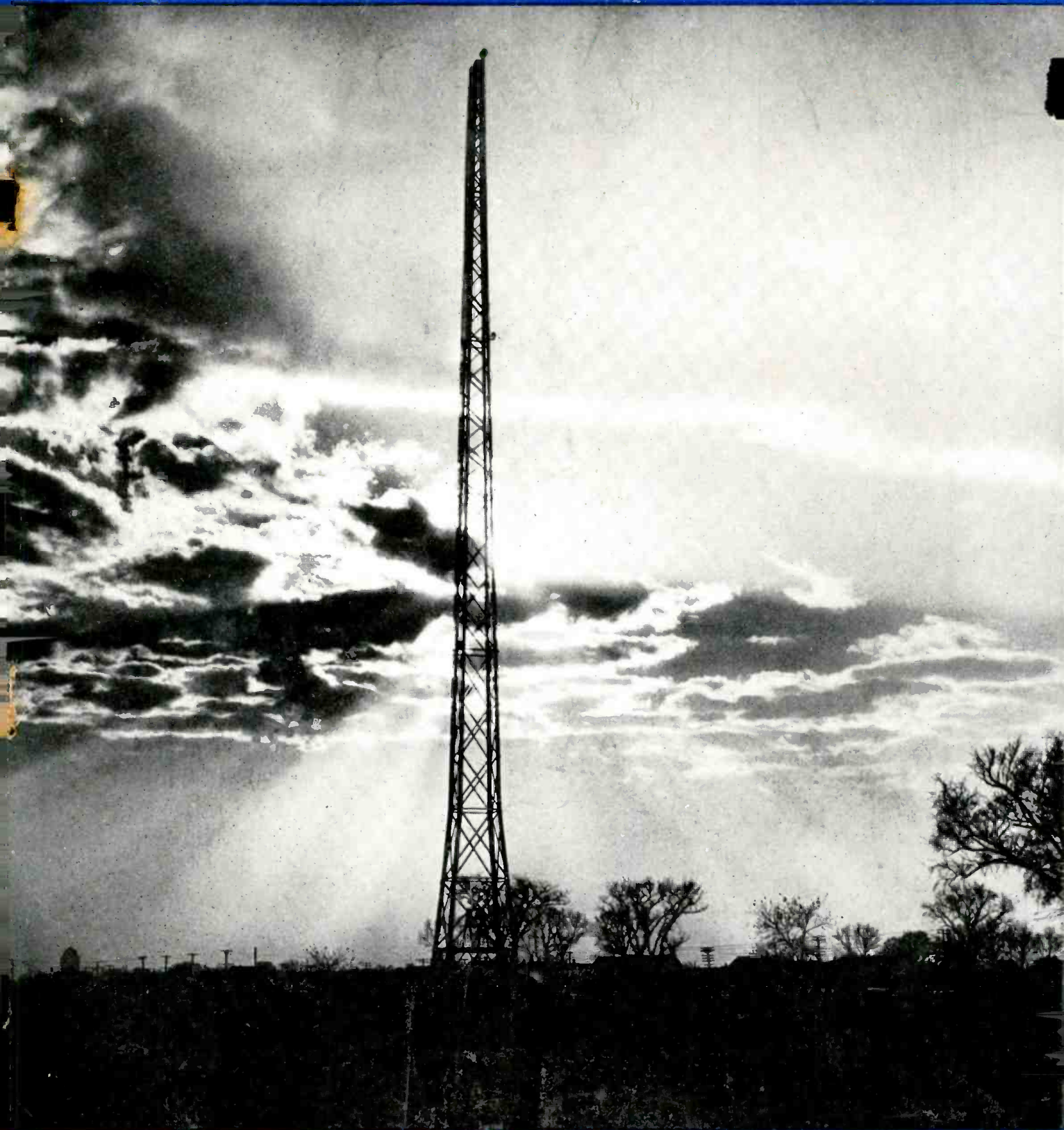
RADIO

Design • Production • Operation

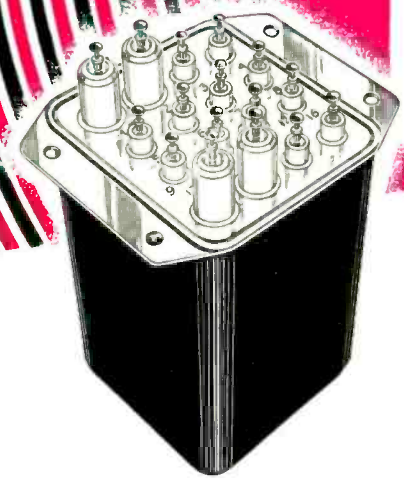
JULY, 1945

WITH FREQUENCY ALLOCATION CHART



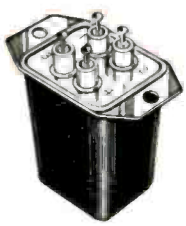
The Journal for Radio & Electronic Engineers

