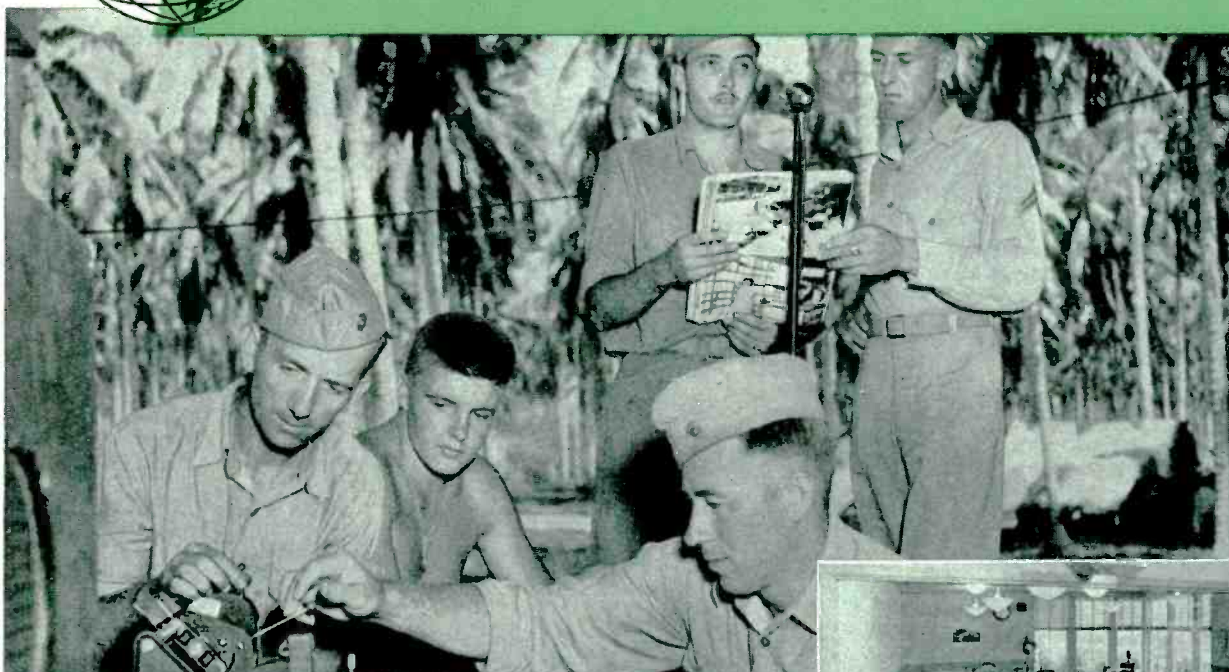
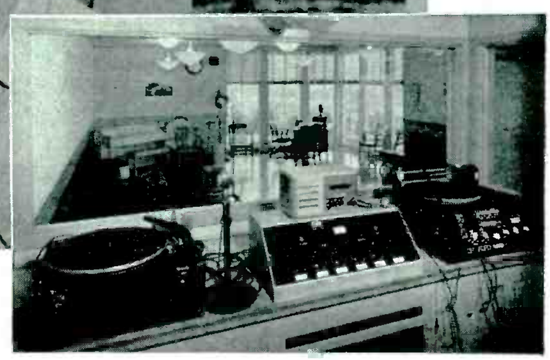
COIL FORMS OF Steatite
AND
*Centradite
CRL
* Especially indicated where Low Thermal Expansion, High Resistance to Heat Shock, Low Porosity and Low Loss Factor are requisites.
We have adequate facilities to process coil forms up to 5 inch diameter and pressed pieces to approximately 6 inches square.
Our ceramic experience dates back to 1930...and our engineering and laboratory facilities are at your disposal.
Centralab
CRL
Division of GLOBE-UNION INC., Milwaukee
PRODUCERS OF VARIABLE RESISTORS • SELECTOR SWITCHES • CERAMIC CAPACITORS, FIXED AND VARIABLE • STEATITE INSULATORS

On war and production fronts 'round the world

Radiotone IMPROVES MORALE



Official U. S. Marine Corps Photo



Radiotone installation at Consolidated Steel Company's Wilmington Shipyards

RADIO • RECORDING PUBLIC ADDRESS

Radiotone is giving outstanding performance in hundreds of industrial plants, arsenals, shipyards and on far-flung battle fronts. Because it is versatile, compact and rugged, it serves workers and fighters equally well.

Radiotone is a complete broadcasting system. It assures the finest radio reception . . . records voice, orchestra or radio programs ready for instant reproduction . . . permanently records management messages and directors' meetings . . . and can be equipped with any number of loud speakers or used in conjunction with your present P. A. system.

Radiotone is a convenient, portable instrument which requires no studio facilities. Anyone can operate it. Anyone engaged in essential war work can buy Radiotone TODAY.

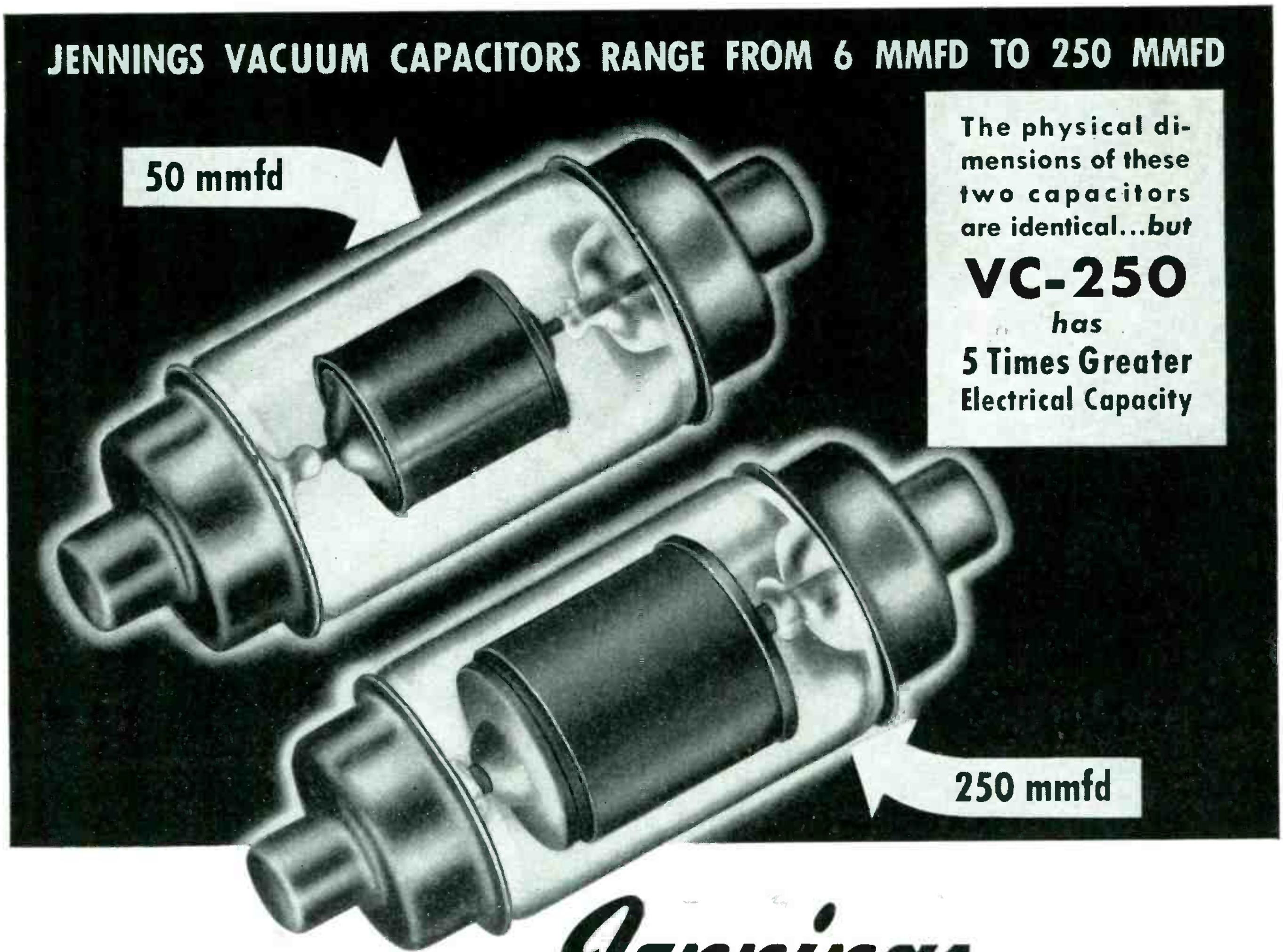
DEALERS CAN PARTICIPATE NOW!

Write for catalog No. T-100 and complete details covering Radiotone models, microphones, speakers, needles and discs.

Radiotone

Division of
THE ROBINSON HOUCHIN OPTICAL CO.
Columbus, Ohio

SHOWROOM, Hollywood, 7356 Melrose Ave. SHOWROOM AND SALES OFFICE, 1011 Chestnut St., Philadelphia



Jennings
RADIO

VC 250 Hits "New High"

The new VC 250 Capacitor is a JENNINGS Radio innovation. It gives five times greater electrical capacity than the VC 50 with a 20,000 volt peak rating.

Actual operation of this JENNINGS VC 250 proves an unmistakable step forward in Capacitor performance.

The name JENNINGS is reflected in the exact, uniform construction and absolute dependability of the Vacuum Capacitors and Transmitting Tubes bearing this name.

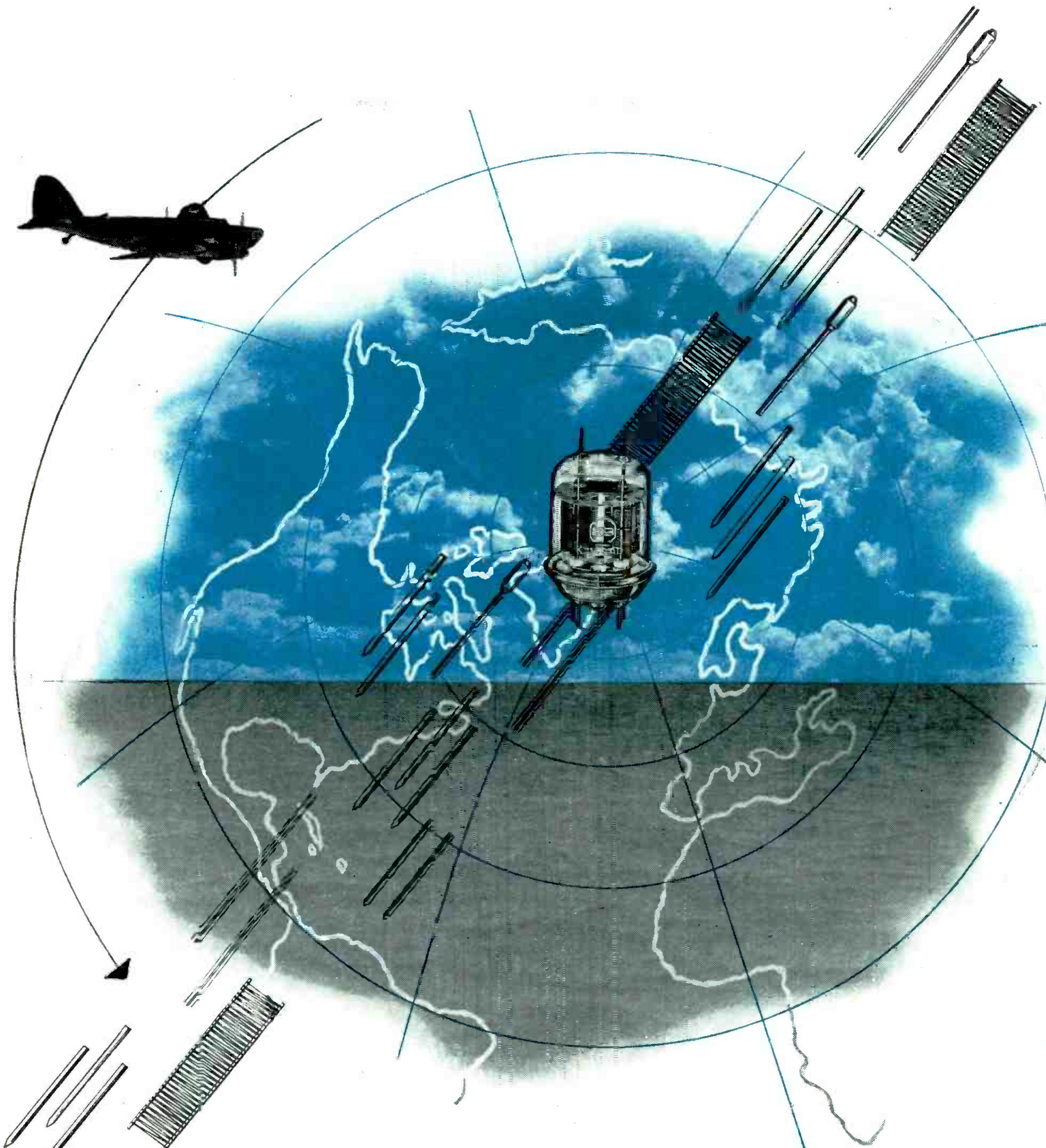
We welcome an opportunity to discuss your postwar needs where our products can be used effectively and economically.

Write today for our 1944 Catalog

JENNINGS RADIO MANUFACTURING COMPANY

SAN JOSE, CALIFORNIA

MEMBER WEST COAST ELECTRONIC INDUSTRIES



Callite tube components
.... elements of stamina

To keep the *fight* in high frequency transmitters, Ken-Rad chose CALLITE components for their Type 829B Tubes now meeting the gruelling tests of battle on every front. From plane-to-ground, plane-to-plane, plane-to-ship, these transmitting tubes are proving their quality is unfailing in great crises.

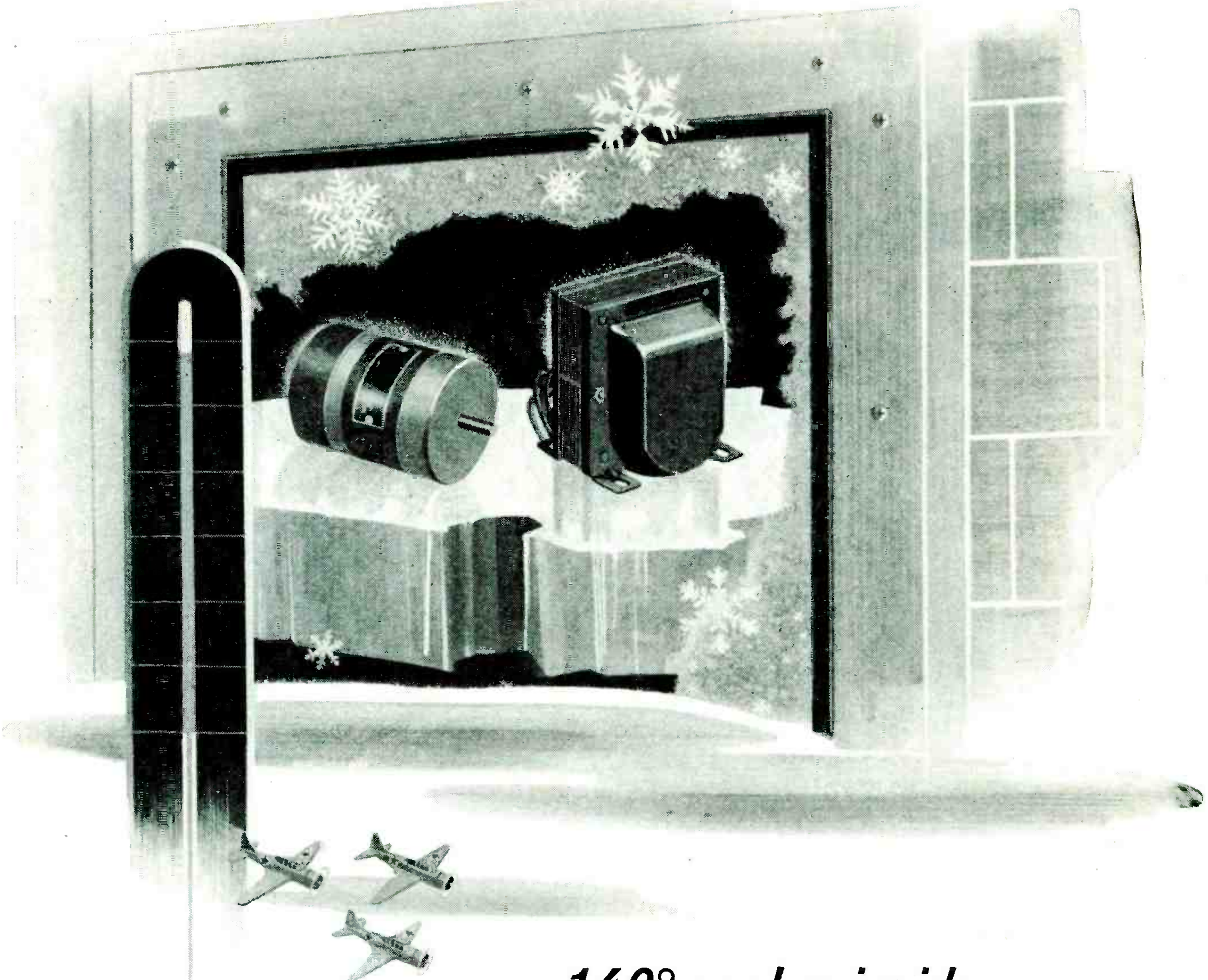
Callite's experience in producing a multitude of special-purpose electronic parts is available to you for quick, efficient assistance in war production now, equally valuable in the postwar battles ahead. Check Callite's important four factors in seeking your source of supply. Callite Tungsten Corporation, 544 Thirty-ninth St., Union City, N. J.

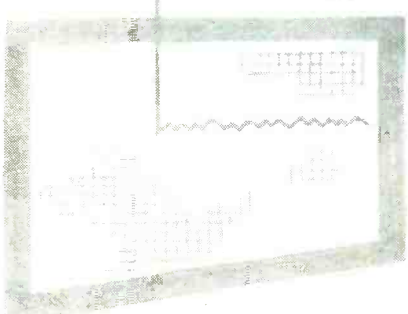
CHECK ALL FOUR Factors important to your production:

✓ Precision-engineered tube components; ✓ Practical help on metallurgical and engineering problems; ✓ Prompt aid in emergencies as well as consistent "usual" deliveries; ✓ Top Quality at a fair price.

Callite

Specialists in the manufacture of welds, hard glass leads, tungsten and molybdenum wire, rod and sheet, formed parts and other components for electronic tubes and incandescent lamps.





140° cooler inside

There is a piece of the stratosphere just beyond that glass door. The air pressure is less than one-fourth of normal air pressure. And the temperature is 70 degrees below zero.

The Utah parts being tested are proving that their performance will be "as specified," whether they are to operate on the ground or high in the air.

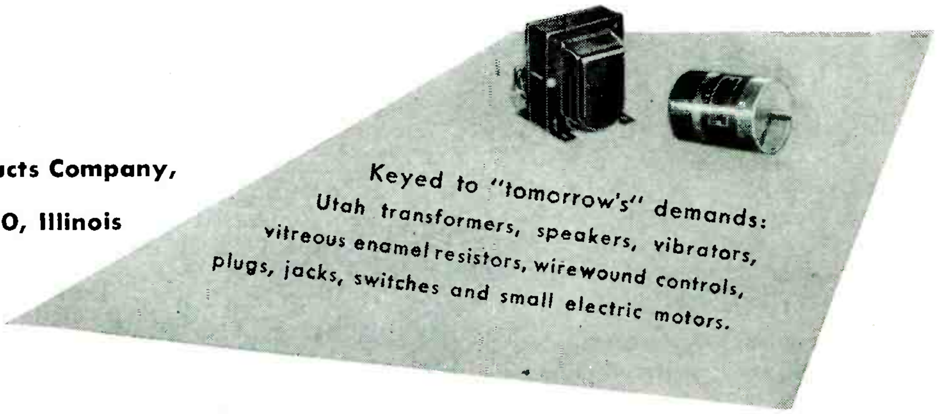
This and other tests which parts undergo in the *complete* Utah laboratory are particularly important in adapting the new electronic and radio developments—in making them militarily and commercially usable—now, and tomorrow!

★ ★ ★

Every Product Made for the Trade, by Utah, Is Thoroughly Tested and Approved

utah Radio Products Company,

837 Orleans Street, Chicago 10, Illinois



Now Available for prompt shipment...

SR-4 STRAIN GAGES

SR-4 STRAIN GAGES AND ACCESSORIES

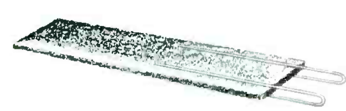
STRAIN GAGES:

Type	Effective Gage Length Inches	Net Width Inches	Resistance Ohms Approx.	Gages Per Set
A-1	13/16	11/32	120	12 & 50
A-5	1/2	9/32	120	10
A-7	1/4	3/16	120	10
A-8	1/8	1/4	120	10
A-9	6-	5/16	300	5
A-11	1-1/16	1/4	120	50
A-12	1-	1/8	120	10
A-13	3/8	5/16	350	10
A-14	3/8	5/16	500	10
AB-1	15/16	3/8	350	5
AB-5	1/2	3/16	75	10
C-1	1-1/16	9/32	500	10
C-5	1/2	5/16	350	10
C-7	1/4	3/16	500	10
C-10	3/8	5/16	1000	10
CB-1	15/16	3/8	1000	5
CB-5	1/2	3/16	200	5
CB-7	1/4	3/16	500	5
CB-8	1/8	1/4	200	5
R-1	13/16	Rosette	120 each leg of three	5
R-2	1-1/16	Rosette	500 each leg of three	5
R-3	13/16	Rosette	120 each leg of four	5
R-4	1-3/16	Rosette	120 each leg of three	5

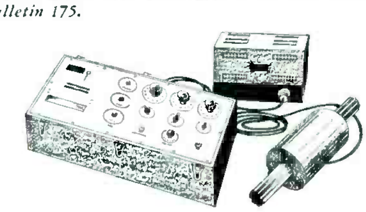
23 TYPES—MANY NEW!
AMPLE STOCKS!

SR-4 Strain Gages revolutionize field determination of static and dynamic stresses in structures and machines. Some types are as small as your little fingernail. Install any place you can reach, on plane or moderately curved surfaces, measure static strains to 1 part in 2,000,000 statically—nearly as small dynamically. No loss in linearity from 0 to 30,000 cycles/sec.

The Baldwin Locomotive Works, Baldwin Southwark Division, Philadelphia, Pa., U. S. A. Pacific Coast Representative, The Pelton Water Wheel Co., San Francisco, Calif. In Canada: Peacock Brothers, Limited, Montreal.

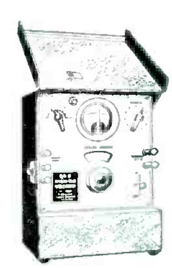


SR-4 STRAIN GAGE
Type A-1—one of 24. Ideal for all static strain measurements and recording problems. Ask for Bulletin 175.

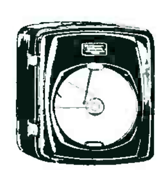


SR-4 TORQUEMETER. *For determining torque in rotating shafts. Accurate, compact. Ask for Bulletin 165.*

SR-4 PORTABLE STRAIN INDICATOR



Sturdy, portable, self-contained. For production testing or laboratory work. Ask for Bulletin 169.



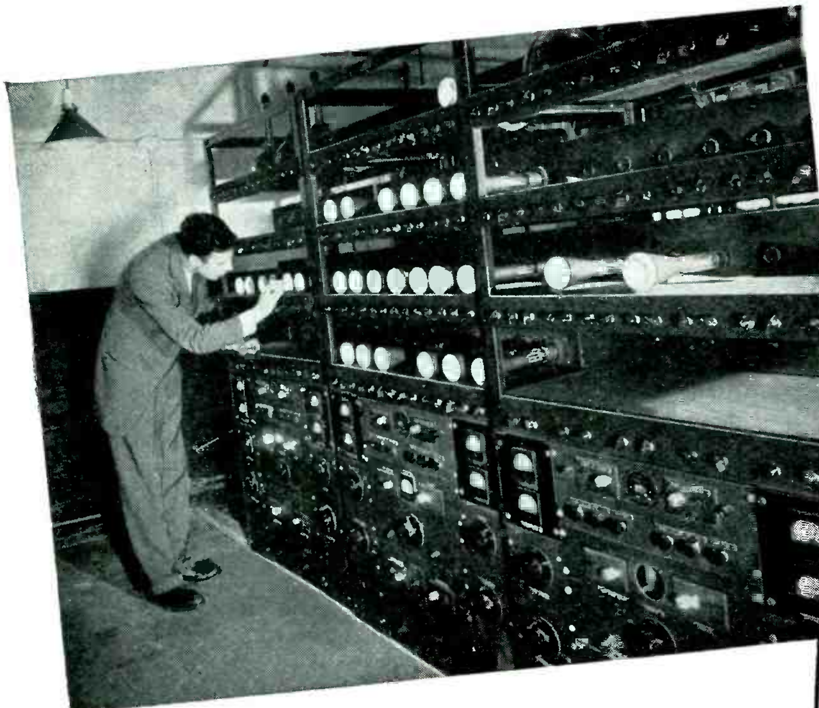
SR-4 STRAIN RECORDERS
Continuously records strains. Ask for Bulletin 170. (Also available: Scanning Recorder, serially records strain from 48 stations. Ask for Bulletin 172.)

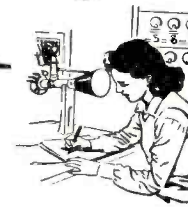
THE BALDWIN GROUP

BALDWIN
SOUTHWARK
TESTING EQUIPMENT

Exhaustive DuMont quality control and life tests take all the guesswork out of

CATHODE-RAY TUBE *Life*





DuMont Quality-Control Checkup

Percentage sample tests—some 100%—are made on production runs for the following:

Brilliance and screen condition—color, spots, burns, etc.

Examination of cathode by using tube as an electronic microscope. The few thousandths of an inch diameter gun aperture is magnified to ½ inch circle to check uniformity of emitting surface. Cathode emission current is measured.

Deflection sensitivity is tested to determine amplitude of signal required to deflect beam by given amount.

Maximum electrode current. Check for excess anode current (to avoid overloading power supply of equipment using tube.)

Determining grid cutoff (when too low, tube life is shortened; too high, might exceed range of intensity control of equipment using tube).

Leakage current of various electrodes.

And other critical and vital factors entering into satisfactory, long, economical tube performance.

DuMont never gambles. Thus each batch of fluorescent material is thoroughly tested in sample tubes. All new metals and other materials are likewise tested. New designs are thoroughly checked with sample production runs. The same with new processes—even to supposedly minor details such as washing and drying of glass envelopes.

DuMont life-test racks eliminate the greatest gamble of all—probable life. Percentage samples are operated in these life racks for 500 hours. A time totalizer keeps score. Tubes are tested weekly for brightness and cathode condition. And at the end of 500 hours the tubes are checked for all characteristics that might be affected by such intensive operation.

So again we repeat: there is no guesswork regarding performance and life with DuMont cathode-ray tubes.

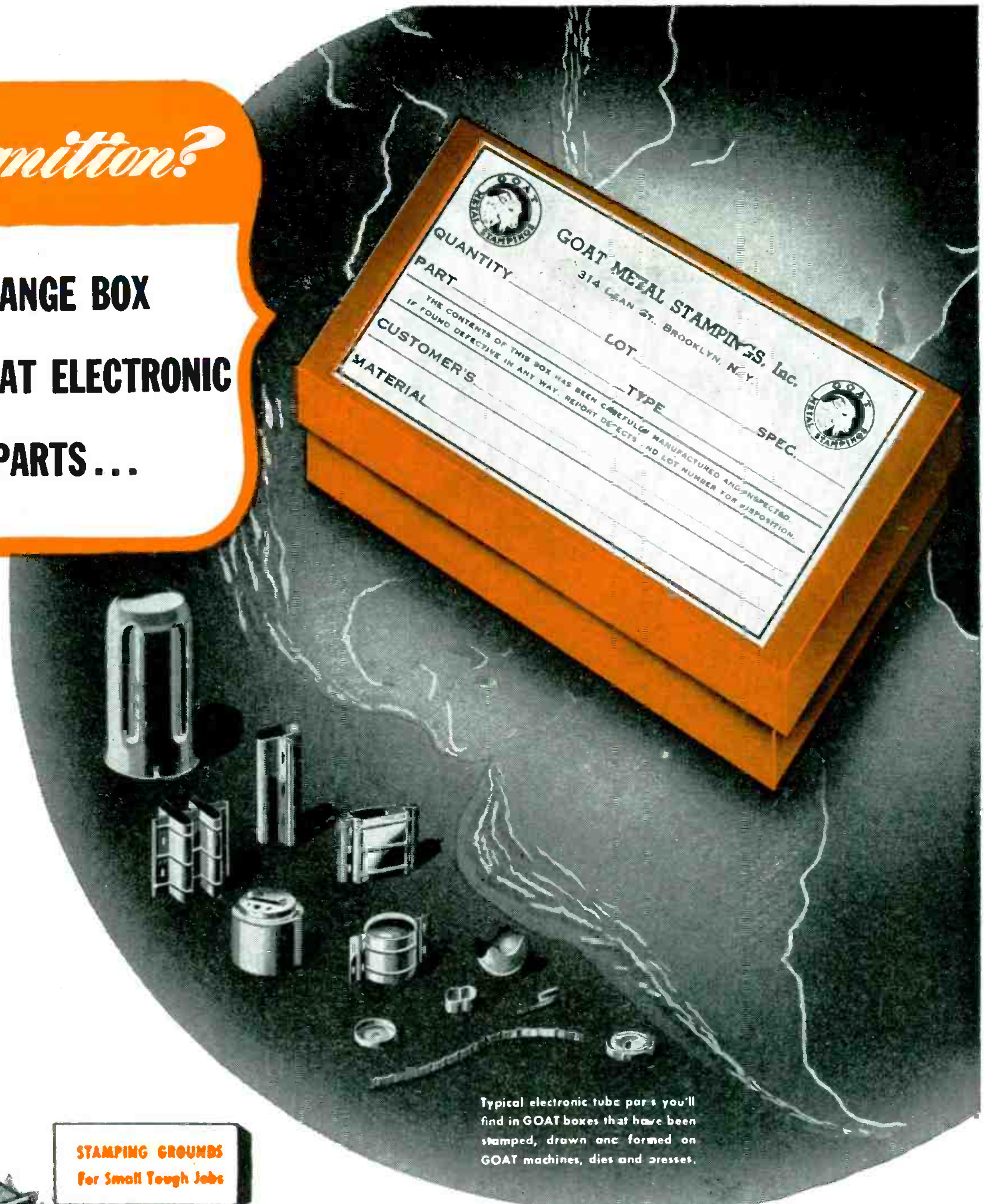
Write for literature . . .

DUMONT *Precision Electronics & Television*

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

Recognition?

THIS ORANGE BOX CONTAINS GOAT ELECTRONIC TUBE PARTS...



Typical electronic tube parts you'll find in GOAT boxes that have been stamped, drawn and formed on GOAT machines, dies and presses.

Wherever electronic tubes are made, you will probably see this orange GOAT box. For GOAT serves almost every electronic tube manufacturer with a tremendous variety of stock and special parts, made of any metal to any specified degree of accuracy. Because of experience gained since the days of radio infancy, GOAT has been able to meet the demands of this industry for greater quality, durability and quantity production. GOAT'S recognition, today, is based on this consistent ability to handle tough jobs requiring skill, precision and efficiency.

GOAT METAL STAMPINGS, INC.

A DIVISION OF THE FRED GOAT CO. INC., EST. 1893
314 DEAN STREET • BROOKLYN, 17, N. Y.

Production Executives agree:

"No Reconversion from American Phillips Screw-Driving

. . . from now on we'll need that Speed and Cost-Control more than ever before"

There's one sure thing in the plans of modern war plant executives . . . they'll never go back to the slow, slip-and-slash, high cost method of assembly with old-fashioned slotted head screws. They'll hold the gains they've made with American Phillips Screws which average better than 50% in assembly time, plus the elimination of rejected work and spoiled materials, thanks to the automatic alignment of the 4-winged Phillips Driver that stays with the tapered recess until the screw has been set up straight and tight.

A comparison of the cost of driving Phillips and Slotted Head Screws will show that it actually costs less to have the advantages of the Phillips Recess.

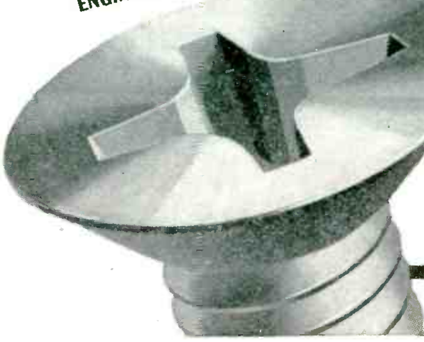
American brand of Phillips Recessed Head Screws are made under rigid laboratory check, and a unique system of piece inspection. Delivery service is maintained by high speed production. And engineering service is at *your* service on any special fastening problem.

AMERICAN SCREW COMPANY

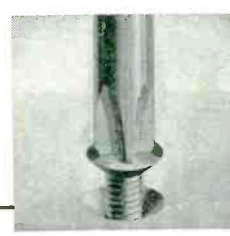
PROVIDENCE, RHODE ISLAND

Chicago: 589 E. Illinois Street — *Detroit:* 502 Stephenson Building

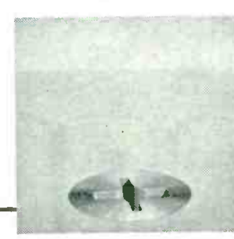
ONLY PHILLIPS SCREWS HAVE THE ENGINEERED TAPERED RECESS



1. **Fast Starting**—Driver point automatically centers in the recess . . . fits snugly. Screw and driver "become one unit." Fumbling, wobbly starts are eliminated.



2. **Faster Driving**—Spiral and power driving are made practical. Driver won't slip out of recess to injure workers or spoil material. (Average time saving is 50%.)



3. **Better Fastenings**—Screws are set up uniformly tight, without burring or breaking heads. A stronger, neater job results and there are no gouges on work surface.

Put the Screws on the Axis ★ ***BUY WAR BONDS***

15-KW OF HIGH-SPEED ELECTRONIC HEAT

WITH THE NEW RCA 15-B

IN nearly every case where electronic power has been applied for heating, important savings in time have resulted. The high-frequency power generated by the new RCA 15-B is suited to heating a wide variety of non-metallic substances because of the wide choice of frequencies it offers—from 2 million to 10 million cycles per second.

Why Electronic Heating? When high-frequency electricity is applied to non-metallic materials, it heats them—*all the way through*. For example, a block of wood can be heated uniformly by high-frequency power while with ordinary heating methods, the heat would have to "seep" in from the outside.

The uniformity of electronic heating makes it possible to introduce heat at a high rate. Processes that once took hours can now be completed in minutes.

The uniform heating often means better uniformity in the finished product, and little or no internal stresses to cause warping.

What Materials Can Be Heated? Wood, plastics, paper, glass, rubber, foods, chemicals, tobacco, ceramics—and many other industrial materials can be heated electronically.

How Much Heat Will the 15-B Give? The new RCA 15-B electronic generator is rated at 15 kilowatts output. It will deliver up to about 50,000 B.T.U. per hour, depending on the load conditions.

Easy to Operate. The 15-B is push-button controlled. Once the correct processing procedure is established, any intelligent operator can use it with ease. RCA field engineers are available to help with your application problems.

Get the Full Story. A comprehensive 12-page descriptive catalog on the RCA 15-B generator is yours for the asking. Use the convenient coupon below. If you have a specific application for electronic heat in mind, write, stating particulars, to RCA, Electronic Apparatus Section, Camden, New Jersey.

FREE

BUY WAR BONDS

RCA

RCA ELECTRONIC HEAT

RADIO CORPORATION OF AMERICA

RCA, Electronic Apparatus Section, Camden, N. J.

Please send me details on the new RCA 15-B electronic generator.

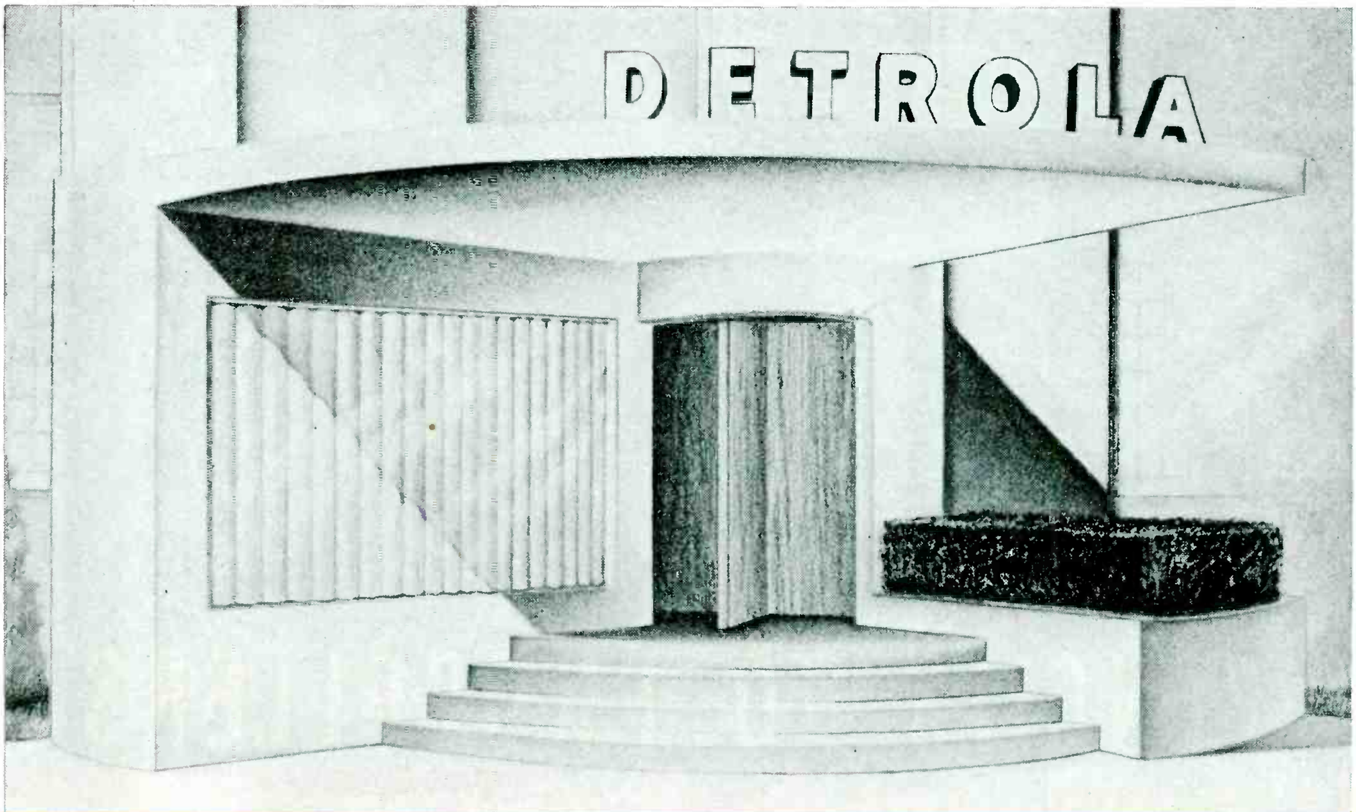
Name..

Company..

Address..

City..State..................

70-44H



PORTAL to PRECISION for War and Peace

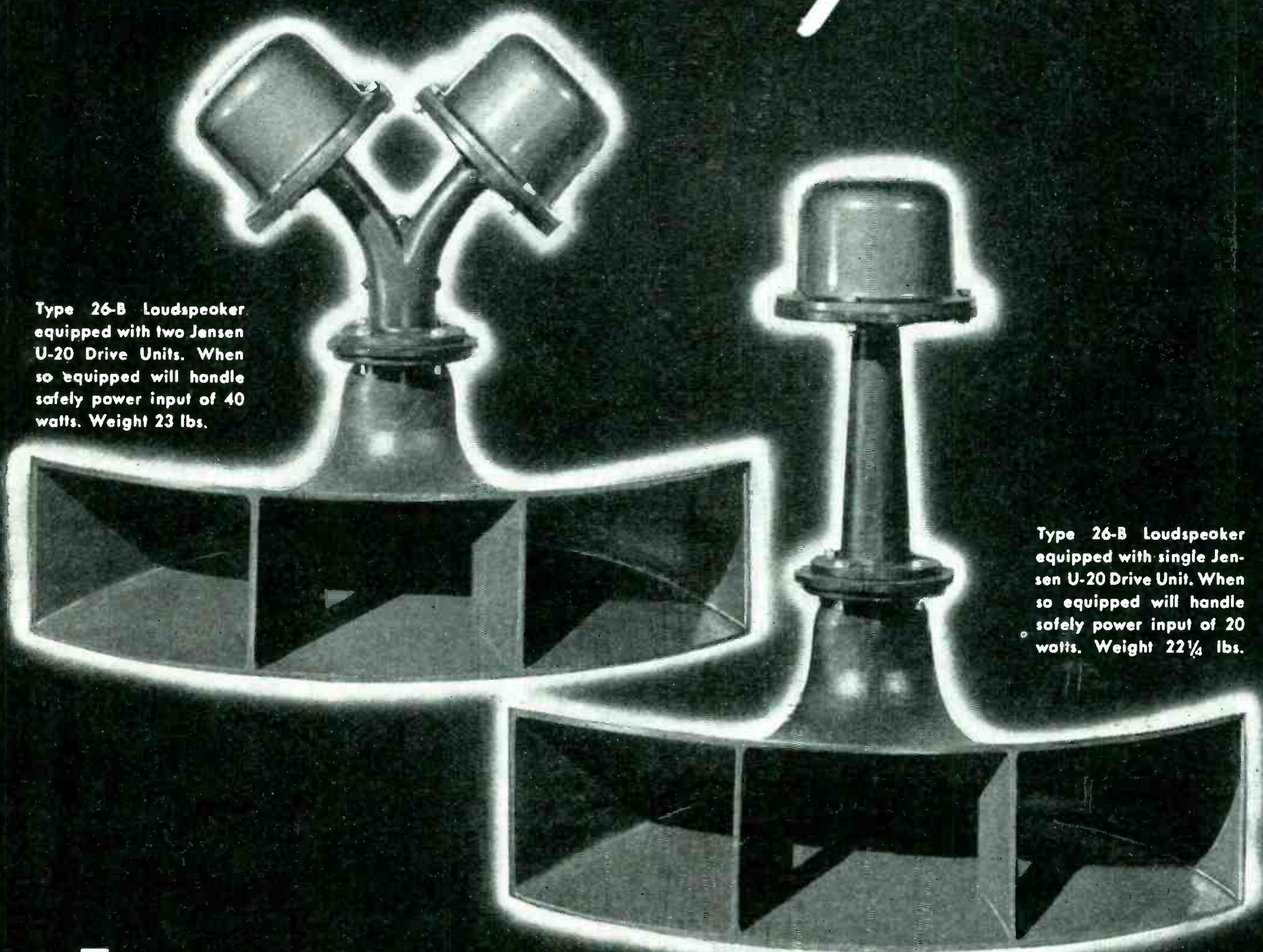
Shown here is the proposed new doorway to Detrola's offices and laboratories. It will soon be a part of the building—to serve not only as a practical and functionally beautiful entrance-way, but to stand as an outward symbol of the many changes that have brought the NEW DETROLA into being. Today this great radio-electronic plant is streamlined throughout—with new research and engineering talent, new production facilities and hundreds of highly trained workers. All of these are dedicated, now, to the manufacture of highest quality war equipment. After Victory, in combination with the experience gained in war, they will be dedicated to the production of highest quality electronic products for civilian use. *Help Secure Victory and Make Victory Secure—Buy War Bonds.*

DETROLA RADIO

DIVISION OF INTERNATIONAL DETROLA CORPORATION • BEARD AT CHATFIELD, DETROIT 9, MICH.

C. RUSSELL FELDMANN dr PRESIDENT

THE TYPE 26-B *Loudspeaker*



Type 26-B Loudspeaker equipped with two Jensen U-20 Drive Units. When so equipped will handle safely power input of 40 watts. Weight 23 lbs.

Type 26-B Loudspeaker equipped with single Jensen U-20 Drive Unit. When so equipped will handle safely power input of 20 watts. Weight 22¼ lbs.

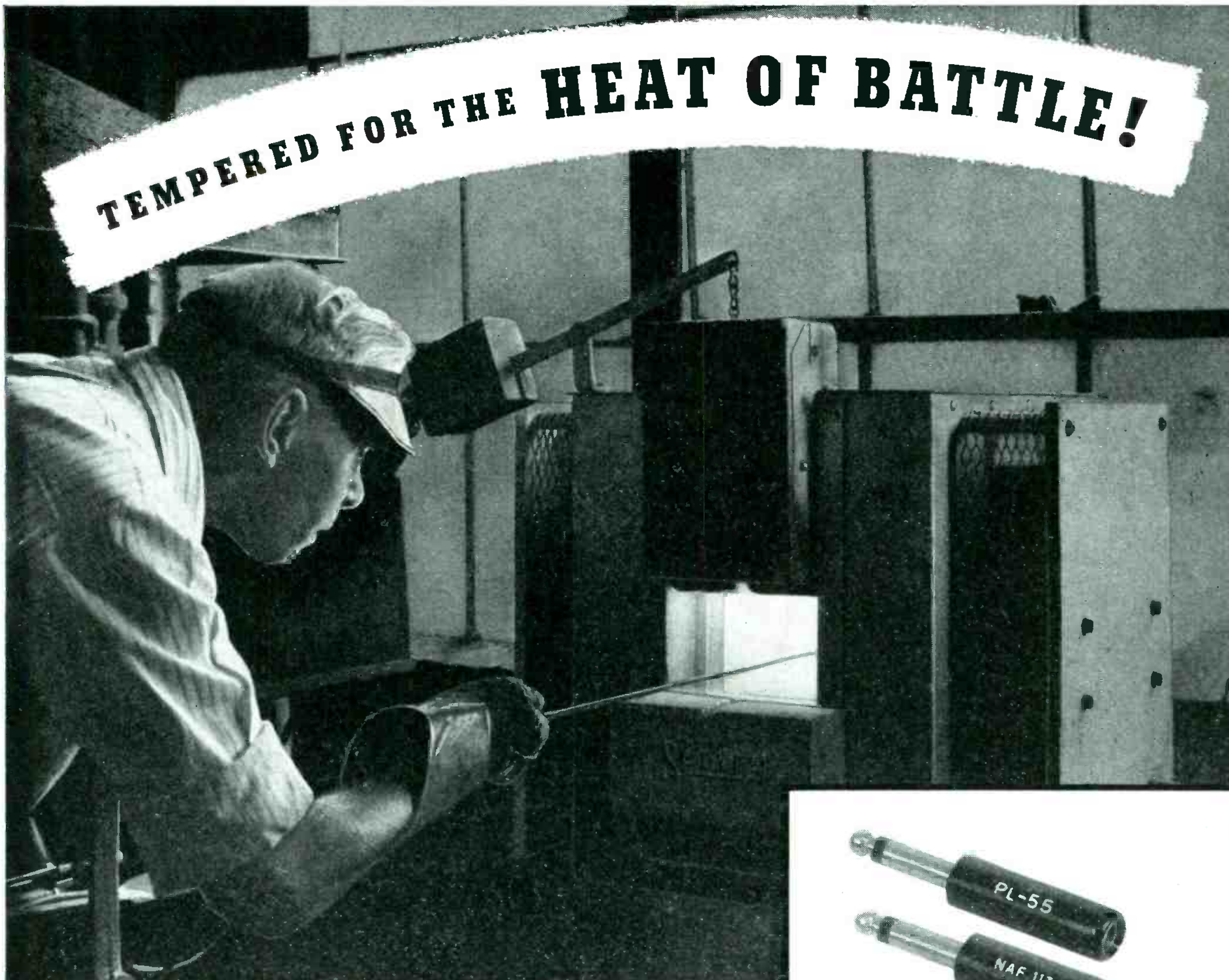
THE Type 26-B Loudspeaker is designed for voice reproduction when used by itself. It is also excellent as the high frequency component of a wide range loudspeaking system. One Type 26-B Loudspeaker provides uniform sound distribution both as to frequency and power over a horizontal angle of 120° and a vertical angle of 40°. Made of one piece cast aluminum. 22″ wide, 14½″ deep, and 20″ high, including Drive Unit and Adapter. Supplied with heavy universal mounting bracket. Complete specifications upon request.

The Langevin Company

INCORPORATED

SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

NEW YORK	SAN FRANCISCO	LOS ANGELES
37 W. 65 St., 23	1050 Howard St., 3	1000 N. Seward St., 31



Remler craftsman heat treats welding and cutting dies and tools for automatic screw machines.

ELECTRONIC TOOLS OF WAR . . . in quantity and on time! There are no delays because Remler has the facilities and experience to do the job from design to finished product —plus the know-how to cut production time which frequently permits quotations at lower prices. This organization of skilled specialists manufactures components and complete electronic equipment for our armed forces and components for *your* application. Inquiries invited.

Wire or telephone if we can be of assistance

REMLER COMPANY, LTD. • 2101 Bryant St. • San Francisco, 10, Calif.

REMLER

SINCE 1918

Announcing & Communication Equipment

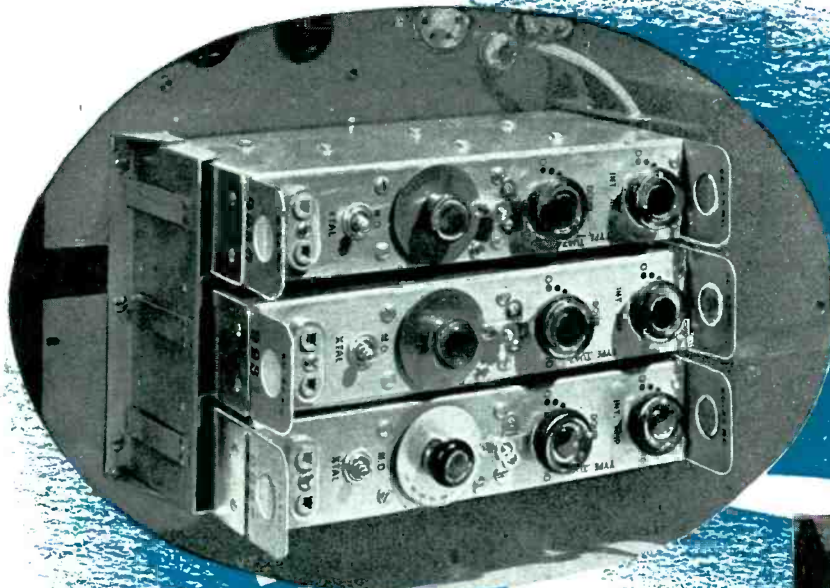
PLUGS & CONNECTORS

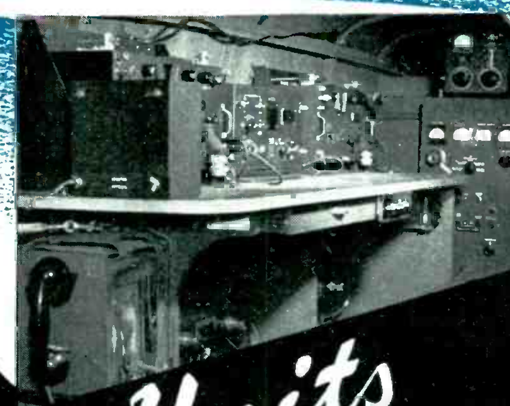
Signal Corps · Navy Specifications

Types:	PL				NAF
50-A	61	74	114	150	
54	62	76	119	159	
55	63	77	120	160	1136-1
56	64	104	124	291-A	
58	65	108	125	354	No.
59	67	109	127		212938-1
60	68	112	149		

PLP		PLQ		PLS	
56	65	56	65	56	64
59	67	59	67	59	65
60	74	60	74	60	74
61	76	61	76	61	76
62	77	62	77	62	77
63	104	63	104	63	104
64		64			

OTHER DESIGNS TO ORDER





GUTHMAN *Super Tuning Units*

IN THE FAMOUS SCR-299 MOBILE TRANSMITTER

We at Edwin I. Guthman & Company are proud of the Super Tuning Units that we manufactured completely in our splendidly equipped plant for the Hallicrafters' SCR-299 mobile transmitter. Operating under most trying combat conditions on all Allied Fronts, the SCR-299 has distinguished itself amongst America's most vital "weapons" . . . and always the Guthman Super Tuning Units rendered dependable and accurate service.

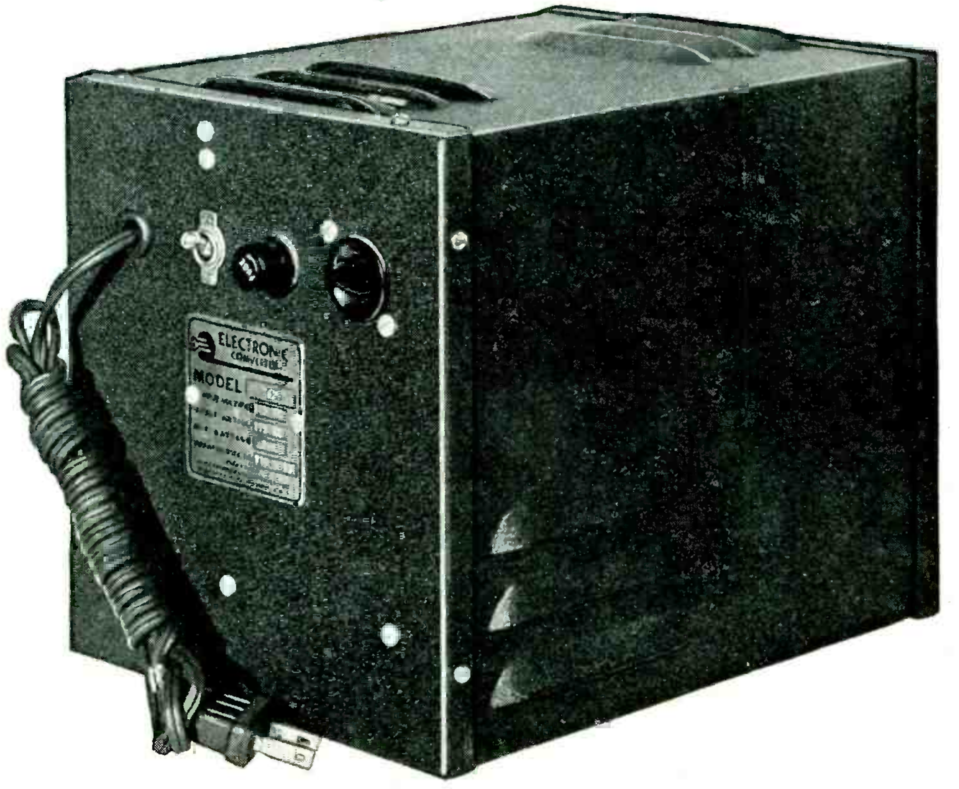
"GUTHMAN . . . Leader in INDUCTRONICS"

EDWIN I. GUTHMAN & CO. INC.

15 SOUTH THROOP STREET · CHICAGO

PRECISION MANUFACTURERS AND ENGINEERS OF RADIO AND ELECTRICAL EQUIPMENT

For Operating 110-Volt A.C. Equipment from 110-Volt D.C. Power Source



THE E·L MODEL 262

TYPICAL APPLICATIONS OF MODEL 262

The operation of—**Radio Receivers • Radio Transmitters • Public Address Systems • Radio-Phonographs • Inter-Office Communication Systems • Sewing Machines • Electric Fans • Office Equipment • Electric Trains**

This unit was designed for, and has met, the severe demands of war-time service for the operation of 110-volt A.C. radios, on land and sea, with complete success. It is engineered to eliminate R.F. noise over a frequency band from 550 kilocycles to 20 megacycles, and will operate satisfactorily under wide extremes of temperature and humidity. Further information on this and other *E·L* Vibrator Power Supplies will be gladly supplied on request.

E·L MODEL 262 SPECIFICATIONS AND PERFORMANCE DATA

LOAD POWER FACTOR: 85% to 100%
INPUT: 110 volts D.C.
OUTPUT: 110 volts A.C.
OUTPUT POWER: 250 volt-amperes
FREQUENCY: 60 cycles
EFFICIENCY: 85% at rated load
REGULATION: 15% approximately
TEMPERATURE RISE: 50 degrees F.
HUMIDITY: Will operate under any degree of humidity up to 95%
VIBRATION: Unit is built to withstand severe shock and sudden jar
SIZE: Length, 10¾"; width, 9 7/32"; height, 8 5/32"; weight, 28½ pounds

OTHER E·L 110-VOLT MODELS

Model	Watt Rating	Load Power Factor
267	2–5 Watts	High
261	5–75 Watts	High
204	50–150 Watts	High
262	250 Watts	High
260	250 Watts	Low
263	400 Watts	Low
264	500 Watts	High
268	750 Watts	Low
269	1500 Watts	Low

Electronic LABORATORIES, INC.
INDIANAPOLIS

E·L ELECTRICAL PRODUCTS — Vibrator Power Supplies for Communications . . . Lighting . . . Electric Motor Operation . . . Electric, Electronic and other Equipment . . . on Land, Sea or in the Air.

Disposal of Government Inventories

How to dispose of government surpluses when the war ends need not be an insuperable problem – if we face it promptly and intelligently. But if we do not, peacetime markets may be disrupted, government funds wasted, production discouraged, and reconversion of the whole economy to peace seriously hampered.

What we need most in order to attack the problem is estimates of how much surplus there will be, in what types of goods, and where.

At the war's end, government inventory of war goods is likely to total around 60 billion dollars. Most of this will consist of aircraft, ships, and other ordnance. Only some 15 billion dollars or less will be in food, clothing, trucks, tools, chemicals, medical supplies, transportation, engineering and communication equipment, and other goods for which there is a civilian market.

In addition, war contractors will have about 10 billion dollars of inventories, the bulk in specialized raw materials, goods in process, and finished products. Only about one-fifth of the total, or some 2 billion dollars, will be marketable or usable for civilian purposes. While the government takes over the usable inventory, the ex-war-contractors will have to build up their stocks for peacetime production, so that on balance, they will not be disposing of usable inventories in large volume.

Not even all of the usable war-end inventory will be "surplus" for sale to civilians in competition with new production. Some of it will be needed by the sizable peacetime Army and Navy we are likely to maintain, and such additional items as can be stored without serious deterioration or obsolescence will be held against possible future war emergencies. Some of it will be disposed of abroad. And up to half of it will be abroad and may be sold there or used for relief.

After allowing for these factors, the war supplies to be disposed of in our own markets probably will be less than 10 billion dollars (cost basis). While the total is not overwhelming – the equivalent of two months' retail sales – in certain lines the surplus will be several years', instead of a few months', normal supply. In particular, the volume of scrap metals available from otherwise unusable munitions will present a problem.

A great deal can be done now to reduce the size of the postwar surpluses by achieving a better balance between military needs and supplies and avoiding excessive inventories of particular raw materials or finished goods. This work needs to be pressed, not only to simplify our transition to peace but also to prevent wasting productive energies during the war. Furthermore, when the war ends on one front, inventories of war materiel should be worked down to the reduced scale of remaining military activity.

We cannot develop programs of action until we know approximately how much of each type of item is to be sold, and where and when it will be available. Wide margins of error are inevitable as long as large-scale procurement and large-scale consumption are still taking place; yet such information is essential and must be developed. Indeed, improved inventory records and estimates are badly needed for the conduct of the war as well as for managing the surpluses after hostilities cease.

In decisions on the disposal of war-goods inventories, the public interest must be the prime consideration. Proposals that none of these goods should be sold domestically because of competition with new production obviously are untenable. Everything that is not needed by the Armed Services or for other special purposes should be disposed of ultimately. The real problem is not whether surpluses should be sold, but rather to whom, at what price, and at what time the sale should be effected.

In the distribution of such large quantities of goods, we believe that established trade channels should be used wherever possible. Otherwise, we shall witness widespread speculation in war goods and the mushroom growth of inefficient and disruptive fly-by-night distributors. This will benefit only a few speculators and will discourage legitimate producers and distributors from making their normal commitments.

All war contractors should have the privilege of retaining those inventories for which they are willing to pay actual cost or a fair price negotiated with the government procurement agency. The balance of the inventories in the hands of war producers should be assembled by the government and sold in an organized manner. It is of great importance that the plants be cleared of these inventories at once so that the process of conversion to peacetime operation can proceed without further delay. To accomplish this, preparations must be made before the end of the war for speedy determination of the inventories to be moved and for a huge volume of storage space to accommodate them.

The price which can be realized and the timing of sale are closely related. Certainly the best prices will not be secured if the government attempts to dispose of large supplies of material and products suddenly without regard to market conditions. Most businessmen rightly favor an early transfer of surplus inventories from government to private ownership. But, they also realize that if all the surpluses are dumped indiscriminately as they become available, many markets will be badly depressed, and the resulting low prices will bring lower production. If this depression effect becomes general, as it easily can, it will be costly to the nation in terms of jobs, income, and goods.

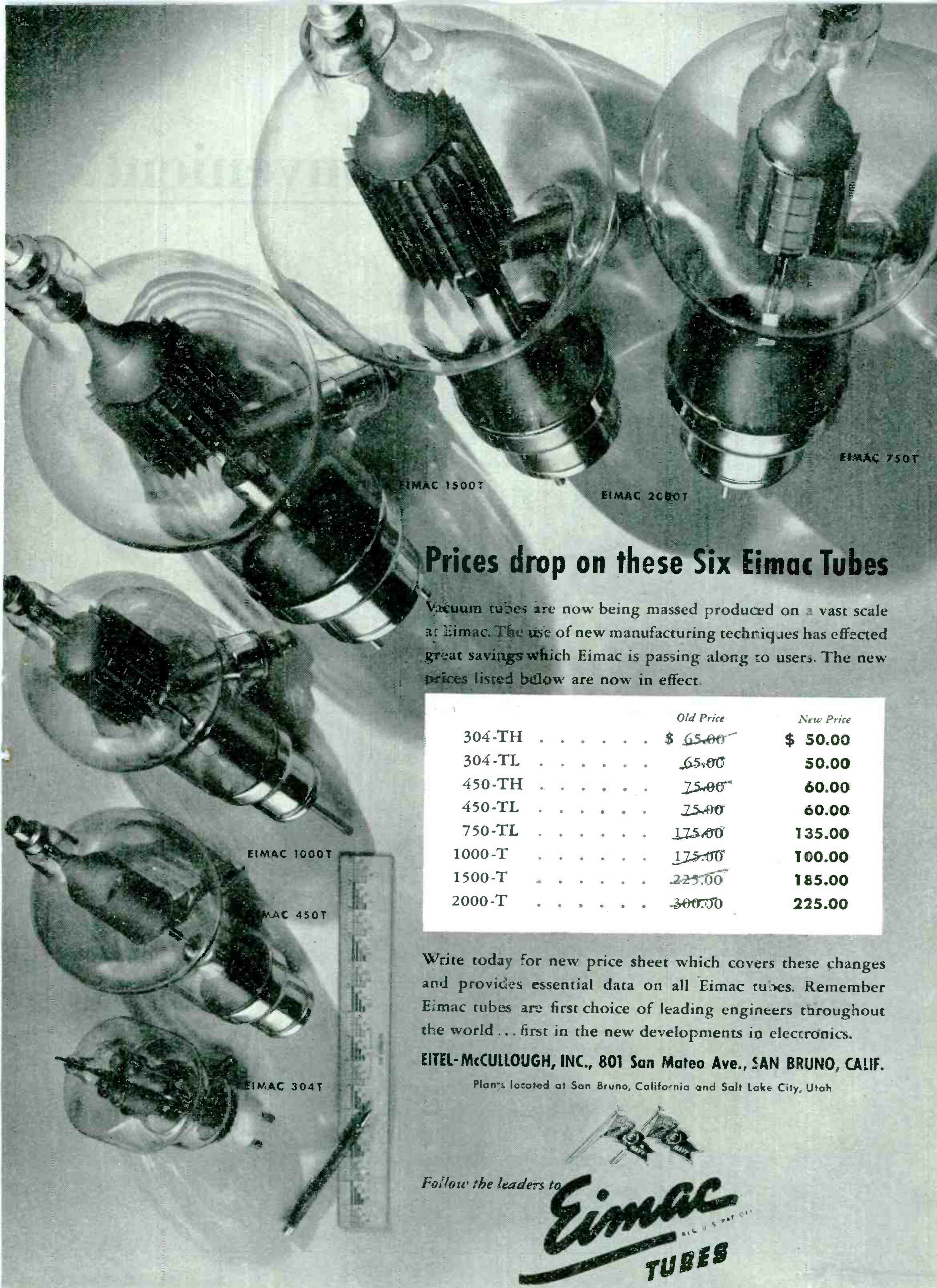
In industries in which production is inadequate to meet postwar demands, an immediate sale of government inventories can prevent inflated prices and preserve balanced market conditions. In cases in which the surpluses are large in relation to annual production, the disposition can be scheduled over a period of years. Generally, however, it will be best to clear the surpluses as quickly as orderly sale can be accomplished rather than to leave them as a continuing threat overhanging the market. Most industries can, and should, take the disposal process in their stride without special dispensations from the government. In this connection, it should be noted that the tax provisions for carry-back of losses and excess profit credits after the war greatly increase the possibilities for speedy disposal of surpluses without serious injury to producers.

There will be some industries, however, in which the postwar surplus is so large that it would practically saturate the market for years to come. The problem of these industries is further complicated by their wartime expansion of capacity many fold in excess of peacetime requirements. These lines of production are, moreover, crucial for our national defense. Aircraft and shipbuilding are cases in point. Each of these situations calls for careful study and discussion by all concerned to devise means to keep alive the necessary production organizations, the research effort, and the spirit of enterprise. Insofar as possible, the individual manufacturers should work out their own salvation in the conversion to peacetime markets. They can do this by taking on new lines, by increasing their production efficiency, and by developing technical improvements which make the existing inventories obsolete. But they still will need some kind of government protection or assistance while the huge surpluses are being worked off. It is most important, however, that such protection or subsidy be limited to a period of three to five years. It must not become permanent unless it is really essential for our national security.

The disposal of surplus inventories is part of the whole process of demobilization of the war effort and conversion to peace. If this process is to be accomplished with minimum dislocation and injury to our economy, it will have to be directed by a central agency which has developed adequate information service and is in position to coordinate the policies of the Armed Services and the other interested executive branches of the government. This agency should draw freely on the knowledge of businessmen in the specialized problems of marketing surpluses in each industry. It should formulate definite programs of inventory disposal for all industries in which the problem is acute; and it should make these programs public as soon as possible, so that business can plan for the future with confidence. In large measure, the success with which we make the economic transition to peace will depend on the quality of government administration in the process of industrial demobilization. We shall need better organization for the transition to peace than we had in mobilization for war if we are to avoid needless unemployment, loss of production, and frustration of business enterprise.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.



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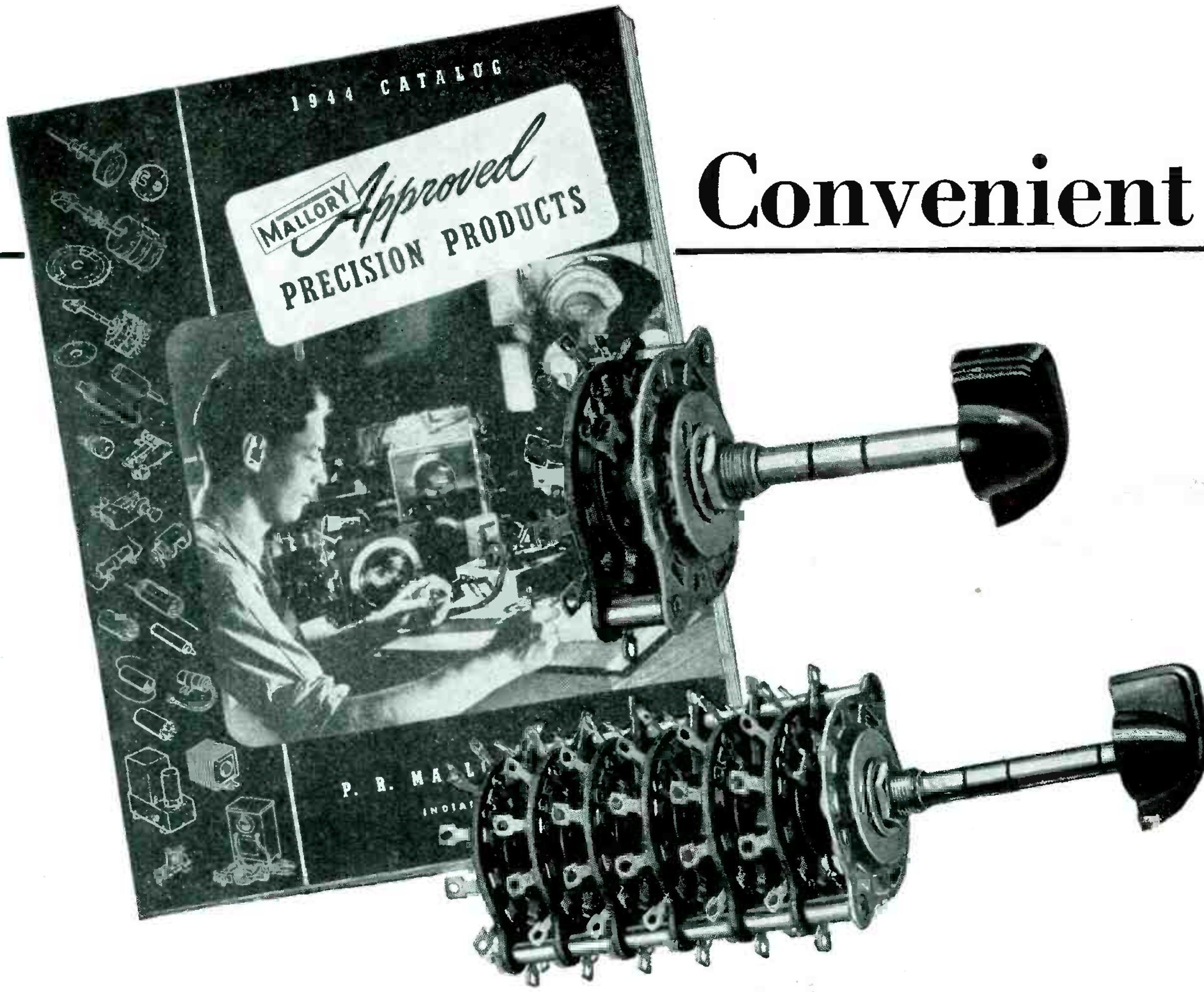

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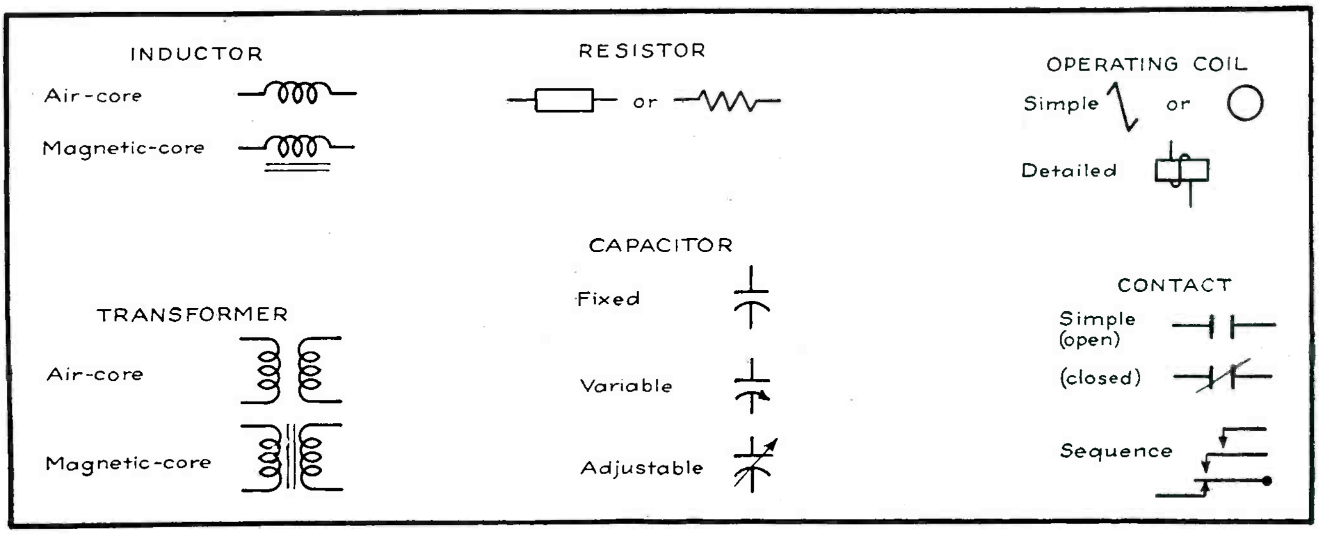
CROSS TALK

▶ **SYMBOLS** . . . Meeting in New York on January 22 under the auspices of the American Standards Association, representatives from industry and from the armed forces prepared a compromise set of symbols covering component parts commonly found in most electronic circuits, regardless of their nature. Minutes of the meeting together with drawings showing the proposed standards, and ballots with which to indicate approval or recommend reconsideration, were mailed February 2 to men who attended and others who have an interest in the subject.

The symbols involved included capacitors, contactors, resistors, inductors, transformers, and operating coils. The first recommendation voted by the meeting eliminated as a symbol for a capacitor the parallel straight lines conventionally used in communications diagrams, substituting one straight line and one curved line. It was suggested that parallel straight lines hereafter represent a contactor, as in power diagram practice, with the proviso that the lines be short and that the space between the lines roughly equal the length of the lines. Indication of sequence contacts by means of a more elaborate symbol, shown in the accompanying illustration, was approved. It was recommended that a zig-zag line or simple rectangle, rather than a crenelated line, be used to indicate a resistor. Inductors, and the windings of transformers, are to be drawn as a series of closed loops, with the use of parallel straight lines to indicate metallic cores left optional. Three types of symbols for operating coils, shown in the accompanying illustration, were tentatively approved.

The spirit of cooperation shown at the meeting was most encouraging. Communications men and power men whose symbols have long been used in their respective branches of the art appeared willing to give and take a little for the good of the industry in general and the war-effort in particular. Men representing services which classify strictly at neither one extreme nor the other appeared willing to string along. It is hoped that when letter ballots are returned by all concerned some very old and confusing differences in symbols will be finally reconciled.

Compromise Symbols Recommended by Representatives of Industry and the Armed Forces



WARTIME ELECTRONIC

How government and industry, British and American, are exchanging patented and unpatented technical information in furtherance of war production, with minimum delay and with the goal of avoiding infringement suits and other post-war legal tangles

AT the beginning of the War, two fundamental problems, both based on patents, faced the Armed Forces and American industry. The first was the difficulty in transferring research and development information between laboratories, on both sides of the Atlantic, that were working on parallel or closely related developments.

In the early summer of 1941, when the program was first conceived, many of the "secret weapons" which have since made history were in their earlier stages. Each organization was inclined to believe that it was far ahead of its competitors in the commercial field, and most of them were reluctant to give information to the others lest "hedging" patents might be granted that would deprive them of the benefit of their own original work. Military security regulations tended to foster this view. Further, many officers, to whom patents were a mystery, were more hesitant about asking one company to give information to another than the companies would have been to give it if asked.

The "Save Harmless" Clause

The second problem had to do with responsibility for infringement in the manufacture of equipment for the government. By statute this responsibility rests on the government, but because in time of peace the contractor had better facilities than the Armed Services for determining what patents were involved in a piece of equipment, and in order to prevent wholesale piracy of patents, nearly all government contracts carried the so-called "Save Harmless" clause, whereunder the contractor indemnified the government against liability for unauthorized use of inventions.

Some twenty-five years use of such clauses had endowed them, in the minds of most contracting officers, with almost the sanctity of Holy Writ. Procurement instructions practically made their use mandatory. But in time of rearmament and approaching war, they were a constant source of irritation and delay. Contractors resented receiving orders to build new and unfamiliar equipment, utilizing scores or even hundreds of patented inventions, and being required to assume the unknown patent liability. Smaller companies simply signed and took their chances. The largest stalled the actual signing of the contracts while they made patent searches, and then tried to obtain necessary licenses, if any. Many contractors, of intermediate size, set up reserves to pay estimated royalties or damages. But one and all they argued with the contracting officers, who could do nothing but follow instructions.

Open Patent Pool Was First Proposed

It appeared to certain officers in both the Army and Navy that both of these problems would be much simplified by the formation of an open patent pool in the radio industry. If membership in such a pool were so general as to be practically universal no member would need fear being blocked off from the use of his primary inventions by the improvement patents of another—he would be automatically licensed. And with the vast majority of radio and electronic patents in a pool, the liability of infringement would be much reduced, and it might be possible to delete the "Save Harmless" clause from procurement instructions.

The major factors in the industry were sounded out on this plan, with varying results. Finally the Under Secretary of War called a general meeting of the industry to discuss it. The date of the meeting may have had much to do with the result—the industry representatives met in the new War Department Building on December 9—two days after Pearl Harbor, under the chairmanship of Lt. Col. (now Col.) Conrad E. Snow.

Formation of Patent Committee

The Open Pool plan was not adopted. Some members were definitely opposed to it, some felt that while desirable it presented difficulties which would delay its effectiveness indefinitely, some were heartily in favor. All appeared to recognize the problems, and agreed that some action was desirable, and the meeting, before adjourning, recommended that a committee of the industry be appointed by Army representatives, to formulate recommendations to the Services for meeting the problems involved.

The appointment of the committee was delegated to Major (now Lt. Col.) Donald K. Lippincott, who was chairman without vote.

Three meetings were held, on Decembed 12, 19 and 30, 1941, and on the 30th, after three days of sometimes heated debate, in which, it must be admitted, Army and Navy "observers" joined on occasion, the following recommendations were unanimously adopted:

1. That all manufacturers and developers in the Radio Industry in the United States of apparatus useful to the Government for communication, signaling, remote control, navigation, and direction and position indication, undertake, subject to payment of reasonable compensation in these instances in

PATENT POOL

which compensation is deemed equitable, to supply all pertinent technical information relating to such apparatus to, and to confer with, any party designated by the Government after consultation with the manufacturer or developer concerned.

2. That, in its discretion and where feasible, the Government endeavor to obtain licenses, or other rights, from owners of rights under inventions, patents, and patent applications to make or to have made, to use, or to sell or otherwise dispose of pursuant to law, apparatus for communication, signaling, remote control, navigation, and direction and position indication.

3. That the "Save Harmless" provision, sometimes included in government contracts, be eliminated from all future government contracts pertaining to apparatus for communication, signaling, remote control, navigation, and direction and position indication.

The recommendations were circulated among the members of the industry, and a second general meeting was called, under Col. Snow's chairmanship, on Jan. 20, 1942, at the Hotel Roosevelt in New York. The debate here was short; the committee made its report, stated the reasons for the phraseology, gave its interpretation on some points, and the recommendations were unanimously adopted as those of the industry to the War and Navy Departments.

Approval of Services Secured

The Departments acted more slowly. The recommendations called for major changes in policy, and many approvals were necessary. By the middle of March, however, these approvals had been obtained, and the recommendations were adopted as policy by both Services, with the reservation that the inclusion of the "Save Harmless" clause was not forbidden, but was made discretionary. This, however, was a vast change of emphasis from the former practice which made its omission require discretionary action by higher authority. The Services immediately began to solicit licenses.

To secure them was not as simple as might appear from their unanimous recommendation by the industry. No terms were specified in the recommendations, and ideas as to what such terms should be were diverse, both in industry and the Services. Some thought licenses should all be royalty free, some that they should be paid for. Some thought an unvarying form should be insisted on, others that flexibility of form was essential. The early

Procurement of Patent Licenses

By the end of June, however, the problems had been largely resolved by virtue of cooperation by all parties and their spirit of compromise to achieve the end desired. Thirty-two licenses had been accepted, and the terms of others had been settled, so that they required only formalization. The program was definitely a success.

License-Negotiating Principles

Broadly, the principles adopted in negotiating the licenses were these: Where royalties had been the main source of revenue, license fees were paid for the Government licenses, particularly where there were research or development laboratories to be supported by such payments. Where patents had been used primarily in their own products or for their trading value by concerns which obtained their revenue from manufacture, the licenses were royalty free.

In all cases except one, the license agreements contained a covenant by the Under Secretaries of War and Navy to omit or waive "Save Harmless" clauses in supply contracts with the licensors. The one exception refused such a covenant, maintaining that the indemnity clause should be omitted as a matter of common justice, and refusing to make it an element of a bargain. (It may be added that both Signal Corps and Navy omit the clause in supply contracts with this company and its subsidiaries.) No extent-of-use royalties are paid; wherever payments are called for by the licenses, they are on a flat fee basis, either for the duration and six months or at a rate of so much per year.

Results

The number of licenses so far accepted by the Government now exceeds 140. The program is not complete, and the Signal Corps says it doesn't expect it ever will be. Patents, they point out, issue every Tuesday. But an overwhelming majority of existing patents are included in the program, and the more difficult problems continue to be settled by patient negotiation, and new licenses continue to be granted.

The Government proponents of the program are happy about the way it has worked. The Signal Corps estimates that the average time for the negotiation of contracts has been cut by two weeks through the elimination of all arguments on patent liability.

The Government's payments in license fees for all licenses accepted to date are somewhere betwen five and six million dollars per year. Computation of royalties is extremely complex; there are deductions to be made, sliding scales to be considered; even the figures on which such computations are based are military secrets.

The Signal Corps expects almost complete freedom from post-war patent litigation. Some litigation there certainly will be, for claimants whose very existence is now unknown to the Government will almost certainly arise, maintaining that they are the true inventors of the spectacular developments that come out of the war. But in spite of the enormous use of radio and electronic technique by all branches of the Services, it is not believed that any litigation comparable to that which followed the last war (some of it still unsettled) will follow this one.

Captured AXIS

A detailed description of the German FUG-10 panel used in bomber and reconnaisance aircraft. Included in the installation are two separate transmitters and receivers, a direction-finder, blind-landing gear and an intercom system

American manufacturers have exhibited considerable interest in captured Axis equipment, wherever it has been shown. The following detailed description of the German FUG-10 panel used in bomber and reconnaisance aircraft should, therefore, prove useful.

The German FUG-10 panel, or rack, contains two transmitters and two receivers. One transmitter and its companion receiver operate in the 300–600 kc band. The other transmitter and its associated receiver operate in the 3000–6000 kc band. Both units employ cw and mcw operation. No voice communication is used. In addition, the following units are mounted on the panel: A remote-controlled direction-finder operating in the 100–1100 kc band, a blind-landing device operating in the 28–32 Mc band, and an interphone system which serves to supply communication to the aircraft crew as well as to interrupt the cw transmission for purposes of ground homing.

Equipment is non-crystal controlled and relies on capacitance compensation for frequency stability. Facilities are available for tuning a predetermined spot on a dial to a master-signal station which is undoubtedly maintained on frequency by crystal control. This corrects the calibration of the two receivers. The transmitters are then operated at low power and tuned to zero beat with the receivers. This can be done during flight to compensate manually for changes in temperature and humidity.

Mounting

The two transmitter units and the two receiver units, as well as the associated dynamotor power supplies, are mounted on the large bulkhead-shaped rack by means of strong metal hooks and each is secured in place by two locking screws. A mounting of the various

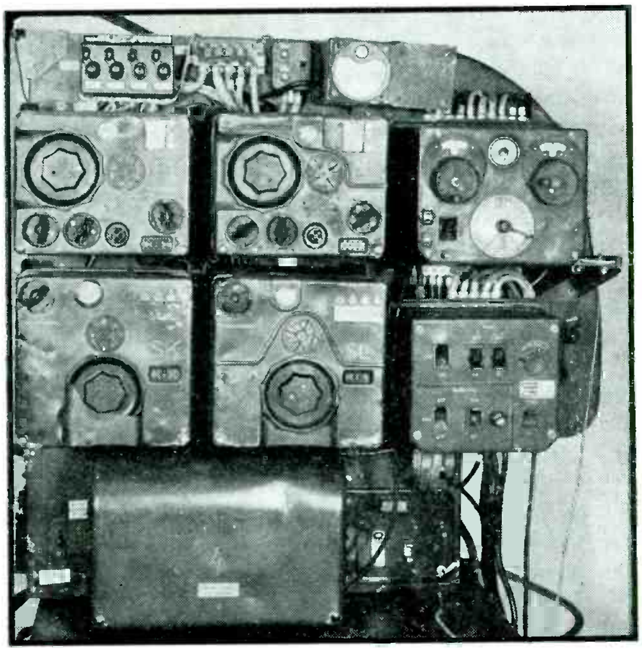


FIG. 1—The FUG-10 panel with all units in place

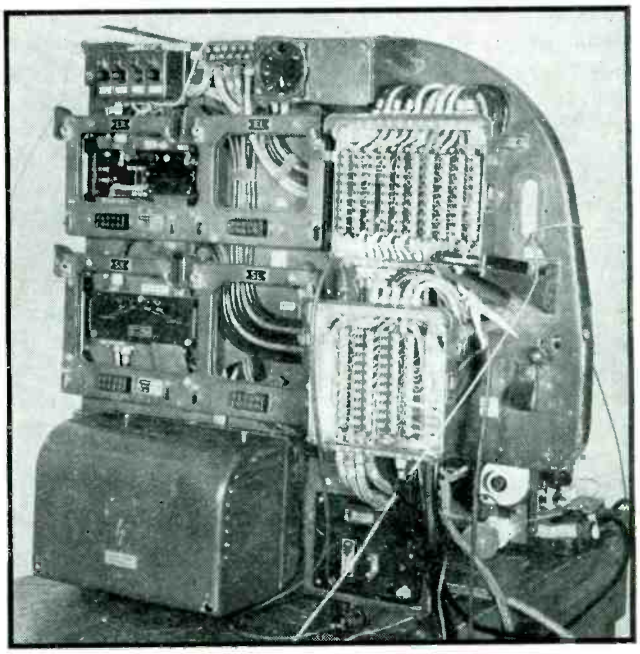


FIG. 2—Panel with the plug-in units removed

EQUIPMENT

By R. A. GORDON

Chief of Aircraft Section
Naval Research Laboratory
Anacostia Station
Washington, D. C.

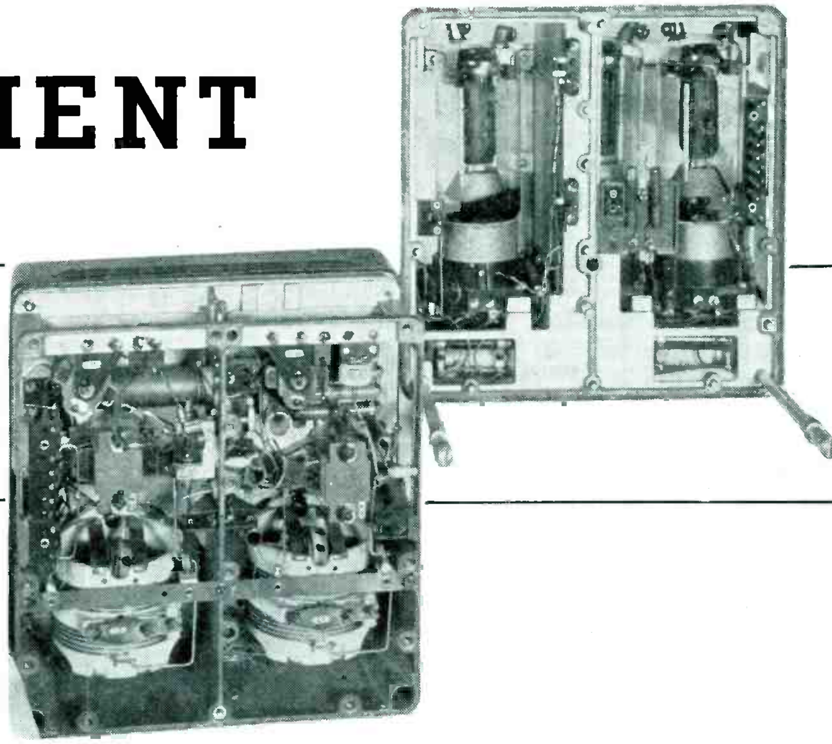


FIG. 3—One of the two transmitters. The two sections bolt together, forming one unit

units is shown in Fig. 1. From the shape of the bulkhead rack, it is evident that this equipment is mounted in the forward starboard side of the airplane.

Plugs

Each transmitter and receiver unit is provided with a test plug receptacle, mounted on the front. A set of indicating meters can be readily plugged into this receptacle, and the various circuits in either the transmitters or receivers can be instantly checked. If the trouble is due to vacuum-tube failure, an entire unit is removed and another unit is put in its place. The inoperative unit is probably taken to a central repair base for repair. If trouble is experienced in the wiring of the bulkhead rack, the whole rack can be readily swung out on its hinges and removed entirely from the airplane.

Cables

From Fig. 2, it can be seen that the Germans use a multiple spring-contact system for making interconnections between the various units, the control boxes and the power supplies, 90 such plug connections being used on the master-control unit. It will be noticed that r-f cables are run promiscuously through the rack from each transmitter to the master-control unit (which is located at the upper right-hand corner), back to the master unit, and from there to the antenna tuning units. These r-f cables consist of flexible coaxial lines using synthetic insulation and are of approximately 52 ohms impedance.

Channel Selection

Each transmitter and receiver unit is constructed so that four channels may be quickly selected. This is done manually by rotating the tuning dial until a series of clicker points engage preset mechanical stops determining the position of the tuning capacitor and variometer. These settings can be changed at will by loosening set-screws, turning the dials to the desired frequencies and relocking the mechanism.

Operating Procedure

The radio operator has complete control of the receivers and transmitters. The navigator has control of the blind-landing and d-f navigational equipment. The radio operator, in addition to having control of the equipment's functions for communication, can select either the crew and the pilot or each separately for communication information. The pilot simply has a pair of earphones and a throat microphone with which to direct information to the radioman or the crew. There is no indication of any attempt to obtain dual operation of this equipment.

The operation of the complete equipment, from the radio operator's standpoint, is very simple. If he desires to operate on the medium-frequency band, he simply sets the medium-frequency transmitter and receiver to the selected spot frequency, turns the master-control knob to the medium-frequency position and tunes the remote-control antenna unit until a meter located on the master-control box indicates maximum antenna current. The operator may select either a fixed or a trailing-wire antenna.

There is a novel feature connected with the tuning of the trailing antenna, in that when it is used for either medium or high-frequency operation, an electrically-operated reel automatically runs out or in, as the case may be, the correct length of antenna. For instance, if the operator selects operation at 400 kc, the antenna reel automatically runs out approximately 325 ft. If he suddenly requires operation in the high-frequency band at 4000 kc, the reel automatically runs in the antenna to approximately 35 ft. Thus, maximum antenna efficiency is obtained. The antenna is normally set at or near the quarter-wave length.

Mechanical Construction, Parts

The construction of the transmitter and receiver units is considered a marvel of mechanical design and assembly. The chassis of both receiver and transmitter are die-cast. There is no evidence of any appreciable machine work other than the tapping of screw holes. The component part mountings are either molded, die-cast, or stamped, and where screws are used for securing, a paste is used under the screwhead in place of the usual lock washers. This construction is indicative of a well-planned program of standardization, and it should be noted that other German equipment uses the same type chassis, the same type construction and often the same component parts as the FUG-10.

Component parts are interesting in detail. The fixed resistors used in both transmitters and receivers number but seven different values. Where 10,000 ohms is desired, two 5,000-ohm resistors are connected in series, and where 2500 ohms, is required, two 5,000 ohm resistors are connected in parallel. Thus, great standardization in resistors is accomplished.

Vacuum tubes consist of one transmitting tube type which is equivalent to an American 50-watt tube, and one receiving tube type which is the equivalent to the 9001 series American tubes. By a standardization of receiving tube types particularly, enormous saving in manufacture is accomplished, and the tests made on this equipment indicate that the Germans have probably sacrificed receiver performance and transmitter performance in order to gain this standardization. The one type of receiving tube employed functions as an r-f amplifier, detector and audio amplifier, for both pentode and triode operation. It may be stated here that types of tubes used for transmitting and receiving perform well over a frequency range of 200 kc to 40,000 kc.

The transmitter tubes can be seen in Fig. 3. The receiver tubes are always mounted in what could be termed upside-down position. This is clearly shown in Fig. 4, which shows the interphone amplifier, from which tubes have been removed but in which their sockets are visible. This eliminates the use of sub-panels and allows wiring to the tube sockets and other components in this unit to be on the same level without running through shields or panel holes.

The Germans use as little strategic material as possible. The wiring in the transmitter and receiver units employs small solid wire conductors with synthetic insulation. In general, these conductors are No. 24 tinned copper wire. This, of course, means a great saving in copper, and also a saving in space within the units. Further considering the matter of using a minimum of copper, the Germans make great use of powdered-iron cores. The variometers used for tuning the master-oscillator and power-amplifier circuits of the transmitters have such cores. The variable loading-coils in the antenna remote-control unit shown in Fig. 5 also contain large powdered iron cores. The actual weight of copper used in the direction-finder loop antenna is one-half pound, while the amount of powdered iron core used in this coil is 12 pounds. German iron is excellent and, in general, appears to have an effective permeability of approximately 10.

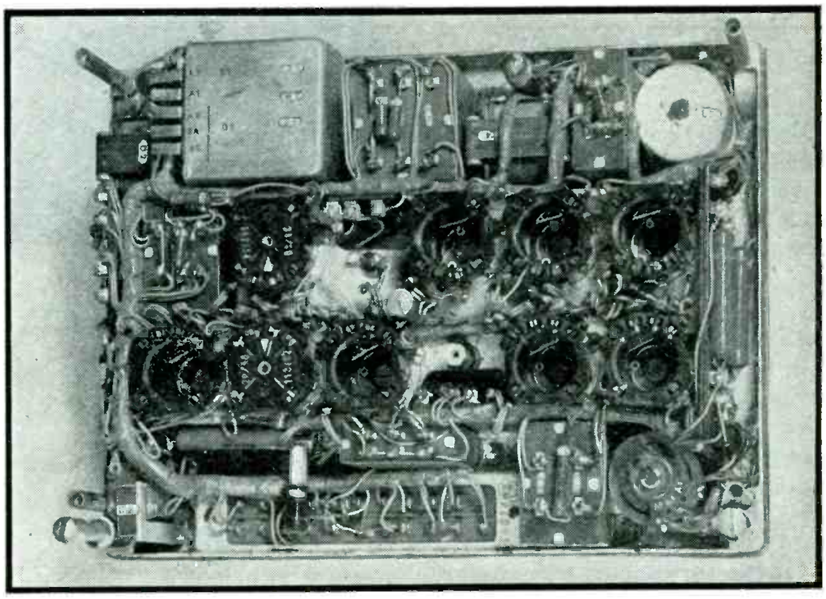


FIG. 4—Intercom amplifier, shown with tubes removed

Iron-Core D-F Loop

The iron-core direction-finder loop is used both for aural-null direction finding and left-right operation. However, as this is a loop antenna and is of course, affected by horizontal polarization such as is encountered in night operation, the Germans also use the airplane's transmitter for homing. A signal is transmitted to a ground d-f station. This signal is interrupted or pulsed. When operating over fairly short distances, of the order of 30 to 40 miles, the ground station synchronizes on the ground wave, excluding the sky wave, and thus homes the airplane without adverse night errors.

The overall sensitivity of the direction finder for a 5:1 signal-plus-noise to noise ratio with 15 milliwatts output is approximately 55 μv per meter over the 100–1100 kc range. This is not considered very advantageous in view of the tremendous weight of the equipment, its low power output and somewhat low overall sensitivity. Sacrifices apparently have been made primarily for great reduction in the use of copper.

The Germans make great use of ceramic insulation, even to the extent of using ceramic shafts on the ganged variable capacitors in the receiver units. Ceramic forms are used for all variometer tuning at frequencies above 600 kc. Below 600 kc, a high-grade plastic form is used. Wherever a meter is to be used for r-f measurements, d-c instruments with copper-oxide rectifiers are used and these are usually calibrated in terms of r-f current. The meter used on the FUG-10 equipment is very small and has a full-scale reading of approximately 200 microamperes.

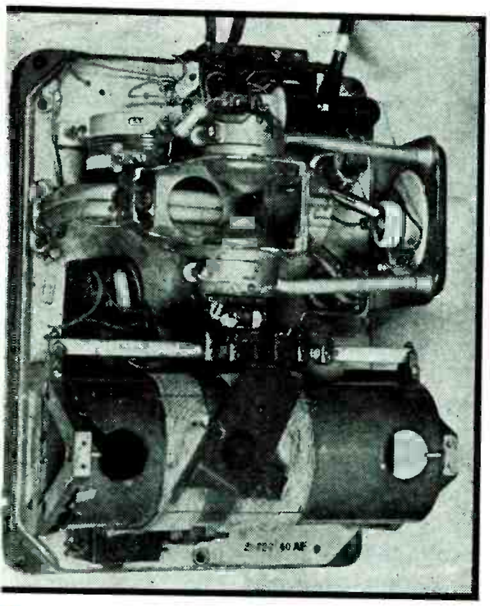


FIG. 5—Remote-controlled antenna tuner

Materials, Shock Mounts

No provision is made for indicating failures in flight due to low voltage in any of the circuits; the only meter being supplied is that which indicates transmitting antenna resonance.

The complete equipment operates from a 24-volt d-c supply. This supply operates two dynamotors. One of these supplies power to the transmitters and one supplies power to the receivers, blind-landing equipment, direction-finding equipment, and intercom.

Considering the standardization of parts, it might be well to note that the antenna insulator used on this equipment is considerably larger and heavier than is required. This insulator is capable of withstanding 30,000 volts at high altitudes but is used in a circuit which, under the highest voltage conditions, is subjected to not more than 3500 volts. It is apparent from this that the antenna insulator is a standard unit, probably used on tanks, mobile equipment, and even on shipboard.

Synthetic rubber shock mounts are provided for each individual unit.

Performance Characteristics

The operating characteristics of the equipment are as follows:

For the medium-frequency transmitter, the optimum antenna load is found to be 200 $\mu\mu$fd and 30 ohms resistance for an output of 55 watts. For the high-frequency unit the optimum antenna load was found to be 8 ohms and 250 $\mu\mu$fd, the output varying from 39 to 62 watts over the range 3000–6000 kc. Frequency deviation on both the medium and high-frequency transmitters was found to average 0.001 percent, or 10 parts per million per degree Centigrade. These tests were made over a temperature range of +50 to −30 deg C. This is considered very good stability.

The frequency stability due to conditions of humidity, however, is considered inadequate for normal service conditions, the deviation being 0.09 percent at a temperature of 50 deg C, with humidity ranging from 27 percent to 98 percent on the medium-frequency transmitter, and 0.7 percent on the high-frequency transmitter. Thus we can see that engineering effort was made to stabilize the master-oscillator for temperature changes but no particular provision was made for stabilization under conditions of varying humidity conditions. This is borne out by the fact that no effort has been made to protect the fixed tank capacitors in master-oscillator power-amplifier circuits, choke coils, or loading coils, by either impregnation, shielding or sealing. It is evident that this equipment was never intended for use under tropical conditions.

The overall transmitter efficiency is 9.7 percent, which is considered low. The calibration accuracy of the mechanical reset mechanisms is within 300 cps for the medium-frequency unit and 700 cps for the high-frequency units. This is considered adequate for cw operation. The receivers have a low noise output content, this being from 0.72 to 1.3 milliwatts over the entire frequency range, with the receivers operating at full gain. The effective sensitivity of both receivers is approximately 4 microvolts for a 10-mw signal output, measured with a signal-to-noise ratio of 5:1. The selectivity of the medium-frequency receiver was 3.3 kc at 6 db down and 10 kc at 60 db down. Selectivity of the high-frequency receiver is 9 kc at 6 db down, 28 kc at 60 db down. This appears to be normal receiver design. The audio fidelity varies ± 6 db relative to zero db at 1000 cps. The total harmonic distortion is approximately 5 percent. The receivers are supplied with some noise-limiter action but no substantial avc action is in evidence.

Both transmitter and receiver units operate entirely satisfactorily under conditions of vibration. The control knobs and dials on the front of the transmitter-receiver units are hinged, so that when not in use they may be recessed back flush with the front panel. This eliminates the nuisance of the operator or crew catching their clothes on these controls when passing, detuning the equipment.

The complete equipment as described above weighs 358 lb. While no definite information can be given on the performance of equivalent American equipment, it can be stated that, for the same size and weight, comparable American equipment will furnish a much greater frequency range, possess much better operating features under high temperature and humidity conditions, and provide voice operation. However, from an over-all production standpoint American equipment could not at present compete with the German construction due to the standardization of chassis and parts.

D-C AMPLIFIER

Design equations with practical examples, stabilization of negative feedback amplifiers, cathode follower and phase inverter considerations, tube drift problems in high-gain d-c amplifiers, and operation of multistage amplifiers from common power supplies

By
EDWARD L. GINZTON
Sperry Gyroscope Co. Inc.
Garden City, L. I., N. Y.

A METHOD of directly coupling successive stages of a vacuum-tube amplifier without using a common B-supply has been described by W. M. Brubaker.[1] Except for the verbal description in this note, the circuit does not seem to have appeared in print in spite of its usefulness and simplicity. In the simplified version of this circuit given in Fig. 1a, a battery is shown tapped near the middle, with a resistor connected across the entire battery. It is obvious that regardless of the position of the tap on the battery, there is always a point on the resistance which is exactly at the same potential as the tap on the battery. Thus, it is possible to tap a source of voltage ($E_1 + E_2$) and, regardless of the load placed upon the source of voltage, find a point on the load which will be at the same potential as the tap.

In Fig. 1b, this tap has been applied to the amplifier coupling. A source of voltage ($E_1 + E_2$) is tapped, and this point is connected to the cathodes of the two tubes. Then resistances R_1, R_2, R_3, and the (d-c) plate resistance R_p of the tube are so chosen that the junction between resistors R_2 and R_3 is at the same potential as the tap on the source of voltage ($E_1 + E_2$). Any number of tubes may be cascaded in this manner, all using the same power supply.

This method makes it possible to eliminate the zero-signal d-c component from any similar circuit. Several other modifications are illustrated in later sections of this article, with circuit data.