KYLE TRANSFORMERS



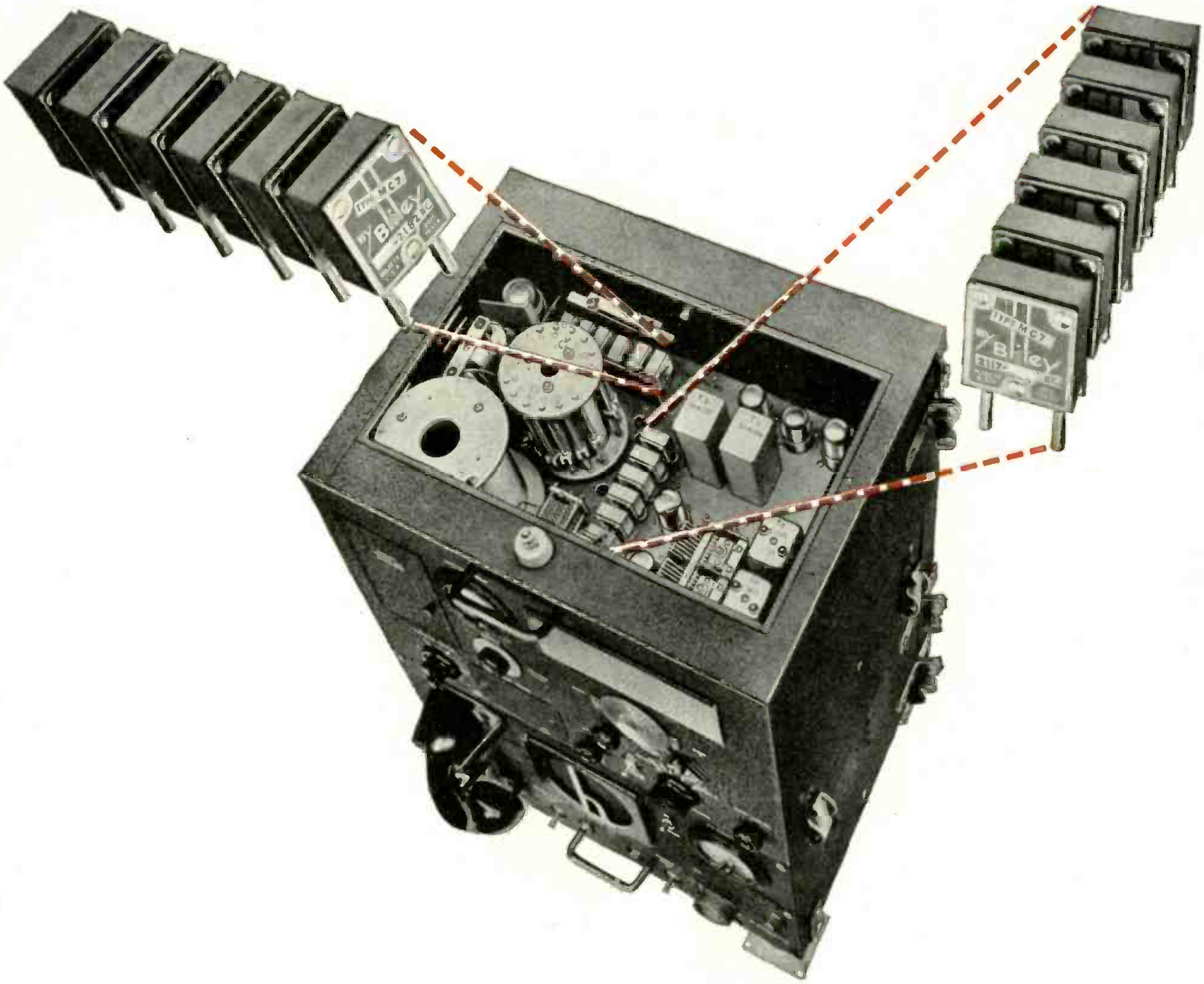
Engineered to take advantage of latest trends in radio design

New products, new ways of doing things will require transformers engineered to take advantage of the latest trends in electronic equipment design and manufacture . . . Kyle Transformers built to meet exact specifications. ¶ Kyle engineers have constantly met and solved ever changing problems involving application of transformers to the wartime fields of radio communication, radar detection and electronic controls. ¶ Kyle Transformers are hermetically sealed to function perfectly under conditions they are designed to meet . . . whether for use in cold, temperate, or tropical climates. ¶ This alert, young-thinking organization is at your service. It is backed up by long experience in the manufacture of electric power distribution equipment. Kyle engineering, manufacturing, and plant facilities are top notch. It will pay you to send your transformer specifications to Kyle.



KYLE CORPORATION

SOUTH MILWAUKEE, WISCONSIN



The 6 operating frequencies are BLILEY CRYSTAL-controlled

For dependable communications on the high seas here is a battle-tested set incorporating every modern feature that experience has shown to be most desirable for ship-to-shore and ship-to-ship radiotelephone service.

The six Bliley crystal-controlled operating frequencies permit instant and positive channel selection in both transmitter and receiver.

The Bliley *acid etched** Crystals used in this Hallicrafters HT-14 set were designed to meet specific objectives in the operation of two-way radiotelephone communications. They, too, have been battle-tested.

It's a habit with most communications engineers to specify Bliley for all crystal requirements. This is particularly true today when new applications and complex designs require technical excellence in every component. There is no substitute for the 15 years of experience offered by Bliley craftsmen and engineers.

✢ ✢ ✢

**Acid etching quartz crystals to frequency is a patented Bliley process.*

Bliley CRYSTALS

Do more than before . . .

buy **extra** War Bonds

BLILEY ELECTRIC COMPANY
UNION STATION BUILDING · ERIE, PENN.

RADIO

Published by RADIO MAGAZINES, INC.

John H. Potts .... Editor
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JULY 1945 — Vol. 29, No. 7

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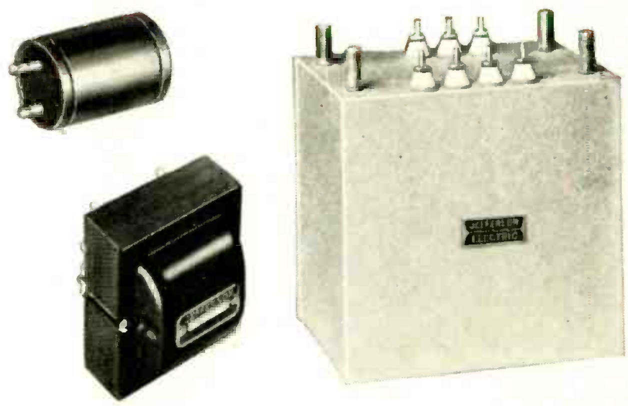
AIDING THE WAR TODAY . . . .

. . . . SERVING THE PEACE TOMORROW

Tomorrow, when the tools of strife are turned to the ways of peace, Jefferson Transformers will serve with the same fidelity. Improved manufacturing techniques established under the stress of war will be turned to producing still better transformers for your post war needs. Let Jefferson engineers examine your particular requirements now and make suggestions that will save you time later . . . JEFFERSON ELECTRIC COMPANY, Bellwood (Suburb of Chicago), Illinois. *In Canada:* Canadian Jefferson Electric Co. Ltd., 384 Pape Avenue, Toronto, Ont.



In all theatres of war, on the invasion beaches, wherever allied forces march against aggression, Jefferson Electric Transformers establish records of dependable performance. Today—on radio, radar, "walkie-talkies," television communications systems, electronic and control applications,—Jefferson Transformers aid our war effort with a long-life reliability based on engineering skill and Jefferson's basic principle of "quality—with quantity" production.

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Transients

PATENT LICENSING

The announcement that RCA has arranged to continue licensing Philips U. S. patents clears up a potential threat to prompt resumption of civilian radio communications apparatus manufacturing. Under the previously announced arrangement, it would have been necessary for most radio manufacturers to take out new licenses from the Philips organization, thus complicating the patent setup, as was pointed out in our editorial in the May issue.

It is stated that RCA has informed its licensees that it is extending to them rights under the Philips' patents at no extra charge.

A. T. & T. MOBILE RADIOTELEPHONE SERVICE

Expansion of the Bell Telephone System to include drivers of automobiles, trucks and other mobile units in a general mobile radiotelephone service is indicated, according to an announcement just issued by the American Telephone and Telegraph Company.

Applications have been filed with the Federal Communications Commission for authority to install radiotelephone stations in the following cities: Baltimore, Chicago, Cincinnati, Columbus, Denver, Houston, Milwaukee, New York, Philadelphia, Pittsburgh, St. Louis, Salt Lake City, and Washington, D. C. In addition, surveys are being undertaken to find out if this service is feasible and needed in many other cities.

The plan is to use transmitters of about 250 watts in metropolitan centers. The mobile units will have a power rating of about 15 watts. The assigned frequency range for urban mobile service is 152 to 162 mc.

Another type of mobile radiotelephone service which will be tried would furnish two-way voice communication to motor vehicles operating on intercity highways and to boats on adjacent waterways. This service would require transmitting and receiving stations along the highways to be served.

Inauguration of this service will tend to limit to some extent the field of application of the Citizens Radiocommunication Service, but there will still be plenty of potential customers for the latter type of service. And it promises to open a new field for radio engineers which will absorb a large number of trained personnel and thus benefit the industry as a whole.

FCC FREQUENCY ALLOCATIONS

Now that the Federal Communications Commission has completed its frequency allocations for FM and other services in the 44 to 108 mc range, those factors in the radio industry which opposed moving FM to higher frequencies seem disposed to accept the allocations with good grace. The complete FCC report on which the action was based is published in this issue, and it must be admitted that they present a good case. With this matter definitely settled, it would be well if the radio industry should concentrate on other problems, such as component and tube allocations, pricing, etc., which are the only remaining obstacles to reconversion among those manufacturers not operating at capacity on war orders.

THE RADIO INDUSTRY AND BRETTON WOODS

According to a recent report issued by the Business and Industry Committee for Bretton Woods, many of the Latin American countries are now ripe for the development of their radio markets. The Department of Commerce recently made a study of conditions in Argentina and reported very favorably on its potential consumption of radio equipment and components from the United States. The industrial development which will be undertaken by these countries and the reconstruction projects of Europe and Asia will also create important markets.

The International Fund and Bank will assist radio manufacturers to expand their markets. It will help foreign countries to buy electronics equipment and will stabilize foreign exchange, previously one of the greatest impediments to expansion of our foreign markets.

Many American manufacturers in the radio/electronic field already realize the potentialities of foreign markets and plan to produce for export even before models for domestic consumption are made available.