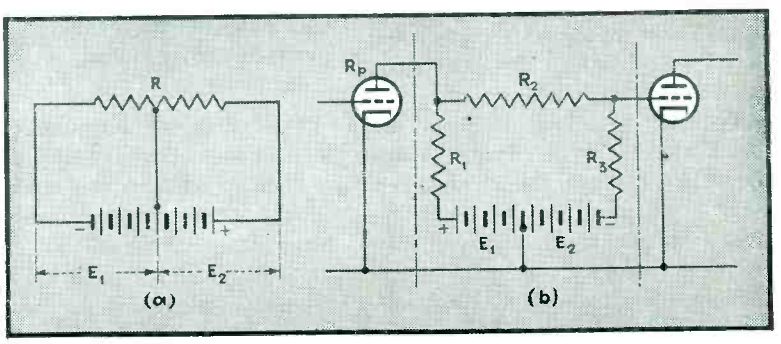


Fig. 1—Basic bridge circuit, and bridge version used for interstage coupling

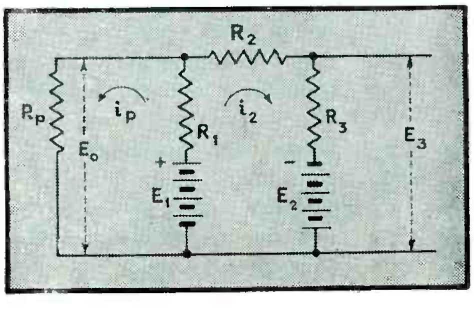


Fig. 2—Equivalent circuit of the coupling network in Fig. 1b

Design Equations

The equivalent diagram of Fig. 1b, together with the symbols which are used below, is shown in Fig. 2. It should be noted that R_p is the d-c plate resistance of the tube, equal to the d-c voltage E_o at the plate of tube divided by d-c plate current I_p. The analysis of this circuit should show how the voltage E_3 depends upon the various constants shown in Fig. 2, and how this voltage can be adjusted to any desired value. Applying Kirchhoff's Law to Fig. 2, one has:

$$\left.\begin{aligned} i_p(R_p + R_1) + i_2(R_1) &= E_1 \\ i_p(R_1) + i_2(R_1 + R_2 + R_3) &= E_1 + E_2 \end{aligned}\right\} \quad (1)$$

$$\text{But } i_p = \frac{E_o}{R_p} \text{ and } i_2 = \frac{E_2 - E_3}{R_3}$$

By combining these equations and rearranging their terms,

$$R_2 = R_1 \frac{E_o + E_3}{E_1 - E_o(1 + R_1/R_p)} \quad (2)$$

$$\text{and } R_3 = R_1 \frac{E_2 - E_3}{E_1 - E_o(1 + R_1/R_p)} \quad (3)$$

Equations 2 and 3 are the design equations. If one designs an amplifier for given supply voltages E_1 and E_2, and a given plate voltage E_0, and if one knows R_1, then R_2 and R_3 may be computed to produce the required E_3. Sometimes, however, one knows all voltages; i.e., E_1, E_2, E_0, and E_3, but R_3 must not exceed a certain value. Then Eq. (3) can be inverted:

$$R_1 = R_3 \frac{E_1 - E_o}{E_2 - E_3 + E_0(R_3/R_p)} \quad (4)$$

Now, from Eq. (2) and (3),

$$R_2 = R_3 \frac{E_o + E_3}{E_2 - E_3} \quad (5)$$

DESIGN TECHNIQUES

forming an alternate set of design equations.

If a resistance-capacitance coupled amplifier is designed to produce a certain amplification A_0, and is converted into a d-c amplifier by means of the circuit described above, the amplification A of the d-c amplifier will be less than A_0 due to the voltage drop across R_2. "Efficiency" of amplification may then be defined as $\eta = A/A_0$. While an exact expression for the efficiency can be derived, it is more significant to use an expression based upon a few assumptions. If the resistance-capacitance coupled amplifier is a pentode tube with an infinite dynamic plate resistance, load resistance R_1, and grid leak resistance R_3, and a trans-conductance g_m, its amplification is:

$$A_o = g_m \frac{R_1 R_3}{R_1 + R_3} \qquad (6)$$

If a d-c amplifier is now designed using the same load resistance R_1 and the same grid leak resistance R_3, then the amplification of the d-c amplifier will be:

$$A = g_m \frac{R_1 (R_2 + R_3)}{R_1 + R_2 + R_3} \frac{R_3}{R_2 + R_3}$$
$$= g_m \frac{R_1 R_3}{R_1 + R_2 + R_3} \qquad (7)$$

Efficiency of Amplification

The efficiency of amplification η can be computed by combining Equations (3), (5), (6), and (7), giving

$$\eta = \frac{1}{1 + \dfrac{E_0 + E_3}{E_2 - E_3 + E_1 - E_0 (1 + R_1/R_p)}} \qquad (8)$$

The significance of this relation can be seen more clearly when $E_3 = 0$ and the supply voltage $E_B = (E_1 + E_2) >> E_o (1 + R_1/R_p)$, all of which is accurate enough for qualitative discussion, remembering that R_p can be considered infinite. Then

$$\eta \approx \frac{1}{1 + E_0/E_B}$$

This means that for best efficiency, E_0 should be as small as possible in comparison to the supply voltage. As an example, a 6SJ7 may be operated under the following conditions:

$$E_B = 400 \text{ v}, E_1 = E_2 = 200 \text{ v},$$
$$E_0 = 100 \text{ v}, E_3 = 0 \text{ v}, R_1/R_p = 0.5.$$

Using Eq. (8), the comparative amplification is found to be 71.4 percent. By means of more careful design, efficiencies in the neighborhood of 80 percent can be realized.

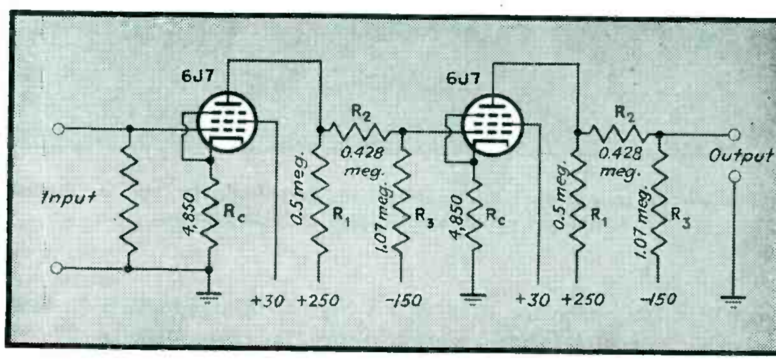


Fig. 3—A two-stage d-c amplifier using pentode tubes

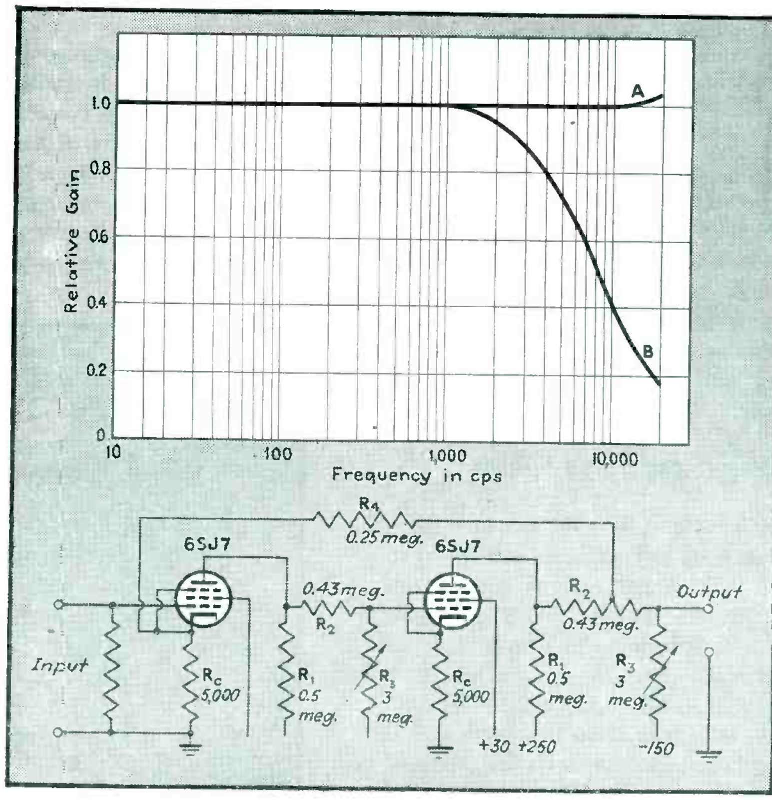


Fig. 4—A two-stage direct-coupled amplifier employing negative feedback. Curve A shows the frequency response with feedback; B, without feedback

An Illustration

As an example, Fig. 3 shows a two-stage amplifier using two 6J7 tubes. Suppose a 400-v power supply is available. From a tube manual, one finds the recommended operating conditions for such a tube

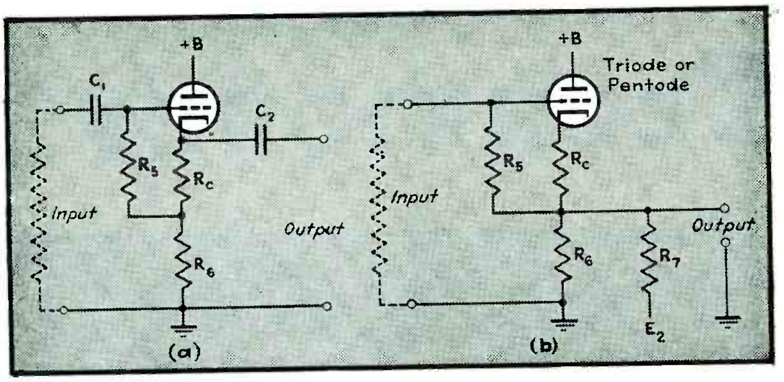


Fig. 5—The conventional R-C coupled cathode follower (a) and the Brubaker equivalent of the conventional cathode follower (b)

(older manuals, such as RCA-RC-12 give more complete information than the later ones). For 6J7:

Plate supply voltage	180 v
Screen voltage	30 v
Grid voltage	1.55 v
Plate voltage (E_0)	60 v
Plate current (i_p)	0.24 ma
Screen current	0.08 ma
Plate load (R_1)	0.5 meg
Grid leak (R_s)	0.5 meg
Cathode resistor	4850 ohms
Voltage amplification	93
Transconductance g_m	375 μ mhos

The d-c amplifier operating under similar conditions will have the following modifications in its design formulas, obtained from the above data and the notation previously given:

$$R_p = \frac{E_0}{i_p} = \frac{60}{0.24 \times 10^{-3}} = 0.25 \text{ meg}$$

$$E_0 = 60 \text{ v} \qquad E_2 = 150 \text{ v}$$

$$R_1 = 0.5 \text{ meg} \qquad E_1 = 250 \text{ v} \qquad E_3 = 0 \text{ v}$$

E_3 may be any practical value, zero being the most convenient. From Eq. (2) and (3), $R_2 = 1.07$ meg and $R_3 = 0.428$ meg. The amplification per stage can be computed from Eq. (7), and is found to be 100. This is higher than the corresponding resistance-capacitance coupled stage because of the higher grid leak resistance. If the resistance-capacitance coupled amplifier were to use the same grid-leak resistance, its amplification would be about 125 for the same value of plate current.

It should be noticed that in single-ended amplifiers with cathode resistors, there is a loss in amplification due to negative feedback introduced by the cathode resistors, so that the effective amplification per stage is $A_{eff.} = A_0/(1 + R_c\, g_m)$, where R_c is the cathode resistance. In the example shown in Fig. 3, this reduction in amplification is from 100 to 37. If the screen voltage is obtained by means of a series dropping resistor, even a further reduction of gain could be expected.[2]

The decrease in amplification due to negative feedback introduced by the cathode and screen resistors can be eliminated either by using push-pull amplifiers, in which case there is no degeneration, or by using fixed grid bias and screen supplies.

The amplifier shown in Fig. 3 should have an overall amplification of about 1400, a uniform frequency response from zero to 20,000 cps, and should be able to deliver about 50 v peak without appreciable distortion.

Stabilization of Negative Feedback Amplifiers

Since the output of the Brubaker amplifier can be adjusted to have a zero d-c component, conventional negative feedback circuits can be used to stabilize the amplifier. The principles involved in applying negative feedback are now so well known that it is not necessary to say very much about either the method or the final results. A few remarks, however, might be helpful in realizing the best performance.

In applying negative feedback in a multi-stage amplifier of the Brubaker type, the same oscillation criterion applies as in the case of the ordinary resistance-capacitance coupled amplifiers: unlimited feedback can be applied in one or two stages without any oscillation troubles, and over a larger number of

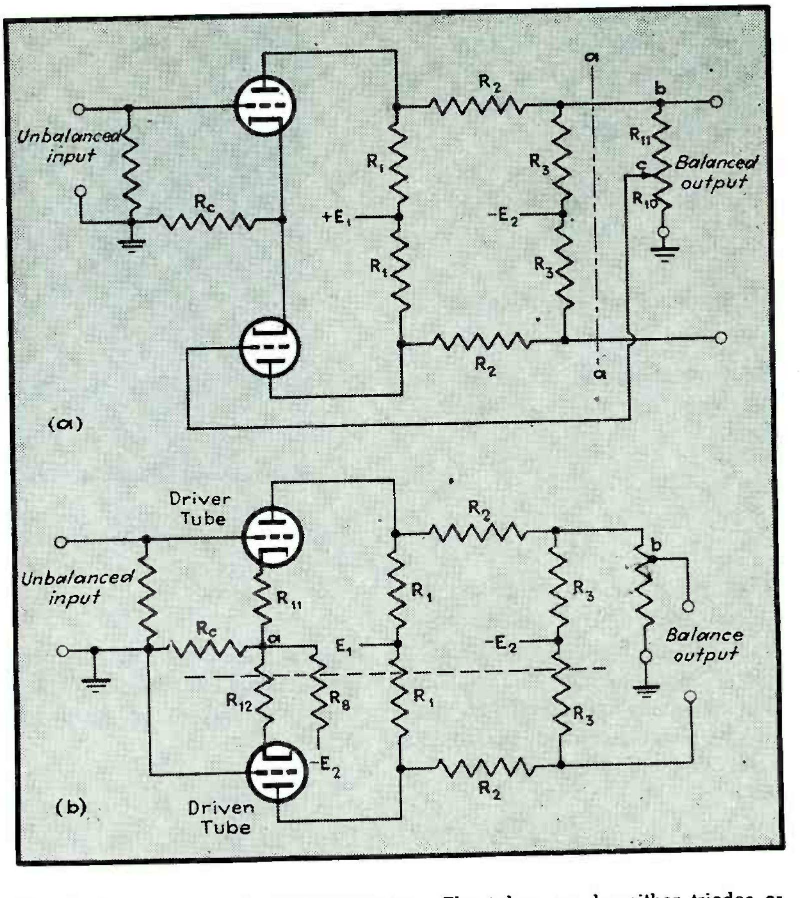


Fig. 6—Two types of d-c phase inverters. The tubes can be either triodes or pentodes in the circuit at (a)

stages if proper care is taken.[8] In general, application of feedback to one stage does not produce great benefits, and more than two stages require a compromise design between frequency response and the degree of stabilization. It is the two-stage amplifier that is easiest to handle *if audio frequencies as well as d.c. have to be amplified.*

If negative feedback is applied to a two-stage amplifier, (or any even number of stages), such as shown in Fig. 4 the feedback resistor R_4 has to be connected from the plate circuit of the last stage to the cathode resistor of the first stage. As a result of this, there is an undesirable loss of amplification due to two effects: (1) the un-bypassed cathode resistor R_c in the first stage, and (2) the loss in gain of the second stage due to the shunting of the plate load by $(R_4 + R_c)$.

As was shown in the preceding section, the first of these could be appreciable, while the effect of the second depends upon the magnitude of the feedback desired. These two effects are inter-related in such a way that the greater one attempts to make β (the fraction of output that is introduced into the input), the lower is the amplification of the two stages. This just means that in order to obtain a high degree of the stability, and at the same time the highest possible amplification, these two effects must be minimized.

In practice, this can be done by (1) designing the output stage to operate with the lowest possible impedance so that the shunting effect of a given $(R_4 + R_c)$ is as small as possible, (2) designing the input stage with the highest possible impedances so that for a given β, R_4 becomes as high as possible, (3) adjusting the operation of the first stage so that its gain is obtained for the lowest possible value of g_m, to reduce the degenerative effects of R_c, the un-bypassed cathode resistance of the first stage; (4) obtaining the bias for the second stage either with a bias cell, or merely by choosing the proper value of E_3.

If properly designed, it is possible to obtain both a stabilization factor of 100 and an amplification of approximately 100 with a two-

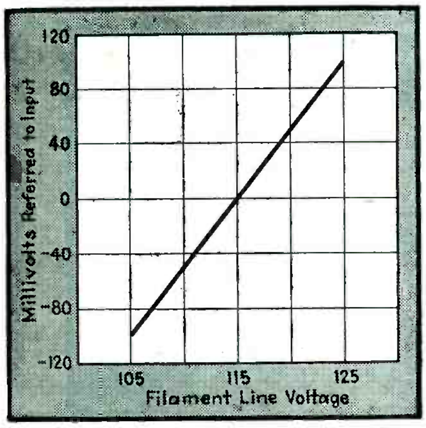


FIG. 7—Output voltage variation of the amplifier shown in Fig. 4 due to filament voltage changes

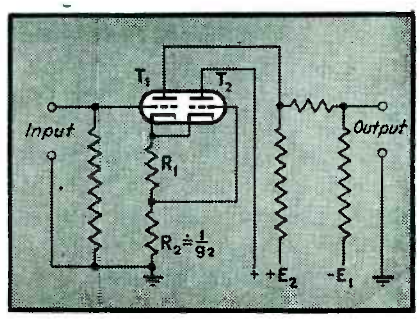


FIG. 8—The basic Miller circuit which improves the drift problem of the input stage of the d-c amplifier. If g_2 is the transconductance of T_2 then R_2 is nearly equal to $1/g_2$

tube pentode amplifier. Figure 4 shows the circuit and frequency response of an amplifier similar to one of Fig. 3, but stabilized by means of negative feedback. It will be observed that in order to connect resistance R_4 without disturbing the potentials of the circuit, a tap on resistance R_2 had to be used which had the same potential with respect to ground as the upper terminal of R_c of the first stage.

Cathode Follower Considerations

Cathode followers of the type shown in Fig. 5a find application in circuits where a high impedance has to be converted into a low one without the use of transformers. In most such cases, in addition to the bias resistor R_c, a resistance R_6 is added which allows greater output voltages and at the same time develops degenerative feedback which tends to stabilize the action of the tube against voltage and tube characteristic changes.

In conventional cathode followers, the proper bias voltage developed across R_c is introduced to the grid through the resistance R_5. The voltage across R_6 is kept from altering the situation by a blocking capacitor C_1 on the input side. Capacitor C_2 prevents the direct voltage across $(R_c + R_6)$ from appearing at the output terminals.

Figure 5b shows the d-c equivalent of Fig. 5a. Here the capacitors are omitted and the undesired direct voltage across R_6 is eliminated by connecting R_7 to E_2, which may be the same voltage as is used in the amplifier proper. The proper value of resistance R_7 is chosen so that the current supplied from E_2 through R_6 and R_7 just equals the total cathode current of the tube; that is,

$$i_p = \frac{E_2}{R_6 + R_7} \text{ or } R_7 = \frac{E_2}{i_p} - R_6 \qquad (9)$$

Phase Inverter Considerations

Push-pull arrangements have even greater advantages in d-c amplifiers than in resistance-capacitance coupled ones. Single-ended input voltages can be converted to push-pull ones by means of phase inverters, which are shown in Fig. 6. It will be seen that these are again merely modifications of the well known a-c circuits.

Figure 6a shows a push-pull amplifier in which one grid is driven by the unbalanced input and the second grid from the output circuit of the first one. The circuit to the left of the line *a-a* is designed in the obvious manner, using formulas previously given. If this is done, then the d-c potential from point *b* to ground will be zero, and point *c* can be chosen so that the ratio $(R_{10} + R_{11})/R_{10}$ equals the voltage amplification of the driven stage. If properly designed and adjusted, the input to both tubes will be balanced, there will be no degeneration due to cathode resistance R_c, and the gain will be the highest possible with the tubes used.

The phase inverter shown in Fig. 6b is perhaps the more useful of the two. If one were to bisect the circuit by a horizontal line into two symmetrical parts, then each one would again be designed along the general principles outlined before. Each half of the circuit could possess a high degree of stability due to degenerative feedback de-

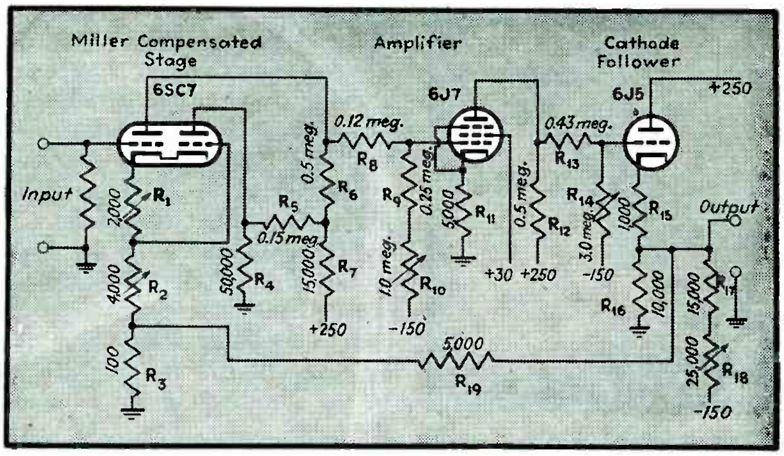


FIG. 9—A two-stage d-c amplifier using a Miller compensated stage, a cathode follower, and stabilized negative feedback

veloped by the resistor R_c. In the form shown in Fig. 6b the lower tube is driven by the signal voltage developed across R_c due to the driver tube. If

$$\frac{R_c R_8}{R_c + R_8} g_m > 1,$$

then the output of the device will be balanced to the same degree as the above inequality. The balance, of course, can be made perfect by adjusting the tap b to the proper point.

It should be pointed out that resistors R_{11} and R_{12} provide the proper bias voltages for the two tubes, whereas R_c and R_8 are so adjusted as to give the highest possible value of $R_c R_8/(R_c + R_8)$ and still maintain the potential from point a to ground zero, to provide for the condition that $R_c R_8/(R_c + R_8) >> R_{11}$ or R_{12}. Other types of phase inverters often used in a-c circuits can be easily converted for d-c applications.

Tube Drift Problems in High-Gain Amplifiers

The most difficult problem in a high-gain d-c amplifier is the change in the plate current of the first tube due to random changes in the work function of the cathode surface. These current changes are usually small, but are always present. Negative feedback cannot eliminate these changes because they act as if they were input signal variations and as such cannot be distinguished from the signal itself.

The most serious immediate cause of these current changes is the filament voltage, although ambient temperature affects the current also. (In addition, there seem to be other causes which are not yet understood.) To illustrate the magnitude of these changes, Fig. 7 shows the variation of the output voltage due to changes in filament voltage. The ordinate is an equivalent input voltage; i.e., change in output voltage amplification.

A great improvement can be realized by means of a circuit described by Miller.[4] Miller uses a double triode with a common cathode, and the circuit is so arranged that if one triode behaves in the same manner as the other, cancellation of the variation takes place. The basic circuit is shown in Fig. 8. If $R_2 = 1/g_2$, then $\Delta e = \Delta i_1 R_1 - (g_2 \Delta i_1 R_1) R_2 = O$; and changes in emitter characteristics that are common to both sections will produce no net change in the plate current of the active amplifier T_1. An amplifier built with the first stage modified in this manner is shown in Fig. 9. Figure 10 shows the variation of the output voltage (again referred to input) as a function of the filament voltage of the first tube. It is seen that for a proper value of the resistance R_2, a marked improvement is produced.

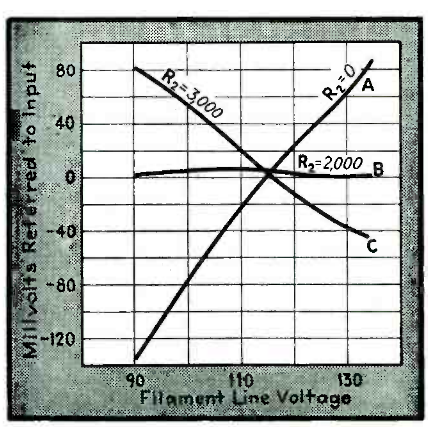


FIG. 10—The effect of Miller compensation on the stability of the amplifier shown in Fig. 9. in respect to filament voltage changes

Operation of Multi-Stage Amplifiers from Common Power Supplies

If many stages are used in an amplifier, currents flowing through the source of voltage (E_2 and E_1) from the last stages can introduce voltages into the earlier stages. This causes regeneration which can express itself either in oscillation or other undesirable effects. There are two ways to avoid the trouble: (1) use of low-impedance power supplies, (2) separately filtered lines to groups of stages. The former can be accomplished by means of either batteries or properly designed electronic voltage regulators, and the second by voltage regulator tubes such as VR-105.

The general method described is useful in extending practically all known techniques now used in a-c amplifiers to zero frequency. These methods are not restricted to amplification alone.

One of the objectionable features of this method is the necessity of two voltages, positive and negative with respect to ground. Miller[4] attempts to get around this difficulty by using cold-cathode regulating tubes as circuit elements. The use of these tubes in this manner brings up other problems, however. The VR-tubes need a fairly high voltage to start them and draw heavy currents. This causes troubles in design, adjustment and operation. The VR-tubes also tend to be noisy, so that their use is usually restricted in amplifiers, at least as circuit elements. The two required voltages can be obtained from one power supply and do not require additional parts.

References

(1) Brubaker, W. M., D-C Amplifier, *Bulletin of the American Physical Society*, Vol. 14, No. 6, Dec. 7, 1939. (Program for the University of California meeting.)

(2) Terman, F. E., Hewlett, W. R., Palmer, C. W., and Wen-Yuan Pan, Calculation and Design of Resistance-Coupled Amplifiers using Pentode Tubes, *Transactions of the A. I. E. E.*, Vol. 59 (1940).

(3) Terman, F. E., ELECTRONICS, Jan. 1937.

(4) Miller, Stewart E., Sensitive D-C Amplifier with A-C Operation, ELECTRONICS, Nov. 1941.

N. Y. Winter Meetings

Highlights of winter meetings held in New York City during the week of January 23 by the Institute of Radio Engineers, FM Broadcasters Inc. and American Institute of Electrical Engineers. Captured enemy radio equipment was displayed by Signal Corps

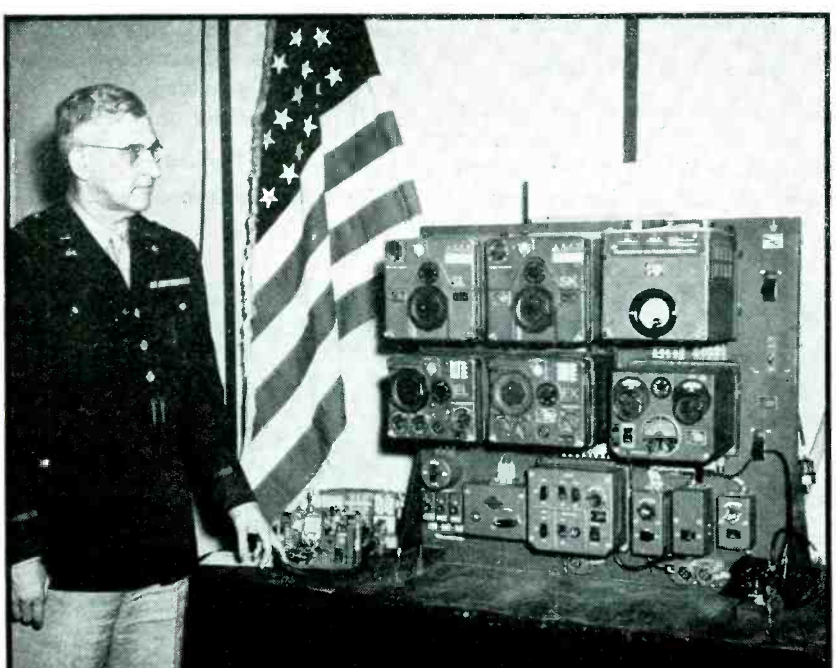
ATTENDANCE figures attested to the popularity of the plan adopted this year by IRE and AIEE winter convention committees for scheduling their programs in the same week, with one big joint get-together on an overlapping day. Over 1200 registered at the Engineering Societies Building in New York for the AIEE meetings and approximately 1700 were issued IRE identification cards at the Hotel Commodore. In addition, some 600 radio engineers, program managers and station owners attended the FMBI convention running concurrently with AIEE sessions at the Commodore on January 26 and 27.

IRE Technical Sessions

In Group A, on Friday morning January 28, "Joint Army and Navy Tube Standardization" was covered in a paper by Lt. C. W. Martel. Tube specifications, preferred lists, special selection, and type approvals were among the subjects discussed.

Another paper was "A New Studio Antenna", in which M. W. Scheldorf of the General Electric Company presented a procedure for obtaining the highly directional radiation pattern needed for uhf studio-transmitter links. Reflector arrangements were discussed, with special attention to the energized reflectors used for the 333.4–333.6 Mc antennas used in linking a Schenectady GE studio to a transmitter in the Helderberg mountains.

The session for Group A was closed with a discussion of "Orthicon Cameras in Television Studio Work", by H. R. Lubcke of the Don Lee Broadcasting System. The RCA pickup tube discussed, ordinarily used only for outdoor programs, was found highly satisfactory for studio work. It gave a realness, roundness and naturalness considered highly desirable in comparison with images produced by the iconoscope camera, with no shading difficulties. It was possible to get dramatic effects against dark backgrounds, due to maintenance of the black level in the orthicon, though admittedly this tube requires more care and adjustment than the iconoscope.



Major General Roger B. Colton, who talked about enemy communications equipment at the joint IRE-AIEE dinner meeting Jan. 27, is shown here with a captured German FUG 10 aircraft radio set exhibited at the conventions. This particular enemy set is described in detail elsewhere in this issue

The following three papers were presented to Group B Friday morning:

"The Limitations Imposed by the Quantum Theory on Resonator Control of Electrons", by L. P. Smith of Cornell University, dealt with the considerations of the energy exchange-rate between electrons passing through a resonant cavity above 300 Mc, where the controling electromagnetic field would be of the order of 100 micro-electron-volts. In such cases, the customary concept of the energy exchange relationship as a continuous effect is contrary to what we know about the quantum theory. Accordingly, the relationship is defined as taking place in definite steps, or jumps, of one quantum at a time. The probability of an exchange of two quanta taking place at a single instant is negligibly small. . . . "In these days, when the frequency is going higher and higher, we should expect to run into (these) difficulties; where the results are far different from those expected from classical theory."

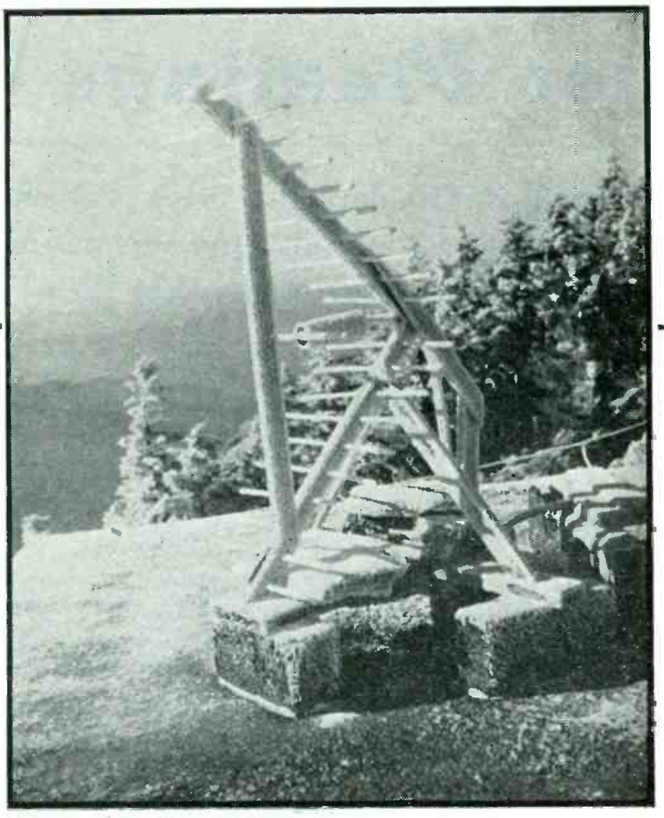
"The Piston Attenuator", by Harold Wheeler of the Hazeltine Electronics Corp., illustrated the

(*Continued on page 312*)

A 337-Mc

By PAUL DILLON

Acting Chief Engineer, Station WMIT Winston-Salem, N. C.



Square-corner antenna originally used at Clingman's Peak to receive 337-Mc signals from the 25-watt Winston-Salem relay transmitter W4XGG

IN NOVEMBER 1941 Gordon Gray began construction of an f-m broadcast station at Clingman's Peak, N. C., a 6,571-ft. site within three miles of Mt. Mitchell, the highest point east of the Mississippi. The nearest town of any size, Marion, was 35 miles away. Seven miles of intervening road was of the unimproved variety and it was necessary to construct one mile of new road over mountainous terrain at a time when temperatures frequently dropped below zero and wind velocities ranged up to 50 miles per hour.

Despite these difficulties and largely through the effort of chief engineer C. M. Smith, Jr. (now on leave and an Ensign, USNR), work which included the construction of water-supply and sewage systems and the necessary buildings had progressed sufficiently by June 1942 to permit W41MM to begin transmitting test programs. The construction permit called for 50,000 watts on 44.1 Mc to serve 70,000 square miles. Wartime restrictions made it necessary to begin operation with 3,000 watts and this power is still used at WMIT (the new call-letters of the Clingman's Peak station). Original plans for higher power were, however, kept in mind during design and construction and an additional amplifier is eventually to be added.

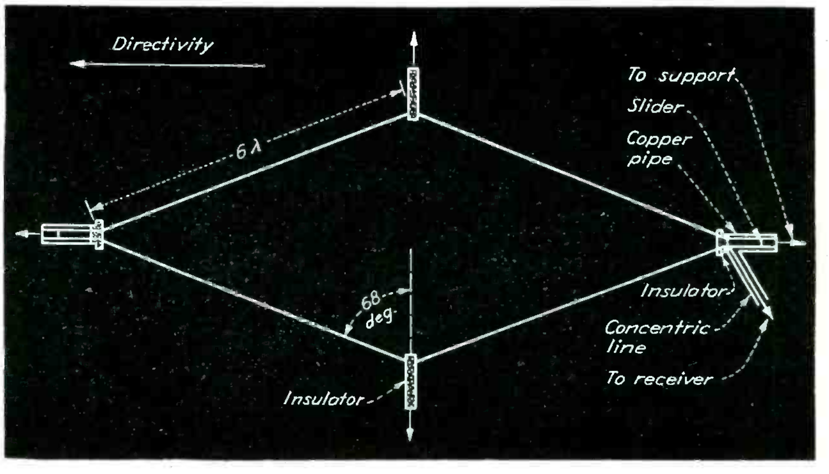
Studio at Winston-Salem

Studio facilities were provided at Winston-Salem, N. C. The use of an f-m radio relay transmitter as a means of piping program service from this point to the distant Clingman's Peak station was decided upon for two reasons: The audio-frequency range and fidelity characteristics of such a system were known to be better than those of available telephone lines, and it was not possible to obtain a land line in the mountains without prohibitive construction and maintenance expense.

The air-line distance of 116 miles between the relay transmitter (W4XGG) at Winston-Salem and the receiver at Clingman's Peak involved a gradually rising terrain interspersed with numerous hills and low mountain ranges. Even with the relay transmitter antenna on the roof of the Reynolds Building, 21 stories above Winston-Salem's streets and the highest structure in the city, the path to be covered was slightly beyond the optical line-of-sight, at just about the maximum distance a "space wave" can be received without being intercepted by the earth.

STL Transmitter

The relay equipment consists of



Rhombic receiving antenna. Theoretical signal gain is 11.5 db, theoretical directivity gain 15.8 db

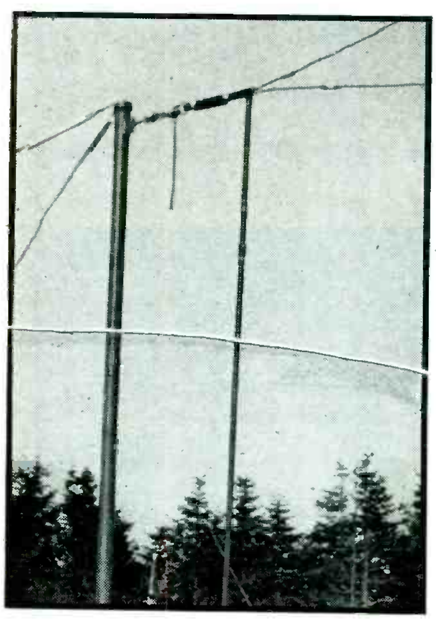
FM Studio-Station Link

A report on the performance of a 25-watt frequency-modulated transmitter used to relay broadcast programs from the Winston-Salem studios of WMIT to the 3,000-watt, 44.1-Mc f-m station on Clingman's Peak, 116 airline-miles distant

a 25-watt transmitter and a companion receiver, both units having been especially designed for broadcast STL (Studio Transmitter Link) service.

The transmitter is of the "direct f-m" type, using a 6J5 master oscillator tube and a type 1853 reactance modulator. The master oscillator operates on 4,640 kc. Oscillator output is multiplied and amplified by frequency triplers and a converter tube. The frequency-modulated signal from one of the tripler stages is added in the plate circuit of the converter tube to the amplified harmonic output of a crystal-controlled oscillator utilized to maintain center-frequency stability of the master oscillator. The resulting signal at the output of the converter is tripled to the final operating frequency of 337 Mc. The output of the final tripler excites the final power amplifier. The tubes used in the final tripler stage and in the power amplifier are 8010-AR's, especially designed for high-frequency use.

The antenna for the Winston-Salem STL transmitter is a two-wire horizontal rhombic with a leg-length of 4.2 wavelengths, and has a theoretical signal gain of 11.0 db relative to a half-wave dipole. The transmitter is coupled to the antenna through a ⅞-in. concentric line by means of a half-wavelength matching section made from copper tubing. Adjustment for optimum operating conditions is obtained by moving sliders on the matching transformer until maximum signal strength is reported by Clingman's Peak. A "square-corner" reflector type antenna was originally tried for transmitting, but its use was discontinued when the rhombic was constructed and found to be consistently better.



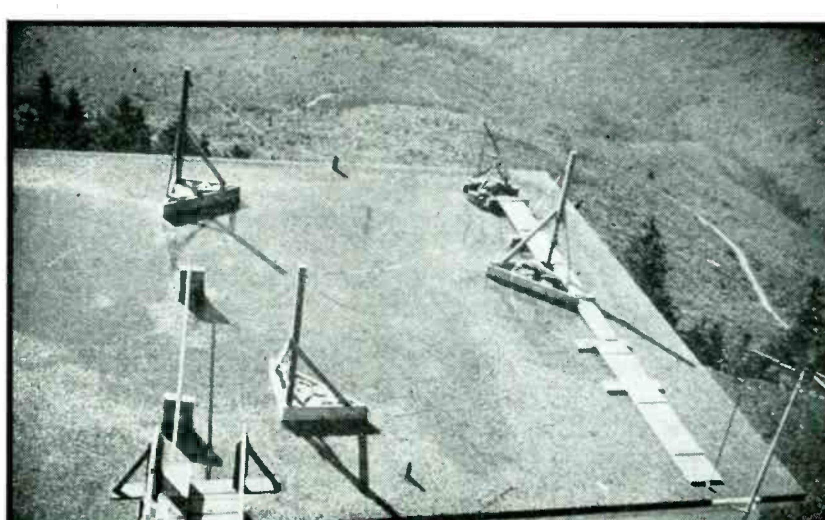
Close-up of the receiving rhombic, showing the feed-line end at which the quarter-wave transformer section encased in a copper pipe and the concentric line discussed in the text are used

Clingman's Peak Receiver

The 16-tube receiver in use at Clingman's Peak is a double intermediate frequency superheterodyne having two separate audio output channels. Frequency stability is assured by a temperature-controlled crystal oscillator incorporated within the set.

Another precaution taken to maintain stability is the use of a power-supply voltage regulator. The advantages of the voltage regulator are particularly apparent while making critical tuning adjustments, which are necessary from time to time to keep the sensitivity and bandwidth characteristics of the receiver at their best.

A convenient feature of the receiver is the built-in noise-suppressor or squelch circuit, which silences the audio output of the set when the incoming carrier falls below usable strength. Front-of-panel controls make it easy to adjust the discriminator transformer second-

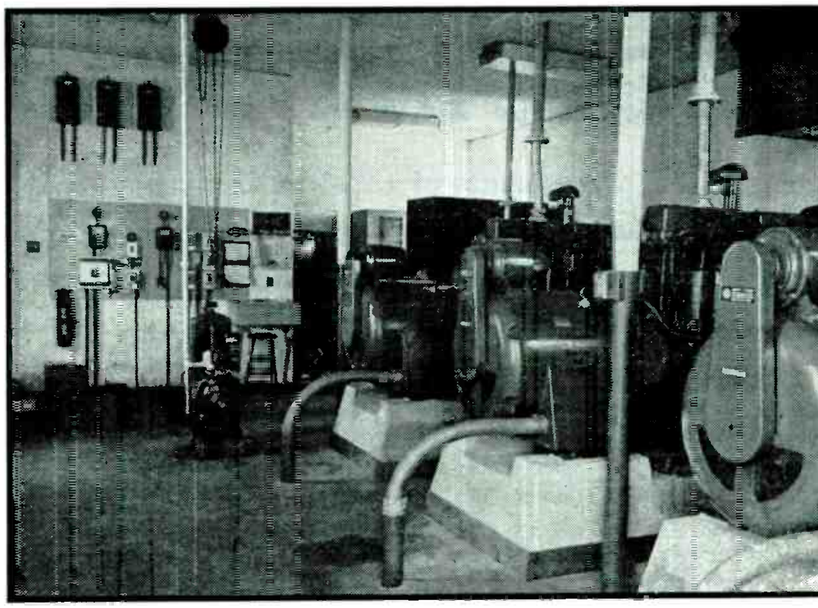


The 337-Mc receiving rhombic antenna now used at Clingman's Peak. The old square-corner antenna, visible in the far corner of the roof, is retained for emergency use. The background of this photo gives a good idea of the terrain at the WMIT transmitter site ary trimmer to correct for any frequency drift which might occur during the warming-up period, and to make rapid changes in the audio output level of the program channel.

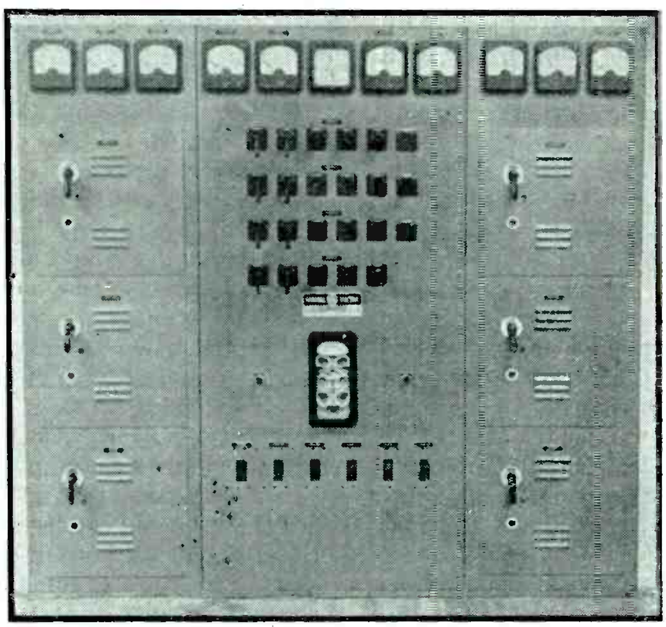
Receiving Antenna

The original antenna used for receiving the W4XGG signal at Clingman's Peak was a half-wavelength dipole, with a square-corner reflector spaced with its vertex ½-wavelength behind it. This antenna worked surprisingly well considering its small physical size, and is still in place for use in emergencies. Normal signal at the receiver input, using this antenna, was of the order of 100 microvolts.

During the early part of 1943 a rhombic receiving antenna was constructed on the roof of the WMIT transmitter building and this new antenna is now in regular use. It has been giving us an average signal input to the receiver of from 150 to 250 microvolts, together with a background-noise reduction of 6 to 10 db compared to the older antenna. The receiving rhombic is of the single-wire type and embodies one or two constructional details which we feel are worthy of mention.



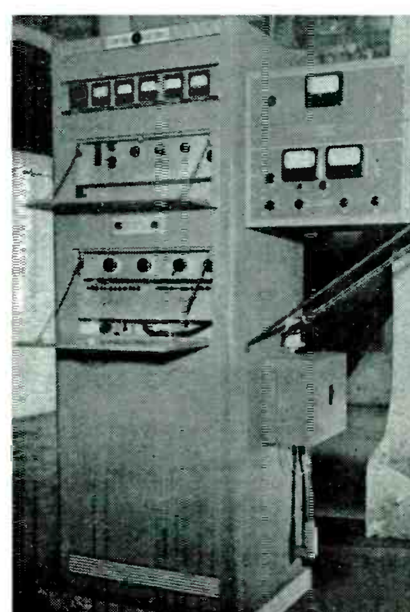
Generating plant at WMIT transmitter site, Clingman's Peak. Three diesel-electric sets generating 75 kw apiece are used



Power-control switchboard at the transmitter site. It permits remote control of the station's generators

The legs of the antenna are six wavelengths long, which at 337 Mc approximates 16½ feet. The angle of tilt in our case is 68 degrees, and the height above the roof is eight feet or about 3½ wavelengths. A quarter-wavelength transformer section, made up as a two-wire line suspended inside a piece of one-inch copper pipe, is used instead of the conventional insulator at the open end of the rhombic. The position of the shorting-bar on the line can be varied by removing a cover which is normally placed over a slot in the side of the pipe. This adjustment is made by using the STL receiver as a field-strength indicating device, setting the shorting-bar for maximum signal from W4XGG.

At the feed-line end of the antenna another quarter-wave section similar to the one just described is used, with the center conductor of a ⅞-inch concentric line being connected to one side of the quarter-wave line at the end of the antenna, and the outer conductor connected to the copper-pipe sheath surrounding the line. The reasoning back of this idea is that because of the ratio of the impedances of the antenna and the coupling line, (approximately 300 ohms and 75 ohms



The 25-watt General Electric 337-Mc f-m relay transmitter. Equipment extending from the right side includes frequency and modulation monitors and remote control apparatus respectively) a theoretically perfect match is readily obtained. Looking at the quarter-wavelength section as a transformer with midpoints grounded, it can be seen that a connection made to one side of the line and ground would have an impedance equal to one fourth of the total impedance, or in this case 75 ohms, the impedance of the coupling line.

In addition to simplifying the problem of connecting the antenna to the receiver, this method of coupling permits the entire antenna system to be maintained at d-c ground potential, which is a decided advantage, considering protection from minor lightning discharges adjacent to the antenna as well as the reduction of interference from rain-static.

The transmission line from the antenna is connected to the input stage of the receiver through a slider on the r-f stage grid inductance.

Power, Emergency Gear

As we must necessarily generate all of the power used at Clingman's Peak, one of the most important items of equipment at that point is a generating plant. This power plant consists of three 110-hp Caterpillar diesel-electric sets with 220-v, three-phase generating capacity of 75-kw each. A power-control switchboard especially designed for the purpose provides means of starting and controlling the generators from the transmitter room and includes a synchroscope which makes it possible to adjust the machines accurately to proper speed before connection is made to the main bus.

An emergency studio is maintained at Clingman's Peak so that transcriptions may be played from the mountain station itself in the event that the STL fails. This studio is also used for communications between Clingman's Peak and Winston-Salem for purposes of equipment adjustment.

STL Performance

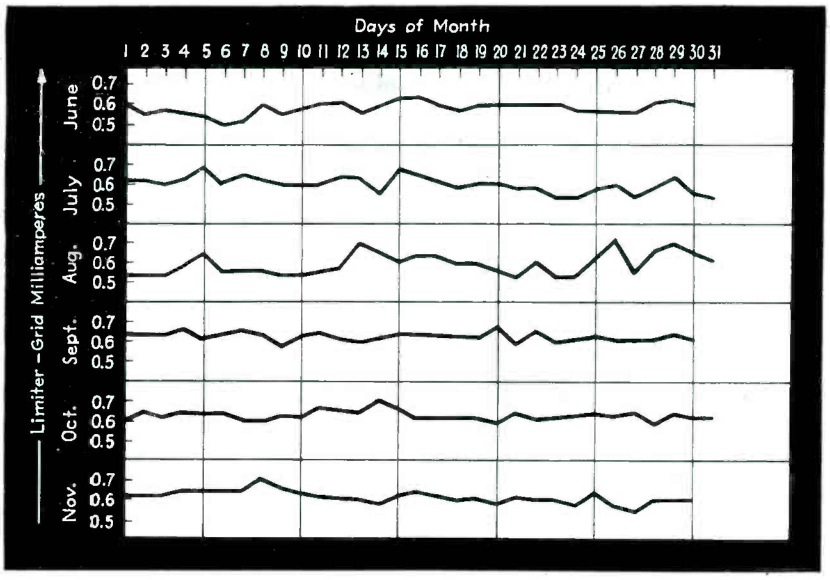
We have kept complete hourly records of signal strength at the receiving point for more than a year. The signal has been surprisingly consistent.

The one phenomenon which gives trouble occasionally is very rapid and severe tropospheric fading. These fades are infrequent, but are generally so severe when they do occur that use of the STL must be discontinued for a short time. As a matter of record, we have had six sharp fades of this type during the past seven months, causing a loss of air time of approximately three hours in that period.

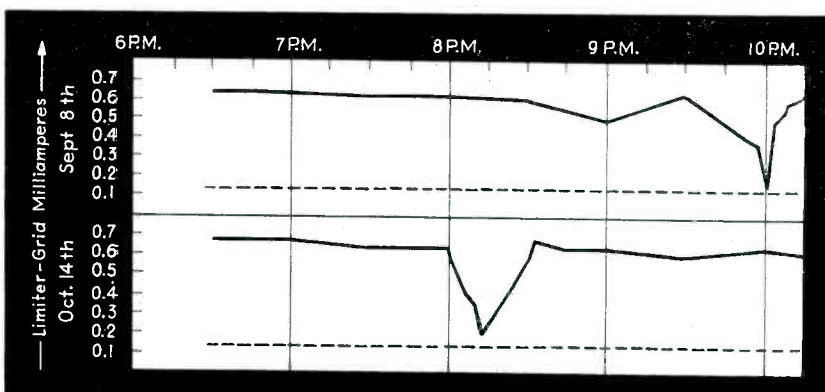
We have been unable to notice any characteristic of weather conditions that occurs coincidentally with the fading, other than the effect of layers of billowy clouds in the path of the signal. The effect of such clouds is not necessarily direct, from what information we have gathered. Fading is apparently due to some condition of humidity or temperature in the air surrounding or immediately adjacent to the cloud layer. With cloud banks low and in the transmission path, the signal may fade. With clouds at a higher level, an exceptionally strong signal rather than a fade is often noticed.

It has been noted that when the path between Winston-Salem and Clingman's Peak contains rain or dense clouds over most of its length the signal received is unusually strong, but dense fog or clouds at one end of the circuit only, causes no apparent change in signal.

The STL equipment described has been operating very nicely as far as freedom from failure is concerned. Both the transmitter and receiver have been giving consistent service with no more than the usual care and maintenance which would be given to conventional broadcast apparatus.



Graphs showing signal received at Clingman's Peak from the 25-watt, 337-Mc f-m relay transmitter W4XGG at the Winston-Salem studios. Readings were all taken in 1943. Limiter-grid current of 0.5 ma indicates 100 μv input



Graphs showing effect of tropospheric fading on two occasions during 1943. Eastern War Time is indicated. Dotted lines indicate limiter-grid no-signal current

R-F Heating for Fabricating WOOD AIRCRAFT

Discussion of future possibilities in application of electronic heating to manufacture of curved or molded wood parts for aircraft and for the furniture and cabinet-making industries, and description of r-f heating setup used in making wood fuselage rings

By JOHN P. TAYLOR
RCA Victor Division
Radio Corporation of America
Camden, N. J.

RADIO-FREQUENCY heating can be used to speed the production—and may eventually be used to reduce the cost—of many kinds of wood aircraft parts. Such parts, whether of the laminated or the plywood type, consist essentially of a multiplicity of wood layers joined by an adhesive. The best adhesives are of the resin type. The time required for curing or setting these adhesives depends on the temperature. The better adhesives usually require eight hours or more to set at room temperature (80 deg F), whereas they will set in a few minutes at higher temperatures (180 deg F to 280 deg F, depending on the type). Some of the phenol-resin adhesives which are particularly desirable because of their moisture-proof qualities can be set only at elevated temperatures. Radio-frequency heating has been found to be one of the most satisfactory means of producing these temperatures.

At the present time r-f heating is being used quite extensively in the production of flat laminated stock from which certain aircraft parts such as spars are made. This application was described in detail in the January issue of ELECTRONICS.[1] It is also being used to some extent in the production of thick plywood from which other parts such as nose rings are carved, as shown in Fig. 1. By comparison, r-f heating is presently being used only to a very limited extent in the production of curved or formed parts. This is not because the exploratory work has not been done—nor because equal advantages are not obtainable. A very considerable amount of experimental work in the application of r-f heating to curved forms has been done—and the results have been such as to justify the prediction of eventual widespread use. Why, then, the apparent reluctance in the adoption of the process? The answer is to be found in the relatively difficult application problems met with and the relation of these problems to the quantities of parts involved.

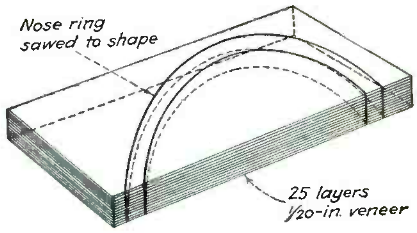


FIG. 1—Curved wood aircraft parts such as nose rings are formed by sawing the required shapes from a thick slab of plywood as shown.

Quantities Needed Are Limited

The application of r-f heating to the production of flat laminated stock such as spars is relatively easy. Generally the available presses or clamps can be used as is. The electrodes can be flat sheets of metal, sometimes the press plates

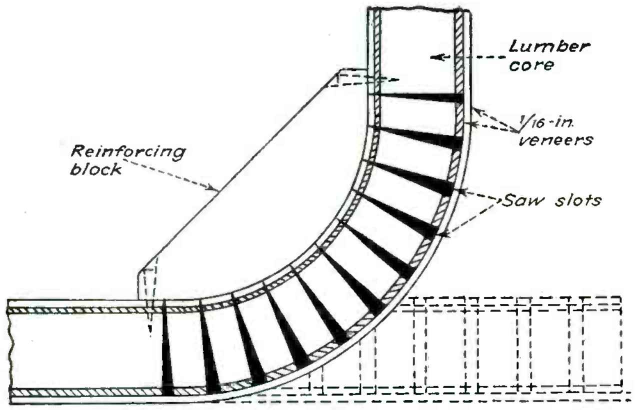


FIG. 2—Corner of a table model radio set made by the process of slotting, steaming and bending as now used

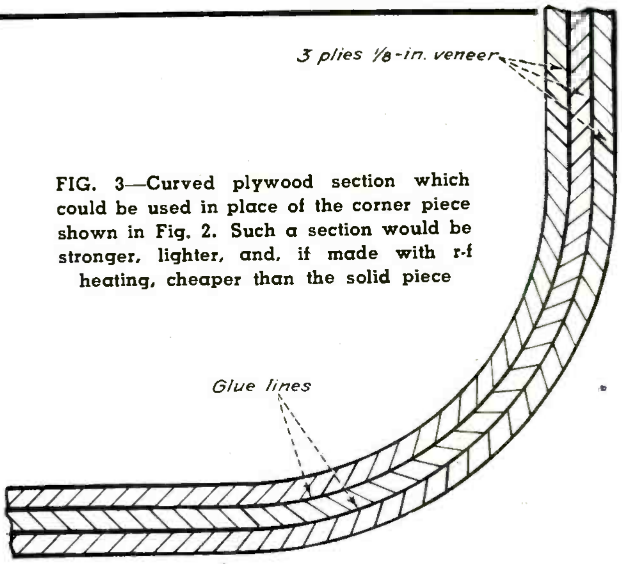
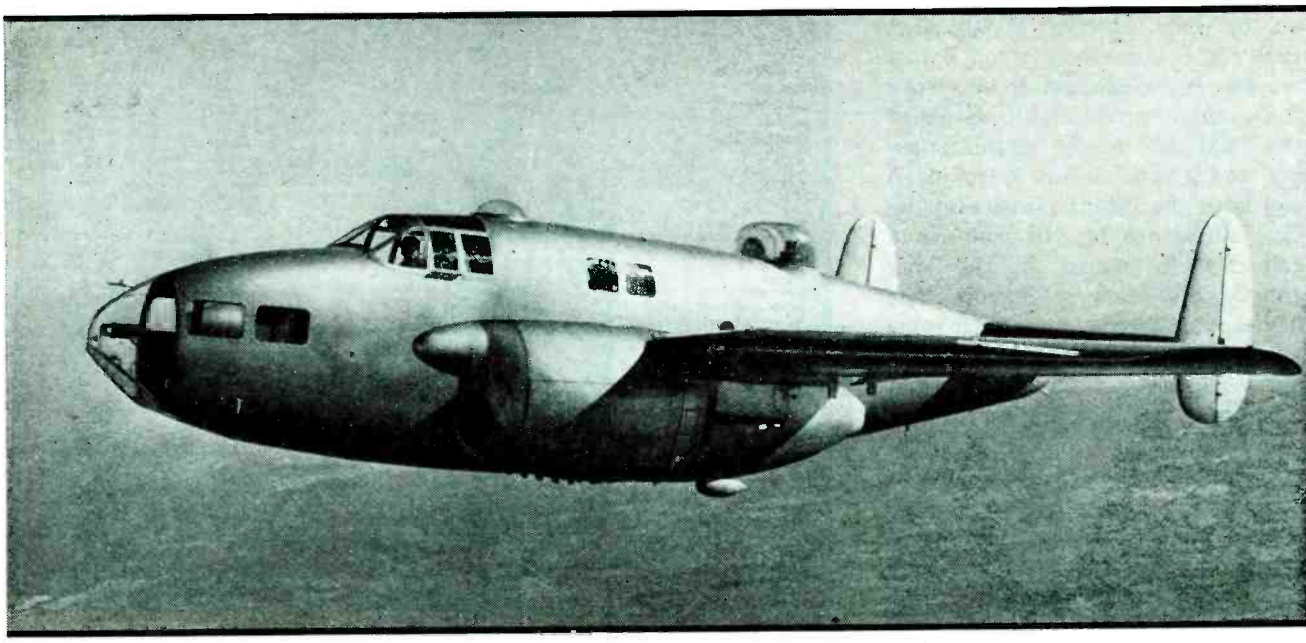


FIG. 3—Curved plywood section which could be used in place of the corner piece shown in Fig. 2. Such a section would be stronger, lighter, and, if made with r-f heating, cheaper than the solid piece



The Fairchild AT-21 Gunnery Crew Trainer, a "plastic plywood" plane of the type referred to in this article. The only metal used in its construction is in the engines, the engine supports, instruments and certain other equipment, supports and controls

themselves. Moreover, the same press setup can be used for a wide variety of sizes and types of parts. Thus, in making flat stock we have a situation where (a) the application problems are simple and (b) the quantities to be manufactured are considerable.

On the other hand, consider the problem with relation to curved or formed parts. Except in the simplest cases, the application work may involve quite unusual problems—problems which at the present time must be solved mostly by experimental methods. Such work might easily be justified if the quantities to be produced were considerable. At present they are not. Each different curved form, as a rule, requires a separate fixture or jig, so that there is an application problem for each part. And, of course, the quantity of that part to be manufactured is only as great as the number of planes of that type to be produced.

The largest program for all-wood planes envisaged a peak production of the order of a dozen planes a day. The total production of any one model probably will not exceed a few thousand. That may sound like a large number of airplanes—and it is. But a few thousand parts of a relatively inexpensive item obviously do not justify a large expenditure of time or money in devising fixtures for quantity production.

Future of Wood Aircraft

The above is the situation at present. It probably is not representative of the conditions to be met in the future. At the present time laminated wood parts are being used not only in all-wood planes of the trainer and transport types but also in particularly chosen places in planes which are otherwise of all-metal or metal-and-fabric construction.

The all-wood plane—at least in its present resurgence—is distinctly a war phenomenon, a stratagem employed to circumvent not only the metal shortage but also the bottleneck in metal fabricating plants. As such, its post-war status is decidedly uncertain.

Most design engineers feel that planes of the future will not be all-metal, all-wood, or all-plastic; rather, that they will employ each material where it is best suited. In such a competition wood will have the advantage of low first cost. (Plastics are more expensive than most people realize.) It will also have certain other advantages, such as a stiffness-to-weight ratio which is unapproached by any of the metals and a tensile strength-to-weight ratio unequalled by any of the present plastics.

At the same time, wood will have several disadvantages. One of these is the lack of uniform characteristics—a big drawback where structural parts are concerned. This can be overcome to a very considerable degree by the intelligent use of laminated and plywood constructions. It is obvious, for instance, that any multi-element construction tends to average out small inconsistencies. Similarly, the difference between tensile strength with the grain and tensile strength across the grain may be compensated for by a plywood construction in which alternate layers have the grain direction at right angles.

It is possible and not unusual to go a step further and obtain special characteristics. Thus, where a given part must have the most strength in one direction, an advantage can be gained by the use of a laminated construction in which the grain is parallel in all layers. This is done in the fuselage ring described below. The ultimate step in this material "tailoring" is, of course, the selection of species in order to obtain various qualities of hardness, stiffness and tensile strength as required. The framework of PT boats is a laminated member in which three different woods are used to obtain specific qualities.

The biggest disadvantage in the

use of wood, however, is the fact that the centuries-old wood industry has never adopted or developed the quantity-production methods of the relatively newer metal industry, and it even suffers by comparison with the infant plastics industry. Furniture is still made to a considerable degree in the way Hepplewhite made it. Such archaic devices as hand-clamps and glue wheels are still found in practically every plant.

If the wood industry is to compete with metals and plastics in the border zone where one or more of these materials might serve equally well, it must obviously adopt quantity-production methods. Radio-frequency heating is one of the most promising adjuncts of such methods.

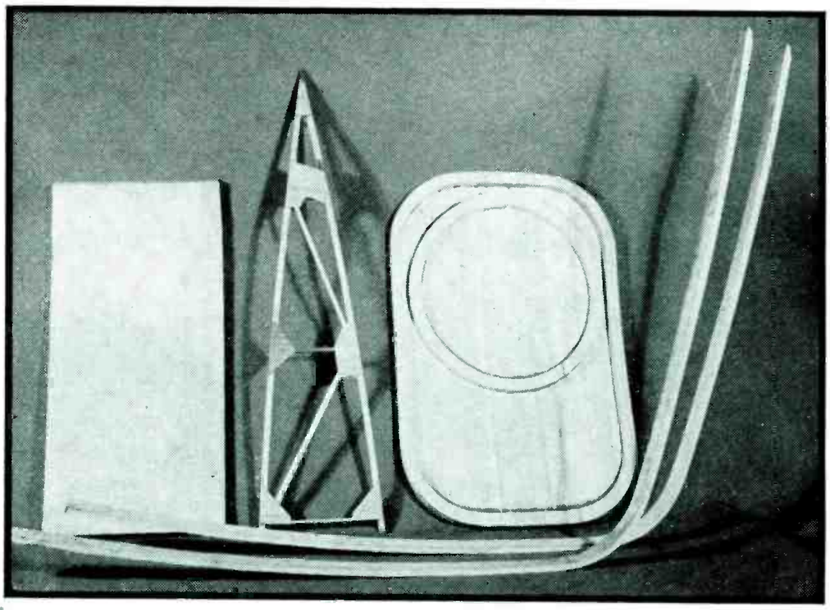


FIG. 4—Some aircraft parts made by the use of r-f heating. Left to right: curved-laminated stock for fuselage reinforcing; wing rib web; bomber door; sections of fuselage ring

Furniture and Cabinet Making

If the manufacture of aircraft parts represented the only reason for the adoption of r-f heating and other production methods by the wood industry, the future would not be encouraging. Fortunately, aircraft manufacture is not the only likely outlet for formed wood components. It is, in fact, one of the smallest. Curved parts play an important part in the construction of all kinds of furniture. In some of these they are, in themselves, a small part, and yet they represent the bottleneck in manufacture.

A typical example is the present-day radio cabinet. Most cabinets, table as well as console, have rounded front corners—the reasons being practical as well as esthetic. In many of these, particularly table models, the corner pieces are formed by slotting one side, then steaming and bending, as shown in Fig. 2, after which the piece may be strengthened by reinforcing blocks in back. Such a construction is time-consuming and expensive.

A curved-laminated member made

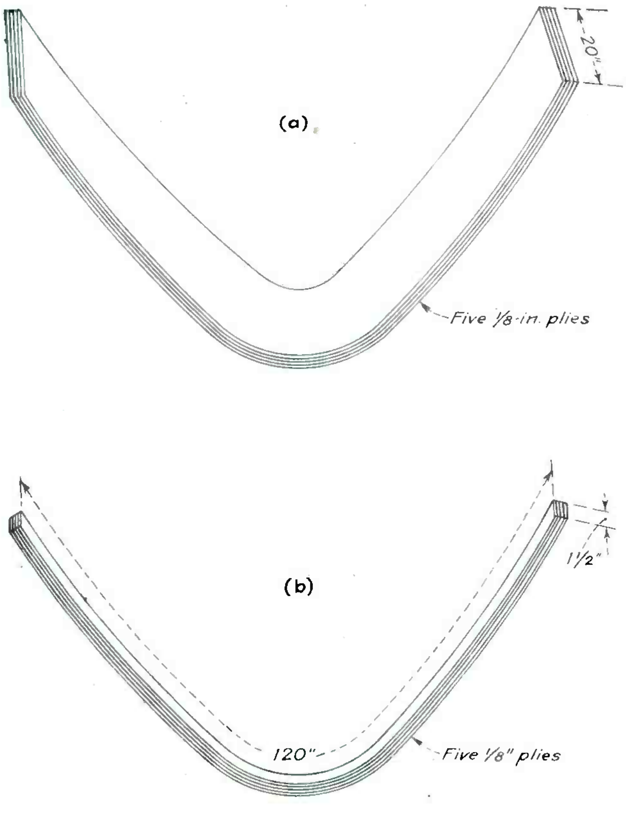
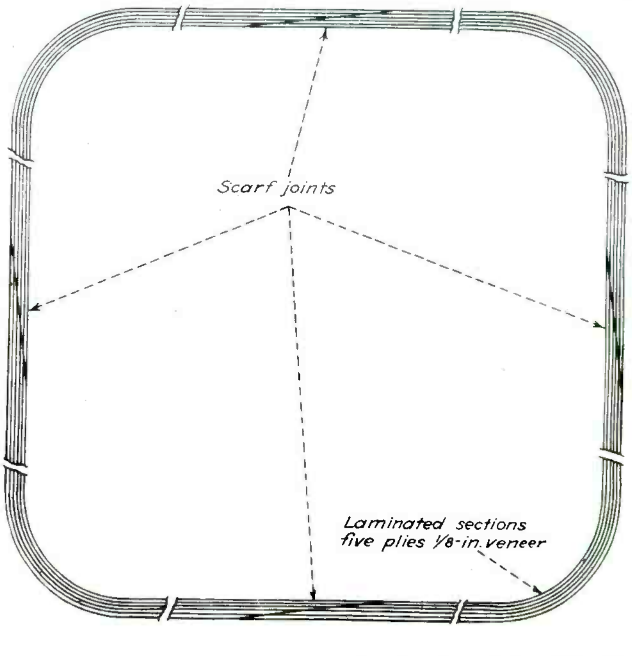


FIG. 5 (left)—Sketch showing makeup of the fuselage ring section shown in Fig. 4. A wide piece of curved-laminated board (a) is formed, and sections (b) are then sawed to required width

FIG. 6 (below)—Four sections as shown in Fig. 5 are scarf-jointed to form a complete fuselage ring. In this illustration the thickness of sections is exaggerated to show method of joining



as shown in Fig. 3 would have greater strength, would be lighter and, once the fixtures were developed, would be cheaper to make. Since these parts are made in tens or even hundreds of thousands, the work necessary to develop a production setup would be amply justified. Several radio cabinet manufacturers have already investigated this field.

Similar problems, even more important from a cost standpoint, are met with in piano manufacture (for example, the manufacture of rims for grand pianos). At the present time at least four large piano companies are using r-f heating in the production of wood aircraft parts. Two of these companies experimented with r-f before the war. That they will be actively using r-f after the war seems certain.

Thus, although the present use of r-f heating in the manufacture of curved-laminated parts for wood aircraft is not in itself a very big or important application, it is, nevertheless, of considerable interest for the light it throws on the future of r-f heating in the wood field. Moreover, while the quantities involved in aircraft production are not comparable with what may be expected in the post-war period, the other problems met with are, in general, similar. For this reason the work done to date, although very limited in scope, should be of interest.

"Laminated" and "Molded" Constructions

The aircraft parts normally made of multiple wood layers divide roughly into two types. One of these includes the curved-laminated members which form structural parts such as bulkhead rings, nose rings, wing tip bows, gas tank supports and wing rib caps. Usually these members require greatest strength in one direction and for that reason they are made up of a number of layers of wood with the grain in all layers running in the same direction.

The other type includes the various kinds of "skins" or coverings which form the surfaces of fuselages, wings, empennages and ailerons. In these members uniform strength in all directions is desirable, particularly in monocoque or semi-monocoque constructions, and for that reason these are usually made of from three to nine layers of thin veneer, with alternate layers of veneer having the grain at right angles. From the manner in which these are formed they are usually called "molded" parts.

Present Laminating Process

Of the afore-mentioned two types of parts, the curved-laminated members are the simplest to manufacture and the equipment presently used is the most readily adapted to the use of r-f heating. The fuselage ring, of which two sections are shown in Fig. 4, will serve as an illustration of the way in which parts of this type are presently made and the several means by which r-f heating has been experimentally adapted to the process. This ring section is made up of five layers of ⅛-inch veneer, as shown in Fig. 5. After these sections have been formed as described below, they are scarf-jointed together as shown in Fig. 6, to make up a complete ring. In a wood transport plane such rings are placed every two feet or so along the length of the fuselage. Since the fuselage tapers somewhat, the rings are of different size and shape at each station. Thus a different set of forms is required for each piece.

A set of forms of the type used in making these rings is shown in Fig. 7. Although each ring is only 1½ inches wide, it is usual to make use of forms which allow a laminated piece about 20 inches wide to be made. From this wide piece individual pieces of the required width are sawed. The male and female forms used for this purpose are made of wood built up to the necessary dimensions and carefully finished to shape. The inner faces of the forms, that is, those next to the veneer, are covered with $\frac{1}{16}$-inch steel sheet.

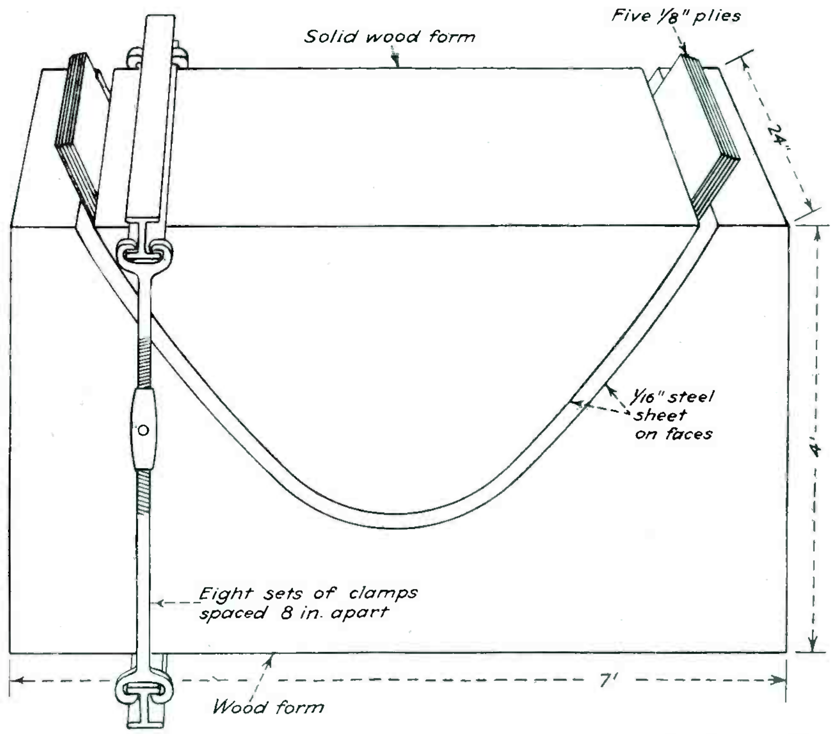


FIG. 7—Arrangement of male and female forms for making the laminated section shown in Fig. 5. Pressure is applied by means of a large number of hand-clamps. Radio-frequency heating is applied by utilizing the steel face plates of the forms as electrodes

With the present cold-gluing method the veneers on which the glue has been previously spread are placed between these forms, a series of hand-clamps applied as indicated in Fig. 7, and the whole assembly allowed to stand at room temperature for eight to ten hours. By this lengthy process the relatively small quantity of these sections presently required can be made without too much difficulty. It is

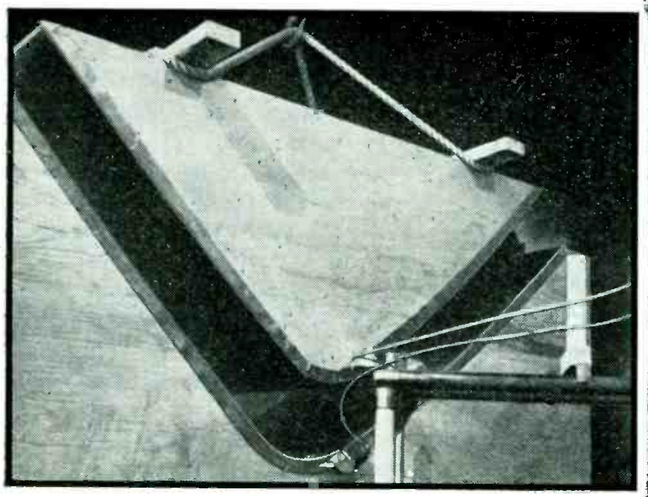


FIG. 8—Photograph of the male and female forms used to make fuselage ring section, with r-f connections in place

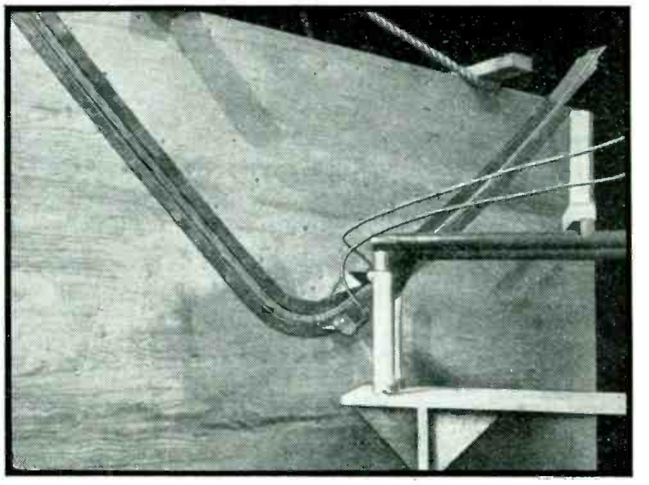


FIG. 9—The forms shown in Fig. 8 with the load in place. Eight sets of hand-clamps are used to obtain pressure

obvious, however, that if production in the hundreds per day were required, the number of forms and the floor space required would be prohibitive.

Applying R-F Heating to Laminating Process

In order to determine the possibilities, r-f heating was experimentally applied to the setup described above by the simple expedient of utilizing the steel faces of the forms as electrodes. In order to insure even current distribution a copper strip was run the full length of the side of each face sheet. The forms so equipped are shown in the open position in Fig. 8 and, in Fig. 9, with the load in place. The electrodes were fed by a short transmission line which may be seen in the foreground.

The selection of a suitable frequency for r-f heating involves consideration of a number of factors, as has been previously pointed out.[2, 3] In the setup described here the spacing between electrodes was small ($\frac{5}{8}$ inch). Moreover, glue which was squeezed out when pressure was applied tended to run down over the laminations. Under such conditions the likelihood of voltage flashover was considerable and for this reason the use of a relatively high frequency seemed desirable. On the other hand, the capacitance formed by the load placed between the closely spaced plates was such that an upper limit of frequency was set by the necessity of having some means of tuning the load. As a practical compromise a frequency of 8 Mc was determined upon.

The method of feeding power to the load is shown in Fig. 10. Parallel tuning of the load was required since the shortest oscillator-to-load leads which could have been arranged would still have had too much inductance to tune the load at 8 Mc—or at any frequency at which flashover would not occur.

The parallel inductance used consisted of a stub formed by 6-foot lengths of $1\frac{1}{2}$ inch copper pipe spaced about 8 inches apart and provided with a heavy copper shorting bar. The near end of this tuning stub can be seen at the right in Fig. 8. Originally the shorting bar was moved by hand; later a motor-driven bar, controlled by pushbuttons, was built up. With an arrangement of this kind a considerable range of loads can be tuned without any change in the tuning or coupling circuits of the oscillator.

Results Obtained

With the arrangement as described above, very quick and satisfactory heating of the laminated piece was obtained. A temperature of 235 deg—enough to set the glue almost instantaneously—could be attained in about $2\frac{1}{2}$ minutes, using a power of 8 kw (oscillator output).

When the forms were accurately shaped, and providing they were carefully centered so that adequate and uniform pressure was secured over the whole area, the glue joints made by this method had very good strength characteristics. However, considerable difficulty was encountered in obtaining consistent results because of nonuniform pressure. Wood-workers do not ordinarily work to the close toler-

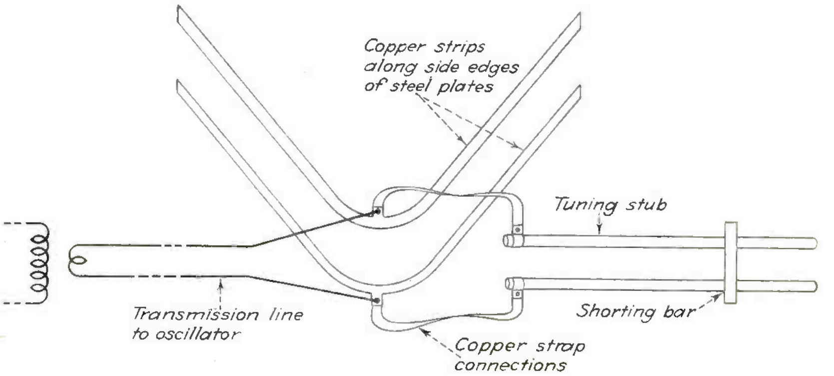


Fig. 10—Schematic illustration of the r-f connections used to feed the forms shown in Fig. 8 and Fig. 9. A tuning stub is used to parallel tune the load

ances followed in making metal dies. It was found that forms of the type described here were seldom accurate to closer than $\pm\frac{1}{16}$ inch and that tolerances of $\frac{1}{8}$ inch were not unusual.

It is obvious that if the differences were in such direction as to make the space between the forms vary from, say, $\frac{5}{8}$ inch at some points to $\frac{1}{2}$ inch at other points, then the corresponding differences in pressure would be very large—in some instances such that there would be no pressure at some points and actual voids would occur.

In cold-gluing, some difference of pressure can be tolerated since cold-setting glues—for instance, the casein types—act something like a cement and tend to fill up spaces. Hot-setting resin adhesives, however, contract somewhat on setting, which means that good adhesion will not be obtained unless the surfaces are held in intimate contact by application of sufficient pressure.

A series of further tests which have been made indicates that this method—i.e., using rigid male and female forms—is satisfactory provided the size of the piece is not large and the curvature not too great. The actual limits will depend on the accuracy of the forms and the means provided to insure that they close correctly. With respect to the latter, it can probably be assumed that in a quantity production set-up a hydraulic press would be used and that by rigidly attaching the male and female forms to the press platens accurate closure could be insured. Where the quantity justifies, it would be worthwhile to consider metal dies, one of which, of course, would have to be insulated.

Use of a Flexible Electrode

A means of getting around the biggest difficulty with the above method is to make use of only one fixed form, either male or female, and to apply the pressure to the other side of the piece by some arrangement intended to give a flexible pressure somewhat akin to the "fluid pressure" attained in bag molding. One way of doing this is illustrated in Fig. 11. The male form as described above was hollowed out as shown and a heavy rubber bag made up to fit the cavity. With this in place (and inflated at low pressure) the load was inserted and the clamps placed on the forms as before. The bag was then inflated to a pressure of 75 pounds. Since the top electrode used in this case was a copper sheet thin enough to flex easily, the result was to provide a very nearly uniform pressure over the whole piece regardless of the curvature. With this setup the results were more uniform from the pressure standpoint. The arrangement, however, is more complicated to design and can be expected to give trouble with bursting bags unless the latter are designed and made exactly.

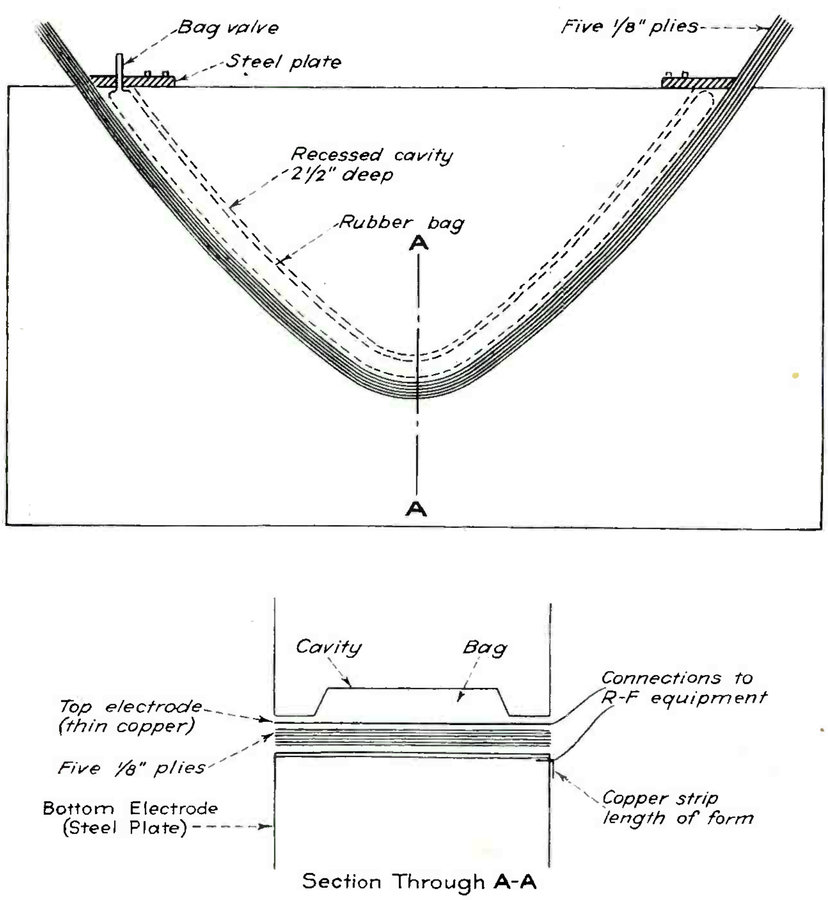


Fig. 11—Sketch of the arrangement used to obtain "flexible" pressure on one side of the laminated assembly. A rubber bag which occupies a cavity in the upper form is inflated to 75 psi after the clamps are applied. Using a thin copper sheet for the upper electrode gives an approximation of "fluid" pressure

Other Means of Obtaining "Flexible" Pressure

Another means of applying a more or less flexible pressure to one side of the laminated piece has recently been described by Bilhuber and Godfrey.[4] The arrangement they have successfully employed entails the use of a single rigid form—in this instance, the male form. The veneers to make up the laminated piece are pressed tightly against this form by means of a large number of clamping devices. These are spaced along the form at close intervals so that the stiffness of the veneers themselves suffices to provide a reasonably uniform distribution of pressure.

In general, it has been the experience of the wood industry that some method of flexible pressure is required when hot-setting glue is used in making curved parts for critical uses such as aircraft parts. There are a number of ways of obtaining flexible pressure in addition to the two mentioned above.

References

(1) Taylor, J. P., R-F Heating Sets Glue in Laminated Aircraft Spars, ELECTRONICS, January, 1944.

(2) Taylor, J. P., Heating Wood with Radio-Frequency Power, *Trans. A. S. M. E.*, p. 201, April, 1943.

(3) Bierwirth, R. A. and Hoyler, C. N., Radio-Frequency Heating Applied to Wood Gluing, *Proc. I. R. E.*, p. 529, October, 1943.

(4) Bilhuber, P. H. and Godfrey, W., High-Frequency Heating Applied to Aircraft Woodwork, *Aero Digest*, p. 178, October, 1943.

VHF Behavior of

Measurements of power factor and apparent capacitance for several makes of capacitors, sockets, tubes, and concentric cables over a frequency range of 27.5 to 200 Mc, using a high-frequency Q-meter. Apparent capacitance increases greatly as leads are lengthened

USE of higher and higher radio frequencies in military and scientific applications has vastly increased the field in which a knowledge of the electrical characteristics of the component parts is of prime importance and of considerable interest. It is well known, for example, that a component, such as a capacitor with necessary connecting leads, may be considered at one megacycle as a capacitance only. At frequencies 50 to 200 times higher, the capacitance appears to increase because of the inductance of the capacitor[1] and leads. Power losses also may become excessive. Therefore, it becomes impossible to predict results accurately in an ultrahigh-frequency circuit in which this device is used. Components for use at very high radio frequencies are therefore made with as small dimensions as possible. The best insulation should be employed at these frequencies.

It is likely that considerable experimental and development work of the past few years has been accomplished without much thought as to whether the given radio components yielded the maximum performance possible. The chief requisite was to get results quickly. The enormous demand for all types and grades of components has compelled the designer or engineer to accept such parts as were finally made available to him. After long delays in obtaining parts he was not inclined to question whether the components provided would best meet requirements for the particular frequencies involved.

A technician might be assigned a specific project involving the design of apparatus to operate at 150 Mc, for example. The design would involve some tubes, sockets, capacitors, coils, etc. Use of the first components at hand might result in very poor operation of the device and consequent delay of an important project, because components unsuitable for this frequency were used. The technician constructing the device saw only tubes, sockets, and capacitors, but the radio frequencies within the circuits found tubes, sockets, and capacitors all with relatively low-impedance paths across them, wherein much of the r-f energy was wasted, before a small amount arrived at the output terminals for useful work. If a much lower frequency had been selected, with appropriate changes in L and C values, the device probably would have operated satisfactorily with those components.

TABLE I. DOUBLE PLUGS

Double Plug No.	Description	Power Factor in Percent at Freq. in Mc							
		27.5	50	75	100	125	150	180	220
1	Exposed terminals, black molded phenolic resin	4.51	2.92	2.98	2.98	2.54	2.85	3.07	3.02
2	Enclosed terminals, black molded phenolic resin	5.00	4.15	4.16	3.86	4.71	4.90	5.18	4.86
3	Enclosed terminals, orange molded low-loss	0.94	0.84	0.82	0.76	0.91	1.21	1.25	1.16
4	Enclosed terminals, chocolate molded polystyrene	0.11	0.12	0.19	0.27	0.12	0.45	0.49	0.50
5	Enclosed terminals, yellow molded phenolic resin	1.38	1.00	1.12	1.11	0.64	1.30	1.43	1.68
6	Exposed terminals, transparent methacrylate resin	1.00	0.66	0.44	1.13	0.47	0.59	0.90	0.96

VHF Measuring Technique Used

It was with some such ideas as given above that a number of measurements were made on several types of components to determine their comparative suitability for use at frequencies from 27.5 to 200 Mc. These measurements were made with a type 170-A Boonton Q-meter.[2] This instrument gives a measurement of voltage at resonance across a variable capacitor before the unknown component is connected and again after it is connected in the circuit. Readings of Q-meter voltage and tuning capacitance are taken for both conditions, from which other characteristics can be calculated. The power factor in percent was calculated from the following:

$$\text{Percent power factor} = \frac{100\, C_1\,(Q_1 - Q_2)}{(C_1 - C_2)\, Q_1\, Q_2}$$

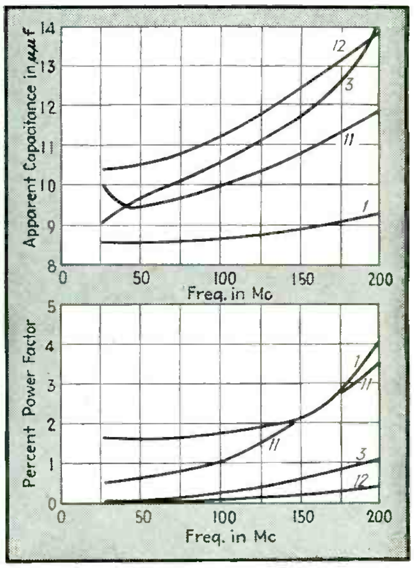


FIG. 1—Curves showing how power factor and apparent capacitance change with frequency for four of the small capacitors for which VHF data is given in Table II

Radio Components

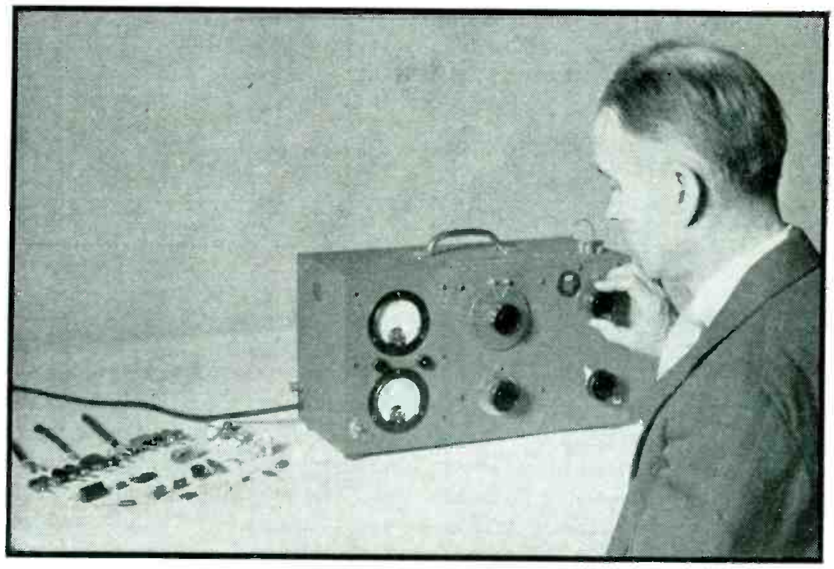
By E. L. HALL

Radio Engineer
National Bureau of Standards
Washington, D. C.

where C_1 and Q_1 are capacitance and Q readings at resonance before adding the capacitor to be tested, and C_2 and Q_2 are capacitance and Q readings at resonance after adding the capacitor to be tested. The values of C were read directly in micromicrofarads, and the values of Q were read from two vacuum-tube voltmeters.

While the results presented below were usually made on only one of a make of component, the variation in results among the various units is such as to emphasize the need for knowledge of the electrical characteristics of components to be used at very high frequencies. These measurements were all made at room temperature. Change of characteristics of components with temperature and humidity and for frequencies above 200 Mc were not determined. That such information has been available to some designers of communications equipment for our own armed forces and those of the enemy is not doubted. Such knowledge permits the selection of components suited to the particular conditions of service, and thus insures satisfactory operation, or reveals limitations to be expected.

The type 170-A Q-meter is particularly useful in measurements involving small capacitances up to 25 $\mu\mu$f, although not limited to this range. It therefore lends itself to measurements wherein the capacitance is small.



Q-meter used in VHF investigations of radio components covered in this article

To determine relative losses in several kinds of insulating materials, measurements were made on a number of double plugs of the kind supplied by General Radio Co. for connecting circuits and apparatus. The power factor was calculated and is given in Table I.

Twelve 10-$\mu\mu$f Capacitors

Power factor measurements were made at six frequencies upon twelve varieties of 10-$\mu\mu$f capaci-

TABLE II. 10-$\mu\mu$f CAPACITORS

Capacitor No.	Description	Power Factor in Percent at Freq. in Mc							Apparent Capacitance in $\mu\mu$f at Freq. in Mc						
		27.5	45	50	75	100	150	200	27.5	45	50	75	100	150	200
1A*	Mica midget capacitor molded in brown Bakelite	1.64	1.61	....	1.65	1.77	2.12	4.09	8.6	8.6	....	8.5	8.8	9.1	9.0
2B	Mica midget capacitor molded in brown Bakelite	0.50	....	0.48	0.47	0.56	0.69	0.98	11.0	...	10.8	11.0	11.2	12.0	11.6
3B	Silver mica midget capacitor molded in low-loss red Bakelite	0.07	0.10	....	0.17	0.24	0.61	1.13	8.8	9.8	....	10.1	10.6	11.7	14.1
4C	Silver mica midget capacitor molded in low-loss red Bakelite	0.06	....	0.05	0.12	0.14	0.25	0.45	9.9	...	9.3	9.4	9.5	10.0	9.7
5D	Mica midget capacitor molded in brown Bakelite	1.09	....	1.13	1.03	1.15	1.40	1.92	9.0	...	8.5	9.0	8.9	9.7	9.8
6E	Mica midget capacitor molded in yellow Bakelite	0.57	0.71	....	1.08	1.40	2.79	....	9.2	9.0	....	9.3	9.7	10.2	....
7F	Zero temperature coefficient tubular ceramic capacitor	0.04	0.05	....	0.06	0.07	0.11	0.10	9.7	9.6	....	9.8	9.7	9.7	9.1
8F	Negative temperature coefficient tubular ceramic capacitor	0.00	....	0.00	0.01	0.01	0.03	0.00	9.2	...	9.5	9.6	9.3	9.4	8.6
9	Trimmer capacitor, mica on bakelite base (old design)	0.86	....	0.86	0.83	0.88	0.98	1.16	9.8	...	9.5	9.5	9.7	9.9	9.1
10	Trimmer capacitor, mica on ceramic base	0.04	....	0.04	0.08	0.09	0.15	0.21	9.0	...	9.0	9.1	9.5	9.5	9.1
11F	Trimmer capacitor, ceramic	0.54	0.59	....	0.85	1.03	2.14	3.56	10.0	9.4	....	9.8	10.0	10.8	11.9
12G	Variable air capacitor, ceramic insulation	0.02	....	0.02	0.07	0.09	0.23	0.40	10.4	...	10.5	10.9	11.1	12.4	13.9

*Letters represent manufacturers. Capacitors 1A, 2B, 3B, 5D and 6E are of same physical dimensions and 4C is 1/8 inch longer than these.

TABLE III. 25-$\mu\mu$f MICA CAPACITORS

	Small Capacitor		Large Capacitor	
Freq. in Mc	C in $\mu\mu$f	% change in C	C in $\mu\mu$f	% change in C
27.5	24.9	0	24.8	0
50	25.0	0.4	25.6	3.2
75	25.7	3.2	27.7	11.7
90	....	....	32.8	32.2
103	26.4	6.0	....	....
115	....	....	45.5	83.5
125	30.5	22.5	....	....
180	45.5	82.7	....	....

TABLE IV. 25-$\mu\mu$f CAPACITOR WITH VARIOUS LEAD LENGTHS

Test Freq. in Mc	Percent Change in Capacitance for Various Lead Lengths						
	0.6 cm	1 cm	2 cm	3 cm	5 cm	8 cm	11.6 cm
27.5	0	0	1.2	3.2	6.8	12.8	18.9
50	0.4	1.2	4.8	9.6	19.6	41.0	81.1
56	....	....	....	....	22.5	53.0	91.5
75	3.2	5.2	12.0	25.6	69.0	100+	100+
103	6.0	14.0	40.5	93.2	....	....	....
125	22.5	44.6	....	....	....	....	....
180	82.7	....	....	....	....	....	....
Plotted (Fig. 2) in Curve	A	B	C	D	E	F	G

tors. Considerable change was noted in apparent capacitance. Tables of power factor and apparent capacitance values are given in Table II, and corresponding curves for four of the capacitors are shown in Fig. 1. It will be noted from the table of power factors that the curve for the No. 4 silver-mica midget capacitor, if shown, would be similar to the curve for No. 12, the variable air capacitor with ceramic insulation; also that the No. 4 silver-mica capacitor has about half the loss of No. 3, a silver-mica capacitor of another make.

25-$\mu\mu$f Mica Capacitors

The importance of keeping all components for use at ultrahigh frequencies physically as small as possible and keeping connecting wires as short as possible will be shown in the following data. Two 25-$\mu\mu$f mica capacitors were selected. One was a midget type about $\frac{5}{8}$ inch long not counting leads and the other was $1\frac{1}{4}$ inches long. The Q-meter was used in the measurements, with leads on the capacitors as short as possible. The apparent capacitance was measured at frequencies from 27.5 Mc to as high a frequency as could readily be obtained. The larger capacitor required longer leads than the smaller in order to fasten on to the binding posts of the Q-meter. Taking the capacitance at 27.5 Mc as a basis, the percent change in capacitance was calculated for the different frequencies for the two capacitors, and the results are given in Table III. Curves *A* and *H* in Fig. 2 are plotted from this data, and show that the apparent capacitance of the small capacitor was about 6 percent larger at 100 Mc, while the large capacitor was 50 percent higher in apparent capacitance.

In the following tests the small 25-$\mu\mu$f mica capacitor of the previous test was provided with two leads 11.6 cm long. These leads were much longer than would probably ever be employed at the frequencies used in the test, but it was desired to exaggerate the effect produced. The apparent capacitance was measured for several frequencies for a number of leads of different lengths, down to the minimum

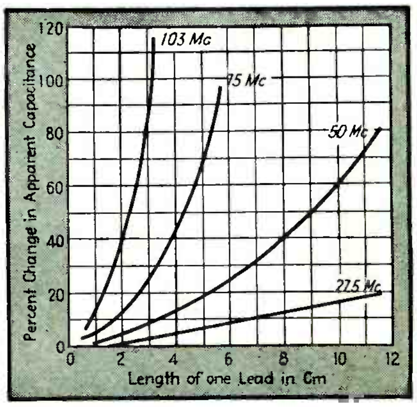


FIG. 3—Curves for four frequencies of Table IV, showing percent change in apparent capacitance for different capacitor length leads

length required to connect to the terminals of the Q-meter. The percent change in apparent capacitance, based on the capacitance with minimum-length leads at 27.5 Mc, is given for the different leads in Table IV and in curves *A* to *G* in Fig. 2.

The measured values of Table IV are plotted in Fig. 3 to show the percent change in apparent capacitance with leads of different lengths at four frequencies from 27.5 to 103 Mc. It will be evident from Fig. 2 and 3 that if the apparent or effective capacitance of a capacitor is to remain within, say, 10

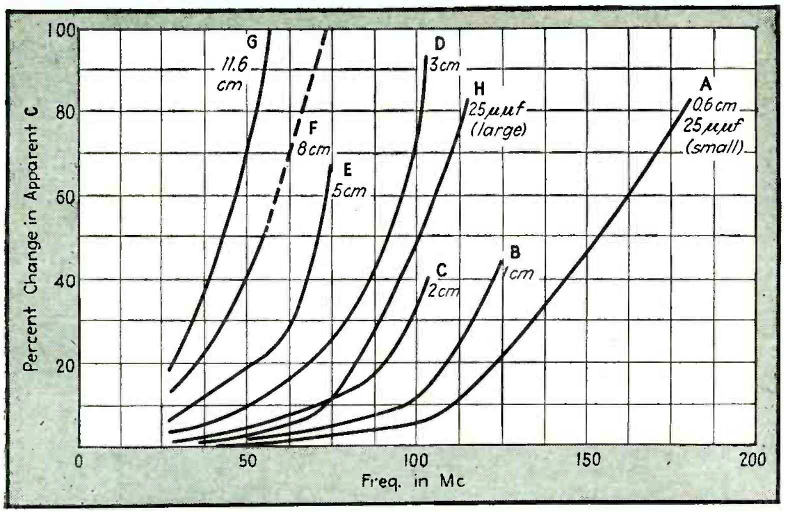


FIG. 2—Percent changes in apparent capacitance with frequency for a midget 25-$\mu\mu$f capacitor (*A*) and a 25-$\mu\mu$f unit with physical dimensions twice as large (*B*). These curves are based on data in Table III. Curves *A* to *G* show percent changes in apparent capacitance with frequency for a 25-$\mu\mu$f midge capacitor used with leads from 0.6 to 11.6 cm long, as given in Table IV

TABLE V. TUBE SOCKETS

Socket No.	Description of Socket	Percent Power Factor at Freq. in Mc							Capacitance in $\mu\mu f$ at Freq. in Mc						
		27.5	35	50	75	100	150	200	27.5	35	50	75	100	150	200
1	Black molded miniature	3.6	3.4	3.2	3.1	3.1	3.7	4.0	3.0	3.0	3.0	3.0	2.9	2.7	2.8
2	Miniature wafer; mica-filled insulation	0.25	0.26	0.24	0.22	0.22	0.15	0.22	1.9	1.9	1.9	1.9	1.8	1.7	1.8
3	Miniature molded; clear polystyrene	....	....	....	....	....	....	....	2.7	2.6	2.2	2.2	2.4	2.3	2.4
4	Five-prong ceramic	0.67	....	0.84	0.72	0.74	....	....	1.6	...	1.2	1.3	1.4	...	...
5	Five-prong ceramic	0.29	....	0.70	0.55	0.76	....	....	1.0	...	0.9	0.7	0.7	...	...

percent of its low-frequency value, connecting leads must be short or the capacitor must be used at lower frequencies. These curves explain why calculations involving inductance and capacitance at ultrahigh frequencies often fail to check experimental data.

Tubes and Sockets

Power-factor measurements were made on three miniature sockets at seven frequencies and on two ceramic sockets at four frequencies, using the Q-meter. The measurements on a polystyrene socket gave an apparent zero power factor because this material was used in the construction of the Q-meter capacitor. The results on the other sockets are given in Table V. For sockets 1, 2 and 3 the seven contacts were connected together to form one terminal of the test capacitor, and the center metal sleeve formed the other terminal. For sockets 4 and 5, the grid terminal and the adjacent heater terminals were used.

Since considerable variation was found in the losses in small capacitors and sockets of different types, it was decided to make similar measurements on several types of vacuum tubes. Black phenolic compound has been long known to have higher losses than some other materials, yet it has been employed for the base of many types of vacuum tubes. It has been customary to remove the base of tubes used in some high-frequency applications, or bring out the r-f terminals through the glass away from the phenolic base, but nevertheless some tubes are employed at fairly high frequencies where such expedients are neglected.

Table VI gives power factor and capacitance for a number of types of tubes, measured between grid and cathode with the Q-meter. Figure 4 gives curves of power factor and apparent capacitance for six of the tubes listed in Table VI. All tubes but the type 9003 and 3A5 were measured without a socket. The polystyrene socket previously mentioned was used in the tests on these two tubes.

The first five tubes in Table VI presumably have a base made of the same black molded material. There may, however, be a difference in the glass used in the seal, or in the coating or deposit within the tube, which would account for the rather large differences in the results on these tubes.

Tube 807(M) used a yellow molded material called "Micanol" for the base. Tube 807(C) had a ceramic base. The glass of the 954 tube was the only solid dielectric involved in the measurements on this tube as it had no phenolic base and connections were made directly to the tube terminals. Comparing the results on the 954 tube with those on the 9003 tube and socket, it appears that the former used glass having a higher loss than that in the 9003 tube, or some coating within the tube increased the loss. Two 3A5 tubes were tested, and are designated *A* and *B*. The numbers 3–4 and 4–5 indicate the base pins to which connections were made.

Concentric Cables

Power-factor measurements were made with the Q-meter on three 6-inch lengths of concentric cable

TABLE VI. VACUUM TUBES

Tube Type No.	Percent Power Factor at Freq. in Mc						Apparent Capacitance in $\mu\mu f$					
	28	50	75	100	150	200	28	50	75	100	150	200
6L6G	0.68	0.89	1.36	....	too large	....	10.9	11.4	13.2	...	...	...
1852	0.46	0.54	0.78	0.94	2.04	....	7.6	7.5	7.8	7.7	8.8	...
6SK7	1.00	0.97	0.94	0.99	1.33	1.80	4.5	4.2	4.0	4.5	4.5	5.0
76	1.08	1.24	1.84	3.38	....	too large	7.5	7.7	8.3	9.2	...	...
6C5	0.82	0.78	0.73	0.83	1.29	1.83	3.8	3.6	3.8	3.8	3.9	4.3
807 (M)	1.30	1.60	1.96	....	too large	....	13.7	13.6	14.9	...	...	...
807 (C)	1.09	1.41	1.95	....	too large	....	13.2	13.9	15.1	...	...	...
954	0.92	1.05	0.99	0.94	1.13	1.51	2.7	2.3	2.3	2.5	2.7	2.8
9003	0.20	0.19	0.18	0.19	0.30	0.50	3.2	3.4	3.6	3.7	3.8	3.7
3A5 (A3–4)	0.25	0.36	0.50	0.69	1.14	2.31	4.2	4.3	4.2	4.5	4.8	4.7
3A5 (B3–4)	0.19	0.28	0.42	0.60	1.08	2.14	4.3	4.4	4.5	4.6	4.9	4.7
3A5 (A4–5)	0.14	0.20	0.28	0.40	0.74	1.64	3.2	3.2	3.2	3.2	3.4	3.2
3A5 (B4–5)	0.62	0.51	0.50	0.55	0.86	1.90	2.8	3.1	3.4	3.2	3.4	3.1

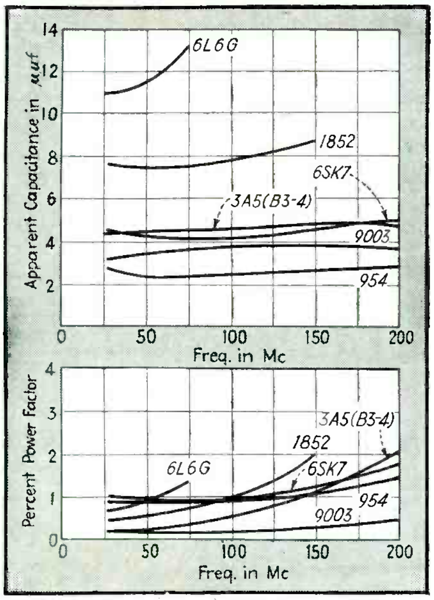


FIG. 4—Curves showing power factor in percent and apparent capacitance for six types of vacuum tubes in Table VI

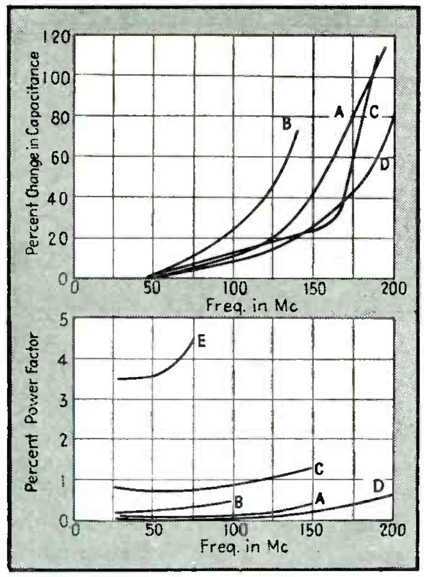


FIG. 5—Curves showing power factor and percent change in apparent capacitance for concentric cables in Table VII

having solid insulation, a six-inch length of line consisting of a ⅝-inch copper tube with a No. 12 AWG copper wire supported by six ceramic spacers, and a length of shielded twisted pair with rubber and cotton insulation. The capacitances of the samples tested ranged between 10 and 16 μμf at 27.5 Mc. The percent change in apparent capacitance from the value at 27.5 Mc was calculated. Table VII gives the data taken, and Fig. 5 gives curves of power factor and percent change in apparent capacitance. Considerable change in apparent capacitance is not surprising since the capacitance is distributed along six-inch conductors.

The data presented on several types of components are comparative and show that there is a wide range in the power factor or losses in many of these parts at frequencies up to 200 Mc. If the most efficient equipment is to be constructed, the best parts must be used. Knowledge of the best parts can only be obtained by measurement of the characteristics of the parts as available from various manufacturers. Such information should be available to builders of radio-frequency equipment.

A given component may be unsuited for use at ultrahigh frequencies and yet be entirely satisfactory at low frequencies. Likewise, it would usually be extravagant to use a ceramic or polystyrene socket in an audio-frequency application, when a cheaper socket would suffice and the high-frequency types are so scarce. In further work[3] of this kind, similar information taken at other temperatures and humidities would be of value.

No limiting value of power factor can be stated for radio components intended for use at very high frequencies. This is because other factors such as frequency, power considerations, position of use in the circuit, physical and mechanical considerations, and availablity of desired types of components must be considered.

The data presented above cover a fair range of values of power factor and indicate that there is a choice possible. If very high-frequency applications are in mind, use components having the lowest losses consistent with other requirements of the problem. Do not use low-loss components in audio and low-frequency applications, when materials having higher losses will be equally satisfactory.

REFERENCES

(1) "Radio Instruments and Measurements", Bureau of Standards Circular No. 74, p. 111.

(2) Brown, H. A., "Radio-Frequency Electrical Measurements", McGraw-Hill Book Co., Inc., New York, N. Y., 1938, p. 70; Rao, V. V. L., *Proc. I. R. E.* 30, p. 502, 1942; Terman, F. E., "Radio Engineers' Handbook", McGraw-Hill Book Co., Inc., New York, N. Y., p. 916, 1943.

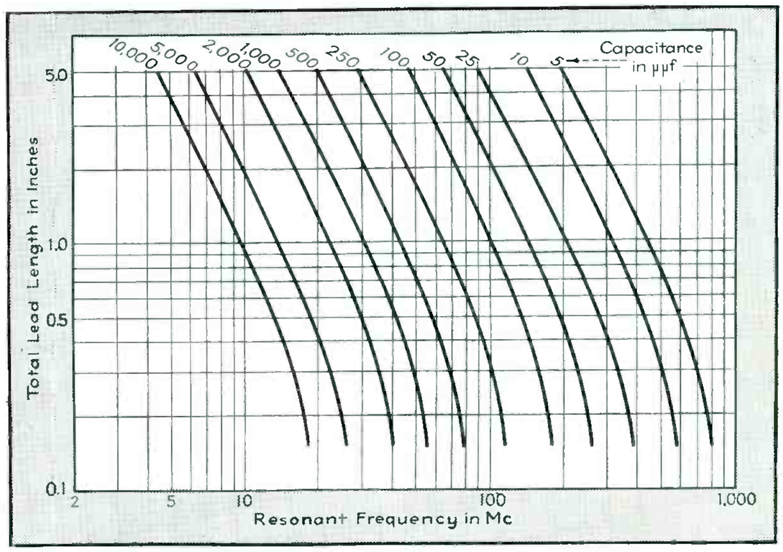
(3) Matthews, A. C., Characteristics of Radio Electronic Components, *Radio*, p. 24–28, July 1943.

TABLE VII. SAMPLES OF CONCENTRIC CONDUCTORS AND A TWISTED PAIR

Sample No.	Description of Conductors	Power Factor in Percent at Freq. in Mc						Percent Change in Apparent Capacitance (from Value at 27.5 Mc) at Freq. in Mc								
		27.5	50	75	100	150	200	27.5	50	75	100	140	150	190	195	200
A	5/16" diam. bare copper braid over 7 No. 22 AWG copper with dark, stiff insulation	0.07	0.08	0.12	0.09	0.42	....	0	0	5.3	10.6	..	41.0	...	11.5	....
B	5/16" insul. copper braid over 7 No. 20 AWG copper with white, flexible insulation	0.18	0.23	0.30	0.47	....	....	0	1.2	11.1	23.4	73	....	....	....	....
C	11/32" insul. copper braid over 1 No. 15 AWG copper with black, flexible rubber insulation	0.79	0.76	0.78	0.90	1.31	....	0	1.5	7.4	14.1	..	23.0	110	....	....
D	5/8" copper tube over 1 No. 12 AWG copper wire with 1/4" diam. loose fit ceramic spacers	0.03	0.04	0.08	0.09	0.20	0.66	0	0	4.8	7.7	..	25.0	...	....	80.7
E	Twisted pair, each with 10 No. 30 AWG tinned copper insulated with rubber and cotton; copper shield over pair but not grounded	3.52	3.56	4.52	....	....	....	..	...	....	....	..	....	...	....	....

Resonance in MICA CAPACITORS

By A. P. GREEN
and
C. T. McCOMB
Washington, D. C.



The chart gives lead lengths and capacitance values for series resonance at any frequency from 5 to 800 Mc, for postage-stamp mica by-pass capacitors with No. 20 tinned copper leads

In numerous high-frequency electronic applications the requirement exists that several physically separated points in a circuit be established at a common potential. To satisfy this condition most efficiently it is necessary to operate by-pass capacitors in a series resonant condition.

The simple capacitor element is composed of an effective capacitance in series with an inductance; this inductance is composed not only of the inductance of the associated leads but also the inherent inductance of the foil or plates of the capacitor itself. From this it is seen that for any particular capacitor size or shape there will be associated with the capacitance an absolute minimum of effective series inductance. At low frequencies the magnitude of the inductive component of reactance is so small that it is negligible in comparison to the capacitive component. As the frequency is increased the capacitor element behaves as an ordinary series resonant circuit.

For the most efficient application of a by-pass capacitor to function at a given frequency or band of frequencies, the best unit will be the largest practical capacitance that will meet both the physical and resonance requirements. The physical requirement will be fixed by the space available and the necessary lead length. With the lead length factor being determined by circuit requirements, the size of capacitor for resonance is then fixed by the frequency.

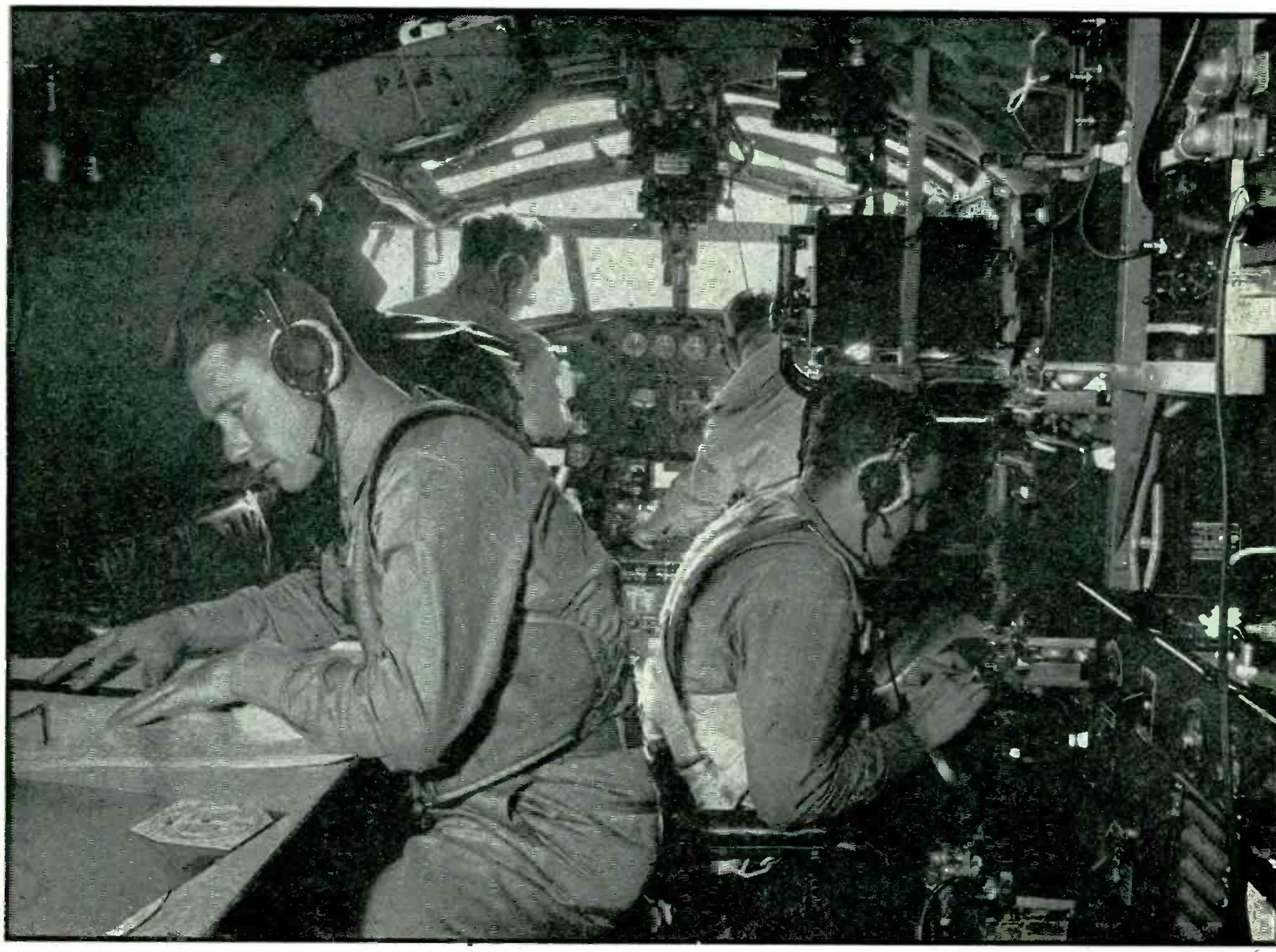
The above consideration has been applied to the case of the common postage-stamp mica capacitor. An experimental determination of the resonant frequency variation as a function of lead length has been carried out using mica capacitors with leads of No. 20 tinned copper wire. The accompanying chart gives the results of measurements conducted over the practical range of lead lengths for numerous sizes of mica capacitors. The characteristic shape of the curves demonstrates the existence of the above-discussed inherent inductance of the capacitor element. Since the functional variation of resonant frequency is plotted with respect to actual lead length, the residual inductance of the unit manifests itself as an asymptotic maximum resonant frequency for any particular capacitor.

Example of Use of Chart

A by-pass capacitor is desired for 100 Mc. Reference to the chart shows that there are four capacitor sizes that exhibit a usable resonance at this point, these being represented by the four curves that intersect the vertical 100-Mc line. The largest capacitance is most desirable as discussed above, but the choice of unit will be determined partially by the lead length requirement. It is seen from the chart that the range of available capacitances varies from 250 μμf with a total lead length of 0.31 inches to 25 μμf with a lead length of 4.0 inches. Assuming that a lead length of 1.0 inch would be most desirable for the circuit, a 100-μμf capacitor would be chosen.

An examination of the chart reveals an interesting yet expected relationship. It is seen that for a constant lead length the resonant frequency varies inversely as the square root of the capacitance. Thus for a 1.0-inch lead length, 500 μμf is resonant at 43.5 Mc, and 5 μμf is resonant at 435 Mc.

Military Radio Sets



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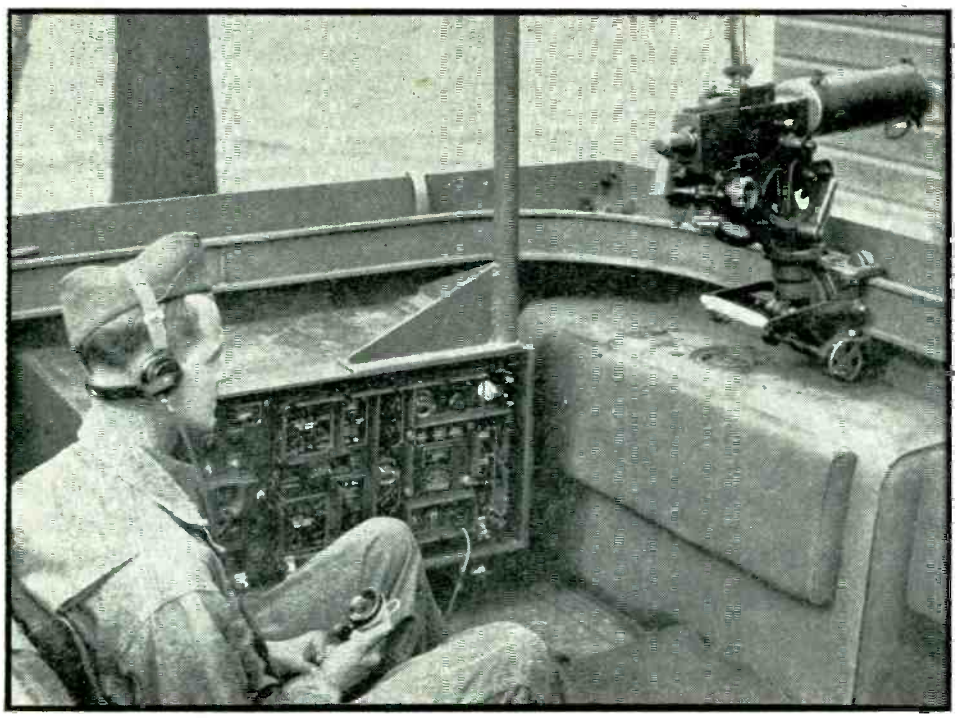
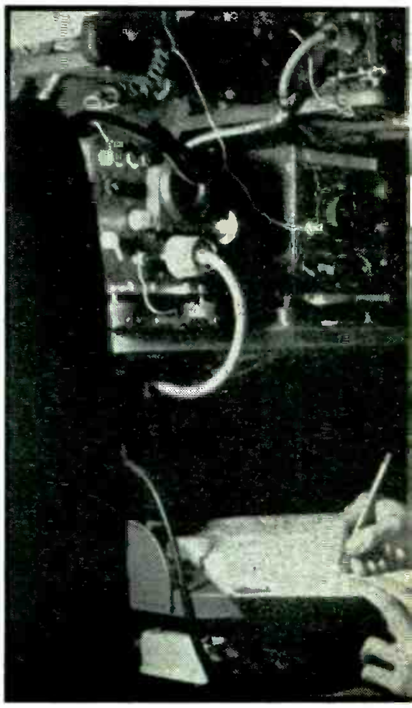




in Use

1

Interior view of radio and pilot compartments in a Martin PBM "Mariner" twin-engine Navy patrol bomber

2

Signal Corps radio set installed in half-track—General Electric photo

3

Aviation Radioman Second Class Hobart Singleton listens for SOS signals at his post in a giant PBY "Catalina" Navy patrol bomber

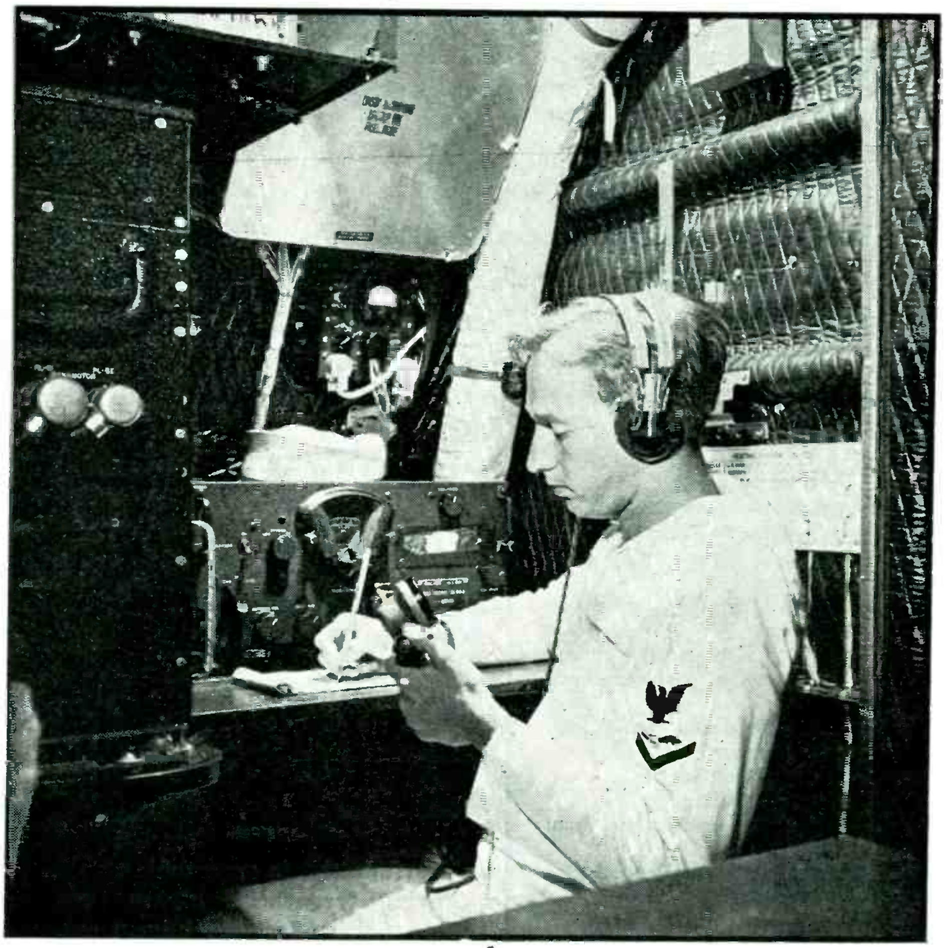
4

Radio operator's position in a Naval Air Transport cargo plane. Soundproofing material insulates the compartment from the roar of twin Cyclone engines

5

Radio operator at transmitting key aboard a Navy bomber

Official U. S. Navy Photographs



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5

3

SUPERSONIC

Current interest in applications for acoustic waves above 20,000 cps gives timeliness to this survey of basic methods for generating supersonic waves. Related facts on energy transfer through wave motion and effects of supersonic wave power are also covered

By V. J. YOUNG *Sperry Gyroscope Co., Inc. Garden City, N. Y.*

SUPERSONIC APPLICATIONS

- Precipitation of smoke
- Homogenization of milk
- Emulsification, giving smoother ice cream, mayonnaise and other food products
- Acceleration of aging of wines and spirits
- Acceleration of chemical reactions
- Transformation of chemical compounds
- Stimulation or destruction of bacteria in food products
- Underwater signalling
- Echo depth sounding
- Treating seeds to stimulate plant growth
- Flocculation of suspended particles or gas bubbles in liquids
- Transformation of crystal structures
- Compression and expansion of media through which sound waves pass
- Killing of small fish and frogs
- Heating of media that absorb supersonic waves
- Movements of particles into nodes of standing wave systems
- Mixing of metals to produce alloys
- Detection of imperfections in castings

WITH an acoustic wave as with any other kind of wave motion, there are certain facts that are always true and certain others that can be relied upon with certainty only for audible sounds produced in the normal fashion with moderate amplitude.

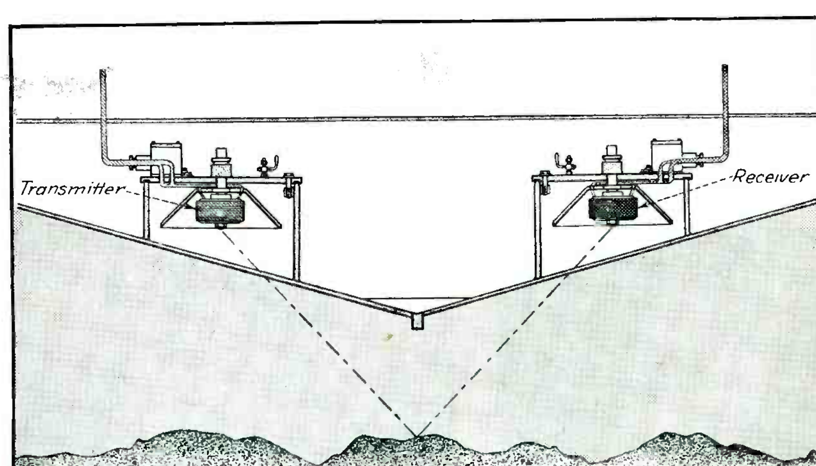
For example, with a simple tone such as might be obtained from a tuning fork or a resonant organ pipe, the velocity of propagation can be quite accurately stated in terms of the temperature and the nature of the conducting gaseous medium. Even though the pitch is still in the audible range, this is not at all true for violently excited sources of a transitory nature such as are encountered with explosions. In that case very peculiar effects are often noted. The velocity of the wave in the neighborhood of the explosion may be as much as three times as great as at a large distance where its loudness is comparable to that of ordinary sounds.

Comparison of Audio and Supersonic Waves

Fortunately, in supersonic waves (having frequencies higher than those which affect the human ear, i.e., above about 20,000 cps) we are not usually concerned with the effect of huge amplitudes which are only generated for such a short lapse of time. In fact, it has been the practical difficulty of obtaining sufficiently powerful sources that has made the whole field one to be successfully investigated only in the last twenty years or so, and it is readily possible to deal only with steady-state experiments in which measurements are much easier to make.

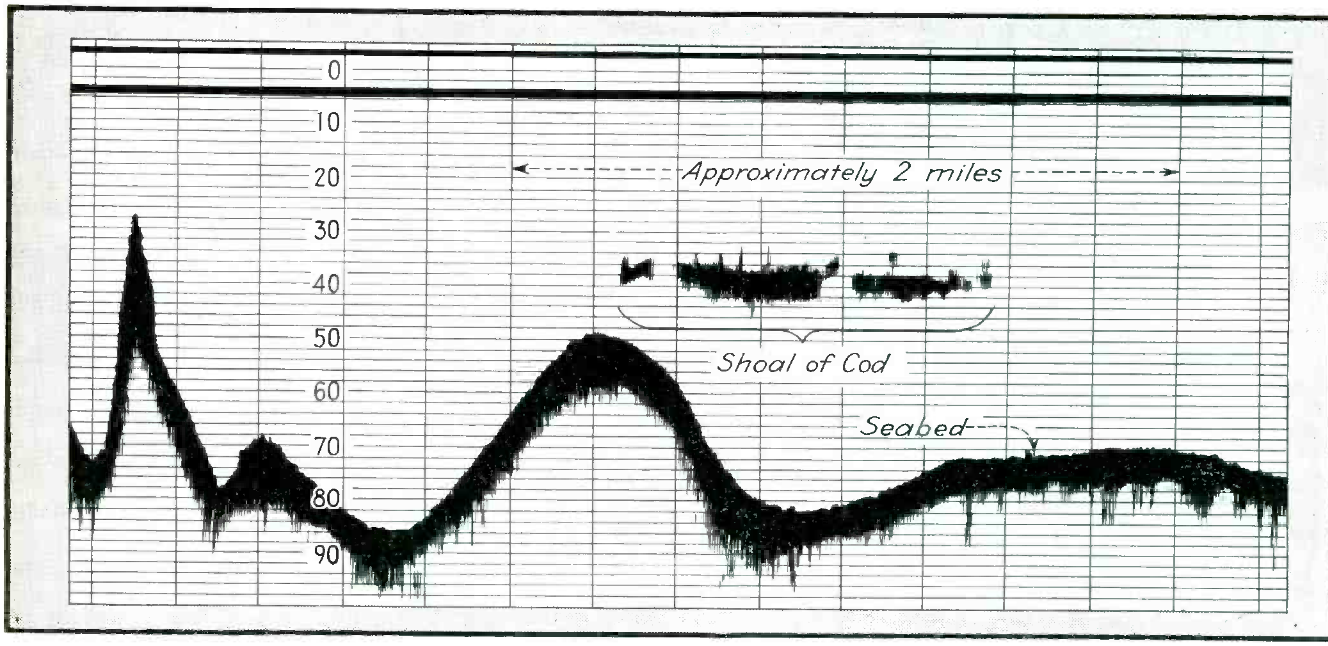
Nevertheless, the point is still well made that supersonic waves are like ordinary sound waves only in certain respects and that a good starting point to their study is to enumerate the similarities and point out where differences may be anticipated.

Probably the most characteristic statement that can be made about any wave motion concerns itself with a description of the flow of energy from the source to the receiver. If this is accomplished by the motion of matter through the whole distance, we do not ordinarily speak of the transmission as a wave motion; on the other hand, if



Echo sounding is one important application of supersonic waves. A typical arrangement in a boat is shown here; the transmitter mounted against the hull inside the ship sends supersonic waves down to the ocean bottom, and the receiver picks up the reflected waves. Electronic equipment plots depth on moving tape as ship moves. (From "Precision Echo Sounding and Surveying")

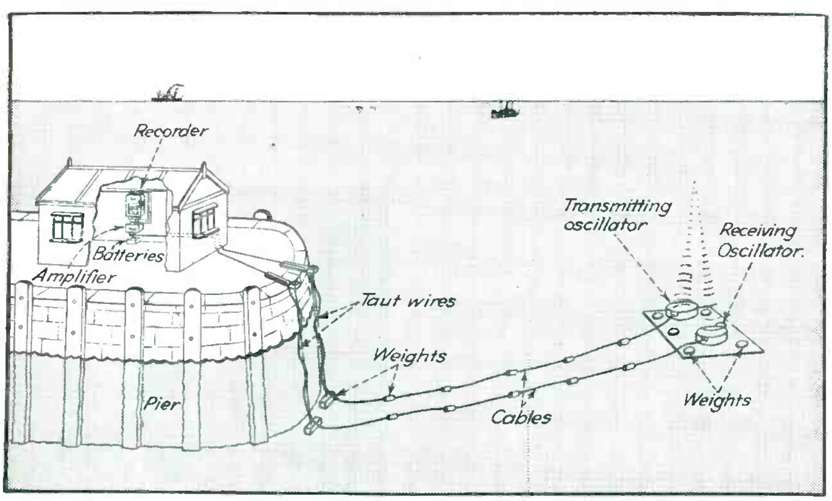
FUNDAMENTALS



Example of supersonic depth record obtained on a ship. Such objects as fish above the ocean bottom give indications also, making the equipment of great value to deep-sea fishing boats

none of the particles of matter in the neighborhood of the source ever reach the receiver while carrying energy with them, but rather only move a part of the distance so that the energy is repeatedly relayed along the way, then wave motion is indicated.

With acoustic waves this may be visualized in a very graphic way. The source is always a member moving with some type of periodic motion even though complicated. This motion pushes particles of the medium in the near neighborhood of the member and causes them to move also with periodic motion of some sort. These in turn excite other particles and so on, until the matter in the neighborhood of the receiver is in motion and energy is transmitted to the receiver.



This schematic diagram of a harbor tide-recorder is an interesting practical supersonic application. (From "Precision Echo Sounding and Surveying", by Lt. Commander D. H. Macmillan, Henry Hughes & Son, Ltd, 59, Fenchurch St., E.C. 3, London). Both oscillators are on ocean bottom

Facts About Wave Motion

Because of the periodic motion executed by elements of the material in the path between the source and receiver, it is clear that if the medium is observed at some single point, the material there will at certain times show a certain velocity, acceleration, or displacement. At the same time some other nearest point along the path will show the same velocity, acceleration and displacement. This distance between nearest points showing the same dynamical condition is called a wavelength.

Likewise if a series of snapshots of the wave train can be taken one after another and if the dynamical properties of the elements of the material are recorded upon them, it may be seen that any particular value of a dynamic quantity, such as a certain velocity, acceleration, etc., can be observed in successive pictures to have moved along the path. The velocity of the wave may be said to be the velocity with which

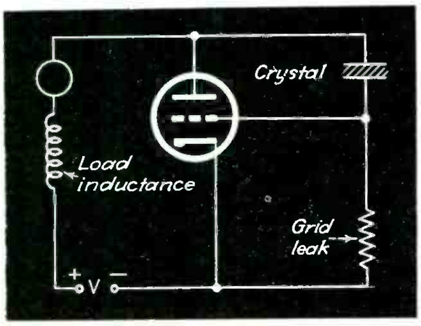


FIG. 1—Simple circuit for driving a quartz crystal serving as a supersonic source of sound

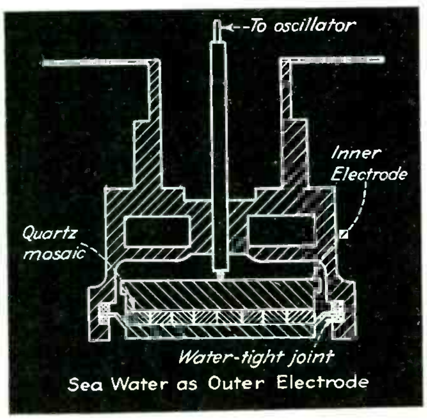


FIG. 2—Langevin quartz supersonic source for underwater signalling

the chosen value of the chosen dynamical property moves.

If the wave is modulated and we follow the motion of a point on the modulation envelope, the velocity observed is said to be group velocity. If instead we choose to watch the progress, for example, of the maximum acceleration of the particles due to the carrier wave, then the velocity measured is the phase velocity. In any event, for a steady-state solution, we can always write down a very simple relation between velocity, the corresponding wavelength, and the corresponding frequency. It is $f\lambda = v$, where λ is the wave length, f is the frequency, and v is the velocity. That this is true can easily be seen by imagining an observer who is able to place a mark on the wave train as it goes by and then take a picture of the wave train one unit of time later. His mark will then have moved v units of distance away, which is equivalent to f wavelengths since by definition f is the number of waves generated per unit time.

So far we have reviewed facts of wave motion which are true for all waves. To go further we would need to consider more completely the way in which the individual particles of the medium executed their periodic motion and how much of the transmitted energy is dissipated in heat rather than being transmitted to the receiver. In these respects supersonic waves sometimes act quite strangely.

Figure 1 shows a circuit for an oscillating quartz crystal used by G. W. Pierce[1] for the generation of high-frequency sound waves. When it is in operation the plate voltage varies sinusoidally at a frequency dictated by the crystal. Every time the plate voltage starts to rise, a potential begins to appear across the crystal by way of the grid and grid leak.

In due time, depending upon the mechanical period of rearrangement of molecular units in the crystal, this potential causes a polarization charge to appear on the surface of the quartz and in doing so gives the effect of a flow of positive charge to the grid. The tube thus becomes more conducting, so that the plate voltage begins to fall and a voltage drop begins to appear across the inductive load instead of across the tube. Ninety degrees later in phase (because of inductive phase shift) the greater part of the voltage is across the inductance and the plate voltage is a minimum.

During this fall in plate potential, the crystal finds itself in a relaxed or even reversed electric field to the one described before. This occurs at a time that is just right to fit in with the natural mechanical period of the crystal. In consequence, the grid loses positive charge and the voltage across the vacuum tube again starts to increase. The crystal thus essentially acts like an electrically resonant element and the inductance and vacuum tube serve to time the application of a driving voltage across this element so as to keep it going at its natural frequency.

The crystal used by Pierce was a slab cut so that its thickness lay along an electric axis of the quartz and its length along the optic axis. When such a plate finds itself in an electric field in the direction of its thickness, its length and thickness change in such a way that the volume of the crystal is constant. Such a crystal used in the circuit of Fig. 1 can generate supersonic waves of modest intensity by virtue of the periodic change in its thickness. The fact that these waves have a constant and stable frequency determined in the main only by the crystal is a great advantage inasmuch as it furnishes an accurate basis for many other measurements.

Quartz Crystal as Supersonic Wave Generator

With the arrangement just described, early work was done with supersonic waves in gases using frequencies between 40 and 1500 kc. As Pierce's crystals were cut, the highest of the three natural frequencies of the crystal was used. When this is done an empirical formula may be given for the frequency as a function of thickness. It is $f = 287 \times 10^3/d$, where d is in cm. This indicates that at 40 kc a completely unloaded crystal would need to be 7.2 cm thick.

Further empirical data tells us that even if a fairly high voltage (of the order of 1000v) is used to drive such a crystal, the acoustic energy to be expected is less than a watt per square cm of surface area. Because of this relatively small power which has to be divided between so many waves at this high frequency and because of the status of the art of electronics in 1925, Pierce was then able to generate waves only of small amplitude, although the principle of operation is the same as that used by later experimenters

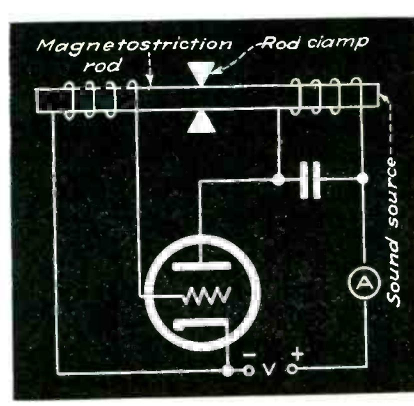


FIG. 3—Magnetostriction generator circuit for producing supersonic waves

who repeated his measurements with slightly different results.[2]

Langevin Piezoelectric Oscillators

At an even earlier date due to the needs of subaqueous sound signalling in the first world war, a French physicist, Langevin, devised a piezoelectric source for the transmission of sound at frequencies up to 50 kc in sea water. This was somewhat simpler because it is easier to establish an efficient coupling between the crystal and the liquid.

Langevin did not attempt to use crystals of large area to obtain increased power, but instead used a mosaic of several crystals embedded in a nonconducting resinous material. This is possible because although it is necessary to have electrodes on both sides of the crystal in the thickness direction, it is not necessary that the electrodes make actual contact with the quartz. The direct piezoelectric effect, by the use of which polarization currents are made to reinforce and control a periodic applied voltage, is purely a dielectric phenomenon and does not depend on conduction between the electrodes in any way.

Crystal Mounting Methods

There are two ways to mount crystals which are used to generate supersonic waves. One is by the use of a steel-quartz sandwich in which the acoustic waves are transmitted through the plates into the medium; the other is that in which the medium itself can be used to conduct current and serve as one of the electrodes. This second scheme is shown, in Fig. 2.

The decision as to which mounting to use when a choice is possible depends on several factors. In general, the crystal is easier to get into oscillation and its frequency easier to keep constant and known, if the load is as light as possible. To grind it to a given frequency with a negligible load is difficult enough; to do so for a given fixed load is still harder; and if the load is variable the job is impossible except within errors dependent upon that variability.

On the other hand, it may be advisable to have a fixed load imposed by the steel plates so that variations due to reflections back on the source by objects in the medium will be negligible. Also, at moderately low supersonic frequencies when maximum piezoelectric effect is needed, it may be desirable to use fixed loading to avoid excessively thick crystals.

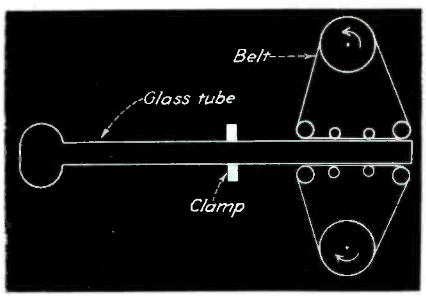


FIG. 4—Holtzmann's ultrasonic generator using two moving belts

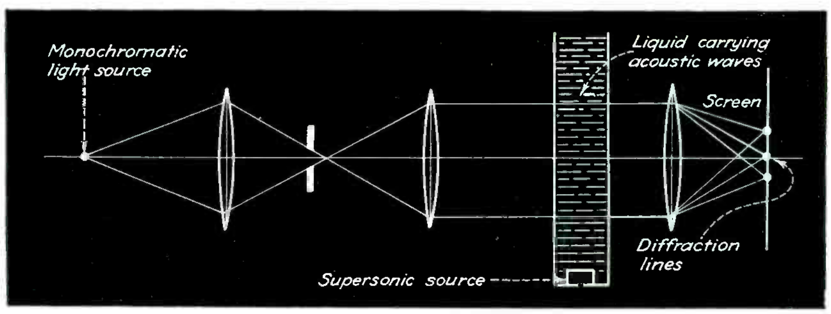


FIG. 5—Arrangement for obtaining diffraction patterns from light that has passed through a liquid carrying supersonic waves

Magnetostriction Oscillators

Another easier to construct but somewhat less commonly used electro-mechanical method of generating supersonic waves makes use of the magnetostriction properties of materials such as nickel or an iron-nickel alloy. The chief advantage of such generators lies in the simplicity and cheapness of their construction. The chief disadvantage is that when any appreciable amount of power is desired the practical upper limit on frequency is about 60 kc.

A simple magnetostriction generator is shown in Fig. 3. In order to make it operate, a magnetostriction tube or rod is chosen which is a half wavelength long for the frequency which it is desired to produce. In calculating this length from $v = f\lambda$, it must be remembered that v will be the velocity of the sound in the rod. The ordinary equation for the velocity of sound in a solid will generally suffice for this. The resonant L and C tank connected to the plate is tuned to the same frequency.

When energy is supplied, oscillation starts in the plate circuit and is built up to its full value by feedback through the grid by virtue of the magnetic coupling between the grid and plate coils furnished by the rod. To see just how this electrical frequency ties in with the acoustical frequency, we must consider the phase of this feedback and the magnetic behavior of the iron in more detail.

Referring again to Fig. 3 and specifically looking at the L and C tank in the plate circuit, the desired resonant condition is obtained if the charge on one plate of the capacitor is urged to move through the coil over onto the other plate of the capacitor and then return back over the same path, making f complete trips per second where f is the resonant frequency. Because in so doing the charge must build up and collapse electric and magnetic fields, it would take high applied voltages to make the charge oscillate in strength at a nonresonant frequency.

At the frequency f, no energy at all is needed to maintain the oscillation except to make up for that lost in heat because of copper and iron losses or that drained off the system as acoustic power. This extra energy is supplied to the circuit through the vacuum tube.

Timing is Important

The trick, therefore, is to get the grid to allow negative charge to flow through the tube onto the capacitor at the same time that the capacitor plate is receiving

(Continued on page 204)

RC Oscillator

Practical performance data on relaxation, transitron and phase shift types of RC oscillators. Suggestions are given

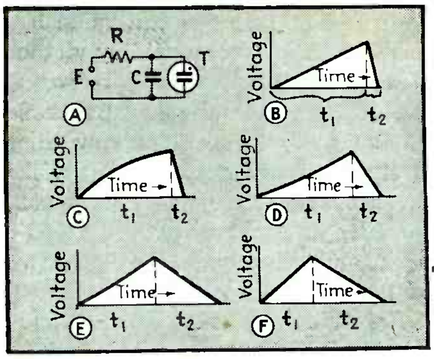


FIG. 1—Characteristics of a typical relaxation oscillator consisting of a potential source *E*, a limiting resistor *R*, a capacitance *C*, and a gaseous discharge tube *T*. The curves illustrate various charging, t_1, and discharging, t_2, conditions

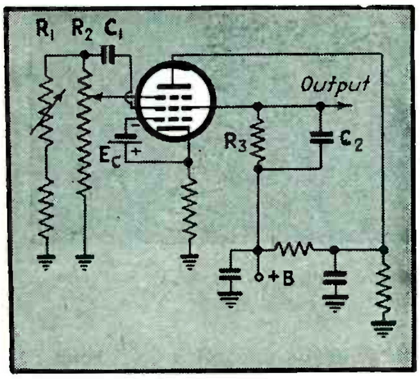


FIG. 2—Basic transitron oscillator circuit. R_1 is the frequency adjustment, R_2 the feedback adjustment, and C_1 the feedback capacitor; R_3 and C_2 are screen grid resonant circuit components. E_c is the grid bias used to produce sine waves

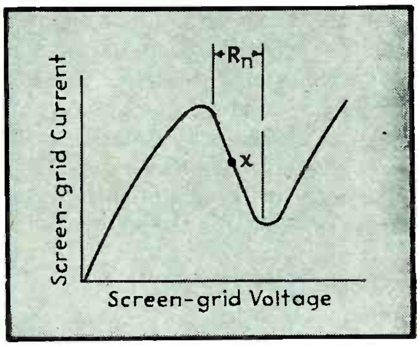


FIG. 3—Typical negative resistance curve of transitron oscillator. R_n is the negative resistance portion of the screen characteristic, where an increase in screen voltage gives a decrease in screen current

THERE are numerous practical applications of oscillator circuits employing resistance and capacitance as frequency-determining constants. The main types are:

1. Gas tube discharge
2. Van Der Pol or transitron
3. Phase shift and multivibrator.

The first employs the ion path in a gaseous conduction tube to produce a rapid discharge of voltage built up relatively slowly across an impedance. Such an action is called "relaxation oscillation" and is usually saw-tooth in wave shape.

The second can produce either relaxation, sine-wave or square-wave oscillation, and even short-duration pulses. This is the most versatile *RC* circuit since it can not only duplicate the action of the other types but is also able to do many things which cannot be accomplished by the others. When employed for saw-tooth wave production, the fundamental principle of this type is essentially the same as the first, except that the operating conditions of a vacuum tube, are altered to provide a rapid discharge path by the development of negative resistance.

The transitron, an improvement of the original Van Der Pol circuit, can be used where an audio oscillator is needed to produce waves for test purposes, sweep circuits, synchronous adaptations and energy sources for various applications. Since it can be easily synchronized, the transitron may be used as a frequency divider or waveform changer. It may also be used as a highly selective amplifier when proper neutralizing adjustments are made. Furthermore, for synchronizing purposes it can produce a waveform of poor frequency stability, which may then be converted to a sine wave. Such a system constitutes a sine-wave source which has the synchronous qualities of a saw-tooth oscillator. The system can thus be made to synchronize in both frequency and phase with periodic pulses.

The phase-shift type is chiefly used for the production of high-precision sine waves and when properly operated can be utilized as a calibrated audio oscillator for laboratory work. Its advantage over other oscillators is indicated in the fundamental formula for the two types. In the phase shift oscillator, $f_o \propto 1/RC$, whereas in most other types, $f_o \propto 1/\sqrt{RC}$. The inductance type belongs in the latter category by replacing *R* with *L*. Accordingly, the phase-shift oscillator can be tuned through a range of about 10 to 1 with an ordinary variable capacitor. Tuning ranges can be conveniently changed by switching *R* values. This type of oscillator makes use of a filter network which produces the 180 deg shift necessary to excite its grid

The well known multivibrator, which is a form of phase-shift oscillator although its qualities and many uses do not put it in the same category, employs a second tube to obtain the 180 deg phase shift, rather than an *RC* filter, and thus produces a voltage with which to drive the first tube. In essence, it is a two-stage *RC* amplifier with its output connected to its input.

Gaseous Discharge Oscillator

The simplest type of *RC* oscillator is shown in Fig. 1A. When voltage *E* is impressed upon the cir-

By J. H. NEWITT

Federal Telephone and Radio Laboratories
New York, N. Y.

Performance

for overcoming the difficulties encountered in the production of sine waves from saw-tooth waves with filters

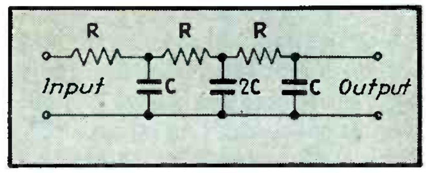


FIG. 4—Low-pass filter for converting isosceles waves of 10 to 20 kc to sine waves. R = 50,000 and C = 0.001 μf

cuit, the capacitor charges slowly due to R being in series with it. The charge curve is represented graphically in Fig. 1B by t_1. When the striking voltage of T is reached by the charging of C, T ionizes and becomes effectively a short circuit across C, thus rapidly discharging it as represented by t_2 on Fig. 1B. C then proceeds to charge again as before, T having become deionized by the previous discharge of C. Such charging and discharging takes place at a frequency dependent upon the value of R and C. In Fig. 1B, the linear part of the capacitive charge characteristic is used, making t_1 linear. The waveshapes produced by such a device are characteristically called the saw-tooth or relaxation type. If smaller values of voltage are employed, the charge may reach the nonlinear portion of the charge characteristic before T ionizes. Such a case is illustrated by Fig. 1C.

Increasing the discharge time by inserting a resistance between C and T changes the slope of the discharge curve, t_2. This is indicated in Fig. 1D, where t_2 is greater than in Fig. 1B, whereas Fig. 1E shows t_1 equal to t_2, and Fig. 1F shows $t_1 < t_2$.

Gaseous Triode Circuits

There are many variations of this circuit employing gas tubes with control electrodes such as grids to allow more flexible circuit control. The type 884 tube falls in this latter category and is used as a cathode-ray oscilloscope sweep generator. It is important to operate such control-grid oscillators with just the required amount of voltage to produce synchronism. If the sync voltage is above that needed, the frequency of the oscillator will be shifted in discreet multiple steps when the sync frequency is higher than the oscillator frequency. Such action takes place when the sync voltage is increased, because ionization occurs at a lower than normal voltage level, and thus the RC constants take less time to reach this new level and consequently increase the frequency of oscillation.

Transitron Oscillator

Other than the dynatron, the Van Der Pol oscillator was one of the first circuits employing negative resistance with RC constants to form an oscillatory circuit. At first, pentodes were not available and the circuit had certain difficulties which Van Der Pol predicted would be overcome with the advent of the pentode. And when it finally came, the original circuit transformed into the transitron circuit became highly practical and proved useful in many new ways.

The transitron works on the simple principle of producing negative resistance between two grid circuits containing the frequency-determining constants. Negative resistance is produced between the plate and screen grid of a tetrode by dynatron action when secondary emission takes place. Since dynatron secondary emission is not always reliable due to variable factors in tube manufacture, the oscillator resulting cannot always be relied upon for consistent results.

The transitron obtains its negative resistance characteristic in a different manner and so has the advantages of the dynatron without the attendant disadvantages. Stability of the circuit is excellent because only the RC values determine frequency, the electrode voltages consequently having practically no effect whatever. Such a circuit is comparable to the crystal oscillator in stability since E_b variations of 25 percent only change the frequency a few parts in a million.

The oscillator can be used

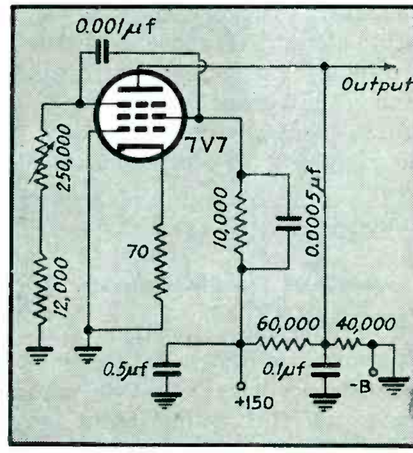


FIG. 5—Practical transitron oscillator circuit for production of sawtooth waves between 7 and 26 kc

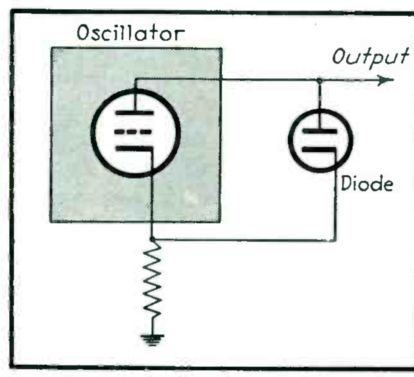


FIG. 6—Automatic amplitude control of this transitron oscillator is used to compensate for a falling off in output voltage

throughout the audio range and considerably above, using RC circuits alone. The upper practical limit with RC constants is approximately 0.5 Mc. Transitron circuits employing inductance can be operated with reliability to 20 Mc and even to 60 Mc if careful design is observed. Operation above 20 Mc is somewhat difficult as regards efficiency and reliability. The transitron can be made to oscillate at three distinct frequencies at the same time by having LC circuits of different constants in its grid and cathode circuits. Thus, the tube can operate at radio frequencies and be its own a-f modulator. The transitron circuit presents great potentialities for use with battery-operated equipment in which constancy of calibration as the battery ages is important.

Action of Transitron Circuit

In the basic transitron circuit shown in Figure 2, the suppressor grid goes negative with respect to the cathode due to applied voltages. Electrons are attracted by the positive screen and repelled by the negative suppressor. A negative voltage change on the screen grid is transmitted from this grid to the suppressor through C_1, causing the suppressor to repel more electrons and resulting in a net increase in screen current. Such an increase with a negative increment in voltage is effectively negative resistance between the screen and suppressor grids.

A typical negative resistance curve is given in Fig. 3. An a-c fluctuation in screen voltage operates above and below point x. By this method an alternating current is produced which is 180 deg out of phase with its initiating voltage.

Any circuit whose output can supply all input losses by the creation of negative resistance can sustain continuous oscillations. By applying bias to the control grid, the total space current of the tube and the slope of the negative resistance curve can be controlled. In this interval an increase in screen voltage will give a decrease in screen current, and conversely. Sine-wave output of the oscillator is obtainable when the operation is confined to the linear portions of the R_n curve. Consequently, grid bias is used to produce sine waves and omitted to produce highly distorted waves.

Transitron Waveforms

The saw-tooth waveform may be varied from a strictly isosceles shape to other saw-tooth shapes, depending upon adjustments of the inverse feedback or cathode resistance. Sine waves may be produced in the transitron oscillator by supplying fixed bias to the suppressor and control grids while properly adjusting the feedback.

Sine waves may be produced by operating the transitron to give an isosceles-shaped wave in the plate circuit and then to pass such a wave through a low-pass RC filter of the type shown in Fig. 4. Such a combination may then be synchronized by the impression of a sync signal in the control-grid circuit of the transitron. This produces synchronism not only in frequency but in phase as well, when periodically occurring pulses are used as a sync voltage.

Square waves may be produced by proper feedback adjustment of the suppressor grid potentiometer as shown in Fig. 2. The square wave output is taken from the screen circuit. Feedback adjustment controls the waveform together with the spacing between adjacent crests of the wave.

The transitron may be used as a source of pulses by adjusting R_2 so that a square wave derivative is formed which produces a sharp peak over a small portion of the electrical cycle. When such a pulse is derived from a balanced square wave, negative pulses may be eliminated by rectification, while the pulses may be sharpened by passing them through voltage delay circuits. Both operations can be accomplished with one biased diode.

Waveform or Frequency Control

Figure 5 shows a simplified form of the transitron oscillator which operates in the range of 7 to 26 kc and delivers a saw-tooth waveform output. This waveform may be kept isosceles in shape over the range by making the cathode resistor variable. With the transitron, any feedback adjustment or other waveform control will cause a frequency shift and the frequency control will, through its range, cause a waveform change. Thus, a reference to waveform or frequency control refers only to the major effect of the control upon the circuit. Thus, in Fig. 2, R_2 is mainly a feedback control, whereas R_1 is mainly a frequency control.

An alternative method for feedback control consists of making the screen resistance a voltage divider, the center arm of which is connected through a capacitor to the control grid. This system is useful in direct sine-wave production when using proper bias on control and suppressor grids.

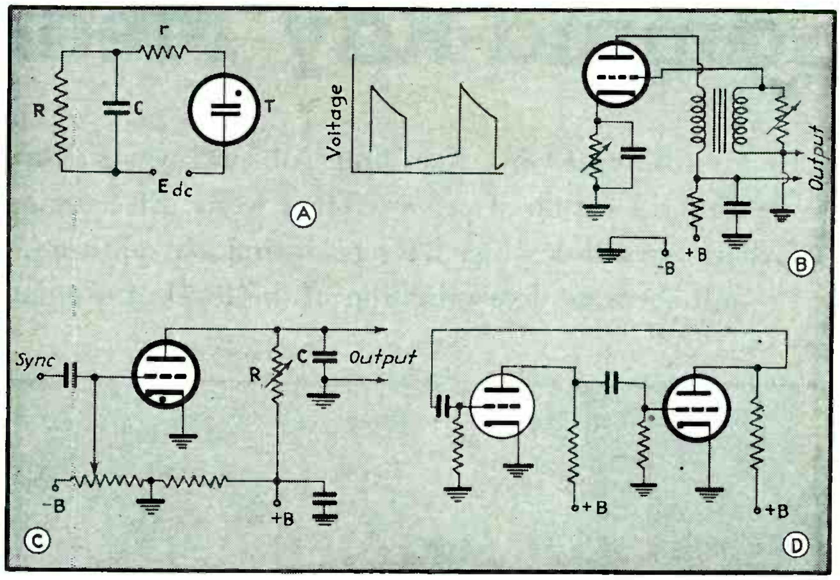
The transitron circuit may be made to perform over a great frequency range, its upper practical limit being 0.5 Mc and its lower practical limit being in the vicinity of a few cycles per second. In a given circuit design for operation over a wide frequency range, circuit control becomes complex when constancy in output voltage and waveform is desired. If these latter factors are unimportant, wide-range operation may be obtained with a single circuit control. It is possible, however, to retain constant waveform and output voltage with a single circuit control if it is designed to operate near a specific frequency or within a limited range.

Production of Saw-Tooth Waves

In Fig. 5, the waveform in the screen circuit is square wave or its derivative type. The waveform in the plate circuit is saw-tooth due to the large capacitance. To produce an isosceles-shaped saw-tooth wave, the capacitance must be large enough to employ only the linear portion of its charge characteristic.

Values of capacitance above those needed to correct the nonlinear slope of the saw-tooth waveshape merely reduce the voltage output of the oscillator. Naturally, such a capacitive filter has a frequency characteristic; when designing an oscillator for a wide frequency range, attenuation of the output voltage must be suffered at the high end to preserve the linearity at the low end. The linearity of the saw-

TABLE I. MISCELLANEOUS RC OSCILLATORS



A—Direct voltage produces ionization in *T*, charging *C* through *r*. Voltage across *C* builds up, with an accompanying decrease across *T*, until ionization can no longer be sustained and *C* is discharged through *R*, after which the circuit conditions are returned to their initial state, and the sequence repeats

B—Circuit using hot-cathode gaseous discharge tube with grid to permit synchronism. Frequency-determining constants *R* and *C* may be placed in cathode circuit instead of plate circuit

C—This blocking oscillator employs a feedback device to produce 180-deg phase reversal (negative resistance) in the grid circuit

D—This multivibrator is used as a frequency divider, square or sawtooth wave generator. The second tube provides the necessary 180-deg phase reversal to drive the first tube, the output of which drives the second

tooth wave should be established at the low end of the desired range by inserting the minimum amount of capacitance necessary to produce linearity at that point and unless this value is gradually decreased with the frequency increase, attenuation in oscillation output voltage must be suffered. Also, the type of saw-tooth waveform changes with frequency and must be compensated over a frequency range by a feedback adjustment.

To obtain constancy of waveform and voltage output over a wide frequency range, a complex circuit control is necessary. When operating the oscillator over a limited frequency range, waveform and attenuation do not vary appreciably and thus do not require compensation.

Falling off in output voltage can be compensated by the use of an automatic amplitude control as shown in Fig. 6. Best results are obtained by using voltage delay in the diode circuit so that oscillations must reach a certain level before amplitude control takes place. This may be accomplished by inserting a bias cell in series with the rectifier tube or by tapping the cathode return above ground on the power supply bleeder.

The transitron can be used as a selective audio amplifier by varying the negative feedback through zero and to a slightly positive value, producing neutralization. Such action is accomplished by adjusting the feedback control to the point just below that for oscillation and then using the control grid as a signal input while taking the output from the screen grid. The only trouble with such a circuit is that a change in g_m causes a change in selectivity, and the circuit hence does not possess equal qualities of inverse feedback circuits used for the same purpose. The effect is not too great at most audio frequencies, but increases as the upper part of the range is approached and is of considerable magnitude at frequencies above the audio range.

Phase Shift Oscillator

Properly adjusted phase shift oscillators generate high-precision sine waves accurate to 0.1 percent. The phase-shifting network usually introduces so much attenuation that considerable amplification in the tube must exist to sustain oscillation. Proper filter design together with the use of high-μ tubes will, however, produce favorable results from this type of oscillator. The use of fixed grid bias will facilitate the production of oscillation in some difficult cases. It may also be found necessary to include small by-pass capacitors to prevent high-frequency parasitics.

The variation of frequency in this oscillator does not make for simplicity in construction since at least one constant of each section of the filter must be varied. An attempt to control the frequency over any appreciable frequency range by variation of only one component in the circuit would cause such attenuation in the filter circuit as to stop oscillations.

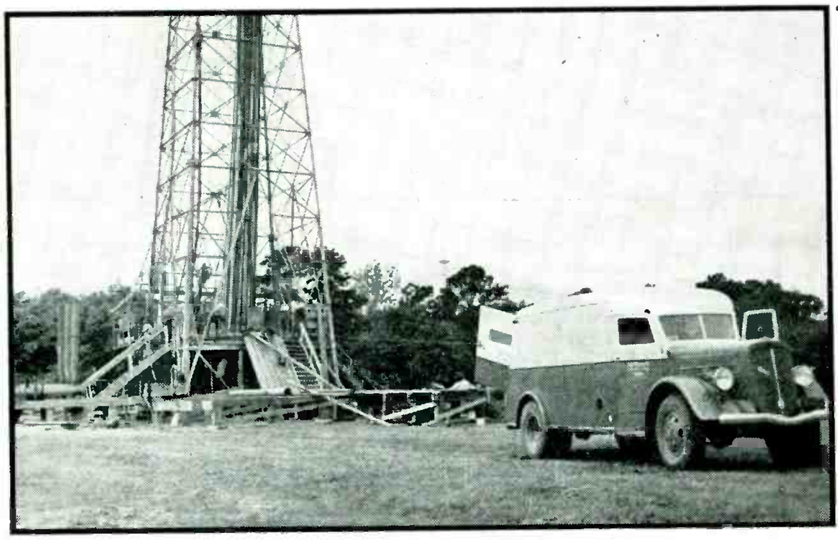
The phase shift oscillator is frequently very sluggish in starting and should always be allowed to stabilize after being set into operation. Since many tubes will not operate in this circuit, the 6SL7 is recommended. In addition to the excellence of waveform produced by this oscillator, inherent difficulties which arise in the conventional heterodyne audio type, such as poor beat-frequency stability due to high frequency drift, poor frequency synchronism and poor constancy of calibration are overcome. The phase shift oscillator will operate from a fraction of a cycle per second throughout the audio range.

Best sine wave production is obtained where oscillations are barely sustained. Automatic amplitude control can be used. Many laboratory audio oscillators employ such an arrangement to control operation over extended frequency ranges. Usually a three- or four-gang variable capacitor is used to tune each section of the filter simultaneously while ranges are changed

(Continued on page 252)

Gamma-Ray Measurements

Information obtained by examining sub-surface structures through which existing wells pass facilitates location of proposed new wells. Electronic method of exploration functions even where metallic casings have been sunk. In addition, radioactivity measurements permit accurate determination of the level of cement as casings are being set



Truck set up for making an oil well log (Halliburton Oil Well Cementing Co.)

DURING the last two decades, methods of exploring for oil have undergone widespread advances due to the introduction of geophysical techniques, some of which employ electronic equipment.

It was early discovered that oil pools occur in and around several different types of subsurface structures such as, for example, domes and faults. Search for these structures, as a consequence of the knowledge that they were likely to indicate presence of oil, stimulated a great deal of activity in surface measurements as aids in locating such geologic formations. Surface measurements are fairly well known today. This article, therefore, will not deal with them but only with measurements down in wells which have been drilled or are being drilled.

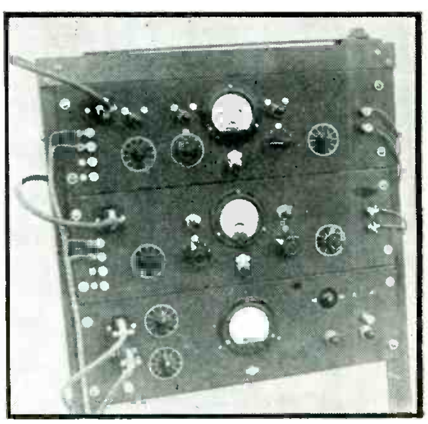
Once drilling operations have begun in an oil field it is apparent that as much subsurface information as possible should be gotten from each well in order to map the subsurface structure. Such a map is quite useful in locating succeeding wells and in predicting the level at which oil may be found beneath the surface.

Electrical Logs

At first, cuttings and cores taken from the bottom of the hole were examined and "logs" showing the types of rock encountered were plotted from this information. Then paleontologists were engaged to examine the fossil content of the rock so that the strata could be identified more exactly as to geological age and category. As rotary drilling became more prevalent, however, the cutting information was not too reliable since the cuttings were taken from a constant mud stream in which they were diffused as they came up from great depths. Also, even where cores give reliable information, coring is a relatively expensive operation.

The next stage was the introduction of geophysical methods into well-logging technique, and within the last decade "electrical logging"[1] has been widely adopted. In general, the electric log shows two graphical traces as a function of depth, one a measure of the electrical resistivity of the formations, and the other a measure of the difference of potential between a point on the surface and a moving electrode in the well. These logs are made continuously as an electrode (or electrodes) suspended on a conducting cable is moved in the well. Special trucks are equipped with power-driven cable drums and recording apparatus for making the logs.

Interpretation of electrical logs indicates that, with some exceptions, sands have a relatively high resistivity as compared to shales and also give rise to a relatively high potential peak. Fortunately, the pattern of these changes is

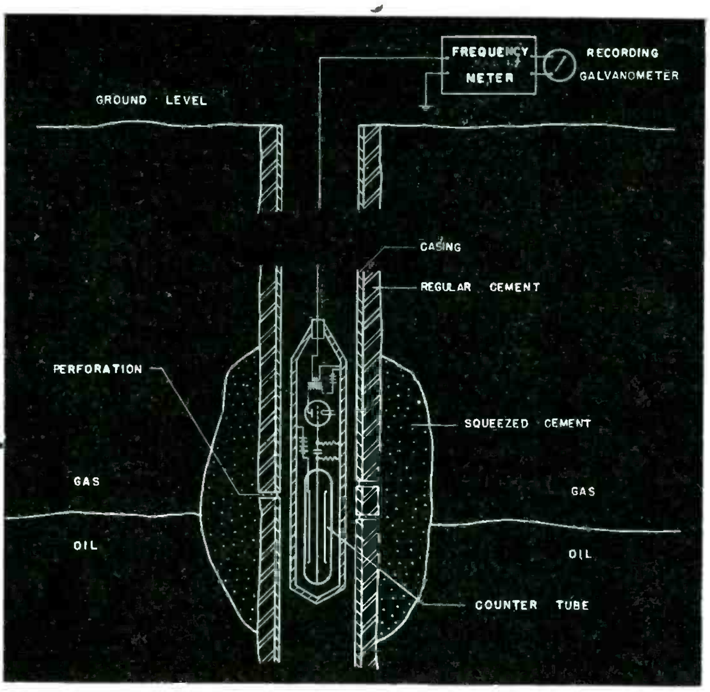


Electronic surface equipment used in conjunction with gamma-ray detector employing two counter tubes

*On leave at Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Md.

in Oil Wells

By LYNN G. HOWELL*
*Humble Oil and Refining Company
Houston, Texas*



Gamma-ray counter used to detect squeezed cement

usually fairly characteristic from one well to another, so that a remarkable correlation of strata information can be obtained from well to well. In many fields, once the producing section has been logged and cored in key points other wells can be safely drilled in intervening locations with the help only of electrical logs. Thus, a large saving in time and money in coring is effected. In "wildcat" or new-field wells, the electrical log sometimes shows up sands which are "good bets" as oil sands and which would otherwise be passed up in ordinary drilling operations.

Electrical logs can be made only in open sections of wells, sections containing no conducting (metallic) pipe. Many old fields exist in which the formation data is meager, and in which electrical logs cannot be made due to the presence of steel casing. Some of these fields are known to have oil sands in the upper formations, sands which were not found when the wells were first drilled and cased. If these sands could be logged *through* the pipe, production could be effected by perforating the casing with a special gun.

Use of Gamma-Rays

Since gamma-rays from radioactive elements can be detected through steel pipe, work was begun on making radioactive measurements of the formations in oil wells to see if useful data could be obtained. Radioactive elements include the uranium series to which radium belongs, the thorium series, and potassium.

The first measurements[2,3] were made with an ionization chamber filled with nitrogen at a pressure of about 500 pounds per square inch. The chamber was made of 4½-inch drill-pipe and was capable of withstanding the pressures of several thousand pounds per square inch encountered in wells. Housed in a compartment adjacent to the ionization chamber was a detecting circuit and batteries. The ionization current was fed to the grid of an electrometer tube which was grounded periodically at 3-second intervals by a clockwork mechanism. The grid voltage at the time of grounding was proportional to the ionization current, so that pulses proportional to the ionization current and, therefore, proportional to radioactivity, were produced. These pulses were fed to the surface through the supporting multi-cable conductor from a line transformer in the plate circuit of the electrometer tube. The pulses were amplified at the surface and read on a galvanometer. Measurements were made at various points in the well, a number of galvanometer deflections being read at each point. The producing sections of wells explored gave a promising correlation between the radioactivity curves and electrical logs made in the same wells.

Although the curves showed the possibility of using radioactive data in logging wells, the technique was not immediately applicable to making routine measurements. It is always desirable to make *continuous* logs, with as much speed as possible.

Geiger-Müller Counter Method

We began work with Geiger-Müller counter-tubes as detectors. Pulses from individual secondary particles produced by gamma-rays are "counted" in the G-M tube, as contrasted with measurement of the integrated ionization current in the ionization chamber. Thus, one starts with pulses which can readily be amplified and detected.

The G-M tube operates at a higher voltage than is required for the ionization chamber and in some of our early measurements we included batteries in the logging chamber. We also started using two counter tubes with separate circuits to get more data in a given time interval. The two tubes were placed within a common protective chamber, the top one being hereafter called the "Upper Counter" and the bottom one being called the "Lower Counter." No amplifier tubes were used down in the well in this setup. Each counter tube was coupled to the high impedance side of a line transformer, which was connected through a cable to an input transformer at the surface. This transformer fed into an amplifier. The

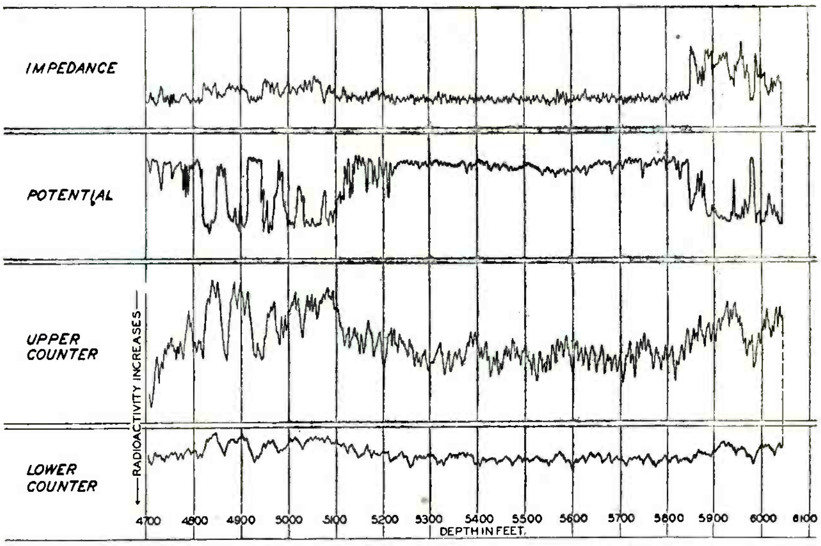


FIG. 1—Comparison of gamma-ray (two lower curves) and electrical logs made in an uncased well

primary of the line transformer was a poor match for the exceedingly high impedance of the counter tube circuit; however, the pulses could be sufficiently amplified at the surface to compensate for losses. The final measurement was made with a thyratron-controlled frequency meter.

In these measurements one of the biggest problems results from the random nature of the radioactive processes. The measured "frequency" is a fluctuating quantity, which must be averaged out over as long a time interval as is convenient. Thus a fairly large *RC* product must be used in the tank circuit of the frequency meter. On the other hand, a large value of *RC* gives a slow response to sudden changes. A compromise therefore, must be made between the desired smooth, average curve and the ability to detect sudden changes in radioactivity. The larger the *RC* used, the slower must the device be moved to pick up the changes in radioactivity. However, since the section to be logged in a well is often very long, the speed of logging must not be too low.

We found that with an *RC* time constant of about 12 the logging could be carried out at a speed of the order of 25 feet per minute. The frequency of pulses from a counter tube was of the order of 5 per second. The copper anode of the counter tube was 18 inches long and 2$\frac{1}{8}$ inches in diameter and was sealed in glass. In the two-tube setup tubes were mounted within a piece of drill-pipe three and a half inches in outside diameter.

Electrical-Electronic Log Comparisons

Figure 1 shows a comparison of gamma-ray logs and electrical logs. The Upper Counter curve was recorded with a more sensitive galvanometer than the Lower Counter curve. Although some of

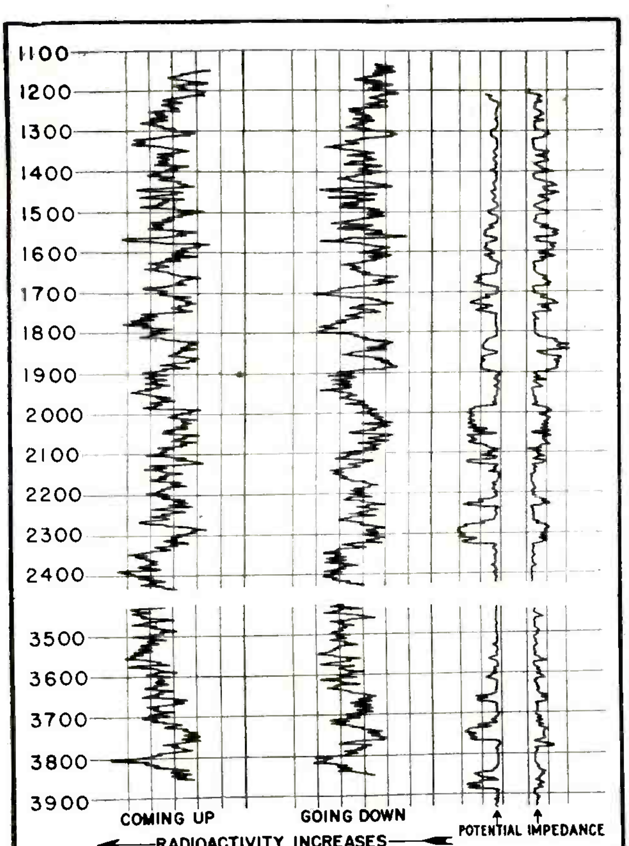


FIG. 2—Comparison of electrical logs in an uncased well with gamma-ray logs made in same well after casing

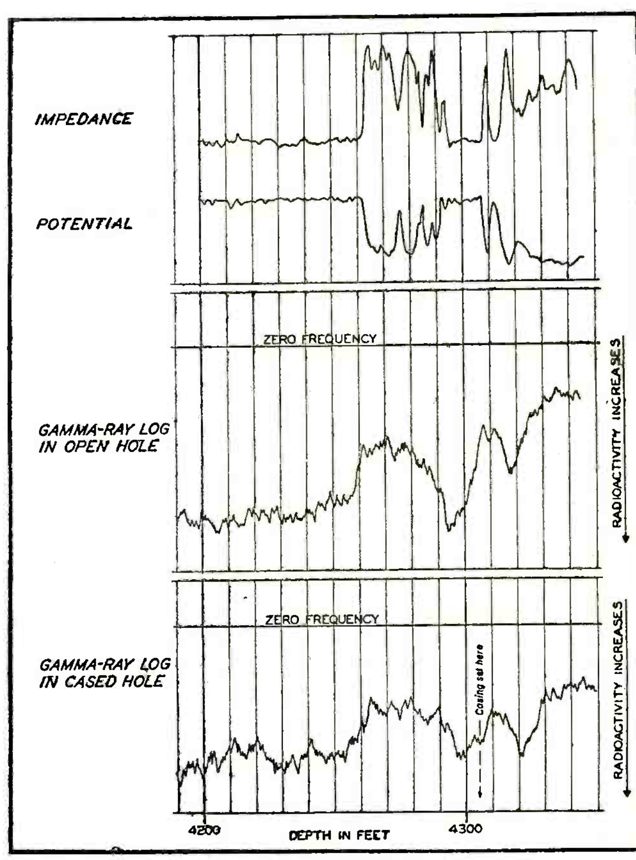


FIG. 3—Detailed logs made in a producing section of a well, electrically, and electronically in open and cased holes

the variations are merely statistical it will be noticed that upper water sands, which show up well on the electrical potential curve between 4800 and 5100 feet in depth, also appear with good correlation on the gamma-ray curves as radioactive lows. The shale section intervening between water sands and oil-gas sands starting at a depth of 5800 feet is seen to be high in radioactivity.

As the signal-to-noise ratio was not sufficiently high with the two-tube circuit, especially in wells cased with pipe, one counter tube was removed and a stage of amplification was added in the detecting chamber. Figure 2 shows a comparison between repeat runs of such a counter in a cased well and of the electrical log made before the well was cased. The correlation between large changes is quite obvious in the various logs. The presence of statistical variations in the gamma-ray curves is evident also.

Figure 3 shows the electrical logs made in the producing section of a well, the gama-ray log made before the well was cased and the gamma-ray log made after the well was cased. The gama-ray logs were made at a low logging speed, with a large RC time constant in the tank circuit of the frequency meter.

It so happens that when the well was cased the casing was provided from the surface down to 4305 feet and then ceased. This provides additional data. It will be noticed that beginning at this point in depth there is a tendency toward lower radioactivities of the gamma-ray curve made inside the casing, due to the absorption effects of the casing. Also it will be noticed that there is a discrepancy of about two feet in depth measurements on the two gamma-ray curves. It is quite important to be able to define the sands accurately in this manner. Although substantial errors may be made in measurements from the surface, quite accurate measurements can be made from the bottom of the hole, for example. Errors in the driller's measurements can thus be detected.

In more recent work the principal changes made in the equipment have been those of adapting the technique to commercial logging equipment. For example, cable having a single conductor, insulated in a steel sheath, (used extensively in making electrical logs) is employed instead of the multi-conductor cable used in our experimental truck. Various circuits have been tried in which power is fed down the cable from the surface to the vacuum-tube in the chamber at the same time as pulses are transmitted up to the surface.

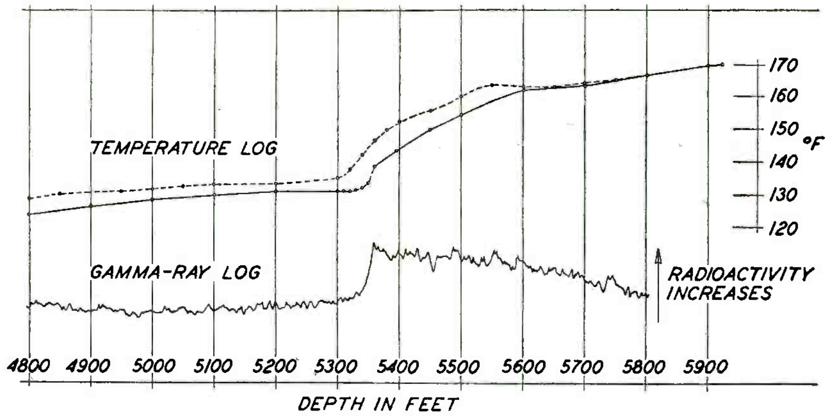


FIG. 4—Comparison of temperature log and gamma-ray curve in a well containing activated cement

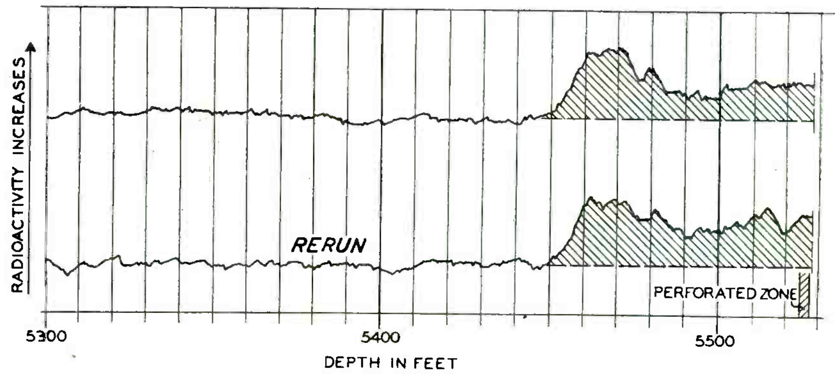


FIG. 5—Gamma-ray curves obtained when using radioactive "squeezed cement." The extent the cement traveled is clearly shown

Radioactive Cement Measurements

An interesting application of the gamma-ray logging technique has been the tracing in oil wells of cement which has been made radioactive by addition of carnotite ore.

In present-day drilling practice all casing is set in cement in the well. The cement is pumped down the pipe and up between the wall of the hole and the pipe. Cement is easily detected by running a temperature curve in the well while the process of setting the cement is still proceeding, due to the heat developed. Figure 4 shows a comparison of temperature and gamma-ray measurements made in a well in which the top of the cement is shown to be between 5300 and 5400 feet in depth. Only the first batch of cement was treated with carnotite and it will be noticed that the radioactivity falls off below the sharp break at the top of the cement as the carnotite becomes more dilute at the greater depths.

The temperature measurement method is satisfactory for such work but there is another cementing process in which the temperature method is not often readily applicable. This is the so-called "squeeze job", in which the cement is forced out under great pressure through holes made in the casing made by bullets fired from a gun. Very often new cement is squeezed out behind old cement, so that the heating effects are not easily detected. Furthermore, when the cement on the inside of the pipe is drilled out, circulating mud

(*Continued on page* 286)

Impedance-Combining

Timed tests indicate that impedance combined in series or parallel may be computed several times faster with the accompanying chart than with a vector slide rule

COMPUTATION of a-c circuits involving complex parallel impedances has always been a laborious process. The usual methods are slow and involve so many steps that errors and mistakes are altogether too common. Lacking the necessary time for computing and checking, a designer may resort to cut-and-try methods or add unnecessary circuit elements to insure the desired characteristics without the necessity of making the calculations.

The graphical method presented here is fast and accurate under all conditions, and is applicable to series as well as parallel combinations of impedances. In several timed tests it was found to be about two and one-half times as fast as a vector slide rule on parallel combinations, and faster by a narrower margin on series combinations. A common slide rule was found to be slightly slower than the vector type. The new method is of value in solving many other problems, electrical and otherwise, involving vectors or triangles.

All that is required for the method is the chart in Fig. 1, a slide rule, and pencil and paper to tabulate results. The chart is designed so that its accuracy is better than practical considerations normally require, regardless of the impedance values. This has been acchieved by a fortunate choice of parameters and coordinates that prevent crowded values in some parts of the chart and unnecessarily expanded values in others. Impedance values are kept in polar form. This avoids the need of repeatedly converting impedance from one form to another, and also allows multiplication and division to be performed readily in solving complex-number equations of some of the more involved types of circuits (such as bridges) not solvable simply by combining impedances successively in series or in parallel.

Dual Application

The combining of series and parallel data on one chart is based on the selection of a parameter N which applies to both cases as shown below:

$$Z_s = Z + z \qquad (1)$$

$$Z_p = \frac{Z\,z}{Z+z} = \frac{Zz}{Z_s} \qquad (2)$$

in which z is the smaller given impedance
Z is the larger given impedance
Z_s is the series combination of Z and z
Z_p is the parallel combination of Z and z

Let us now define a complex number N equal to Z_s/Z, *making*

$$Z_s = ZN \qquad (3)$$

It then follows that

$$Z_p = Zz/ZN = z/N \qquad (4)$$

Thus we have a number N which relates the series or parallel impedance combination very simply to the larger or smaller given impedance. It is for determining this value N that we use the chart. The entire principle of the graphic solution is based upon this operation.

Substituting Eq. (3) in Eq. (1) gives

$$N = \frac{z}{Z} + 1 \qquad (5)$$

Since N is a complex number, we may express it in polar form and call its angle β. If the given impedance vectors are also expressed in polar form, the determination of their series or parallel combination is a matter of multiplying or dividing one of the given impedances by N and adding or subtracting β from its angle. N and its angle β depend on z/Z, as Eq. (5) shows. The ratio z/Z of the given impedances is another complex quantity, having an angle α which is simply the angular difference between the given impedance vectors. N and β are determined simultaneously from the chart by applying the values of z/Z and α, which will be found along the axes of ordinates and abscissas.

Method of Using Chart

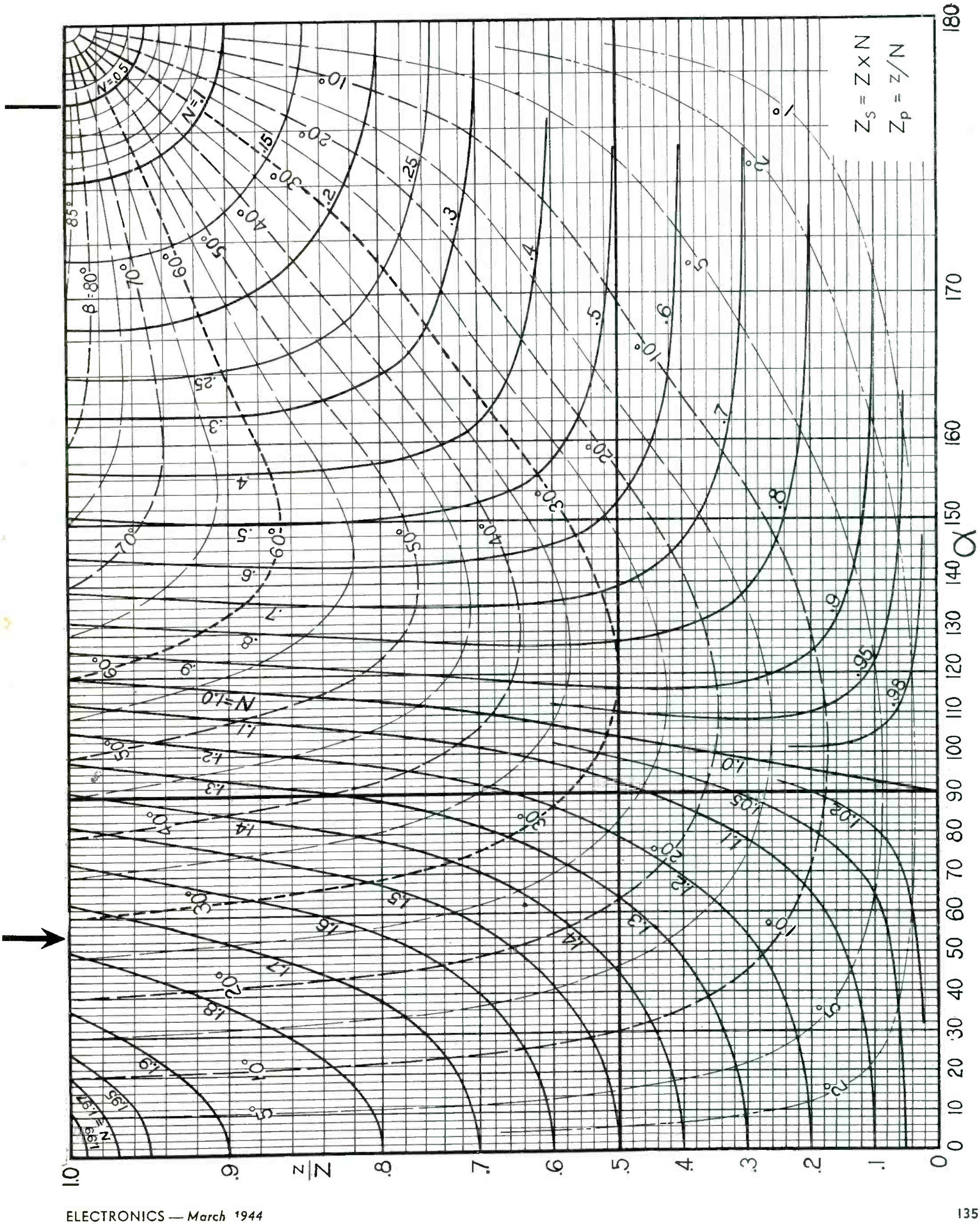
In using the chart, it follows from Eq. (3) and (4) that the N and β values are referred to a reference impedance Z in *series* combinations, and to a reference impedance z in *parallel* combinations. The angle β taken from the chart may add to the reference imped-

FIG. 1—Impedance-combining chart for solving complex networks. Procedure for use: 1. Divide the smaller impedance value z by the larger impedance value Z to get z/Z; 2. Find the difference angle α between the given impedance vectors z and Z; 3. Apply these values of z/Z and α to the above chart to get the values of N and β; 4. If combining impedance in series, multiply N by Z to get Z_s, and add or subtract β from the angle of Z (so the resultant lies between the given vectors) to get the angle of the resultant impedance; 5. If combining impedances in parallel, divide z by N to get Z_p, and add or subtract β from the angle of z (so the resultant lies between the given vectors) to get the angle of the resultant impedance

Chart....

By GARY MUFFLY

Gulf Research & Development Co., Pittsburgh, Penna.



ance (either Z or z) in some cases and subtract from it in others, in determining the angle of the resultant. Since the sign of this angle depends on several other signs, it is best to ignore the signs of all angles and insert the proper sign for β at the last moment. This is easily done by inspection, simply remembering that the resultant must lie between the given vectors, and taking β in the proper direction from the reference impedance to satisfy this rule.

It will be seen that the abscissa and ordinate scales of the chart are expanded arbitrarily to enlarge the upper-right corner, and make the curves become nearly polar in form at the corner. This part of the chart corresponds to resonant conditions. When N drops to 0.05 or thereabout, and the corresponding circuit Q becomes about 20, the circuit may be computed to better advantage by standard methods of approximation, which become very accurate in this region, while the accuracy of the chart falls off.

The N values on the chart are plotted with solid lines and the β lines are broken. The lines are also weighted so that an experienced computer learns to find the desired coordinates with a minimum amount of eye work.

Vector Relations

Before proceeding with the examples below, it may be of interest to consider a method of combining impedances by geometric construction. This will help in visualizing the steps taken in the chart method. Figure 2 illustrates the relationship between the series and parallel combinations of two given impedances. It also includes lines for solution by geometric construction. This type of method is of little or no practical value for quantitative results, but is often helpful in analyzing the effect of combining impedances.

In Fig. 2, Z_s is obtained by the well-known method of completing a parallelogram. From Eq. (2), $Z_p/z = Z/Z_s$. By laying off the length of z on Z_s, drawing BC parallel with the original z, and completing the construction shown (remembering that β is a common angle between Z_p and z as well as between Z and Z_s), the validity of this construction in satisfying Eq. (2) is evident from the similar triangles thus formed. That the angles β are equal follows from Eq. (2) as given immediately above. Since this is a complex-number equation, the angular relationships of Z_p to z and of Z to Z_s must be equal.

Examples

The examples below should help in learning to use the chart and in tabulating the resulting circuit data efficiently.

Example I: What are the series and parallel impedance combinations of a resistance of 30 ohms and a capacitive reactance of 40 ohms?

The given impedances may be written: $z = 30 \angle 0°$, $Z = 40 \angle -90°$. By division and subtraction, $z/Z = 0.75$, and $\alpha = 90°$. From the corresponding point on the chart, $N = 1.25$, and $\beta = 37°$. The resultants are determined as follows: $Z_s = N Z = 1.25 \times 40 \angle -90° + 37° = 50 \angle -53°$; $Z_p = z/N = 30/1.25 \angle 0° - 37° = 24 \angle -37°$.

The solution would ordinarily be abbreviated as follows, using numbers or letters in parentheses in the text (corresponding numbers on diagrams are encircled) to identify the four impedances:

Solution:	Explanation:
(1) $30 \angle 0$	This is z
(2) $40 \angle -90$	This is Z
0.75, 90	$\begin{cases} z/Z = 30/40 = 0.75; \\ \alpha = 0 - (-90) = 90 \end{cases}$
1.25, 37	Get N and β from Chart
(s) $50 \angle -53$	$Z_s = NZ$
(p) $24 \angle -37$	$Z_p = z/N$

It should be recalled here that the angle β (37 degrees here) is sometimes added to, and sometimes subtracted from the reference impedance to get a resultant lying between the given angles. Thus, 37° from −90° toward 0° gives −53° for the series combination above, and the same 37° taken from 0° toward −90° gives −37° for the parallel combination.

Example II: Determine E_2/E_1 for the circuit of Fig. 3 at frequencies of 250, 800, 1,000 and 2,000 cps.

The first step is to number all the impedances and their combined values, preferably in the order in which they will appear in the solution. Thus, impedance (1) of Fig. 3 combines with (2) in parallel to get (3), which in turn combines in series with (4) to get (5), the input impedance. Next, the given impedances for the proposed frequencies of solution are computed and entered in the incomplete table shown directly under the circuit diagram. The values may be kept in thousands of ohms or megohms, to avoid carrying unnecessary digits through the tabulation. The p and s at the left are to remind us whether parallel or series combination is to be made. Blank spaces are left for the chart parameters and the unknown impedances. These are filled in by the method of Example I in a systematic manner, preferably carrying the slide rule or chart work as far as possible at one time to avoid switching back and forth more than necessary.

The tabulation as completely filled in at the bottom of Fig. 3 provides for easy checking and

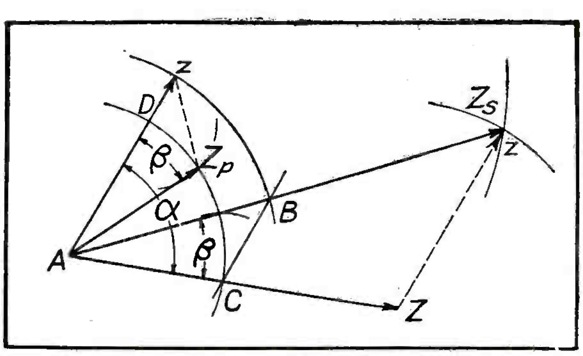
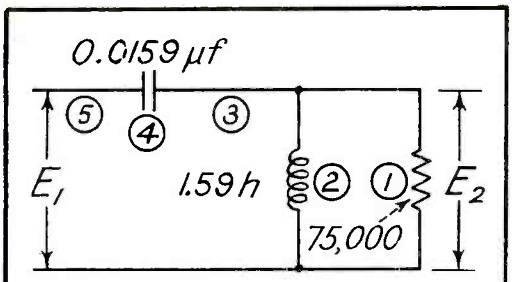


FIG. 2 — Geometric method of combining two impedances in series or parallel



FREQ.	250	800	1000	2000
①	75∠0	75∠0	75∠0	75∠0
②	2.5∠90	8∠90	10∠90	20∠90
p Z/Z,α N,β				
③				
④	40∠-90	12.5∠-90	10∠-90	5∠-90
s Z/Z,α N,β				
⑤				

FREQ.	250	800	1000	2000
①	75∠0	75∠0	75∠0	75∠0
②	2.5∠90	8∠90	10∠90	20∠90
p Z/Z,α	.033,90	.107,90	.133,90	.267,90
N,β	1.00, 2	1.006, 6	1.01, 7.5	1.04,15
③	2.5∠88	7.95∠84	9.9∠82.5	19.2∠75
④	40∠-90	12.5∠-90	10∠-90	5∠-90
s Z/Z,α	.062,178	.635,174	.99,172.5	.26,165
N,β	.938, .2	.375,10	.13, 82	.75, 5
⑤	37.5∠89.8	4.69∠-80	1.3∠-8	14.4∠70
$\frac{E_2}{E_1}=\frac{③}{⑤}$	.0666	1.7	7.61	1.33
$\angle_3-\angle_5$	177.8°	164°	90.5°	5°

FIG. 3—Circuit for Example II in text, and tabulated solution for four different frequencies. Impedances are numbered in the order of their appearance in the solution

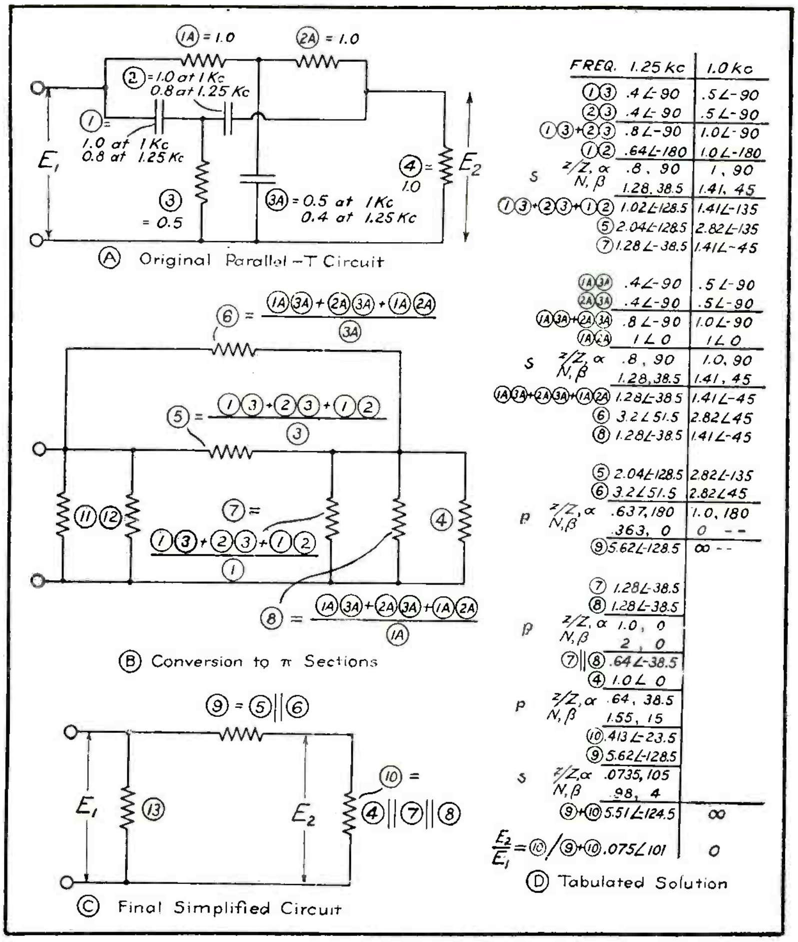


FIG. 4—Original circuit and steps in simplifying it for Example III in text, with complete tabulated solution for two different frequencies. An orderly compilation of data minimizes changes of mistakes and permits checking any part of the work quickly. Impedances are numbered for the same reason

contains complete data that can be used to compute any of the relative phases or amplitudes within the circuit. This form of tabulation is not an essential part of the method, but it is a systematic trouble saver that keeps things running smoothly.

Example III: Solve the parallel-T circuit of Fig. 4A for values of E_2/E_1 at 1,000 cycles and at 1,250 cycles.

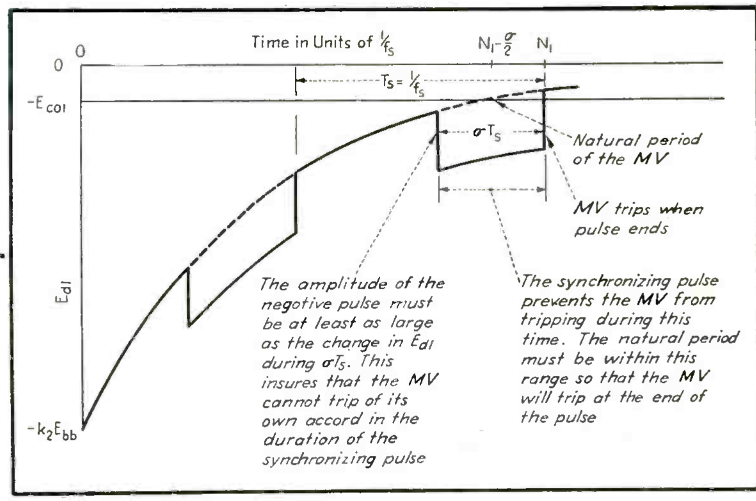
In the first step, the two T-sections in Fig. 4A are transformed to π sections as in Fig. 4B, using the standard equations for this purpose as shown, but doing the vector addition by means of the chart. In the second step the resulting equivalent impedances are combined in parallel as in Fig. 4C. Impedances (11), (12) and (13) in Fig. 4B and 4C do not enter into the solution, and so are not evaluated.

In the tabulated solution in Fig. 4D, some of the equivalent impedances have the unusual angles of more than plus or minus 90 degrees. This means that they must contain negative resistance to substitute successfully for the actual circuit elements. This does not affect the method of solution, however.

When two impedances are equal in absolute value but 180 degrees apart they combine to form a perfect steady-state resonant circuit whether they are pure reactances, pure positive and negative resistances, or combined quantities. This is nicely illustrated in the solution of Fig. 4 for 1,000 cycles. Impedances (5) and (6) combine in perfect parallel resonance to give an infinite impedance, (9). The succeeding impedances were left uncomputed for 1,000 cycles since the attenuation is obviously infinite at this frequency.

This effect of resonance has no physical reality since the equivalent impedances are merely values on paper. What is happening is that the circuit is bridge-like in nature and is operating at the balance frequency, where transmission through one of the T-sections is equal and opposite to the transmission through the other T-section. This circuit is described by H. H. Scott in "A New Type of Selective Circuit and Some Applications", *Proceedings of I. R. E.*, p. 226-235, Feb., 1938.

Fig. 3.1—The MV can be synchronized by a negative pulse in the grid circuit of the tubes



The MULTIVIBRATOR Applied Theory

Synchronization of only one tube, variations in amplitude of the synchronizing pulse, and effects of ripple and feedback voltages in the power supply are considered in this concluding article

In part one of this paper, which appeared in the January 1944 issue of ELECTRONICS, it was shown that if

$$C_{h1}\left(R_{L2} + \frac{R_{d1}\,R_{g1}}{R_{d1} + R_{g1}}\right) \lessapprox \frac{T_2}{5} \quad (1.9)$$

and if

$$C_{h2}\left(R_{L1} + \frac{R_{d2}\,R_{g2}}{R_{d2} + R_{g2}}\right) \lessapprox \frac{T_1}{5} \quad (1.9)$$

then the natural period of the multivibrator is defined by

$$T_{MV} = T_1 + T_2 = \frac{1}{\alpha_1}\log_e(k_2\,\mu_{co1}) + \frac{1}{\alpha_2}\log_e(k_1\,\mu_{co2}) \quad (1.7)$$

where $T_1 = N_1T_s$ = portion of the MV period contributed by section 1, i.e., the non-conducting time of V_1, and T_2 is the non-conducting time of V_2.

It was shown in the February 1944 issue of ELECTRONICS that if T_{1c}/T_1 is the ratio of the controlled T_1, which is equal to N_1/f_s, to the natural T_1, which by Eq. (1.7) is $C_{h1}R_1\log_e(k_2\mu_{co1})$, then the ratio $T_{1c}/T_1 = N_1/f_sC_{h1}R_1\log_e(k_2\mu_{co1})$ can—if the MV is properly designed—be permitted to increase to $N_1/f_sC_{h1}R_1(1 - \delta_{d1})\log_e(k_2\mu_{co1})$ and to decrease to $N_1/f_sC_{h1}R_1(1 + \delta_{i1})\log_e(k_2\mu_{co1})$ as long as (2.8) is satisfied.

$$\left[\frac{1+\delta_{i1}}{1-\delta_{d1}}\right] < \left[\frac{N_1}{N_1 - 1}\right] \quad (2.8)$$

For the three special cases $\delta_{d1} = \delta_{i1} = \delta_{d1=i1}$, $\delta_{i1} = 0$ and $\delta_{d1} = 0$, (2.8) reduces to (2.8) a, b and c respectively.

$$\delta_{d1=i1} < \frac{1}{2N_1 - 1} \quad (2.8a)$$

$$\delta_{d1} < \frac{1}{N_1} \quad (2.8b)$$

$$\delta_{i1} < \frac{1}{N_1 - 1} \quad (2.8c)$$

When synchronizing pulses of negative polarity are used, the natural frequency of the MV *must* be greater than the frequency at which it is to be controlled. As indicated in Fig. 3.1, the synchronizing pulse then prevents the tube from conducting at the time determined by the natural period of the circuit. The MV is not permitted to trip until the end of the synchronizing pulse.[12]

This method of synchronizing is not essentially different from the case for positive synchronizing pulses. For example, visualize the synchronizing pulses of Fig. 3.1 as growing constantly wider ($\sigma \rightarrow 1$) until the negative pulse occupies essentially the entire period of the synchronizing wave. This condition is readily seen to be the equivalent of a larger C_hR product or a larger value of kE_{bb}, and positive synchronizing pulses of extremely short time duration. It is, therefore, apparent that the variations permissible in the time constants can be calculated by considering the synchronizing pulses as positive and of a duration equal to the zero voltage portion of the synchronizing wave.

It can be seen from Fig. 3.1 that the percent variations permissible in the time constant are proportional to the duration (σT_s) of the synchronizing pulse. For the case

[12] This is in direct contrast to the case of positive synchronizing pulses where the natural frequency *must* be less than the controlled frequency and the MV trips on the front edge of the synchronizing pulse.