For radio engineers, it would be a good idea to develop greater familiarity with the technical requirements of apparatus designed for export. Often these are far more exacting than for domestic apparatus, particularly in regions where line voltages vary widely and in tropical climates. Experience in production of apparatus for war use will help greatly in reducing the cost of production of apparatus for export. —*J.H.P.*

SYLVANIA NEWS

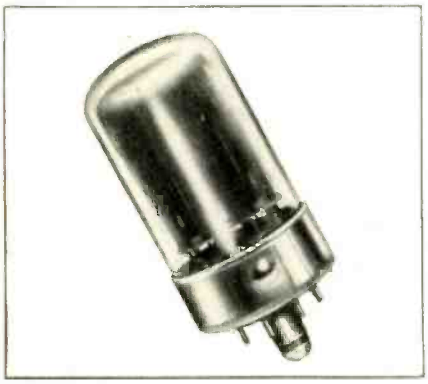
ELECTRONIC EQUIPMENT EDITION

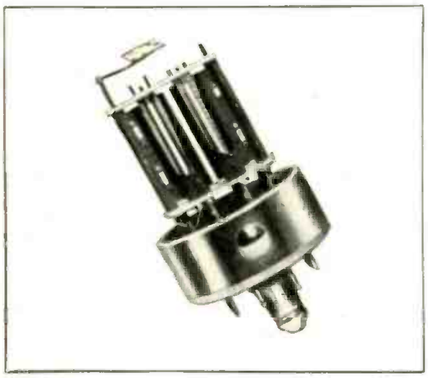
JULY *Published by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. 1945

NEW TUBE HAS SEPARATE CATHODES

Construction Permits Use As A Discriminator

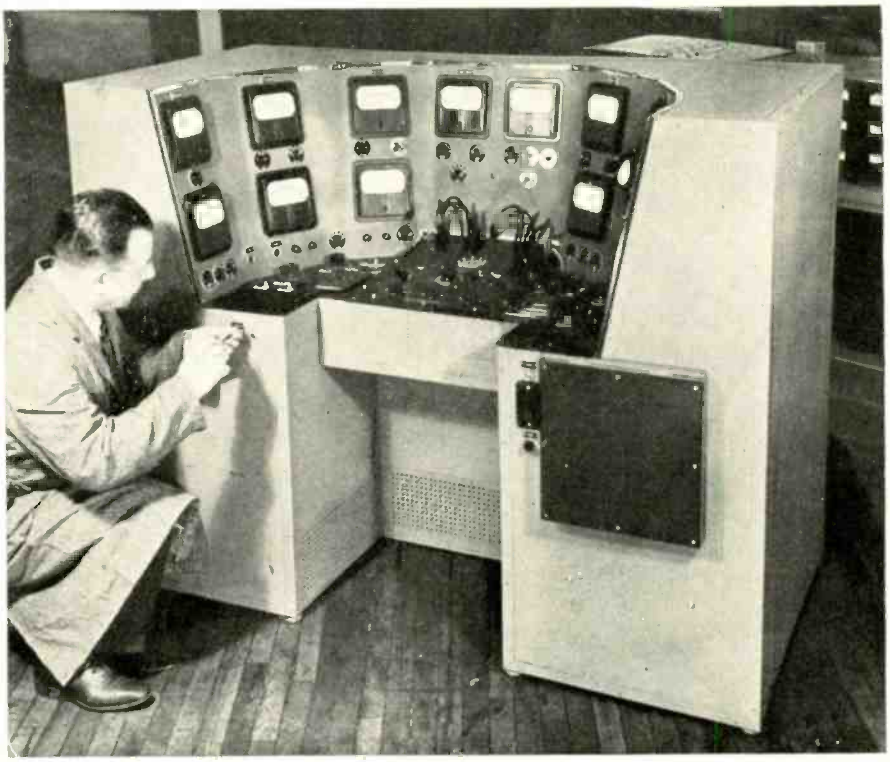
Sylvania Type 7K7 is a duo-diode high-mu triode differing from the usual diode-triode by having two separate cathodes, one for the triode and the other for the diodes.





This difference permits the tube to be used as a discriminator.

The cut-away view shows that although the construction looks like a duo-triode the second plate is really a shield around the two diodes.



SYLVANIA RADIO TUBE BRIDGE SET INSURES PERFECT PERFORMANCE

Measures Static And Dynamic Characteristics Of Vacuum Tubes

As ultra-high frequencies and a very wide range of intricate electronic applications make strict demands on tube performance and circuit designs, an accurate testing of tube and circuit characteristics becomes of the greatest importance.