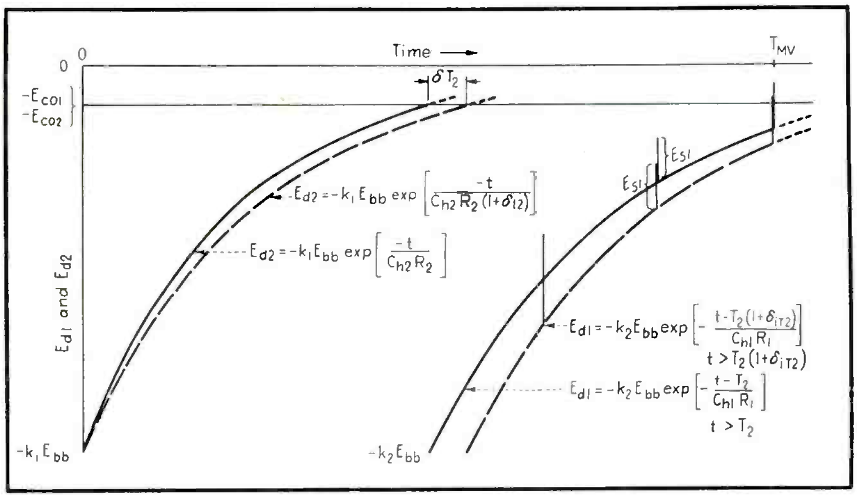


Fig. 3.2—Synchronizing voltage supplied to only one tube. Since T_{MV} must remain constant, the ratio T_2/T_1 will vary with changes in the characteristics of the uncontrolled section. It is not necessary that $k_1E_{bb} = k_2E_{bb}$ as it does in this figure

By EUGENE R. SHENK

RCA Laboratories
New York City

.nd Design Part III

illustrated, the natural period occurs at the center of the synchronizing pulse. Therefore, equal positive and negative variations from the nominal $C_{h1}R_1$ product are permissible. The magnitude of these allowable variations, expressed as a fraction of the original $C_{h1}R_1$, is

$$\frac{\sigma\, T_s/2}{N_1\, T_s - \sigma\, T_s/2} = \frac{\sigma}{2\,N_1 - \sigma}$$

This result corresponds with Eq. (2.8a) for $\sigma = 1$ and with Eq. (2.82a) of Appendix II. σ in Fig. 3.1 corresponds to $(1-\sigma)$ in Fig. 2.31 of Appendix II.

If the synchronizing voltage is applied to only one tube of the MV, say V_1, then the value of N_1 is a function of V_2, $C_{h2}R_2$, and R_{L2}. The reason for this is that since no synchronizing voltage is applied to V_2, the time T_2 depends entirely upon the values of the components in that section of the circuit. Therefore, T_2 is subject to variation with changes in temperature and humidity as well as with replacement of V_2. If the period of the MV is to be maintained constant under these conditions, the portion T_1 of the MV period must increase or decrease by whatever amounts T_2 decreases or increases.

In the preceding work on synchronized multivibrators, T_1 and T_2 have been treated as constants, which they are when synchronizing voltage is supplied to both tubes. Quantitative information was derived concerning variations that could be tolerated in the time constants for various fixed orders of division. However, in the case where the synchronizing voltage is supplied to only one tube, V_1 for example, the variations that can be permitted in the value of $C_{h1}R_1$ become a function of the variations in $C_{h2}R_2$.

Figure 3.2 is a plot of the grid voltages of a MV in which only V_1 is synchronized. For the case illustrated, the waveshape is normally symmetrical, i.e., $T_1 = T_2$. The solid curves indicate the grid voltages for the symmetrical condition. V_1 and its associated circuits are dividing by 3. The overall division is 6. If T_2 remains constant, the percentage variations that can

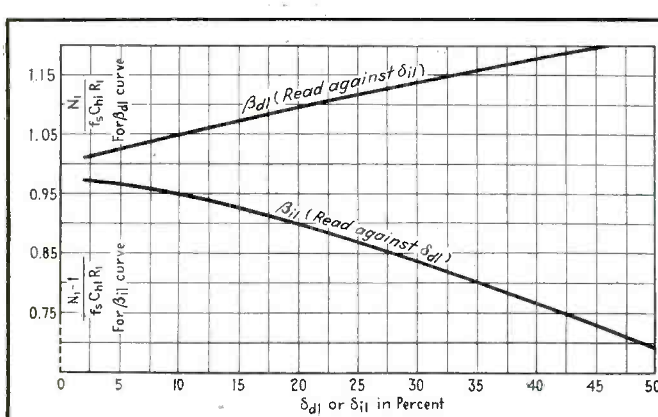


Fig. 4.1—Value of $N_1/f_sC_{h1}R_1$ that maximizes β_{d1} or β_{i1} as a function of δ_{i1} and δ_{d1}. Multiply the ordinate by $N_1/(N_1-1)$ to obtain $N_1/f_sC_{h1}R_1$ for the β_{i1} curve

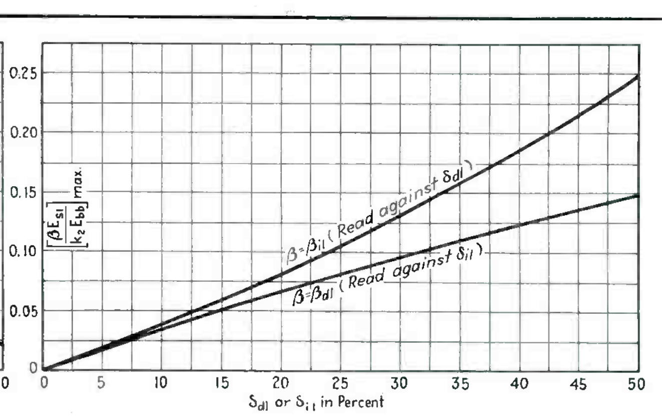


Fig. 4.2—Maximum number of volts increase and decrease permissible in the amplitude of the synchronizing pulse vs. δ_{d1} and δ_{i1}. The maximizing values of Fig. 4.1 were used

TABLE III

N_{MV}	N_1	N_2	N_1/N_2	$\delta_{d1} = \delta_{i1}$	δ_i^{1-2}	δ_d^{1-2}	Total Range
4	1.5	2.5	0.60	50	15.5	12.2	27.7
4	2	2	1	33.3	15.3	13.	28.3
4	2.5	1.5	1.67	25	15.	13.4	28.4
6	2	4	0.50	33.3	9.5	8.3	17.8
6	3	3	1	20	9.6	8.6	18.2
6	4	2	2	14.3	9.2	8.6	17.8
10	2	8	0.25	33.3	5.4	5	10.4
10	5	5	1	11.1	5.6	5	10.6
10	8	2	4	6.7	5.1	5.3	10.4

Some typical calculations based upon Eq. (3.9a) and (3.10a). $N_{MV} = N_1 + N_2$ = the overall order of division of the multivibrator. The values in the last four columns are in percent.

be allowed in $C_{h1}R_1$ are determined by (2.8) through (2.8c). However, if T_2 changes, then the percent variations that can be tolerated in $C_{h1}R_1$ are altered. Assume T_2 increases to $T_2(1 + \delta_{iT2})$. This condition is illustrated by the dashed curve of E_{d2}. V_1 is delayed $\delta_{iT2}T_2$ seconds in becoming non-conducting. The synchronizing pulses continue to occur at the same values of time as before T_2 increased. Therefore, each pulse occurs at a value of E_{d1} which is more negative than it was in the original case. As a result, the pulse does not raise the grid voltage to as high a value as it did before the increase in T_2. It is apparent from Fig. 3.2 that an increase in T_2 has an effect in the grid circuit of V_1 which is similar to the effect of an increase in $C_{h1}R_1$. As indicated in the figure, the dashed line curve of E_{d1} is a plot of

$$E_{d1} = -k_2 E_{bb} \exp \left[-\frac{t - T_2(1+\delta_{iT2})}{C_{h1} R_1}\right]_{t > T_2(1+\delta_{iT2})} \quad (3.1)$$

To obtain this same effect on the basis of an equivalent increase in $C_{h1}R_1$, the equation becomes

$$E_{d1} = -k_2 E_{bb} \exp \left[-\frac{t - T_2}{C_{h1} R_1 (1 + \delta_{i1eq})}\right]_{t > T_2} \quad (3.2)$$

If these two equations are to have the same value at the occurrence of the pulse that synchronizes the MV (the 3rd pulse in Fig. 3.2), i.e., at $t = T_{MV}$, the exponentials of Eq. (3.1) and (3.2) must be equal for $t = T_{MV}$.

$$\frac{T_{MV} - T_2(1 + \delta_{iT2})}{C_{h1} R_1} = \frac{T_{MV} - T_2}{C_{h1}R_1(1 + \delta_{i1eq})}$$

$$\delta_{i1eq} = \frac{\delta_{iT2} T_2}{T_{MV} - T_2 - \delta_{iT2} T_2} \quad (3.3)$$

Since $T_{MV} - T_2 = T_1$, Eq. (3.3) can be written

$$\delta_{i1eq} = \frac{1}{\left(\frac{T_1}{T_2}\right)\left(\frac{1}{\delta_{iT2}}\right) - 1} \quad (3.4)$$

Similarly, if T_2 decreases to $T_2(1 - \delta_{dT2})$, the equivalent decrease in $C_{h1}R_1$ based upon the two curves having the same value at time equal $T_{MV} - T_s$, which is the point at which the $(N_{MV} - 1)$th pulse threatens to trip the MV, is

$$\delta_{d1eq} = \frac{1}{\left(\frac{T_1 - T_s}{T_2}\right)\left(\frac{1}{\delta_{dT2}}\right) + 1} \quad (3.5)$$

On the assumption that the entire increase or decrease in T_2 results from variations in the time constant $C_{h2}R_2$, δ_{iT2} and δ_{dT2} in Eqs. (3.4) and (3.5) can be replaced by δ_{i2} and δ_{d2} respectively.

$$\delta_{i1eq} = \frac{1}{\left(\frac{T_1}{T_2}\right)\left(\frac{1}{\delta_{i2}}\right) - 1} \quad (3.6)$$

$$\delta_{d1eq} = \frac{1}{\left(\frac{T_1 - T_s}{T_2}\right)\left(\frac{1}{\delta_{d2}}\right) + 1} \quad (3.7)$$

From these equations it can be seen that a given percentage change in $C_{h2}R_2$ may be equivalent to either a smaller or a larger percentage change in $C_{h1}R_1$, depending upon the original ratio of T_1/T_2.

If δ_{i1} is the percentage increase permissible in $C_{h1}R_1$ as obtained from (2.8), then

$$\delta_{i1} = \delta_{i1eq} + \delta_{i1a} \quad (3.8)$$

where δ_{i1eq} = The equivalent percentage increase in $C_{h1}R_1$ which results from δ_{i2} percent increase in $C_{h2}R_2$.

δ_{i1a} = The actual percentage increase in $C_{h1}R_1$.

The components associated with V_1 and V_2 in a given MV usually have approximately the same temperature coefficients. Therefore, it is desirable to design the MV to permit equal variations in the two time constants.

Let $\delta_{i1a} = \delta_{i2a} = \delta_i^{1-2}$. Substituting (3.6) into (3.8),

$$\delta_{i1} = \frac{1}{\left(\frac{T_1}{T_2}\right)\left(\frac{1}{\delta_i^{1-2}}\right) - 1} + \delta_i^{1-2}.$$

Solving for δ_i^{1-2},

$$\delta_i^{1-2} = \tfrac{1}{2}\left[\left(\delta_{i1} + \frac{T_1}{T_2} + 1\right) - \sqrt{\left(\delta_{i1} + \frac{T_1}{T_2} + 1\right)^2 - 4\,\delta_{i1}\frac{T_1}{T_2}}\right]. \quad (3.9)$$

By a similar development

$$\delta_d^{1-2} = \tfrac{1}{2}\left[\left(\delta_{d1} - \frac{T_1 - T_s}{T_2} - 1\right) + \sqrt{\left(\delta_{d1} - \frac{T_1 - T_s}{T_2} - 1\right)^2 + 4\,\delta_{d1}\left(\frac{T_1 - T_s}{T_2}\right)}\right]. \quad (3.10)$$

These equations may be written in terms of the orders of division of the tubes.

$$\delta_i^{1-2} = \tfrac{1}{2}\left[\left(\delta_{i1} + \frac{N_1}{N_2} + 1\right) - \sqrt{\left(\delta_{i1} + \frac{N_1}{N_2} + 1\right)^2 - 4\,\delta_{i1}\frac{N_1}{N_2}}\right] \quad (3.9a)$$

$$\delta_d^{1-2} = \tfrac{1}{2}\left[\left(\delta_{d1} - \frac{N_1 - 1}{N_2} - 1\right) + \sqrt{\left(\delta_{d1} - \frac{N_1 - 1}{N_2} - 1\right)^2 + 4\,\delta_{d1}\left(\frac{N_1 - 1}{N_2}\right)}\right] \quad (3.10a)$$

The value of δ_{d1}, δ_{i1} and N_1 must satisfy (2.8). If the MV waveshape is normally symmetrical, i.e., $N_1 = N_2 = N$ and if $\delta_{d1} = \delta_{i1} = \delta_{d1-i1}$ then by (2.8a) $1/(2N - 1)$ can be substituted for δ_{d1} and δ_{i1}. Making these substitutions in Eq. (3.9a) and simplifying the result gives

$$\delta_i^{1-2} = \frac{0.50}{2N - 1}\left[4N - 1 - \sqrt{16N(N-1) + 5}\right] \quad (3.11)$$

For N equal to 1.5, 2, 3 and 10 the bracketed term has values of 0.88, 0.92, 0.96 and 1 respectively. Hence, as N increases $\delta_i^{1-2} \rightarrow 0.50/(2N - 1)$ which is half the value given by (2.8a) for the case of both tubes synchronized.

Equation (3.12) is the result of introducing the previously outlined substitutions into Eq. (3.10a).

$$\delta_d^{1-2} = \frac{0.50}{2N - 1}\left[\frac{1}{N}\sqrt{[(4N-1)(N-1)]^2 + 4N(N-1)(2N-1)} - \frac{(4N-1)(N-1)}{N}\right] \quad (3.12)$$

For N equal to 1.5, 2, 5 and 10 the bracketed term has values of 0.69, 0.78, 0.92 and 1 respectively. Therefore, as N increases $\delta_d^{1=2} \rightarrow 0.50/(2N - 1)$ which is also half the value given by (2.8a). Consequently, it is noted that if an MV in which only one tube is synchronized is arranged to provide a normally symmetrical waveshape and the controlled section is designed according to the methods outlined earlier in this paper so as to allow equal increases and decreases from the nominal value of its time constant circuit, then approximately equal increases and decreases will be tolerable in both time constant circuits of the MV. The magnitude of these tolerable variations in the individual time constant circuits is approximately half that which would be allowable if both tubes were controlled. For a given N_{MV}, the ratio of N_1 to N_2 has negligible effect upon the values of $\delta_i^{1=2}$ and $\delta_d^{1=2}$. Several examples are tabulated in Table III. To a very good approximation, (2.8) a, b and c can be used in the case of one tube synchronized, if N_{MV}, $\delta_d^{1=2}$ and $\delta_i^{1=2}$ are substituted for N, δ_d and δ_i. For a constant synchronizing frequency, $\delta_d^{1=2}$ and $\delta_i^{1=2}$ are the allowable variations from the nominal time constant values; or, for given time constants, $\delta_d^{1=2}$ and $\delta_i^{1=2}$ are the permissible variatons in the frequency of the synchronizing voltage supplied to the controlled tube. A change in the frequency of the synchronizing voltage changes the order of division of the uncontrolled section just as effectively as though f_s had remained constant and the value of the time constant had changed.

Variations in Amplitude of Synchronizing Pulse

The variations permissible in the time constants, the synchronizing frequency, and $k_2\mu_{co1}$ were developed on the basis of a constant amplitude pulse of synchronizing voltage. It is desirable to know what variations can be tolerated in the magnitude of the synchronizing pulses, assuming no variation from the nominal values of $C_{h1}R_1$, f_s or $k_2\mu_{co1}$. The MV design provides a value for $E_{s1} = A_1E_{co1}$ that satisfies

$$\frac{1 + A_1}{k_2\mu_{co1}} = \exp\left[\frac{-N_1}{f_sC_{h1}R_1\,(1 + \delta_{i1})}\right] \quad (2.6)$$

A_1 in this equation is sufficiently large to insure synchronization on the N_1th pulse, even though $f_sC_{h1}R_1$ should increase to $f_sC_{h1}R_1(1 + \delta_{i1})$. If it is assumed that once the MV circuit is built and adjusted, no increase will take place in f_s or in the time constant circuit, i.e., $\delta_{i1} = 0$, A_1 in Eq. (2.6) can decrease by the amount β_{d1} where $\beta_{d1}A_1$ has a value that satisfies

$$\frac{1 + A_1 - \beta_{d1}A_1}{k_2\mu_{co1}} = \exp\left[\frac{-N_1}{f_s\,C_{h1}\,R_1}\right] \quad (4.1)$$

and β_{d1} is the maximum fractional decrease in E_{s1} that can be tolerated, if the order of division is to be maintained at N_1. Subtracting (4.1) from (2.6) gives the allowable decrease in A_1

$$\beta_{d1}A_1 = k_2\,\mu_{co1}\left\{\exp\left[\frac{-N_1}{f_s\,C_{h1}\,R_1\,(1+\delta_{i1})}\right] - \exp\left[\frac{-N_1}{f_s\,C_{h1}\,R_1}\right]\right\}$$

$$\frac{\beta_{d1}A_1}{k_2\,\mu_{co1}} = \frac{\beta_{d1}\,E_{s1}}{k_2\,E_{bb}} = \exp\left[\frac{-N_1}{f_s\,C_{h1}\,R_1\,(1+\delta_{i1})}\right] - \exp\left[\frac{-N_1}{f_s\,C_{h1}\,R_1}\right] \quad (4.2)$$

From this equation, it is noted that the amount of decrease that can be permitted in E_{s1} is a function of the amount of increase originally allowed for in the value of $f_sC_{h1}R_1$. For given values of $k_2\mu_{co1}$ and δ_{i1}, there is an optimum value of $N_1/f_sC_{h1}R_1$ that will maximize $\beta_{d1}A_1$. This value can be found by differentiating (4.2) with respect to $N_1/f_sC_{h1}R_1$ and equating the result to zero.

$$d\,(\beta_{d1}\,A_1)/d\left(\frac{N_1}{f_s\,C_{h1}\,R_1}\right) = k_2\,\mu_{co1}\left\{\frac{-1}{1+\delta_{i1}}\exp\left[\frac{-N_1}{f_s\,C_{h1}\,R_1\,(1+\delta_{i1})}\right] + \exp\left[\frac{-N_1}{f_s\,C_{h1}\,R_1}\right]\right\} = 0$$

Simplifying gives

$$\frac{N_1}{f_s\,C_{h1}\,R_1} = \left(\frac{1 + \delta_{i1}}{\delta_{i1}}\right)\log_e\,(1 + \delta_{i1}). \quad (4.3)$$

Equation (4.3) is plotted in Fig. 4.1. If a MV is designed to allow a maximum of δ_{i1} increase from the nominal value of $f_sC_{h1}R_1$, then the value of $N_1/f_sC_{h1}R_1$ as given by Eq. (4.3) or Fig. 4.1 will permit the greatest number of volts (not percentage) decrease in E_{s1}.[13] Figure 4.2 is a plot of Eq. (4.2) using the optimum value of $N_1/f_sC_{h1}R_1$ given by Eq. (4.3) for each value of δ_{i1} employed. Therefore, the β_{d1} curve in Fig. 4.2 gives the maximum decrease in volts that can be tolerated for a given δ_{i1} allowed for in the MV design. (δ_{i1} is related to N_1 by (2.8 a, b and c.) This maximum

[13] Selection of a tube type for V_2, its plate load resistor and δ_{d1} fixes a maximum value for $N_1/f_sC_{h1}R_1$ equal to $(1-\delta_{d1})\log_e(k_2\mu_{co1})$. Consequently, the value of $N_1/f_sC_{h1}R_1$ recommended by Eq. (4.3) can be used only if it is equal to or less than this maximum. This usually is the case.

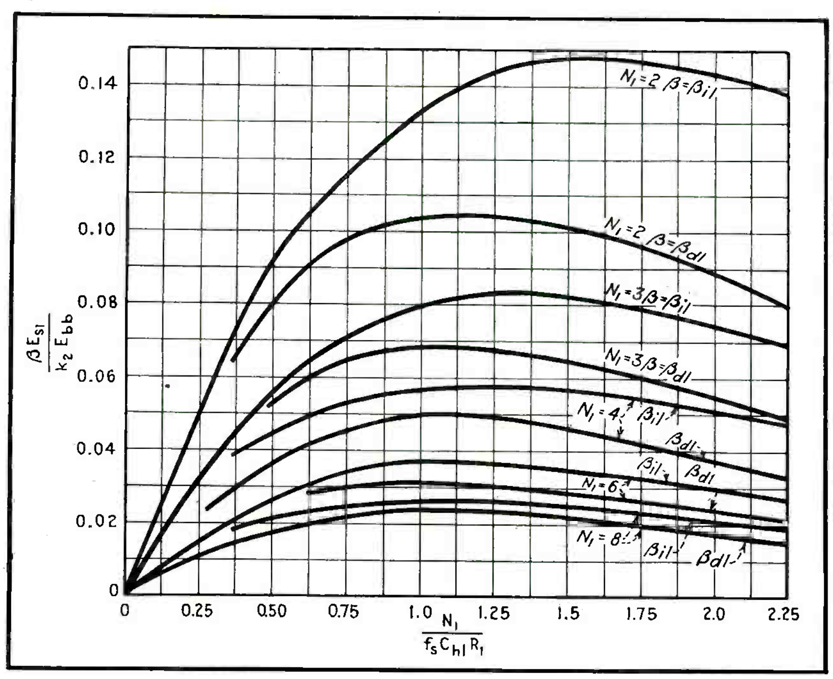


Fig. 4.3—Increase and decrease permissible in the amplitude of the synchronizing pulse for various orders of division as a function of $N_1f_sC_{h1}R_1$. These curves are applicable only in the special case of $\delta_{d1}=\delta_{i1}=1/(2N-1)$

decrease in E_{s1} will be tolerable only if the value of $N_1/f_sC_{h1}R_1$ given by Eq. (4.3) or Fig. 4.1 is used. For any other value, the permissible decrease in E_{s1} will be less. This effect is illustrated in Fig. 4.3 where $\beta_{d1}E_{s1}/k_2E_{bb}$ is plotted as a function of $N_1/f_sC_{h1}R_1$ for the special, but very useful, case of $\delta_{d1} = \delta_{i1} = 1/(2N_1 - 1)$. This figure indicates that the value of $N_1/f_sC_{h1}R_1$ is not critical, because all of the curves are quite flat around the maxima. While all of the curves plotted in Fig. 4.3 are for integral values of N_1, it will be recalled that N_1 is not limited to integral values, although the overall order of division $(N_1 + N_2)$ of the MV must be an integer.

Equations (2.4), (4.5) and (4.6) apply to an increase in E_{s1} in the same way that Eq. (2.6), (4.2) and (4.3) apply to a decrease in E_{s1}.

$$\frac{1 + A_1}{k_2\ \mu_{co1}} = \exp\left[\frac{-(N_1 - 1)}{f_s\ C_{h1}\ R_1\ (1 - \delta_{d1})}\right] \quad (2.4)$$

$$\frac{\beta_{i1}\ A_1}{k_2\ \mu_{co1}} = \frac{\beta_{i1}\ E_{s1}}{k_2\ E_{bb}} = \exp\left[\frac{-(N_1 - 1)}{f_s\ C_{h1}\ R_1}\right] - \exp\left[\frac{-(N_1 - 1)}{f_s\ C_{h1}\ R_1\ (1 - \delta_{d1})}\right] \quad (4.5)$$

$$\frac{N_1}{f_s\ C_{h1}\ R_1} = \left(\frac{1 - \delta_{d1}}{\delta_{d1}}\right)\left(\frac{N_1}{N_1 - 1}\right)\log_e\left(\frac{1}{1 - \delta_{d1}}\right) \quad (4.6)$$

Equations (4.6) and (4.5) are plotted in Figs. 4.1 and 4.2 respectively. From Fig. 4.2 it can be seen that if the MV is designed to permit equal percentage increases and decreases from the nominal value of $f_sC_{h1}R_1$, i.e., $\delta_{d1} = \delta_{i1}$, then a greater increase than decrease will be tolerable in E_{s1}. Because the MV design (see Part II) provides identical values for $N_1/(1 + \delta_{i1})$ and $(N_1 - 1)/(1 - \delta_{d1})$ through Eq. (2.8), the sum of $\beta_{d1}E_{s1}$ and $\beta_{i1}E_{s1}$, as given by Eq. (4.2) and (4.5) respectively, is always equal to the change in the exponential component of E_{d1} between the $(N_1 - 1)$th and the N_1th synchronizing pulses.

Use of Figures 4.1, 4.2 and 4.3

In Example III, Part II of this paper, $N_1 = 7$, $\delta_{d1} = \delta_{i1}$ (hence Fig. 4.3 applies), $N_1/f_sC_{h1}R_1 = 1.62$, $k_2E_{bb} = 129$ volts and $E_{s1} = 14.4$ volts. Although $N_1 = 7$ is not plotted in Fig. 4.3, the value of $\beta_{i1}E_{s1}/k_2E_{bb}$ can be estimated at 0.028. Then $\beta_{i1}E_{s1} = 0.028 \times 129 =$ 3.51 volts, i.e., the amplitude of the synchronizing pulse can decrease 3.51 volts (25 percent) and the order of division will remain at 7. From Fig. 4.2, the maximum value of $\beta_{i1}E_{s1}/k_2E_{bb}$ that can be tolerated for δ_{d1} equal 7.7 percent is 0.030. Reading Fig. 4.1 for δ_{d1} equal 7.7 percent, the maximum value of $\beta_{i1}E_{s1}/k_2E_{bb}$ occurs for $N_1/f_sC_{h1}R_1$ equal to $0.96N_1/(N_1 - 1) = 0.96 \times 7/6 = 1.12$. This can be checked in Fig. 4.3.

For section 1 of the MV designed in Example IV, $N_1 = 3.2$, $\delta_{d1} = 21$ percent and $\delta_{i1} = 15$ percent. Fig. 4.3 is not applicable in this case ($\delta_{d1} \neq \delta_{i1}$), but Fig. 4.2 gives $[\beta_{d1}E_{s1}/k_2E_{bb}]_{max}$ equal to 0.052 and $[\beta_{i1}E_{s1}/k_2E_{bb}]_{max}$ equal to 0.070. From Fig. 4.1, the values of $N_1/f_sC_{h1}R_1$ that allow these maxima are 1.072 and $0.89 \times 3.2/2.2 =$ 1.29 respectively. Since only one value of $N_1/f_sC_{h1}R_1$ can be used, $\beta_{d1}E_{s1}$ and $\beta_{i1}E_{s1}$ cannot be maximized simultaneously. However, a value of about 1.2 is quite satisfactory, because the maxima are broad.

Percentage Variation in E_s

The value of $N_1/f_sC_{h1}R_1$ given by Eq. (4.3) permits the greatest *number of volts* decrease in E_{s1}. It frequently is more desirable to maximize the *percentage* decrease permissible in E_{s1}. The percentage decrease in E_{s1} is 100 times the quotient of (4.2) by (2.6).

$$\beta_{d1} = \frac{\exp\left[\frac{-N_1}{f_s\ C_{h1}\ R_1\ (1 + \delta_{i1})}\right] - \exp\left[\frac{-N_1}{f_s\ C_{h1}\ R_1}\right]}{\exp\left[\frac{-N_1}{f_s\ C_{h1}\ R_1\ (1 + \delta_{i1})}\right] - \frac{1}{k_2\ \mu_{co1}}} \quad (4.4)$$

The first term in the numerator is identical to the first term in the denominator. It is apparent from a consideration of the problem, that the maximum value of β_{d1} will be less than unity, i.e., a 100 percent decrease in the amplitude of E_{s1} cannot be tolerated, unless the natural value of T_1 is exactly equal to the desired controlled value. Hence, $\exp[-N_1/f_sC_{h1}R_1]$ must always be greater than $1/k_2\mu_{co1}$. This is always the case in a properly designed (positive pulse synchronized) MV [See Eq. (2.9) and the discussion following it in part two.] The allowable percentage decrease in E_{s1} will increase as $1/k_2\mu_{co1} \rightarrow \exp[-N_1/f_sC_{h1}R_1]$ or, in another form, as $N_1/f_sC_{h1}R_1 \rightarrow \log_e(k_2\mu_{co1})$. These quantities can never be permitted to become equal; for, if they did, no decrease from the nominal values of f_s or $C_{h1}R_1$ could be tolerated. As a consequence, some of the otherwise permissible percentage decrease in E_{s1} must be sacrificed to allow for decreases from the nominal values of f_s, $C_{h1}R_1$ and $k_2\mu_{co1}$. In Appendix V it is shown that the maximum allowable percentage decrease in E_{s1} ordinarily obtainable in practice—allowing for δ_{d1} decrease in $f_sC_{h1}R_1$—approximates 50 percent. Equation (4.7) gives the allowable percentage increase in E_{s1}.

$$\beta_{i1} = \frac{\exp\left[\frac{-(N_1 - 1)}{f_s\ C_{h1}\ R_1\ (1 - \delta_{d1})}\right] - \exp\left[\frac{-(N_1-1)}{f_s\ C_{h1}\ R_1}\right]}{\exp\left[\frac{-(N_1 - 1)}{f_s\ C_{h1}\ R_1\ (1 - \delta_{d1})}\right] - \frac{1}{k_2\ \mu_{co1}}} \quad (4.7)$$

(*Continued on page 341*)

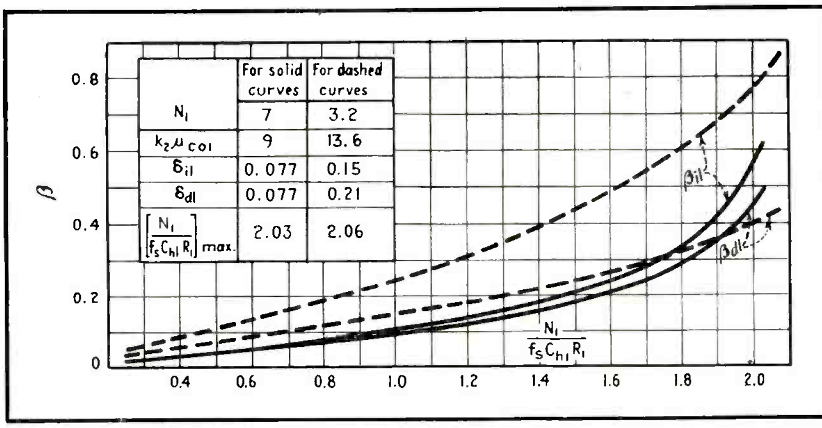


Fig. 4.4—Percentage variation permissible in the amplitude of the synchronizing pulse as a function of $N_1/f_sC_{h1}R_1$ for the MV's designed in Examples III and IV

HARMONIC ANALYSIS of Overbiased Amplifiers

Quick graphical method of determining harmonic components up to the tenth for voltage or current in various classes of amplifiers. Amount of distortion can thus be predicted

By ULRICH R. FURST

Chicago, Ill.
Russell Electric Co.,

It is well known that the efficiency of an amplifier can be improved by increasing its grid bias so that no plate current flows during a part of the cycle. Unfortunately considerable harmonic distortion is introduced at the same time. The amount of this distortion and its distribution among the various harmonic frequencies depends mainly upon the fraction of the cycle during which the tube conducts and to a small extent also on the curvature of the characteristic of the tube. It is important that the designer of such amplifiers can predict what distortion is to be expected.

Harmonic distortion can be computed with the assumption that the tube characteristic can be approximated by a straight line intersecting the abscissa axis at the point of plate current cut-off as shown in Fig. 1. The curves have been plotted from values obtained by a Fourier analysis of that part of a sine function which has been shown shaded in Fig. 1. This portion of the function represents the current actually flowing in a tube having an idealized straight-line characteristic. If the coordinate system is selected so that the ordinate axis coincides with the line of symmetry, only cosine terms appear in our Fourier series:

$$f(\chi) = A_0/2 + A_1 \cos\chi + A_2 \cos 2\chi + A_3 \cos 3\chi + \ldots\ldots$$

where the coefficients A_0, A_1, A_2, A_3 . . . are not constants, but depend on the angle of conduction, i.e. that fraction of the full cycle of the signal voltage during which the tube is conducting, expressed in electrical degrees. They are the peak values of the harmonic currents, expressed as a fraction of the peak value I_m (Fig. 1) of the current actually flowing through the tube.

Mathematically these coefficients are expressed by the integral

$$A_n = \frac{1}{\pi}\int_{\pi}^{+\pi} f(\phi)\cos n\phi \, d\phi$$

Evaluating this integral we obtain

$$A_o = \frac{2}{\pi}\frac{1}{1-\cos\theta/2}\left[\sin\frac{\theta}{2} - \frac{\theta}{2}\cos\frac{\theta}{2}\right]$$

$$A_n = \frac{1}{n\pi}\frac{1}{1-\cos\theta/2}\left[\frac{\sin(n-1)\frac{\theta}{2}}{n-1} - \frac{\sin(n+1)\frac{\theta}{2}}{n+1}\right] \text{for } n \gtreqless 1$$

where θ is the angle of conduction (as defined above) in radius and n is the order of the harmonic. For the first few harmonics this can be rewritten for greater ease in calculating as

$$A_1 = \frac{1}{2\pi}\frac{1}{1-\cos\theta/2}\left(\theta - \sin\frac{\theta}{2}\right)$$

$$A_2 = \frac{2}{3\pi}\frac{1}{1-\cos\theta/2}\sin^3\frac{\theta}{2}$$

$$A_3 = \frac{2}{3\pi}\frac{1}{1-\cos\theta/2}\sin^3\frac{\theta}{2}\cos\frac{\theta}{2} = A_2\cos\frac{\theta}{2}$$

It can be seen that these coefficients are oscillating functions of θ, i.e. they assume positive and negative values in alternate ranges of θ.

It is desirable to have curves of this kind plotted in a logarithmic rather than in a linear scale, as the former permits reading all values with the same percent accuracy as compared to the absolute accuracy

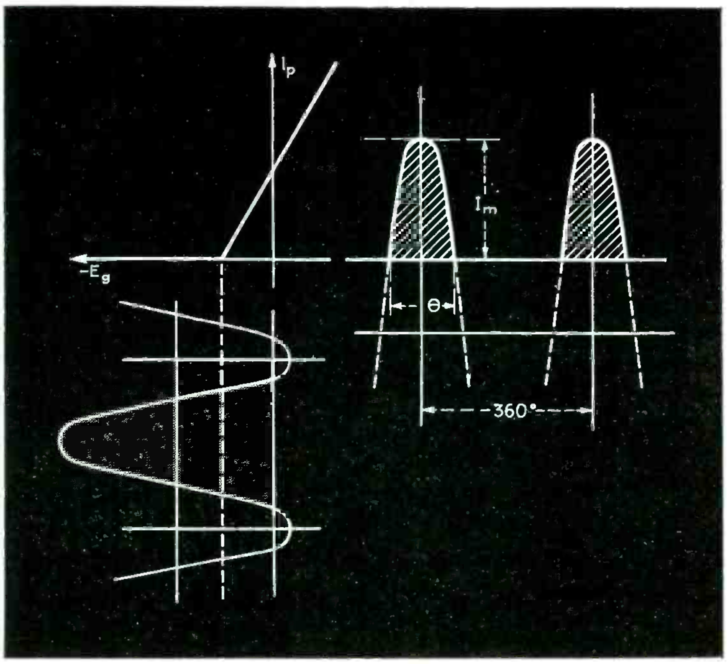


FIG. 1—Diagram illustrating the idealized linear amplifier characteristics on which the main graph in Fig. 2 is based

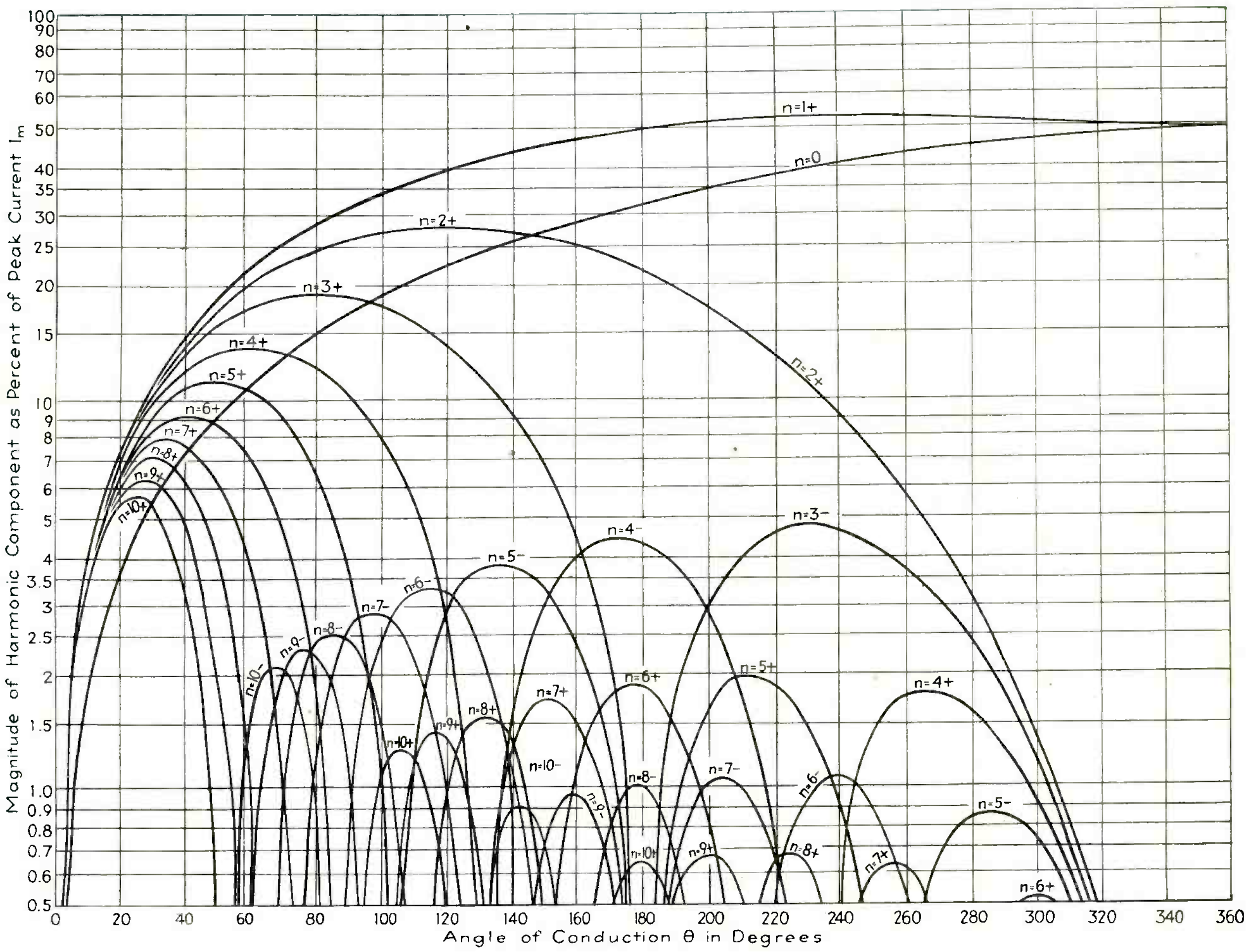


FIG. 2—Graph illustrating the magnitude and phase of the first ten harmonics of an overbiased amplifier. The harmonic amplitudes are expressed in percentages of the peak current, for various conducting angles in degrees

of a linear scale. Unfortunately, a logarithmic scale does not allow the plotting of negative values. In most cases, however, no distinction need be made between the positive and the negative values, so their absolute values only have been plotted.

For the rare case that the phase relation of the components is important, the symbols + and − have been added on the chart after the number designating the order of the harmonic. All values marked + are in phase with a harmonic produced by a very short impulse.

The scale on the abscissa axis has been so selected that the chart can be used for all types of amplifiers: Class A ($\theta = 360°$), class AB ($\theta = 360° - 180°$), class B ($\theta = 180°$) for high-power audio amplifiers and modulators, and class C ($\theta = 180° - 0°$) for r-f oscillators and frequency multipliers.

The following examples explain the use of the diagram:

(1) A frequency quintupler ($n = 5$) shall be operated under such conditions that the amplitudes of the neighboring harmonics ($n = 4$ and $n = 6$) of the output frequency are much smaller than the amplitude of the output frequency. Inspection of the chart shows that at $\theta = 140$ deg the peak current of the fifth harmonic is 3.7 percent, and those of the fourth and sixth harmonics are respectively only 1.5 and 1.0 percent of the peak value of the actual current I_m.

(2) The peak value of the third harmonic of a class C amplifier operated at $\theta = 100$ deg is 17 percent, that of the fundamental 34 percent and the d-c component ($n = 0$) 18 percent of the peak value of the actual current I_m.

(3) To operate a push-pull audio amplifier for good fidelity no odd harmonic distortion should be present. Inspection of the chart shows that this is the case for $\theta = 180$ deg, a well-known property of class B amplifiers which makes it possible to use them in push-pull as audio power amplifiers. Of course, the curvature of the tube characteristics will produce some additional distortion which is not covered by this chart.

(4) A class AB amplifier shall be operated with an angle of conduction of 280 deg. The direct current will be found to be 46 percent, the peak signal-current is 53 percent and the second and third harmonics are 3.2 and 2.4 percent respectively of the actual peak current I_m, which corresponds to 6.1 and 4.5 percent respectively of the signal current.

It should be noted that the plotted curves represent peak currents; these must be multiplied by 0.707 to obtain rms values of current, and multiplied by the impedance of the load at the particular frequency to obtain the desired voltage values.

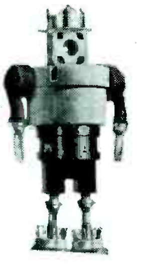
No. 1044
Actual Size

CINCH *Mounting Strap*

FOR MINIATURE TUBE SOCKET

★*Mounting strap fastened to chassis by central single rivet (see above) and two removable screws.*

• To design and manufacture satisfactory miniature tube sockets is one of Cinch's primary functions. This is our contribution in an all-out war effort. However, the job is not finished until the socket is satisfactorily mounted in the radio chassis, hence *"Cinch mounting straps."* Examine the illustration, the simplicity of assembly is obvious. Note lug (No. 1044) makes it possible to "hitch" ground wires for electrical connections, also strap can be supplied without lugs (No. 1028) both threaded 4-40. *(Samples available on request.)*



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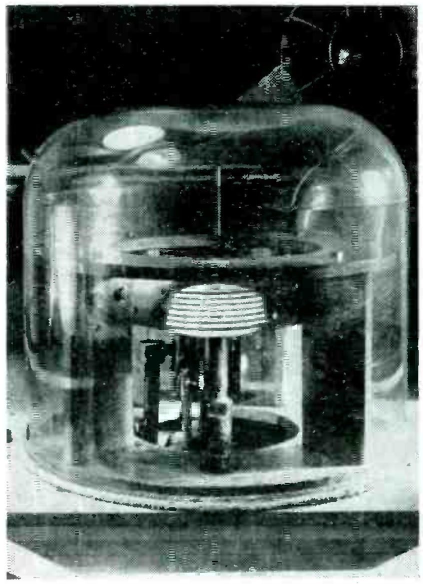
TUBES AT WORK

New Uses for Induction Electronic Heating

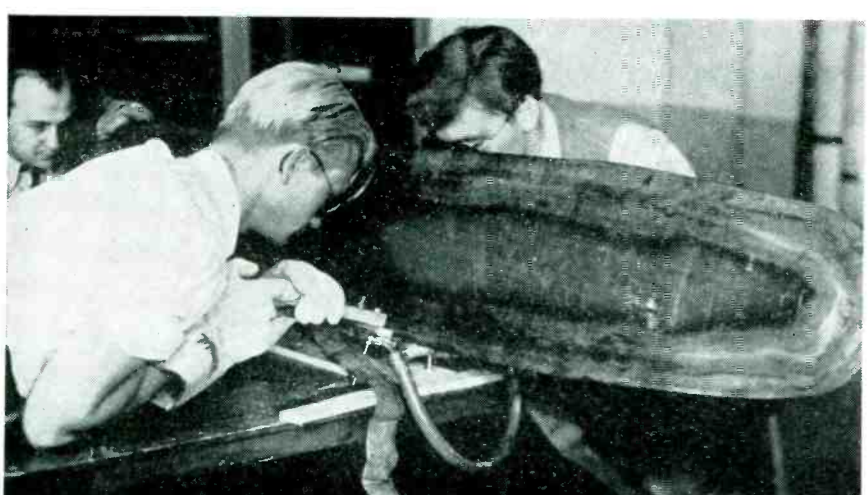
ELECTRONIC TUBES AT WORK can now be used to braze the edges of hollow metal propeller blades for planes by induction heating. Methods now in use for manufacturing propeller blades require a copper or copper-alloy fillet in the leading and trailing edges to prevent forming sharp corners. Welding of the two sections along the outside edge does not hold the sections together and cannot be used on the inside edge.

The induction brazing process consists of placing beads of brazing material along the inner edge of the propeller and then moving it edgewise through the output coil of an electronic oscillator. The heat produced at the joint then securely binds the edges together. Attempts to do the same work with a torch resulted in greater warpage of the blades than the electronic method, required greater skill and took longer.



A red hot rock bit for drilling oil wells is hardened in an experimental induction furnace. Tungsten carbide, held in place by an adhesive coating, is deposited on the teeth of the bit under the high heat

Oil-well drill bits that bore through solid rock get their toughness from a layer of tungsten carbide that is deposited on the teeth under high temperature. The practice has been to carbide the teeth one at a time with a torch. Recent experiments in the Westinghouse high-frequency laboratory have resulted in all the teeth being carbided at once in a few seconds. This is accomplished by passing the toothed cutter into the inductive field produced by a high-frequency electronic oscillator. The carbide particles are held in place by an adhesive coating until they merge with the steel base. The new method permits the use of protective gas atmospheres to improve the quality of the carbide surface and can be high-speed and semi-automatic using unskilled operators.



Technicians braze a fillet along the inner edge of a hollow propeller by induction electronic heating in the Westinghouse high-frequency laboratory

Cellophane Tape Recorder

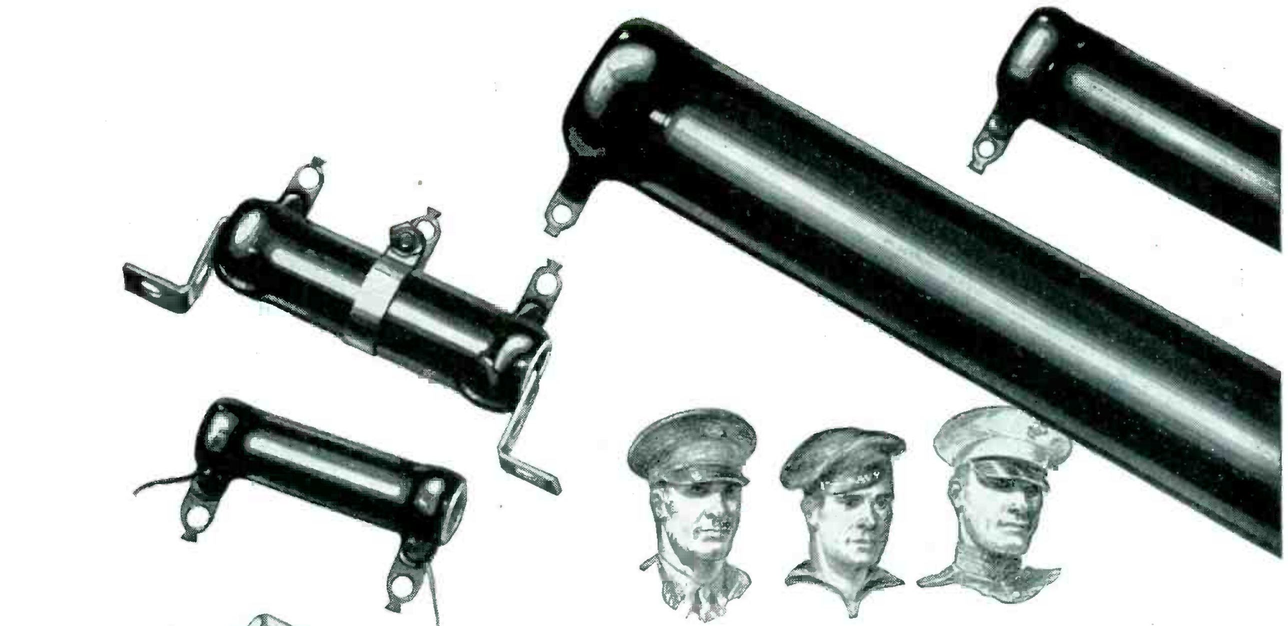
EIGHT HOURS OF RECORDING is accomplished on a 350-foot endless cellophane tape by a new portable recorder at an operating cost of about fifty cents an hour.

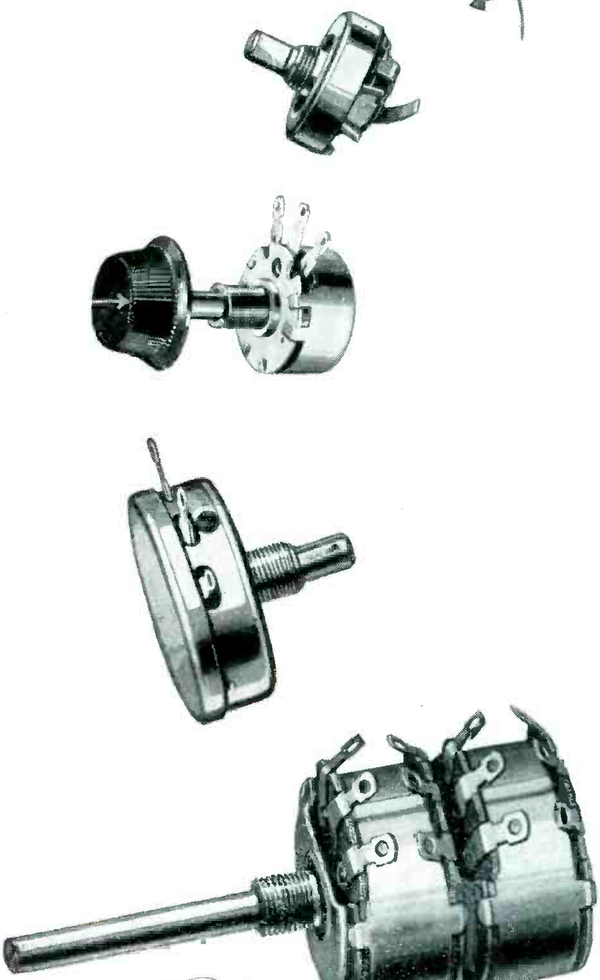
The problem of pressing a sound track on the cellophane, about twice the thickness of the usual grade, was solved by use of a yieldable felt bed directly under the recording stylus. Permanent gem points are used for both recording and reproduction. These require no changing and produce no shavings. The tape is one inch wide and runs under the needle at a rate of about 40 feet per minute in standard models, and has room for 60 adjacent grooves.

The new recorder, developed by Fonda Corp. of New York City, can be connected to a radio set, program line, or directly to a microphone. Loading of the tape is simpler than threading film into a home movie projector. No supervision is required during use; pressing one button starts recording, pressing another stops it. Any portion of a recording can be identified by marking directly on the tape with crayon.

Quality of reproduction depends upon the tape speed. For voice reproduction, 40 fpm is adequate; at 60 fpm the useful frequency response is extended to 6,000 cps, uniform within 2 db. The low-frequency response extends to 80 cps.

The recorder mechanism consists of a motor drive system that passes an endless loop of tape over a ring of idler wheels. One loop passes over the felt bed where the stylus embosses a groove of constant depth. Sound modulation is applied laterally in the groove. A worm and gear arrangement moves the





Companions in Service
...and Parts for the Peace

There's no place in this war for equipment that can't really "back the attack." So the mere fact that Mallory variable resistors are serving on every battle front is proof in itself that they've got what it takes.

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Consult with Mallory *now*—while your plans are still in the blue print stage—on special resistor problems. The following units are ready to serve you at once: they're standard entries in the Mallory catalog—and we'll be glad to supply you with further information.

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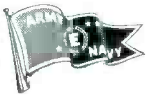
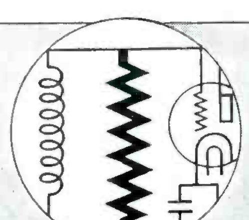
It Takes Money To Win— Buy War Stamps and Bonds





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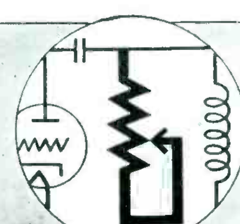
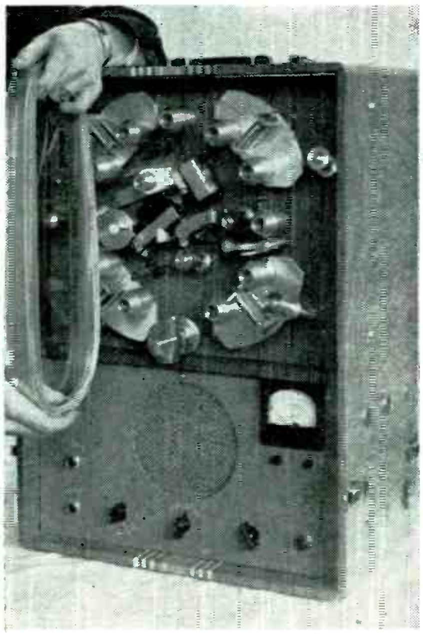
MALLORY
FIXED AND VARIABLE RESISTORS



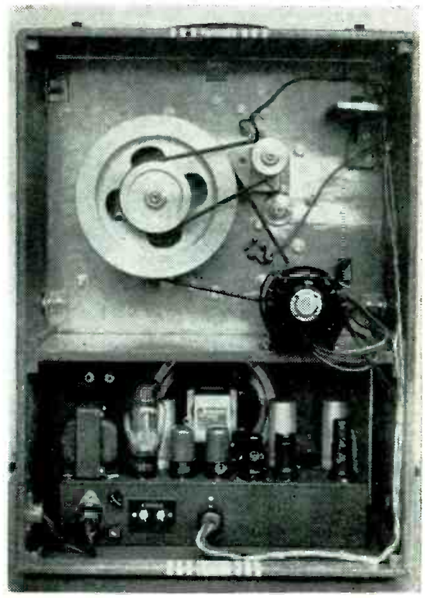


Loading the inch-wide cellophane tape on the feed mechanism of the recorder. The cellophane passes between the recording stylus and a felt bed. Both recording and playback are made with permanent jewels

recording head across the width of the tape to make a continuous groove at a pitch of 60 grooves to the inch.

A self-contained amplifier has a gain of 110 db and a power output of 5 watts. The background noise, due to combined mechanical vibration and needle friction, is 25 db below maximum signal level at 40 fpm and down 30 db at 50 fpm. Reproduction of sustained tones shows no noticeable "wows" and indicates sufficient speed regulation.

The standard model, for reference recording, requires attention only three times in a 24-hour day, for changing of tape. A stationary 1 to 8-hour unit is available for such permanent applications as at airports, radio stations and government uses, while a smaller unit recording for up to one hour has promising possibilities for office dictating uses.



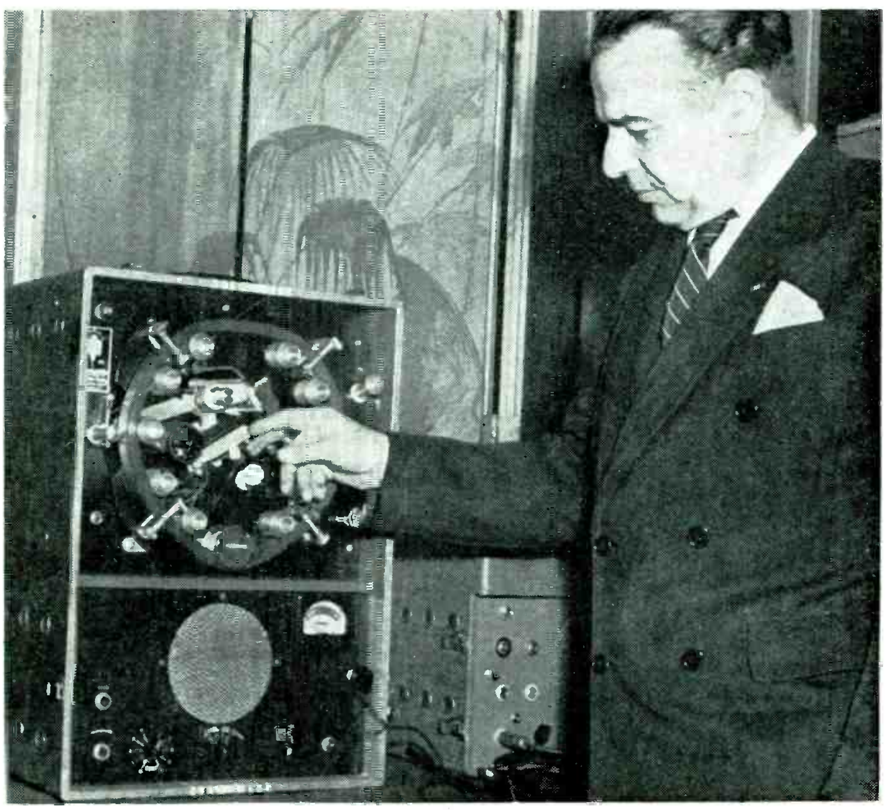
Rear view of the cellophane tape recorder shows the electronic equipment and speaker, at the bottom of the case, and the motor drive mechanism that feeds the tape through the machine

Post-War Control of Air Traffic

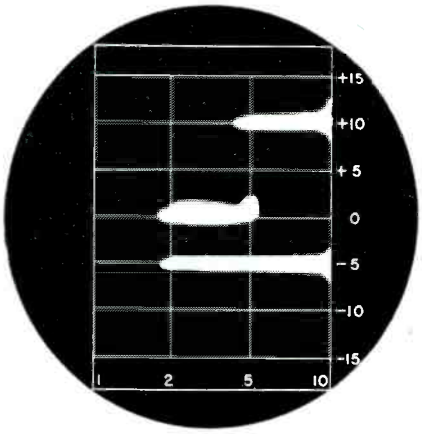
THE PRESENT RADIO navigation facilities of the U. S. that have been planned, developed, and established under the Civil Aeronautics Administration were reviewed by Glen A. Gilbert, chief of the Air Traffic Control Division of CAA in a speech delivered at the AIEE meeting in New York during January. He stated that the plans of the CAA are now ready and can be placed in operation in the immediate future to result in an increase in capacity of the traffic control system to at least 4 times its present capacity. His remarks on the future developments in air traffic control are given in the following paragraphs. If these expectations become a reality, it is obvious that the improvements now planned will merely be stop-gaps.

Much has been said about the possibilities of wartime developments revolutionizing or at least radically changing the present system of air traffic control. The war without question has accelerated many technical developments. Special progress has been made in the field of electronics. However, application of the various principles and techniques developed has of necessity been directed entirely toward wartime needs.

Very few, if any, wartime technical developments will be immediately applicable without change to meet peacetime needs. The end of the war will bring improved technical principles and techniques, but their application to peacetime requirements will have to be worked out. Such wartime technical developments as will be available and gradually adopted for



Jay Fonda adjusts the embossing stylus of the cellophane tape recorder he developed. The machine records eight hours of sound on a 350-foot endless cellophane ribbon one-inch wide



This vertical separation indicator shows a pilot the vertical distance between his plane and others within a fixed radius. A rough indication of the horizontal separation is also provided by the scale

peacetime aviation before, say—1950, will be only supplemental and assisting with respect to the present air traffic control system.

Radar

There is a widespread opinion that radar devices will greatly change air traffic control in the immediate post-war period. An analysis of the principle of radar indicates that its main advantage is detecting the presence of objects which will not "cooperate", such as enemy airplanes and ships during wartime. To obtain such detection it is necessary to provide complicated apparatus involving high cost, substantial weight and special technique for operation.

In the control of peacetime aircraft, the situation is entirely the reverse in that all aircraft will cooperate. In other words, devices can be placed on board peacetime aircraft which will reveal their presence. A different technique for the detection of aircraft for air traffic control purposes in peacetime will involve less complex apparatus, less cost, less weight and simpler operation. Some of the improved electronic techniques developed during wartime will be used for air traffic control, but application will be for peacetime requirements, meeting entirely different specifications than those existing under wartime conditions.

Flying Weather

In the post-war period and up to at least 1950, it is believed that weather will continue to be a factor affecting flying. Private pilots will refrain from flying during low cloud and restricted visibility conditions in the same way that the average automobile driver avoids using his car during poor driving conditions. There will probably be an increasing number of private pilots who will be qualified to fly in weather conditions requiring instrument flight as a result of wartime pilot training programs. By and large, however, it is expected that the great majority of private pilots will continue to be "fair weather" fliers.

Commercial air carriers can be expected to constitute the bulk of poor weather flying after the war in the same way as they did before the war. Scheduled air carrier service is economically successful only if conducted regularly. Hence, this type of service must operate under practically all weather conditions.

DEFINITIONS

AIRPORT TRAFFIC CONTROL is localized to a small zone around an airport.

AIRWAY TRAFFIC CONTROL extends out along all airways crossing the country.

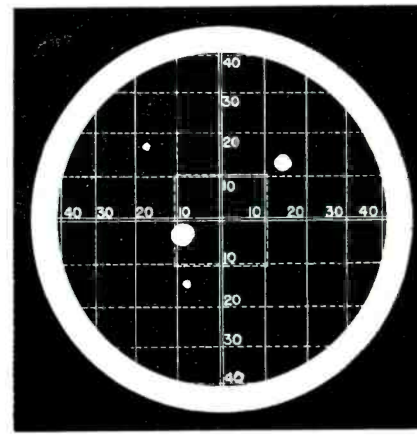
AIR TRAFFIC CONTROL is the combination of the above two controls for protection of life and property by avoidance of collisions and the expeditious movement of traffic.

Some military flying of large aircraft will probably be accomplished in a manner comparable to the scheduled air carriers. However, it is expected that the majority of postwar military flying will be done only during the more favorable weather conditions.

Air traffic control, therefore, will continue to have two types of flying to contend with—good weather or "contact" flying and poor weather or "instrument" flying.

Future Equipment

In attempting to eliminate or reduce all limitations of air traffic control so as to increase the capacity and raise the efficiency of the system, several devices for installation in aircraft appear to provide possible solutions. These devices



Horizontal separation indicator for aircraft. The dots indicate the relative position of nearby planes, while the size of the dots shows approximate distance from the observer

will be identified as a "collision warning device", an "automatic position reporter", and a "traffic clearance indicator". The latter two devices may ultimately be combined to provide a "block signal system".

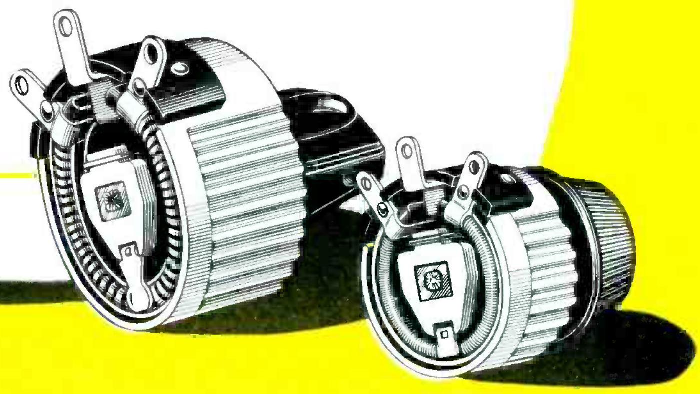
The ultimate solution for the control of the large number of aircraft anticipated in the future will require that some means be provided which will permit the shifting of a substantial amount of responsibility for the avoidance of collision from ground agencies to the individual pilots of aircraft. In other words, each pilot flying in instrument weather conditions should be able to avoid collision with other aircraft by directly observing indications of the position of the other aircraft. The means to accomplish this will probably be in the form of a "collision warning device".

Development of one such device, identified as a "vertical separation indicator", was commenced some time prior to the war by CAA. This device will permit a pilot, by reference to an instrument upon the aircraft instrument panel, to determine at a glance the vertical separation between his aircraft and other aircraft within a fixed radius, and will also indicate roughly the horizontal distance of the other aircraft. The pilot will thus be enabled to maintain a specified minimum amount of vertical separation between his aircraft and other aircraft within a certain radius during climb, level flight and descent.

A somewhat different device

IRC will be Ready

with RHEOSTATS



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Built to surpass rigid Army-Navy "specs," IRC Resistors will offer greater values than ever because of modern mass production methods and greatly increased plant capacity.

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It's none too soon for manufacturers of electronic equipment to survey their immediate post-war resistor needs. If you anticipate design or engineering problems involving resistances, we may be able to help in their solution. Feel free to call upon us and be assured your confidence will be respected.

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1. All metal *shatter and vibration-proof construction.*
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5. *Enclosed construction as protection against dust, dirt and damage to the moving parts.*
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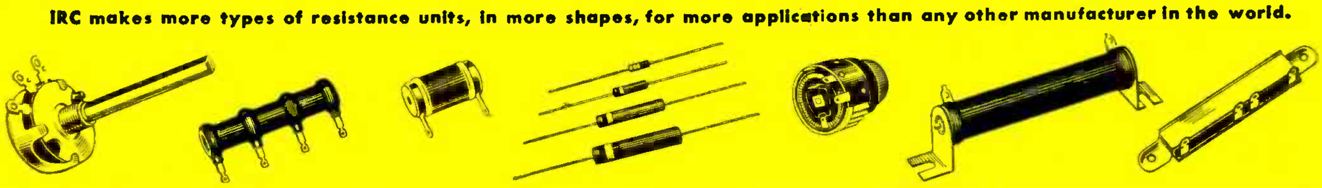
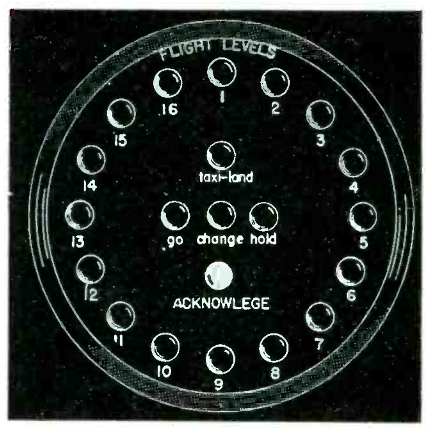


might be provided as a "horizontal separation indicator". This instrument would be a screen on which various size dots would indicate the relative position of other aircraft located within an area ahead of the aircraft concerned and within at least 45 deg above and below as well as to the right and left. The size of each dot would represent the approximate distance to the indicated aircraft and the location of the dot the angular position of the other aircraft.

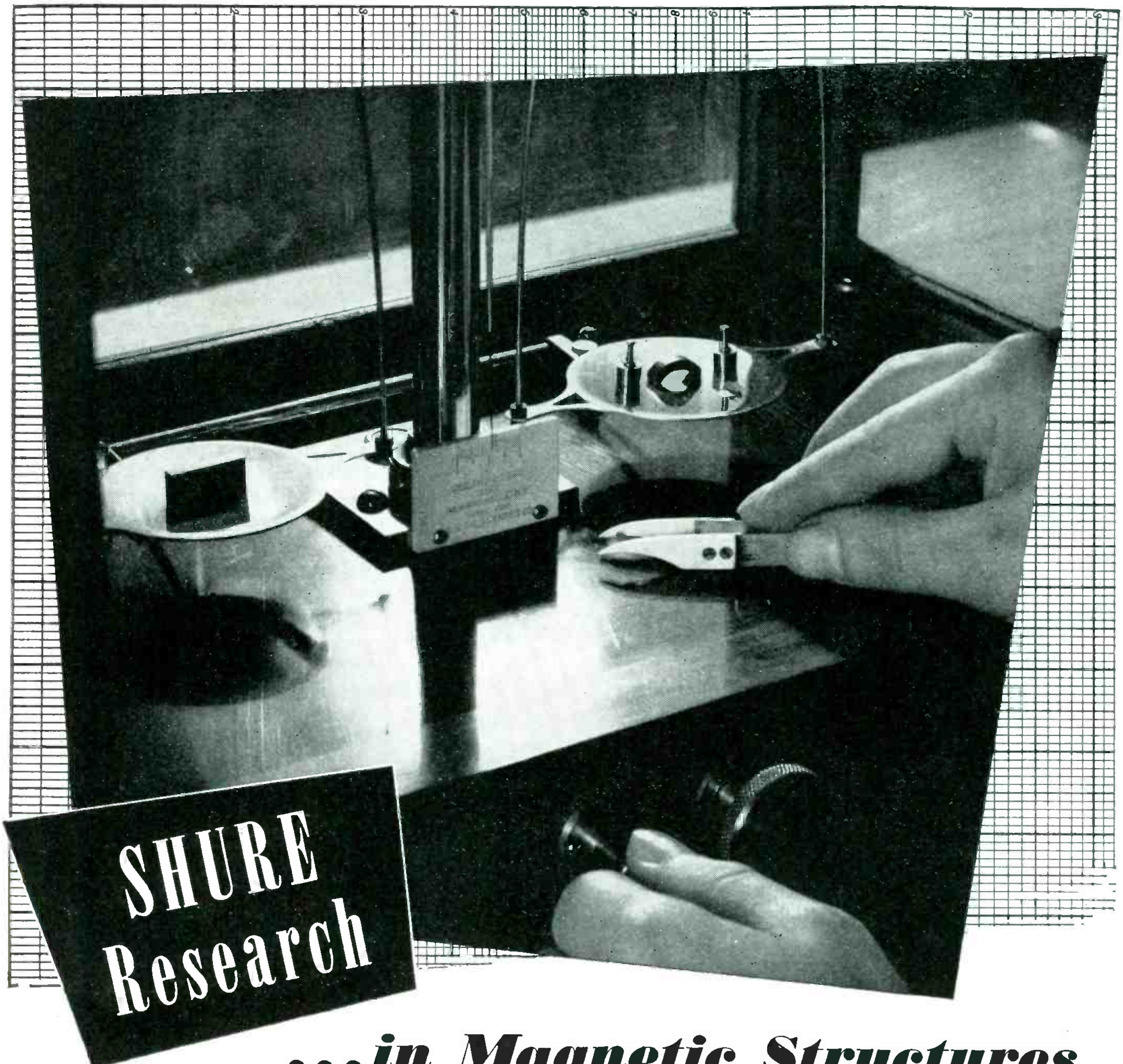
Position Reporting

The development of an automatic aircraft position reporter would materially contribute to the reduction of one of the major limitations of the present air traffic control system—the use of voice as a communication medium. This device would permit an aircraft to actuate a reporting mechanism as it passes each fix along the airways in much the same way as a train trips certain signals as it passes predetermined points on its route. This



The traffic clearance indicator contains a number of lamps around its circumference to indicate the various flight levels on which the plane is directed to fly by the ground station. The indicators in the center of the dial authorize movement of the plane on the ground as well as landings and take-offs

plan, briefly, would involve the use of a vertical pattern transmitter at each fix, a receiver in each aircraft to indicate the entrance of the plane into this pattern, an aircraft transmitter continuously set by a controlling altimeter and put into operation under the control of the fix pattern receiver, and a receiver at the fix capable of receiving the automatic report signals and relaying



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Designers and Manufacturers of Microphones and Acoustic Devices

SHURE MICROPHONES

them onward to the Airway Traffic Control Center. At the control center the position reports would be fed directly into automatic posting equipment and would appear in proper form and position before the controlling personnel.

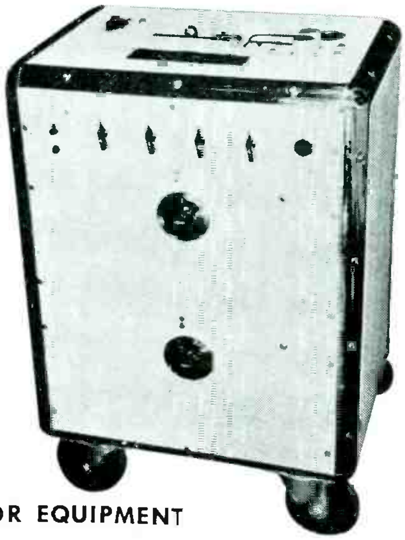
Traffic Clearance

With the establishment of automatic transmission and posting of aircraft position reports and by providing for the automatic transmission of traffic control instructions from ground personnel to pilots, voice as a communication medium could be entirely eliminated in the control of air traffic. This plan involves the storage of traffic clearance data on mechanized flight progress boards in airway traffic control centers and the automatic transmission of these data by radio at appropriate times to actuate a device in the aircraft which might be called a "traffic clearance indicator".

As visualized, the circumference of the traffic clearance indicator would be taken up by a series of lamps, one for each flight level. As the plane proceeds at an altitude for which clearance has already been received, the lamp for that level remains lighted. When a clearance to another altitude is received, the lamp for that altitude starts to flash and the lamp in the center, over the word "change", lights to attract the pilot's attention to the fact that new instructions have been received. This light is extinguished by the pilot when he pushes the "acknowledge" button, causing at the same time the transmission of his aircraft identification and the clearance as it appears on his instrument. This acknowledgment is automatically compared at the control center with the posted clearance and a disagreement warning appears before controlling personnel if an error is apparent.

Automatic Signals

The indicators shown in the center of the dial include "go", "hold", "change" and "taxi-land". The "taxi-land" light is used for airport traffic control when the aircraft is to move on the ground or to authorize a landing. "Go" authorizes a takeoff or forward progress at the indicated altitude. "Hold" calls for



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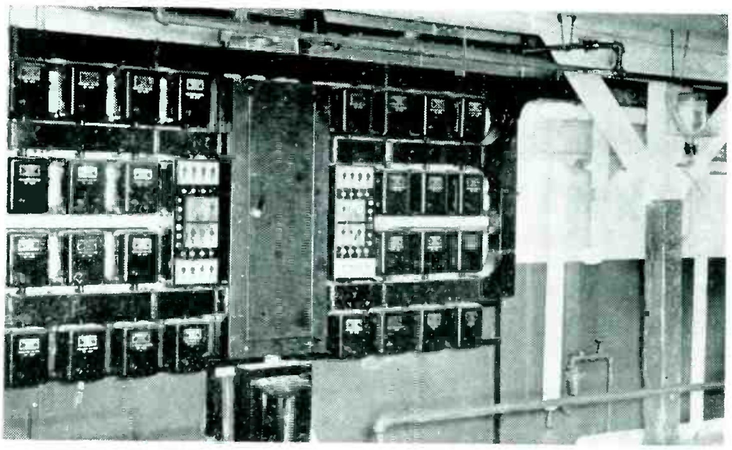

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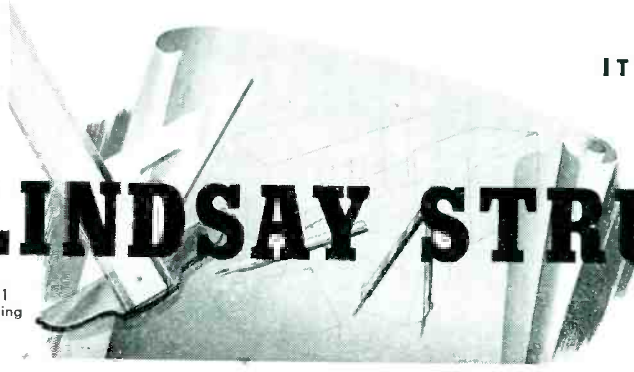

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LINDSAY STRUCTURE

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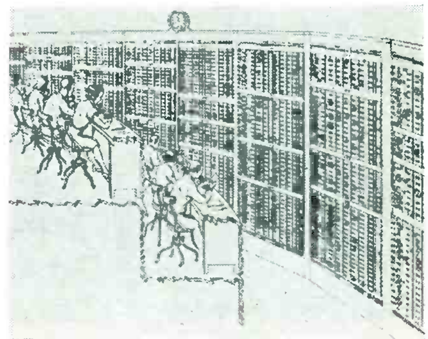
For details, see Sweet's Catalog File

TOP—Airway traffic control centers now require manual posting of aircraft positions

BOTTOM—Automatic flight data posting equipment of the future. Controllers are located on the lower level; calculators on the upper level



remaining stationary while on the airport and for maintaining the indicated altitude at the next fix while enroute.

It should be understood that transmissions will be made and a pilot's indicator changed only when the pilot must make a change in the procedure he has been following. In many cases only a brief transmission upon departure will be required plus one or more in connection with landing at destination.

In the much more distant future it may be found necessary to combine the traffic clearance indicator and the automatic aircraft position reporter into an automatic "block signal system" of a type similar to that used by the railroads. This system, as visualized at this time, would consist of marker transmitters producing a screen across the airways at block signal "fixes" 10 to 15 miles apart. An aircraft proceeding along an airway so equipped would set up a "hold" signal for succeeding aircraft at the same level which would not be can-

celled until the preceding aircraft had climbed or descended to the next level or had passed the next block signal fix along the route. Thus, the block signal system would provide a warning to prevent 2 aircraft from being in the same "block"—the airspace between 2 adjacent fixes—at the same altitude.

Ground Facilities

In planning for additional ground facilities required to control air traffic of the future, the nature of such facilities will largely be dependent upon the accepted aircraft equipment. If the automatic air traffic control devices just described are adopted, then corresponding ground facilities also must be provided.

It has been estimated that approximately 850 air stations will be required within the next few years to provide an adequate scheduled air carrier traffic pattern. This is over 3 times the present number of scheduled air carrier stops. Such a service pattern undoubtedly would require that air traffic control protection be afforded over all air space within the continental United States. It is not believed that the extension of air traffic control to include all air space will mean the discontinuance of civil airways. Rather, it is expected that civil airways will be continued as channels where a continuous heavy flow of traffic ordinarily exists. Flight outside of these channels will follow individual routes, but, nevertheless, will be afforded air traffic control protection to the same extent as is provided on the civil airways.

Basically, it is expected that the radio ranges, or comparable directional facilities, will delineate the civil airways system. Flight off the civil airways probably will be accomplished largely by use of automatic direction finding facilities.

With the establishment of automatic air traffic control devices in aircraft and with the provision of corresponding ground facilities, there appears to be but one remaining need of air traffic control which will require additional ground facilities. This is the constant portrayal of actual positions of aircraft to controlling personnel.

By the installation of "scanning

A pair of water-cooled RCA-9C21's in a 100-KW, 25 megacycle, r-f heating oscillator.

*Power output, approx., at max. ratings

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Addition to the RCA high-power family of these two new types means exceptional flexibility of equipment design both for industrial uses in the war effort now and for future broadcast needs.

RCA application engineers will be glad to assist you in applying these tubes to your problems. Data sheets on the 9C21 and 9C22 are available on request. Address RCA, Commercial Engineering Section, 592 South 5th St., Harrison, New Jersey.

RADIO CORPORATION OF AMERICA

screens" in airport traffic control towers, it appears that this requirement can be met. One screen would portray the positions of aircraft in a horizontal plane within perhaps 25 miles of the airport. The aircraft positions would be indicated by a spot of light which would be constantly moving as the aircraft positions change. Another screen would show the relationship of aircraft in a vertical plane along the path followed by aircraft when approaching the airport under instrument weather conditions. A dot appearing on this screen would indicate the altitude of the aircraft and its position in the holding flight path.

Future Procedures

It would be highly desirable if the automatic air traffic control equipment for aircraft could be light enough and cheap enough so that all aircraft flying under instrument flight rules would be equipped with these devices. However, it is expected that at least for a long time only the larger aircraft will be so equipped. The most optimistic estimate would place not more than 50 percent of the aircraft flying in instrument weather by 1950 in the category of those having full automatic air traffic control equipment. This means that the air traffic control system would have to continue to be capable of controlling a substantial amount of air traffic involving aircraft having only the minimum air traffic control equipment required at the present time.

Air Traffic in 1950

500,000 aircraft in service, compared to 30,000 before the war
600,000,000 ton-miles of freight, express and mail, 30 times present amount
10,000,000,000 passenger-miles of scheduled passenger traffic, 5 times present traffic

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The automatic devices for aircraft and the ground aids for air traffic control previously described point to the possibility of obtaining the ultimate objective of permitting the flow of air traffic under instrument weather conditions in the same volume and with the same frequency as is possible under contact weather conditions. This means that at an airport prop-

IN

TELEVISION

BROADCASTING...

RCA pioneered the development of electronic television.

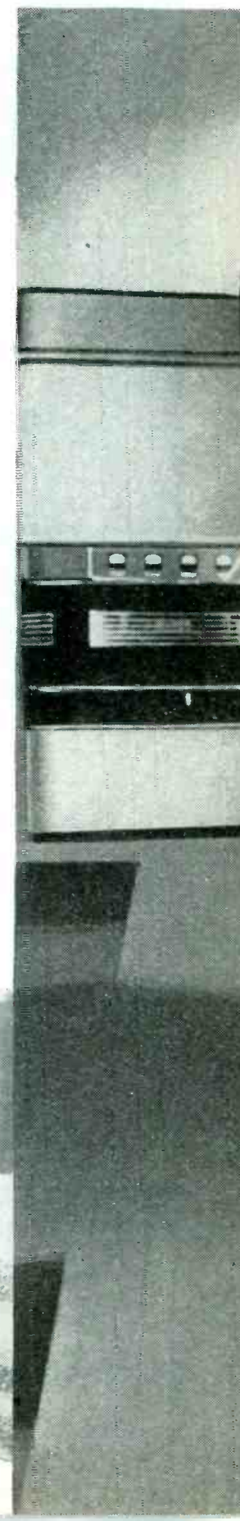
RCA engineers developed the Iconoscope, the Kinescope and the Orthicon, as well as circuits for their use.

NBC, a member of the RCA family, operates a commercial television station which has pioneered program development—a station whose programs are rebroadcast by other stations.

RCA had developed a full line of commercial television transmitting equipment before the war and had offered it to broadcasters.

RCA is now utilizing its engineering experience by building for the armed forces a large quantity of electronic equipment.

RCA will be prepared to offer for postwar service a full line of new and improved television equipment, including studio equipment, film equipment, portable equipment, relay equipment, studio-transmitter-link equipment, and, of course, audio and video transmitters.



BUY MORE WAR BONDS

RCA

RCA BROADCAST EQUIPMENT

RADIO CORPORATION OF AMERICA

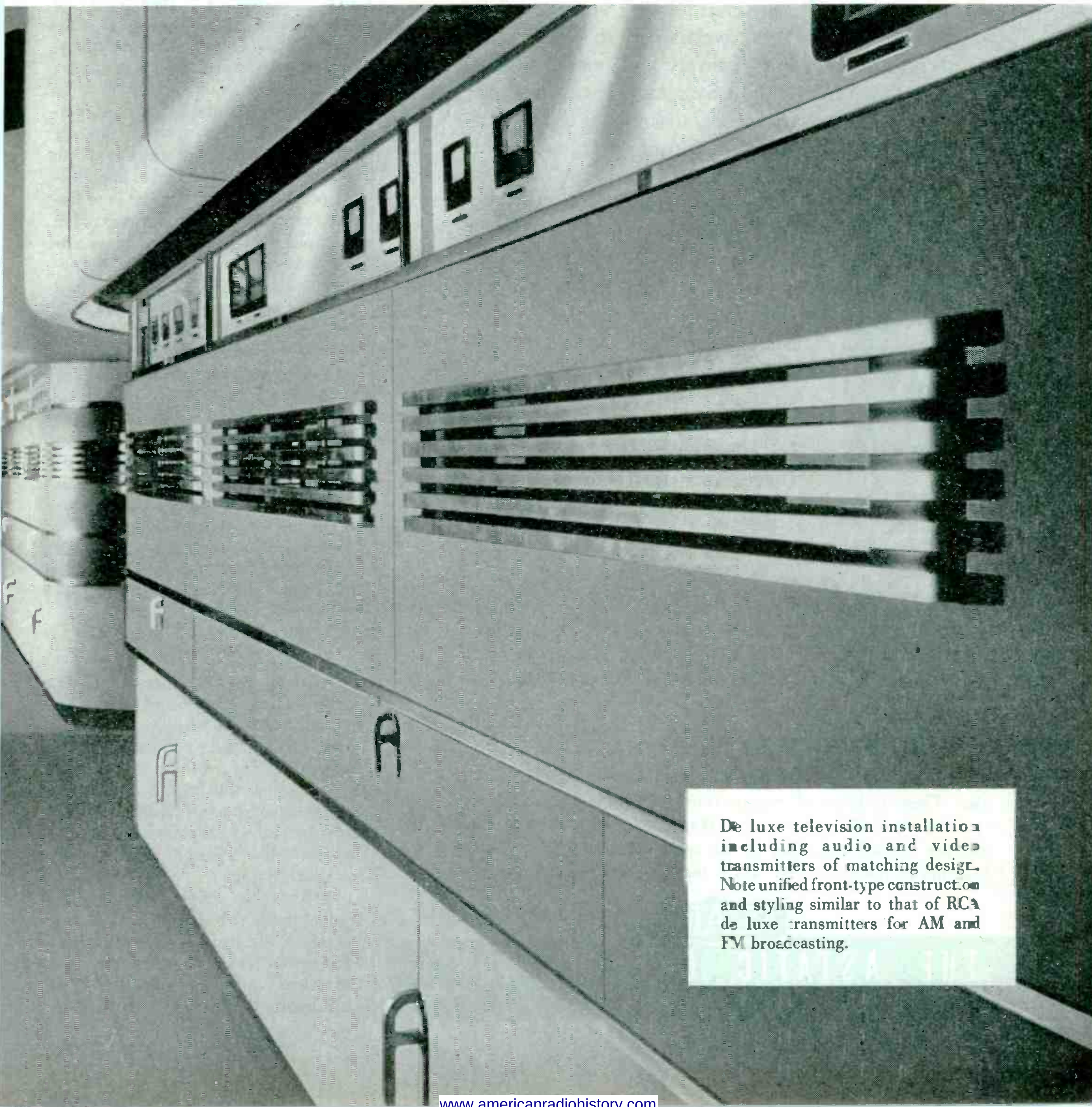
RCA installations now in operation

The de luxe-type installation shown below is one of several RCA Television Transmitters installed before the war.

All of these installations are standard transmitter models, designed and constructed to broadcast specifications and installed for regular television stations.

They are in addition to a number of experimental and relay-type television installations made by RCA as part of its own television development program.

RCA's experience in this field is unequaled.



De luxe television installation including audio and video transmitters of matching design. Note unified front-type construction and styling similar to that of RCA de luxe transmitters for AM and FM broadcasting.

erly designed and adequately served by navigational and air traffic control facilities, landings under instrument weather conditions would be possible at 50-second intervals or approximately 70 landings per hour per runway in use. Future planning seems to indicate that it will be possible for the air traffic control system within the United States to reach the level of safety and efficiency which ultimately will be required by mature air transportation.

International Aspects

Most expert opinion anticipates that post-war air transportation will develop internationally in substantial proportions. As air transportation becomes global in scope, it is increasingly apparent that world wide standards for the control of air traffic must ultimately be established if international air commerce is to develop to the fullest possible extent. An airplane flying from Moscow to Chicago, for example, would pass over areas under the control of at least 7 different countries. If each country had different systems of air navigation, different flying regulations and different systems of air traffic control, an extremely difficult if not impossible situation would result.

One of the most important phases of post-war planning for aviation is the planning of world wide standards for air traffic control. Such planning should include the formulation of navigation standards, communications standards, aircraft equipment standards, standards for flight rules and standards for control procedures.

Conclusion

In conclusion, the present basic system of air traffic control in the United States is expected to continue without radical change in the forseeable future. Improvements now planned will help, but further advancements in air traffic control must be made in the next few years to meet the expected demands of post-war flying.

Military technical developments undoubtedly will become available for air traffic control purposes, but application will be to peacetime specifications meeting different requirements than those existing dur-

Reaction of Representative Durez Compounds to Lubricating Oils
SHOWING DIMENSIONAL GAIN OR LOSS (%)

	1 WEEK				6 MONTHS				1 YEAR				
	W	T	L	Wt	W	T	L	Wt	W	T	L	Wt	Type of Material
Toluene	.00	.00	-.02	.02	-.07	-.13	-.05	-.07	-.06	.00	-.04	-.10	General Purpose
Heptane	.00	.00	-.03	-05	.07	.00	-.02	-.05	-.13	-.13	-.03	-.05	
Toluene	.00	-.07	-.02	-.09	.00	-.07	-.09	-.31	-.20	-.19	-.09	-.40	Special
Heptane	.00	.00	-.03	-.15	-.13	-.13	-.05	-.19	-.20	-.06	-.07	-.26	
Toluene	.00	.00	-.02	.03	.00	.00	-.07	-.18	-.06	-.06	-.03	-.12	Heat Resisting
Heptane	.00	.00	-.01	-.07	-.07	.00	-.01	-.14	.00	.00	.00	.04	
Toluene	.00	.00	.00	.01	.00	.00	.00	-.07	.00	.00	-.03	-.01	General Purpose
Heptane	.00	.00	-.01	-.04	.00	.00	-.03	-.01	-.13	-.13	-03	.06	
Toluene	.00	.13	.00	.05	.07	.00	-.04	-.06	-.13	-.20	-.04	-.52	Impact
Heptane	-.07	.00	.00	-.01	.00	.00	-.03	-.09	-.06	.00	-.02	.11	

W = Width T = Thickness L = Length Wt = Weight

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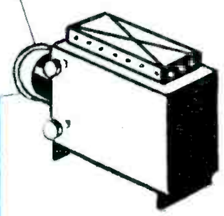

THE ACTION of OIL on Phenolic Plastics

The man who's paid to pick the best plastic material for an electrical part sometimes has to consider operating conditions where oil is present. Petroleum oils are the common problem, but there are cases where vegetable and animal oils have been a factor.

Unfortunate results have been recorded where this problem was overlooked.

Durez phenolics, when fully cured, are practically unaffected by all petroleum solvents. Their resistance to organic solvents, weak acids and alkalis is one of their most noteworthy characteristics. The Durez phenolic type of material ranks at the top of the list among all plastics for its satisfactory performance in the presence of oil.

In our laboratory, tests are going on constantly to check the behavior of Durez phenolics with all types of solvents. The two shown in the chart will be readily recognized as those which would be most indicative of any reaction to lubricating oils.

In the tests, ½x½x5" bars are weighed to the nearest milligram and measured to the nearest thousandths in the 3 dimensions. The bars are then placed in quart jars and completely submerged in the respective liquids. The temperature is maintained between 25°C and 30°C. Dimensional change and weight change are determined at end of one week, six months and one year. In all calculations the "as received" condition is taken as 100%. Upon removal from solvent, specimens are wiped dry and allowed to air dry one week before weighing and measuring. All specimens are molded with a minimum cure with no special care to obtain maximum density or strength.

This is but one explanation for the popularity of Durez phenolics in the electrical manufacturing industry. When this factor is added to other considerations—operating temperatures, conditions of humidity and electrical properties—the analysis usually points in favor of a Durez phenolic. Because of the versatility of Durez, the engineer who is looking for excellent dielectric properties, inertness to solvents and resistance to impact, high heat and climatic changes often finds that working with our staff will prove a short-cut in development work. We certainly welcome your inquiry on any plastic material problem. Durez Plastics & Chemicals, Inc., 83 Walck Road, North Tonawanda, N. Y.

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Typical Paper-Base Grades For Electrical Applications

	Grade #520 Nema Grade XXX	Grade #550 Nema Grade XX	Grade #750 Nema Grade X	Grade #770* Nema Grade P	Grade #772 Nema Grade P	Grade #774 Nema Grade XXP	Grade #776 Nema Grade XXXP
Dielectric Strength Short Time Method 1/8″ volts/mil.	575	625	700	775	785	675	600
Power Factor at 10^6 cycles/sec.	.033	.039	.045	.048	.057	.035	.022
Dielectric Constant at 10^6 cycles/sec.	4.8	5.1	5.6	5.5	5.9	5.0	4.8
Loss Factor at 10^6 cycles/sec.	.158	.199	.250	.264	.336	.175	.106
Tensile Strength, lbs. per sq. in.	11,000	12,000	15,000	11,000	11,000	10,000	9,000
Flexural Strength, lbs. per sq. in.	16,000	17,500	23,000	18,000	18,000	15,000	13,000
Compressive Strength, lbs. per sq. in.	39,000	40,000	44,000	38,000	38,000	35,000	32,000
Moisture Absorption, 24 hr. immersion, 1/8″, %	0.70	1.10	1.90	1.60	1.80	.087	.050

NOTE: All tests were made in accordance with the latest A.S.T.M. test specifications.
All values represent average test figures.
*Special radio grade punching material with better electrical properties than Grade 772.

Complete technical data on PANELYTE Plastics and performance records are available. Test samples furnished upon request. The expanded facilities of the PANELYTE plant, and new manufacturing techniques developed by our engineering staff, permit the mass production of the most intricate parts — molded or fabricated in strict accordance with specifications. Our comprehensive knowledge, gained through long and close cooperation with leading manufacturers in the electrical field, may be of help to you. This assistance is yours either on immediate problems or in planning for peace-time markets.

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ing wartime. Automatic air traffic control devices must be perfected which will make it possible for pilots to exercise a substantial amount of traffic separation on their own responsibility. These devices also should eventually make possible the elimination of voice as a communication medium in the control of air traffic.

Comprehensive planning must be accomplished so that air traffic control, both domestic and international, will not become a bottleneck in the future development of air transportation.

• • •

Electronic Octane Tester

AN ELECTRONIC octane rating indicator for use with internal combustion engines was described by Alfred Crossley, Chicago consulting engineer, before the Chicago Section of IRE in January. He stated that application of the direct-reading instrument has proven extremely useful in the development of gasolines having octane ratings higher than have been previously available.

The principle of operation depends upon the fact that the ideal internal combustion gasoline engine operates on an Otto cycle such as that shown at (A) in Fig. 1, in which a smooth curve may be drawn between *e* and *f* during expansion of the gas within the cylinder. Actually, the expansion curve contains a number of oscillations of comparatively high frequency

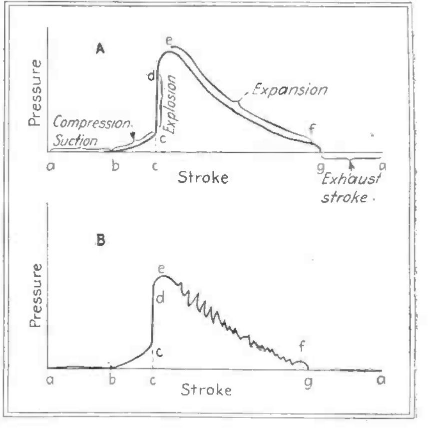
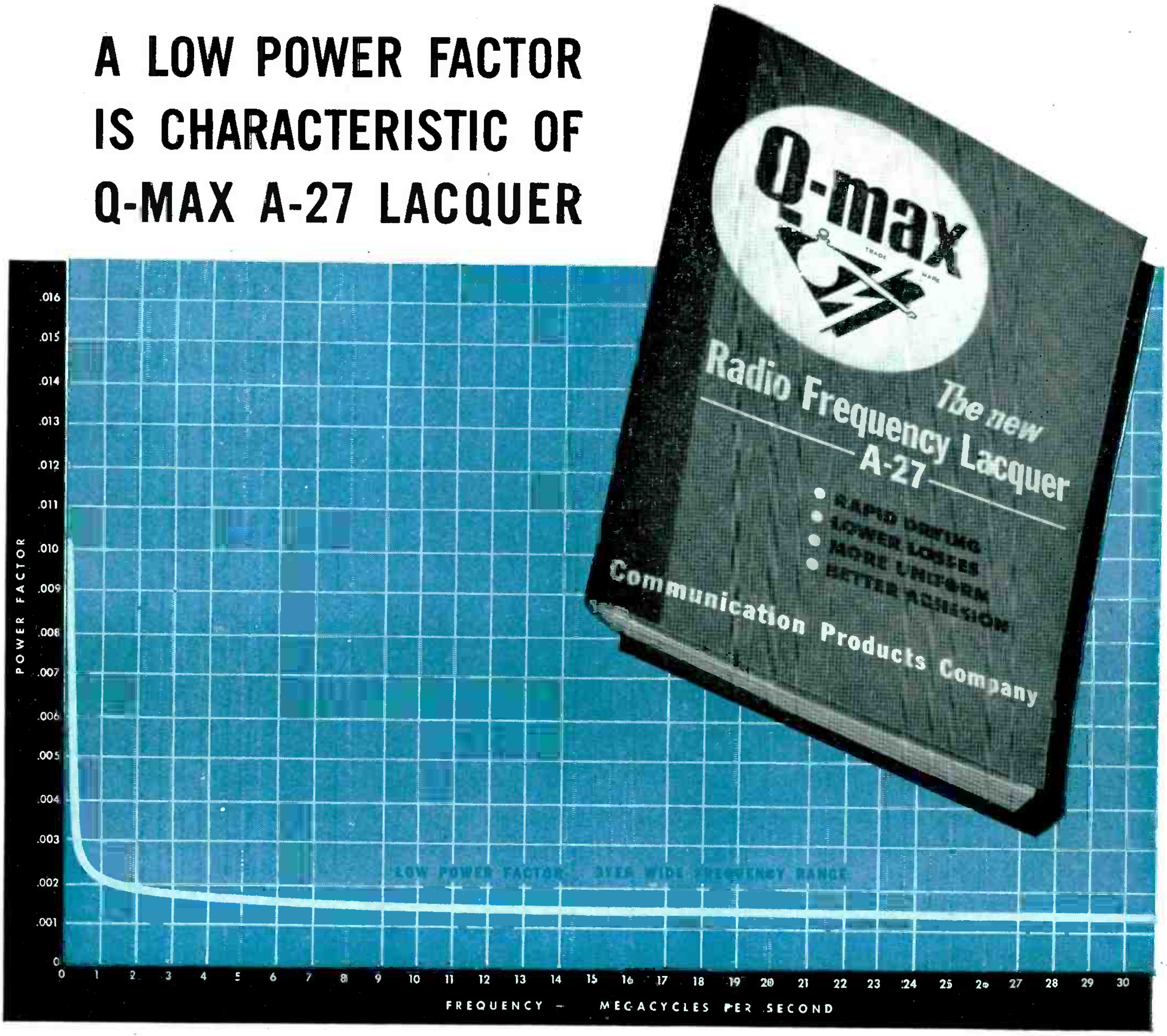


Fig. 1-(A)—Curve of an Otto cycle for an ideal gasoline engine. (B)—The portion of the curve during the expansion period (from e to f) actually contains high-frequency oscillations of about 6,500 cps

A LOW POWER FACTOR IS CHARACTERISTIC OF Q-MAX A-27 LACQUER



Comparison of the curves published in the new Q-Max A-27 Booklet indicates that the power factor of Q-Max, along with its dielectric constant, decreases as the frequency increases. This is a correlation to be expected, for it is known that the power factor curve reaches a maximum whenever the material undergoes any form of polarization. The power factor of Q-Max continues to decrease gradually from one megacycle up to 30 megacycles, indicating that probably no further change will take place until atomic polarization of the material occurs.

Polarization in Q-Max films, should it occur, would probably take place somewhere in the upper limit of the frequency band.

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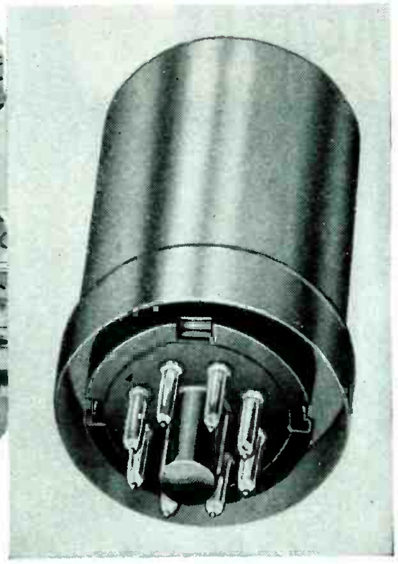


INSURES PERFECT OPERATING CONDITIONS!

PRECISE, positive action even at 40,000 feet is *normal* for this highly sensitive relay, because FEDELCO-SEAL has created an ideal operating sphere *within the housing of the relay itself*.

That is why this device can be depended upon to function perfectly under *any* condition—in the thin air of the stratosphere, in the moisture-laden atmosphere of the sea, or below it for that matter, or even in places where abrasive dust, corrosive fumes or explosive gases prevail.

Yes, the FEDELCO-SEAL method of providing ideal working conditions around the operating parts themselves makes good products *better* products, because now the element in which the device operates at its peak efficiency can be incorporated as an integral part of the unit. Ordinary air, which contains moisture, can be sealed out and a pre-determined operating condition—dry air or gases such as oxygen, helium or nitrogen under any desired pressure—can be permanently sealed in.

Federal Electric engineers will consult with you in regard to surrounding the operating parts of your products with working conditions ideally suited for the job they are required to do. FEDELCO-SEAL will enhance the reputation of your product by giving the user this *extra* in performance.

FEDELCO-SEAL may be the something new for which you have been looking. Send us details of your problem and a sample of your product, and let our engineers show you what FEDELCO-SEAL can do for you. Call or write our engineering department today for detailed information.

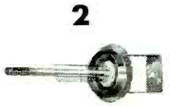
How Pre-determined Operating Conditions Are Sealed Into a Device by FEDELCO-SEAL

Example: Clare Type "K" Relay

1

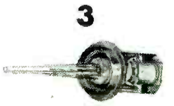
Steel base is stamped. It is shown here ready for mounting of relay assembly.

2



Glass button with fused-in lead wires is sealed to a metal ring. This ring is then brazed to a metal skirt and finally to the steel base.

3



Relay is mounted and lead wires are soldered to the contact and coil.

4

Steel enclosure is placed over the relay assembly and brazed to the base, making an air-tight assembly.

5

Vessel is evacuated. Any pre-determined working conditions . . . dry air, inert gas . . . at any reasonable pressure . . . is then introduced into the chamber. Glass tube is then sealed off as shown.

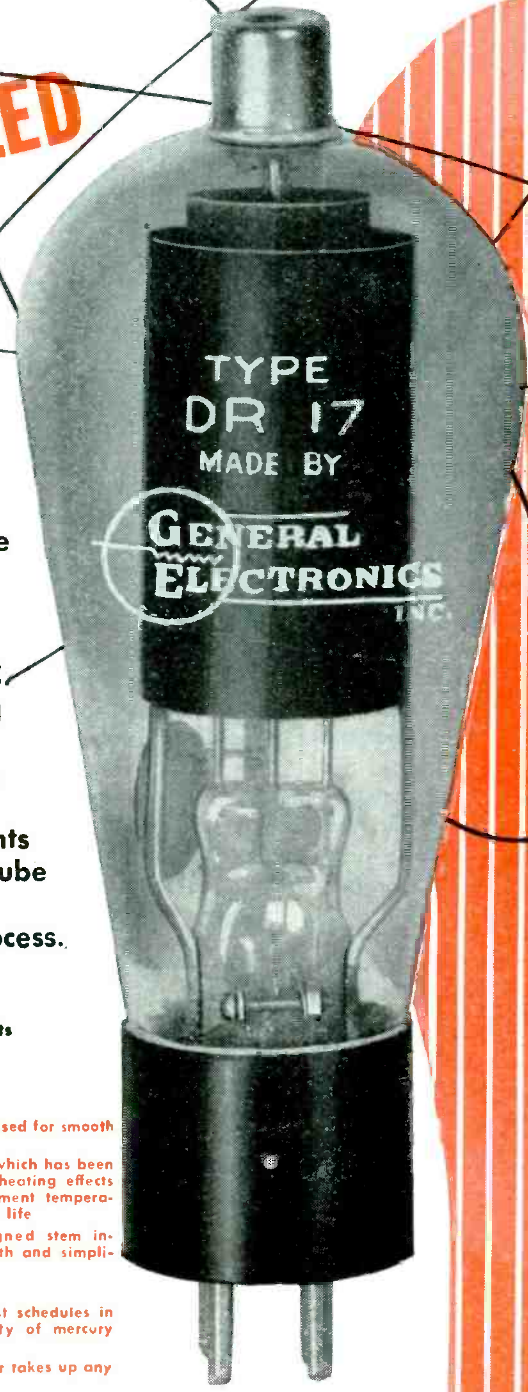
6

Octal base is placed over header skirt and wires are soldered to base pins. The relay within the housing is now ready for use under any pre-determined conditions without regard to atmosphere, pressure, or temperature.

FEDERAL ELECTRIC COMPANY, INC.

8700 South State Street, Chicago 19, Illinois

a better GRID CONTROLLED rectifier

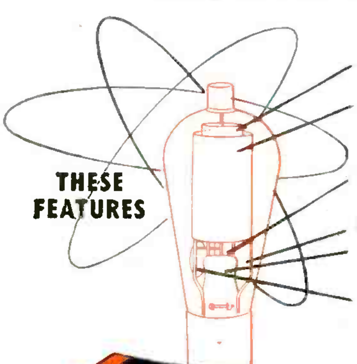


DR-17 is a most useful electronic tube combining in its use a high voltage rectifier together with a means for varying the rectified D.C. output continuously from 0 to 5000 volts D.C. This is accomplished without changing the applied input voltage and without appreciable loss in efficiency. In the DR-17 grid-controlled rectifier, this tube type has reached new heights of quality and dependability. Every tube is carefully made and inspected at each step in the manufacturing process.

RATINGS

Filament: 25 volts, 5 amperes
Average D.C. Output: Variable from 0 to 5000 volts
Average D.C. Output Current: 0.50 amperes

THESE FEATURES



A. Discharge completely enclosed for smooth control and long life.
B. Filament of a spiral type which has been designed so that mutual heating effects provide very uniform filament temperature insuring long filament life.
C. 3-pillar, specially-designed stem increases mechanical strength and simplifies construction.
D. Ample mercury provided.
E. Rigidly adhered-to exhaust schedules in manufacture insure purity of mercury vapor for tube operation.
F. Chemical getter and keeper takes up any released impurities.

GENERAL ELECTRONICS INC.

101 HAZEL STREET, PATERSON, N. J.
CHICAGO 47, 1917 No. SPRINGFIELD AVE.
EXPORT DEPT., 85 BROAD ST., NEW YORK 4, N. Y.

(in the vicinity of 6500 cycles per second) which cause engine knocking and which impair engine efficiency and operation. These oscillations are shown at (B). By measuring the oscillations during the expansion period, the successful operation of the octane rating indicator is made possible.

A pressure-operated pickup (see p. 302, Jan. 1944, ELECTRONICS) is inserted in the wall of the engine cylinder in such a manner that it responds to the variations of pressure within the cylinder. The changes of pressure vibrate a steel disc serving as the diaphragm of the pickup which is, essentially, an electrodynamic microphone. Behind the diaphragm is an iron core coil in which variations of the diaphragm induce voltages. Thus the pickup provides the necessary means of converting pressure variations into electrical energy which is then amplified to a suitable level.

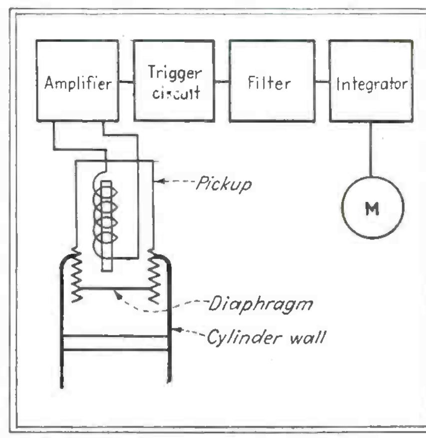


Fig. 2—Cross-section view of pressure-operated pickup in engine cylinder and block diagram of electronic stages in the direct reading octane rating indicator

A diagram of the functional elements of the octane indicator is shown in Fig. 2. The output of the amplifier is fed to a trigger circuit which maintains the electrical circuit inoperative until the pressure in the cylinder reaches the point *d* in the Otto cycle. The trigger circuit is essential in the operation of the instrument for accurate recording of knock intensity because it eliminates extraneous impulses from adding to the knock intensity indicated value.

An alternative to the trigger circuit is a mechanical contactor which is driven by the shaft of the

THE WICKED WOMEN...

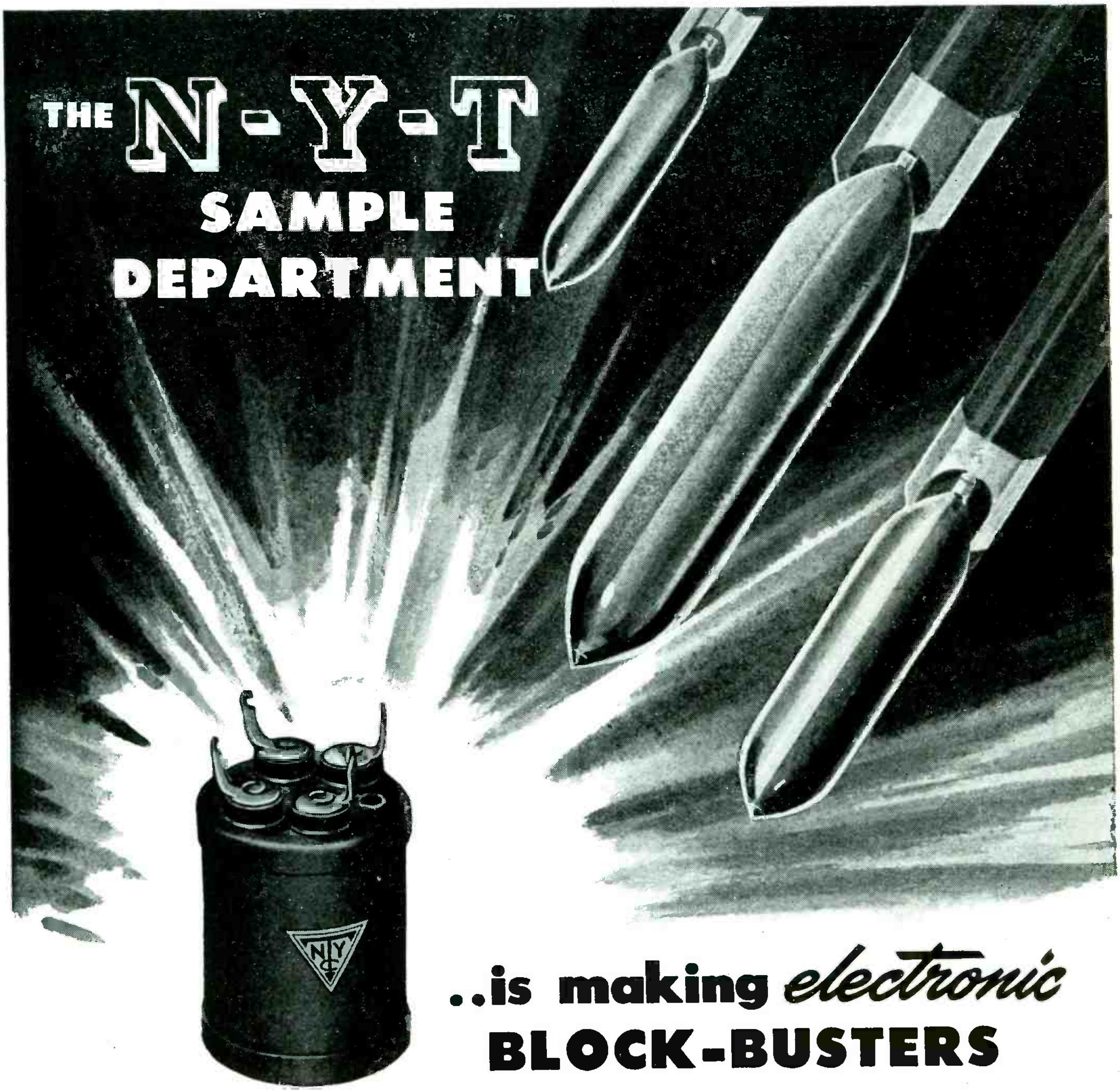
FEW women were daring enough, fifty years ago, to brave the withering blasts they faced by working. A prominent author of the time wrote: "Men still prefer and always will prefer, the home girl to any other kind. They want a girl who has not...rubbed off the peach bloom of innocence by exposure to a rough world. It will be seen how many times greater are the chances of a girl who stays at home of retaining her virtue." How times have changed! In this, our fiftieth anniversary year, more than half the people producing radios, telephones and sound equipment at Stromberg-Carlson are women! These women are becoming more and more important factors in applying the craftsmanship that enables us to say: "There is nothing finer than a Stromberg-Carlson!"

Stromberg-Carlson has complete facilities for the design and production of electronics equipment. Why not call on us now for advice and consultation on your postwar planning?

STROMBERG-CARLSON

ROCHESTER 3, NEW YORK

A HALF-CENTURY OF FINE CRAFTSMANSHIP



..is making *electronic* BLOCK-BUSTERS

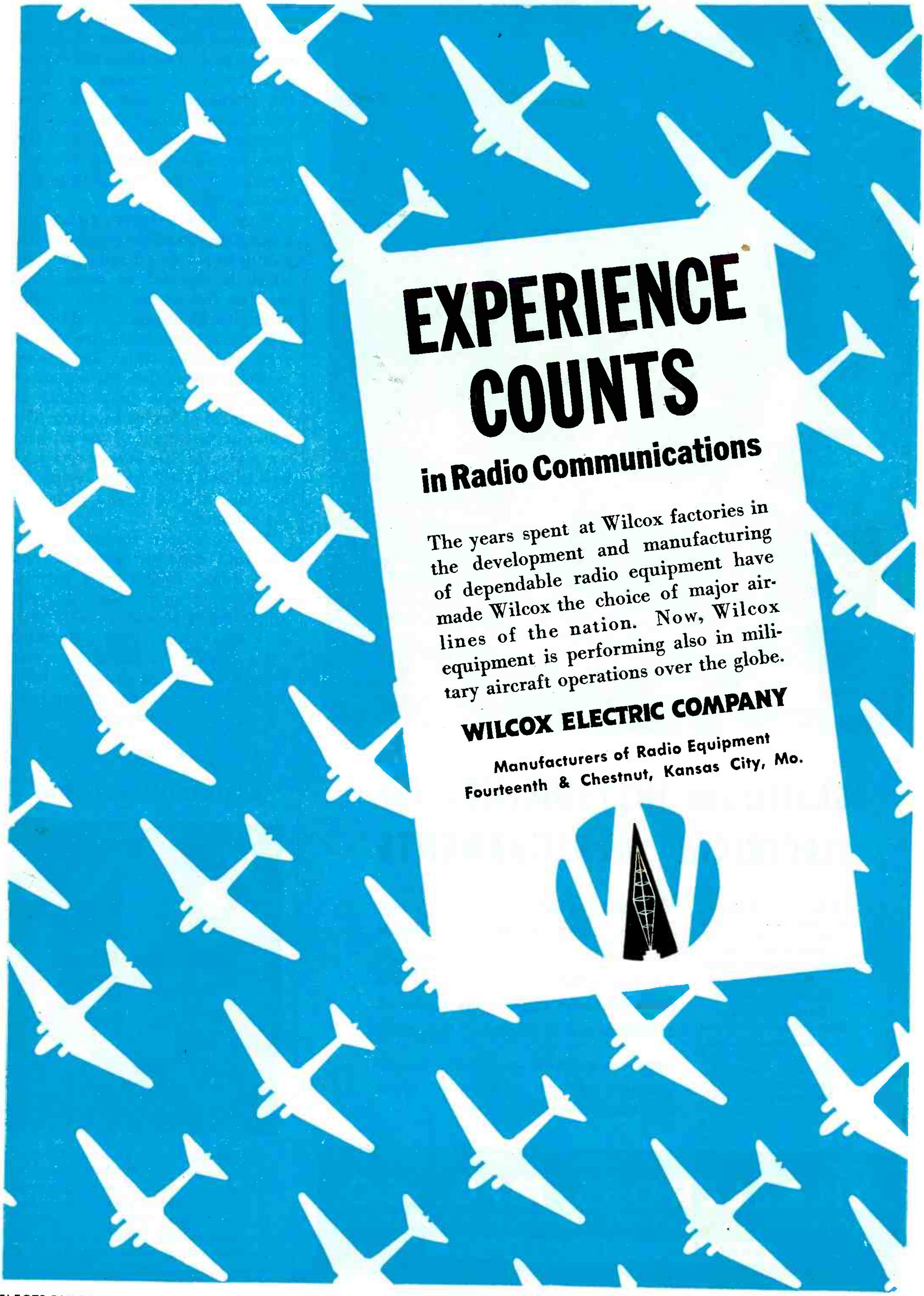
A design problem holding up some war project in electronics is no less important than a strategic enemy stronghold which must be blasted out of action. Immediate and skillful handling is essential.

Seemingly insuperable difficulties, such as climate, weight, shock, vibration, moisture, etc., assume an almost routine status at N-Y-T. Unusual frequency characteristics, critical limits on distributed capacity, immunity to surges, special shielding and regulation requirements find speedy solutions under constant testing, devising and experimentation.

Electronic "block-busters" will be needed in the post-war period, too. The N-Y-T Sample Department will be available for such assignments.

NEW YORK TRANSFORMER COMPANY

26 WAVERLY PLACE **NEW YORK, 3, N. Y.**


EXPERIENCE
COUNTS
in Radio Communications
The years spent at Wilcox factories in the development and manufacturing of dependable radio equipment have made Wilcox the choice of major air-lines of the nation. Now, Wilcox equipment is performing also in mili-tary aircraft operations over the globe.
WILCOX ELECTRIC COMPANY
Manufacturers of Radio Equipment
Fourteenth & Chestnut, Kansas City, Mo.

engine and is therefore synchronized with it at all times. The contactor may be arranged to short-cuit the pickup for all of the engine cycle except that portion for which the detonation occurs. This eliminates valve clatter and other extraneous impulses and permits the true detonation impulse to pass through the electronic circuits and be recorded.

When the trigger circuit is tripped, the amplified output of the pickup is fed to a band-pass filter which is adjusted to accept that band of frequencies which results in engine knocking. An electrical integrating circuit totalizes the energy variations which are passed by the filter, so that the output of the integrator is proportional to the amount of engine knocking. The meter at the output of the integrator measures this energy and may be calibrated in octane rating by burning fuels of known rating in the cylinder.

The integrator comprises a diode with capacitor reservoir and time delay circuit which permits the building up of detonation voltage impulses to such a value that, in a given time, their integrated value exceeds the blocking or bias voltage of the knock meter tube. When this occurs, the charge built up in the integrating capacitor

• • •

ALUMINUM WELDING

Spot-welding two .062-inch thick pieces of aluminum with 48,000 amperes of current. The ignitron welding control in the background allows the current to flow for eight cycles in this application and permits adjustment for spot-welding various other thicknesses of metal

Thinnest rectangular magnet wire

RIBBON FORMEX

NOW AVAILABLE IN SIZES ALMOST AS THIN AS THE HUMAN HAIR

The new and novel shapes of G-E Formex* magnet wire now being made for the war program are vitally interesting to makers of fine electronic and other electric components.

Heretofore, .015 inch was considered the low limit for thickness of rectangular magnet wire. Now, G-E Formex magnet wire is available in ribbon-rectangular shapes as thin as *four one-thousandths of an inch.*

Smooth, strong, flexible, and able to withstand high-speed winding without damage to insulation, the new ribbon-rectangular Formex offers great possibilities. On jobs where previously round wire had to be used, it will *substantially increase* winding space factor. It may also be used in place of larger-size, rectangular magnet wire to *increase magnetic effect* or *reduce size* of coil.

In coil winding, varnish treatment, assembly, and actual operation, this new, ribbon-rectangular magnet wire, like all other Formex shapes, offers many advantages. Note the variety of the rectangular shapes, shown at right.

For further information on the use and selection of Formex magnet wire, ask the nearest G-E office for Bulletin GEA-3911. *General Electric Company, Schenectady, N. Y.*

HERE ARE SOME OF THE SIZES OF RIBBON FORMEX

THICKNESS IN MILS	WIDTH IN MILS	NOMINAL CIRCULAR-MIL AREA	NOMINAL RESISTANCE, OHMS PER 1000 FT AT 25 DEG C
4.0	100	506	20.85
5.0	100	632	16.70
5.0	85	537	19.65
5.0	125	791	13.33
5.6	112	793	13.30
6.0	125	946	11.15
6.7	100	845	12.50
7.5	85	802	13.15
8.0	100	1007	10.50
9.5	125	1496	7.07

Every week 192,000 G-E employees purchase more than a million dollars' worth of War Bonds.

GENERAL ELECTRIC

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GENERAL CABLE
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TELEGRAM
DAY LETTER
SERIAL

"dumps" or flows over to the grid of the meter tube and causes current to flow through it; this current is indicated visually on the meter to register knock intensity.

In use, the engine is run with a fuel of known octane rating, and the electronic circuits are so adjusted that the maximum amplitude of the damped wave has some known value. The engine is then switched to burn the unknown fuel, and the deflection is again noted. A greater deflection for the unknown fuel would indicate higher knock and therefore a lower octane rating. The octane rating for the unknown fuel can then be ascertained from the ratio of the readings for the two different fuels.

The very rigid requirements of the pickup made it necessary to develop a device whose electrical output would not only be proportional to the pressure on its diaphragm but which was rugged and capable of continuous operation at temperatures as high as 350 deg. The pickup and amplifier may be fed into an oscilloscope to trace out the Otto cycle if this is required.

• • •

Electronic Control for Constant Illumination

By John K. Hilliard
Altec Lansing Corporation

High pressure mercury vapor lamps have been available the past few years as high-efficiency sources of light in the blue and ultraviolet spectrum. Lamps of this type using pressures beyond 100 atmospheres have an intrinsic brightness equal to that of the sun at the earth's surface.

The lamps consist of a small evacuated capillary of glass or quartz into which a small amount of mercury has been sealed in manufacture. The pressure of the mercury in the vapor phase depends upon the temperature of the mercury in the liquid condition. The least flicker occurs when all of the mercury is in the vapor stage and the pressure rises in proportion to the increase in temperature. In this state, slow changes in temperature cause variation in output. The lamps are cooled by air in the case of the small 100 to 400-watt lamps and by a stream of

. . . Federal's Coaxial Transmission Line Proves Its Stamina on Every Front

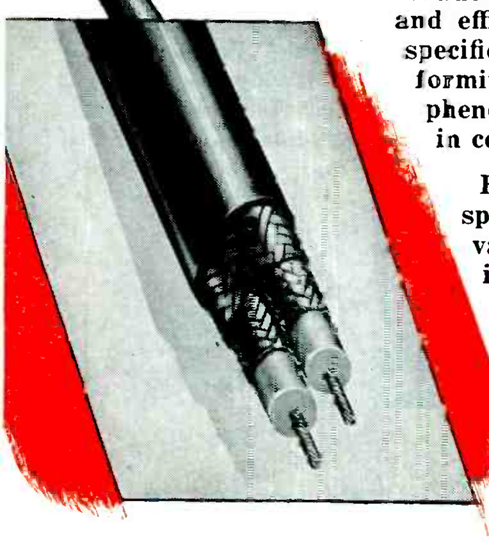
In any area of combat and wherever the performance requirements are most severe, there Federal's Ultra High Frequency Coaxial Cable measures up to every test for extreme ruggedness, strength and endurance.

Made of solid dielectric, flexible, moisture-proof and efficient in any temperature — meeting all specifications with precision accuracy and uniformity — Federal's Transmission Line embodies phenomenal characteristics never before achieved in coaxial cable manufacture.

Federal is outstanding in the field because it specializes in High Frequency Coaxial Cable, with vast experience and knowledge behind its pioneering developments. It is the largest high frequency cable manufacturer, producing in volume a range of sizes from the smallest for delicate and sensitive instruments to power cable for heavy service.

Federal's engineering skill is ready to solve any high frequency cable problem. Its productive capacity, keyed to all special demands, will make and deliver any required size, low loss, quality, Solid Dielectric Ultra High Frequency Coaxial Transmission Line.

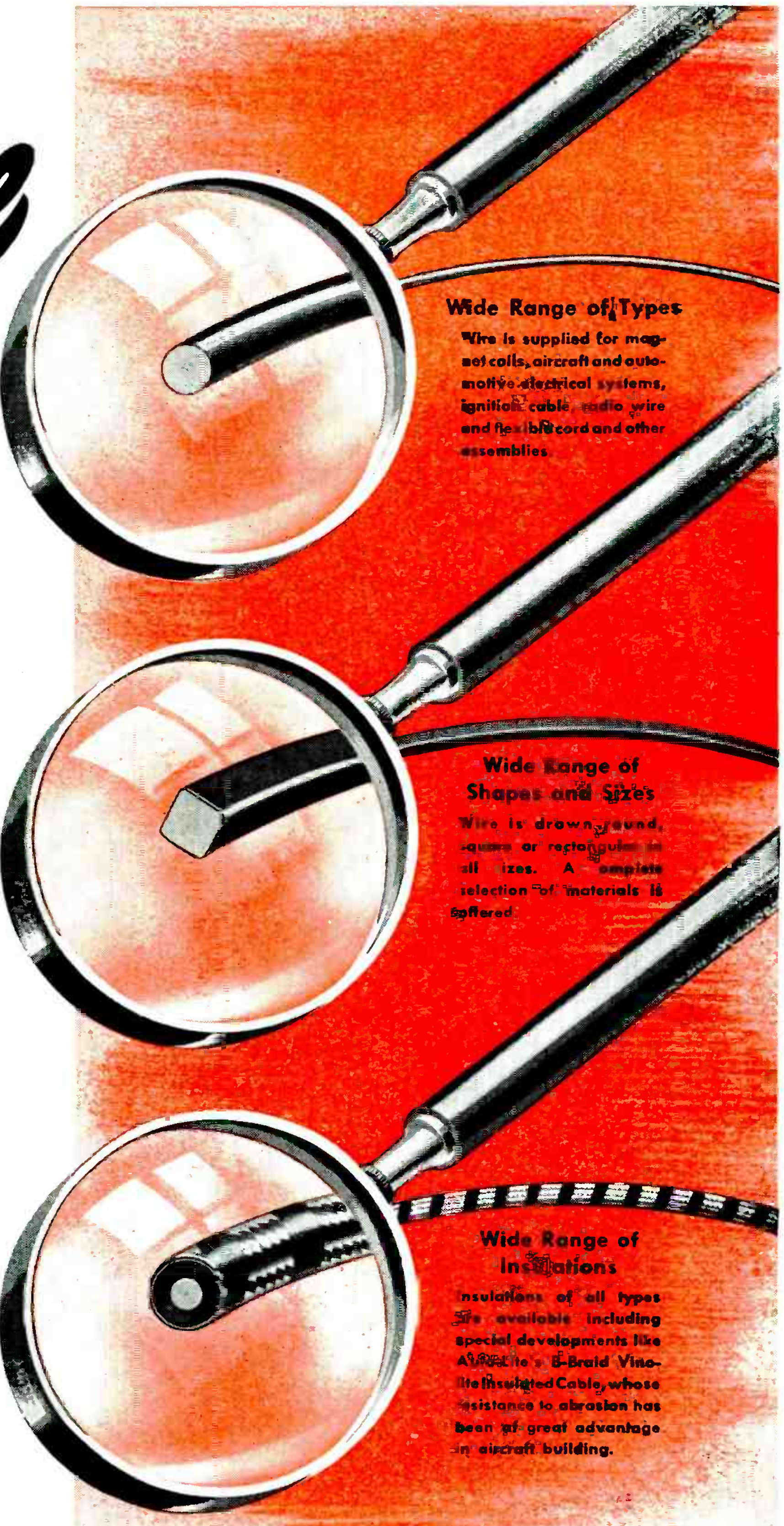
Radio Ranges and Instrument Landing Systems manufactured by Federal mark the principal air routes of the Nation and control the landing at many leading airports. Pioneers in the development of Aerial Navigation Equipment, Federal has made spectacular contributions to aviation progress.



Federal Telephone and Radio Corporation

INTELIN DIVISION — AN IT&T ASSOCIATE — Newark, N. J.

The wire you need...



You can get Auto-Lite wire and cable in a full range of sizes, shapes and materials.

The conditions for wire and cable vary greatly. Auto-Lite can supply your needs and, when it is desirable, help you determine the wire or cable which will give you best results.

Insulations of all types are available including special developments like Auto-Lite's Vega Chromoxide Enamel, an insulation of decided advantage where resistance to heat is of paramount importance.

For further information on your specific problem, write to

THE ELECTRIC AUTO-LITE COMPANY
Wire Division
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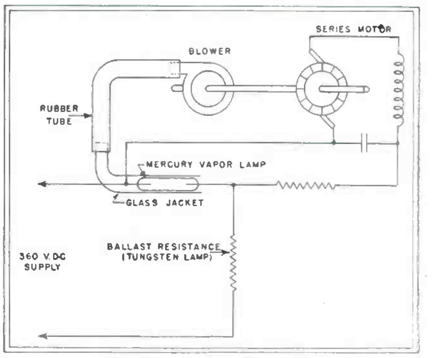
Back the Attack—Buy War Bonds

AUTO-LITE *ELECTRICAL* WIRE and CABLE

TUNE IN "EVERYTHING FOR THE BOYS" STARRING RONALD COLMAN—EVERY TUESDAY NIGHT—NBC NETWORK



Circuit for maintaining constant illumination by blowing more air around a mercury vapor lamp when the line voltage rises and less air when it decreases

water in the case of the 1-kw lamp.

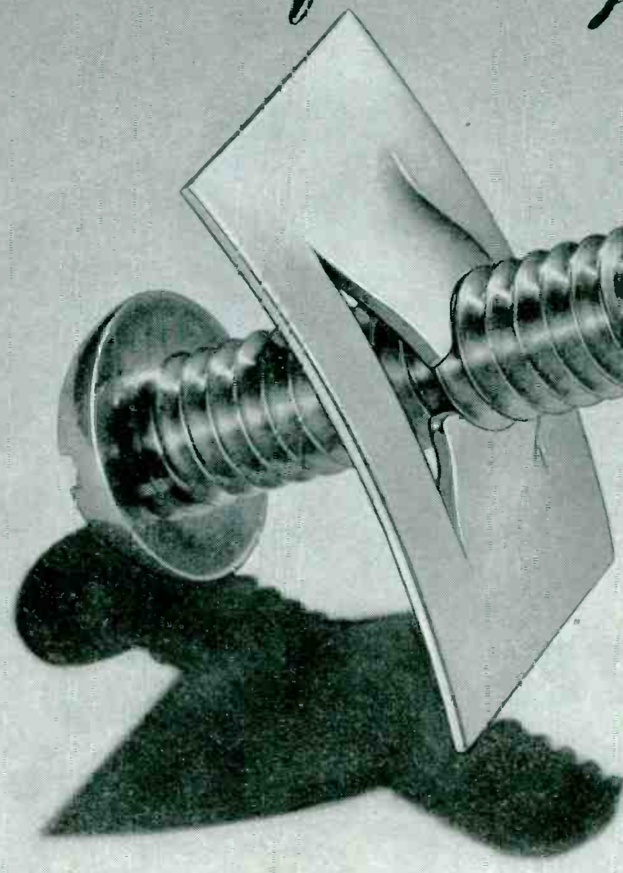
Normally on a-c the lamps are operated with a ballast reactor and on d-c with a ballast resistance. For good regulation, the drop in the ballast should be at least equal to the arc drop. In order to obtain a variable range of illumination by varying the power supplied to the lamp, some auxiliary equipment must be used.

Precise control of the air cooled lamps may be obtained by using a blower motor to force air directly around the capillary tube. The standard mercury vapor lamp is modified by removing the envelope near the base. This envelope is normally supplied around the capillary so that there will be a small amount of still air surrounding the capillary and thus keep moving air from changing the temperature of the tube and, as a result, change the illumination. A new jacket is supplied which provides for a connection to the blower on one end and an exhaustion on the other end. This method consists of using a small d-c motor placed directly across the lamp terminals to operate the fan blower. The amount of air delivered then is proportional to the square of the voltage across the arc.

Striking Arc

The motor is so selected that it will not blow air through the lamp jacket until the arc voltage builds up to at least 100 percent greater than its voltage after the arc has struck (15–25 volts). This is necessary, as otherwise, the cool air from the blower would never allow the pressure in the lamp to build up. In order to limit the starting

Speed Nuts *perform more than a fastening function*



They prevent vibration loosening by means of their exclusive Double Spring-Tension Lock that ABSORBS the vibration • They are applied faster and so reduce assembly time and costs, tremendously • They avoid use of wrenches and needless handling of parts • They are even made in scores of ingenious shapes that completely eliminate two or more parts • Their wide bearing surface removes the need for spanner washers • They save from 50% to 80% in weight • If you do not have our 20 page summary catalog No. 185, write for your copy today.

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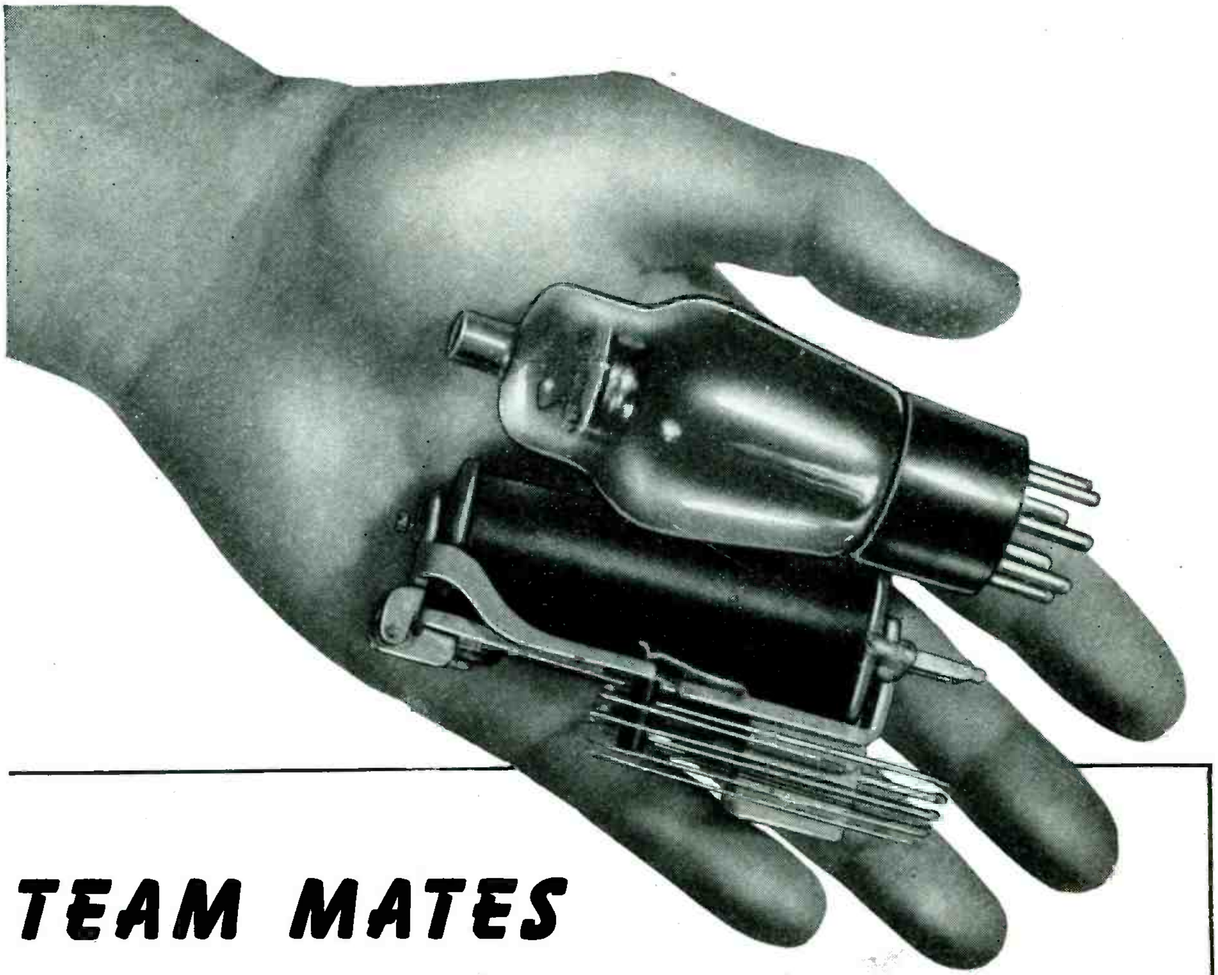
FASTEST THING IN FASTENINGS..



TEAM MATES

THAT MAKE ELECTRONS "GO TO TOWN"

HERE are two partners that have taken the "impossible" out of hundreds of wartime control problems. One is the electronic tube in its infinite variety of types and applications. The other is Automatic Electric control apparatus—the relays, stepping switches and other devices which serve as "muscles" for the miracles of electronic science. Together, they are helping to speed new electronic ideas through the laboratory and put them to practical use on the production line and on the fighting fronts.

Automatic Electric field engineers are working daily with the makers of electronic devices of every kind, offering time-saving suggestions for the selection of the right control apparatus for each job, and extending the benefit of the technique which comes from fifty years of experience in electrical control applications.

Let us pool our knowledge with yours. First step is to get a copy of the Automatic Electric catalog on control devices. Then, if you would like competent help in selecting the right combination for your needs, call in our field engineer. His recommendations will save you time and money.

Relays
AND OTHER CONTROL DEVICES
by AUTOMATIC ELECTRIC

ARMY E NAVY

AUTOMATIC ELECTRIC SALES CORPORATION
1033 West Van Buren Street
Chicago 7, Illinois
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MUSCLES FOR THE MIRACLES OF ELECTRONICS

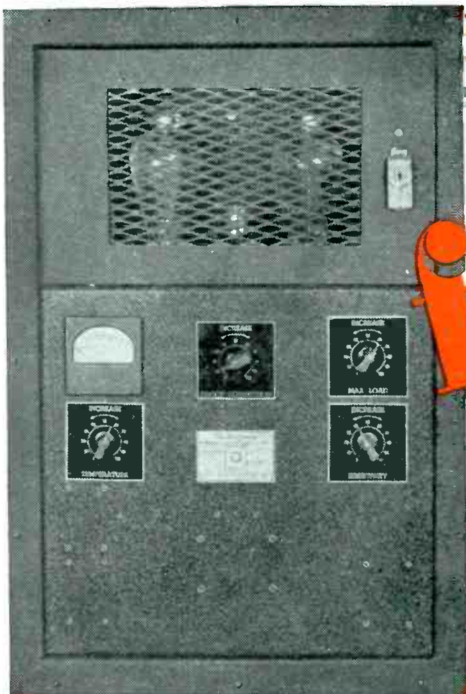
Mercury vapor lamp assembly as used in a typical motion picture printer at Paramount Pictures, Inc. for making release prints

current of the arc lamp when used on d-c, the ballast resistance is a tungsten lamp of the proper rating. Because of the positive resistance characteristic of the lamp, it permits a high current to flow until the filament becomes hot and then, as the resistance increases, the current decreases to a nominal value.

If the supply voltage tends to decrease, the motor slows down, delivering less air, the lamp heats up, decreasing the rising current to keep the voltage constant and the illumination remains unchanged. If the voltage rises, the motor speeds up and forces more air to cool the lamp and the voltage goes down and the current rises to a normal value to maintain a constant wattage and illumination. Such a regulator varies the current and voltage over a wide range and yet maintains the lamp at a given wattage and constant illumination.

Electronic Method

Another method that has been found very practical for photographic printing has been to use a photoelectrically controlled lamp in series with a resistance adjusted to absorb the difference of vol-



furnatron*

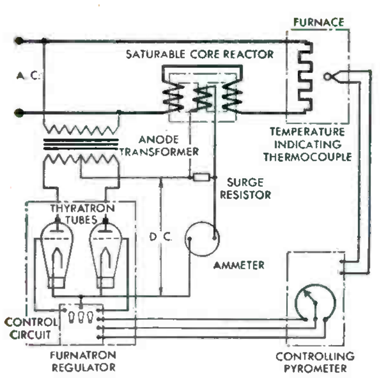
FOR ACCURATE AUTOMATIC FURNACE CONTROL

The answer to fluctuating temperatures in resistance-type electrical furnaces is provided by the new Westinghouse-developed electronic device—Furnatron*. This regulator operates to provide accurate control of the alternating current reaching the furnace, and is equally adaptable for single-phase or three-phase systems.

Furnatron is available as a separate regulator or as a complete control unit, panel mounted. The complete unit normally consists of the Furnatron regulator, a controlling pyrometer, control switches, and, in certain cases, an anode transformer. If desired, meters to indicate the power flowing into the furnace can be incorporated in the panel.

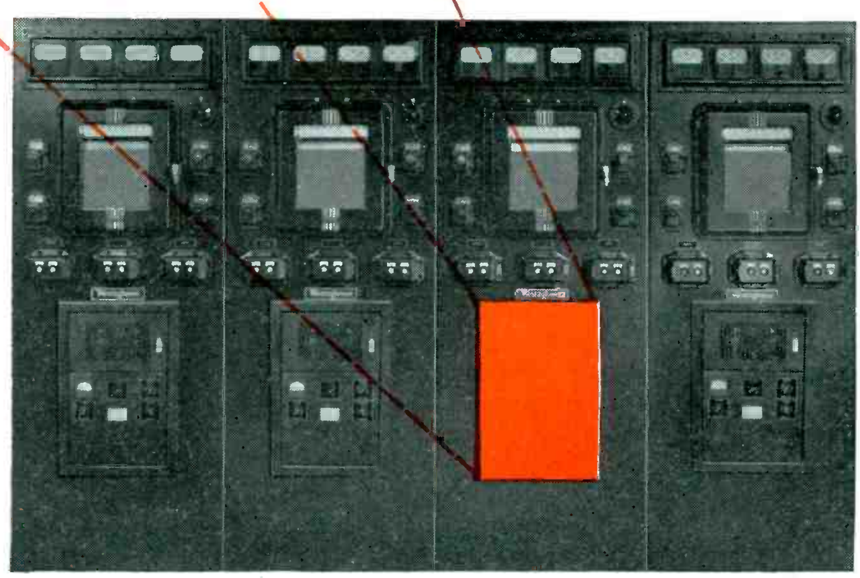
The Furnatron system of controlling the furnace temperature is the most accurate available today. Its speed of response is limited only by the pyrometer and furnace itself. For complete details, call your nearest Westinghouse representative. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania. J-60546

*Trade-Mark Registered



HOW THE FURNATRON WORKS

Fundamentally, the Furnatron regulator automatically controls the saturation current of a saturable core reactor connected in the furnace element supply line. The Furnatron functions as an electric rectifier, to supply d-c power to reactor core, and thereby adjust the line voltage to the furnace. The flow of current is adjusted automatically, in accordance with the indications of a controlling pyrometer which operates in conjunction with a thermocouple in the furnace.



Westinghouse

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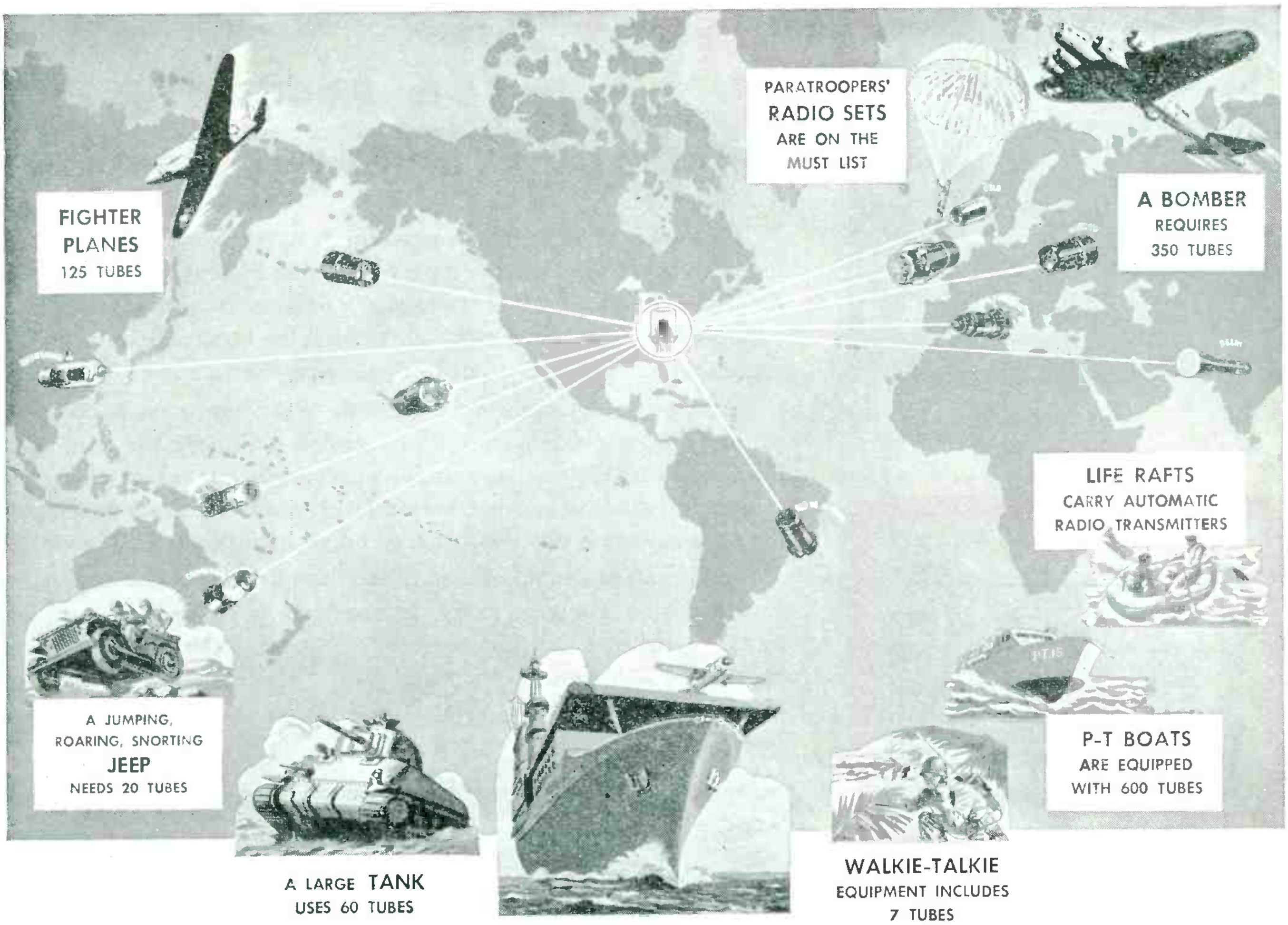
electronic controls

Westinghouse ELECTRONICS

KEN-RAD
ELECTRON TUBES



KEN-RAD

Every ship that sails the sea every plane that flies the air every tank in every terrain must first have its full complement of electron tubes

Years before Pearl Harbor Ken-Rad tubes were shipped to sixty countries on every continent and to major islands in every sea In war or peace Ken-Rad serves the world

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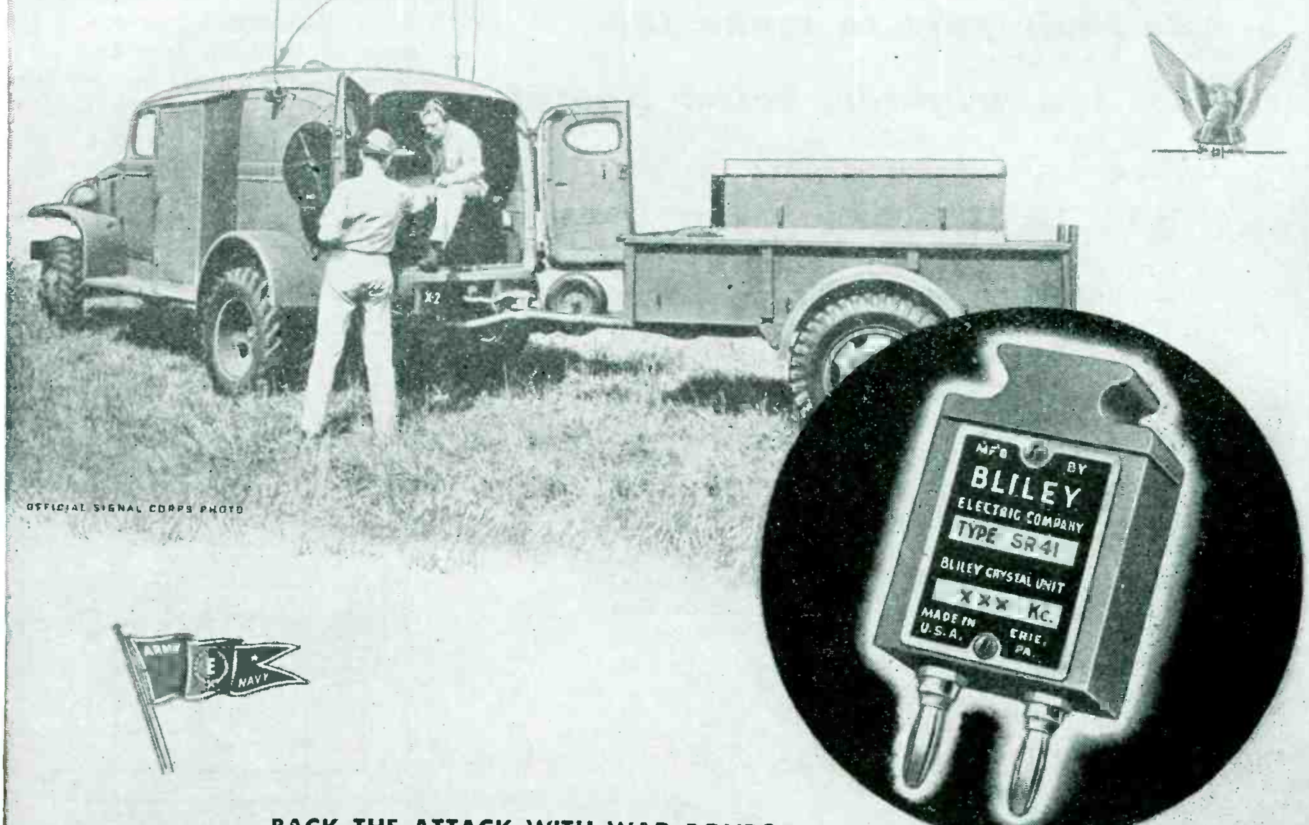
BLILEY CRYSTALS
RIDE WITH THE SCR-299
Built by hallicrafters

ONE of the outstanding achievements in wartime radio transmitter design is the SCR-299. Serving equally well as a mobile or stationary radio station, this now famous equipment is doing a real job on our battle fronts.

This war is run by radio. The vital importance of maintaining reliable communications necessitates the selection of quartz crystal units that are accurate and dependable. Bliley Crystals are engineered for service . . . they are used in all branches of military communications and are, of course, supplied for the SCR-299.

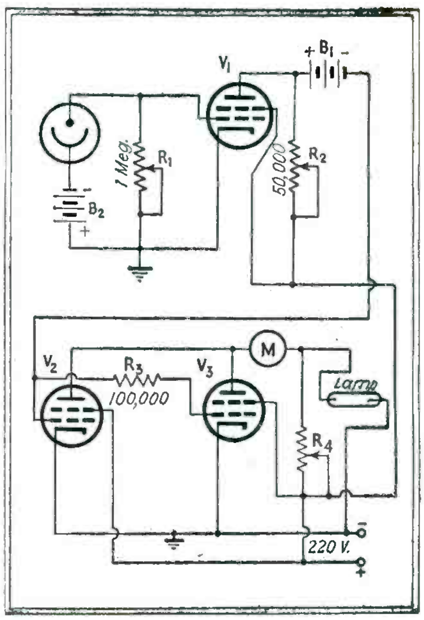


BACK THE ATTACK WITH WAR BONDS

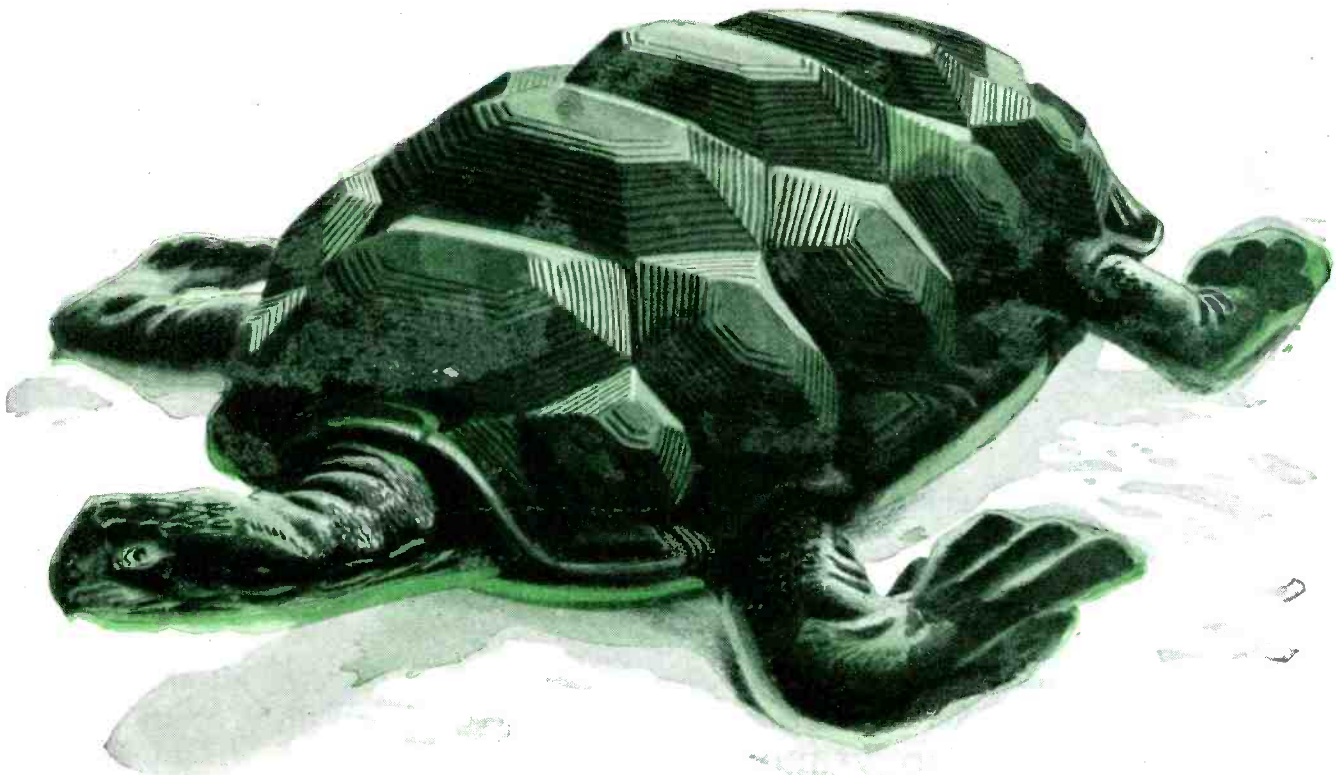
BLILEY ELECTRIC CO., ERIE, PA.

tage between the line and that needed by the lamp. This method was suggested by Hanovia Chemical & Mfg. Co. The control circuit is shown and consists of two 6L6-type vacuum tubes connected across the lamp so that the plate-to-cathode current of these tubes is in parallel with the lamp. Plate current is adjusted to approximately 75 ma, halfway between zero and the maximum allowable current. The grid voltages are then varied so as to render the tubes capable of changing the current through the lamp over the range of 0 to 150 ma. The control grids are operated by the amplified voltages from a phototube which derives its light from the optical path between the lamp and the film. A 929 blue-sensitive phototube is connected in series with a small microammeter. In this manner the meter serves to indicate exposure, and it is possible to replace lamps from time to time and be able to repeat these exposures consistently.

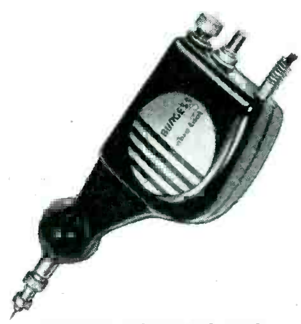
Since the maximum rating of the phototube is 20 microamperes, it is necessary to restrict the metered light to less than this amount. The voltage generated by the phototube across a resistor R_1 controls the bias on the control grid of amplifier V_1. If no current flows in the phototube the bias of V_1 be-



Circuit of electronic method of obtaining constant illumination. Variation of light causes the phototube and amplifier to change the current through the lamp instantaneously



Let's Talk About Plastic Housings



Burgess Vibro-tool with LUMARITH housing . . . shock-proof—comfortable to handle—50% lighter than metal.

When housing problems arise, take a tip from the turtle. His plastic casing is a model of good design. Light in weight, it has toughness and strength in proportion to the protection it must give—and, large or small, the housing of the turtle always fits its tenant and his operations.

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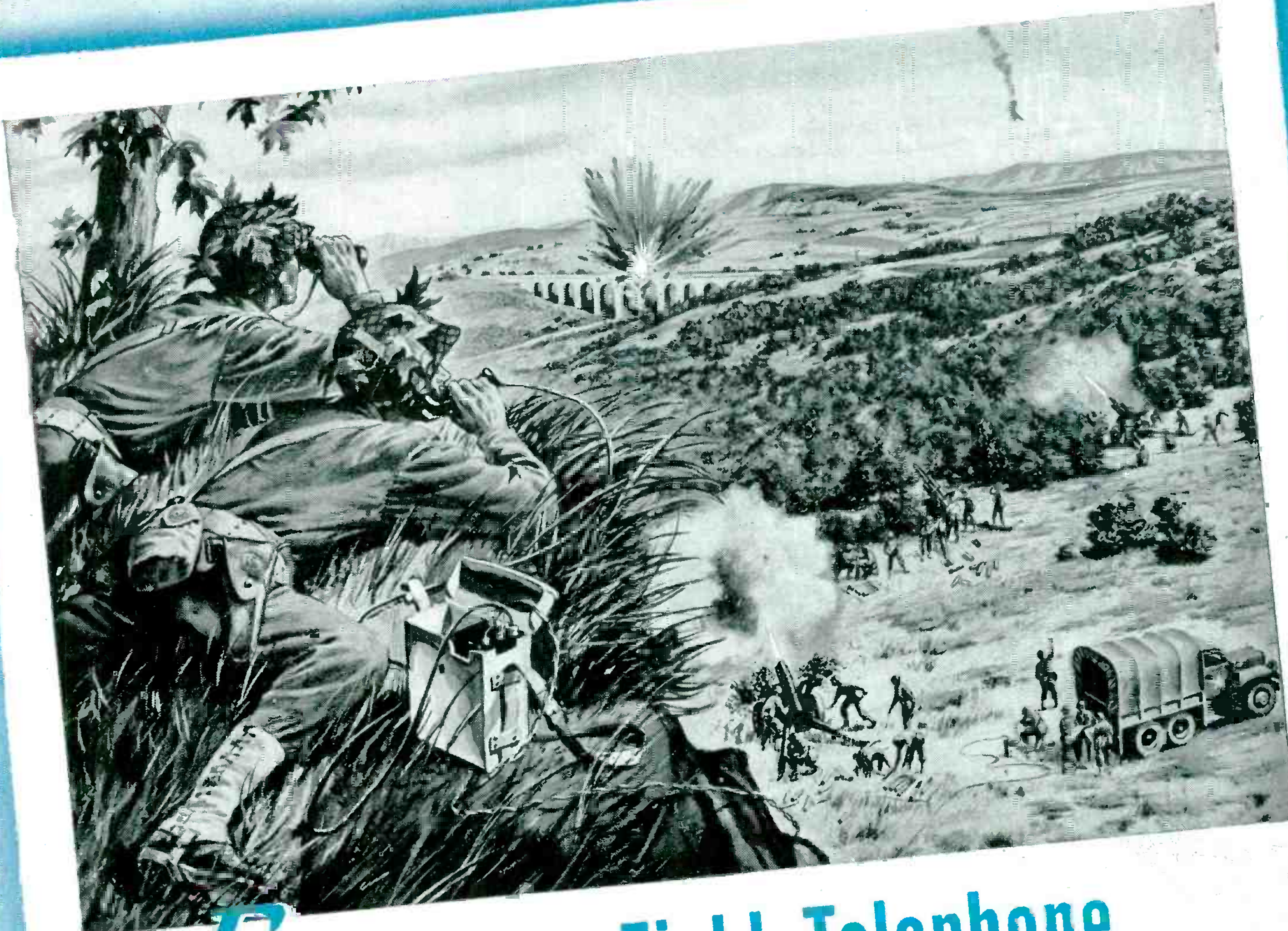

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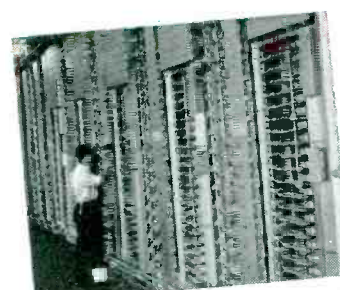

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comes zero. This allows the tube to draw current through its plate resistor, and the plate assumes a low potential with respect to its cathode. The plate of this tube is connected through a battery to the control grids of V_2 and V_3 in such a way that the grids of these tubes are always this amount negative with respect to the plate of V_1. Therefore, whenever the plate of V_1 assumes a potential less than 22½ volts above its cathode, the grids of V_2 and V_3 become negative with respect to their cathodes and the plate current is varied.

Accuracy

Since these tubes have a high amplification factor, a very small change of phototube current is capable of completely controlling the plate currents of the last two tubes, which in turn control within very close limits the exposure provided by the mercury arc lamp. The circuit is arranged so that an increase of light on the phototube will reduce the current through the lamp and correspondingly reduce the exposure of the film. Inasmuch as the operation of the control circuit is practically instantaneous, any fluctuations in the arc lamp or changes in supply voltage that might vary the exposure are suppressed. This type of control circuit operates very satisfactorily with low-voltage mercury arc lamps of 100 and 250-watt size and permits the use of mercury lights from a 220-volt d-c supply.

The motor blower control method permits accurate control over a range of 50 to 150 watts with the 100-watt lamp while the phototube method is limited to approximately plus and minus 10 percent of the rated 100-watt unit. Both of these methods can be used for lamps of different sizes by changing the constants of the control circuits.

Operation of both types of control over a long period of time has indicated that it is possible to hold the illumination such that the variation will be not greater than 1 to 2 percent as a result of a change in line voltage, room temperature or age of the arc lamp.

Mercury arc lamps with this type of control are particularly suited for printing motion picture film since the spectrum of the lamp (violet and ultra-violet) is in the

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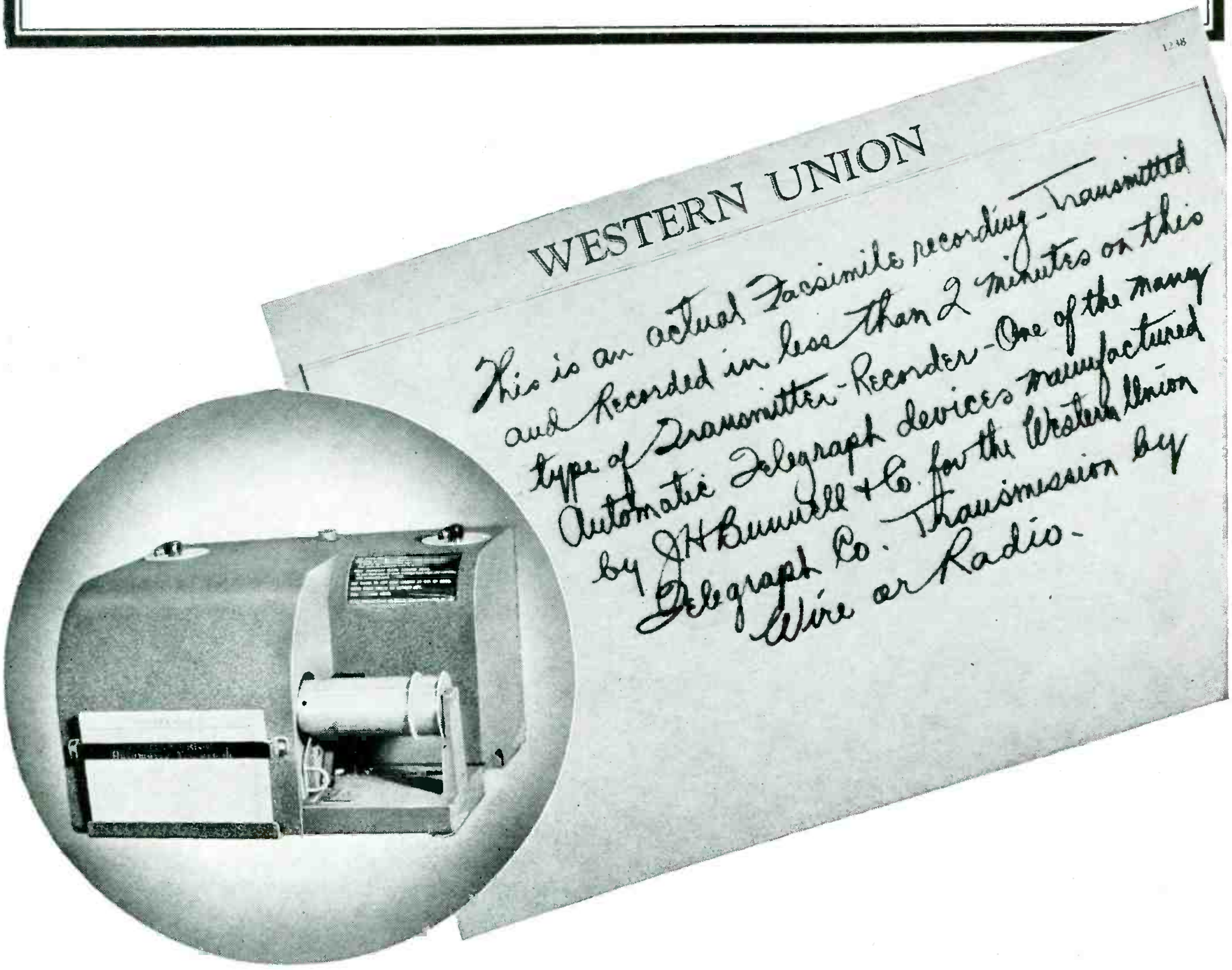

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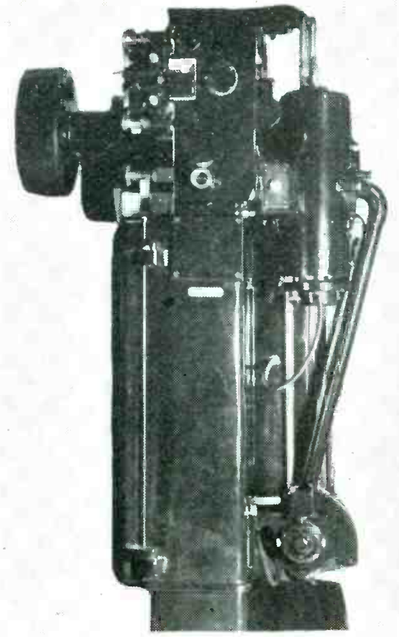

This motion picture printing machine contains a mercury vapor lamp at upper right and a motor blower for illumination control at lower right. The cylindrical pipe connects the two units

region where the film is most sensitive. For this reason only a small fraction of the wattage necessary with an incandescent lamp is required with the mercury lamp to obtain the necessary exposure. This reduction in power permits cooler operation of the optical system as well as less chance for the film to buckle or shrink as is sometimes the case when high-powered incandescent lamps are used.

The extensive use of fine grained films which have a speed from one-half to one-tenth of regular positive stock has been considerably advanced by the mercury lamp and control, and several commercial film laboratories use these methods to print hundreds of millions of feet of film per year. Film is now printed at a speed of 500 to 1000 feet per minute as compared to the common speed of 75 to 100 fpm used for years by the commercial laboratories. Use of fine grain duplicating stocks of very slow speed is encouraged by the mercury arc lamp method.

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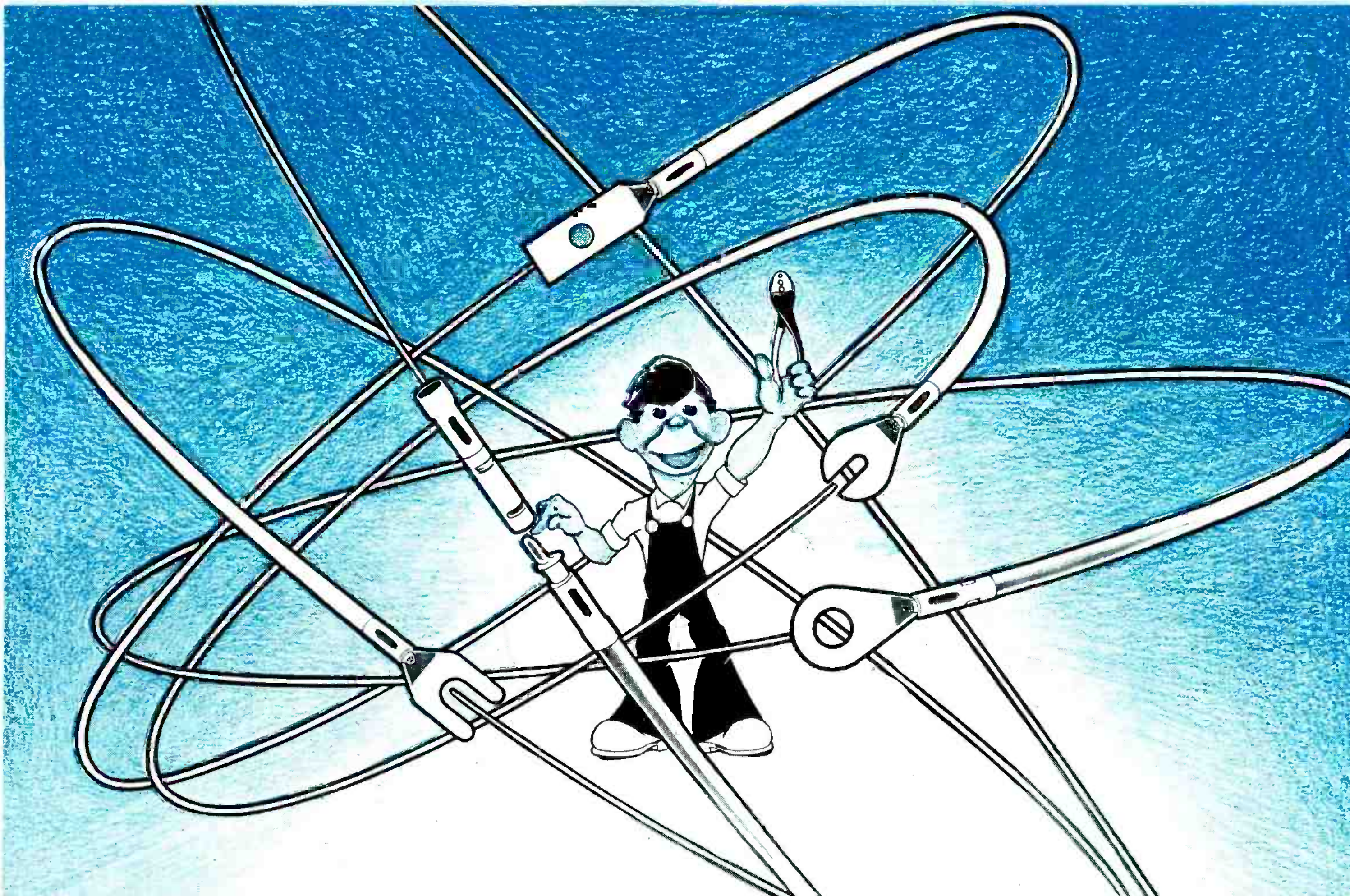

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Supersonic Fundamentals

(*Continued from page* 125)

negative charge by virtue of the L and C oscillation. To allow the tube to conduct at any other time would weaken rather than strengthen the resonance.

It is in this timing that the properly chosen length of the rod is important. At the time when a maximum current flows in the plate coil, that end of the rod becomes magnetized and by virtue of the attractive force of magnetization the molecules are drawn closer together so that the rod shrinks in length. This mechanical shrinkage is in reality an acoustic disturbance, and the effect travels down the rod with an acoustic velocity to the grid coil where a voltage is induced.

With polarities properly connected, the time of travel along the rod is just right to cause the grid to pass charge to the plate at the proper time and in the proper amount. The result of all this is that when the circuit is in operation the rod contracts and expands in a periodic fashion and its ends serve as a suitable supersonic source.

From what has been said, it appears that the higher the frequency of a magnetostriction oscillator, the shorter must be the magnetostriction rod so as to introduce less delay in the feedback. The velocity of sound in nickel, for example, is about 5,000 meters per second. At 60 kc this corresponds to a wavelength of only slightly greater than 8 cm, so that a magnetostriction rod of about 4 cm length is required. Any shorter rod than this makes it impossible to locate the coils with sufficient accuracy while preventing direct magnetic coupling between the coils in addition to that through the magnetostriction rod. It is possible to make arrangements to work on harmonics of the mechanical frequency of the rod but only at a sacrifice of efficiency.

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waves are also of some importance. One is called a Galton whistle and is merely a whistle designed for frequencies as high as 100 kc. It is usually built with a micrometer screw adjustment of pitch.

If the input air pressure can be held sufficiently constant, it makes a reliable and simple source for use in gaseous mediums. A Galton whistle when blowing a true supersonic note is nevertheless usually detectable in the audio range because of a hissing sound of the air stream. Aside from this the emitted note is quite pure.

The other type of mechanical supersonic generator which is of some interest is one of the sort first made by Holtzmann.[3] He produced by means of the arrangement shown in Fig. 4 a frequency of 33 kc at a power level 100 times as great as can be realized with a whistle. He used a glass tube 7.5 cm long which he clamped at the center and excited into oscillation by the friction of two silk-covered leather belts.

Effects of Supersonic Waves

Some of the most striking experimental results obtainable with supersonic waves depend on the relatively large amount of power which is associated with waves of very moderate amplitude. This has been pointed out before as a reason for the difficulty in generating such waves, but when it has been accomplished strange results are rather easy to obtain.

If several watts of power flow between the source and the observer, that power is divided up among so many waves that none need carry very much and the amplitude of the vibrations in the medium may be very small. For example, in water a radiation of 0.3 watts per square cm at 40 kc requires an amplitude of vibration of 0.27×10^{3} cm, only about one hundredth of that required at audio frequencies.

Power Possibilities

Wood and Loomis[4] have generated waves in an oil bath by using a piezoelectric quartz crystal at 50,000 volts and a frequency of about 300 kc. They obtained a radiation pressure estimated to be equal to 150 grams—enough to

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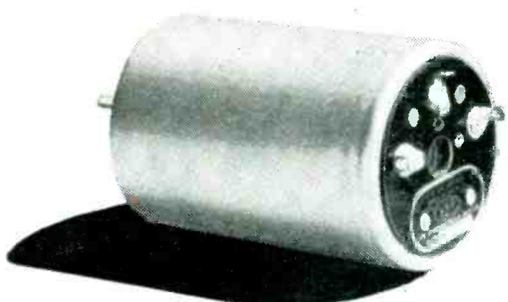

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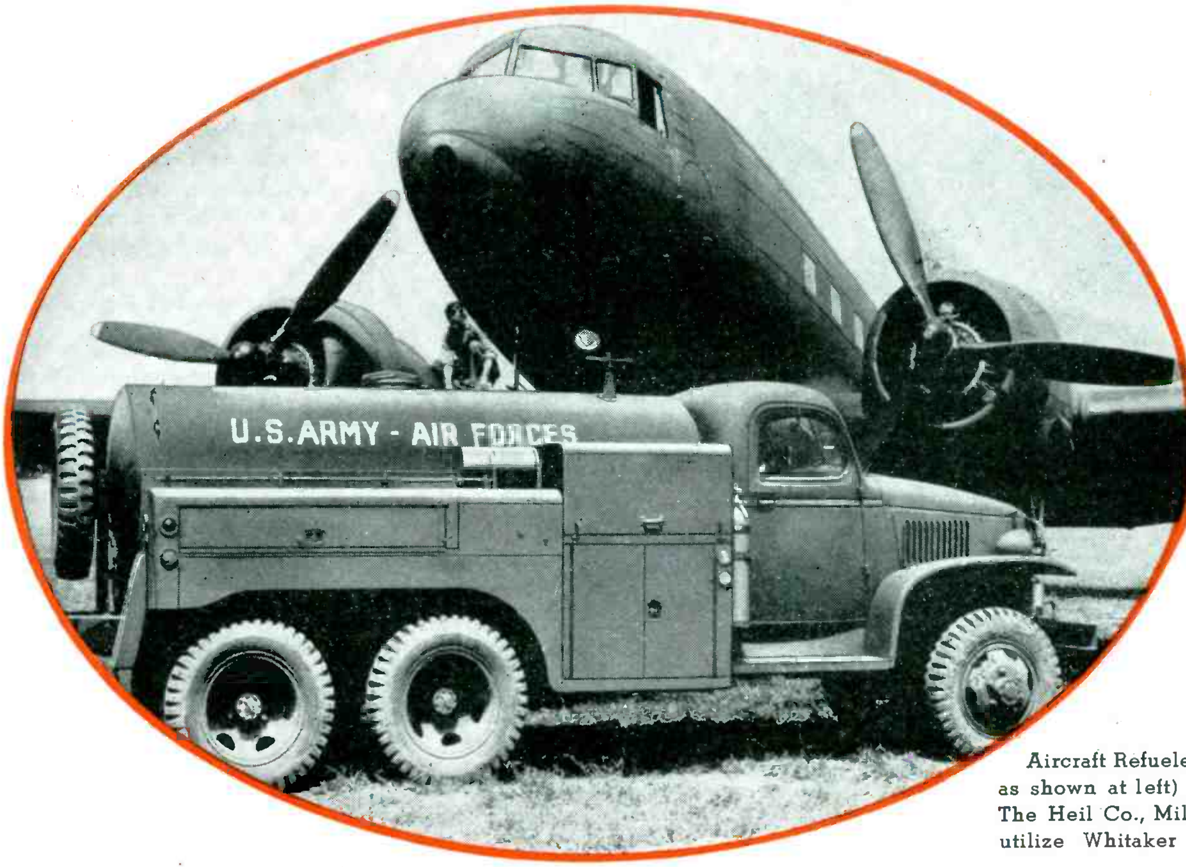

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raise the free surface of the oil into a mound 7 cm high.

Without especially large vibrations, it is possible to transmit enough supersonic energy through a small rod so that a painful burn is obtained if the rod is squeezed with the fingers. It is because of these rather large amounts of energy transmittible by supersonic waves that the process has become so useful in making unusual and very fine emulsions.

Geometric Supersonics

Another interesting set of supersonic phenomena depends upon the fact that the wavelength is as small or smaller than the dimensions of the apparatus. This means that such instruments as acoustic interferometers may be conveniently built. Also, as in geometric optics, line constructions may indicate rays and wave fronts. In fact, geometric supersonics is even easier to work with than equivalent optical cases, and much less precision can be used in the construction.

Mirrors of convenient dimensions may be used to focus the energy or to act as reflectors behind a point source such as the end of a magnetostriction rod. Whereas with audible frequencies it is difficult to limit echoes and unwanted reverberations, with supersonic waves the apparatus is small and the reflections can be easily handled.

An immediate demonstration of the realness of the elastic waves that travel through a liquid excited by a supersonic source is furnished by a change in the optical properties of a liquid which is so disturbed. Points along the wave at which the medium is most compressed may become nearly opaque. The arrangement is shown in Fig. 5. The presence of the supersonic waves cause the liquid to act like a diffraction grating and the light is diffracted into its characteristic spectrum.

REFERENCES

(1) *Proc. American Academy* **60**, p. 271, 1925.
(2) Loomis and Hubbard, *Jrl. Optical Soc. Amer.*, **17**, p. 295, 1928; *Phil. Mag.* **5**, p. 1177, 1928.
(3) Holtzmann, M., *Phys. Z.*, **26**, p. 147, 1925.
(4) Wood, R. W., and Loomis, A. L., *Phil. Mag.*, **4**, p. 417, 1927.

THE ELECTRON ART

VHF Use of Oscilloscopes

By Stanley Cutler

Project Engineer
Radio Division, Air Associates, Inc.

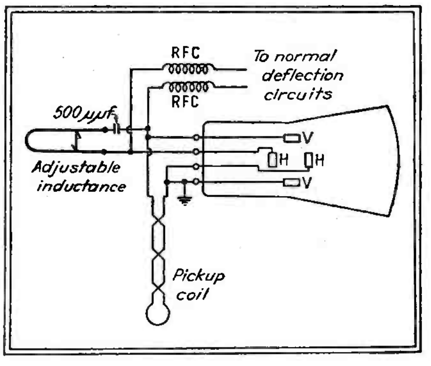
THE CATHODE-RAY OSCILLOSCOPE has been universally recognized as one of the best means of rapidly investigating the characteristics of amplitude-modulated r-f amplifiers.

Unfortunately most available commercial oscilloscopes are not too satisfactory for this application when used at frequencies above 50 Mc, inasmuch as it is very difficult to obtain a straight vertical trace when the voltage is applied to the vertical plates. Considerable horizontal deflection is simultaneously produced even though no apparent voltage is applied to the horizontal plates. When sweep voltage is applied to the horizontal plates the result is a pattern in which considerable overlapping exists and generally nothing of value can be decoded from it.

Investigation of a number of commercial oscilloscopes indicated that the trouble is caused by capacitive coupling between the vertical and horizontal deflection plates within the tubes. The actual network is made up of distributed inductance in the leads to the plates within the tubes, and of distributed capacitance between these leads and the plates themselves. Consequently the voltage that is induced on the horizontal plates generally appears to be shifted in phase considerably from that applied to the vertical plates. From the above it would appear that tubes having shorter leads and smaller deflection plates would be more satisfactory. That this is true is amply demonstrated by the fact that this effect becomes more troublesome as the size of the cathode-ray tube is increased. In addition, the frequency at which the effect begins to take place is lower with the larger tubes.

All attempts to cure the condition by grounding the free horizontal deflection plate for r-f at the socket terminal proved futile, apparently because of the distributed inductance represented by the internal lead between the plate and the bypass capacitor.

A satisfactory solution to the problem can be had by connecting the horizontal plate to the vertical plate through a small inductance as shown in the diagram. When properly adjusted it is possible in this manner to apply to the horizontal plates a voltage of approximately opposite phase and equal magnitude to that applied within the tube by the electrostatic coupling between plates. The result is an essentially straight vertical trace with no unwanted horizontal deflection due to the r-f voltage.



Amplitude-modulated frequencies above 50 Mc can be observed satisfactorily on a commercial oscilloscope when this circuit is used to correct for capacitive coupling between the plates of the tube

The frequency to which this correction will extend the use of the scope is limited by the amount of distributed inductance represented by the leads to the plates within the tubes. However, if the horizontal and vertical plates are joined at the socket by a short direct connection, useful patterns may be obtained considerably beyond this limit frequency, particularly if the pickup coil is carefully oriented.

The method described above was applied to an RCA model 160-B 5-in. oscilloscope and yielded excellent results to frequencies somewhat above 150 Mc. The load leads from the tube socket to the terminal jacks were replaced by leads directly from the tube to a terminal board mounted right at the socket. In this way a minimum of additional inductance and stray coupling is introduced. It is also desirable to isolate the vertical and horizontal plates from the other parts of the scope circuit by using r-f chokes between the terminals of deflection or positioning voltages.

If it is desired to apply low frequency saw tooth or other deflection voltages to the horizontal plates a small capacitor, of approximately 500 μμf, in series with the inductance will prevent coupling back to the vertical plates.

Although it might seem that this would only aggravate the condition, since the sign of the reactance path thus formed is the same as that within the tube, it does not because its reactance is small compared to that of the inductance of the leads within the tube and consequently the voltage developed across this inductance predominates.

A convenient method of obtaining a continuously adjustable inductance, in order to provide for rapid adjustment as the frequency is changed, is to use a section of balanced transmission line made up of two pieces of No. 12 or larger wire spaced approximately 1½ in. apart. This arrangement can be supported by standoff insulators mounted on the rear of the case. A small shorting bar held in place by friction provides adjustment. A little experimenting will quickly determine the maximum value of inductance needed, depending on the size of the scope tube and the operating frequency.

The coupling loop may be a single turn on the end of a twisted pair. Somewhat better results may be obtained by using an unbalanced coaxial line, providing the outer conductor can be located at a ground plane along most of its length. A line of this type supported in air above ground will usually develop standing waves on the outer

conductor, making it difficult to obtain a good pattern.

Although the above measures have so far only been applied to 3-in. and 5-in. tubes it is assumed that equal or better results would be obtained with the larger tubes having short direct connections to the deflection plates from the side of the glass envelope.

• • •

Field Distribution in Electronic Heating

MEASUREMENT OF electric field strength distribution between two capacitor plates of a high-frequency generator is discussed by K. S. Lion of MIT in the Oct. 1943 issue of *Journal of Applied Physics*, (175 Fifth Ave., New York 10). A series of charts give the field strength distribution between various arrangements of capacitor plates and are of interest to designers of electronic heating equipment, although the article is primarily directed to the problem of dosimetry in the medical diathermy field.

Medical short-wave therapy technique has been developed on an empirical basis, and is practically applied without physical measurements or dosimetry. The technique usually used at present leaves it up to the experience of the physician to estimate the dose, and the heat sensation of the patient is mostly used as subjective of the intensity of a treatment. It is obvious that a physical method is more desirable.

Besides preventing burns there are other reasons for the necessity of a physical measuring method. In comparing the results obtained in treating bacteria or plants with ultrashort waves, some authors report a stimulation of growth, while others observe the killing of seeds or bacteria. Even if a part of the discrepancy is caused by biological variability of the objects (or even the different judgment of the authors) we have to assume that another reason for the differences results from the different intensity of the treatment, for which a measuring method does not exist.

Methods of Dosimetry

Some dosimeter methods have already been proposed. The voltage applied to the electrodes has been

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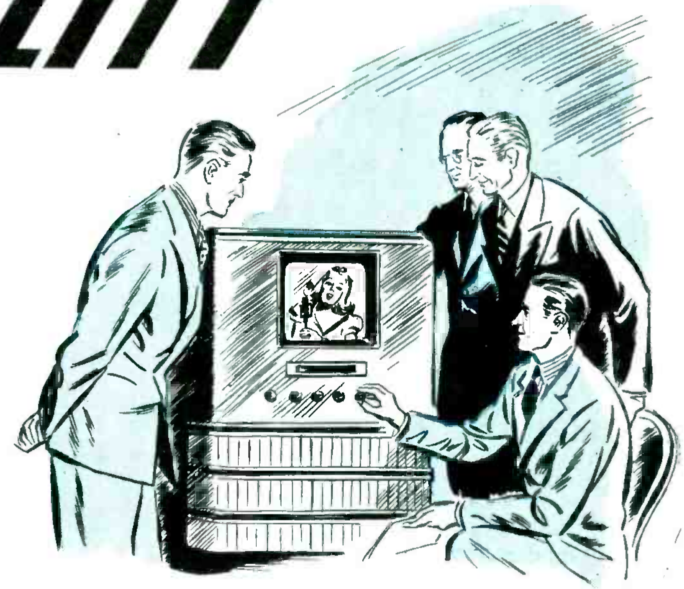

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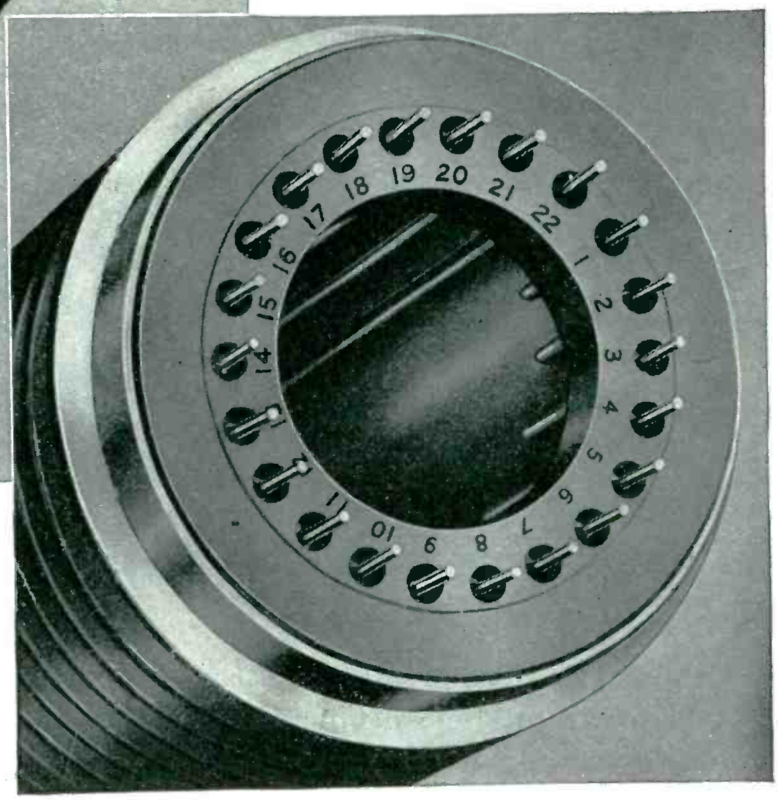

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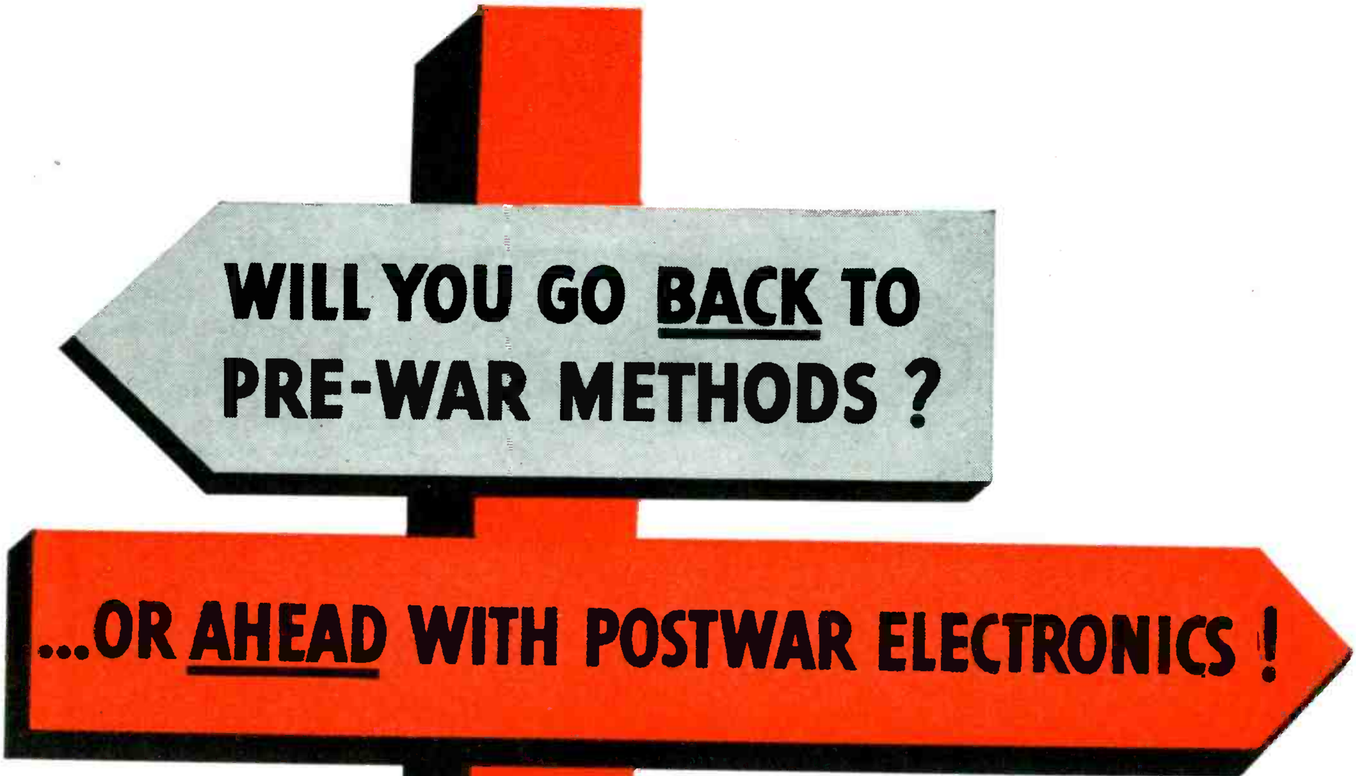

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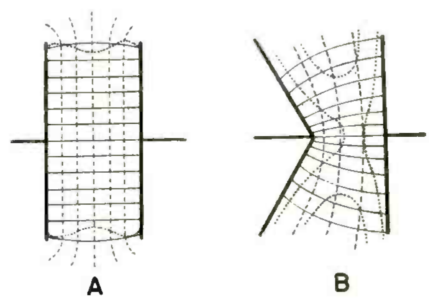

Fig. 1—Homogenous and nonhomogeneous fields. Force lines are shown solid, equipotential lines dashed, and iso-field strength lines dotted

The distribution of the electric field strength can be illustrated as shown in Fig. 1, by connecting all points at which the field strength has the same value. The resulting isofield strength lines indicate where the same effect, in a homogeneous medium, can be expected. Figure 1 shows such curves for a homogeneous and a nonhomogeneous field. The isofield strength lines are not identical with the equipotential lines.

Field Measurements

A measuring instrument applicable to short-wave electric fields has been developed and has been described in a previous paper[1,2]. Its operation is based on the phenomenon of the electrodeless luminous

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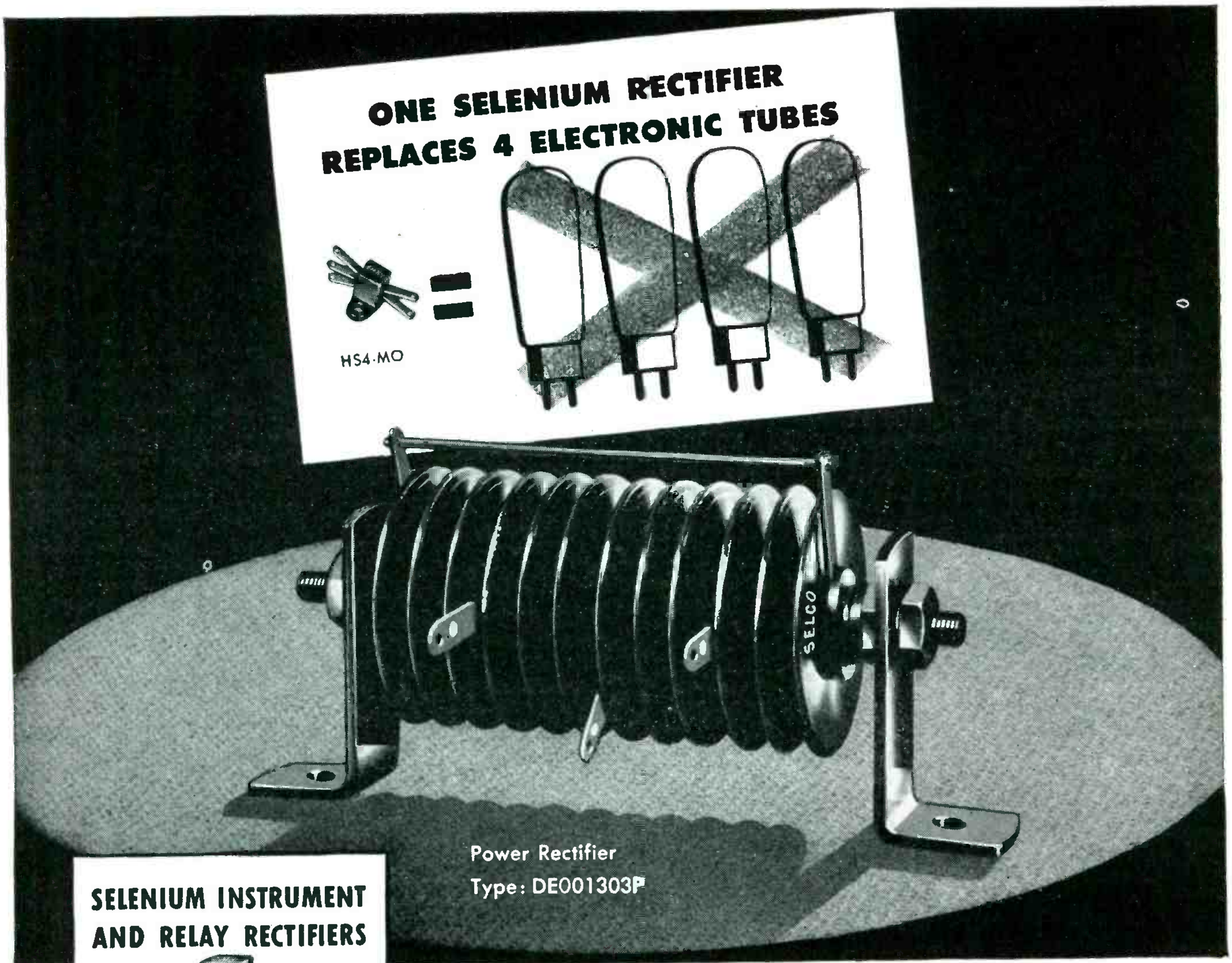

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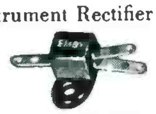
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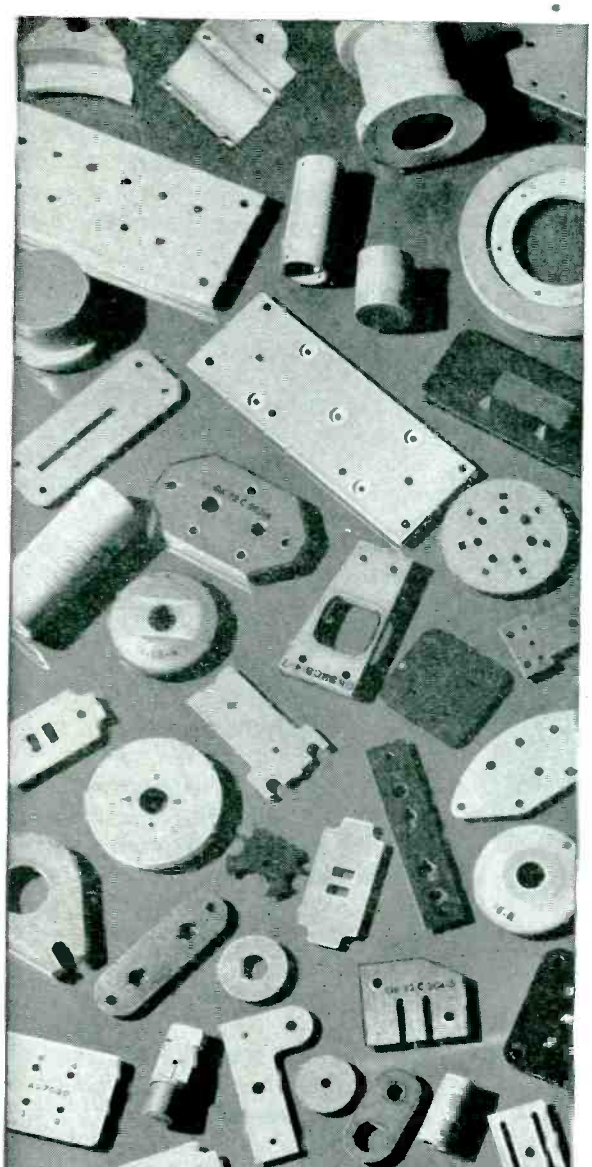

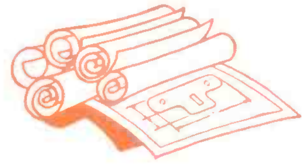

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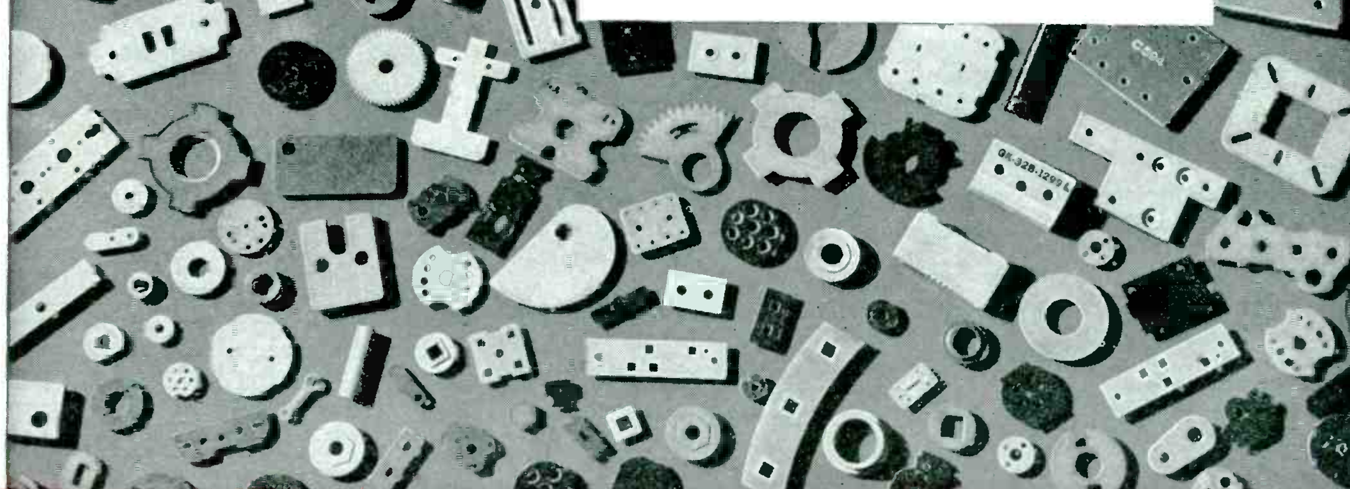

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The dosimeter is calibrated in a field in which the field strength can be calculated from the applied voltage and the physical dimensions of the capacitor plates. The calibration constant depends on the wavelength and can be adjusted, if the wavelength of the short wave generator is known.

By means of the dosimeter, the field distribution in models may be investigated. Such knowledge is particularly valuable for clinical application of short-wave fields and permits of a certain amount of control over the distribution of energy, to increase it at points at which higher energy is desirable, and to protect other points from too great field strengths.

Parallel Plates

Figure 2 shows the field distribution between two parallel circular

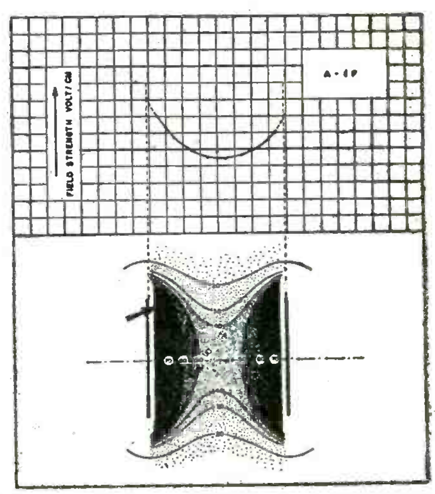

Fig. 2—Field distribution in a meridional plane between two parallel circular plates

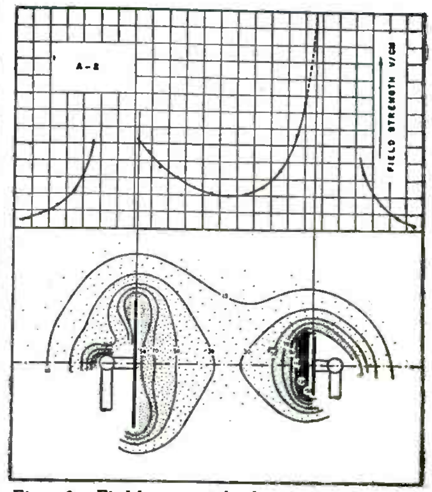

Fig. 3—Field strength between two circular plates of different size

plates. Since the distance between the plates is of the same order of magnitude as the plates themselves, the field, as expected, is not homogeneous and is more concentrated towards the plates. Only in the middle a small area arises in which the field is approximately homogeneous. This space is the one used in therapy employing Schliephake distance electrodes. The field also is not homogeneous in the direction parallel to the plates. In immediate proximity of the plates the intensity is smaller in the middle and greater towards the edges. Along the vertical symmetry line, however, the field decreases from the center towards both sides, as expected.

The maximum nonuniformity arises at the edges of the plates. The point of maximum field strength, however, is not directly on the plate edges but shifted more towards the horizontal symmetry line as indicated by an arrow. At this point the danger of burning (in a homogeneous medium) is a maximum.

The ratio of minimum to maximum field strength in the space between the plates is about 1:3. If, therefore, this field should be applied for treatment of a homogeneous body, one part of this body, near the plates, would get nine times the dose of the center part.

Plates of Different Size

Figure 3 shows the field picture between two plates of different size. (Diameters of the plates are 15 cm and 7 cm, respectively; separation distance, 20.6 cm) The field strength, as expected, is higher

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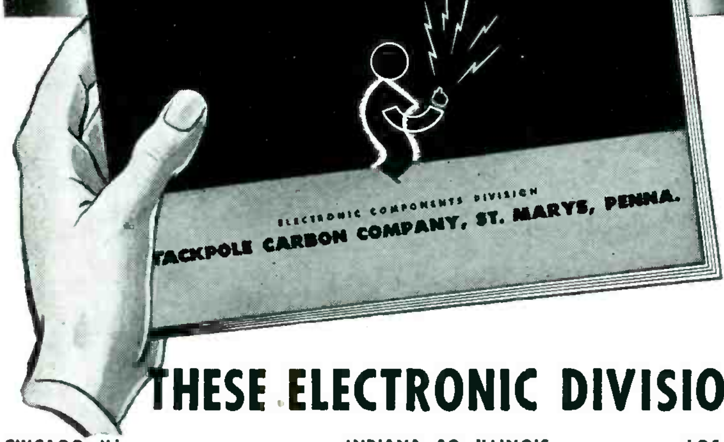

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near the smaller electrode than near the larger one; the ratio of field strengths along the symmetry line is about 1:2.4 (extrapolated).

One should generally expect, therefore, in treatments using two electrodes of different size that the greater effect would arise at the smaller electrode. It appeared, however, in one practical case, that the dosimeter showed a small reading at the smaller electrode while the field strength near the larger (so-called inactive) electrode was relatively high. This could be explained by the fact that the output circuit of the short-wave generator was unsymmetrically grounded. The voltage between the smaller electrode and the capacitively grounded patient, therefore, was smaller than the one between the patient and the larger electrode.

As a first approximation, the field form near one electrode can be determined without respect to the size and position of the other electrode, if the latter is sufficiently far away.

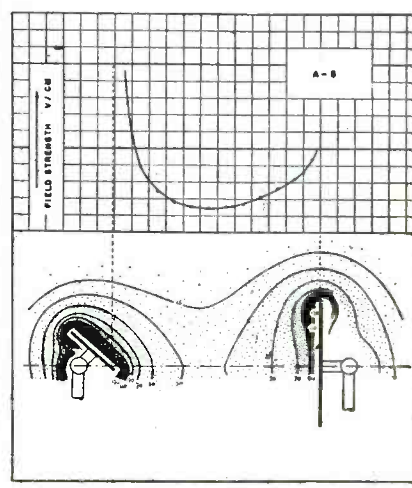

Fig. 4—Effect of change in position of one of the electrodes of Fig. 3

This becomes even more visible in Fig. 4, in which the smaller plate has been rotated through 45 deg. The field in the proximity of the smaller plate is nearly unchanged from the one in Fig. 3. At further distances from this plate, the field, of course, is deformed toward the other electrode. The field distribution in the middle between both electrodes is about the same as in Fig. 3. The high field strength in this case also is concentrated at the electrodes.