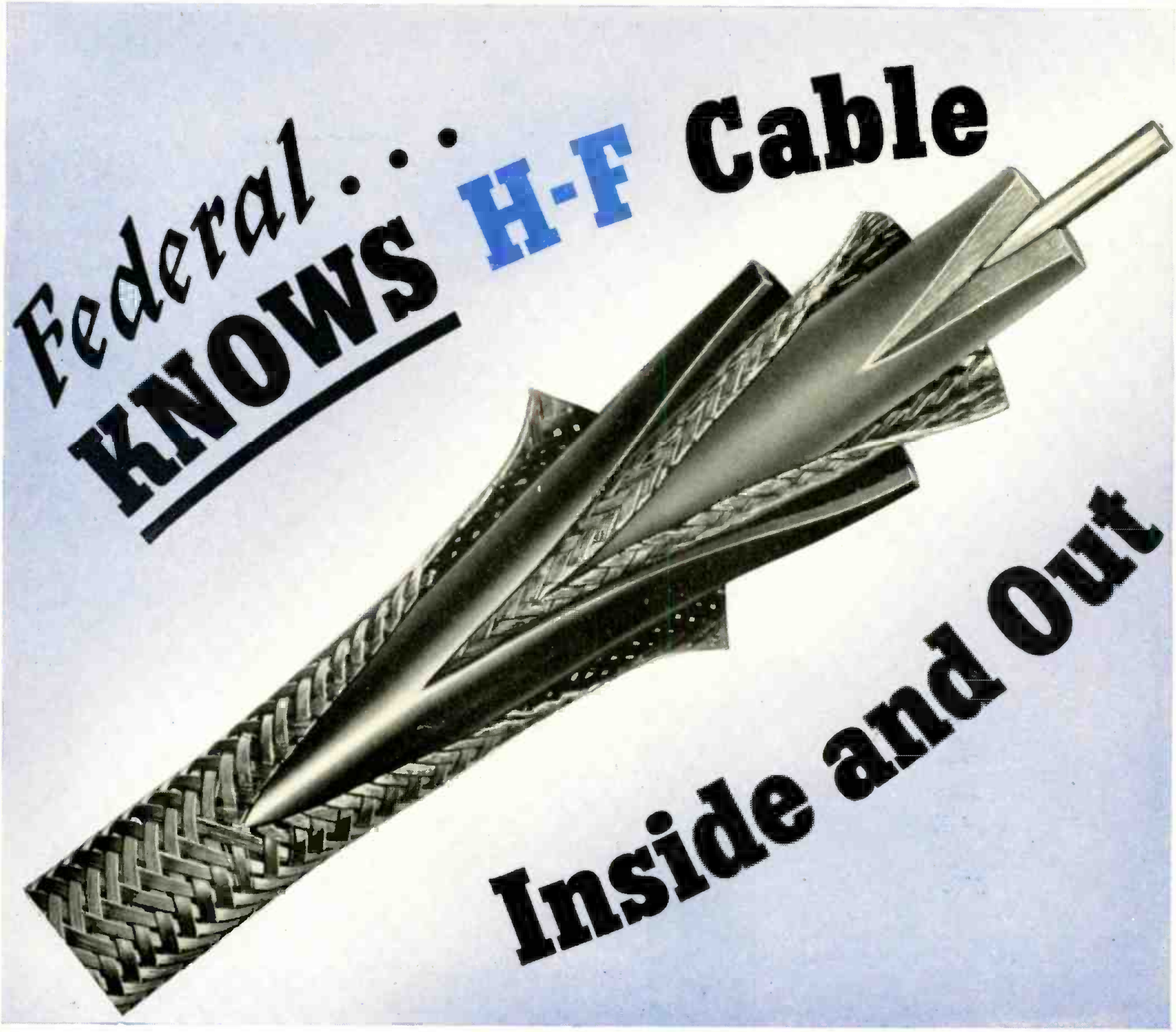
One of Sylvania Electric's latest essential radio vacuum tube bridge test sets for precision engineering data is pictured above. Manufactured at Sylvania's plant at Williamsport, Pa., this equipment measures static and dynamic qualities of radio tubes, such as plate current, filament voltage and current, screen current, gas current, plate resistance, power output, mutual conductance, and amplification factor, as well as the characteristics of electronic devices.

The set is compact, fully shielded, with well-filtered, self-contained power supplies, complete with voltage regulators except AC and DC filament voltages.

SYLVANIA ELECTRIC

Emporium, Pa.

MAKERS OF RADIO TUBES; CATHODE RAY TUBES; ELECTRONIC DEVICES; FLUORESCENT LAMPS, FIXTURES, ACCESSORIES; ELECTRIC LIGHT BULBS



From inner conductor to outer covering . . . Federal really knows high-frequency transmission lines.

And this knowledge was not easily won. As the pioneer in the field Federal not only developed over 80% of all h-f cable types in use today . . . but developed most of the equipment needed to test them.

Attenuation, high-voltage, dielectric and balance testing equipment, velocity of propagation, braid-resistance and electrical length meters . . . were all Federal-*engineered* to fit specific requirements.

That's why it's logical to turn to the acknowledged leader in the field for the finest in h-f cables, specialty-engineered harnesses and cable assemblies.

Where requirements are critical . . . for transmission lines with special characteristics . . . for custom-built and engineered harnesses and cable assemblies . . . take your high-frequency transmission problems to Federal.

FEDERAL TELEPHONE & RADIO FTR

Federal Telephone and Radio Corporation

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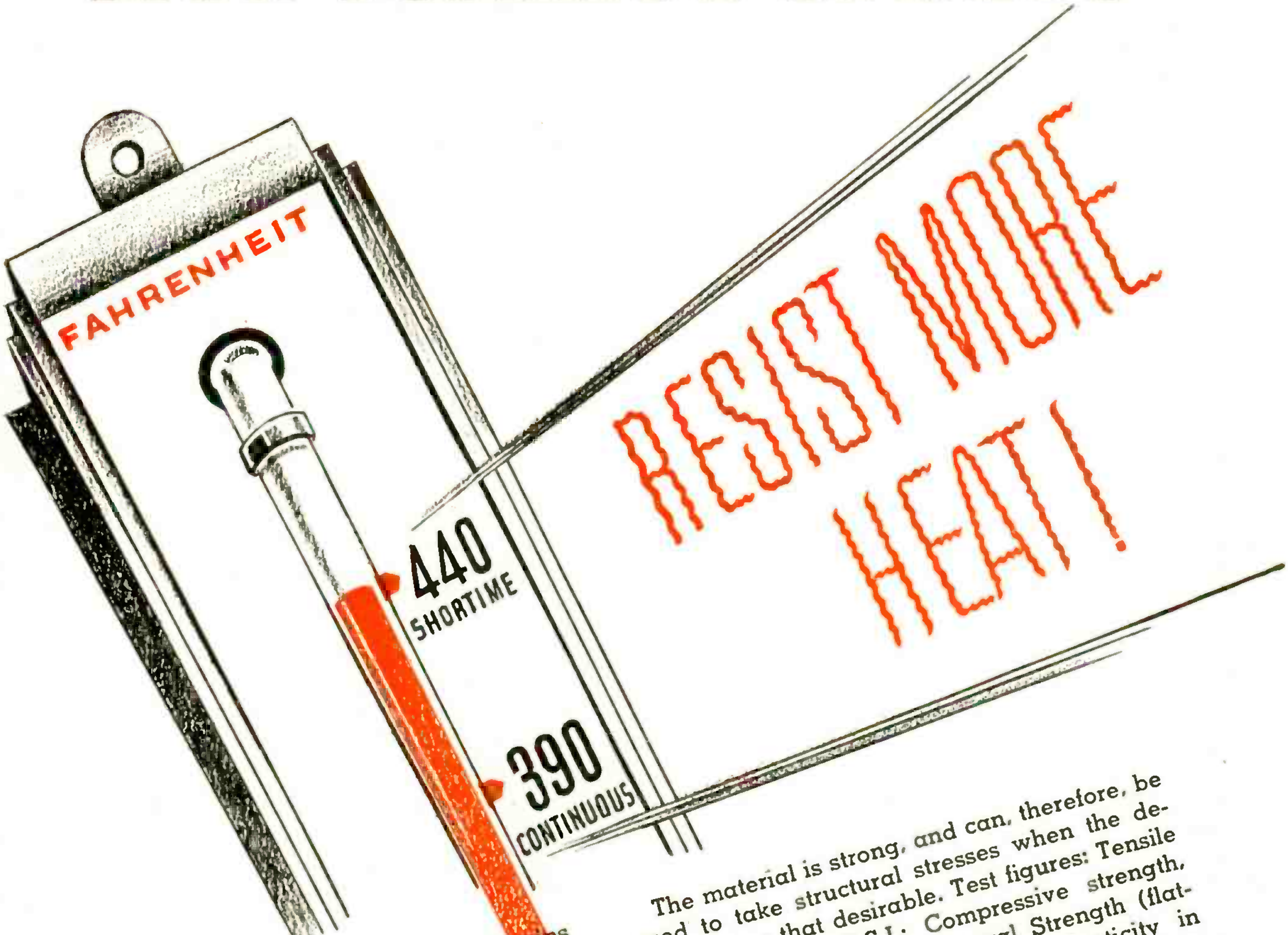
Newark 1, N. J.

New Formica Grades



PROGRESS has recently provided new resins and new fibre bases that have greatly increased the heat resistance of insulating grades of Formica. They will take without injury about 25 percent higher temperatures.

An example of this improvement is FF-55, produced to conform to Navy Grade GMG, made with a glass fibre base and melamine resins. It withstands 440 degrees Fahrenheit for a short period, and 390 degrees continuously.

In this same material Arc resistance reaches a new level — by ASTM test D495-42, it is rated at 185 seconds.