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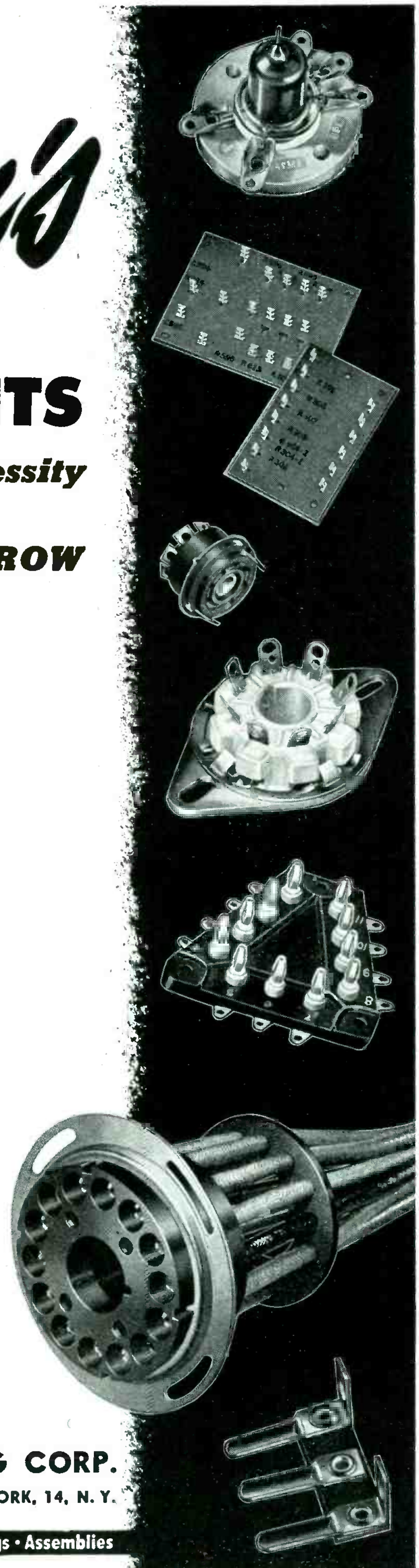

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many practical applications. The maximum effect arises on the surface (skin) of the body to be treated and limits the applicable energy. The field strength at the center of the field is smaller than on the plates, and the relative depth effect is insufficient. By using distance electrodes, Schliephake increases the relative depth dose (ratio of depth dose to surface dose), however, at the expense of efficiency. In keeping the surface of the object at a certain distance from the electrodes he reduces the surface intensity and obtains high relative depth dose. The strong field near the electrodes remains unused.

Curved Plate

An arrangement which serves the same purpose of homogenizing the electric field, especially near the electrodes, by other means, is shown in Fig. 5. For comparison, the left electrode has the normal plate form, and the right one is cylindrically curved, approaching the form of a Faraday cage. The field strength at the concave side of the curved electrode is reduced and the field homogenized, as can be seen from the upper curve of Fig. 5.

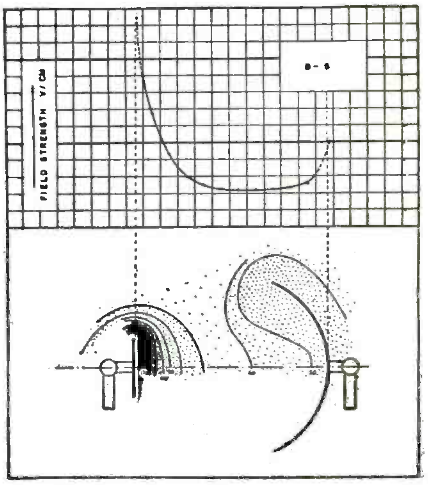
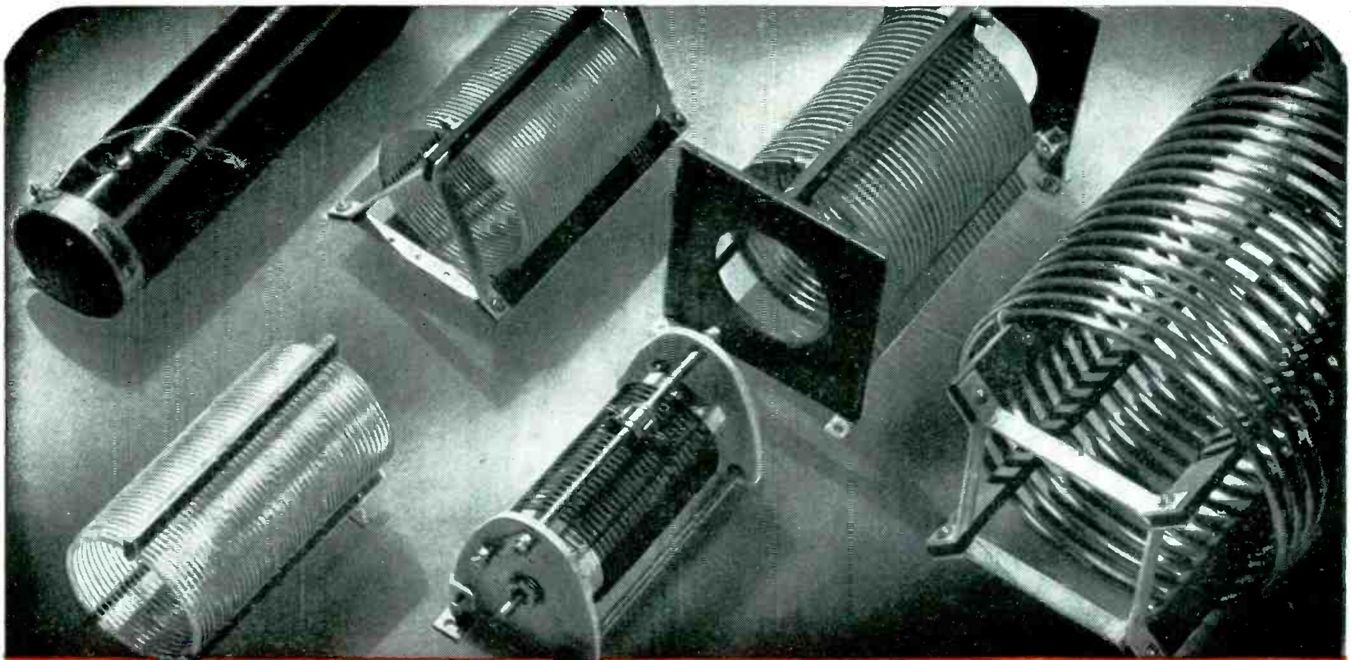


Fig. 5—A cylindrically curved electrode produces this field form

Within 50 percent of the total space between the electrodes, the field strength does not vary more than ±6 percent (measured in the symmetry line). For comparison: in a similar arrangement with straight plates (e.g., Fig. 4) a homogeneity of 6 percent arises in less than 30 percent of the total space between the electrodes. Doubtless an even better homo-



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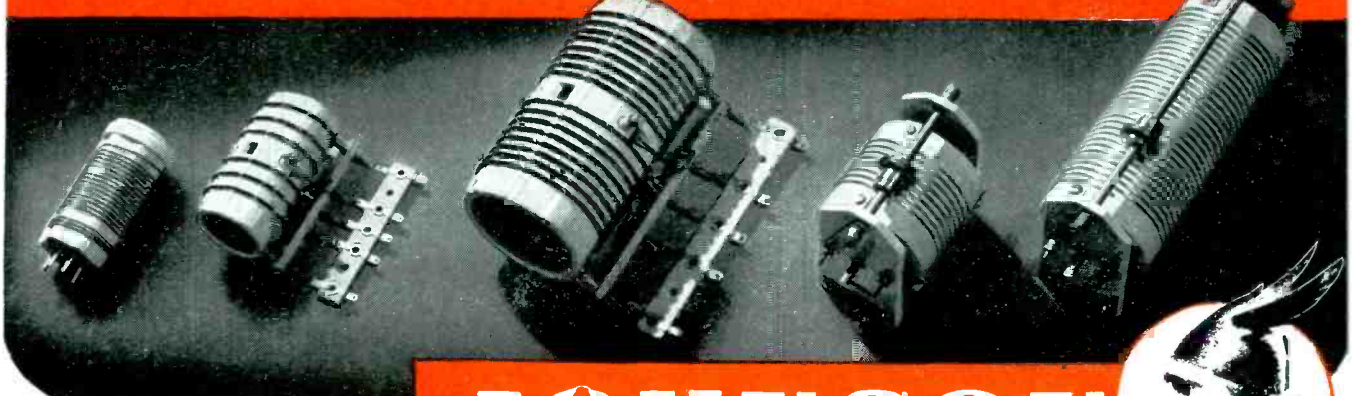

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Circular Plates

An example of such a field which arises between two circular rings is shown in Fig. 6. (Diameter of the rings 10 cm, thickness 1 cm, distance 12.8 cm.) The three upper curves of Fig. 6 show the field strength along the three lines *AA*, *BB*, and *CC*. If one follows the symmetry line *AA* from the middle of one electrode, the field strength increases towards the center about 10 : 1 (!). Also in the direction

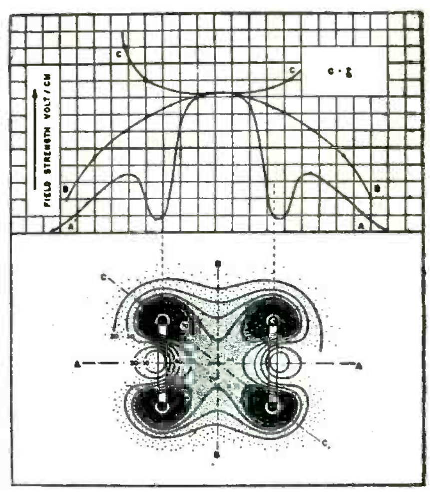

Fig. 3—Field strength between two circular plates of different size

BB a field concentration in the center of the field can be observed, but not in the direction *CC*, in which the field as expected, decreases towards the center. In fact, a similar arrangement has already been used, for treatment of the extremities, by Leistner and

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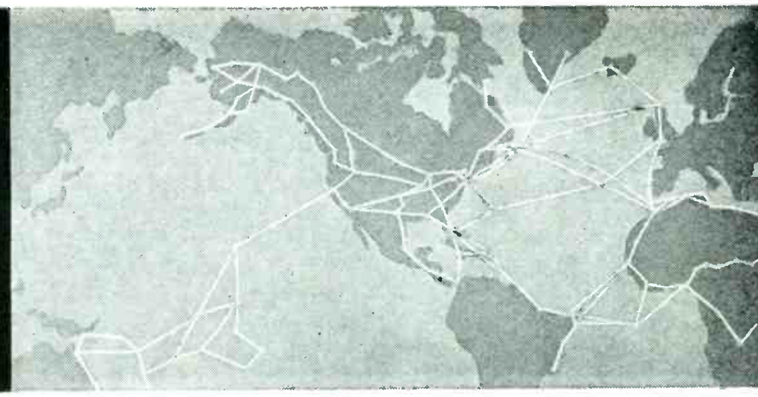

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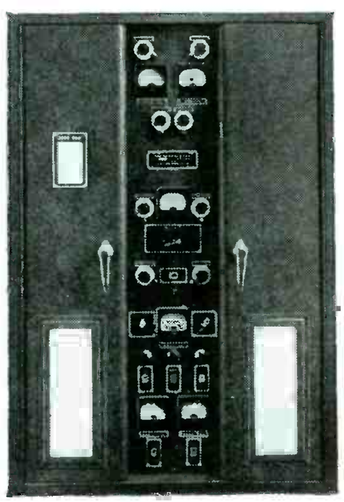

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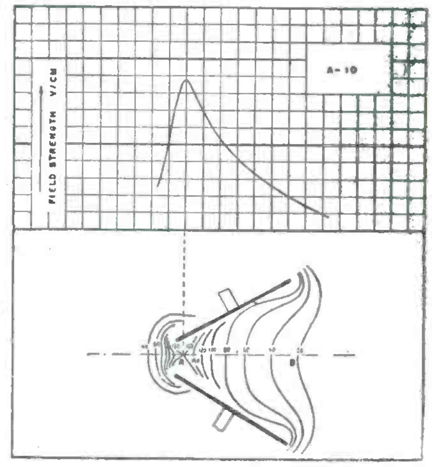

Fig. 7—Nonhomogeneous field produced by tilting circular plates to form an angle

Schaefer (ring electrodes) and the authors emphasize the high depth effect of the arrangement which, from Fig. 6, can now be easily understood.

The field pictures shown here arise in air or in any nonconducting homogeneous and isotropic dielectric substance which fills up the whole area between the two electrodes. If a dielectric substance different from air does not fill up this whole space, a refraction of electric force lines will occur at the interphase of both dielectrics.

Nevertheless, measurements of the empty field may serve, sometimes, as quantitative indications of processes that will occur inside of substances if brought into the electric field. An example of this is shown in Fig. 7. The field between two equal circular plates which form an angle with each other is very nonhomogeneous. The upper curve of Fig. 7 shows the sharply increased intensity at the point *A* where both plates are nearest together and the drop of field strength on both sides of said point *A*.

Experiments of this kind open an interesting aspect of the question of influence of the time factor in treatments with short wave fields.

REFERENCE

(1) K. S. Lion, *Rev. Sci. Inst.* 13, 338-341 (1942).
(2) K. S. Lion, *Helv. Phys. Acta*, 14, 21-50 (1941).

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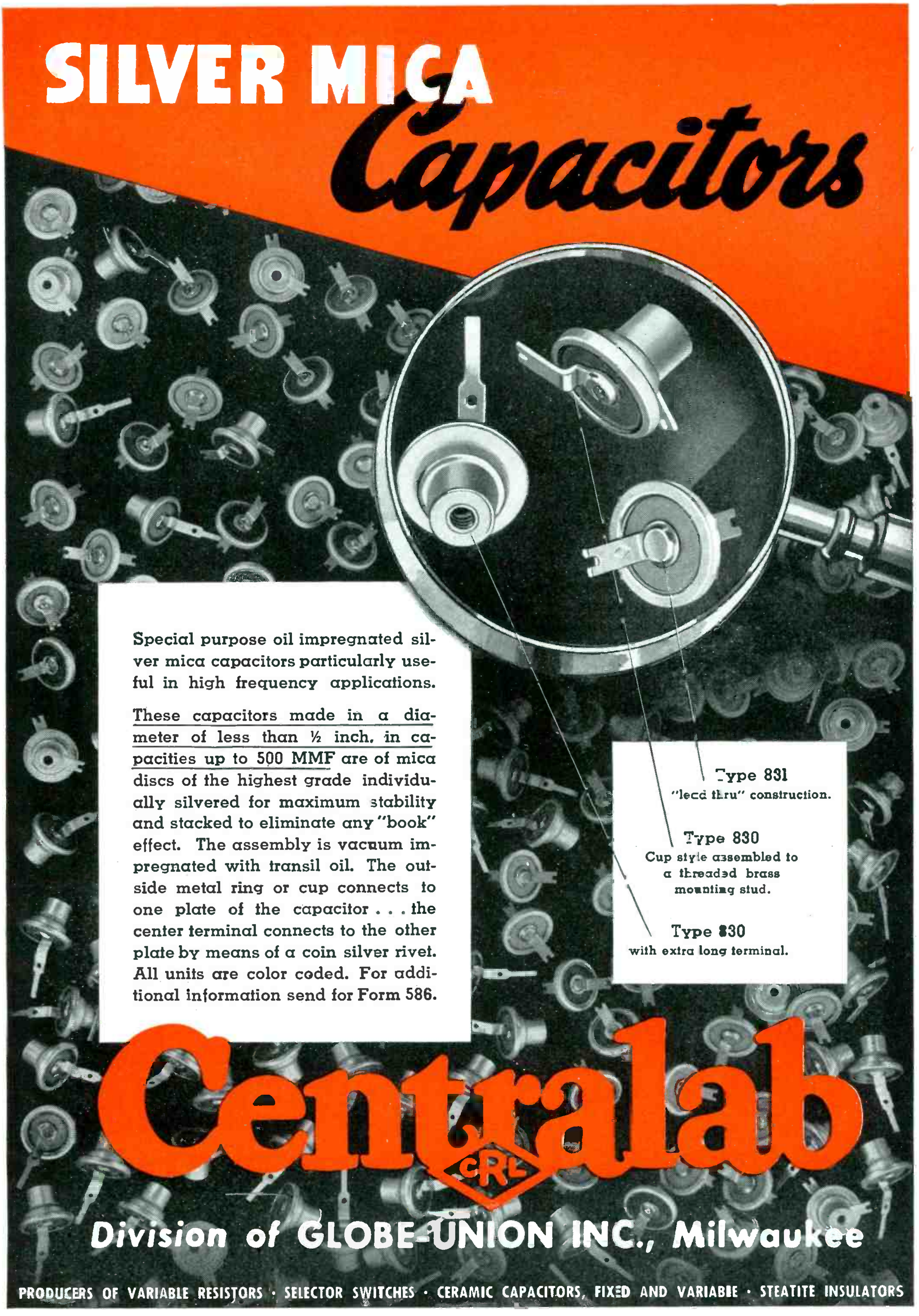
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Flight Paths of Radio Instrument Landing System

PRACTICAL DATA on the use of radio instrument landing systems, in the form of photographic space-time records of the approach paths followed by a DC-3 airplane in making 25 instrument landings with the pilot under the hood, has been recently released by CAA. Issued in booklet form under the title "Technical Development Report No. 32," the report includes curves showing the vertical and horizontal projection of the flight paths, air speeds, and sinking speeds from 100 feet above ground, to and through contact with the ground, including the first hundred feet of ground roll.

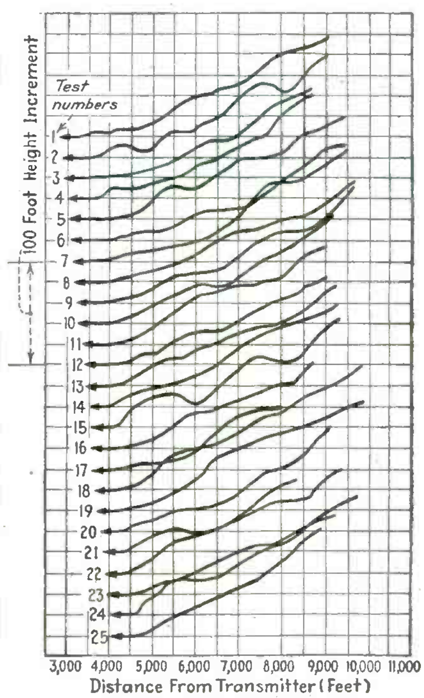

Fig. 1—Flight paths of 25 blind landings. Each curve represents a separate approach and all curves extend through contact

Space-time records of the plane in flight were obtained by photographic recording equipment that operated on the range-finder principle. The field setup consisted of two widely but specifically separated motion picture cameras located about 1,000 feet from the point of contact of the plane with the ground, and symmetrically with respect to the centerline of the runway.

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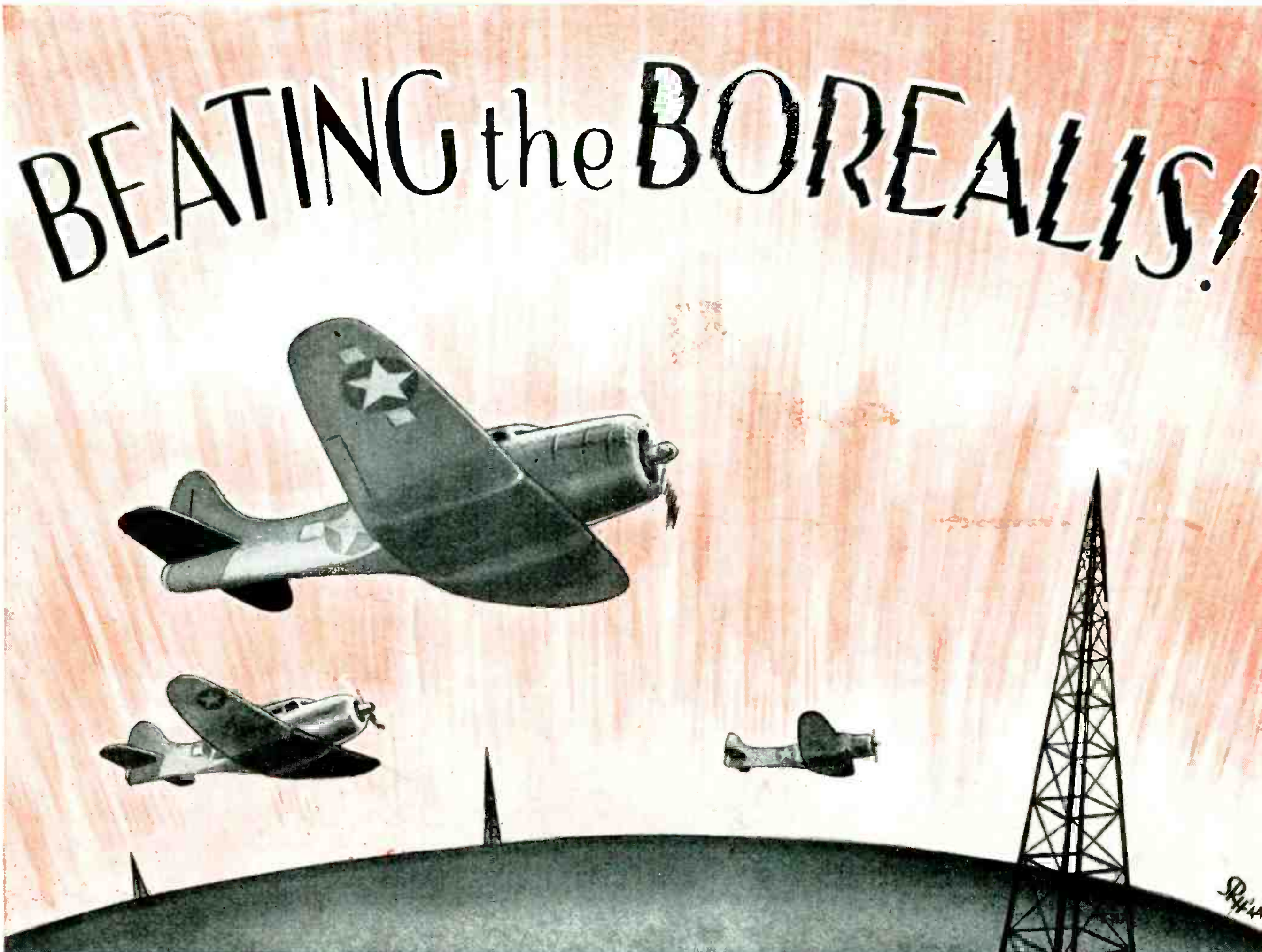

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The instrument landing system investigated was located at Oakland, Calif., and was of the Bendix type involving the use of an equisignal localizer and a constant intensity glide path. The beam path was substantially parabolic in shape.

Curves showing the vertical and horizontal projections of the approach paths from 100 feet to contact for each of the 25 blind landings are shown in Fig. 1. Of these, the individual flight paths numbered 17 and 2 represent the best and the worst of the 25 approaches. The height variation during all approaches was about 30 feet while the lower boundary of the approach paths indicates a distance to height ratio of 43:1 down to a height of 50 feet, below which the landing "flare" is accomplished.

In Fig. 1, the height scales are exaggerated with respect to the distance scales. This scale ratio

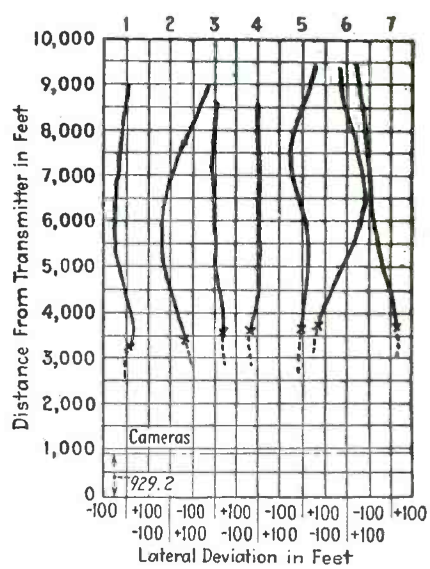

Fig. 2—Several curves of approach paths, showing lateral deviation from the runway centerline. Points marked X indicate contact of the plane to ground and dotted portions of the curves represent taxiing paths after contact

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serves to emphasize the "hunting" of the plane during approaches.

Lateral deviations of approach paths with respect to the centerline of the airplane were within a lane 350 feet wide and symmetrical about the centerline of the runway. Some typical approach paths as examples of the lateral deviation are shown in Fig. 2. The complete set of curves show that the best and the worst flight paths do not represent the best and worst lateral deviation approach paths.

During all 25 instrument approaches the air speeds varied from 105 to 135 miles per hour at a height of 100 feet, while contact speeds varied from 75 to 105 miles per hour. This indicates a variation of 30 mph during all approaches. The sinking speeds in all 25 approaches did not exceed nine feet per second.

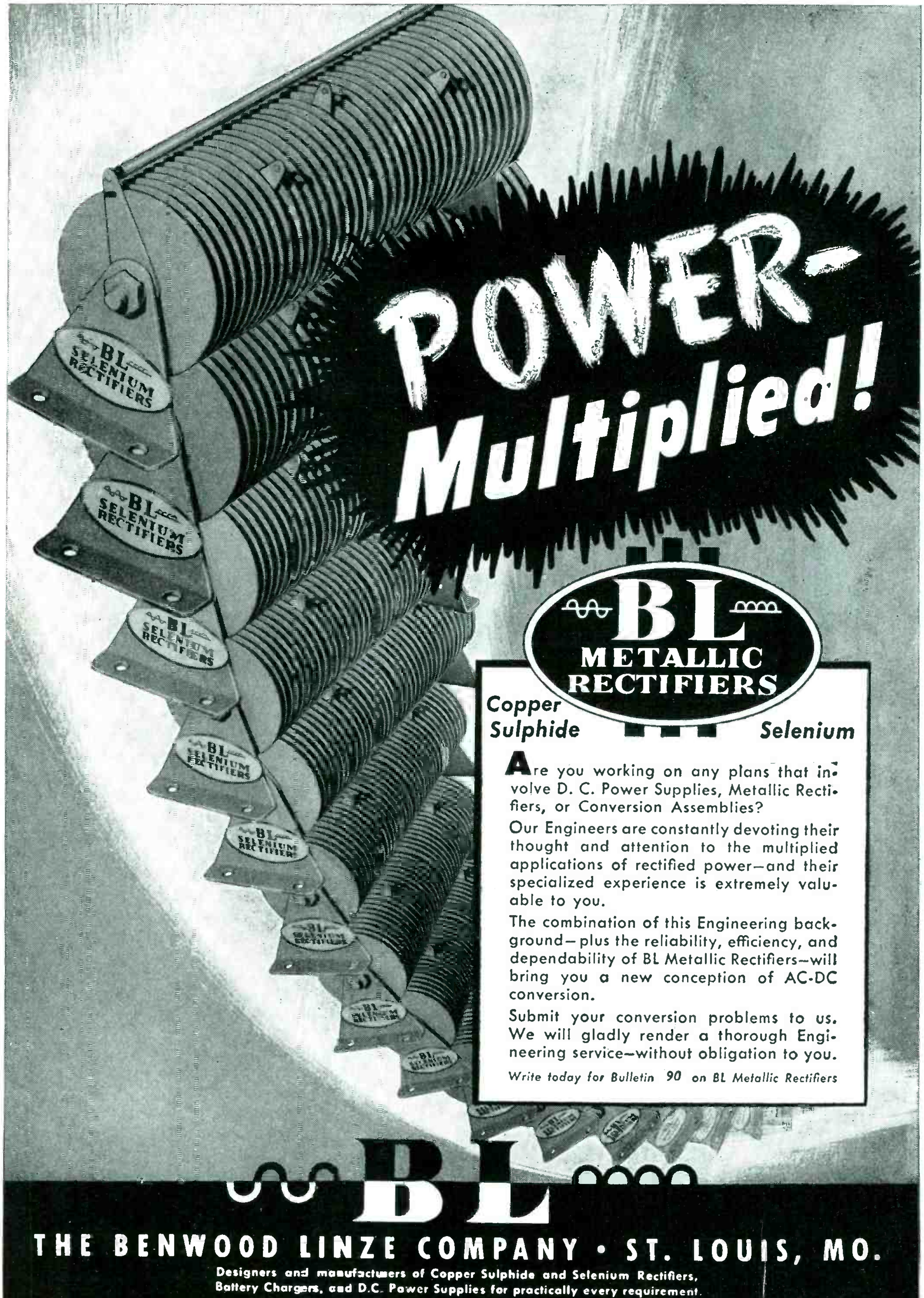
• • •

Future Electron Microscopy

MAGNIFICATION AS HIGH as 2,000,000 diameters appears to be the theoretical limit of electron microscopes of the future, but before this optimum resolving power may be realized it will be necessary to solve other problems which limit present electron lenses. This theoretical concept, and the limiting factors of present instruments, were presented in a joint paper by Drs. V. K. Zworykin, James Hillier and E. G. Ramberg, of RCA Laboratories, at a meeting of the Electron Microscope Society of America in New York during January.

It was pointed out that practically all the limitations due to inaccuracies of machining or unsuitable materials have been removed and that further improvement will come only by removing the optical difficulties due to aberrations. Spherical aberration, or aperture defect, is the most important of these and in the electron microscope is caused by electrons going through the outer edges of the lens and being focused at a different place from those going through the center. Correction techniques used in ordinary optics cannot be used since there is no such thing as a diverging electron lens.

"However," said Dr. Ramberg, who read the paper, "we now have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a method which it is believed will overcome this defect of electron lenses. The idea behind it is basically as follows: Electrons leaving the specimen must take a little longer to reach the outer edges of the lens than they do to reach the middle region, simply because they have further to go. If, during this short interval of time between the arrival of the electrons at the middle and outer portions of the lens, we adjust the power of the lenses slightly so that the focal length of the lens is just right for the electrons when they arrive, then all the electrons should be focused to the same place in the image. This has assumed, of course, that the electrons left the specimen only during a very short period, otherwise some electrons would continue to go through the middle of the lens after its focal length has been changed again blurring the picture.

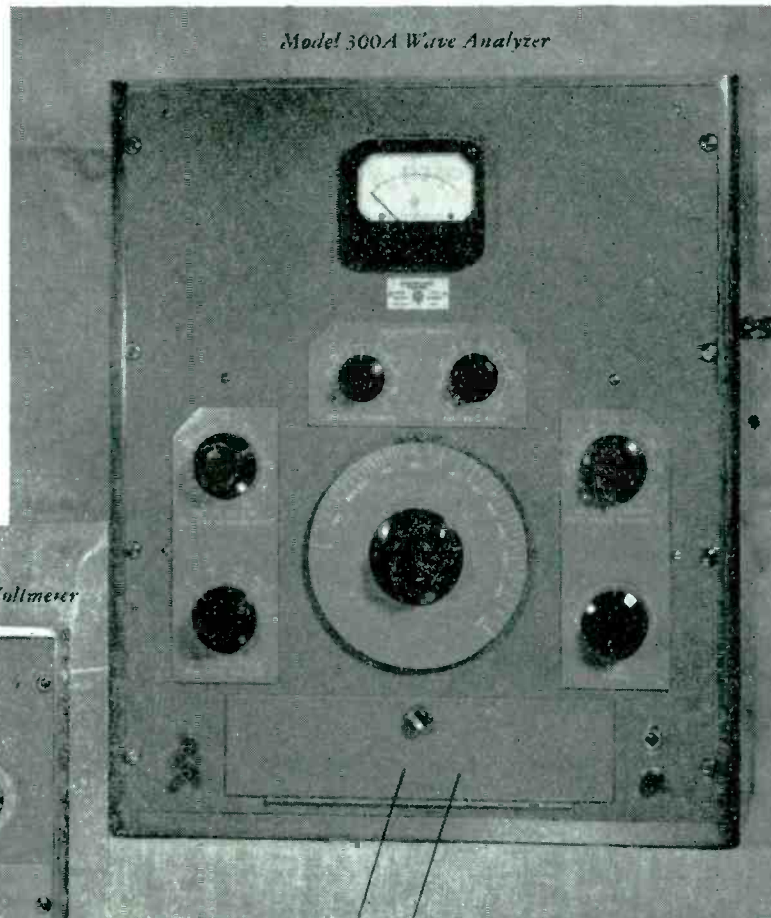
"Actually, the idea can be extended to take care of a steady stream of electrons coming through the specimen simply by applying an alternating potential of the right frequency and wave shape in such a way that it controls both the initial velocities of the electrons and the focal length of the lens."

A total of thirty papers were presented at the meeting, held jointly with that of the American Physical Society at Columbia University. The subjects covered by the papers included many branches of industrial research as well as details of techniques involved in various applications of the electron microscope. Some of the highlights of the papers follow.

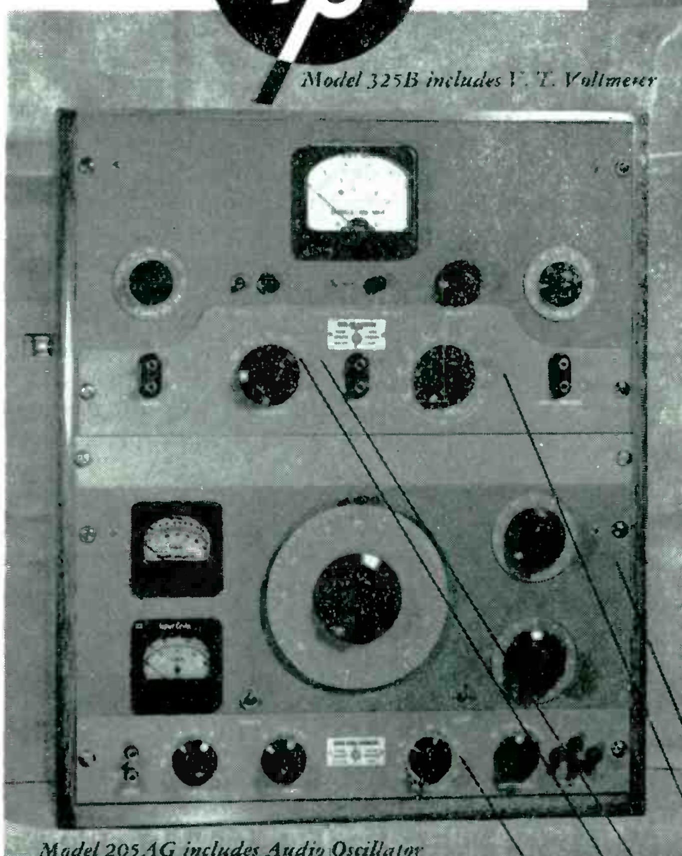
Details of the optical system, of the stage mechanism, of the airlocks and of the power supplies of the electron microscope at Stanford University were given in a paper by Ladislaus Marton of Stanford University.

The results of investigations of magnetic lenses were covered in a paper by L. Marton and R. G. E. Hutton of Stanford University. They reported that optimum aperture sizes and their location for objective lenses, as well as optimum numerical apertures for condenser lenses, have been calculated for magnetic lenses. The results necessitate a revision of former estimates of voltage and current constancy for the transmission type

In these two compact units there are really seven instruments



Model 300A Wave Analyzer



Model 325B includes V. T. Voltmeter

Model 205AG includes Audio Oscillator

Remember! The *-hp-* audio oscillator (in 205AG) requires no zero setting, the Model 300A wave analyzer provides variable selectivity, *-hp-* vacuum tube voltmeter indication is proportional to the average value of the full wave and the *-hp-* Audio Signal Generator makes standardized frequencies and voltage instantly available. Get full information about these and other outstanding *-hp-* electronic instruments today. Ask for the new 24-page catalog which gives much valuable information in addition to complete data on *-hp-* instruments.

There are only three standard *-hp-* instruments included in this laboratory set-up yet the two units include the following seven: an *-hp-* Resistance-Tuned Audio Oscillator, an attenuator, a vacuum tube voltmeter, a set of fundamental elimination filters, an input meter, an output meter, and a wave analyzer. The uses for this combination of instruments are too extensive to list here but some idea of its scope is shown by the following:

- **Measure voltage level, power output and amplifier gain.**
- **Measure noise and hum level in audio frequency equipment.**
- **Measure individual components of a complex wave.**
- **Measure voltages from 3mv to 300v—from 10cps to 100kc.**
- **Measure total distortion of frequencies from 30cps to 15kc.**
- **Integrate noise spectrum for acoustic measurements.**
- **Generate a known voltage as well as a known frequency at common impedance levels and make many another test or measurement on audio frequency equipment.**

805

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of magnetic electron microscope.

A modified form of specimen holder was described by L. Marton and C. Martin of Stanford that allows easy handling of the specimen both before and after observation and is so constructed that the "right" face is always recognized.

A description of some equipment used in the preparation of electron microscope specimens, particularly valuable in the preparation of stripped replicas, and a description of a system for keeping and indexing mounted specimens, were given by L. E. Hagmann of General Electric Co.

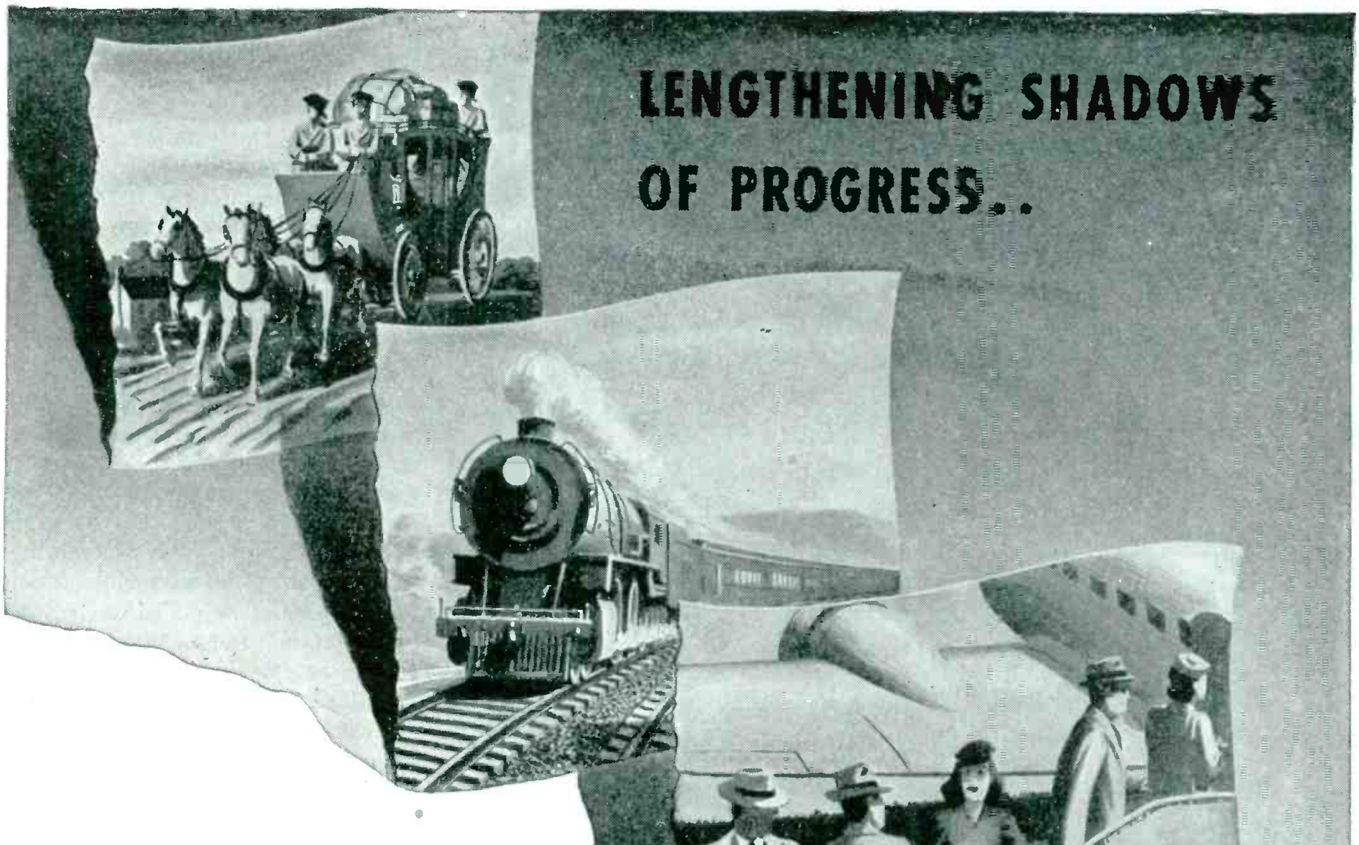
F. Baker, RCA Laboratories, led a discussion of the following miscellaneous results which have been obtained in the course of the past two years in development of the electron microscope: (a) limiting resolving power (b) effect of objective aperture on resolving power (c) effect of aperture on alignment (d) the study of first, second, and third minimum focal lengths for magnetic lenses of various dimensions and at various voltages (e) the effect of lens length on image distortion (f) a study of multiple gap lenses.

The structure and organization of the bacterial cell as shown by electron microscopy were covered by Stuart Mudd, T. F. Anderson and Katherine Polevitzky, University of Pennsylvania. Insight into structural differentiation has been gained which has already led

• • •

GIRLS FOR ENGINEERS

The shortage of engineers has caused Sylvania's Emporium plant to transfer girls having high production and education records to jobs as engineering assistants. Here, Dorothy Nebraska and two assistants use a tier of meters while working on an engineering assignment



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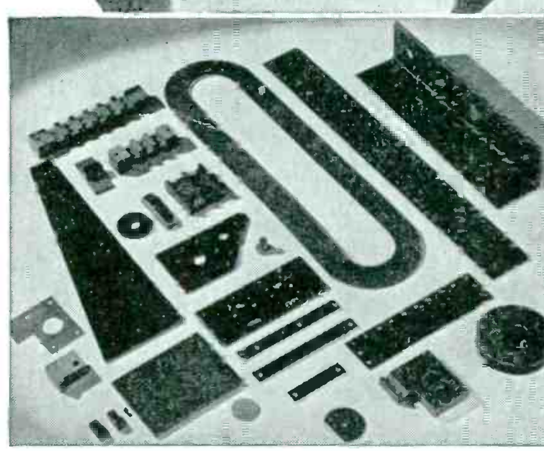

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Established 1895 . . Manufacturers of Laminated Plastics since 1911 — NEWARK • DELAWARE to useful applications; at least one hitherto unknown structure, believed to be the locomotor organ of spirochetes, has been discovered by electron microscopy.

Techniques in the preparation of biological specimens for electron microscopy were discussed by Thomas F. Anderson, University of Pennsylvania. A new method involves the deposition of a suspension of the material to be studied as a very fine spray on the collodion membrane while the latter is still on the distilled water on which it was cast. The droplets then shrink rapidly as salts and other material dialyse through the membrane leaving behind all materials which fail to pass. The collodion is then picked up on the fine wire specimen screen as usual and is ready for examination.

Electron microscopy of the etiological agent of lymphocytic choriomeningitis was described by Gregory Shwartzman, Mt. Sinai Hospital, and involved purification of infected mouse and guinea-pig brains by a method presented in detail.

The effect of sonic vibration, ultraviolet light and pH on the bacteriophage virus was discussed by Thomas F. Anderson, University of Pennsylvania. While the activity of the virus is readily destroyed by ultraviolet light, it requires some 300 to 600 "lethal doses" to

• • •

BRITISH RADIO MISSION

Sir Robert Watson-Watt (left), one of Great Britain's greatest scientists, is shown electronics equipment for the army and navy by Joseph H. Gillies, vice-president in charge of radio production of Philco Corp. Looking on is Rear Admiral Julius A. Furer, U. S. N. Coordinator of Research and Development

NOW

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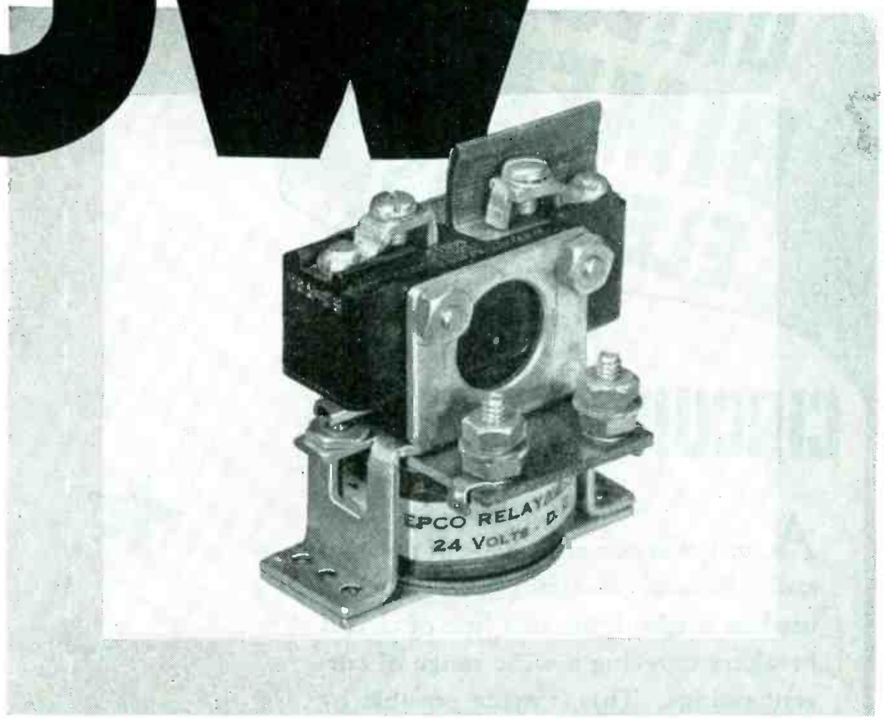

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Weight	5.7 Ounces
Coil Terminals	6-32 Bolt Connections
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Dimensions	Overall of base 3-4" x 2 1-16" Overall width of unit 1 5-8" Overall height of unit 2 3-8"
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effect the disintegration of the virus particles by irradiation. Both sonic vibration and irradiation, however, cause the partial disintegration of the virus particles. The dense material of the head first appears to escape from what appears to be a membrane originally surrounding this structure and attached to the "tail". With continued treatment even these traces of the phage particles disappear and only amorphous masses of material can be found in the electron microscope. Short exposure of the virus to pH's below 2 and above 12 bring about only a gradual blurring of the structures without a selective effect.

G. L. Clark and Robert B. Fischer, University of Illinois, discussed an attempt made to study exceedingly thin specimens, particularly of aluminum alloys used in airplane construction, by direct transmission of the electron beam through the specimen. The beginning stages in age hardening and the results in the electron micrograph were compared with the new technique of X-ray microradiograph. The replica technique is not as advantageous as transmission, although it is extremely difficult to prevent rapid precipitation and age hardening at room temperatures.

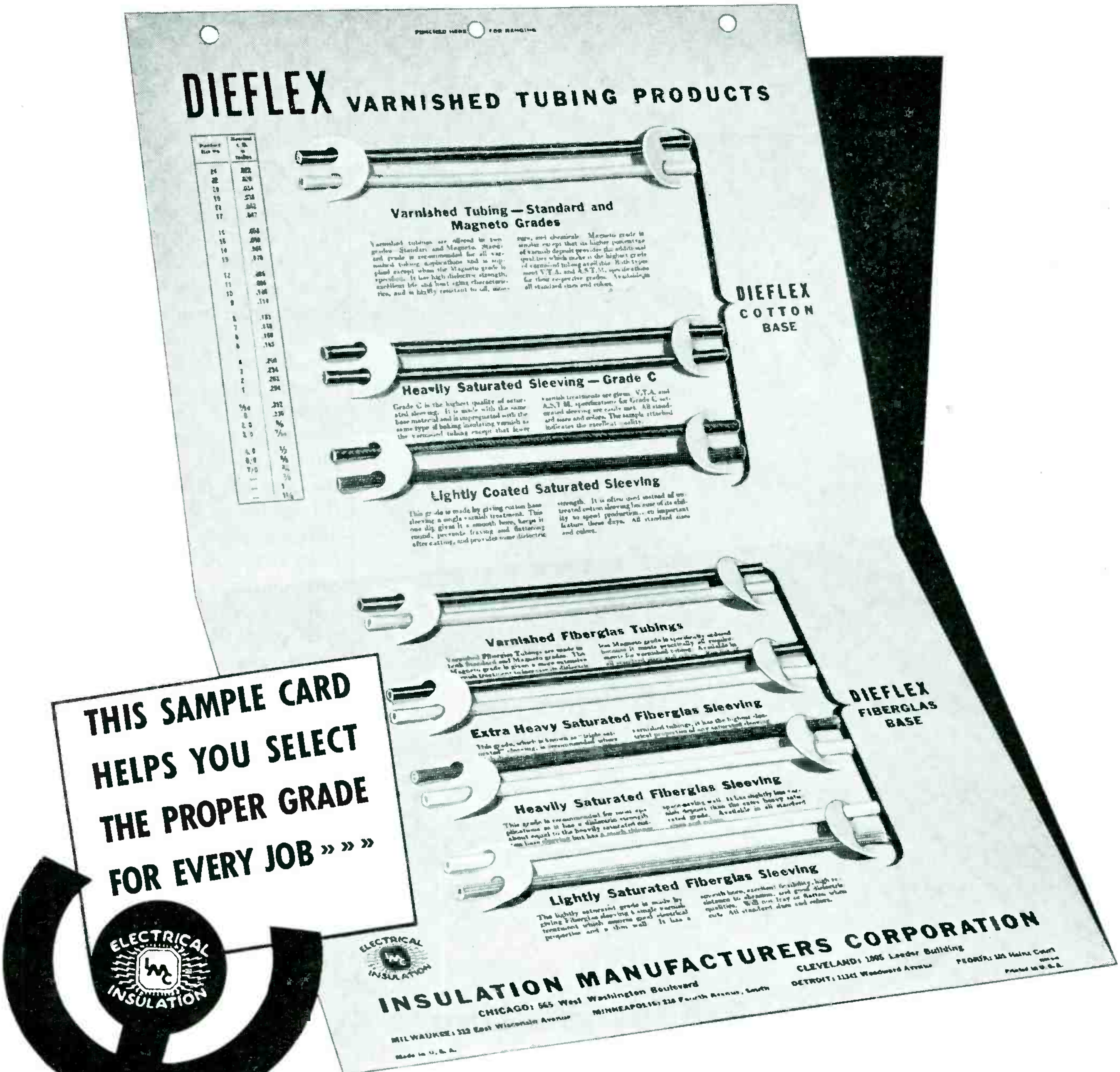
The general technique of producing replicas of the surfaces of opaque bodies for use in the electron microscope was considered from the viewpoint of detailed interpretation by R. D. Heidenreich and L. A. Matheson, of Dow Chemical Company.

• • •

Vacuum in Tubes

THE RANGE OF VACUUM required for electronic tube manufacture extends from 0.01 or 0.02 millimeters of mercury to 10^{-5} or 10^{-6} mm of Hg. Receiving tubes can be manufactured using only mechanical oil sealed pumps capable of pumping down to an actual pressure (including pressure of vapors) of 0.01 to 0.02 mm of Hg. The final pressure in the tube must be lowered by the use of getters.

Power tubes, cathode-ray tubes and special purpose types require lower pressures during exhaust that range down to 10^{-5} or 10^{-6} mm Hg. With these low pressures, get-



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ters are still often necessary.

The present trend in tube manufacturing is toward higher vacuum rather than higher capacity. The need for pumps of larger capacity is now subordinate to the need for connecting tubing of lowered resistance to provide a reduction in the pumping time.

The types of pumps used on receiving tube exhaust machines are usually mechanical oil-sealed types of both one- and two-stages with speeds from 15 to 45 cubic feet per minute. Many machines also include metal mercury diffusion pumps in the final positions. Similar equipment is used on some of the smaller power tube machines. On others, a small metal mercury diffusion pump is installed for each port. Exhaust machines for large cathode-ray tubes have larger metal mercury diffusion pumps at each port. Glass mercury diffusion pumps are usually used in trolley exhaust of large power tubes.

Oil-diffusion pumps are used on a few special exhaust systems. Single-stage mechanical oil pumps are satisfactory for backing up diffusion pumps but when used alone a two-stage pump is preferable. Besides vacuum tubes, the pumps may be used to evacuate electric light bulbs, mercury switches, fluorescent and neon tubing, vacuum insulated bottles and vessels, filters and vacuum dryers.

• • •

MARINE GIRL OPERATOR

Corp. Priscilla Wilson, USMCWR, contacts a plane at the Marine Air Station at Cherry Point, N. C. She is one of the first women in the Marine Corps to hold down the job of control tower operator

RC Oscillators

(Continued from page 129)

by switching in various resistor values.

The phase shift oscillator shown in Fig. 7 produces a 180-deg phase shift across its *RC* filter, and the output of this filter is used to energize the grid of the tube. The attenuation of the filter makes it necessary for considerable amplification to take place in the tube itself. Pentodes are sometimes utilized. Sine waves of any phase relation between 0 deg and 180 deg may be obtained by appropriate taps on the filter section.

Production of Sine Waves

Since an isosceles-shaped saw-tooth wave is composed of odd harmonics of a sine wave, its conversion becomes relatively simple when using a low-pass filter of the type shown in Fig. 4. Such a filter may be used over a fairly wide frequency range, the limiting factor, of course, being the approach to its cutoff point.

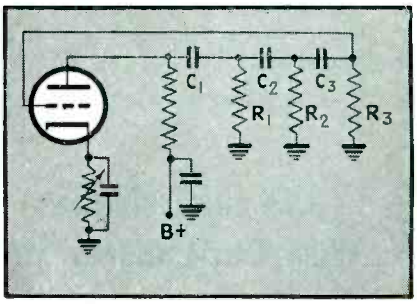


FIG. 7—Usual method of operation of this phase shift oscillator over a frequency range is to make C_1, C_2, and C_3 variable and ganged, while R_1, R_2, and R_3 are switched in steps to change ranges

A general design principle for optimum attenuation throughout a range of frequencies is to make X_c equal to R near the low or mid-part of the range. As many sections as necessary may be used; extra sections, of course, tend to neutralize the effect of input and output impedances upon the filter characteristic.

Where a good isosceles type of saw-tooth waveform is available, an excellent sine wave will be obtained at the output of the filter with as few as two sections. Few sections cause little attenuation and

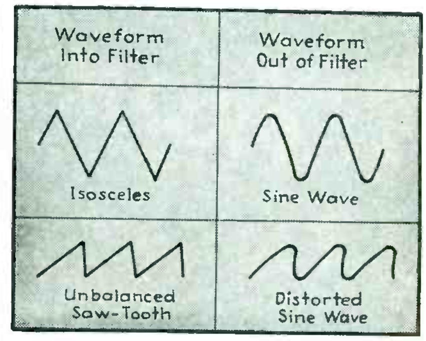


FIG. 8—A graphic illustration of saw-tooth wave transformation by use of *RC* filters designed for wide-range operation. This indicates the importance of keeping the input waveform isosceles in shape

the more nearly isosceles the shape of the wave, the less overall attenuation is necessary for sine wave production.

When the isosceles waveshape deviates to other forms of saw-tooth waves, the filter cannot be used over such a wide range since the nearest harmonics are now lower in frequency and thus are not sufficiently attenuated to eliminate their consequent distortion of the sine wave. It will be noticed, therefore, that when a saw-tooth waveform, other than one of isosceles shape, is passed into the filter of Fig. 4, many of the lower harmonics are not attenuated and a resultant sine wave distortion ensues. For a typical example, see Fig. 8. The only corrections for such a condition are:

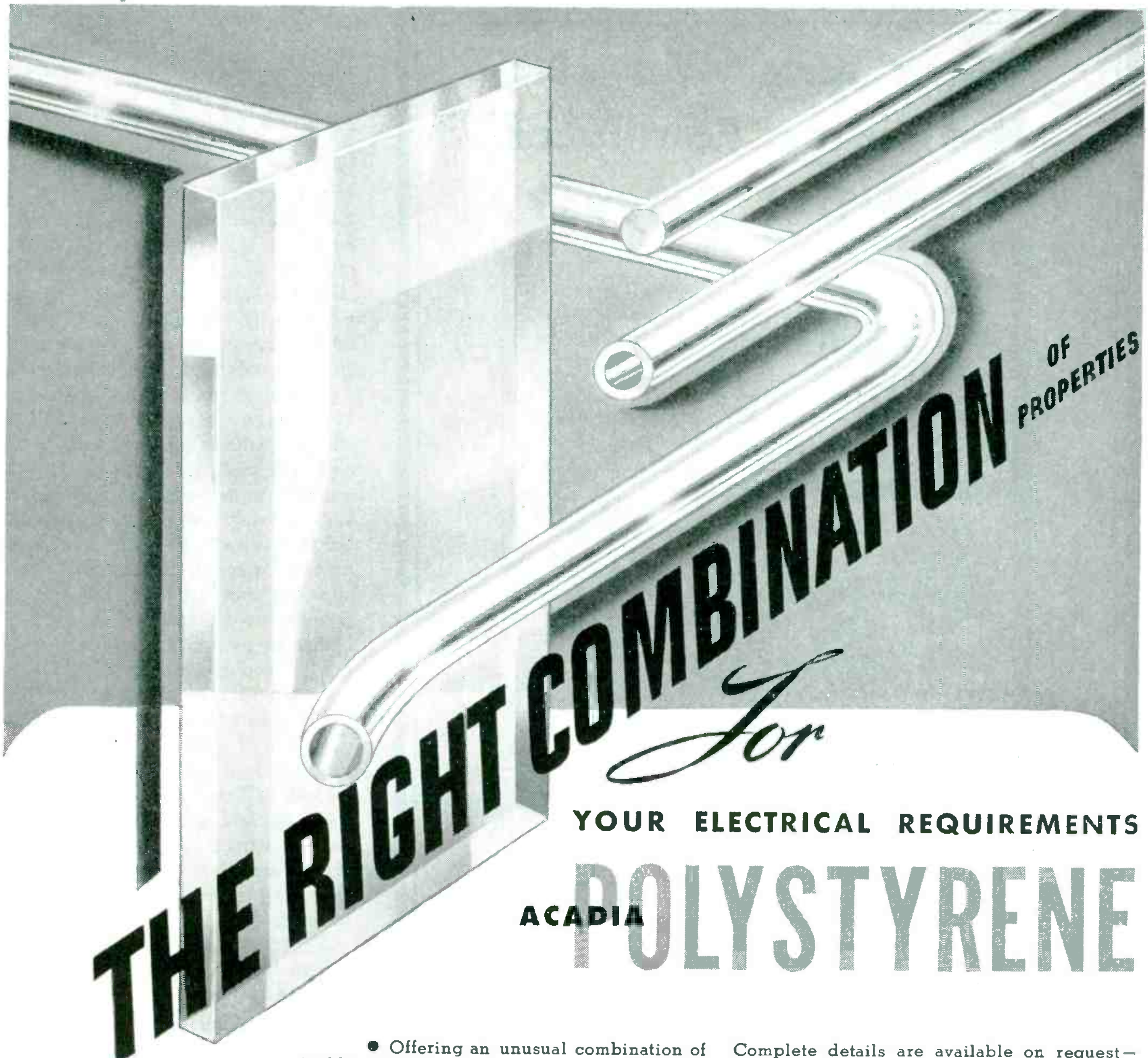
1. Lower the frequency cut-off point of the filter so as to eliminate the unwanted harmonics. This will reduce the effective frequency range through which the filter can operate.

2. Add extra sections to produce more attenuation of the harmonics in relation to the fundamental. This causes such severe overall attenuation as to make it undesirable in many applications.

3. The best solution is to maintain the waveform as close to an isosceles shape as possible and use as few sections as possible to result in minimum attenuation.

Synchronization of Oscillators

The frequency of a vacuum-tube oscillator can be synchronized with an external frequency source when the two are closely related or are of corresponding ratios of integers. The greatest tendency for syn-



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Power Factor, 60 cycles	.0001 to .0003
10^3 cycles	.0001 to .0003
10^6 cycles	.0001 to .0008
Dielectric Strength, Volts/Mil ⅛" thickness	
Short time	500 to 700
Step by step	450 to 600
Volume Resistivity, ohms-cms	10^{17} to 10^{19}
Heat Resistance	150°F to 175°F
Softening Point	190°F to 250°F
Specific Gravity	1.05

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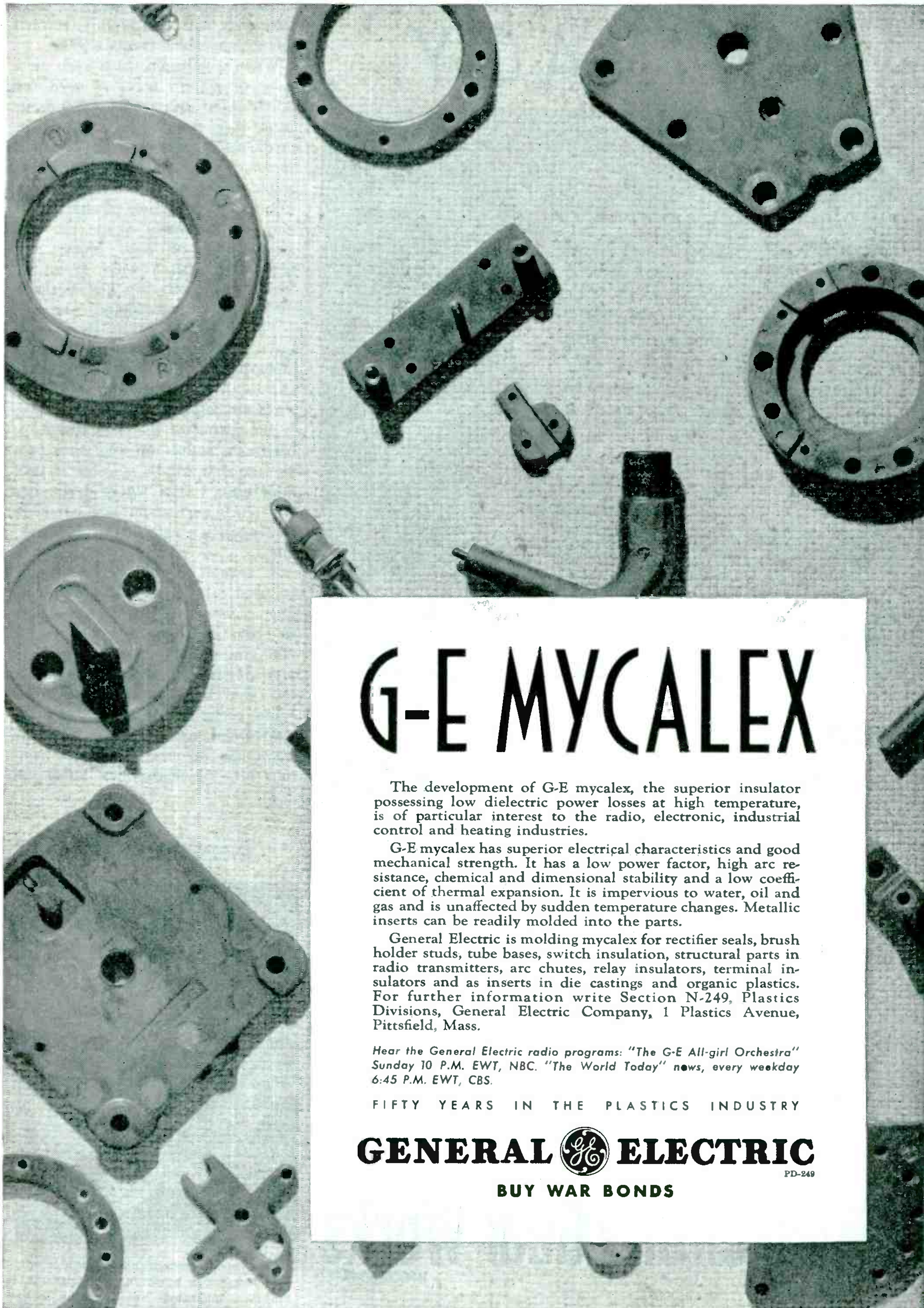
4035-4117 Ogden Avenue • Chicago 23, Illinois • Branch Offices in All Principal Cities chronization exists when synchronization at the same frequency is attempted. The Q of the circuit to be synchronized, together with the amplitude of the sync voltage, determines the degree of frequency deviation allowable between the two sources to be synchronized. A high-Q sine wave source can only be made to synchronize with frequencies which are very close to the circuit resonant frequency. The exact amount of deviation possible while maintaining synchronization depends upon the value of Q.

The piezo-electric oscillator has very high frequency stability, which would be impossible to synchronize without resorting to extremely high sync voltages at a very closely related frequency. Other types of sine wave oscillators having lower values of Q will synchronize more readily, but not to frequencies which have appreciable deviation in relation to their resonant frequency.

Saw-tooth sources which are high in harmonic content and have very poor frequency stability readily synchronize to frequencies which deviate considerably from their natural operating frequency. Such a source may be used to generate sine waves which can be synchronized to considerable deviations in frequency.

Frequency division may be obtained in the transitron by selecting the proper quotient-frequency constants for the oscillator and using the frequency to be divided as a synchronizing voltage. For example, 2000 cps may be divided by using it as a sync voltage to control an oscillator whose frequency-determining constants are set to approximately 1000 cps. The oscillator output will then remain exactly 1000 cps even when small changes in frequency-determining constants are made in the circuit. Thus 2000 cps is divided by a factor of two.

When once synchronized, a low-Q oscillator will remain at the synchronous frequency even with small changes of the frequency-determining constants. If these constants are changed sufficiently, however, the output voltage will move in discreet steps from one sub-multiple to the next. In cases where the sync voltage is not sufficient to obtain synchronism the oscillator



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frequency will tend to shift toward the synchronous frequency.

When a periodic wave such as a pulse or sqaure wave is used for synchronism of a sine-wave oscillator, it is possible to obtain synchronism in frequency but there is no assurance of phase synchronism under these conditions. If the sync voltage has a section of sharp contour in its wave shape, it will synchronize in both phase and frequency with a wave from the oscillator which also has a sharp contour in its waveshape.

Thus, an oscillator producing saw-tooth waves could be accurately locked with pulses or other saw-tooth or similar sharp contour wave shapes used as sync voltages. If the output of the oscillator were used as a source of sine wave production it would be possible to produce sine waves whose frequency and phase correspond accurately to the repetition rate of the sync voltage.

If a regular sine-wave oscillator is used, the sync repetition frequency would have to be very close to the oscillator frequency. A changing phase between the pulses and the sine wave would constantly be occurring because the pulses could occur at different parts of subsequent cycles, since the sine wave has no sharply defined contour into which the sync pulse can lock.

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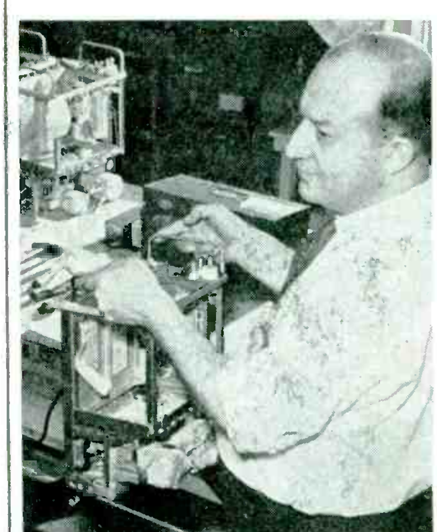
INSPECTION LINE



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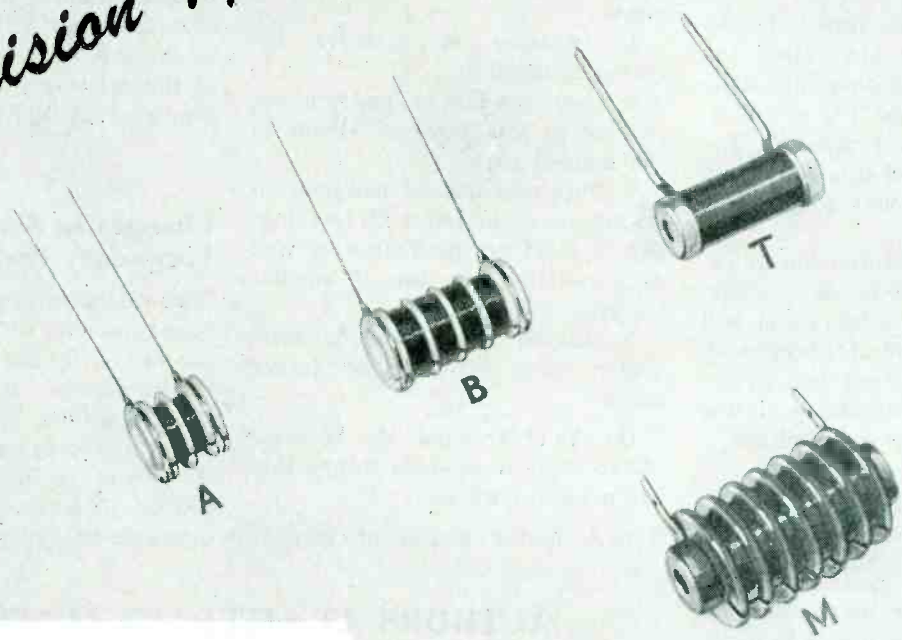


Specifications:

"A"—15/32 long x 1/2" dia.—Mountable with 6-32 flat or filester screw. #21 tinned copper wire leads. 1 to 300,000 ohm value — 1/2% standard accuracy — non inductive pie wound—1/2 watt, 30° C. temperature rise in free air — 100° C. maximum operating temperature — 200 D. C. maximum operating voltage. Baked varnish finish.

"B"—15/16 long x 1/2" dia.—Mountable with 6-32 flat or filester screw. #21 tinned copper wire leads. 1 to 500,000 ohm value—1/2% standard accuracy—non inductive pie wound—1 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—300 D. C. maximum operating voltage. Baked varnish finish.

"T"—1-1/32 long x 7/16" dia.—Inductively wound—1/8 x .015 strap terminals—35 to 35,000 ohms—2 watts, 100° C. maximum operating temperature—normal accuracy 1%. Baked varnish finish.

"M"—1-13/32 long x 3/4" dia.—Mountable with 6-32 screw—1/8 x .015 thick strap terminals—Non inductive wound—1 meg ohm maximum resistance—600 volts maximum operating voltage—100° C. maximum operating temperature—1.5 watts—1% normal accuracy. Baked varnish finish.

Elco wire wound resistors have met the test of proven quality demanded by several of the country's largest radio and instrument manufacturers. They challenged us to make them good and make them fast. We met that challenge. Our plant is staffed with highly trained workers prepared and anxious to fill your order promptly.

ELCO RESISTORS COMPANY

114 West 18th Street, New York, N. Y.

Telephone—Watkins 9-4774-5

NEWS OF THE INDUSTRY

Electronics in plastics molding; additional frequency for WWV; new manufacturers' association; new setup for station approval; television broadcasters form association

Radio Division in State Department

RECENT REORGANIZATION of the State Department has raised the status of the telecommunications section to a division. The new division is headed by Francis C. DeWolfe, who handled this subject in the old international communications division.

Work of the new division in radio will be confined to the commercial and facilities aspects and will provide aid to broadcasters in handling properties abroad and in arranging for program transmission to this country for rebroadcast.

Electronics in Plastics Industry

APPLICATION OF electronic high-frequency heating to plastics has been more or less confined to methods of quickly heating preforms or briquettes of thermosetting materials in an auxiliary unit before placing the preform in the hot mold which gives the final shape to the article, according to Gregory W. Blessing in a recent address to the Plastics' Institute Alumni Association. He is the inventor of a method of bonding metal to metal by using plastics as the bonding agent and fusing the plastic material by high-frequency heating.

In regard to electronic methods of heating preforms, he stated that these are now in use in many plastics molding plants and have not only reduced the molding time cycle but have enabled the production of many shapes and sizes heretofore impossible to produce in the orthodox procedure of heating the plastic material directly in the mold.

He summed up the high-frequency developments as having the following definite advantages:

1. Reduced time cycles in the press.
2. Reduction in pressure required in molding.
3. Improved flow of material resulting in less internal strain in the molded part.
4. Improved flow of material allowing use of inserts with less danger of mold pin breakages as well as permitting the use of smaller inserts.
5. Making it possible to mold either more intricate or larger parts.

On the other hand, Mr. Blessing stated there were some things that are needed, such as

1. A better means of heating molded powder making it unnecessary to make preforms.
2. The ideal molding material that will not gas or sweat excessively causing sticking to the electrodes.
3. Variations in the exact time cycles in heating of the material due to variations in bulk of the material, variations in the apparent impedance of one preform to another due to chemical differences in the materials from one lot to another.
4. The change over from one molded produce to another entails some degree of technical knowledge on the part of the set-up man. Some of the existing equipment could be improved in this respect.

Changes in Standard Frequency Broadcasts

TWO CHANGES in the standard frequency service of WWV have been announced by the National Bureau of Standards. A new frequency, 2.5 megacycles, has been added to the three original frequencies of 5, 10 and 15 Mc regularly transmitted. The second change is the omission of the pulse on the 59th

AUTHORS AT LITERARY LUNCHEON

Keith Henney, editor of ELECTRONICS, is introduced to Mrs. Caverly by Don P. Caverly, author of a new book, "A Primer of Electronics." He is a commercial engineer with Sylvania Electric Products Inc., of which Roger M. Wise (right), is director of engineering.

second of every minute of the regular service.

The service now consists of standard radio-frequency transmissions on 2.5 Mc, 5 Mc, 10 Mc and 15 Mc. Standard time intervals, accurately synchronized with basic time signals, and standard audio frequencies are also provided. Signals are transmitted on the 5-Mc and 10-Mc frequencies continuously day and night. The time of transmission of the other two frequencies are staggered so that at least three carrier frequencies are on the air at all times from 10-kw transmitters. The 2.5-Mc transmitter is on from 7:00 P. M. EWT (1300 to 2300 GMT), and the 15-Mc transmitter from 7:00 A. M. to 7:00 P. M. EWT (1100 to 2300 GMT).

Two standard audio frequencies, 440 and 4,000 cps are broadcast on 5, 10, and 15 Mc. Only the 440-cycle signal is broadcast on 2.5 Mc. This is the standard musical pitch, A above middle C, while the 4,000-cycle signal is a useful standard audio frequency for laboratory measurements.

All the carrier frequencies include a pulse of 0.005-second duration which occurs periodically at intervals of precisely one second. The pulse consists of five cycles, each of 0.001-second duration, and is heard as a faint tick when listening to the broadcast. It provides a useful standard of time interval for purposes of physical measurements and may be used as an accurate time signal. The pulse is omitted on the 59th second of every minute.

The two audio frequencies are interrupted precisely on the hour and each five minutes thereafter; after an interval of precisely one minute they are resumed. This one-minute interval is provided in order to give the station announcement and to afford an interval for the checking of radio-frequency measurements free from the presence of the audio frequencies. The announcement is the station call letters (WWV) in telegraphic code (dots and dashes), except at the hour and half hour when a detailed announcement is given by voice.

The accuracy of all the frequencies, radio and audio, as transmitted, is better than one part in 10,000,000. Transmission effects in the medium (Doppler effect, etc.) may result in slight fluctuations in

the audio frequencies as received at a particular place; the average frequency received is however as accurate as that transmitted. The time interval marked by the pulse every second is accurate to 0.000001 second. The 1-minute, 4-minute, and 5-minute intervals, synchronized with the seconds pulses and marked by the beginning or ending of the periods when the audio frequencies are off, are accurate to a part in 10,000,000.

The beginnings of the periods when the audio frequencies are off are so synchronized with the basic time service of the U. S. Naval Observatory that they mark accurately the hour and the successive 5-minute periods.

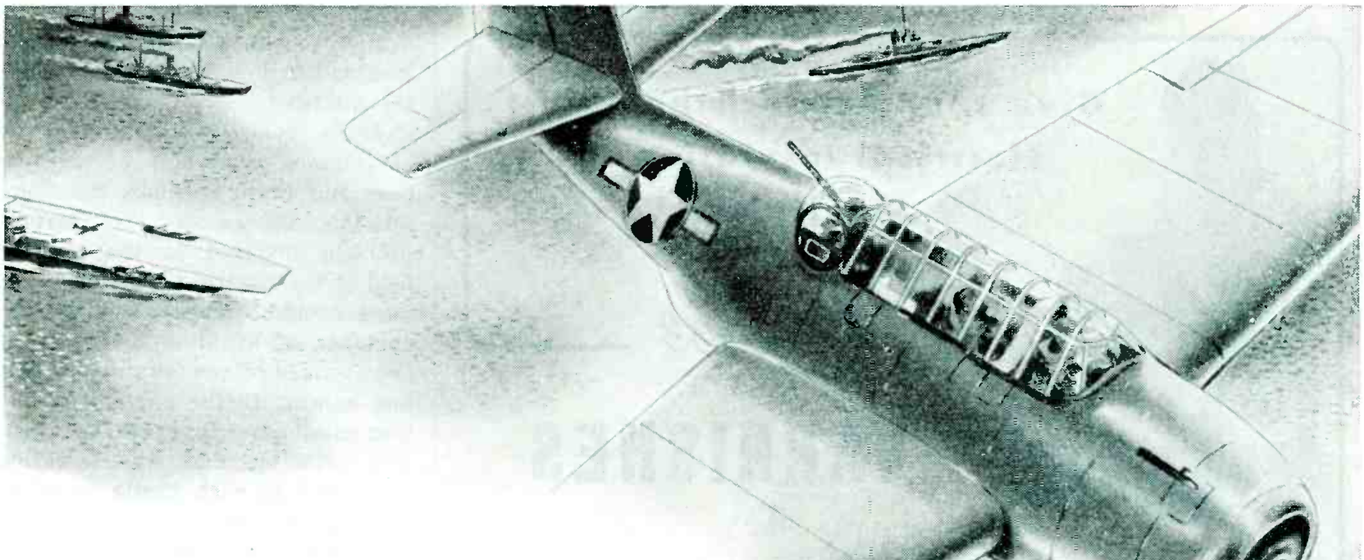
West Coast Electronic Manufacturers Association

LEADING ELECTRONIC and component parts manufacturers located in the western states have formed an organization to be known as the West Coast Electronic Manufacturers Association. The membership comprises more than sixty companies and the association has the full approval of the War Production Board and the U. S. Army Signal Corps.

Participation of the members in such an association should assure full utilization of existing manpower and manufacturing facilities of the electronics industry in the West and clarify information of government rulings and regulations for the members. The group will also attempt to secure uniform consideration of problems concerning renegotiation and termination of contracts, selective service, wage stabilization and other matters of mutual interest.

Newspaper Ownership of Stations

THE MUCH-DISCUSSED question of newspaper ownership of broadcast stations has been closed by the recent decision of the Federal Communications Commission not to adopt any general rule in the matter. A summary of the evidence in the proceeding is being forwarded to the appropriate committees of the Senate and House of Representatives in order to inform them of the facts developed by the in-



(1430* CVE from Curly:)

"Could I Borrow a Destroyer?"

The first message from Curly, pilot of one of the Avengers, was received by the Escort Carrier at 1426—"Sub sighted." At 1427—"Attacking," and at 1430—"Sub sinking. Send destroyer to pick up survivors."

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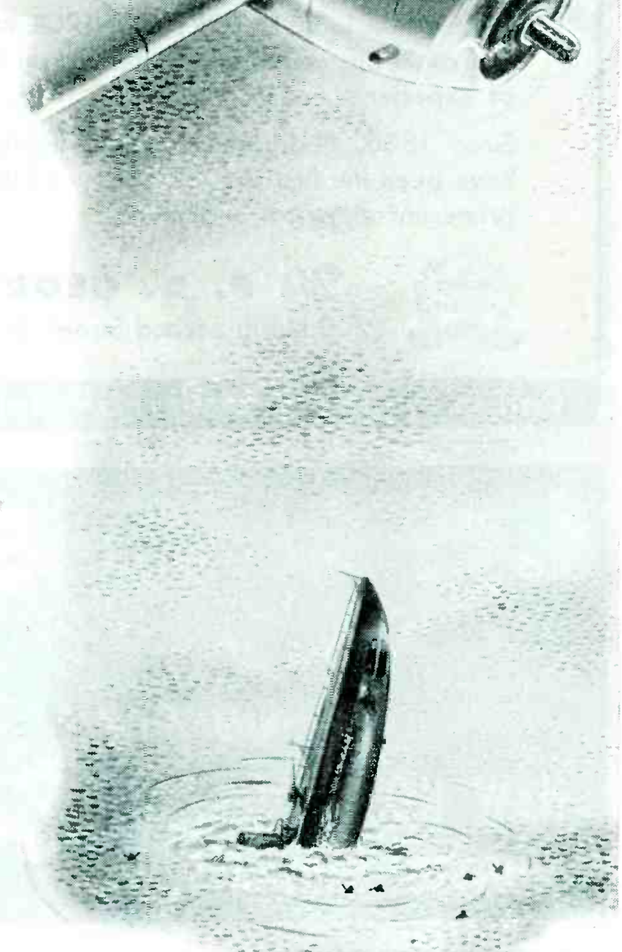


Words like these, brief but pungent, reveal our mastery over the prowling U-boat packs that once were our most feared enemies—a mastery that came about only after ships and planes were linked together into a single fighting unit. Linked by instantaneous Communication from ship to ship, ship to plane, and from pilot to crew.

Into the sea-air-land communication systems of our fighting forces go many Rola products, Transformers, Coils, Headphones and other electronic parts. And into these Products go the knowledge and skill that Rola has acquired through a quarter of a century's leadership in the art of Sound Reproduction. THE ROLA COMPANY, INC., 2530 Superior Avenue, Cleveland 14, Ohio.

*2:30 PM

ROLA

Let's do more ARMY E NAVY *in forty-four!*

MAKERS OF THE FINEST IN SOUND REPRODUCING AND ELECTRONIC EQUIPMENT vestigation and for any consideration which they may desire to give the matter.

Aside from the specific question of common ownership of newspapers and radio stations, the Commission recognizes the serious problem involved in the broader field of the control of the media of mass communications and the importance of avoiding monopoly of the avenues of communicating fact and opinion to the public. All the Commissioners agree to the general principle that diversification of control of such media is desirable and do not desire to discourage legally qualified persons from applying for licenses. They do desire to encourage the maximum number of qualified persons to enter the field of mass communications, and to permit them to use all modern inventions and improvements in the art to insure good public service.

In processing of individual applications, the Commission will inquire into and in its decisions give expression to "public interest" considerations. The Commission does not feel that it should deny a license merely because the applicant is engaged or interested in a particular type of business. However, it does not intend in granting licenses in the public interest to permit concentration of control in the hands of the few to the exclusion of the many who may be equally well qualified to render such public service as is required of a licensee.

Television Course for NBC Engineers

A 50-WEEK COURSE of television instruction for staff engineers has been inaugurated by the National Broadcasting Co. To make the program available to personnel assigned to transmitters located outside New York City, each weekly lesson will be scheduled three times at different hours of the day for each period. An enrollee is permitted to attend the class best suited to his free time.

Each session will have one hour devoted to a lecture and an equal period to a forum. Members of the NBC television group who have had extensive experience in television will collaborate with the instructor. Emphasis will be placed

on the overall functioning of television systems, circuits and equipment, supplemented by discussions of operating practices and maintenance problems. As far as possible, lectures will be devoted to the practical engineering problems of television as they apply to operations rather than to the intricacies of circuit design.

Stevens Research Foundation

A NONPROFIT CORPORATION to carry on scientific and industrial research has been organized in cooperation with Stevens Institute of Technology under the name of the Stevens Research Foundation.

The Foundation is an outgrowth of the extensive program of research which Stevens has carried on in recent years and which has expanded greatly during the war. Several of its laboratories are now engaged in confidential research for Government departments to aid the war effort, and they have also helped industry to increase and improve production in both war and peace after the war ends. The Foundation will aim to help meet the new demands of the reconstruction era including new products, new uses for old products, and new improved manufacturing processes.

New Station Approval Setup

A PROCEDURE that defines more clearly the fields of operation of the Federal Communications Commission and the War Production Board in acting on applications for new or expanded facilities for broadcast stations has been announced by both agencies. Under the new system the FCC will give an applicant a conditional grant, subject to WPB approval for construction or modification of facilities. A permit will be granted by FCC after these conditions are satisfied.

The Radio and Radar Division of WPB pointed out that FCC policy does not mean a relaxation of WPB policy, which is dictated by the need for conservation of manpower, materials and manufacturing facilities of radio equipment and maintenance supplies. Since the requirements of the armed forces in 1944 are half again as large as in 1943, this large demand

on the industry will not allow more than minimum essential production of additional equipment for new stations or the expansion of existing stations.

An applicant desiring further consideration of an application for radio facilities or change in facilities may submit a petition for reinstatement of such application to FCC within 60 days of January 26, 1944, the date of issuance of the supplemental statement of policy by FCC. The petition should be accompanied with amendments and supplemental information appropriate to any change in circumstances.

WPB said that FCC Order 107, which reduced the power used by radio stations, had been very effective in reducing the replacement parts needed by stations without any noticeable impairment of service, and recommended to FCC that this order be kept in effect.

WPB orders restrict radio construction in the following ways:

1. General Limitation Order L-265 prohibits the transfer of electronic equipment from a supplier or manufacturer unless the

• • •

RECORD DRIVE

Thomas M. Kelleher, director of WOR recording studios, looks over the first batch of transcriptions to come in from other stations in answer to his appeal for return of old discs to manufacturers for salvage of much-needed vinylite

order bears a preference rating of A-1-A or better. A rating of AA-4 or better is required for manufacture of such equipment.

2. General Limitation Order L-41 requires an authorization to start construction if the cost of construction is over $200.

3. Authorization must also be obtained from the Office of War Utilities to install power and telephone lines.

4. Several other orders cover the transfer of materials, such as copper, even though they may be surplus stock.

Transcriptions for Schools

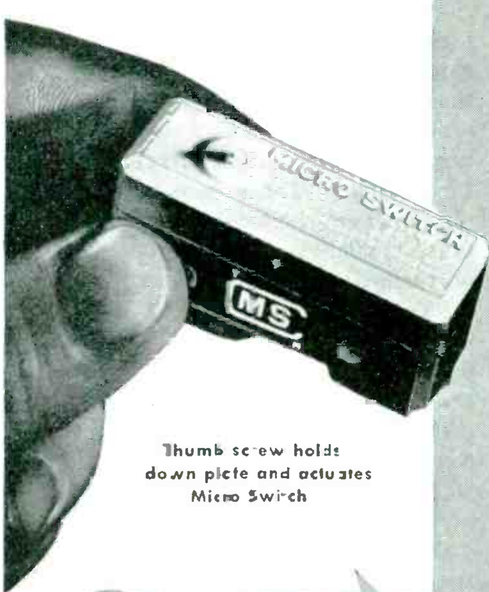
TRANSCRIPTIONS of a radio program devoted to explanations of scientific principles have been made available for loan to high school classes throughout the nation. The recordings were made of some thirty programs selected from "Adventures in Research", a weekly radio feature produced by Westinghouse Research Laboratories and now broadcast by 100 stations.

The company received so many requests for transcriptions of the programs that it was decided to make them available through a central lending source. The discs are now supplied free of charge to the Federal Radio Education Committees of the U. S. Office of Education, Washington, D. C. and may be obtained by high schools from this agency at the present time. The FREC plans to set up 25 loan centers in various parts of the country for decentralized distribution.

WACS in Communications

PRAISE for the WACS at work with the Signal Corps in North Africa comes from Brigadier General J. V. Matejka, Chief of the Personnel and Training Service of the Signal Corps and a recipient of the Legion of Merit for his recent services as Chief Signal Officer, Allied Forces Headquarters in North Africa. His opinion is reflected in official reports to the Chief Signal Officer and is generally shared by other Signal Corps officers recently returned from overseas.

"Even in World War I", said General Matejka, "the Signal Corps recognized the special qualifica-

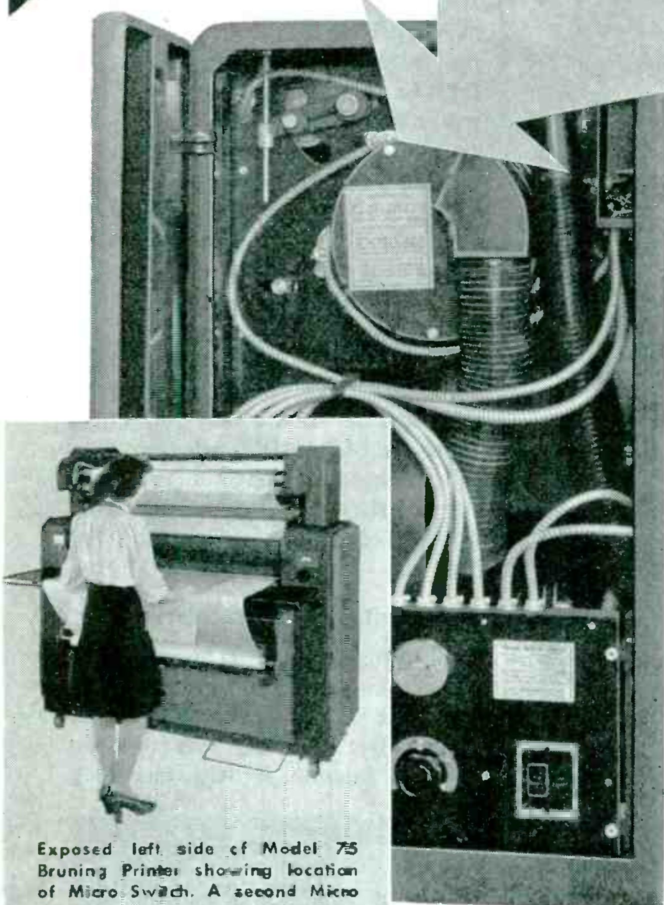


Thumb screw holds down plate and actuates Micro Switch

Charles Bruning Company Uses Two

Micro Switches

to Provide Utmost Protection to Operator of Bruning Printers



Exposed left side of Model 75 Bruning Printer showing location of Micro Switch. A second Micro Switch is on the right side.

Charles Bruning Company of Chicago are the manufacturers of Bruning Printers and Developers, widely used by engineers and draftsmen in every branch of industry. Bruning Printers, which produce black and white prints, are compactly built to do a big job in small space.

The thumb-size, feather-weight Micro Switch is a natural complement to such a design, and the Charles Bruning Company uses two Micro Switches to provide utmost protection to the operator.

The two Micro Switches are located at each end of the Bruning Printer to make it impossible to remove the end plates, which shield the quartz lamp, while the lamp is still burning. This is accomplished by so locating the thumb screws, which hold the end plates in place, that they cannot be turned without actuating the Micro Switch and automatically disconnecting the power from the quartz lamp.

This use of Micro Switch by the Charles Bruning Company is typical of the varied applications in which this small, compact, precision switch is filling the needs of industry. Wherever space is at a premium, wherever small movement and small energy are vital factors in design—Micro Switch has come to be recognized as the one precision switch that will best meet all requirements.

Micro Switches represent a distinct saving in engineering expense over the cost of specially-designed switches. They insure a better product because they are absolutely dependable for millions of accurate repeat operations. The basic Micro Switch is no larger than your thumb—11/16″ x 27/32″ x 1 15/16″. It weighs only an ounce.

With Micro Switch it is just a matter of naming your requirements. Micro Switch can meet them. It is available in over 2000 different combinations of electrical characteristics, housings, and actuators.

Does your design call for the unusual in precision switching? You can count on help from Micro Switch. Send for Micro Switch Handbook Catalog No. 60. For full information on aircraft design you should have Handbook Catalog No. 70, too.

The basic Micro Switch is a thumb-size, feather-light, plastic enclosed, precision, snap-action switch, Underwriters' listed and rated at 1200 V.A., at 125 to 460 volts A.C. Capacity on D.C. depends on load characteristics. Accurate repeat performance is experienced over millions of operations. Wide variety of basic switches and actuators meets requirements varying from high vibration resistance to sensitivity of operating force and motion as low as 2/1000 Oz. In. Many types of metal housings are available.

Buy all the Bonds you can!

Micro Switch Corporation, Freeport, Illinois • Branches: 43 East Ohio Street, Chicago (11) • 11 Park Place, New York City (7) • Sales and Engineering Offices: Boston • Hartford • Los Angeles

The trademark MICRO SWITCH is our property and identifies switches made by Micro Switch Corporation. ©1943

MICRO SWITCH

Made Only By Micro Switch Corporation . . . Freeport, Illinois, U. S. A.

tions of women for certain military duties and 225 American women who spoke French acquitted themselves with great credit in operating switchboards at large military toll centers and central offices in France. These women were placed where the local and long distance traffic was heaviest, and they performed admirably.

"Today a number of WACS are serving in North Africa as telephone operators, teletypewriter operators, clerks and in other capacities to the utmost satisfaction of commanding officers, many of whom are clamoring for more WAC personnel.

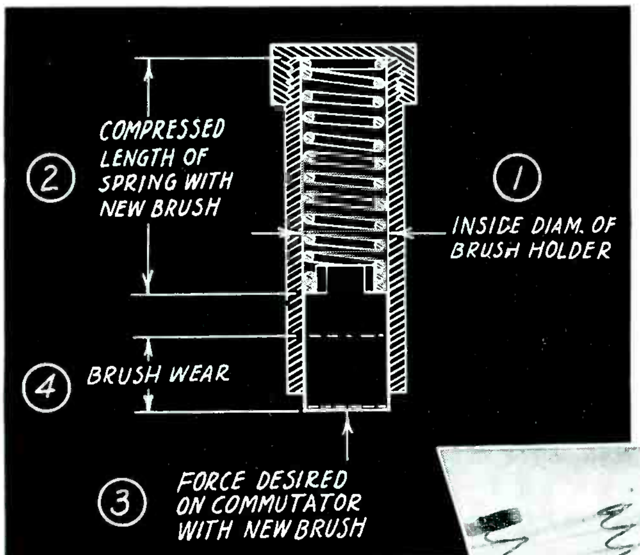
"Of course, a large proportion of the young women who enlist in the WAC will see service at home. Today a number of them are being trained to become radio and photographic specialists, learning to repair and operate radio sets and to develop negatives and print pictures, while many are using their clerical skills to speed the communications of the Army.

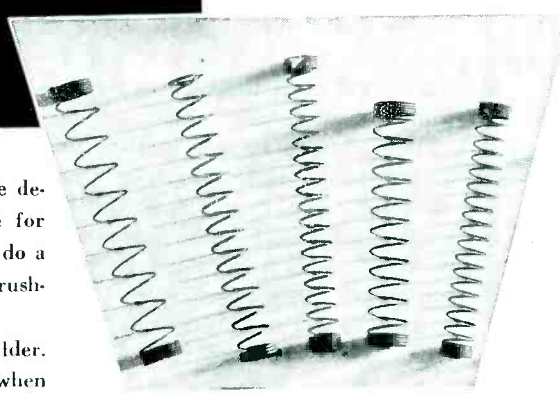
"After observing the cool efficiency and splendid morale of our Signal Corps WACS in North Africa, I believe these fine soldiers are capable—if we had enough of them—of operating all our fixed telegraph and telephone communications throughout the rear areas in the Mediterranean Theater."

War Veteran Speaker

A BATTLE-SCARRED LOUDSPEAKER, torn from its mountings by a Jap shell that hit the U.S.S. Boise when that cruiser sank six ships off the Solomon Islands, is still operating

"Micro-Processing" Makes Possible this New Design Concept for Better BRUSH SPRINGS





The exceptional physical and electrical properties of beryllium copper, when Micro-processed, enable the designer of brush springs to establish new values of performance without increasing the cost of the springs.

Micro-processing eliminates all of the guesswork by controlling and directing the inherent properties of beryllium copper to achieve desired new standards of performance in service.

Whether you are interested in the actual design of better brush springs, or desire to improve the working efficiency of equipment and would like I-S to design your brush springs with you, contact us and compare on your own springs — for your own use — the decided difference that Micro-processing makes.

Samples take about a week; quantity deliveries are shipped in 4 to 6 weeks.

Instrument Specialties engineers have devised a simplified design procedure for determining the best brush spring to do a specific job; based upon only four brush-holder design details:

1 — Inside diameter of brush holder.
2 — Working length of spring when assembled with a new brush.
3 — Force desired on the commutator.
4 — Allowance for brush wear.

From these four details of your motor design, I-S engineers will design the one best "Micro-processed" brush spring giving longest brush life consistent with easy assembly.

"Making Beryllium Copper Behave"
The story behind the development of micro-processing.

"Spiking A Rumor"
The facts about the greatly increased supply of beryllium copper.

"Predicting Spring Performance of Beryllium Copper Wire & Strip"
Why beryllium copper varies in hardening response and what to do about it.

INSTRUMENT SPECIALTIES CO., INC.
DEPT. D., LITTLE FALLS, NEW JERSEY

FIELD ENGINEERING OFFICES: BOSTON · CHICAGO · CLEVELAND · PHILADELPHIA · NEW YORK and serving the war effort at the RCA Victor plant in Indianapolis where it was made. Called "Battling Benny" by plant employees, the speaker is now mounted on a display panel with photos of the cruiser and used for inspirational announcements. Standing at the panel is Franklin Bowman, 24, who served three years on the Boise and is now employed at the plant.

Dry Cell Production

AN INCREASE of 57 percent in production of radio type dry cells during 1943 over the amount produced in 1940 is indicated by a report from the War Production Board. The total production of all types of dry cell batteries, including those for the armed forces, averaged about 35 percent above the 1940 rate during the first nine months of 1943.

Quarterly reports on production and shipments of each of the various types of dry cell batteries are to be made available by WPB in line with its new policy of supplying more statistical data for engineers and business men.

The figures on production and shipments of radio types in thousands of cells are given in the following table. This has been compiled from data supplied by nine companies manufacturing radio batteries. Data on other types of cells may be obtained from Bureau of the Census, Washington 25, D. C.

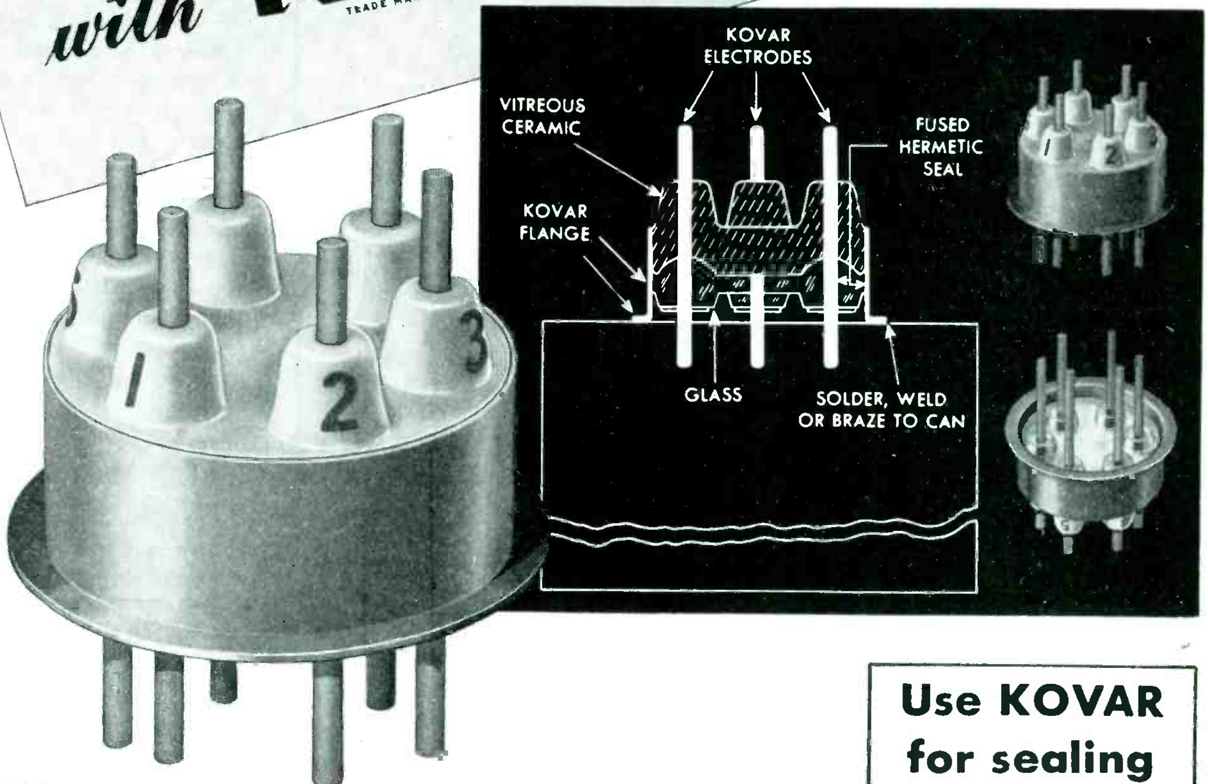
Production (thousands of cells)	
1940	
Total	480,438
Quarterly average	120,110
1943	
First quarter	209,773
Second quarter	170,815
Third quarter	185,660
Shipments (thousands of cells)	
1943	
First quarter	205,086
Second quarter	176,254
Third quarter	185,079

F-M Network Programs

TO STIMULATE THE PROGRESS of f-m broadcasting, NBC plans to make its network programs available to the f-m stations operated by the NBC standard-band affiliated stations. This will permit listeners to hear network programs regardless

Multi-Terminal Hermetic Seals *with* KOVAR

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



HERMETIC transformer or capacitor seals of Kovar and glass may be made in a wide size range and with single or multiple electrodes. Electrodes may be solid or tubular.

The design illustrated uses a vitreous glazed ceramic top, clean and neat in appearance. The vitreous ceramic may be numbered, permitting quick, easy identification of each electrode.

The seal between Kovar and glass is a chemical bond in which the oxide of Kovar is dissolved into the glass during a heating process. The result, a hermetic seal—permanently vacuum and pressure tight, effective under the most extreme climatic conditions —tropical to stratosphere.

Kovar IS the answer to permanent vacuum or pressure tight sealing. Let Stupakoff help engineer YOUR hermetic sealing problems with Kovar.

ARMY E NAVY
"for great achievement"

Use KOVAR for sealing

ELECTRONIC TUBES
TRANSFORMERS
RESISTORS
CAPACITORS
CONDENSERS
VIBRATORS
SWITCHES
RELAYS, ETC.
INSTRUMENTS
GAUGES
METERS
RECEIVERS
TRANSMITTERS

Let's All Back The Attack
BUY WAR BONDS

SINCE 1897

STUPAKOFF

Products for the World of Electronics

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

of whether a standard band receiver or an f-m receiver is used.

The plan would operate by using either improved telephone circuits, covering a broader range of frequencies than is now being used, or by an automatic relay system, capable of transmitting f-m programs from point to point with high fidelity when such facilities become available.

As pointed out by Niles Trammell, president of NBC, as the size of the national f-m audience increases, the number of f-m stations across the country should be sufficient to permit the organization of several new national networks of f-m stations. The present allocation of the radio spectrum will, for all practical purposes, provide as many broadcasting frequencies as there will be broadcasters to use them. The number of such stations, he added, will probably be limited by economic considerations.