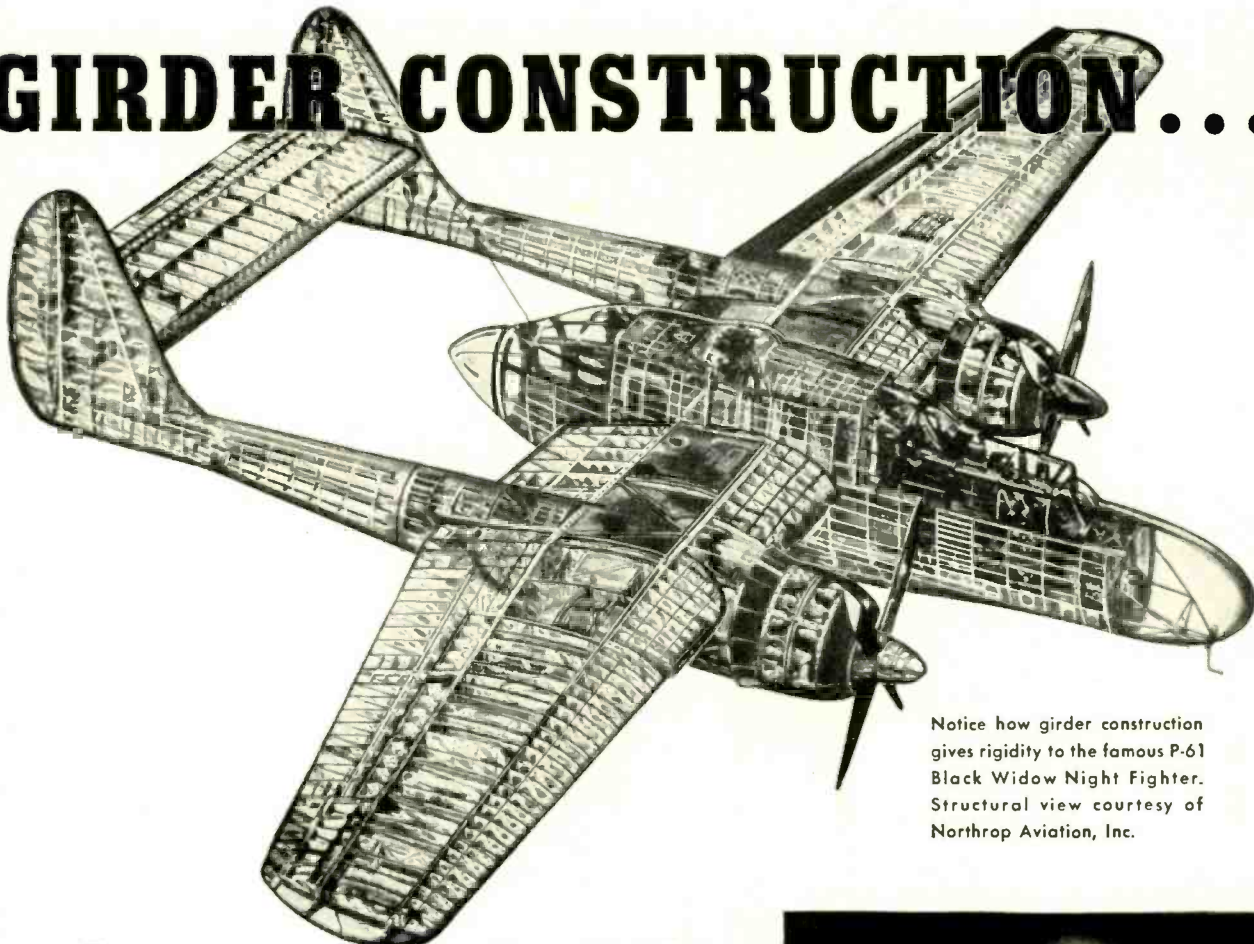
The material is strong, and can, therefore, be used to take structural stresses when the design makes that desirable. Test figures: Tensile strength 25,000 P.S.I.; Compressive strength (flatwise) 90,000 p.s.i.; Flexural Strength (flatwise) 30,000 p.s.i.; Modulus of Elasticity in bending 3,000,000 p.s.i.; Izod impact, 12 ft. lbs. per inch of notch.

This is a new combination of useful qualities, not previously available in one material. Unlike some materials which possess some of these characteristics, the material can be easily punched and machined. It is suitable for rapid fabrication by production methods.

THE FORMICA INSULATION COMPANY, 4670 SPRING GROVE AVENUE, CINTI. 32, O.

FORMICA

GIRDER CONSTRUCTION...



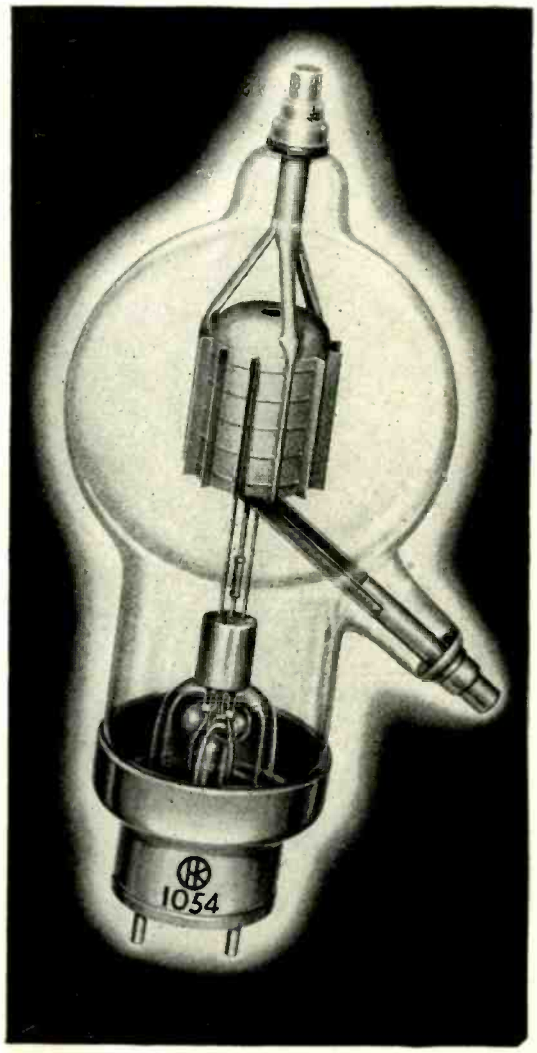
Notice how girder construction gives rigidity to the famous P-61 Black Widow Night Fighter. Structural view courtesy of Northrop Aviation, Inc.

gives greater strength to *Gammatron Tubes*

The same type of construction which gives strength and rigidity to a modern airplane, skyscraper, or bridge has been successfully incorporated into the design of the HK-854 and HK-1054 triodes. Compare the girder construction of the P-61 with the plate and grid supports of the HK-1054—the structural principles are identical! Note particularly how the heavy tripod plate support is welded to large diameter tubing, which in turn is firmly secured to the copper plate cup.