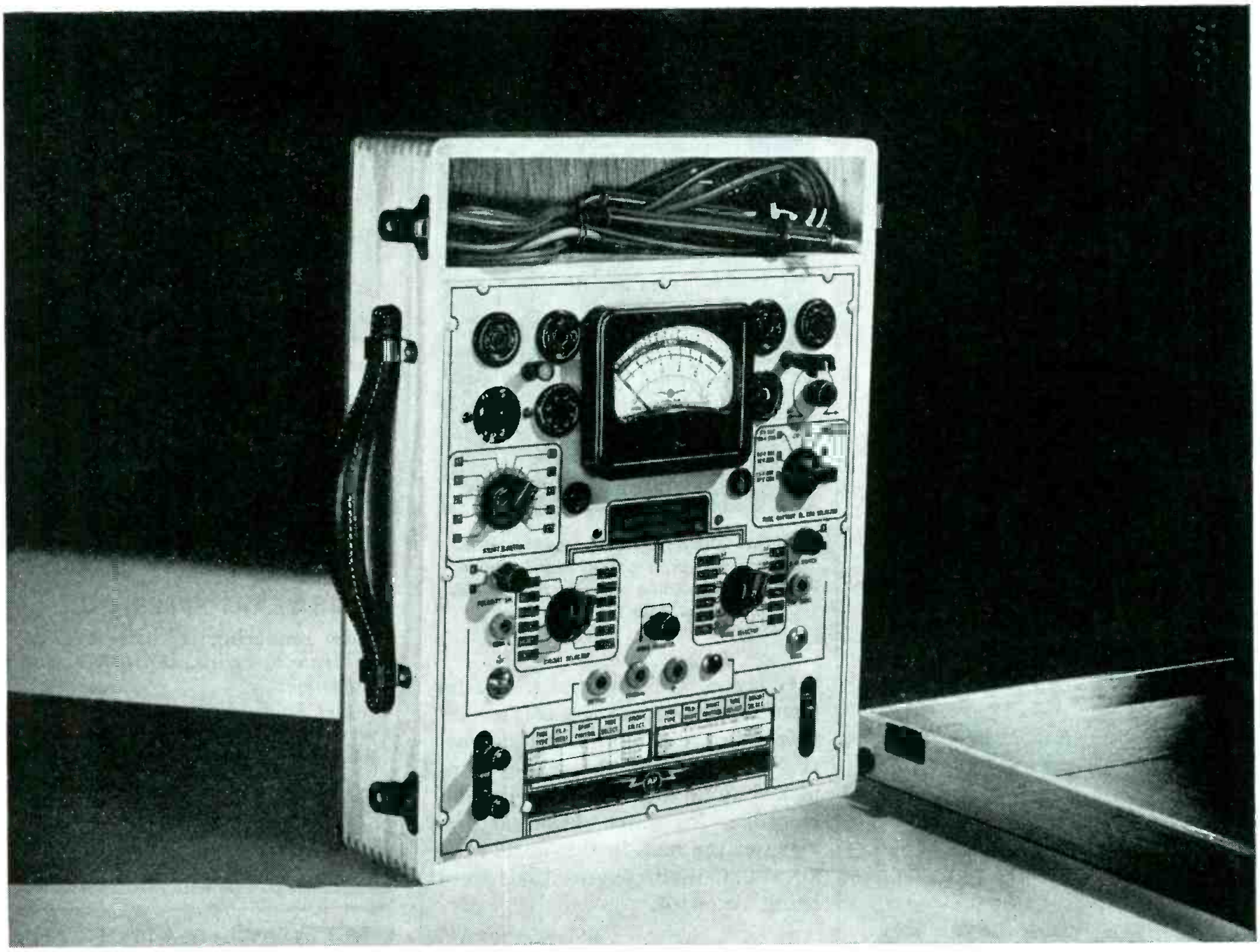
SMPE Meeting

THE 55TH SEMI-ANNUAL technical conference of the Society of Motion Picture Engineers will be held at the Hotel Pennsylvania, New York, April 17–19. Technical sessions, following a general business session opening the conference, are scheduled to be held throughout the three-day meeting. Special sessions will be held in the evening. Papers so far submitted indicate the conference will cover new war developments in the engineering field.

Record U-Boat Attack

THE FIRST RECORDING of an actual attack at sea against a German U-boat was broadcast to radio listeners over the Blue Network on the evening of January 28. The voices of pilots of Grumman TBF Avenger dive bomber planes, the skipper of a destroyer and the commanding officer of an escort carrier were heard during the combined surface-air attack on the U-boat.

Conclusive evidence of a "kill" was not obtained, since the submarine submerged after being sighted by the plane. The recording was made on a second aircraft carrier which was at some distance from



Officers aboard an escort carrier make a transcription of ship-to-plane conversations by holding the recorder microphone near the 'talker'

the scene of operations. Radio transmissions from the carrier involved in the action, from the destroyer and from the plane, were picked up by the second carrier and recorded for later broadcasting. None of the men in the battle area knew that their conversations were being recorded.

Television Broadcasters Form Association

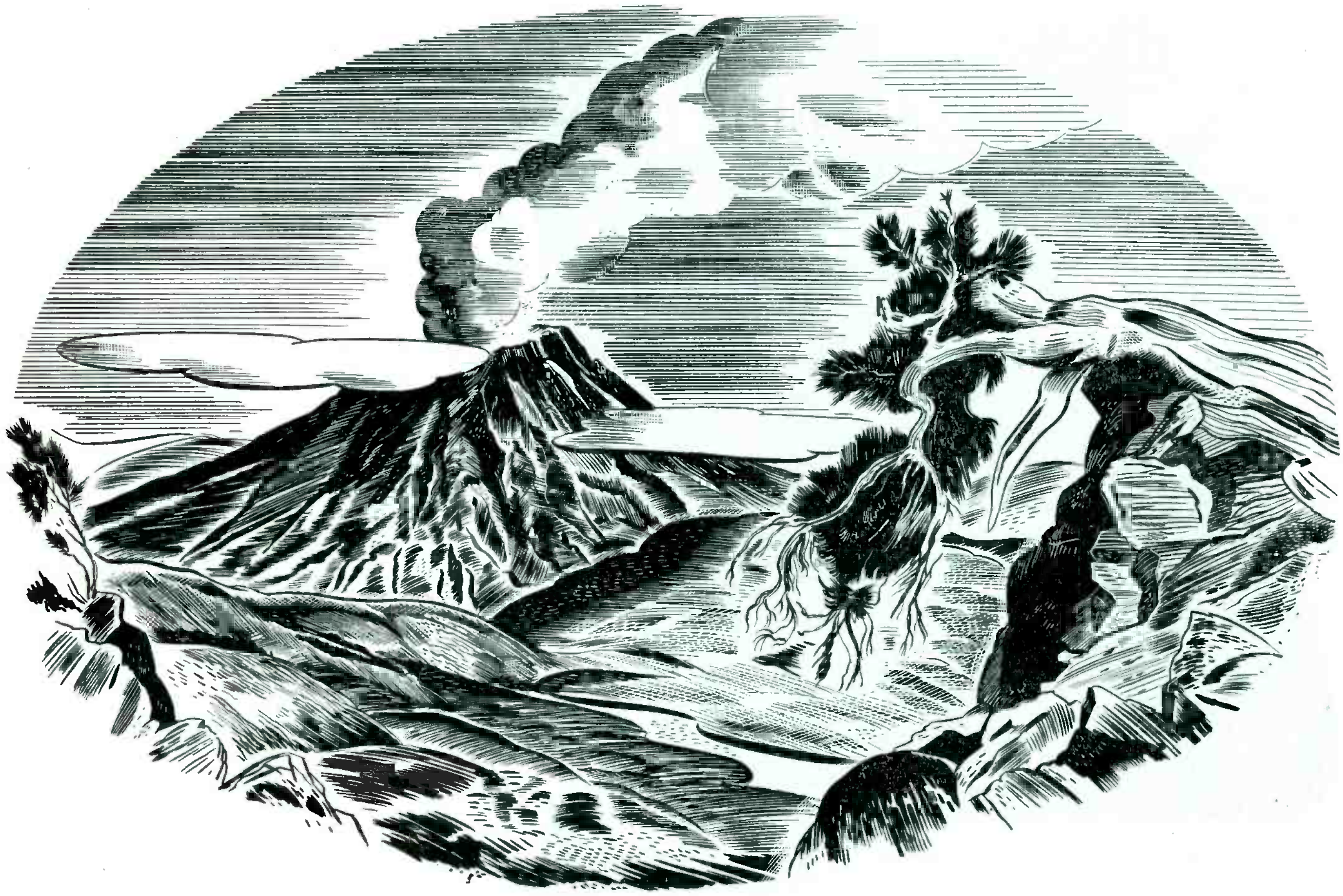
ALLEN B. DUMONT, president of Allen B. DuMont Laboratories, Inc., has been elected president of the newly formed Television Broadcasters Association, Inc., at a meeting of the organization committee in New York.

Other officers elected were: Lewis Allen Weiss, Don Lee Network, vice-president; Jack Poppele, WOR, New York, assistant secretary-treasurer.

Directors elected for three years are O. B. Hanson, NBC; E. A. Hayes, Hughes Tool Co., and Paul Raibourn, Paramount Pictures. Directors for two years are Worthington Miner, CBS; Robert L. Gibson, G-E, and Lewis Allen Weiss, Don Lee Network; and for one year, F. J. Bingley, Philco; Allen B. DuMont, and E. W. Mason of Earle C. Anthony, Inc.

The following committees were organized:

Membership, to consist of the entire board of directors, with the



actual carrying out of the work of the committee to be under the direction of Jack Poppele as assistant secretary.

Publicity, with Robert L. Gibson as chairman. He is assistant to the manager of G-E broadcasting and publicity activities and in charge of the company's television station.

Engineering committee, with F. J. Bingley of Philco as chairman.

Program committee, whose province will be to study, develop and improve programs and technical equipment for better programs, W. C. Miner of CBS, chairman.

Post-war planning committee, to study the effect of television on potential employment and its use as a public service medium for entertainment and educational purposes, Paul Raibourn of Paramount, chairman.

The organization expects to form a television manufacturers' committee from among its associate members to resolve and integrate television manufacturing problems with broadcasting problems.

On invitation of the Radio Technical Planning Board, the organization voted to join the RTPB as a sponsoring member.

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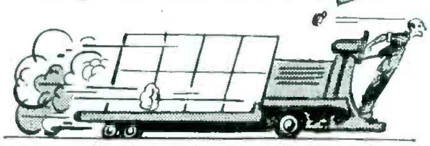
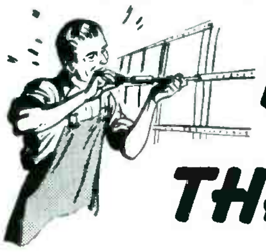
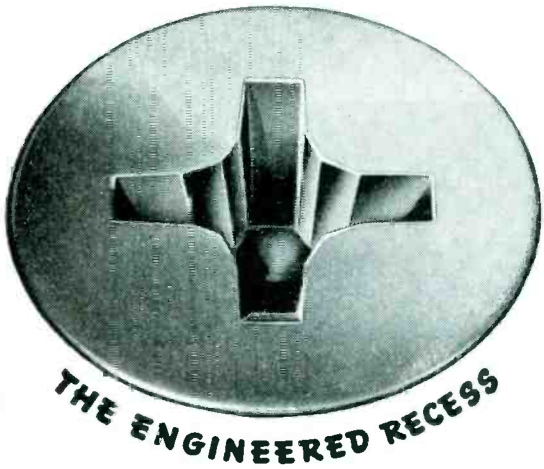
EVACUATING TUBES

More than a dozen heating, baking and pumping operations are undergone by vacuum tubes during a 20-minute trip around this automatic exhaustion machine. Westinghouse engineers report that only one out of every 1,520,000 molecules of air or gas, present in the tube before exhaustion, remains when the tube is finally sealed

WHAT WAS THAT  THAT JUST WENT BY? NOT A FOUR  GENERAL BUT ANOTHER  LOAD OF WAR EQUIPMENT THAT WAS PUT TOGETHER  IN RECORD TIME SINCE . . . THAT FAST-DRIVING RECESSED HEAD SCREW  CAME ON THE JOB..... IT'S PHILLIPS . . .



Sure — the news is swell! But the war isn't over yet. The heat's still on — and production speed is as vital as ever.

One of the surest ways to get more speed in your assembly operations is to put Phillips Recessed Head Screws in the hands of your workers. Hundreds of plants all over the country have standardized on the Phillips screw — and the results have been spectacular. Driving speed has often been doubled. Vital man hours have been saved. Production has been greatly increased — thanks to the Phillips Recess which makes power or spiral driving practical.

Some advantages of Phillips Recessed Head Screws are listed here. Check them against slotted head screws — or any other type you may be using. You'll quickly see why it costs less to use screws with the Phillips Recessed Head.

PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS · MACHINE SCREWS · SELF-TAPPING SCREWS · STOVE BOLTS

TO MAKE WARTIME QUOTAS AND PEACETIME PROFITS

Faster Starting: Driver point automatically centers in the Phillips Recess . . . fits snugly. Fumbling, wobbly starts, slant driving are eliminated. Work is made trouble-proof for green hands.

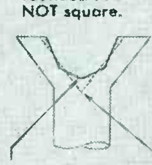
Faster Driving: Spiral and power driving are made practical. Driver won't slip from recess to spoil material or injure worker. (Average time saving is 50%.)

Easier Driving: Turning power is fully utilized. Workers maintain speed without tiring.

Better Fastening: Screws are set up uniformly tight, without burring or breaking of screw heads. The job is stronger, and the ornamental recess adds to appearance.

IDENTIFY IT!

Center corners of Phillips Recess are rounded . . NOT square.



Bottom of Phillips Recess is nearly flat . . . NOT tapered to a sharp point.

23 SOURCES

American Screw Co., Providence, R. I.
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
General Screw Mfg. Co., Chicago, Ill.
The H. M. Harper Co., Chicago, Ill.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
Milford Rivet and Machine Co., Milford, Conn.
The National Screw & Mfg. Co., Cleveland Ohio
New England Screw Co., Keene, N. H.
The Charles Parker Co., Meriden, Conn.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Reading Screw Co., Norristown, Pa.
Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterville, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

BELL SOUND SYSTEMS, INC.,
Columbus, Ohio
ELECTRONIC ENTERPRISES, INC.,
Newark, N. J.
HOLTZER-CABOT ELECTRIC CO.,
Boston Plant,
Boston, Mass.
KEN-RAD TUBE & LAMP CORP.
Owensboro Plant
Owensboro, Ky.
SQUARE D. CO.,
Kollsman Instrument Div.,
Elmhurst, L. I., N. Y.
SYLVANIA ELECTRIC PRODUCTS, INC.
Montoursville Plant
Williamsport, Pa.
TENNESSEE EASTMAN CORP.,
Kingsport, Tenn.
UTAH RADIO PRODUCTS CO.
Chicago, Ill.

ELECTRONIC TUBES handled about ten percent of all electrical energy generated by any source in the United States during 1943, according to the New York Wall Street Journal in a recent article reviewing the use of vacuum tubes in industry.

IN THE PROCESS of printing E. H. Bartelink's article entitled "Wide-Band Oscilloscope," appearing in the February issue, the following sentence was inadvertently omitted and originally concluded the text on page 125: "The author wishes to thank Mr. C. Perleberg for his help with the special transformer and shielding problems, and Mr. R. L. Watters and Mr. S. Sebis for their many suggestions and their help in the development, construction and testing of the instrument.

USE VARIACS*

for Efficient Voltage Control

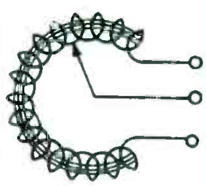
Hundreds of thousands of Variacs are used to control motor speed, heat, light and power, and to compensate for under-voltage or over-voltage lines.

Variacs have ● **LOW LOSSES**
● **GOOD REGULATION**
● **SMALL SIZE**
● **LINEAR VOLTAGE ADJUSTMENT**

These features, plus General Radio quality construction are the reasons for the wide acceptance of the Variac wherever variable a-c voltage is required.

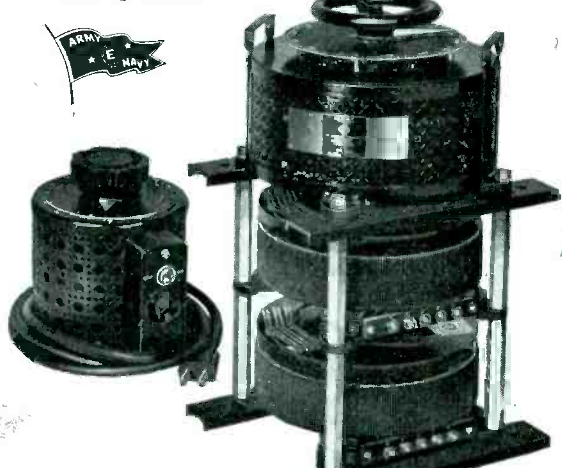
Variacs are more efficient, more economical, and more convenient to use than resistive controls.

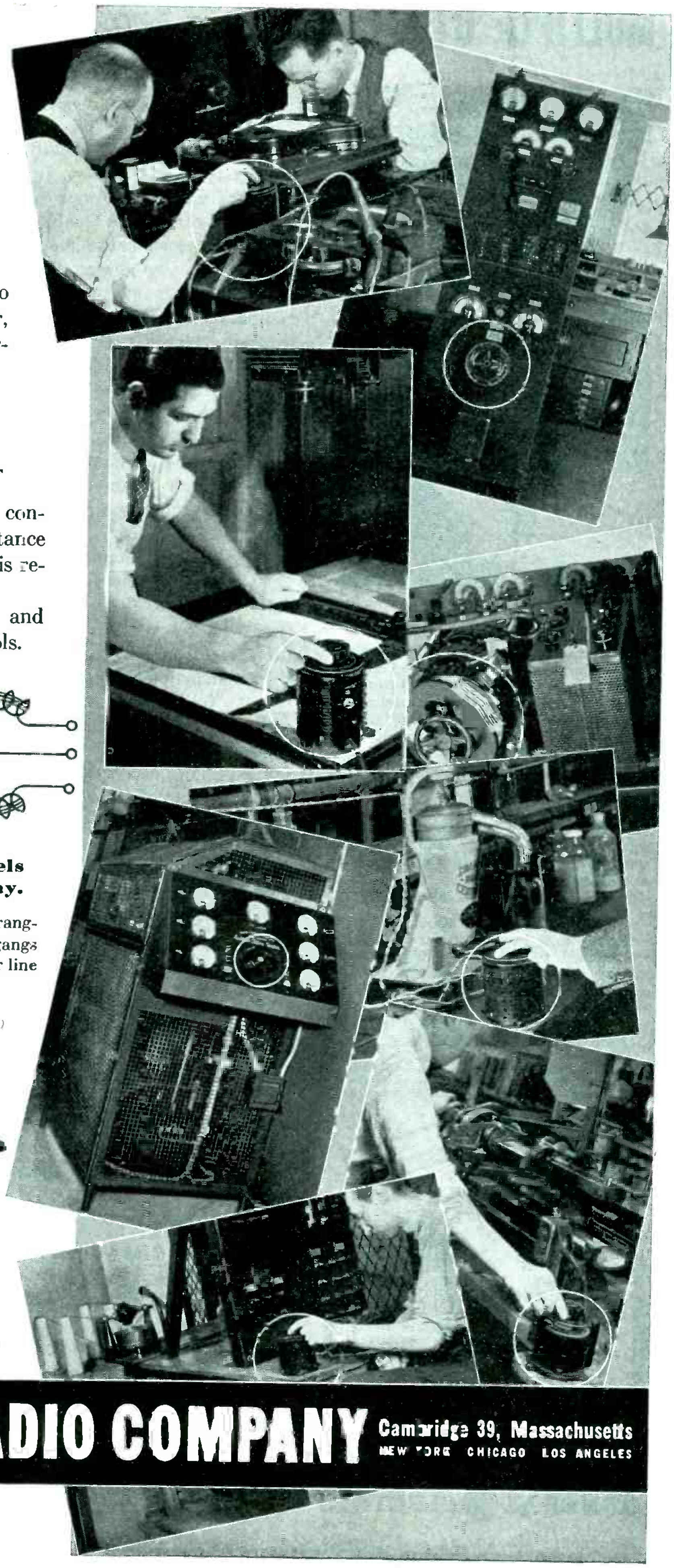
The Variac is an autotransformer with a toroidally shaped winding. As the control dial is rotated, a carbon brush traverses the winding, turn by turn. The brush position at any setting determines the output voltage, which is read directly from the dial.



Bulletin No. 859 describes current models of the Variac. Write for your copy today.

Variacs are available for 60-cycle service in 9 models ranging from 170 va to 7 kva. They can be assembled in gangs for 3-phase operation in power ratings up to 25 kva for line voltages up to 460.





GENERAL RADIO COMPANY Cambridge 39, Massachusetts
NEW YORK CHICAGO LOS ANGELES

*The name *Variac* is a registered trade mark of the General Radio Company. The Variac is manufactured and sold under U. S. Patent No. 2,009,013.

Gamma Ray Measurements

(*Continued from page* 233)

upsets the thermal condition in the section.

By using heavily-doped cement, squeezed cement is easily located by gamma-ray measurements. Figure 5 shows two gamma-ray curves made in the same well, in which radioactive cement was squeezed through perforations about 5525 feet down. The shaded portion of the curve indicates the zone in which the column of cement squeezed out behind the pipe. In this job, the cement travelled a fairly large distance, about 70 feet, up the outside of the pipe.

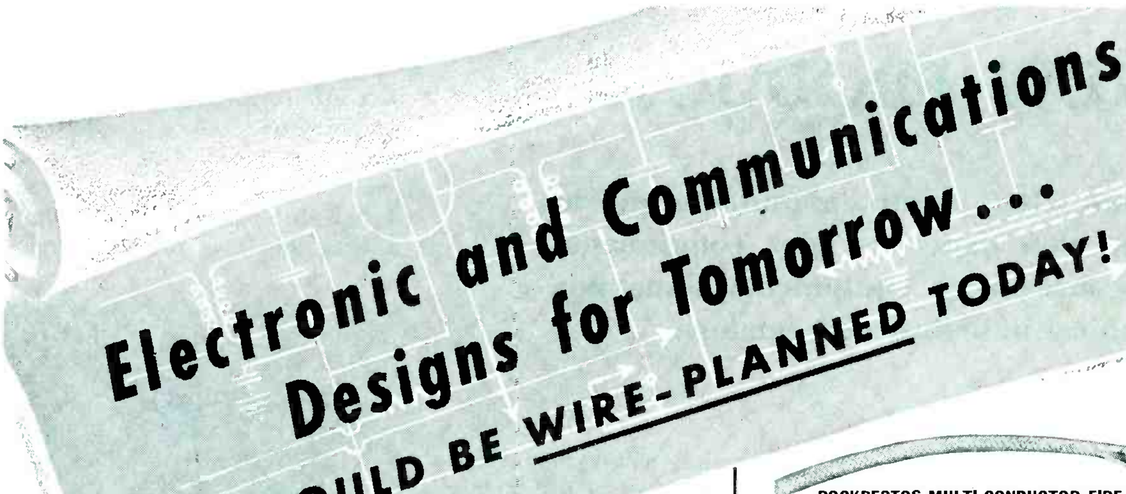
Squeeze jobs are usually used in sealing off objectionable water and gas sands from the producing sand and thus it is quite important at times to know the disposition of the cement.

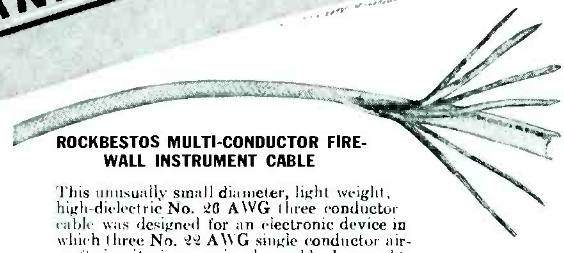
In conclusion, it may be said the recent techniques of electronics and nuclear physics have given the oil industry a much needed tool for exploring cased wells. At present, it would appear that formation logging is the principal application of the gamma-ray method. However, as to tracer measurements, the technique is not limited to cementing operations but is applicable to the location of any extraneous material introduced into a well, particularly to the location of markers for future operations in the well.

REFERENCES

(1) Schlumberger, C. and M., and Leonardon, E. G., *Trans. A.I.M.E.*, 110, p. 237, 1934.
(2) Howell, L. G., and Frosch, A., *Geophysics*, 4, (2), p. 106, 1939.
(3) Howell, L. G., and Frosch, A., *A.I.M.E. Tech.* Pub. No. 1113, 1939.

"*A LITTLE CHEMISTRY, physics or physiology has no value at all in ordinary life. I have never once found . . . where such scientific knowledge as I possess . . . has brought me the slightest advantage . . . When our cars break down, we take them to a garage; when our stomach is out of order we go to a doctor. We live either by rule of thumb or on other people's professional knowledge.*"—G. H. Hardy, A Mathematician's Apology.



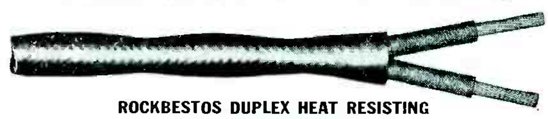


ROCKBESTOS MULTI-CONDUCTOR FIRE-WALL INSTRUMENT CABLE

This unusually small diameter, light weight, high-dielectric No. 26 AWG three conductor cable was designed for an electronic device in which three No. 22 AWG single conductor aircraft circuit wires previously used had proved too bulky. It is made to a nominal diameter of .125" (smaller than a No. 14 AWG single conductor 1000 volt Rockbestos Firewall Radio Hookup Wire).

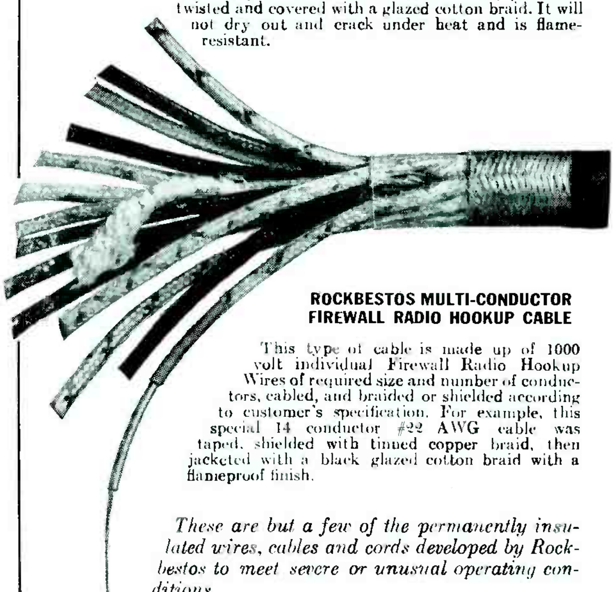
SHIELDED ROCKBESTOS FIREWALL RADIO HOOKUP WIRE

Sizes No. 22 to No. 4 AWG stranded tinned copper conductors insulated with synthetic tapes and felted asbestos, covered with lacquer-finished color-coded glass braid and shielded with a tinned copper braid. Heat, flame and moisture resistant, light weight, small diameter construction. Also available without shielding.



ROCKBESTOS DUPLEX HEAT RESISTING FLEXIBLE CORD

Sizes No. 18 to No. 10 AWG stranded plain copper conductor individually insulated with felted asbestos, polarized, twisted and covered with a glazed cotton braid. It will not dry out and crack under heat and is flame-resistant.



ROCKBESTOS MULTI-CONDUCTOR FIREWALL RADIO HOOKUP CABLE

This type of cable is made up of 1000 volt individual Firewall Radio Hookup Wires of required size and number of conductors, cabled, and braided or shielded according to customer's specification. For example, this special 14 conductor #22 AWG cable was taped, shielded with tinned copper braid, then jacketed with a black glazed cotton braid with a flameproof finish.

These are but a few of the permanently insulated wires, cables and cords developed by Rockbestos to meet severe or unusual operating conditions.

USE ROCKBESTOS PERMANENTLY INSULATED

Wires, Cables and Cords for Trouble-Free Wire Performance

Today, many manufacturers are blue-printing designs for future electronic and communications equipment. It is during these development and experimental stages that you should *wire-plan* your equipment. By selecting the proper wire, cable or cord for the particular job, you will eliminate possible wire-failures later.

Whatever type of equipment you are planning for tomorrow, investigate *permanently insulated* Rockbestos wires. All of them, whether standard or special, are insulated to resist heat, flame, cold, moisture, oil, grease and alkalies. Each and every one will give trouble-free, dependable service under severe operating conditions. One of the 122 standard constructions will probably meet your particular requirements. And if not, Rockbestos Research will develop a wire to fit your needs, such as the special 3 conductor instrument cable and the 14 conductor radio hookup cable illustrated.

Consult Rockbestos Research on your wire problems. They'll help you select the right wire for the right job. Write the nearest branch office or:

ROCKBESTOS PRODUCTS CORPORATION
409 Nicoll Street, New Haven 4, Connecticut

ROCKBESTOS RESEARCH
Solves Difficult Wiring Problems

NEW YORK, BUFFALO, CLEVELAND, CHICAGO, PITTSBURGH, ST. LOUIS, LOS ANGELES, SAN FRANCISCO, SEATTLE, PORTLAND, ORE.

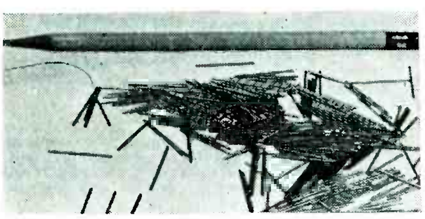
INVEST IN WAR BONDS • MAKE EVERY PAYDAY A LAY-AWAY DAY

NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new measuring equipment; issue new technical bulletins, new catalogs

Stellite Alloy

AN ALLOY OF tungsten, chromium, and cobalt is available from Haynes Stellite Co., Kokoma, Indiana, in a form adaptable to instrument bearing pivots, phonograph and recording needles, needle valves, and similar applications. The properties of the alloy, according ot the manufacturer, include a tensile strength of approximately 65,000 lb per sq in., a hardness of Rockwell C-60 to C-62, high resistance to wear, an



unusually low coefficient of friction, the ability to take a high polish, and excellent resistance to corrosion, whether from atmospheric conditions or chemical agents, such as water solutions of various salts, alkalies, and acids. Easily fabricated and virtually nonmagnetic, the alloy can readily be brazed or welded to steel or other base metals, for use in instruments or mechanisms where nonmagnetic, corrosion- and wear-resistant parts are essential.

Electronic Multitester

AN ELECTRONIC MULTITESTER, RCP Model 663A, is designed to save engineering time in the laboratory and to speed production testing. An a-c and d-c voltmeter, ohmmeter and capacitometer are all combined in one instrument. It features 27 vacuum tube operated ranges; VR 105–30 voltage regulator tube and its associated circuits, insuring freedom from error due to line voltage fluctuations; 13 a-c and d-c voltage scales, measuring from a fraction of a volt to 6,000 v; high voltage test leads; r-f lead; signal tracing probe; resistance and capacity lead.

Other features include a wide scale on 4½ in. D'Arsonval Microammeter with guaranteed accuracy of two percent at full scale. Linear meter movement. Meter burn-out has maximum protection—practically foolproof—meter cannot be damaged by checking a live resistor or using too low a range for making a measurement. There is a pilot light indicator; matched pair multiplier resistors accurate to 1 percent.

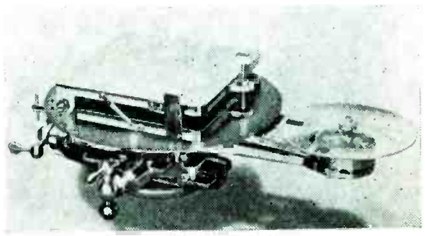
Model 663A has a rugged welded steel case, thoroughly shielded. Complete with five leads; large capacity batteries, easily replaceable; tubes and pilot lamp. Its size is 9¾ x 10½ x 6½ inches. Weight: 7¾ lbs. Model 663A Multitester is priced at $55.50 net.

Radio City Products Co., Inc., 127 West 26th St., New York 1, N. Y.

Precision Table for Cutting Quartz Crystals

A QUARTZ ORIENTATION replacement table, adaptable to any quartz cutting saw, is utilized in positioning quartz to high accuracy cutting the quartz into crystals. This table is said to eliminate the necessity for much of the technically expert manpower formerly required for making corrections. Correction readings may be transferred from either General Electric or Phillips x-ray machines directly to the 10½ in. deg. dial on the table. The minute calibrations are easily visible, and large enough to allow corrections to a fraction of a second.

The table can be rotated 360 deg and provisions are made for the X correction with a plainly visible and conveniently located scale and pointer. The tables and mechanism are chromium-plates cast bronze, designed to minimize wear from vibration and to avoid inaccuracies.



Adjustments are provided to compensate automatically for all wear, a feature which is extremely important in this type of equipment due to the abrasive action of quartz dust. Spring-loaded gears in the gear-train eliminate backlash, thereby assuring setting to minute precision. The gears on the sector-arm and the gear-train are meshed under constantly maintained tension to eliminate any inaccuracies due to tooth wear.

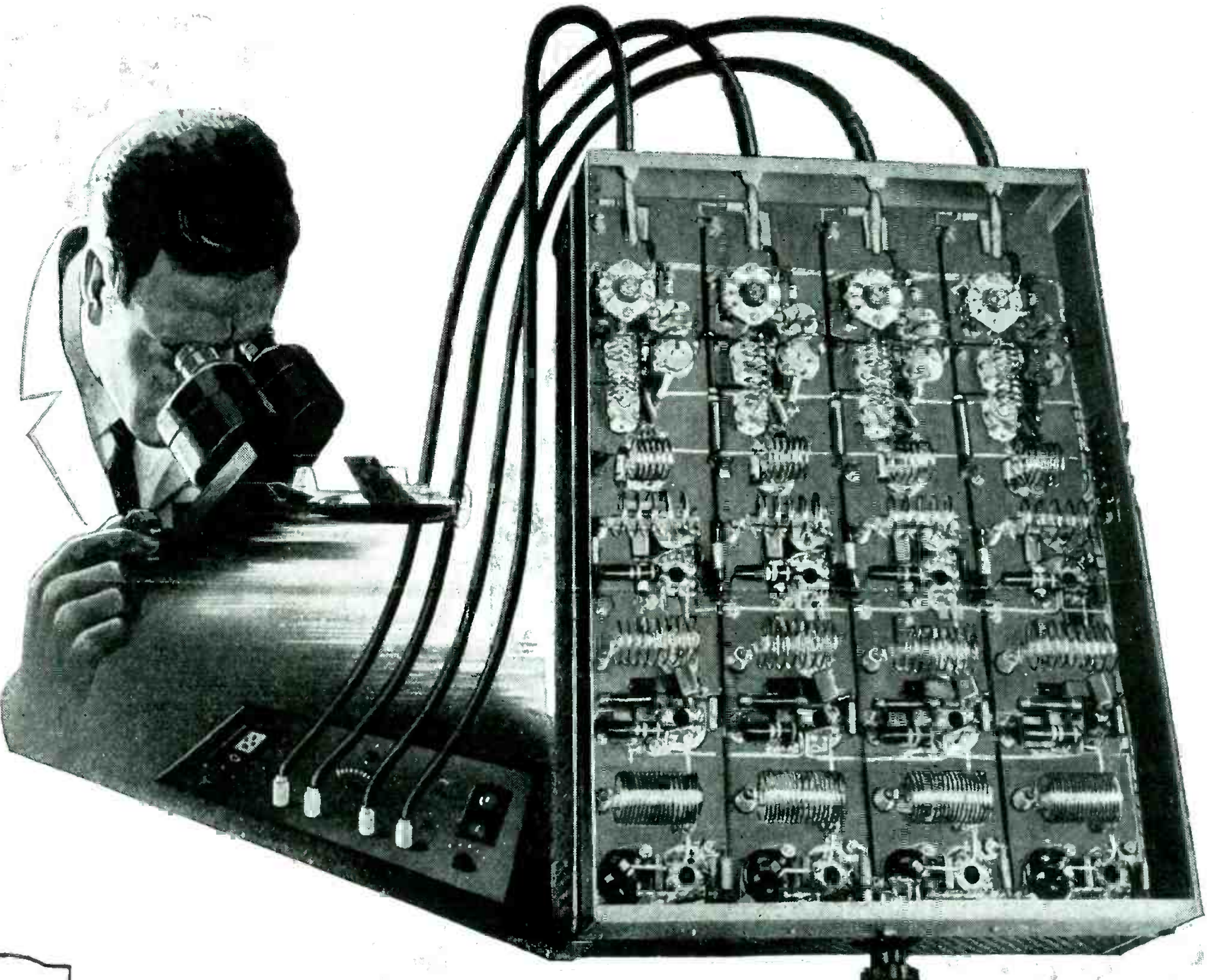
Care has been taken to eliminate any possibility of damage from abrasives which might be deposited by capillary action. The gear case inself is protected by a Lucite cover to prevent quartz loaded coolant from getting into the precision gear mechanism.

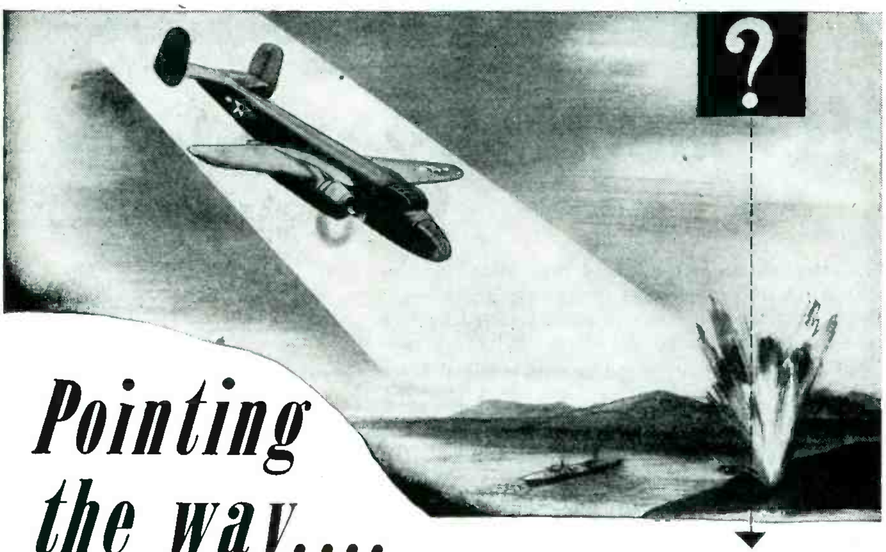
Robert H. Clark, 9330 Santa Monica Blvd., Beverly Hills, Calif.

Webster Products Releases Data on New VR-2200 Series Voltage Regulators

SERIES VR-2200 carbon pile voltage regulators for air-borne applications handle 100 watts in the pile with an air flow through the fins of approximately 25 cu.ft. per min. and up to 50–75 watts without air blast. Piles can be provided with a resistance range of the order of 20 to 1, the total range of maximum values being from less than 1 to about 100 ohms.

In one application, the resistance of the carbon pile is in one side of the line and the regulator operates to vary this resistance automatically so as to produce constant voltage across the load. In another typical application, the voltage reg-



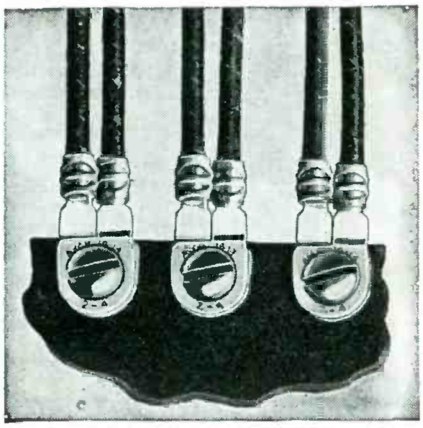


ulator varies the field excitation of an inverter, alternator or special dynamoter in such a manner as to produce constant output voltage across the load. Where the machine is delivering a.c., a rectifier may be provided to supply the regulator solenoid circuit.

Webster Products, 3825 W. Armitage Ave., Chicago 47, Ill.

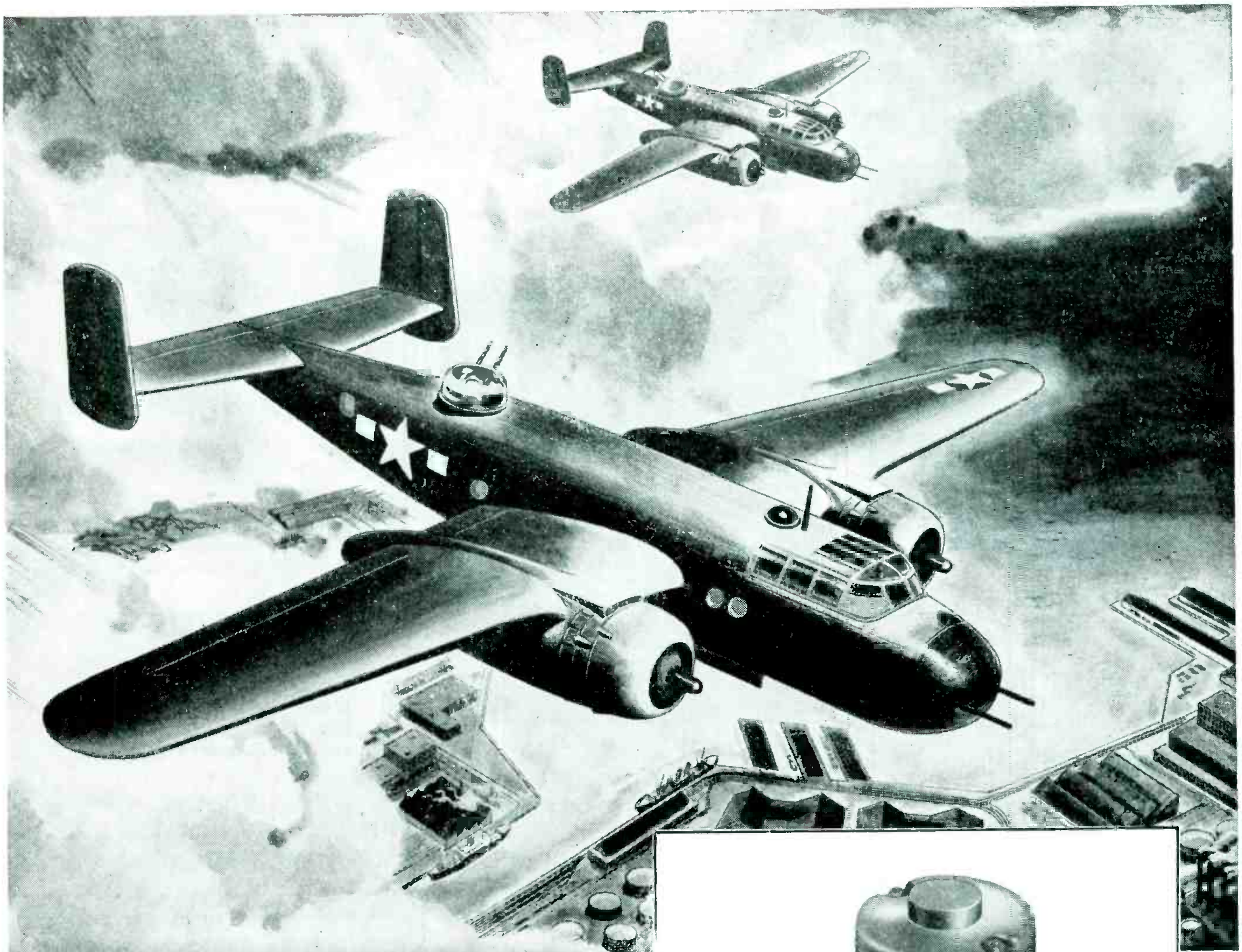
Inter-Locking Terminals

THIS SOLDERLESS TERMINAL permits the application of two wires to a single stud without a lateral motion which might cause short circuiting between adjacent terminal groups.



A unique interlocking principle allows two or more terminals to be used on a single stud when there are no barriers to control the positions.

Aircraft-Marine Products, Inc., 1521–53 No. Fourth St., Harrisburg, Pa.



When "Elmer" takes over...

A SPECIAL FRACTIONAL HP MOTOR GOES TO WORK

SPECIAL MOTORS DESIGNED TO FIT THE APPLICATION

Just as a bomber goes into the final bombing run, "Elmer", the automatic pilot, takes over the big ship and guides it straight and steady right on the target.

It's when "Elmer" takes over the controls that a special motor goes to work . . . driving "Elmer's" intricate mechanisms at a constant, dependable speed which assures precision, pin-point bombing from all altitudes at all temperatures. Providing power for automatic pilots is but one of the many applications for which Holtzer-Cabot specially designed fractional HP motors are used.

Today, the full capacity of Holtzer-Cabot facilities are being used in building fractional HP motors for military use. However, our motor development engineers are available for solving special fractional HP motor problems for contemplated peace-time products.

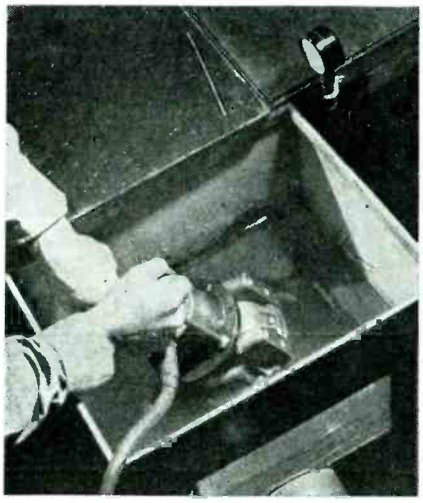
THE HOLTZER-CABOT ELECTRIC COMPANY

Designers and Builders of Special Fractional HP Motors and Electrical Apparatus

125 Amory Street, Boston, Mass. Chicago, Ill., New York, N. Y., Philadelphia, Pa.

Waterproof Navy Motor

A WATERPROOF $\frac{1}{3}$ hp electric induction motor for driving the cams of a multiple-barrel gun has been built to Navy specifications. It operated after being squirted with a one inch jet of water from a distance of ten feet.

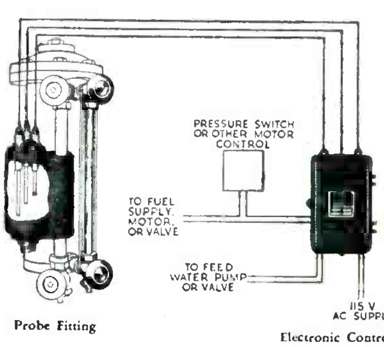


The waterproof design was evolved through use of a labyrinth-type seal having appropriate traps and drains.

Westinghouse Electric & Mfg. Co., 306 Fourth Ave., P. O. Box 1017, Pittsburgh 30, Pa.

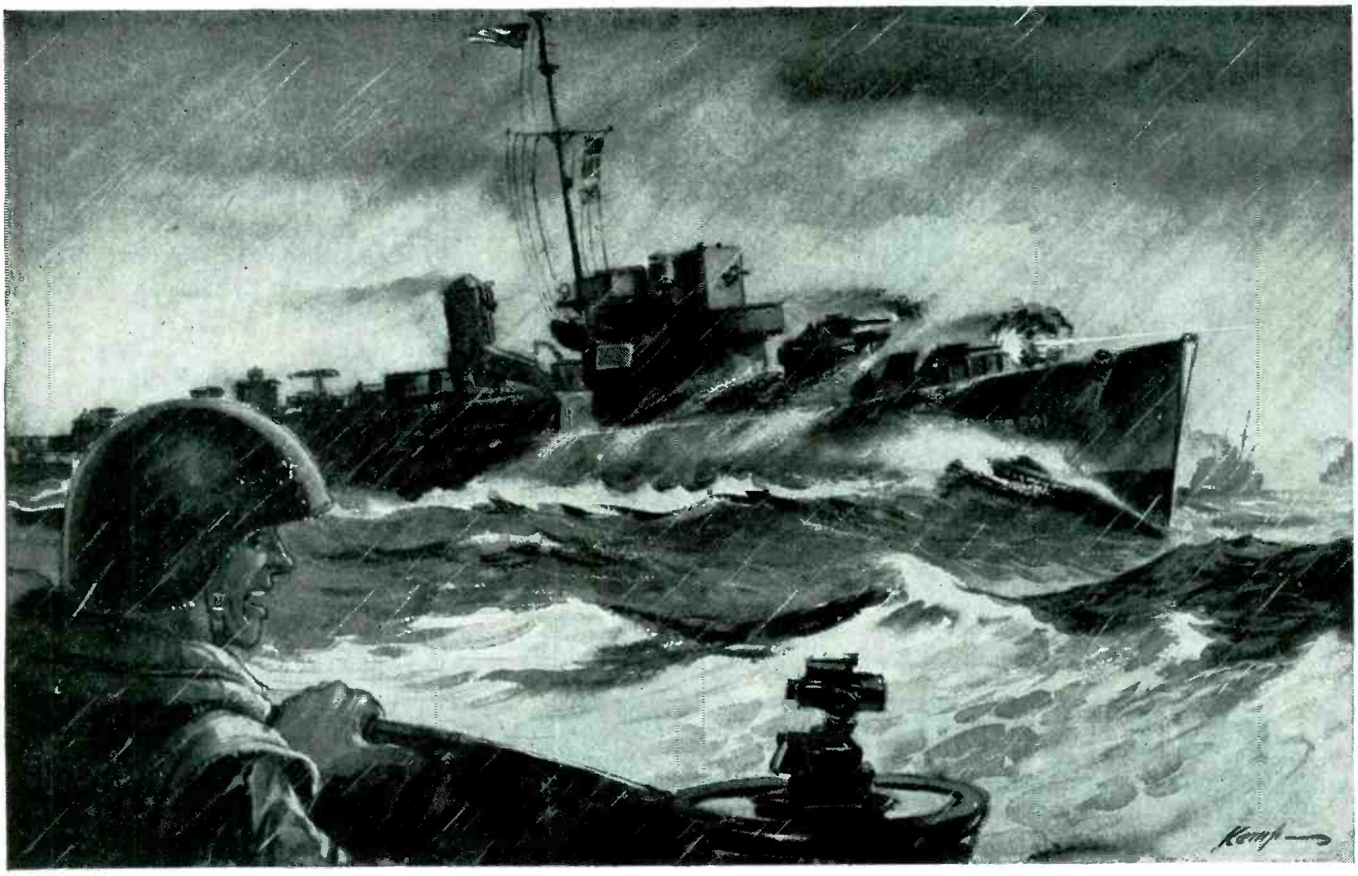
Boiler Feedwater Control

FIREEYE ELECTRONIC FEEDWATER control, Series P156N, automatically maintains constant boiler-water levels and guards against low-water hazards. It is used with probe fitting type H53. The fitting may be mounted parallel to the water column, or directly on the boiler, and is wired to the electronic control. Three probes within Type H53 mark boiler feed-water pump on and off levels and a low-water danger point. The top and



Typical FIREYE Installation For Automatic Boiler Feedwater Control And Low-Level Safeguard

PERMANENT MAGNETS MAY DO IT BETTER



Destroyer Escort Kills Subs with Aid of 225 Permanent Magnets

THE U. S. S. Spangler, a Destroyer Escort built by the Defoe Shipbuilding Company, is illustrative of the constantly increasing uses for which permanent magnets are employed. About two hundred and twenty-five permanent magnets are used in this "floating precision instrument" as vital parts of telephone, audio, radio and sub-detection equipment, compasses and other instruments as well as many other electrical and electronic devices.

Permanent magnets perform a similarly wide variety of tasks *throughout* the great panorama of Allied war equipment. And because of our 34 years of specialization in their development and manufacture, our organization has played an important role in designing and providing permanent magnets for many types of weapons and war machines.

This unusual experience should prove invaluable in solving your problems . . . and our engineers will be pleased to consult with you. Write us on your letterhead, for the address of our office nearest you and a copy of our "Permanent Magnet Manual."

Help Win the War in '44—
Buy War Bonds!

The
INDIANA STEEL PRODUCTS
Company

★ SPECIALISTS IN PERMANENT MAGNETS SINCE 1910 ★

6 NORTH MICHIGAN AVENUE • CHICAGO 2, ILLINOIS

middle probes determine the high and low levels at which the boiler feedwater pump is turned on and off to maintain constant water level.

Supplied as standard for boiler pressures to 300 lb and for operation from a supply of 115 or 230 v a.c. 60 cps. The equipment governs solenoid valves, small horsepower pump motors, or pump motor magnetic starters.

Combustion Control Corporation, 77 Broadway, Cambridge 42, Mass.

Quarter Million Volt Capacitor

THIS 0.02 μf 250,000 v liquid impregnated capacitor is housed in a wet process porcelain tube and filled with a liquid dielectric. The end caps are the Westinghouse solder seal type which act both as a mounting arrangement and as terminals.

The unit is built for total salt water submersion and operation under severe conditions. Voltage ratings range from 7500 v to a quarter of a million volts in single units and can be connected in series for operation up to several million volts.

Industrial Specialty Company, 1725 West North Avenue, Chicago 22, Ill.

Pyro-Plastics

PYRO-PLASTICS is a glass-bonded mica product formed under extremely high temperature and pressure, resulting in a dense, moisture-proof, low-loss, high-frequency insulating material. It has been used for r-f switches and coil forms, oscillator circuits, structural supports for radio circuits, variable and fixed capacitors and other applications.

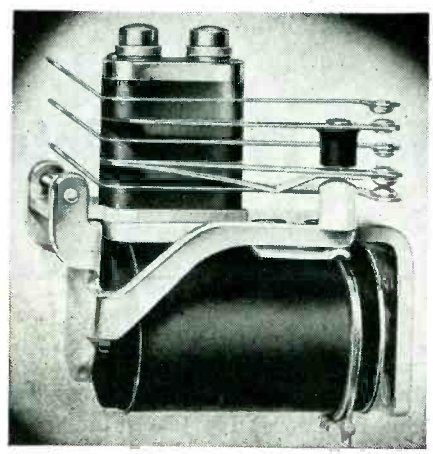
According to the manufacturer it can be readily drilled, cut and machined to close tolerances. Stock sheets are ground to plus or minus 0.015 in., but if closer tolerances

are desired, it can be ground to plus or minus 0.005 in. at a slight additional cost. Available in size 10 x 12 inches in ⅛ to ⅜ in. thicknesses; also 6½ x 18½ inches in ¼ to ½ in. thicknesses.

International Products Corp., 2554 Greenmount Ave., Baltimore 18, Md.

Telephone Type Relays

MODEL TSU TELEPHONE type relay for bottom mounting is designed for crystal switching but is suitable for various high-frequency, plate circuit and general utility applications. Contact arrangements are supplied normally open, normally closed, spdt, or in any two combinations. Contacts will carry two amperes at voltages to 24 v d.c. and 115 v a.c. non-inductive load. Coil resistances are available from a fraction of an ohm to 5,000 ohms.



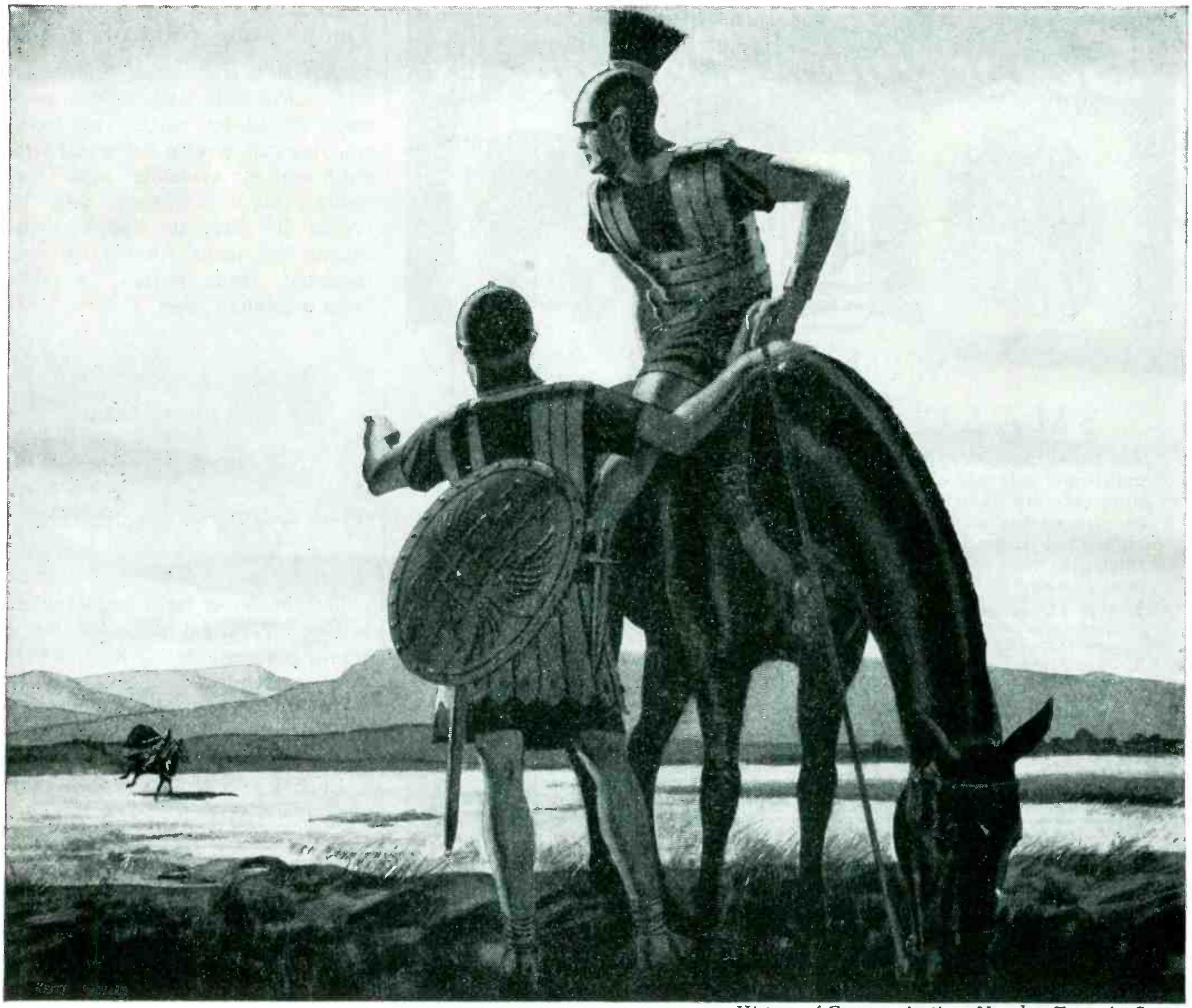
Model TSL, for end mounting, is similar to TSU, and both are available with ceramic or Bakelite insulation. Their overall dimensions are 1¼ in. long, ¾ in. deep and 1½ in. high; weights 1¼ oz.

Dept. T, Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y.

Dielectric Heating Line

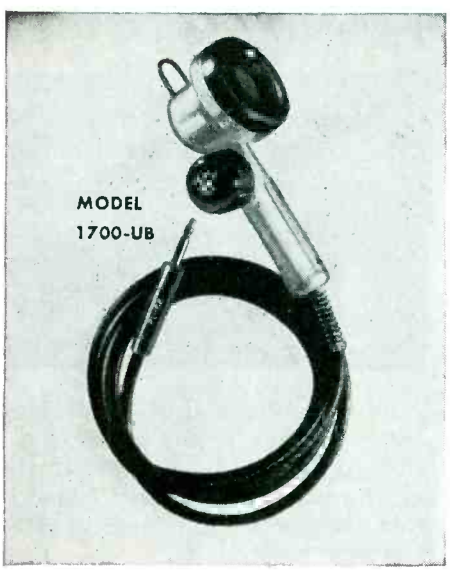
DESIGNED SPECIFICALLY for preheating plastics, this dielectric heating equipment is readily adaptable to the baking and dehydrating industries, according to the manufacturer.

Haines Mfg. Co., 248–274 McKibbin Street, Brooklyn 6, N. Y.



History of Communications Number Two of a Series

COMMUNICATIONS BY ROMAN POST RIDERS



In the early days of the Romans and Phoenicians the fastest means of communication was the post riders, who carried news and War dispatches from the battle front. As fleet as their horses might have been, their speed does not begin to compare with electronic voice communication. The twist of a dial and the pressing of a button—in the flash of a second the message comes through. Clear cut speech transmission with Universal microphones reduces error and expedites the delivery of the message.

Today Universal microphones and voice communication components are being used throughout the world on every battle front filling a vital need and "getting the message through."

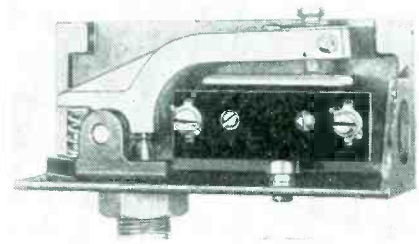
< Model 1700-UB, illustrated at left, is but one of several military type microphones now available to priority users through local radio jobbers.

UNIVERSAL MICROPHONE CO., LTD
INGLEWOOD, CALIFORNIA

FOREIGN DIVISION: 301 CLAY STREET, SAN FRANCISCO 11, CALIFORNIA ·· CANADIAN DIVISION: 560 KING STREET WEST, TORONTO 1, ONTARIO, CANADA

Temperature Control Switch

MODEL H TEMPERATURE limit control is available with switch normally closed for cutting off heat, stopping fan, closing valve and also with switch normally open for lighting lamp or ringing bell. It breaks the heating circuit while closing the alarm circuit. Sturdy, foolproof reset button operates from outside of case.

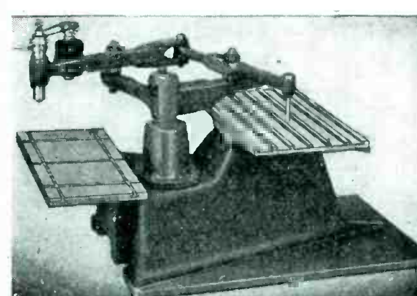


Locking-screw locks temperature setting. Terminal plate has large screw terminals. Snap-action micro-switch eliminates contact troubles. Range 0-1400 deg F. Adjustable range 200–300 deg F. Dimensions are 5⅜ by 1¾ by 3 in.

Burling Instrument Co., 253 Springfield Ave., Newark, N. J.

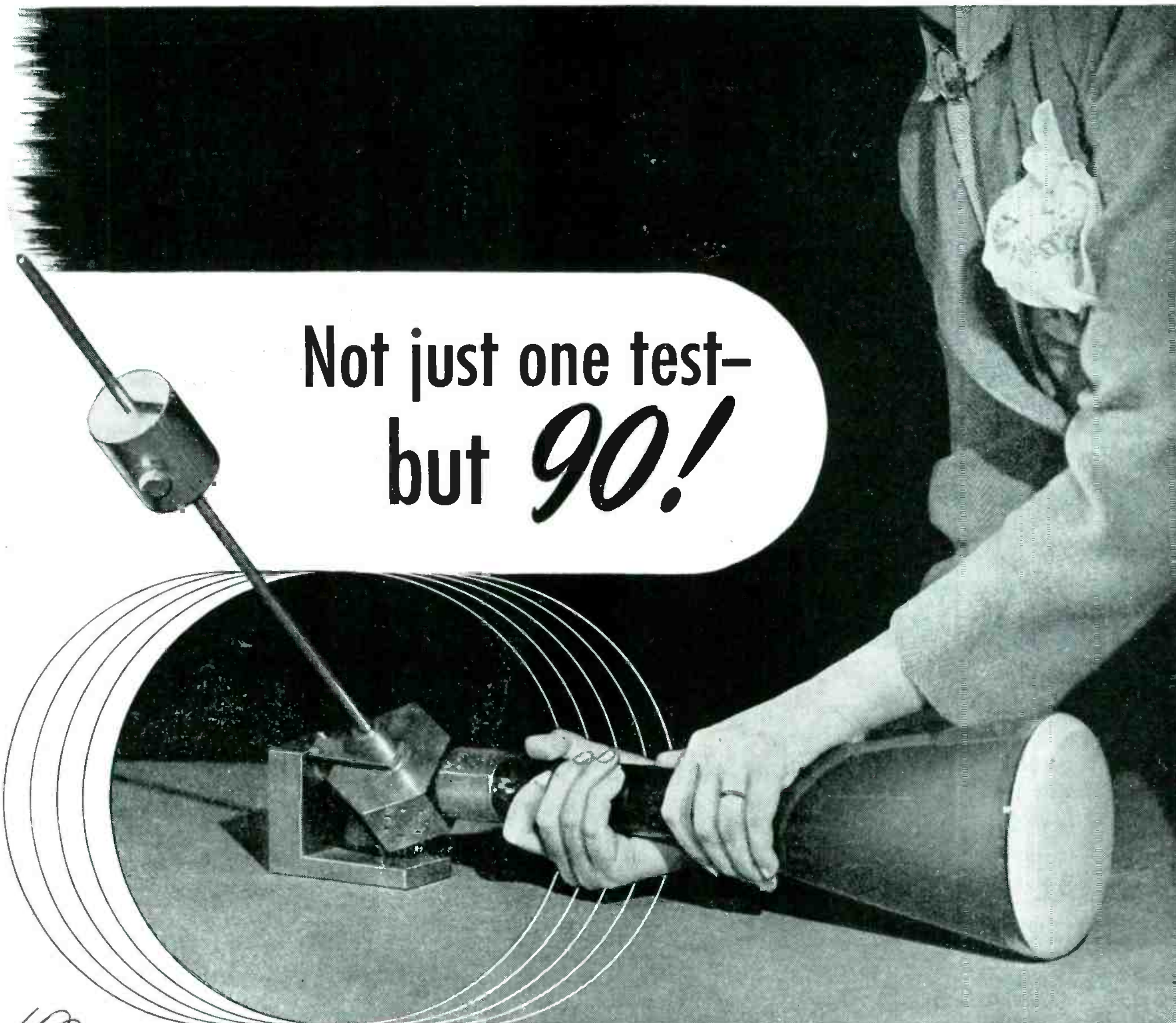
Auto Engraver

THIS VICTORY MODEL duplicating and profiling Auto Engraver was engineered for accurate engraving by unskilled operators and reproduces designs, numbers, letters, signatures and emblems on iron, brass, copper, aluminum, soft steels and plastics.



It can also be used to drill a series of holes, profile small parts, etch glass or to cut an even channel for wiring on panels. Model Nos. 100 and 200 are priced at $850 and $600 respectively.

Auto Engraver Co., 1776 Broadway, New York 19, N. Y.



Longer life and superior performance are distinguished characteristics of NORELCO Cathode Ray Tubes. These qualities are achieved by advanced production techniques—assured by perfect *scores* in 90 exacting tests of raw materials, parts, sub-assemblies, assemblies and performance.

One of the 90, the torsion test, which follows the immersion test, is illustrated above.

It is this precision, this relentless pursuit of perfection which has made North American Philips one of the leading producers of Cathode Ray Tubes. NORELCO power, transmitting and special-purpose tubes, quartz oscillator plates and communications equipment are doing wartime duty on land, on sea and in the air. And for those who carry this equipment on to Victory, every *okeh* on our inspection line is vital.

Tomorrow, these skills, the heritage of long years of world-wide experience in electrical applications, will be available for the development of peacetime industries.

For our war industries we now make Searchray (X-ray) apparatus for industrial and research applications: X-ray Diffraction Apparatus; Electronic Temperature Indicators; Direct Reading Frequency Meters; Electronic Measuring Instruments; High Frequency Heating Equipment; Tungsten and Molybdenum in powder, rod, wire and sheet form; Tungsten Alloys; Fine Wire of practically all drawable metals and alloys: bare, plated and enameled; Diamond Dies.

And for Victory we say: Buy More War Bonds.

Norelco

ELECTRONIC PRODUCTS by

NORTH AMERICAN PHILIPS COMPANY, INC.

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

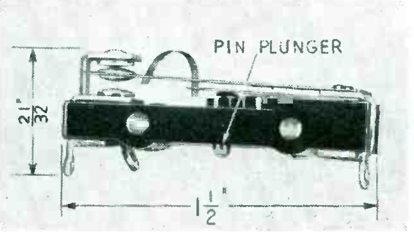
Table Model Developer

DRY-DEVELOPING WHITEPRINT reproductions of engineering drawings and tracings can be made with a sturdy machine known as the Pease "700". It is a developer only, with two forward speeds of four and eight ft. per min. It can be used in conjunction with any blueprinting or direct-process printing machine using any dry direct process paper. It is made in two sizes, 42 and 54 in.

C. F. Pease Co., 2601 West Irving Park Road, Chicago, Ill.

Midget Snap-action Switch

THIS SNAP-ACTION SWITCH built on the rolling spring principle is designed for actuation from either the top or bottom and is adapted to electronic control devices, machine tools, aircraft and electrical appliances. Weighing less than an ounce, it is $\frac{7}{16}$ by $\frac{9}{16}$ in. and is made to the maximum dimension of $1\frac{1}{2}$ in.



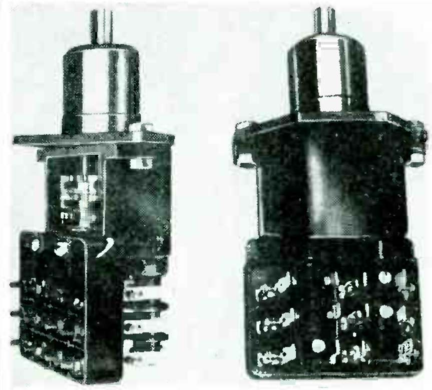
According to the manufacturer, all component parts are non-corrosive. Meeting Army Air Force approval, the switch has shown no failure after 94 million operations in factory tests. When built into relays, smaller coils may be used since only 4 to 6 oz operating pressure is required.

Acro Electric Co., 1316 Superior Ave., Cleveland 14, Ohio.

Geared Limit Switch

THIS IS A LIMIT SWITCH incorporating two individually adjustable trains of intermittent gears, each train operating one contact drum providing three double-break contacts. Of these, two contacts may be normally open and one normally closed, or vice versa. The switch can be adjusted for operation between 2 and 3333 turns of driving shaft at speeds ranging from 10 to 500 rpm.

The switch is of all-molded con-



struction providing easily accessible terminals. Contacts are double break, self cleaning due to wiping action, and of silver. Rated for voltage up to 550 ac or dc.

It is suitable for the control or the position indication of hoist or crane mechanism, automatic doors, valves or dampers, or any mechanism where precision control or position indication is required.

Philadelphia Gear Works, Erie Ave. & G St., Philadelphia 34, Pa.

Blower Unit

THIS 115 V, 400 CPS blower unit consists of a No. 2 L-R blower and a 1/100 hp single phase capacitor J31A motor.

Running at 7200 rpm, the blower circulates 22 cu ft per min continuously. The motor is designed for use in ambient temperatures up to 80 deg C. Overall length of the unit is $4\frac{3}{32}$ in.; weight $19\frac{1}{2}$ oz.

Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y.

Bakelite Plug

THIS COMPACT No. 37212 plug is designed primarily for use with Millen No. 37222 captive head posts and No. 37202 plates. A small cir-

The magic of ELECTRONICS...

No word in industry has achieved more fame than "electronics". Perhaps its excessive use has over emphasized the wonders of an electronic world. However, there is the undeniable fact that the magical performance of electronic equipment is unexcelled.

An outstanding example is the SECO automatic voltage regulator. When its electronic "genie" . . . a special bridge and thyratron tube circuit . . . detects any fluctuation in A-C line voltage, a variable voltage transformer is authorized to correct for a constant output voltage.

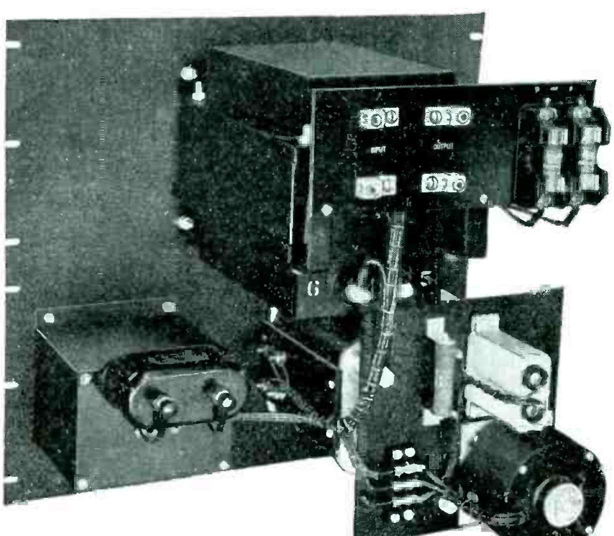
This improved type regulator retains all the desirable characteristics inherent in the variable voltage auto-transformers.

- HIGH EFFICENCY — 98% or better at full load.
- NO WAVE FORM DISTORTION.
- LOW EXCITING CURRENT.
- LOW COST PER KVA.

And it also has additional features offered by no other automatic voltage regulating equipment,

- NO INTERNAL MECHANICAL ADJUSTMENTS.
- OPERATION NOT AFFECTED BY LOAD OR POWER FACTOR.
- OUTPUT VOLTAGE AND SENSITIVITY ADJUSTABLE OVER WIDE RANGE
- CORRECTS A WIDE RANGE OF INPUT VOLTAGES. Standard models correct for input voltage variations of plus and minus 17.5% output voltage.

For all electrical and electronic applications, this modern voltage control is available for 115, 230, or 440 volt circuits in capacities up to 75 KVA.



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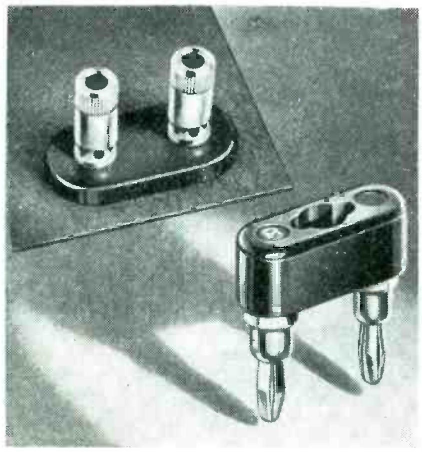
SUPERIOR *Electric Company*

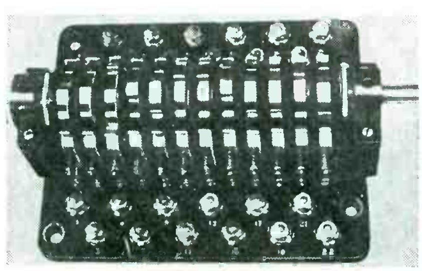


cular depression on top is for "color coding" or polarity indication. Made in black or red regular Bakelite as well as low-loss brown mica-filled Bakelite for r-f uses.

James Millen Mfg. Co., Inc., Malden, Mass.

Rotary Limit Switch

RATED FOR 125 a-c applications, this 12 circuit direct-connected rotary type limit switch has 12 individual contact drums, each separately adjustable by small increments. It can be used as a continuously rotating or reversing switch, and is suitable for operation in any position.



The all-molded construction provides easily accessible terminals, silver to silver wiping and self cleaning double break contacts, and needle bearing shaft suspension.

Philadelphia Gear Works, Erie Ave. & G St., Philadelphia 34, Pa.

Electronic Pneumatic Controller

CELECTRAY PNEUMATIC indicating controller, according to its manufacturer, is the first instrument of its type which does not employ a motor or other continuously moving parts. Some of its features include continuous action, no measur-

How to machine PLAX POLYSTYRENE

. . . from sheets, rods, tubes . . . into special and standard parts

Plax Polystyrene is specially heat treated so that it may be machined without subsequent cracking or crazing. Because its softening point is about 180F, and because it will become gummy at about 220F, one should prevent overheating of the material. When overheated, even if gumming does not occur, subsequent cracking is possible. By avoiding excessive friction, aiding chip clearance, and in some cases using a coolant, *no difficulty is encountered and excellent results are obtained.*

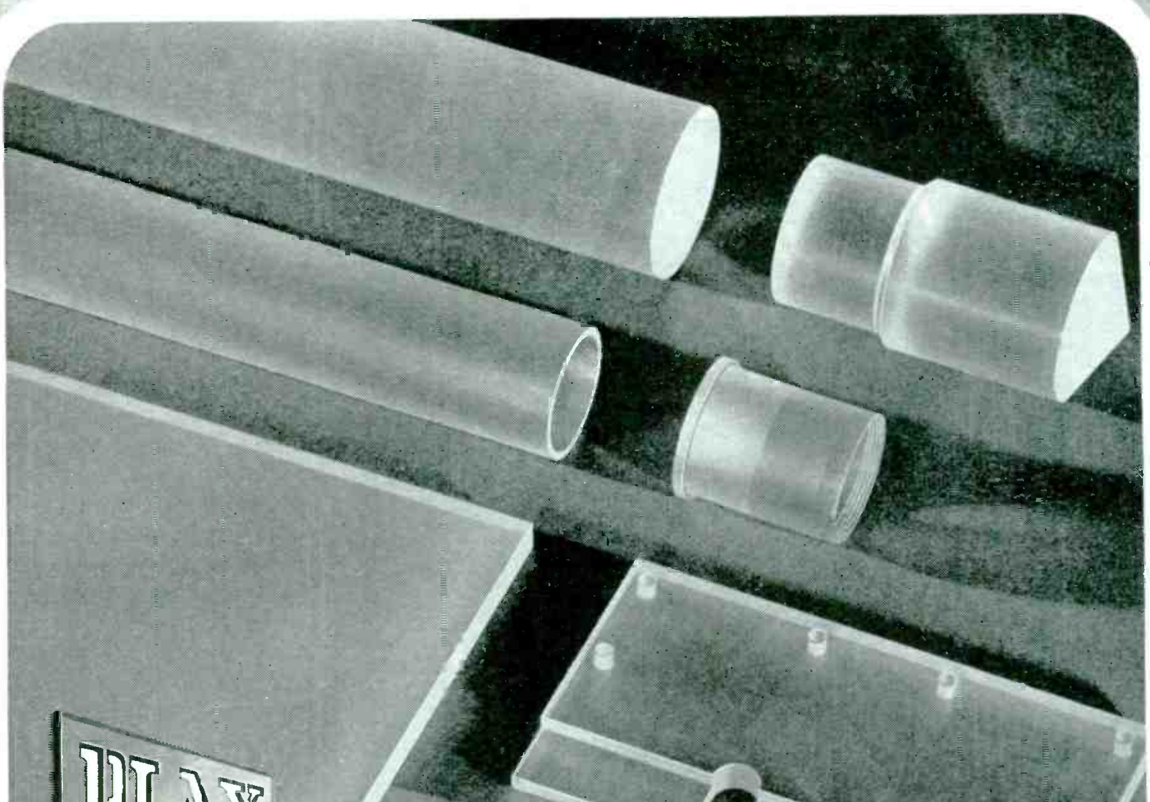
Gasoline, kerosene, and other oils will dissolve Polystyrene. Hands and rags must be free of oil. Use soap and water as a coolant, or, to avoid rusting, a water solution of Solvac 100M special.

SAWING: A 9-inch circular hollow ground saw is satisfactory. It should be 3/32" thick, to avoid vibration. When cutting material less than ¼" thick, a saw with 12-15 teeth/inch is used. When cutting heavier sections, a saw with 10 teeth/inch should be used. No heating occurs if the saw is run at 1850 rpm. with a coolant running through the kerf with teeth.

DRILLING: High speed drills with polished or chromium plated flutes are desirable. Drills should have large clearance with a low rake. When drilling through holes, a neutral rake or slow helix is used to prevent breaking through. When drilling blind holes, a fast helix is preferred. In most instances coolants are used in drilling. Drills are available with a central hole through which the coolant is pumped into the tip, from which it flows back along the flutes. When drilling small holes, the drill must be backed out frequently to clear chips.

TURNING: Polystyrene can be readily turned. Best results are accomplished by using a sharp tool with only a slight rake and large clearance. A coolant is usually used for interval boring.

MILLING: Special cutters with low side friction are desirable. In some cases a coolant is necessary. If a coolant is not used, an air nozzle should be used to blow away chips.



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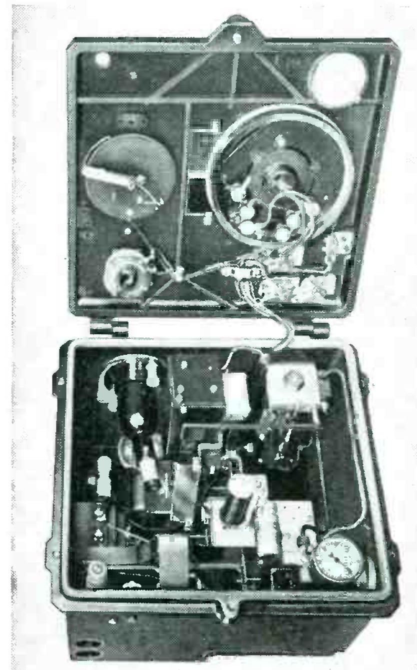


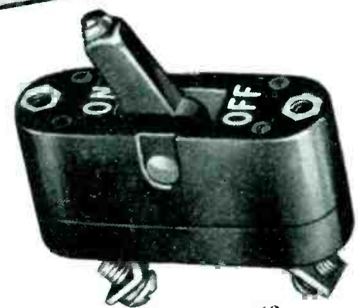
able "dead zone", high sensitivity and adjustment to very low sensitivity, no mechanical connection between galvanometer and pneumatic circuit, and simple load error adjustment.

A mirror galvanometer and photoelectric amplifier are combined with a pneumatic follow-up and a magnetic air-valve acts as an amplifier and converter from electric to pneumatic operation.

C. J. Tagliabue Mfg. Co., 550 Park Ave., Brooklyn 5, N. Y.

Literature

Relays. Several new relays, including a line of very small, lightweight and vibration resisting types for aircraft service, are shown in a 104-page catalog, "Relays and Other Devices for Electronic Control". Complete operating data and scale mounting drawings are given. A chart indicates the important characteristics of each type, simplifying selection of the proper design for any purpose. Other items include carbon and magnetic types of desk microphones, stepping switches, solenoids, counters, switchboard plugs, jacks and cords, handsets, and transmitter and receiver units for telephone and radio use. Copies of this catalog, No. 4071-D can be secured from Automatic Electric



Type C-6363
Switch Circuit Breaker

Type PM (NAF-1131)
Circuit Breaker

SIMPLICITY OF OPERATION

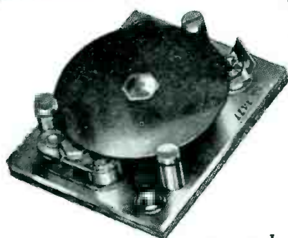
Assures positive performance of Klixon Snap-Acting Controls

Whether it's for motor and transformer overheat protection, or electrical circuit overload protection or temperature controls for radio equipment—Klixon Controls always operate surely and accurately. The reason lies in the actuating element . . . the Spencer snap-acting thermostatic disc. This foolproof scientifically calibrated disc eliminates fussy parts, toggles, relays and magnets, thus assuring positive performance under all operating conditions. And because of the simplicity of operation, Spencer controls are not affected by shock, vibration, motion or altitude regardless of the mounting position.

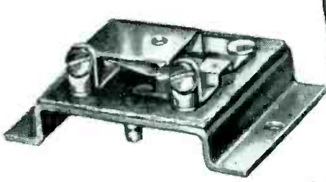
Klixon Snap-Acting Controls are small, light-weight and compact. They are available in many standard types for most control requirements. Write for complete information.

KLIXON

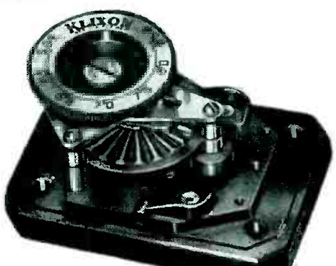
SPENCER THERMOSTAT COMPANY, ATTLEBORO, MASS.



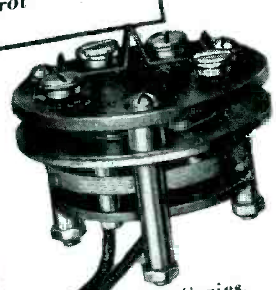
Type B-3120 Crystal
Dew Point Control



Type C-4351 Series. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.



Type RT Adjustable Crystal
Temp. Oven Control



Type ER Series.
Ambient Compensated Time
Delayed Relays

Type C-2851 Series. For such use as Roughing Controls on Outer Crystal Ovens

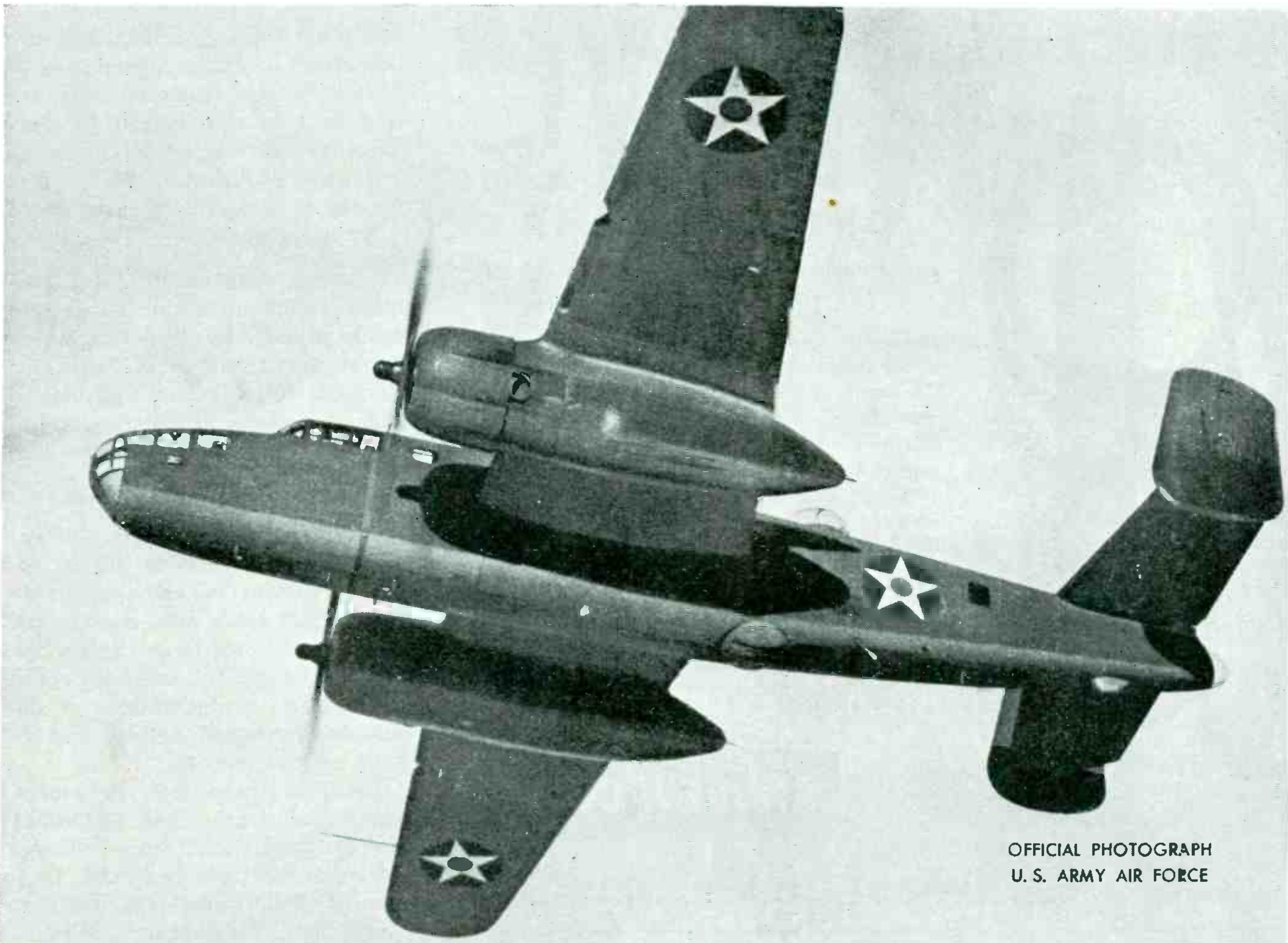
Company, 1033 West Van Buren St., Chicago 7, Illinois.

Another bulletin, No. OF112, obtainable from Guardian Electric Mfg. Co., 1625 W. Walnut St., Chicago, Illinois, also provides a quick reference to standard relay types. Thumbnail descriptions give contact ratings and combinations, power requirements, and size and weight of 17 types of relays used in aircraft, radio, Signal Corps, and general industrial applications. Explanations of time delay methods, solenoids, and the new lightweight solenoid contactors are also included.

Applications of Magnets. An informative and attractive booklet, "Permanent Magnet Manual No. 2" is available from the Indiana Steel Products Co., 6 N. Michigan Ave., Chicago, Ill. It describes the role played by permanent magnets in the field of electronics, radio and sound equipment and their uses in loudspeakers, headphones, hearing aids, batteryless telephones, microphones, phonograph cutting heads and pick up units, electric stringed instruments, electric organs, and radio detecting and measuring devices.

Electrical Connectors. Cannon Electric Development Co., Los Angeles, has issued a 10-page supplement of latest information on Type AN electrical connectors. The supplement contains layouts of new insert arrangements, tabular matter, and special plugs.

Radio Crystals. A small booklet called "The Millionth-Of-An-Inch Girls" has been put out by Reeves Sound Laboratories, Inc., 62 W. 47th St., New York 19, and is available free on request. The booklet tells about the importance of crystals to the war effort and how this company contributes to the production of radio crystals. The booklet gets its title as a mean for designating the facilities of the company to manufacture crystals with great precision. The brochure also mentions how this one manufacturer now makes more accurate production-line crystals in a week than the whole country made in a year before the outbreak of hostilities.

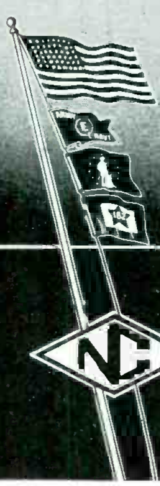


OFFICIAL PHOTOGRAPH
U. S. ARMY AIR FORCE

A LONG WAY FROM HOME!

● Boring into the sunset, this Mitchell has a rendezvous with danger. Armed to the teeth, and freighted with destruction, she will fight her way in to the "target for tonight" and she will fight her way home again. She and her sisters have a deadly job to do, and radio will help them do it.

Ground stations around the world depend heavily on the HRO receiver for dependable communications with aircraft.



NATIONAL COMPANY, INC.
MALDEN, MASS.

Insulated Wire. Specifications and properties of Sureo-American S-W flexible plastic insulated wire are contained in a pamphlet by Surprenant Electrical Insulation Co., 84 Purchase St., Boston, Mass. The plastic is a specially constructed polyvinal compound.

Trimmers, Capacitors, and Controls. Compact, stable capacitors easily adjusted by means of a screwdriver are described in Form 695 Revised. It is devoted to a discussion of ceramic trimmers, and includes construction, dimensions, specifications, drawings, and photographs.

Another bulletin, Form 630 Revised, contains ceramic tubular capacitor dimensions and capacitance values, and color code charts. One section is devoted to an explanation of test equipment and controlled temperature compensation. It describes correlation methods and results of experiments.

Controls, capacitors, trimmers, and switches are listed in Catalog No. 24. Copies of all three bulletins are available from Centralab Division of Globe-Union Inc., 900 East Keefe Ave., Milwaukee 1, Wisconsin.

• • •

INSULATOR FOR HIGH ALTITUDES

Checking dimensions of Prestite insulator used for terminal posts on capacitors for aircraft equipment to prevent flashover at high altitudes. The insulator, a Westinghouse product, holds up at altitudes of 60,000 feet and resists temperature changes from 234 deg. above zero to 15 deg. below. The insulating material is a mixture of clay, feldspar, and flint and can be solder-sealed to metal shield cans

N. Y. Meetings

(Continued from page 103)

practical application of piston attenuation. The natural or exponential law of attenuation in db, in respect to piston displacement, was demonstrated mathematically. Three forms of piston attenuators were covered; an electrostatic type, and the coaxial and coplanar electromagnetic types. The last mentioned type was recommended for its reliability. A trick used with it, at higher frequencies, is to provide coupling to the cavity of the signal generator simply by placing the end of the attenuator at a hole in the cavity where the electromagnetic field is maximum.

"Equivalent Circuits of Discontinuities on Transmission Lines", by J. R. Whinnery and H. W. Jamieson, showed experimental results which not only proved the rules, but also illustrated with equivalent circuits methods of computing values of reflection resulting from such discontinuities to well within the accuracy required by engineering. Mathematical proof of the underlying equivalences was beyond the scope of the presentation, but all practical types of discontinuities were shown to be analogous to the insertion of an admittance at the corresponding point in the circuit form of the line. The quantitative results were given in the form of equations with their graphs.

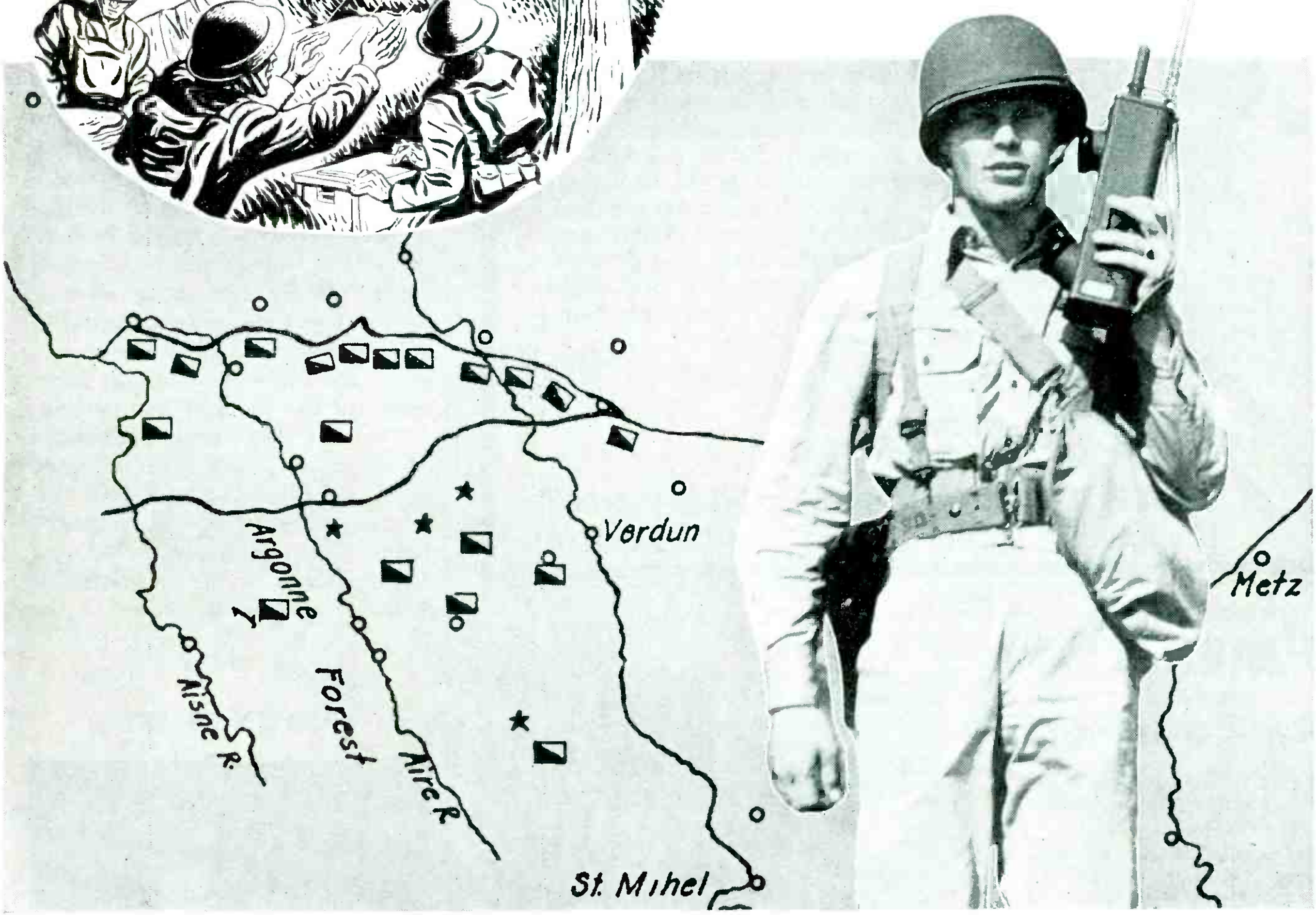
Presented in Group A, the afternoon of the first day's session, were three papers of practical interest to designers of equipment circuits:

The first of two papers on extended studies regarding noise, was titled "The Modification of Noise by Certain Non-linear Devices", D. O. North presented in graphical form, a representation of the statistical behavior of noise, after it has passed through a square-law rectifier, and also the same thing for a "linear" detector. The resulting output from the square-law detector, for an idealized rectangular noise input distribution, was particularly interesting. The audio component became a triangular distribution, of the same bandwidth, but decreasing proportionately with frequency, while the r-f distribution became an isoseles tri-

The Lost Battalion Had No Radios

1918... *Surrounded by Germans in the Argonne Forest, the 550 men of the Lost Battalion were reduced to 194 before rescue came. Communications were one-way by carrier pigeon.*

1944... *Today, in the thickest jungles, in the remotest outposts, in the air and on the sea, messages are exchanged in a split second—distance is annihilated—thanks to radio and electronic products.*



Sentinel

SENTINEL Equipment contributes to the effectiveness of modern radio communications and the prominent part radio is playing achieving victory for the United Nations. Management, engineering and production staffs of Sentinel Radio Corporation are proud of their equipment as it serves on global fronts. When victory comes, distributors and dealers of Sentinel radio and electronic equipment will profit by supplying a long denied demand.

Quality Radio Since 1920

SENTINEL RADIO CORPORATION
2020 RIDGE AVENUE, EVANSTON, ILL.

angle whose base was twice the bandwidth, with the apex at double the carrier frequency.

"Experiments Relating to the Statistical Theory of Noise", by C. M. Burrill, followed with a discussion of the proof of the formula $p = \exp\left(-A^2/BE^2\right)$, where p is the probability that at any instant the amplitude, or instantaneous value of the noise envelope will exceed the value A, and E is the instantaneous value of the envelope, applying where the noise has been passed through a selective circuit which limits the band of the noise spectrum in respect to its mean value. This leads to the fact that, if the bandwidth is made sufficiently small, the effect of variation in the envelope is negligible over periods as long as one-eighth of a second. It is consequently possible to perform the measurement of noise in such a narrow band, over this period of time, within accuracies of the order of one percent.

The criterion for motorboating of oscillator circuits was presented by W. A. Edson in his paper "Intermittent Behavior of Oscillators". Using the well-known feed-back representation of the $\mu\beta$ vector for a closed system, in terms of the

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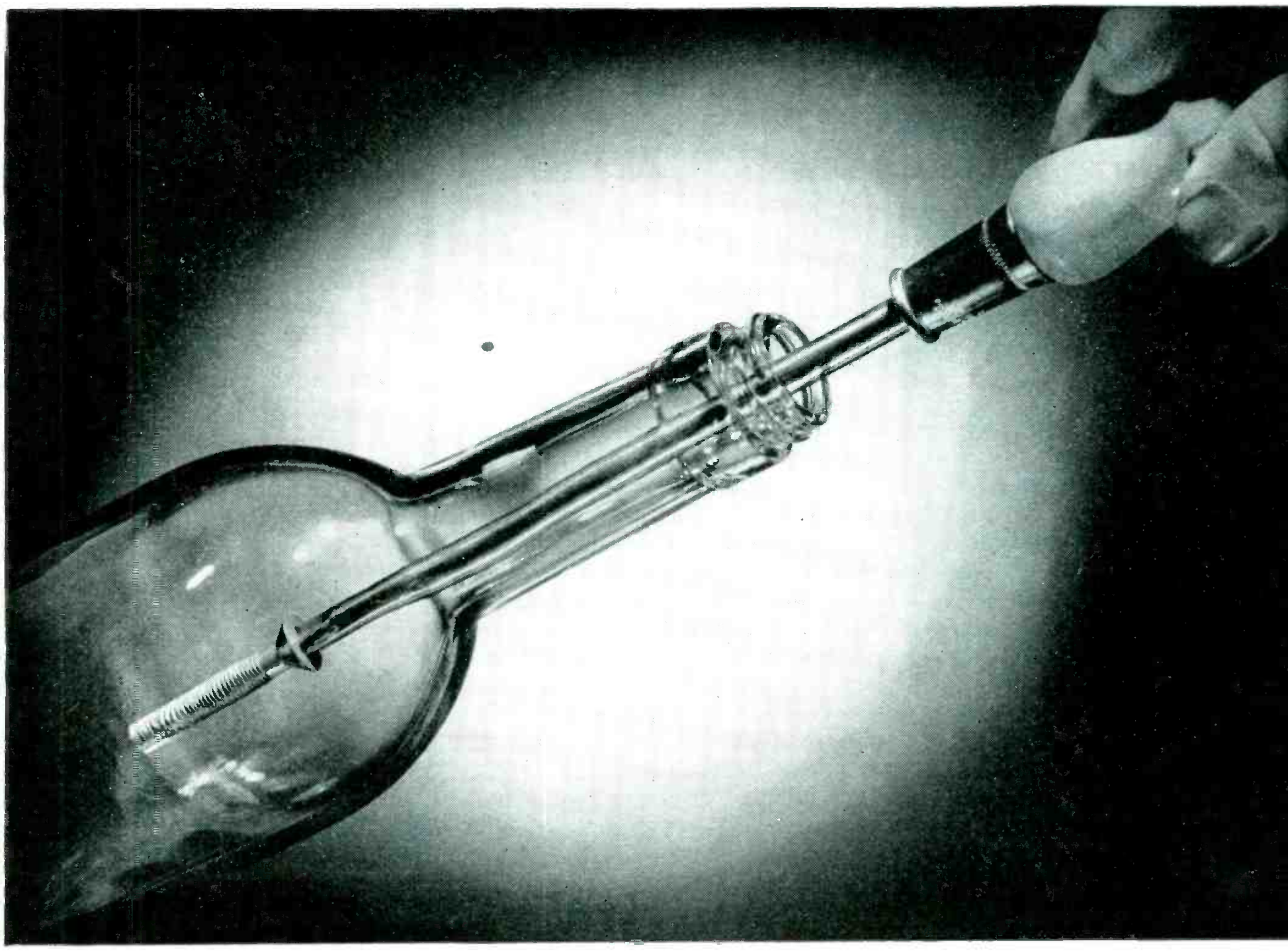
SHOWN AT IRE

Originally designed for cavalrymen, with the bottom of the antenna fitting into a saddle boot, this guidon radio is also used by other troops on the ground or on the bumper of an army vehicle



"Break that Bottleneck!"

Eliminate the slow-down of fumbling around hard-to-get-at spots on assemblies. Here is where the CLUTCH HEAD Lock-On feature, uniting screw and bit as a unit, substitutes seconds for minutes . . . reduces haphazard groping to a speedy, simple, and certain operation by permitting one-handed reaching and driving from any angle. This frictional lock is instantly obtained with a reverse turn of the Assembler's Bit in the recess of the CLUTCH HEAD Screw. The hold is definite; yet it is automatically released when the screw is turned for the drive home. So, too, in field maintenance, this CLUTCH HEAD Lock-On feature bypasses the bottlenecks to save time by simplifying repair and adjustment operations. With a Center Pivot hand driver, service men find it easy to *withdraw and save* CLUTCH HEAD Screws for re-use, undamaged and held securely against dropping and loss. Similarly, the long reach through the bottleneck frequently saves the dis-assembling of surrounding units for access to points beyond.

Would you care to personally inspect and test the many exclusive advantages of CLUTCH HEAD Screws? Then let us send you package assortment along with sample Center Pivot Bit and fully illustrated Brochure.

This is the only modern screw operative with Assembler's Bit or ordinary type screwdriver. It is available in Standard and Thread-forming types for every purpose . . . with features that contribute definitely to smoother and lower cost assembly line operation.

CLUTCH HEAD SCREWS

Note the economy of this rugged Center Pivot Assembler's Bit. It delivers a longer uninterrupted spell in operation and requires only a brief application of the end surface to a grinding wheel to restore its original efficiency.

UNITED SCREW AND BOLT CORPORATION

CHICAGO CLEVELAND NEW YORK

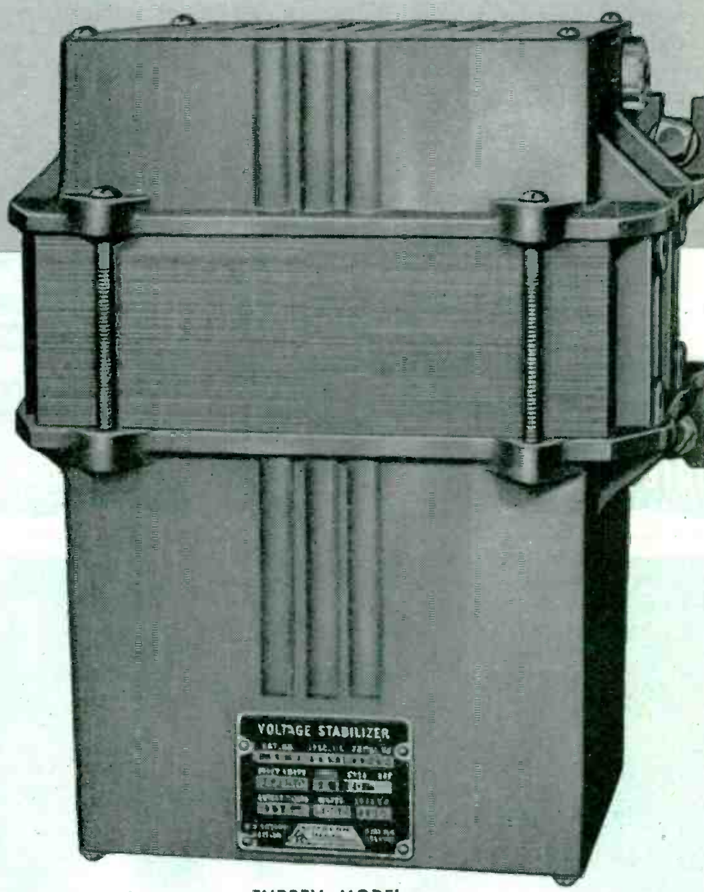
vector ratio between output voltage and input voltage (which can be determined experimentally), he first reviewed the criterion that some kind of oscillation will ensue; namely, that the point on the vector plot should include the point 1,0. He then showed that the same criterion applied for whether an oscillating system will behave with intermittent operation, when the vector diagram is plotted for the voltage ratio with a small amount of superimposed modulation transmitted around the loop. When the condition obtains, the modulation envelope is amplified and the system is capable of self-oscillation. He further pointed out that separate components comprising an oscillating circuit are the gain, tuning, and limiter devices. Three types of limiting devices, the lamp-ballast bridge, the diode rectifier, and the overloaded gain section, were discussed, with attention on means of establishing the highest conditions of frequency and amplitude stability by proper application of control.

The technical session by Group B, at this time, was devoted to problems of Plane Electromagnetic Waves, dealing with four papers summarized here: These were, "Transmission Line Analogies of Plane Electromagnetic Waves", by Dr. Arthur B. Bronwell of the Technological Institute, Northwestern University, and three papers presented by J. F. McAllister, Jr. of the General Electric Co., who read in summary form "Equivalent Circuit of the Field Equations of Maxwell", by Gabriel Kron, "A New Approach to the Solution of High-Frequency Field Problems", by J. R. Whinnery and Simon Ramo, and "Network-Analyzer Studies of Electromagnetic-Cavity Resonators", by J. R. Whinnery, C. Concordia, W. Ridgway, and Gabriel Kron.

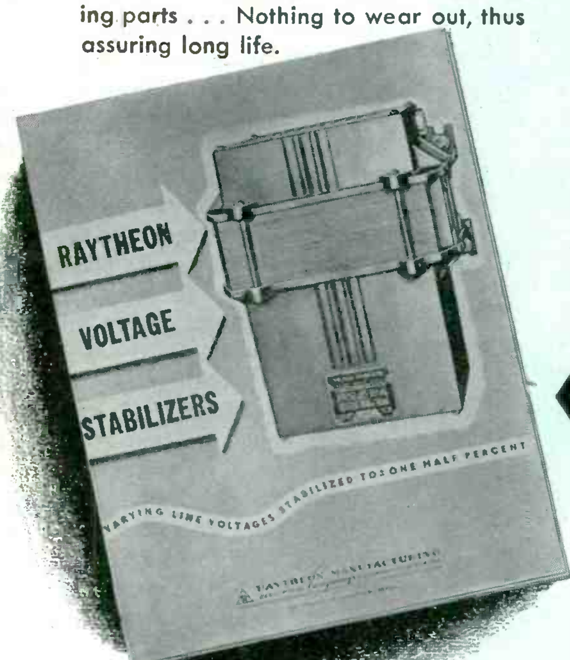
The four papers presented at this Friday afternoon session may be regarded as presenting field problems in such a manner as to enable them to be studied as circuit problems. One of the requisites for treating field problems as circuit problems of only moderate complexity, is that the electromagnetic field is assumed to vary in only two dimensions, or to extend to infinity without variation in the third dimension. This requirement was

How RAYTHEON VOLTAGE STABILIZERS Assure Dependable Operation of Precision Equipment

- **CONSTANT AC OUTPUT VOLTAGE**
  Raytheon Voltage Stabilizers control fluctuating input voltages and hold constant output voltage to ±½%.
- **WIDE AC INPUT VOLTAGE LIMITS**
  Raytheon Voltage Stabilizers will stabilize input voltages varying from 95 to 130 volts.
- **QUICK RESPONSE**
  Raytheon Voltage Stabilizers stabilize the varying input voltage *within 2 cycles.* Variations cannot be observed on an ordinary volt meter.
- **ENTIRELY AUTOMATIC**
  Raytheon Voltage Stabilizers are entirely automatic in operation. They require no adjustments or maintenance.
- **NO MOVING PARTS**
  Raytheon Voltage Stabilizers have no moving parts . . . Nothing to wear out, thus assuring long life.

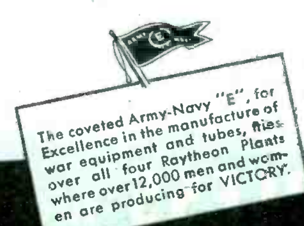


ENDBELL MODEL



SEND FOR THIS NEW BULLETIN . . .

It contains a complete description of how the stabilizer operates, its advantages, performance curves, dimensions and other pertinent facts. Simply request Bulletin DL 48-537 and your copy will be promptly mailed.



RAYTHEON MANUFACTURING Company
190 WILLOW ST. WALTHAM, MASS.

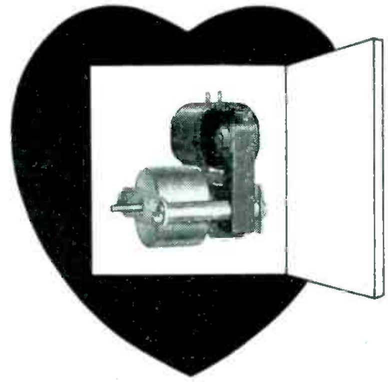
mandatory in the type of problem presented by Dr. Bronwell, and was employed for simplicity in the paper delivered by Mr. McAllister.

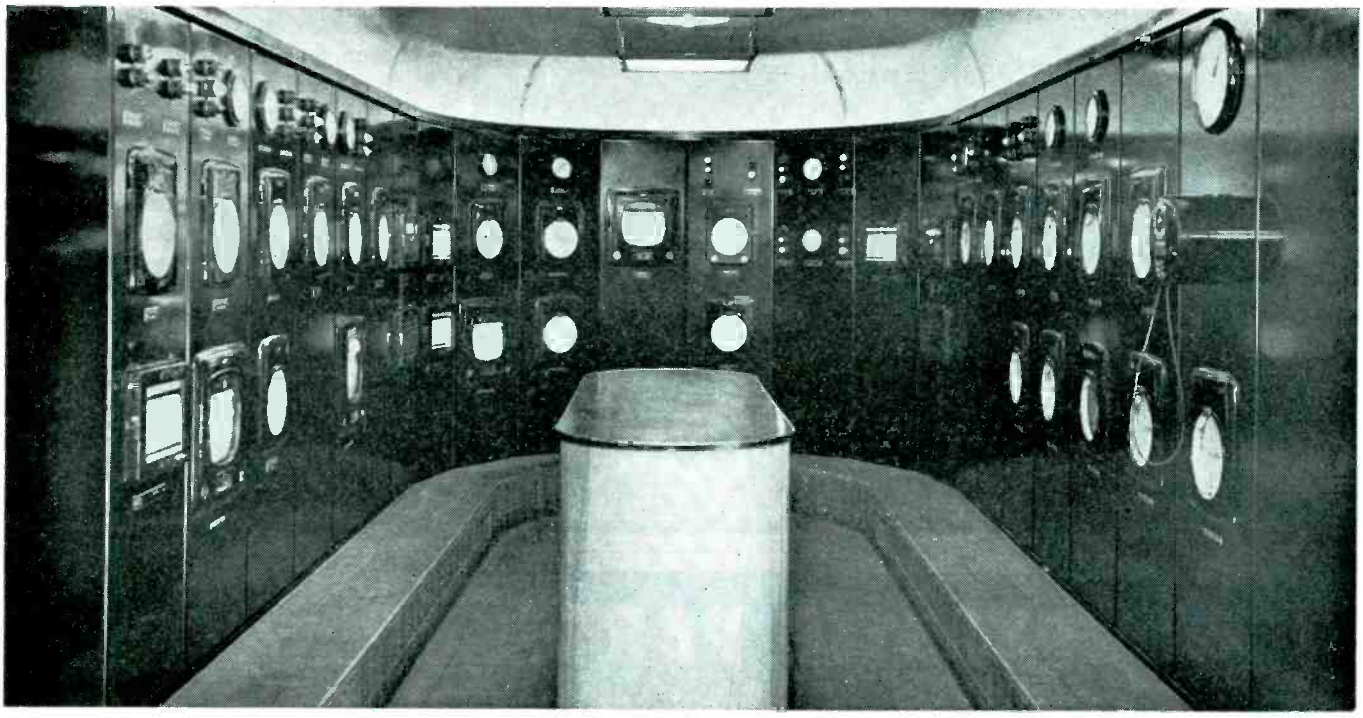
Dr. Bronwell presented the two-dimensional field equations for plane electromagnetic waves, together with the current and voltage equations for a transmission line. It was shown that the voltage equations for the transmission lines were analogous to the electric field equations for the plane electromagnetic waves, whereas the equations for the current in a transmission line are comparable to the magnetic field equations for the analogous case.

Mr. McAllister summarized the work reported in the three G-E papers mentioned above. The mathematical complexity of solving Maxwell's field equations for all but the most simple or symmetrical boundary conditions points to the desirability of studying electromagnetic field problems experimentally by means of a network analyzer. In order for such an experimental procedure to be possible, it is first necessary to establish the type of electrical circuit which is equivalent to the three-dimensional electric and magnetic fields of free space. Theoretical analysis by Dr. Gabriel Kron shows that Maxwell's electromagnetic equations treat field phenomena in the same manner in which Kirchoff's laws deal with electric circuits. Moreover, it has been shown that each elementary volume of free space of homogeneous, isotropic medium can be replaced by an equivalent electrical circuit in three dimensions, each mesh of which appears as a series inductance and shunt capacitance, as in a low-pass filter. For simplicity of explanation, only two-dimensional electric circuit equivalents of two-dimensional field problems were discussed.

Based on the analytical work of Kron, J. R. Whinnery and Simon Ramo showed the application of the equivalent electric circuit to the solution of electromagnetic field problems through the use of a network analyzer. A properly designed and operated network analyzer could be made to replace a volume of free space, and the voltage and currents readings of meters in the electric network are related to, and can be

The HEART of the installation is a Telechron motor!





● This is the Control Room of a petroleum refinery, which is busy making aviation gasoline and butadiene for synthetic rubber.

These instruments accurately control temperature, pressure, flow and level of liquids and gases in many processes. *And back of every round-chart instrument is a sturdy, synchronous Telechron motor.*

Automatic instrument control is absolutely essential in a complex chemical plant like this refinery. It is possible there — and in many other fields — because Telechron motors are so *dependable, accurate* and *adaptable.*

As the world's largest and oldest makers of synchronous motors for instrumentation, we've run into almost every industrial application imaginable. We have motors from 12 to 250 volts for all commercial frequencies and from 1 to 1800 rpm. They are easily adapted to almost any industrial application, including:

Timing	**Recording**	**Signaling**	**Gaging**
Controlling	**Switching**	**Fixed Process Controlling**	**Regulation**
Metering	**Cycling Operations**	**Measuring**	**Communications**

If you're puzzled by some timing, recording or control job that our motor might do, let's sit down and work it out together.

Telechron

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WARREN TELECHRON COMPANY, ASHLAND, MASSACHUSETTS

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interpreted in terms of the electric and magnetic field intensity, respectively, of that region of free space which the network represents. Thus, provided a sufficiently elaborate network analyzer is available, electromagnetic field problems may not be treated and studied as circuit problems.

The network analyzer of the General Electric Co. has been applied to the study of some two-dimensional electric field problems, as shown by Whinnery, Concordia, Ridgeway, and Kron. The example chosen for illustration was that of a rectangular wave guide having a 90 degree bend. Both the theoretical and the network-analyzer circuit solutions for this type of guide were given. In general, the two methods agreed to within less than 10 percent. This agreement was considered quite good considering the fact that only forty-nine meshes were available for illustrating this two-dimensional field problem; greater precision could undoubtedly have been attained had more meshes been available to represent the field within the wave guide.

The Friday afternoon session was concluded with a group of thirteen speakers covering "The Work of the Radio Technical Planning Board."

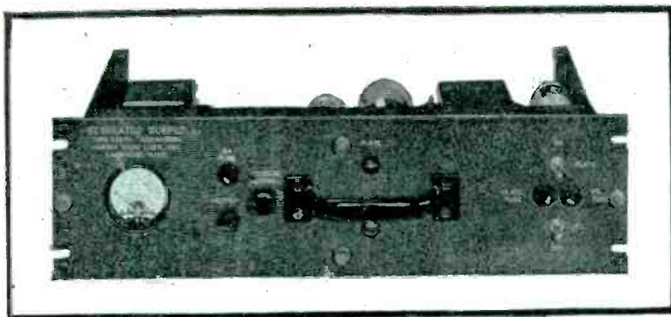
Saturday IRE Sessions

The Saturday morning session opened with the presentation of two papers covering related service problems, followed by a FCC symposium, which closed the session.

"Design Technique for Service Requirements", by I. W. Stanton, discussed various methods of establishing effective policies insuring proper performance of home radio receivers.

Arthur Stringer of NAB followed up with his paper, "Radio in Service of Home and Nation".

Dr. Wheeler, presiding over the symposium on "Engineering Work of the Federal Communications Commission" introduced FCC speakers. E. K. Jett, Chief Engineer, listed the problems that lie ahead; broadcast, maritime, aviation, police, point-to-point, and allocations. He extended a compliment to both the RMA and the IRE for their cooperation in the formation of the RTPB. He outlined needed



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There are separate fuses on each transformer primary as well as the D.C. output circuit; pilot lights on each switch; a D.C. volt-meter for measuring output voltage; a handy two-prong plug or binding posts for the power output. All in all this is a precision instrument that is a model of efficiency and operating convenience.

Years of specialization in the development and building of radio and electronics apparatus such as this Power Supply, I-F and Audio "Ampli-Strips", Radio Transmitters, Police and Marine Telephone Units qualify us to assist you in the development and production of electronics equipment calling for a high degree of technical knowledge and facilities. Whenever you have a problem of this character it will pay you to get in touch with

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information; on propagation, field strength, field patterns, power, frequency stability, bandwidths, and modulation methods, from broadcasters; and sensitivity, selectivity, frequency stability, and noise levels of receivers, adding that unless such information is obtained, and communications engineers are prepared to give authentic testimony, that FCC planning will have to be done on pre-war standards. He touched closely on the state of the art to be expected by 1950, emphasising the acute problems of available channel space and the pertinent questions of relay network systems in determining the future of communication in this country. He gave assurance, however, that there would be adequate space provided to allow for all of the pending developments.

Mr. G. P. Adair, assistant to Mr. Jett, followed with "Timely Broadcast Matters", enlarging more specifically on the details of special FCC studies.

"Police, Aviation, and Maritime Services" was presented by W. N. Krebs, Chief of the Safety and Special Services Division. He opened with the consideration that his subject had international as well as domestic aspects. If there are going to be standards by which international maritime and air services are to function after the

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TUBE WALKIE-TALKIE

Operating a walkie-talkie widely used by infantry troops in front lines. The outfit, shown at the IRE meeting, in New York, weighs 30 lbs. with batteries and contains 18 tubes

war, there will be difficult accompanying problems to be agreed upon.

The symposium was concluded by P. F. Siling, Chief of the International Division, who spoke on "International Point-to-Point Problems". He related briefly the interests and functions of the international division, its particular interest being preparatory work in drawing up treaties at international conferences. Bearing upon the fact that the available space in the spectrum for such communication services is completely filled up, he outlined a number of possible schemes to alleviate the situation. He looked to the vhf range, and also to the narrowing of bandwidths—taking advantage of single-side-band services. He noted the interesting fact that using two-tone f-m telegraph, that 900 words per minute could be handled over 9 channels on a 5 kc bandwidth.

The IRE winter meeting concluded with three papers discussing wartime and postwar problems.

R. A. Hackbusch, presenting "Radio Progress in Canada", described the progressive expansion of radio service to meet the wartime needs of that country, including description of the dovetailing of Canadian production with that of the United States. Canadian

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DIRECTION FINDER

Captured Jap direction finder, type 94, exhibited by Signal Corps at IRE winter meeting, is adjusted by Harry L. Landau, engineer in charge of Signal Corps department that examines and tests captured equipment

Meeting the Requirements of Television, FM, and Critical Electronic Functions . . .

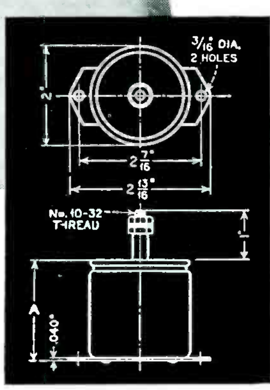
ULTRA-HIGH-FREQUENCY *Capacitors*

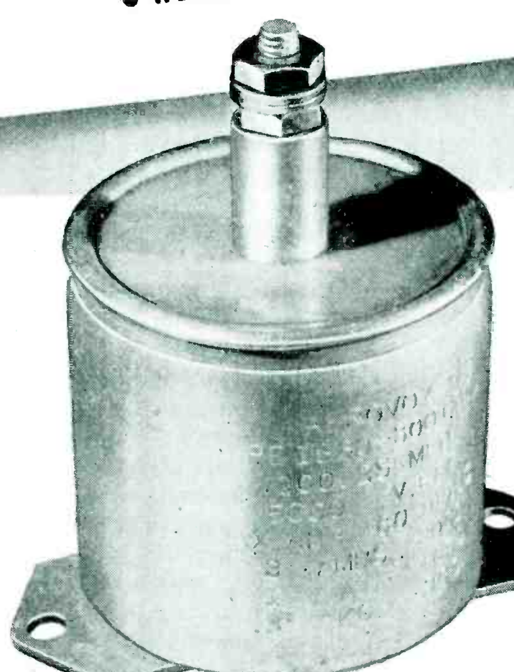
● Aerovox Types 1860 and 1865 capacitors are designed for ultra-high-frequency applications particularly in television and FM transmitting equipment, and also for critical electronic functions, operating at high frequencies. Readily adaptable for use as fixed-tuning, by-pass, blocking, coupling, neutralizing and antenna-series capacitors.

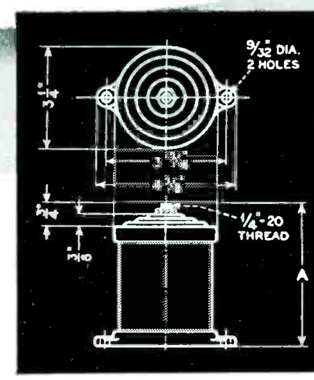
Losses are extremely low due to highly refined sulphur dielectric used. Corona losses are avoided by the unique design and construction, grounded case, and insulated terminal.

When your requirements reach up into the higher operating frequencies, just bear in mind these two Aerovox U-H-F capacitors.

● **WRITE FOR LITERATURE**







Type 1860 (see photo and above drawing) has suitably plated brass terminal mounted in mica insulating plate. Dimension A is from 2 to 3½".

10,000 test volts eff. .00001, .000025 and .00005 mfd.; 5000 v., .00005 mfd.

Catalog lists maximum current in amperes at operating frequencies from 1000 KC. to 75 MC. max., for both types.

Type 1865 (no photo, but see drawing above) differs in the use of cast-aluminum case and steatite insulator to support terminal and withstand higher voltages. Dimension A is from 2-11/16 to 6-11/16".

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Tolerance for both types, plus/minus 10% standard. Available in closer tolerances. Minimum tolerance, plus/minus 2 mmf.

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radio production, he stated, amounted to $250,000,000 in 1943 as compared with $100,000,000 in 1942; while the number of persons employed in the industry was 300,000 in 1939 and 940,000 in 1942 and 1,100,000 in 1943.

T. M. Liang of the Chinese Supply Mission, discussed "Peace, War and the Future Application of Radio in China". After the war it is estimated that there will be needed for reconstruction in China 110,000 civil engineers, 45,000 mechanical engineers and 15,000 electrical engineers.

Commander A. B. Chamberlain, USN, revealed the immense importance of "Standardization of Service Equipment" in the current production program.

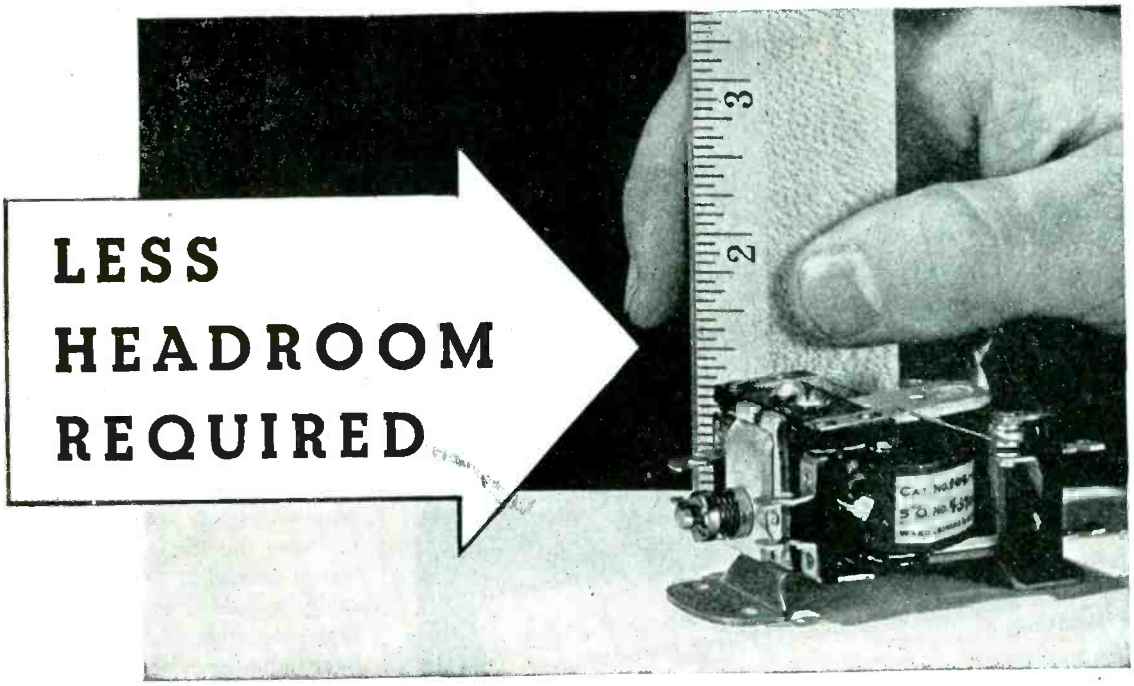
AIEE Technical Sessions

AIEE events began on Monday Jan. 24 and ran through Jan. 28, overlapping the IRE program by one day, with all technical sessions being held in the Engineering Societies Building.

The Edison Medal was presented to Dr. Vannevar Bush at the morning meeting on Jan. 26, "for his contribution to the advancement of electrical engineering, particularly through the development of new applications of mathematics to engineering problems, and for his eminent service to the Nation in guiding the war-research program."

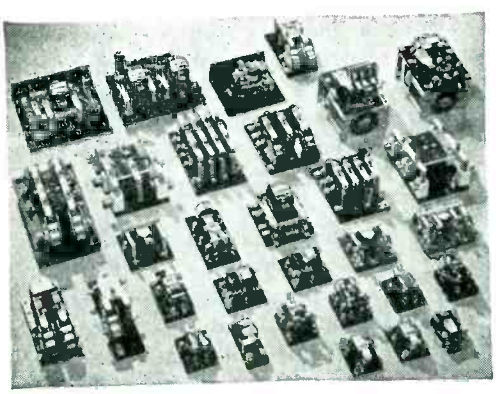
At the joint IRE-AIEE session the evening of Jan. 27, Major General Roger B. Colton of the Signal Corps was the principal speaker, his subject being "Enemy Army Communications Equipment". He presented a detailed description of captured enemy radio and wire equipment, and made performance comparisons to show that the Signal Corps of the U. S. Army is obtaining from American manufacturers the best communication equipment in the world. German radio equipment, General Colton pointed out, is of excellent mechanical design and embodies a high degree of standardization of components and chassis designs.

AIEE technical papers were largely devoted to purely electrical subjects, but a few were devoted to electronic subjects of interest to electrical engineers. One was "Polarized Light Servo-System", by



for THIS RELAY . . .

The WARD LEONARD Midget Metal Relay measures only 1¼" in height. Its sturdy design permits continuous service on standard AC and DC voltages up to 110-115 V. This double pole, double throw relay has the silver-to-silver contacts, characteristic common to all Ward Leonard Relays.



Relay Bulletins

Bulletins are available describing light, intermediate and heavy duty relays in various contact combinations, high voltage relays, metal and molded base midgets, aircraft power relays, transfer relays, sensitive relays, thermal and motor driven time delay relays, latch-in relays, and various types of radio relays. Send for the data bulletins of interest to you.

ARMY E NAVY
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WARD LEONARD

RELAYS • RESISTORS • RHEOSTATS

Electric control WL devices since 1892.

WARD LEONARD ELECTRIC COMPANY, 32 SOUTH STREET, MOUNT VERNON, NEW YORK

T. M. Berry of General Electric, describing a system utilizing phototubes and polarized light beams to amplify small forces or torques. Another paper, "Aircraft Signal Systems", by Raymond A. Rugge of Curtiss-Wright Corp., described photoelectric dimming devices for cockpit or control room signal lamps, to adjust brilliance of lamps automatically to correspond to the natural light present.

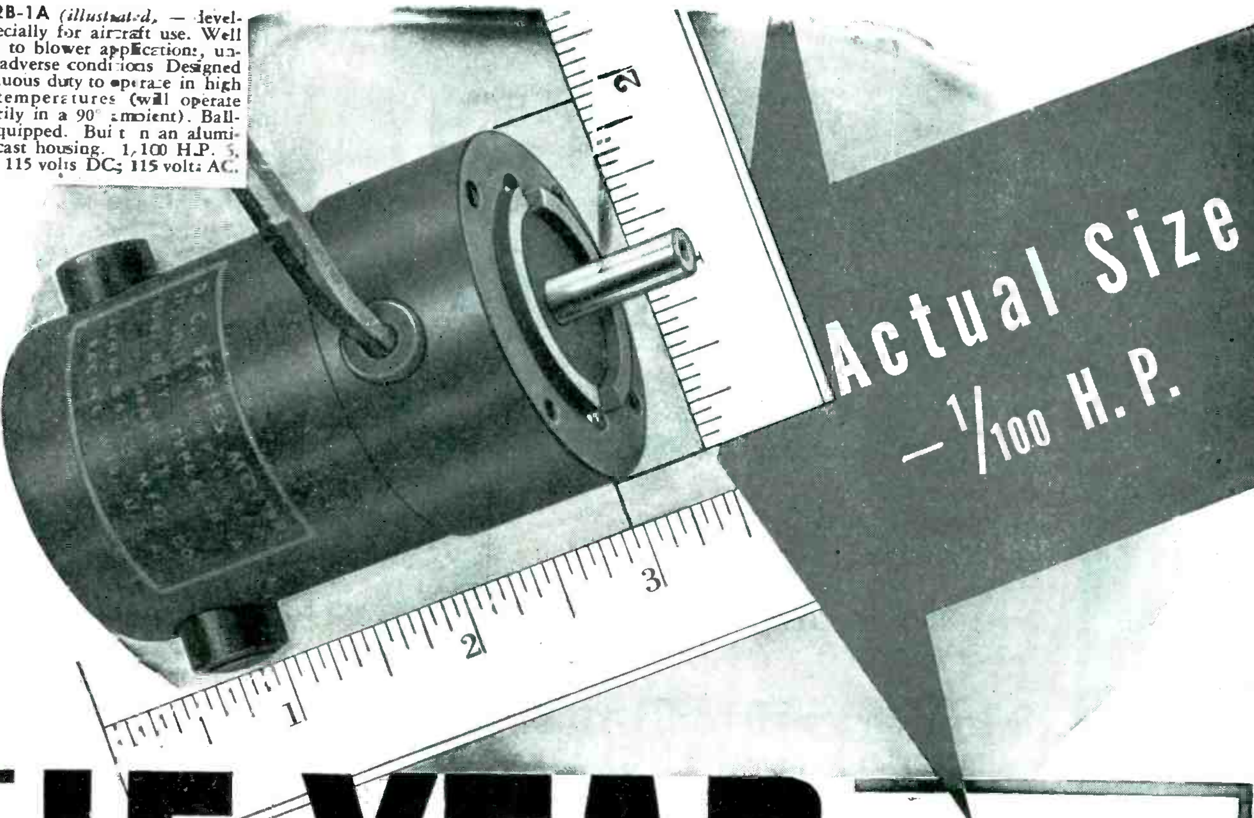
FMBI Convention

At the FMBI meeting, several speakers voiced the need for expansion of the present F-M band to include the frequency range between 42 and 56 Mc. The group formally recorded its position favoring retention of the present F-M band and assignment of an adjacent band to F-M. The RTPB has had this recommendation under consideration. Further impetus to this movement was given by educators at the meeting, many of whom have recently climbed on the bandwagon of license applicants. They were warned several months ago by chairman Fly of FCC that channels for educational purposes would not be held open indefinitely.

The program began with the president's report by Walter J. Damm, in which he traced the history of F-M broadcasting from the early days, when it was called "experimental high-frequency broadcasting with special emission." He included a description of the FMBI setup and disclosed that the association now has 63 active members and 41 affiliate members. Of the latter group, 13 are not broadcasters, while 28 are firms or individuals that have not yet filed applications for construction permits but intend to do so. Under the bylaws of FMBI, such affiliates become active members when notice is received that applications have been filed.

A review of the legislative regulations that govern F-M broadcasting was given by Philip G. Loucks, legal counsel of FMBI. He stated that, while the FMBI has not taken a very active part in the legislative activities of the past year, that at the invitation of chairman Wheeler of the Senate Committee on Interstate Commerce, Dr. Armstrong, Dr. Jansky, John V. L. Ho-

Type C-2B-1A (*illustrated*, — developed especially for aircraft use. Well adaptable to blower applications, under most adverse conditions Designed for continuous duty to operate in high ambient temperatures (will operate satisfactorily in a 90° ambient). Ball-bearing-equipped. Built in an aluminum die-cast housing. 1/100 H.P. 5, 12, 24, or 115 volts DC; 115 volts AC.



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Oster
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FRACTIONAL H.P. ELECTRIC MOTORS

This record is your assurance that you are dealing with a seasoned, dependable source — that you are not "taking a chance." . . . Oster motors, used exclusively before the present war as original equipment on Oster motor-driven appliances, have helped to establish the world-wide reputation of these appliances — for fifteen years the recognized leaders in their field, widely used by the armed services and other departments of U. S. and foreign governments. . . . The same sound, conservative engineering — the same trained labor force and established precision standards — are behind the Oster motors now being built to power vital instruments and mechanisms in war planes and submarines . . . Illustrated is type C-2B-1A, 1/100 H. P. model in current production; other Oster models up to ¼ H.P. Let us help you fit this or other Oster motors to your requirements.

John Oster Mfg. Co. of Illinois, Dept. E-11, Genoa, Ill.

gan and Earl Cullum, appeared before the committee during recent hearings on the Wheeler-White bill to amend the Communications Act and had also presented valuable technical information on the subject of F-M for the committee's consideration.

That the future of F-M will be largely determined by the engineering potentialities of the system, the adequacy of the channels provided by the FCC, the effect of operating rules, and the value of the public service rendered by the broadcasters, was pointed out by C. M. Jansky, Jr., consulting engineer for FMBI. He compared F-M and A-M systems and stressed two basic differences, namely:

(1) Radio carrier frequencies in the F-M band are approximately 40 times as high as those in the A-M band. The laws of radio propagation are radically different at these higher frequencies and better adapted to broadcasting.

(2) The use of frequency modulation rather than amplitude modulation greatly reduces the power necessary to overcome noise or in-

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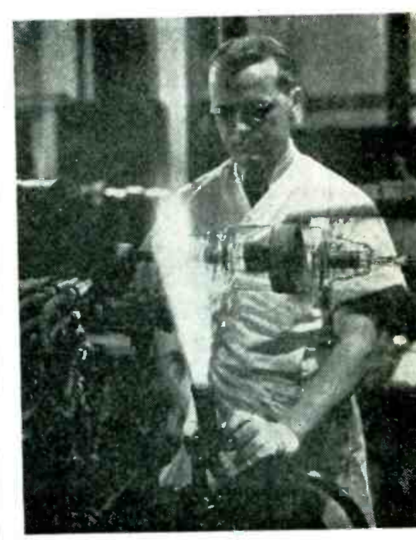
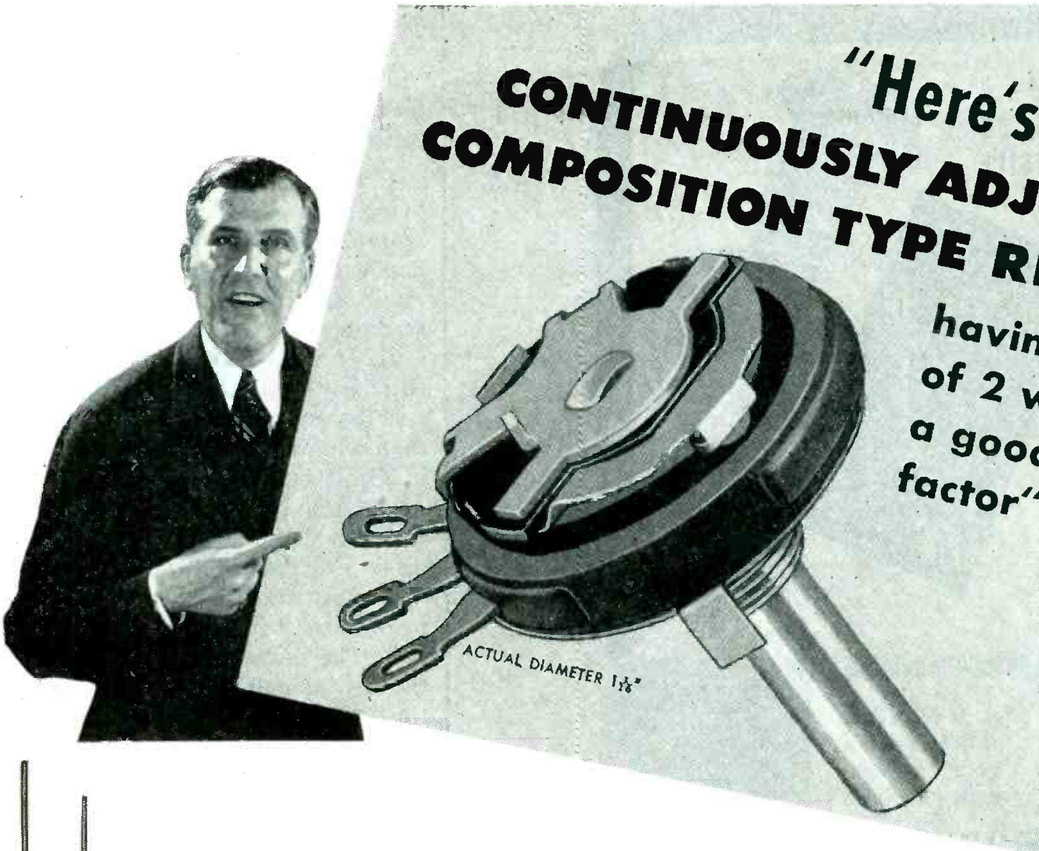
ANNEALING VACUUM TUBE



The photo shows a 400-watt vacuum tube being annealed after the filament mount is sealed. The tube is rapidly rotated in a glass lathe during annealing to remove internal strains that may be set up in the glass during sealing. Jens Aakjer, glass craftsman, adjusts the torch used for heating the glass at the Westinghouse Lamp Division, Bloomfield, N. J.

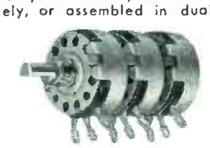


A low resistance carbon brush makes a smooth contact with the resistor and assures long life and quiet operation.

Cross section of Bradleyometer showing how terminals are imbedded in solid, molded resistor. (Actual size.)

Type JS Bradleyometer with positive contact shielded line switch.

Bradleyometers may be used separately, or assembled in dual . . .



. . . or triple construction to fit any control need. Available for rheostat or potentiometer applications.

Actual size 1-watt and ½-watt insulated Bradleyunit fixed resistors.

This is the Allen-Bradley Type J Bradleyometer in which the resistor element has substantial thickness . . . approximately 1/32-inch. In this respect it differs radically from the thin film, paint, or spray type variable resistors. The resistor material, insulation, terminals, face plate, and threaded bushing are molded into a single unit. In the process of manufacture, the resistor material can be varied to produce practically any form of resistance-rotation curve. Once the Bradleyometer has been molded, the toughest war service cannot alter its performance. It is the only composition type variable resistor that will consistently stand up under the Army-Navy AN-QQ-S91 salt spray test. Enclosure is sealed, dust-proof, and splash-proof.

Bradleyometers have high rating and high current carrying capacity. They have no rivets, no soldered or welded connections, and no conducting paints in the electrical circuits. Their simple construction and few parts make them positively reliable and trouble-free.

Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee 4, Wis.

ALLEN-BRADLEY

FIXED & VARIABLE RADIO RESISTORS

QUALITY

terference at any given point of reception.

The Board of Directors of FMBI has approved the following committee recommendations:

I. It is recommended that the principle of allocation based upon assigning service areas to station applicants be retained but the rigid coupling of service areas to trade areas be abandoned.

II. It is recommended that new classification of channels if necessary be made on a regional, rather than a nation-wide, basis.

III. It is recommended that the use of the dual terminology "High Frequency Broadcast Stations" (as used by the FCC), and "F-M Broadcast Stations" (as more commonly used by industry and public alike) be discontinued in fávor of the use of only one such designation, "F-M Broadcast Stations."

IV. It is recommended that in the granting of licenses to F-M Broadcast stations the Commission take into account such factors as:

(1) The natural coverage area which the station would have based upon the proposed location, power, antenna gain, and the laws of propagation for the territory to be served.

(2) The ability of the station to deliver adequate service to the community or communities the station is primarily intended to serve.

(3) That in licensing a station the Commission shall define the area throughout which that station shall be protected against interference from other stations on the same channel, even though the facilities to be originally installed do not provide for coverage of the ultimate area.

V. It is recommended that the Commission allow a period of Commercial, Program and Engineering development to provide for normal growth before requiring installation of facilities to cover the ultimate area proposed, taking into consideration that growth in listener audience in different sections will be at different rates.

1944 *PRODUCTION of meters is scheduled at 39 million units, 55 times as many instruments as were made in 1940. A single large bomber may have 250 meters, a battleship 1,000 and a tank 10.*

Brevity is the Soul of Wit—

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Conserving Paper

SURE IT'S EASIER to let your dictation roll along. Sure it's easier to write long copy. Sure it's easier to do all the good, pleasant things of normal peacetime business when paper is like water, something you can pretty well use as you will.

But now, when the increasing paper needs of the armed services daily decrease the national supply of paper—when paper is a true war essential—that's a different story.

All of us in business must watch every piece of paper or paper board we use. We must judge its use in terms of absolute necessity. We must not use a single piece, a single inch, of paper which thriftier writing or printing or packaging can possibly save.

For multiplied on a national scale, that particular piece or inch of paper or paper board becomes the tonnage needed by our service forces to ship precious food and ammunition and weapons and medical supplies and blood plasma to our troops overseas.

If there's no Paper Conservation Committee in your organization or in your community, why not get one going today?

This advertisement prepared under the auspices of the War Advertising Council in co-operation with the Office of War Information and the War Production Board.

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It takes 25 tons of blueprint paper to make a battleship.

700,000 different kind of items are shipped to the Army—and they're paper-wrapped or boxed.

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Each Signal Corps radio set takes 7 pounds of kraft paper, 3 pounds of book paper.

Each propelling charge for 155-millimeter shell takes 3/5 pound of paper.

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Review all printed forms periodically for essentiality; consolidation; elimination of waste space; standardization of sizes, weights, color, grade; elimination of color where possible.

Eliminate slack fills, thus effecting the economies of a smaller package.

Use 8½x5½-inch letterheads for short letters; inclose them in small envelopes.

Adjust the number of units per case to the maximum practical.

Use and re-use carbon paper consistently.

Conversely, reduce the number of units to utilize lighter carton board when such reduction will result in less tonnage over-all. Be sure that the openings are on the smallest dimension of the shipping container, so that the flaps will have the smallest area possible.

LET'S ALL USE LESS PAPER

Space for this advertisement contributed by ELECTRONICS

NEW BOOKS

Fundamentals of Telephony

By Arthur L. Albert, *Professor of Communication Engineering, Oregon State College. McGraw-Hill Book Co., Inc., New York, 1943, 374 pages, price $3.25.*

A text restricted to cover wire telephony only, and designed for beginning students and telephone workers rather than engineers. With this clear-cut goal in mind, the author devotes the first four chapters to an effective review of basic electrical theory, sound, speech and hearing; this material is largely condensed from his earlier and more comprehensive book "Electrical Fundamentals of Communication". Following chapters cover telephone transmitters, telephone receivers, telephone sets, manual and dial telephone systems, transmission over circuits with distributed constants and with lumped constants, measurements in telephony, inductive interference, and telephone repeaters and carrier systems. Review questions and problems are given at the end of each chapter for class use. Well illustrated, with clear diagrams and clearly presented mathematical treatments where required for understanding of practical telephone problems.—J.M.

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Hyper and Ultra-high Frequency Engineering

By Robert I. Sarbacher and William A. Edson, *Illinois Institute of Technology. 644-pages, price $5.50, 1943, John Wiley & Sons, Inc.*

Dealing exclusively with the phenomena occurring at frequencies between 30 and 10,000 Mc, this volume provides an excellent introduction to the u-h-f field for those engineers whose experience has not already placed them on speaking terms with wave guides and cavity resonators. For the experienced the work will prove an excellent reference source and engineering working tool particularly since an extensive bibliography is to be found at the end of the volume.

The mimeographed notes providing the original basis of the book have been used in courses of instruction for senior students in electrical engineering at the Illinois Institute of Technology. The reader is expected to be well versed in undergraduate electrical engineering and in vector analysis. A good portion of the book is mathematical and appears more formidable than is actually the case because of the detail with which certain of the proofs have been worked out. Apparently little trouble has been encountered, however, in presenting this material to senior electrical engineering students in the better technological institutes.

The first chapter constitutes an interesting and excellent treatment of electrostatics and magnetostatics as a review for some of the more fundamental concepts which will be utilized in later sections of the volume. The electrostatic and magnetostatic equations are presented in parallel columns and, so far as possible, the text is applicable to either type of concept. The parallelism between the two static branches of electricity is thereby forcefully and compactly brought out.

The second chapter plunges immediately into a discussion of both experimental laws and the mathematical formulation which provide the basis of Maxwell's equations. The general form of these equations is given first after which, with suitable simplifications, the static state, steady state, and quasi-steady state equations are derived. Such a presentation has the advantage of acquainting the reader, at the earliest possible moment, with the formulations for the most general state of affairs encountered in radio communications. At the same time, the reader is forced to recognize that any of the simplifications which are so frequently of engineering use, are merely special cases of the generalized Maxwell equations.

The field equations of Maxwell are treated in greater detail in Chapter III which discusses the various types of electromagnetic waves which may be produced and their propagation through an isotropic medium.

Chapter IV to VII inclusive, present a mathematical treatment of the physics of wave propagation in hollow conductors. These chapters are entitled, respectively, "Reflection and Refraction of Plane Waves", "Parallel Plane Wave Guides", "Rectangular Wave Guides", and "Cylindrical Guides". At least in the simpler cases the necessary conditions for the various modes of transmission are treated and a discussion is given of the resolution of propagated waves into what might be termed their elementary components.

For those whose interest lies in the more practical aspects of propagating waves of extremely high frequency, Chapter VIII, "Wave Guide Experimental Apparatus", provides a section of some 24 pages which summarizes the work of Barrow, Southworth, Chu, Clavier, Brillouin, and other leaders in u-h-f technique.

The next three chapters deal with "Transmission Line Theory" (which more or less follows standard treatment on this subject), "Cavity Resonators" and "Radiation From Horns and Reflectors". The mathematical treatment of cavity resonators in Chapter X discusses such topics as resonance in a rectangular cavity, power relations in a rectangular cavity, resonance in cylindrical cavities, power relations in cylindrical cavities, resonance in coaxial cylindrical cavities, spherical cavity resonators, coupling to cavity resonators, and a comparison of the properties of cavity resonators of various configurations. Chapter XI, dealing with radiation from horns and reflectors, is a review of the work accomplished in this field by Barrow and his associates at M.I.T., Southworth and his co-workers in the Bell System, and that of Clavier of about a decade ago in effecting u-h-f communication across the English Channel.

The remaining portion of the book deals with electron tubes and their associated electrical circuits.

The behavior of vacuum tubes at high frequencies, including a treatment of the effect of lead inductances and internal capacitances, transit time effects and noise in vacuum tubes, is given in Chapter XII. The design of audio—, video—, and intermediate-frequency amplifiers using negative grid vacuum tubes is treated in Chapter XIII. Considerable attention is directed to those methods for obtaining amplifier response over a wide range of frequencies as required for video amplifier design. Since negative grid oscillators have not been developed to a point where considerable amounts of power can be developed for those frequencies which this volume aims to treat primarily Chapter XIV on this subject is a short one of some 20 pages.

The final three chapters deal with the more specialized type of u-h-f generators. Chapter XV on "Positive-Grid or Retarding-Field Oscillator" has been quite thoroughly summarized in the August 1943 issue of ELECTRONICS. Likewise, Chapter XVII on "Tubes Employing Velocity Modulation" has been adequately summarized in the August 1943 issue of the *Proceedings of the Institute of Radio Engineers.* The remaining chapter of about 26 pages deals with the mechanism of operation of the magnetron.

The volume ably meets its "intended use by senior students of electrical engineering, and by men with equivalent training who have had at least one course in radio engineering", and is well recommended as a text or reference work.—B.D.

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A Primer of Electronics

By DON P. CAVERLY, *Commercial Engineer, Sylvania Electric Products, Inc. McGraw-Hill Book Co., Inc., New York, 1943, 235 pages, price $2.00.*

THOUGH BEARING AN electronic title, this book announces at the beginning that the old and entirely incorrect convention of current flow from positive to negative will be followed in deference to old electrical rules. This convention is followed only for the first 67 pages, however, covering in somewhat popular manner the fundamental theories of electric current and magnetism. Part III, on electromagnetic radiation, covers the entire gamut of wave motions, from those on water to x-rays and gamma rays. Then, in Part IV on basic electronics, the author reverts to now-accepted practice of tracing electron movements, and proceeds to explain the workings of radio tubes, incandescent, mercury-vapor and fluorescent lamps, strobotrons, phototubes, cathode-ray tubes and the electron microscope.

This book is written for those who must handle or work with electronic products yet know little or nothing about the subject—salesmen, store clerks, stenographers, and the workers engaged in electronic production. The author states definitely that the removal of complex technical aspects was deliberate, hence such technical liberties as the use of X in place of lambda as the letter symbol for wavelength are considered permissible. The book is interesting and easy to read, and this was the goal aimed at by the author.—J.M.

• • •

Graphical Construction for Vacuum Tube Circuits

By ALBERT PREISMAN, *Director of Engineering Texts and Consulting Engineer, Capitol Radio Engineering Institute. First Edition, 1943, 238 pages, price $2.75, McGraw-Hill Book Company, Inc., New York.*

THIS TEXTBOOK is intended to fill a gap in the literature on vacuum tubes, viz., graphical constructions (those geometric manipulations by which solutions to problems on nonlinear circuits are obtained). The first part of the book deals with nonlinear circuits and elementary tube theory, and the middle part with reactive loads and balanced amplifiers. At the end detection and feedback circuits are given proper consideration.

This lucidly written textbook reveals much original thought, although the introductory chapters follow standard textbook routine. This is somewhat unfortunate as certain improper statements found in a large number of recently published textbooks now appear in this volume as well. In spite of the pioneer work on signs done by E. L. Chaffee of Cruft Laboratory more than ten years ago, emphasized by MIT staff in the recently published volumes "Electric Circuits" (1940) and "Applied Electronics" (Jan., 1943), textbooks are still written without a clear sign-convention that makes obvious beyond doubt the direction of the various variational quantities involved. In this volume the lack of a sign convention forces the author to an unconventional definition of μ (page 27 and page 82) and leads him into the common track of presenting the equivalent-plate-circuit (EPC) theorem via a number of equations and additional discussion (p. 35–36). In reality the whole thing boils down to the agreement between the teacher and his student that the super-position theorem holds for the control grid and the plate, so that these electrodes contribute $g_m V_s$ and V_L/R_p *independently.* The total contribution is then, with a simple substitution, $g_m V_s - I_p Z_L/R_p$, which is the EPC theorem, *period.* Added so-called derivations and proofs serve only one purpose in an introductory text: to confuse the issue and hide the fundamental thought behind the EPC equation. The average standard textbook also gives the incorrect information that the EPC theorem cannot be used for calculation of the power dissipated in the tube, and that the screen grid was introduced to prevent interaction between output and input circuits at radio frequencies. In reality there is no objection against the use of the EPC theorem for the power calculation referred to, if only this "theorem" is used correctly. Regarding the screen grid, Schottky himself said, twenty-five years ago, that he did not think his screen-grid tube differed from triodes as far as high-frequency stability was concerned.

It must be clearly understood that the above criticism applies to a large number of textbooks. In the following part of the volume the author falls back upon his own thinking, and the result is an excellent treatment of nonlinear circuits in graphical presentation. He is just after one thing: to give graphical or combined graphical-analytical solutions to problems on non-linear circuits, which solutions answer important questions in the least time and with the least effort; and he is successful in this.

The author makes extensive use of the dynamic characteristic; somewhat unconventional in this country but commonly used in Europe. Thus the treatment of push-pull amplifiers gives much useful information, part of the material being original. As analytical treatments generally lead to messy, unsolvable equation systems, graphical methods for non-linear tube circuits are of the greatest importance, and the author gives many examples on how to perform the graphical solutions in various cases. In the applications he restricts himself mostly to audio-frequency circuits. As graphical construction is still more important for Class-C operation, it should have been advantageous, if a chapter on high-frequency power tubes had been added, emphasizing the shortcomings of i_p–e_g and i_p–e_p diagrams and the usefulness of e_p–e_g diagrams. Such an extension may be possible in the next edition.

Mr. Preisman has a long experience as teacher and technical writer and is recognized for his ability to explain lucidly and in simple words complicated phenomena and calculations. He has successfully transferred this ability into the pages of his book, and it is recommended to every student and engineer, who wants to obtain a proper understanding of the non-linear-circuit problem and its possible solutions.—H. STOCKMAN.

• • •

Electricity and its Application to Civilian and Military Life

By CHARLES A. RINDE. *Harcourt, Brace and Co., New York, 1943, 466 pages, price $1.96.*

WITH THE CONTROL of electrons as its central theme, this presentation of the fundamentals of electricity admirably arouses interest in each new electrical principle by describing an interesting related experiment, then follows the principle with a series of everyday applications. The level of writing is that of a vocational school because the book is organized around the War Department's outline, *Fundamentals of Electricity* (PIT-101), yet the military outline has not been so rigorously followed as to impair the readability and post-war value of the book. Both civilian and military applications of electricity are stressed throughout.

A large part of each chapter consists of detailed explanations of electrical devices employing the principles covered in that chapter, with appropriately selected and exceptionally clear diagrams and photographs for illustrative purposes. Approximately the last 40 pages are devoted to radio, x-rays, fluorescent devices and television. At the end of each chapter are thought-producing, knowledge-testing questions and problems, with suggested experiments and investigations. An appendix contains useful electrical data and a 6-page glossary of definitions.—J.M.

• • •

Practical Radio for War Training

By M. N. BEITMAN. *Supreme Publications, Chicago, 1943, 366 pages, price $2.95.*

A PAPER-COVERED BOOK apparently intended chiefly for pre-induction radio classes and beginner's courses. Subjects covered include the theory of electricity and radio, with radio servicing hints and two chapters on test equipment. Review questions and problems follow each chapter.—J.M.

• • •

OSCILLATORY TOWER

To test radio apparatus under high centrifugal and tangential forces, such as are encountered by equipment used in the crow's nest of a ship, Westinghouse engineers use this pivoted 50-foot steel mast. It swings 45 deg both sides of vertical, making a round trip every six seconds. A 35-hp variable-speed motor with an oil-well reduction-gear and crank supplies the power

Multivibrator

(Continued from page 142)

Equations (4.4) and (4.7) are plotted in Fig. 4.4 for the MV designed in Example III and for section 1 of the MV designed in Example IV of part two of this paper. In both cases, $\beta_{t1} > \beta_{d1}$ as it always will be if $\delta_{d1} \leqq \delta_{t1}$. (See Fig. 4.2.) The maximum value of $N_1/f_sC_{h1}R_1$ plotted in each case is equal to $(1 - \delta_{d1})\log_e(k_2\mu_{co1})$. Any smaller value can be used, provided E_{s1} is increased sufficiently to maintain the order of division at N_1.

To render unnecessary the bridging of C_{h1} and R_{d1} and careful selection of the tubes to be used in the MV, in the designs of Examples III and IV $N_1/f_sC_{h1}R_1$ was arbitrarily decreased to 80 percent of the maximum allowable value. (If the components and tubes selected at random provide a value for $N_1/f_sC_{h1}R_1$ less than the maximum, the proper order of division and apportionment of δ_{d1} and δ_{t1} can be obtained by a simple method of adjusting E_{s1}.) A portion— the size of which depends upon the $N_1/f_sC_{h1}R_1$ actually obtained—of the percentage variations otherwise permissible in E_{s1} is sacrified for this convenience. The relative magnitude of this sacrifice increases with the order of division, N_1.

The reason for the rapid decrease in the percentage variations allowable in E_{s1} with decreasing $N_1/f_sC_{h1}R_1$ is that the magnitude of E_{s1} increases rapidly, while the variation in volts allowable increases very slowly, or may even decrease, depending upon the order of division and the range of $N_1/f_sC_{h1}R_1$ involved. See Fig. 4.3, and compare Figs. 2.10 and 2.11 of Part II. Even though the synchronizing pulses are derived from the output of a limiter tube, the amplitude of the pulses is subject to change with changes in E_{bb} or with replacement of the limiter tube.

Effect of Ripple or Feedback Voltages in E_{bb}

In Fig. 4.5, E_r is the peak-to-peak value of ripple or feedback voltage present in E_{bb}. (Voltages developed across a common power supply are termed feedback vol-

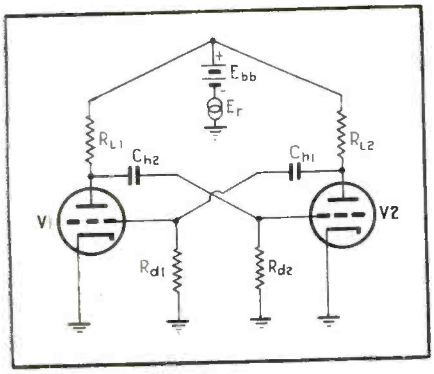


Fig. 4.5—Ripple voltage in the plate power supply is coupled directly into the grid circuit of each tube in the MV

tages.) If V_1 is non-conducting, E_r will cause a voltage of magnitude

$$E_r R_{d2}/(R_{d2} + R_{L1} - jX_{h2}) \qquad (4.8)$$

between the grid and cathode of V_2.[14] This voltage will be amplified by V_2 and will be coupled into the grid circuit of V_1 as a synchronizing voltage of magnitude

$$E_{rs1} = -\mu_2 E_r \left[\frac{R_{d2}}{R_{d2} + R_{L1} - jX_{h2}}\right] \left[\frac{R_{L2}}{R_{L2} + R_{p2}}\right]\left[\frac{R_{d1}}{R_{d1} - jX_{h1}}\right]. \qquad (4.9)$$

The shunting effect of $(R_{d1} - jX_{h1})$ on R_{L2} is neglected in this equation, and R_{d1} is assumed to be considerably greater than $R_{b2}R_{L2}/(R_{b2} + R_{L2})$. The fact that E_r is present in the plate circuits is assumed to be of negligible importance in comparison with the amplified voltage of Eq. (4.9).

If $R_{d1} >> X_{h1}$ and $R_{d2} >> X_{h2}$, Eq. (4.9) becomes

$$E_{rs1} = -\mu_2 E_r \left[\frac{1}{1 + R_{L1}/R_{d2}}\right] \left[\frac{1}{1 + R_{p2}/R_{L2}}\right] \qquad (4.10)$$

Unless f_r is synchronous with f_s, E_{rs1} will drift through E_{s1} causing the synchronizing pulses to vary in effective amplitude by the peak-to-peak voltage of E_{rs1} at a frequency equal to the difference between f_s and f_r. This will result in narrowing the range of $f_s C_{h1} R_1$ through which the order of division can be maintained at N_1.[15] If the positive portion of E_{rs1} is greater than the value of $\beta_{t1} E_{s1}$ as given by Eq. (4.5) for an order of division equal to N_1, or if the negative portion of E_{rs1}

[14] Distortion of the positive portion of the ripple cycle by grid current in V_2 is neglected.

[15] If f_r is synchronous with f_s, it may or may not be detrimental, depending upon its waveshape and its relative amplitude and position as compared with that of E_s.

is greater than $\beta_{d1}E_{s1}$ as given by Eq. (4.2), the MV will slip synchronism. If both of the above conditions do not obtain simultaneously, it may be possible to adjust the amplitude of E_{s1} such that division by N_1 will be obtained over a restricted range of $f_s C_{h1} R_1$. If the peak-to-peak amplitude of E_{rs1} is greater than the increase in the exponential component of E_{d1} between the $(N_1 - 1)$th and the N_1th pulses, it will be impossible to synchronize at N_1. In order that the theoretical maximum values of δ_{d1} and δ_{l1} may be closely realized in practice, E_{rs1} should be considerably smaller than this change in E_{d1}.

$$E_{rs1} << \Delta_1 E_{d1} \tag{4.11}$$

where

$$\Delta_1 E_{d1} = k_2 E_{bb} \left\{ \exp\left[\frac{-(N_1 - 1)}{f_s C_{h1} R_1}\right] - \exp\left[\frac{-N_1}{f_s C_{h1} R_1}\right] \right\} \tag{4.12}$$

Substitution of (4.10) and (4.12) into (4.11) gives

$$E_r << \frac{k_2 E_{bb}}{\mu_2}\left(1 + \frac{R_{p2}}{R_{L2}}\right)\left(1 + \frac{R_{L1}}{R_{d2}}\right) \left\{ \exp\left[\frac{-(N_1 - 1)}{f_s C_{h1} R_1}\right] - \exp\left[\frac{-N_1}{f_s C_{h1} R_1}\right] \right\}. \tag{4.13}$$

Because $k_2 \simeq 1/(1 + R_{b2}/R_{L2})$, the product of k_2 by the first term in parentheses approximates unity for all values of R_{L2}. As a result, the value of R_{L2} is of little importance in (4.13). Since C_{h2} fixes a maximum value for R_{L2} and a minimum value for R_{d2} via (1.9) and (1.6) respectively,[16] a maximum value is placed upon the ratio R_{L1}/R_{d2} in the second parentheses of (4.13). This ratio will seldom be greater than 0.5. A small value of μ_2, i.e., a low-mu tube, is an aid in satisfying (4.13).

To a very good approximation, (4.13) can be written

$$\frac{E_r}{E_{bb}} << \frac{1}{\mu_2} \left\{ \exp\left[\frac{-(N_1 - 1)}{f_s C_{h1} R_1}\right] - \exp\left[\frac{-N_1}{f_s C_{h1} R_1}\right] \right\}. \tag{4.14}$$

The right-hand side of (4.14) can

[16] Satisfaction of (1.9), while not being a requirement for reliability in an MV, is very desirable because it renders T_1 independent of T_2, thereby making it possible to use simpler equations to describe and to predict the operation of the MV. While (1.9) usually is satisfied, even without special consideration, it can be under-satisfied by at least 2 to 1 without seriously affecting the accuracy of such equations. This would permit the ratio of R_{L1} to R_{d2} to be doubled.

be maximized by using a value of $N_1/f_sC_{h1}R_1$ equal to $N_1\log_e[N_1/(N_1-1)]$. This maximum is very broad—similar to the curves of Fig. 4.3—so that the exact value of $N_1/f_sC_{h1}R_1$ is not critical. Figure 4.6 is a plot of the expression in braces in (4.14) versus N_1 using the maximizing value of $N_1/f_sC_{h1}R_1$ which is plotted in Fig. 4.7. Therefore, Fig. 4.6 gives the maximum value the term in braces can have as a function of the order of division.

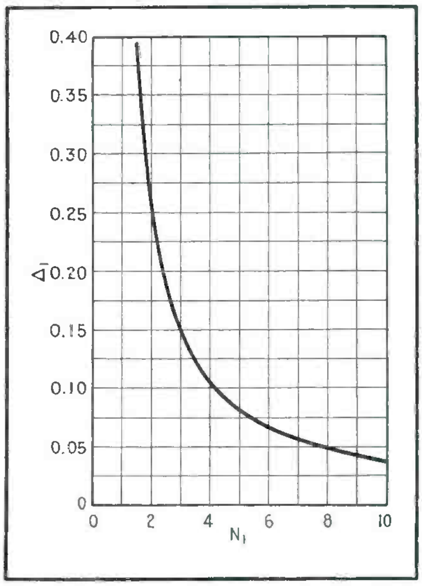


Fig. 4.6—Curve of $\Delta_1 = \exp[-(N_1-1)/f_sC_{h1}R_1] - \exp[-N_1/f_sC_{h1}R_1]$ vs. N_1 using the maximizing values of $N_1/f_sC_{h1}R_1$ as given in Fig. 4.7

For the purposes of a general working rule, it might be stated that the value of Δ_1 as given by Fig. 4.6 should be at least $5\mu_2$ times the ratio E_r/E_{bb}. Hence, for a given tube type, i.e., for a given mu, the greatest order of division of any one section of any MV determines the maximum ripple or feedback voltage that can be tolerated in E_{bb}.

Except for the fact that E_r may consist of a miscellaneous group of waveforms, frequencies and amplitudes as the result of an E_{bb} common to other equipment as well as to the MV stage under consideration, the ratio E_r/E_{bb} could be considered the percentage of ripple at the output of the rectifier and filter.

Examples

For the MV designed in Example III, $N_1 = 7$, $\mu_2 = 20$ and the value of $N_1/f_sC_{h1}R_1$ used is 1.62. What

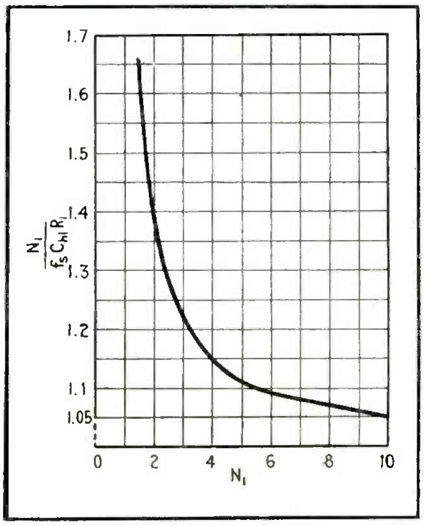


Fig. 4.7—The value of $N_1/f_sC_{h1}R_1$ given by this curve maximizes the increase in the exponential grid voltage between the (N_1-1)th and the N_1th synchronizing pulses

would be a reasonable percentage of ripple voltage in E_{bb}, if the values of δ_{d1} and δ_{t1} allowed for in the MV design are to be closely approximated in practice?

Reading Fig. 4.6 for $N_1 = 7$ gives $\Delta_1 = 0.057$.[17] Therefore, to satisfy $E_r/E_{bb} \ll 0.057/\mu_2$, the ratio E_r/E_{bb} should not be greater than 0.00057. For $E_{bb} = 180$ volts, the peak-to-peak ripple is $0.00057 \times 180 = 0.1$ volt. The voltage gain of one MV section (Fig. 2.9) is 15, so that the ripple voltage at the grid of the non-conducting tube approximates 1.5 volts peak-to-peak. The total allowable change in E_{s1} is about $0.057\ k_2E_{bb}$ or 7.4 volts.

What should be a satisfactory value of the ratio E_r/E_{bb} in the power supply for the MV designed in Example IV?

Section 2 fixes the maximum value of ripple because it uses the same type of tube and has the greater order of division, i.e., 4.8. From Fig. 4.6, $\Delta_1 = 0.085$, hence it is desirable that E_r be less than $0.085E_{bb}/5\mu_1$ which is nearly 0.1 volt. The gain of V_1 in the MV (Fig. 2.12) is approximately 25 so the ripple voltage at the grid of V_2 is about 2.5 volts. The total permissible variation in E_{s2} is about $0.085\ k_1E_{bb} = 11.5$ volts.

Comparison of the above examples shows that the type 6N7 in an MV section dividing by 4.8 places approximately the same lim-

[17] See later discussion concerning the use of Fig. 4.6 in this case.

itation on the ripple voltage as a type 6SN7 in a section dividing by 7. This is the result of the higher mu of the 6N7 and is not due to the greater gain realized in the circuit. [Refer to (4.13) and the discussion following it.] Figure 4.6 was used to find Δ_1 even though the values of $N_1/f_sC_{h1}R_1$ used in the designs were considerably greater than the maximizing values given by Fig. 4.7. However, it has already been seen (Fig. 4.3) that the variation allowable in E_s decreases very slowly for values of $N_1/f_sC_{h1}R_1$ greater than the maximizing values. This, coupled with the fact that exact information on the tolerable ripple is not only more tedious to obtain, but also of little use, justifies the approximate procedure used above for estimating permissible ripple.

If ripple is present in the common power supply, it is likely to affect the circuits supplying the synchronizing voltage to the MV as well as the MV itself. The net effect of ripple in such a general case is difficult to predict. The information provided here concerning ripple and feedback voltages is intended only as an order of magnitude check. For maximum safety against ripple voltages, the number of volts change allowable in E_s—not percentage change—is of importance.

Effect of Shunt Capacitances

Shunt capacitances were not considered in the development of the design equations of this analysis; since, in the light of experimental evidence, it was decided they would add unnecessary complication. For example, using 2500 ohm plate load resistors with type 6SN7-GT tubes, multivibrators were designed for frequencies as high as 100 kc. In most cases, experiment checked these designs within ±5 percent.

The frequency of a symmetrical MV operating at 100 kc using a type 6SN7-GT tube with $R_L = 2500$ ohms, $R_d = 80{,}000$ ohms, $C_h = 50$ $\mu\mu$f and $E_{bb} = 200$ volts, decreased 4.5 kc when 10 $\mu\mu$f capacitors were connected from each grid to ground. Connecting 10 $\mu\mu$f from each plate to ground decreased the frequency only 2.5 kc; 100 $\mu\mu$f capacitors similarly connected decreased the frequency 10 kc, i.e., the natural frequency of the MV became 90 kc. When 100 $\mu\mu$f capacitors were connected from each grid to ground, the frequency *increased* to 107 kc. By increasing the value of C_h to 200 $\mu\mu$f and decreasing R_d to 20,000 ohms, the natural frequency of the MV was made to decrease when the additional 100 $\mu\mu$f capacitors were connected from the grids to ground.

The natural frequency of the MV changed 15 kc as E_{bb} (obtained from a regulated power supply) was varied from 150 volts to 300 volts. Frequency increased as E_{bb} was decreased. This is to be expected, since μ_{co} decreases as E_{bb} decreases. (See Fig. 1.8.) The percentage variation of frequency is greater in this case than it would be at lower frequencies where higher values of R_L and therefore of k could be used. See Appendix I.

Multivibrator Waveshape

If (1.9) is satisfied, the voltage across C_{h1} will, for practical purposes, reach the value E_{bb} by the end of its charge time. Under these conditions, the equation describing the plate voltage, E_{b2}, of V_2 (Fig. 1.1) during the time it is nonconducting is[18]

$$E_{b2} = E_{bb}\left\{1 - \left[\frac{1}{1 + R_{b2}/R_{L2}} - \frac{1}{\mu_{co1}\left(1 + \frac{1}{R_{d1}}\left(\frac{R_{b2}\,R_{L2}}{R_{b2} + R_{L2}}\right)\right)}\right]\left[\frac{1}{1 + \frac{1}{R_{L2}}\left(\frac{R_{d1}\,R_{g1}}{R_{d1} + R_{g1}}\right)}\right]\exp\left[\frac{-t}{C_{h1}\left(R_{L2} + \frac{R_{d1}\,R_{g1}}{R_{d1} + R_{g1}}\right)}\right]\right\} \quad (5.1)$$

where t is zero at the instant V_2 stops conducting. At time equal to zero, E_{b2} has a value E_{bb} times the difference between unity and the coefficient of the exponential. Actually, some time is required for E_{b2} to reach this initial value, the amount of time being determined by the high frequency response of the circuit. As time increases, the exponential term decreases and E_{b2} approaches E_{bb}. Therefore, the waveform of the plate voltage after $t = 0$ is determined by the time constant of the exponential term. By decreasing the magnitude of the

[18] The development of this equation is given at the end of the present section. E_{b2} is total voltage and, therefore, includes the d-c component.

coefficient of this term, the steeper portion of the wave can be increased. One method for accomplishing this is to connect a resistor in series with the grid of V_1 and the junction of C_{h1} and R_{d1}. For this case, R_{g1} of Eq. (5.1) must be replaced with $(R_{g1} + R_{o1})$ where R_{o1} is the series grid resistor. Values of R_{o1} greater than about $3R_{L2}$ secure small additional improvement. Since $(R_{g1} + R_{o1})$ must also be used in the exponent, the rate of rise of E_{b2} after $t = 0$ will be less than it is without R_{o1}. If R_{o1} is comparable in value with R_{d1}, the accuracy of the design equations will be impaired somewhat due to the resulting non-satisfaction of (1.9). The actual frequency will usually be greater than the equations predict.

Connecting R_{o1} in series with the grid of V_1 will improve the high frequency response of the plate circuit of V_2, because the grid-cathode capacitance of V_1 is isolated from the plate-cathode capacitance of V_2. However, the high frequency response of the grid circuit of V_1 will be reduced because its grid-cathode capacitance sees a higher resistance generator. The original high frequency response of these circuits can be partially restored by connecting a condenser, C_{o1}, in parallel with R_{o1}. The capacitance of C_{o1} should be approximately 5 to 10 times the grid-cathode capacitance of V_1. At medium frequencies, inclusion of R_{o1} and C_{o1} usually has negligible effect upon the natural frequency of the MV, increasing it less than 1 per cent. A similar combination may be connected in the grid circuit of V_2.

Another effect of R_{o1} is to decrease the magnitude of a tail occurring in the negative direction on the plate voltage wave of each tube at the time the tube becomes conducting. The tail on the plate wave of V_1 is due to the charge current of C_{h1} driving the grid of V_1 positive. The duration of this tail is determined by the time constant of Eq. (5.1). R_{o1} decreases the magnitude of this tail because it increases the resistance of the generator driving the grid of V_1. Note that R_{o1} steepens the wavefront of E_{b2} and decreases the tail of E_{b1}. Similarly, R_{o2} would steepen the wavefront of E_{b1} and decrease the tail of E_{b2}. C_{o1} will restore the tail, but with somewhat reduced amplitude and duration.

Equation (5.1) is developed as follows: It is desired to write the expression for the voltage appearing from plate to cathode of the tube in the equivalent circuit of Fig. 1.13. This voltage, E_{b2}, will be equal to the difference between E_{bb} and the voltage drop in R_{L2} due to

LIFE BOAT COMMUNICATIONS EQUIPMENT

A combination radio-telegraph-telephone set for use in life boats is demonstrated by employees of Radiomarine Corp. of America. While one man cranks the generator, the other operates the equipment to contact nearby ships

the charging current of C_{h1}. It is necessary, therefore, to first find how much voltage is across C_{h1} at the instant it stops discharging and begins to charge toward E_{bb}. For this purpose, refer to the equivalent discharge circuit, Fig. 1.3a. The instant the voltage across R_{d1} becomes greater (less negative) than $-E_{co1}$, the capacitor will stop discharging and begin to charge. When $E_{d1} = E_{co1}$, the total voltage drop in the resistance of the circuit will be E_{co1}

$$\left[1 + \frac{1}{R_{d1}}\left(\frac{R_{b2}\,R_{L2}}{R_{b2} + R_{L2}}\right)\right].$$

The voltage across the capacitor is *decreasing* toward the applied voltage. Therefore, when $E_{d1} = E_{co1}$,

$$E_{h1} = E_{bb}\left(\frac{R_{b2}}{R_{b2} + R_{L2}}\right) + E_{co1}\left[1 + \frac{1}{R_{d1}}\left(\frac{R_{b2}\,R_{L2}}{R_{b2} + R_{L2}}\right)\right]. \quad (5.2)$$

With this information, the plate-cathode voltage of V_2 is readily written from Fig. 1.13; and, after some simplification, becomes Eq. (5.1).

Comparison of Characteristics of Triode and Pentode Tubes in MV Circuits

1. The a-c plate resistance of the average pentode is many times that of the average triode.

2. The d-c plate resistance, $R_b = E_b/I_b$, is of the same order for both triodes and pentodes.

3. For a given value of grid bias, the d-c plate resistance of triodes decreases as the plate voltage is increased.

4. For given values of control grid bias and screen grid voltage, the d-c plate resistance of pentodes increases almost linearly with plate voltage, except for plate voltages near zero. Therefore, I_b versus E_{bb} and I_b versus R_L approximate horizontal lines.

5. In the case of triodes, the d-c plate current is a function of the plate load resistor. The factor k increases slowly with R_L.

6. Because the d-c plate current of a pentode is practically independent of the plate load resistor, the factor k increases directly with R_L. Therefore, the MV can be designed to provide a logarithmic variation of *period* with linear variation of R_L.

The equations developed for triode tubes in multivibrators hold equally well for pentodes, if the proper interpretation is placed upon the quantities involved. For pentode tubes, Eq. (1.5a) becomes

$$\alpha_1 T_1 = \log_e\left(k_2\,\mu_{co1}\right)\left(\frac{I_{b2}\,R_{L2}}{E_{sg1}}\right) \quad (1.51a)$$

where E_{sg} = Screen grid voltage. (Assumed constant)

$$k_2 = \left[\frac{1}{1 + \frac{1}{R_{d1}}\left(\frac{R_{b2}\,R_{L2}}{R_{b2} + R_{L2}}\right)}\right].$$

$\mu_{co1} = E_{sg1}/E_{co1}$.

I_{b2} = d-c plate current through V_2.

When interpreting Eq. (1.51a), one should remember that I_{b2} is a function of E_{sg2}.

Conclusions

The most important conclusions may be summarized as follows:

1. The percentage variation in the natural period of an MV through which a given order of division can be maintained is not a function of the tube type or of the ratio of the controlled period to the natural period; rather, it depends only upon the order of division.

2. The required amplitude of synchronizing pulse increases rap-

idly with decreasing ratio of controlled to natural period.

3. The number of volts variation in the amplitude of the synchronizing pulse for which the order of division remains constant varies slowly with the ratio of the controlled to the natural period. Consequently, the allowable *percentage* variation in the amplitude of the synchronizing pulse decreases rapidly with decreasing ratio of controlled to natural period.

4. If only one tube of an MV is synchronized, the percentage variation that can be tolerated in the time constant circuits is approximately half that permissible if both tubes are synchronized.

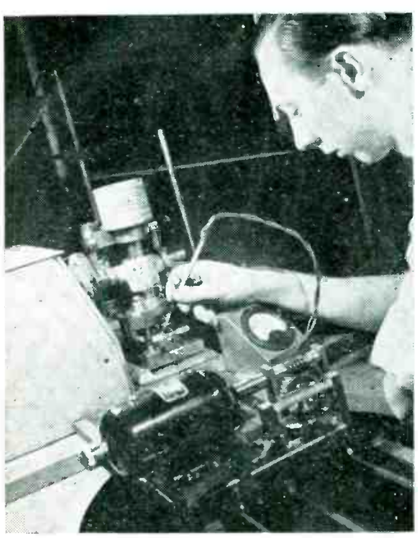
5. The preceding conclusions are based upon the use of a positive impulse of synchronizing voltage. Use of rectangular synchronizing pulses of finite duration is equivalent, in its effect upon the variations that can be tolerated in the time constant circuits and in the amplitude of the synchronizing pulse, to an increase in the order of division.

Appendix V

Since the maximum allowable value of $N_1/f_s C_{h1} R_1$ in Eq. (4.4) is equal to $(1 - \delta_{d1})\log_e(k_{\mu c01})$. β_{d1}

• • •

METER BEARINGS



An operator checks the temperature of a hydrogen flame used in conjunction with a punch press to form glass jewels for meters. The glass rod is fed into the press by the motor drive in the foreground

can be written in terms of $k_2\mu_{co1}$, δ_{d1} and δ_{t1}.
Substitution of

$$[k_2\,\mu_{co1}]^{-(1-\delta_{d1})}$$

for

$$\exp\left[\frac{-N_1}{f_s\,C_{h1}\,R_1}\right]$$

in Eq. (4.4) gives

$$\beta_{d1} = \frac{[k_2\,\mu_{co1}]^B - [k_2\,\mu_{co1}]^{-(1-\delta_{d1})}}{[k_2\,\mu_{co1}]^B - [k_2\,\mu_{co1}]^{-1}}$$

$$\text{where } B = -\left(\frac{1-\delta_{d1}}{1+\delta_{t1}}\right) \qquad (4.41)$$

This equation continuously approaches 1 as $k_2\mu_{co1}$ approaches infinity. For $\delta_{d1} = \delta_{t1}$ and $N_1 = 2.5$, β_{d1} starts at about 40 percent for $k_2\mu_{co1} = 2$ and increases rather rapidly to about 50 percent at $k_2\mu_{co1} = 14$, then slowly approaches 52 percent for $k_2\mu_{co1} = 20$. For $N_1 = 5$, β_{d1} has values of about 46 percent and 50 percent for $k_2\mu_{co1}$ equal to 2 and 10. For $k_2\mu_{co1} > 10$, the values of β_{d1} for all practical orders of division lie within a band a few percent wide with an average value of about 50 percent. Hence, in practice the value of $k_2\mu_{co1}$ is not important so far as β_{d1} is concerned.

Acknolwedgment

This paper is much improved as the result of suggestions made by Mr. C. N. Gillespie and by Mr. J. R. Weiner of these laboratories. The author appreciates the interest indicated by Mr. J. L. Callahan and by Mr. J. E. Smith.

Symbols Used in This Paper

The numerals 1 or 2 appended to a subscript indicate the section of the circuit in which the component or voltage is located.

$A = E_s/E_{co}$.
C_h = Plate to grid coupling capacitor.
E_{bb} = Plate supply voltage.
E_{co} = *Magnitude* of d-c grid voltage required for plate current cutoff.
E_r = Peak to peak ripple or feedback voltage in E_{bb}.
E_{rs1} = Ripple synchronizing voltage as it appears in the grid circuit of V_1.
E_s = Peak amplitude of the synchronizing voltage. Except where it is specifically stated to the contrary, E_s is considered positive.
f_r = Frequency of ripple or feedback voltage in E_{bb}.
f_s = Frequency of the synchronizing voltage.

$$k_1 = \left[\frac{1}{1+\dfrac{R_{b1}}{R_{L1}}}\right]\left[\frac{R_{d2}}{R_{d2}+\dfrac{R_{b1}\,R_{L1}}{R_{b1}+R_{L1}}}\right].$$

$$k_2 = \left[\frac{1}{1+\dfrac{R_{b2}}{R_{L2}}}\right]\left[\frac{R_{d1}}{R_{d1}+\dfrac{R_{b2}\,R_{L2}}{R_{b2}+R_{L2}}}\right].$$

MV = Multivibrator.

N = Order of division of *one synchronized section* of multivibrator.

$N_1 = T_1/T_s$ = Order of division of V_1 and its associated components.

$$R_1 = \left[R_{d1} + \frac{R_{b2}R_{L2}}{R_{b2}+R_{L2}}\right].$$

$$R_2 = \left[R_{d2} + \frac{R_{b1}R_{L1}}{R_{b1}+R_{L1}}\right].$$

R_b = d-c plate resistance of the tube.

R_d = Grid resistor.

R_g = Grid-cathode resistance of the tube.

R_L = Plate resistor.

R_p = Dynamic plate resistance of the tube.

t = time.

T_1 = Non-conducting time of V_1.

T_2 = Non-conducting time of V_2.

$T_{MV} = T_1 + T_2$ = Period of the multibrator.

T_s = Period of the synchronizing voltage.

$$\alpha_1 = \frac{1}{C_{k1}\left(R_{d1} + \frac{R_{b2}R_{L2}}{R_{b2}+R_{L2}}\right)}.$$

$$\alpha_2 = \frac{1}{C_{k2}\left(R_{d2} + \frac{R_{b1}R_{L1}}{R_{b1}+R_{L1}}\right)}.$$

$100\beta_d$ = Percent decrease in E_s.

$100\beta_i$ = Percent increase in E_s.

$100\delta_d$ = Percent decrease from nominal value of discharge time constant or of f_s.

$100\delta_i$ = Percent increase from nominal value of discharge time constant or of f_s.

$\mu_{co} = E_{bb}/E_{co}$. = Usually 1/2 to 3/4 of the rated amplification factor of the tube.

σ = Width of rectangular synchronizing pulse/T_s.

Many of the equations are written only for section 1 of the MV. The corresponding equation for section 2 can be obtained in every case by replacing the sub-numeral 1 with 2 and the sub-numeral 2 with 1.

Bibliography

(1) Abraham, H. and Bloch, E., *Annal d. Phys.*, 12, p. 237, Sept.-Oct. 1919.

(2) Bartelink, E. H. B., A Wide Band Square Wave Generator, *Trans. A.I.E.E.*, 60, p. 371, 1941.

(3) Hull, L. M. and Clapp, J. K., A Convenient Method for Referring Secondary Frequency Standards to a Standard Time Interval, *Proc. I.R.E.*, 17, p. 252, Feb. 1929.

(4) Terman, F. E., "Measurements in Radio Engineering", p. 129-136, 1st ed., McGraw-Hill Book Co., New York, 1935.

(5) Andrew, Victor J., The Adjustment of the Multivibrator for Frequency Division, *Proc. I.R.E.*, 19, p. 1911, Nov. 1931.

(6) Page, R. M. and Curtis, W. F., The Van der Pol Four-Electrode Tube Relaxation Oscillation Circuit, *Proc. I.R.E.*, 18, p. 1921, Nov. 1930.

(7) Wanatabe, Yasusi, Some Remarks on the Multivibrator, *Proc. I.R.E.*, 18, p. 327, Feb. 1930.

—◆—

THE BEST EXECUTIVE is the one who has sense enough to pick good men to do what he wants done, and self-restraint enough to keep from meddling with them while they do it.—Theodore Roosevelt.

Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronic industry or comment on articles which ELECTRONICS has published.

Applause

(1) FOR PAGES 94–95, December ELECTRONICS. My vote goes for communications symbols. I once wrote a similar article (in another field) under the title "Confusion Less Confounded."

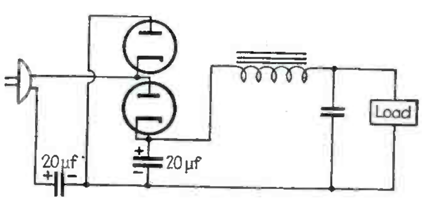
(2) For article on "Permanent Magnet Design." Magnetism is a fascinating subject, though its language is often vague. The present discussion is clearer than most, but still is cloudy in spots.

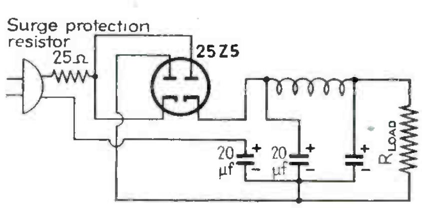
(3) For (a) the high quality of subject matter and (b) the impressive physical size of ELECTRONICS.

NICHOLAS B. COOK
Instructor ESMWT, Rutgers University

Doublers

IN THE "Radio Engineering Handbook" there is the statement "it is not possible to use a dual electrolytic condenser for voltage doubling if the negative lead is common". As a matter of fact, there is a circuit which works almost as well as the one you have presented and has





Two forms of voltage-doubling circuits using condenser networks having common negative leaks. One is for two half-wave rectifiers, and the other for double-diode rectifiers like the 25Z5 a *common cathode* type condenser network. The result is a half-wave doubling effect that requires a little more filtering than the full-wave doubler presented.

CPL WILLIAM H. HOUNSELL
Sioux City, Iowa

You are right in calling the statement incorrect, about the negative electrolytic condenser lead. However, a little consideration of your first circuit will show that it is less desirable than if it had one d.c. output lead at the same potential as one side of the a.c. line. In this latter case both condensers must be independent.

You may be interested in an article "Thermionic D-C Supply Systems" published in February 1944 ELECTRONICS. It gives voltage-current outputs and comparisons for several circuits, using paralleled rectifier tubes. A circuit similar to yours is shown, and in addition the ratings for the full-wave doubler which you mention.

R. C. HITCHCOCK
Lt. USNR
Dept. Elec. Eng.
U. S. Naval Academy
Annapolis, Md.

Meter Dials

IT MAY BE of some interest to you that I am the originator of the symbols for meter dials, of which you have printed a number in the November 1943 issue of ELECTRONICS, when I was the Chief Engineer of Siemens & Halske, Berlin.

It was about 20 years ago, 1922 or 1923, when more and more new types of instruments were developed. The purpose of these symbols was certainly *not* to help the sale of Siemens instruments in foreign countries, but to give every user of an instrument the ability to recognize the nature of the instrument, to use it properly, switchboard instruments as well as portable instruments. An electrodynamic or a moving iron voltmeter might be used on d.c. as well as on a.c., while an induction instrument would burn out very soon if connected to d.c. A rectifier instrument for high frequency might well stand an overload of 500 percent while an instrument with thermoconverter would burn out at once.

The above motive refers as well to domestic customers as to customers in foreign countries. At the same time I had the resistance or voltage drop or similar data printed on the scale, so that it was not necessary to measure it, and it was possible to detect some defect from a change in the resistance. I do not believe in giving such data on a special chart which, when it is needed, is always in some drawer. It was very essential to indicate the test voltage, so that the user might see in what circuit he could use a certain ammeter with safety.

From Siemens the Verband Deutscher Elektrotechniker adopted these scale markings as German standards, and later the International Electrotechnical Commission adopted them as international standards. There were some changes in the symbols, but only very few. Most of them are printed in ELECTRONICS now as they were used by Siemens 20 years ago. Some members of the international committee liked to introduce some of their own ideas, and in fact, some of the new symbols (e.g., for induction instruments) are better than the ones I had used. This was 1935, as far as I remember, and the meeting was in Paris.

Of course, such international symbols are a great help when the instruments were sent to foreign countries.

However, to meet the requirements for the export in at least a dozen foreign language countries, it was necessary to use symbols in place of every word written before. This started with the units, amperes, volts, watts and so forth. There was not only the necessity to make a special scale for every 5-dollar switchboard instrument, but there was always, believe it or not, a complaint that a word was not properly spelled. To get away with all this, I had only V, A, kW on the scale, which are written in the same way in all countries except the United States, where small letters are used.

The next step was to add other inscriptions like "zero adjustment" or "to be used only in horizontal position", or "battery", and so on. These symbols were developed to help sell the instruments in all countries without having translations made (which were many times not correct). I think I developed quite some ingenuity in doing this. It was a great help for the manufacturer and the customers liked the symbols very much too.

You are certainly right in suggesting that such symbols should be adopted also for American products, and I would say not only for practical but also for sentimental reasons. Latin countries like very much to have their own language on their instruments, but if they cannot get this, they will prefer symbols to a foreign language.

I think there is nobody in this country who has so much experience in this very special field as I have and if there should be the desire to adopt this European system of symbols (I called them also HIEROGLYPHS), I would be willing to give every assistance.

GEORGE KEINATH
Larchmont, N. Y.

Electronic Recording

Re: Messrs. Parny, p. 280, August, 1943 and Seaman p. 348, November 1943.

IN CONSIDERATION of your suggestions for a new type of electronic pickup employing a fixed film, scanned by a cathode-ray tube, may I point out the following:

Compression of the sound track dimension in one axis, as proposed, requires compression in the other; i.e., the "light source" slit aperture must be decreased by the same ratio by which its length has been decreased in order to obtain the same fidelity of sound reproduction.

Two of the factors which prevent decreasing the slit aperture dimension are light interference and light intensity; i.e., the slit of 0.0015 to 0.0005 inch now used in film sound reproduction is very near a lower limit due to light interference caused by the edge effects of the aperture itself. Cutting down the light intensity from such a feeble source as the illumination furnished by cathode-ray screen fluoresence would require a current amplifier tube, a FP54 or the like, to indicate such minute signals.

Might I suggest using a more powerful source of light, mechanically scanned, rather than the cathode-ray tube whose only advantage is electronic scanning, the slow, stable motion of which could be produced only with difficulty.

Light interference from the narrow aperture is the greatest problem, as I see it. A compromise between fidelity of reproduction and sound track width, at constant ratio of aperture length to width must be arrived at ("Electrical Engineer's Handbook," 6–46, Pender & McIlwain) and is the limiting factor for this system as well as for every conventional sound on film system which probably ever has been built.

DONALD F. PENNIE,
Junior Physicist, Aero Laboratory
Minneapolis Honeywell Regulator Co., Minneapolis, Minn.

Tube Shortages

THE ARTICLE "Tubes for Civilians" on your page for November 1943 is rather misleading; from a personal interest in obtaining a particular tube I can give a new angle to the subject.

From a painful survey of all local radio suppliers it appears that no tubes of the type 12SA7 have been available for at least four months. As you know, many of the last few radios manufactured used this tube and many of them have failed by now. Owners of such sets are doing either one of two things, having an old set extensively rebuilt and repaired at considerable expense in both materials and labor, or having rather involved circuit changes made in their newer set so that it may use a substitute tube (6SA7) which is sometimes available.

R. L. ALCORN, JR.,
Beaumont, Texas

Curriculums

THANK YOU for publishing "A New Curriculum in Electrical Engineering" by Gray and Frazier in the October 1943 issue.

The terms of employment of technicians keep them out of touch with, and inarticulate about, the education which is producing their successors. This is particularly true as compared with the parts taken by medical people and the legal gentry in their sorts of education. Articles such as these will give us information otherwise unavailable.

M.I.T. is to be commended for formulating a curriculum which stresses fundamentals, common principles, and sequences. There has been too much teaching of discrete information, each like a small pill to be separately swallowed, without too much reference to what preceded or was to follow.

It would be an added gain if the social studies were likewise organized. For instance, anthropology could well have been included in these courses. Combined with the History already there, it would help in coordinating the characteristics of human nature to human behavior, similar to the way advanced techniques in these courses make use of engineering fundamentals.

Personally, I believe it would be better to displace "economics" entirely, in favor of Anthropology. Since this could not be considered wise—and certainly not fashionable—the inclusion of Anthropology would give a touch of causal sequence to studies in "the" Humanities which "economics" is unable to offer. It would furnish desirable realism and sophistication to offset some of the naivete and poignant make-believe on which orthodox Economics must rest.

I trust you will publish other articles on education.

J. A. Douglas,
Anniston, Alabama

West

A copy of your October issue has just come to my attention through a friend here in North Africa. My own copies are now going to my U. S. address rather than risk losing them in transit.

I am now taking the liberty of pointing out that you have negligently offended me and doubtless others of your readers.

I refer to your announcement that Mr. Dudley will henceforth be located in Chicago as your Western Editor. It has been the source of considerable annoyance to me to note the attitude of some ill-informed people in regard to the geography of the United States and I am sorry to find a publication with which I find so little fault placing itself in such company.

May I point out that Chicago is in the eastern third of the United States and that to really be in the west, one must be on that side of the Rockies that drains into the Pacific Ocean? Your attitude is exactly represented by that map of the U. S. (possibly from the New Yorker) which depicts the country as consisting of Manhattan Island surrounded by the suburbs of Pennsylvania, Texas and a few others whose exact names have been heard once or twice but not remembered.

I suppose that I should have the good sense to keep quiet about this matter. If we continue to demand credit where credit is due, some of you easterners are going to have a look at the other side of the mountains and once there you will never return to the land of smoke, filth and crowds.

I still think it's a good magazine and wish I could afford to have copies sent here for reading in addition to my others for filing.

WM. R. PATTON

Personnel

THIS IS WRITTEN in response to your invitation for comment on the article by Mr. S. S. Egert in the January issue of ELECTRONICS entitled, "Post-War Industrial Equipment Distribution."

By and large, my reaction to the reasoning of and the conclusions drawn by Mr. Egert is as an echo to the original wave. I consider this article to be a fine sounding board for general ideas on the subject. One of my criticisms of the article would be that, throughout the whole process of manufacture, sale, service and maintenance—where the availability of trained specialists is constantly emphasized—there is only peripheral treatment of the probably retarding influence on developing uses of electronics in industry as a result of not having an adequate source of qualified technicians. I hold that a dearth of trained specialists for work in this field can just as surely retard development as any flaws in the process of distribution.

Possibly I over-emphasize the importance of this point because I am presently concentrating my efforts on securing these qualifications myself. But I am not so

(*Continued on page 362*)

POSITIONS VACANT

SALES ENGINEER WANTED, Chicago territory, for established manufacturer of metal fasteners widely used by industry on war and peacetime products. Prefer resident Chicago area, age 30-35 with engineering training. Give full details, education, experience, draft status, age, salary expected and recent photograph. Require statement of availability if engaged in war work or essential activity. P-615, Electronics, 330 W. 42nd St., New York 18, N. Y.
(See also page —)

ELECTRONICS ENGINEER ($4000) Post-war opportunity with old established national manufacturing firm. Requires department head calibre scientist well experienced research and development electrically controlled mechanisms and radio apparatus. Rush credentials. P-625, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

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ENGINEER 20 years electronics, radio; inventor. 5 research papers published, several electronic devices originated. Seek long-time connection small or moderate-sized firm, West Coast (or abroad). Nature of undertaking, locale, etc., outweigh remuneration. PW-628, Electronics, 68 Post Street, San Francisco 4, Cal.

ENGINEER, Radio and Electronic, ten years wide experience desires position in charge of research and development with manufacturer who will be in post war work. Salary $8,000. L. J. F., 128 Colorado Ave., Buffalo, N. Y.

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ELECTRICAL ENGINEERING SALES

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330 W. 42nd St., New York 18, N. Y.

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P-621 Electronics,
520 North Michigan Ave., Chicago 11, Ill.

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A Large, well established manufacturer of communication and remote control equipment desires to get in touch with inventors and others who may have patentable inventions available for sale or license. Inventions should relate to wire communication, point to point radio, remote control, or the like, and mechanical or electronic devices used with these systems. Replies held in strictest confidence.

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Additional Position Vacant Advertising on pages 340, 353, 356 and 361

(*Continued from page 359*)

deeply buried in the woods that I can't see the soundly rooted oaks in Mr. Egert's article, and I should thoroughly appreciate seeing his ideas on other phases of industrial electronics.

CHESTER E. MILES,
(Camp Crowder, Mo.)

Inventor

WITH REGARD to the note about the electron microscope on page 282 in the January issue of ELECTRONICS, may I bring the following fact to your attention.

The electron microscope was invented in Germany early in 1931, but the inventor, to whom the fundamental American patents have been issued*, is now serving this country as a professor in Electrical Engineering at Harvard University. The inventor is Dr. Reinhold Rüdenberg, who has published a discussion of his earlier work on the electron microscope in *Journal of Applied Physics*, Vol. 14, No. 8, p. 434–436, August, 1943.

I am always enjoying the interesting articles which you publish in ELECTRONICS.

*See U. S. Patents No. 2,058,914 and No. 2,070,319, also *Naturwiss.* 20,522 (1932).

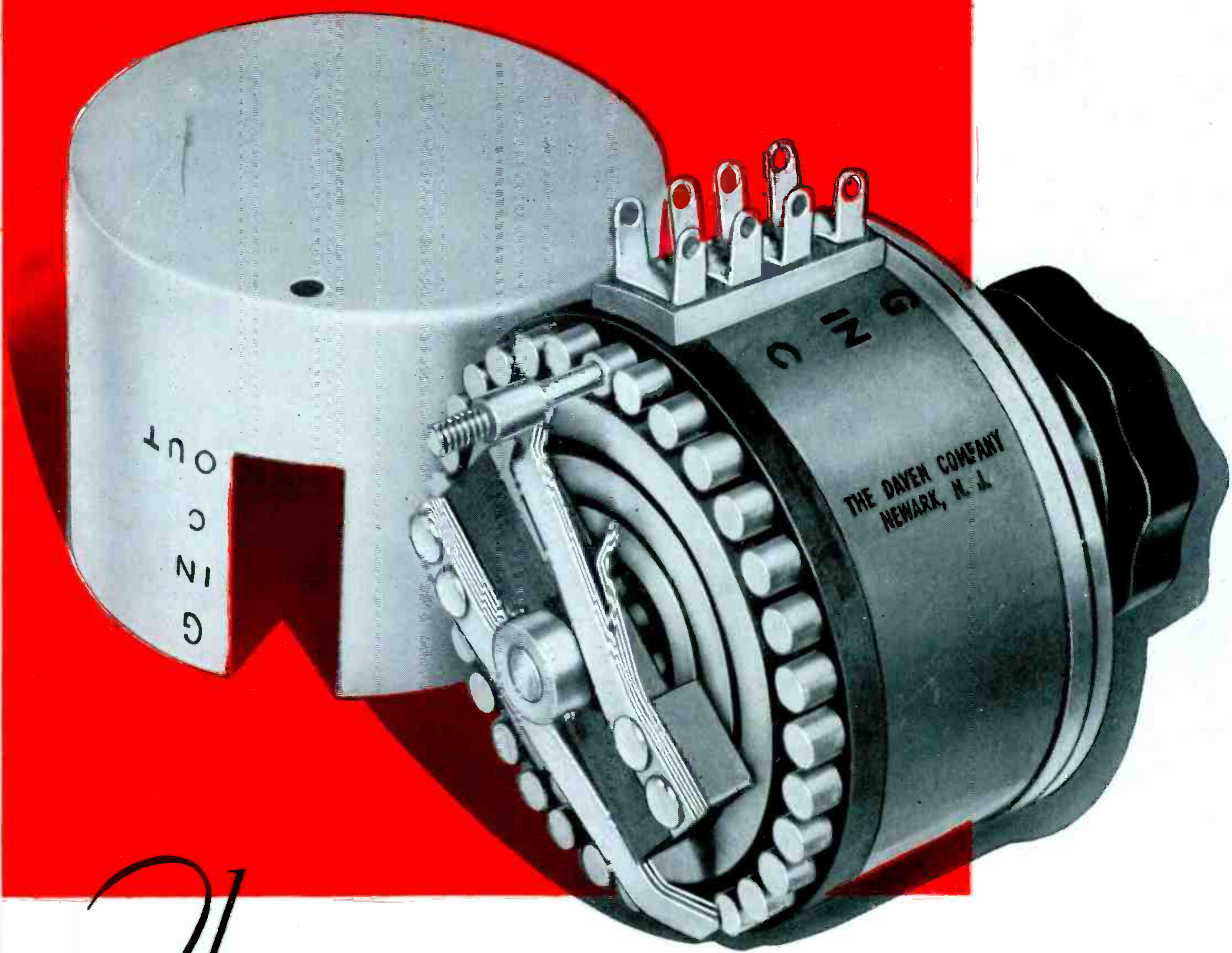
HARRY STOCKMAN,
Cruft Laboratory
Cambridge, Mass.

INGENIOUS METHODS of camouflage used by the Japs on Guadalcanal were described by Lt. Colonel Maurice P. Chadwick, Signal Corps, at a recent meeting of the Southern District of AIEE.

"We found quantities of Japanese signal and other equipment buried in graves and marked with grave markers. That which they did not have time to bury was very ingeniously camouflaged and could only be located by careful search. For instance, one high-powered air-ground radio transmitter with generator and Diesel engine was entirely overlooked by our infantry and was found later by a Division chaplain.

"A Jap power plant in operation near Henderson field was taken over and used. It is now called "The Tojo Light and Power Company."

Index to Advertisers



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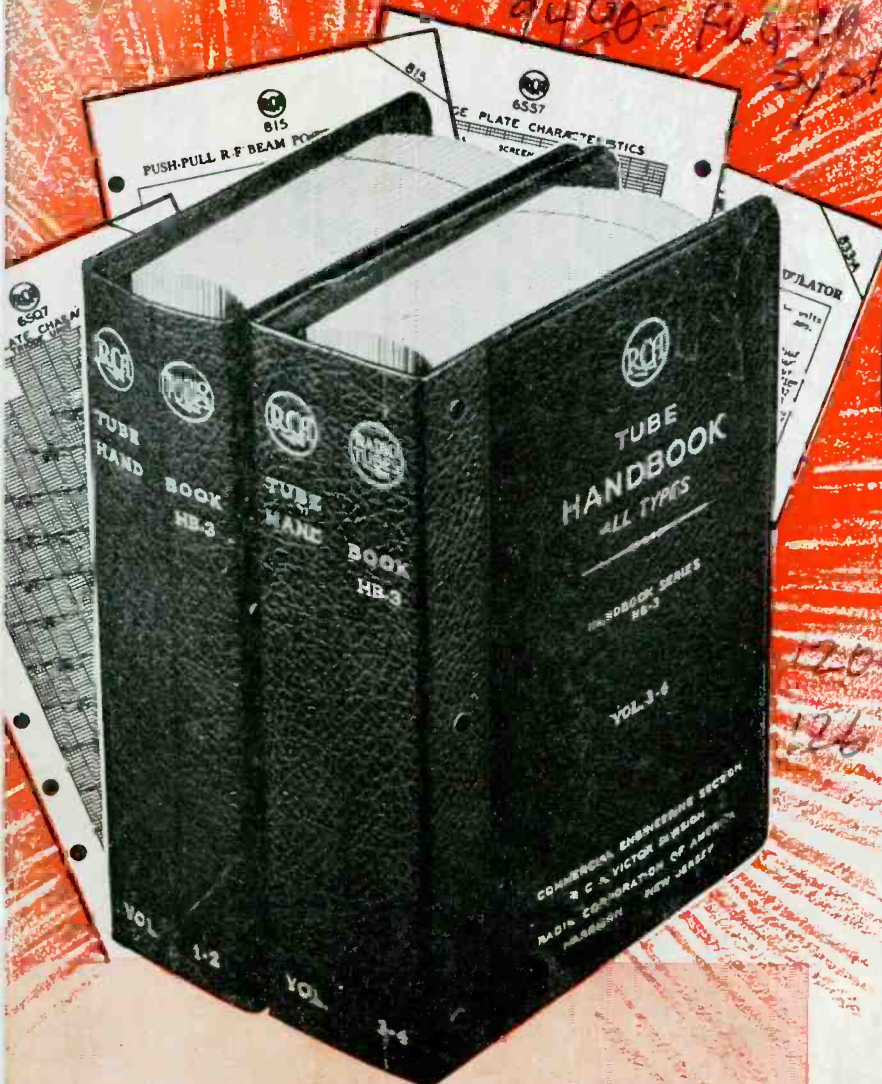

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