Because of their girder construction, HK-854 and HK-1054 Gammatrons stand up exceptionally well even when subjected to the vibration and stresses which usually accompany their use in such industrial applications as dielectric heating.

This superior internal strength is important since it prevents internal shorts, and variations in the characteristics of the tubes due to movement of the elements.



NEW LOW PRICES NOW IN EFFECT

TUBE TYPE		NEW LIST PRICE
HK 854-H	(High amplification factor) . .	Now only **$60.00**
HK 854-L	(Low amplification factor) . .	Now only **60.00**
HK 1054-L	(Low amplification factor) . .	Now only **135.00**

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10 POINTS OF *Superiority*

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7. GRADE L4 STEATITE LOW LOSS INSULATION CORRECTLY PLACED FOR LONG LEAKAGE PATH AND SMALL DIELECTRIC LOSS

10. THICK, ROUNDED EDGE, ALUMINUM PLATES FOR MECHANICAL STABILITY AND INCREASED VOLTAGE BREAKDOWN.

8. LOW RESISTANCE ROTOR CONTACTS OF LONG LIFE, PHOSPHOR BRONZE, SPRING MATERIAL

1. REMOVABLE BRACKETS FOR MOUNTING COILS ON TOP OR MOUNTING CONDENSER INVERTED

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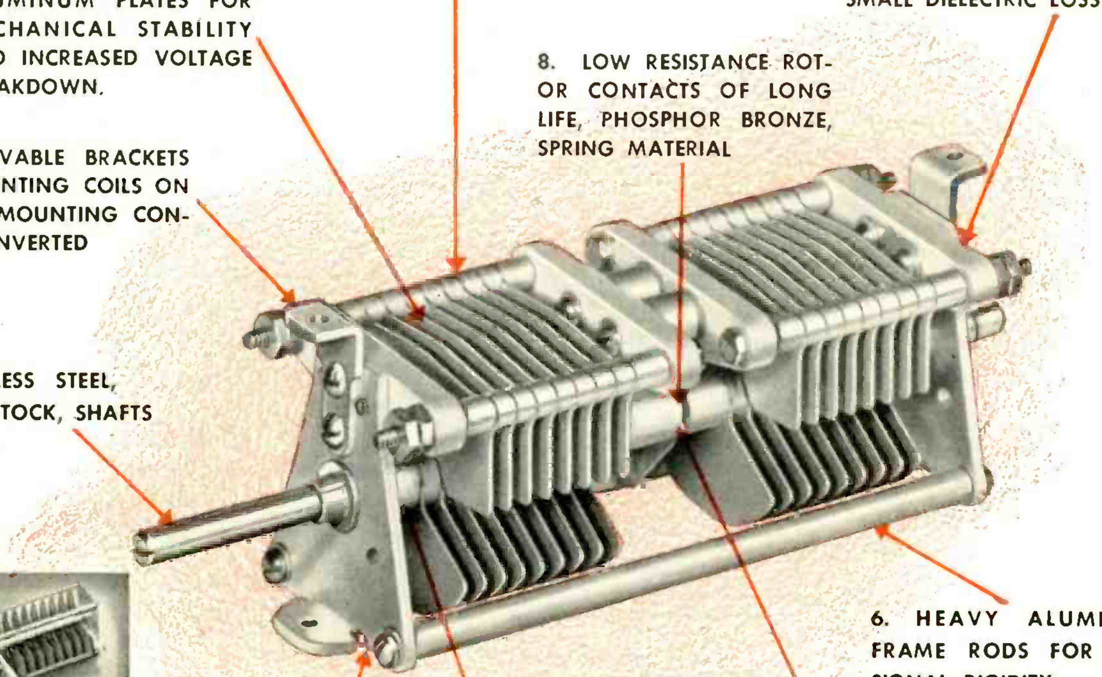


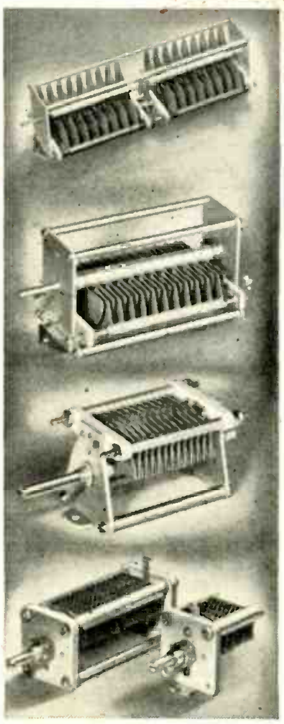
6. HEAVY ALUMINUM FRAME RODS FOR TORSIONAL RIGIDITY.

CATALOG NO. 100FD20

3. HEAVY END PLATES FOR STRENGTH

5. CENTER CONTACT BETWEEN SECTIONS FOR SHORT R. F. LEADS

4. PERFECTLY ALIGNED ROTOR SHAFTS FOR CALIBRATION ACCURACY

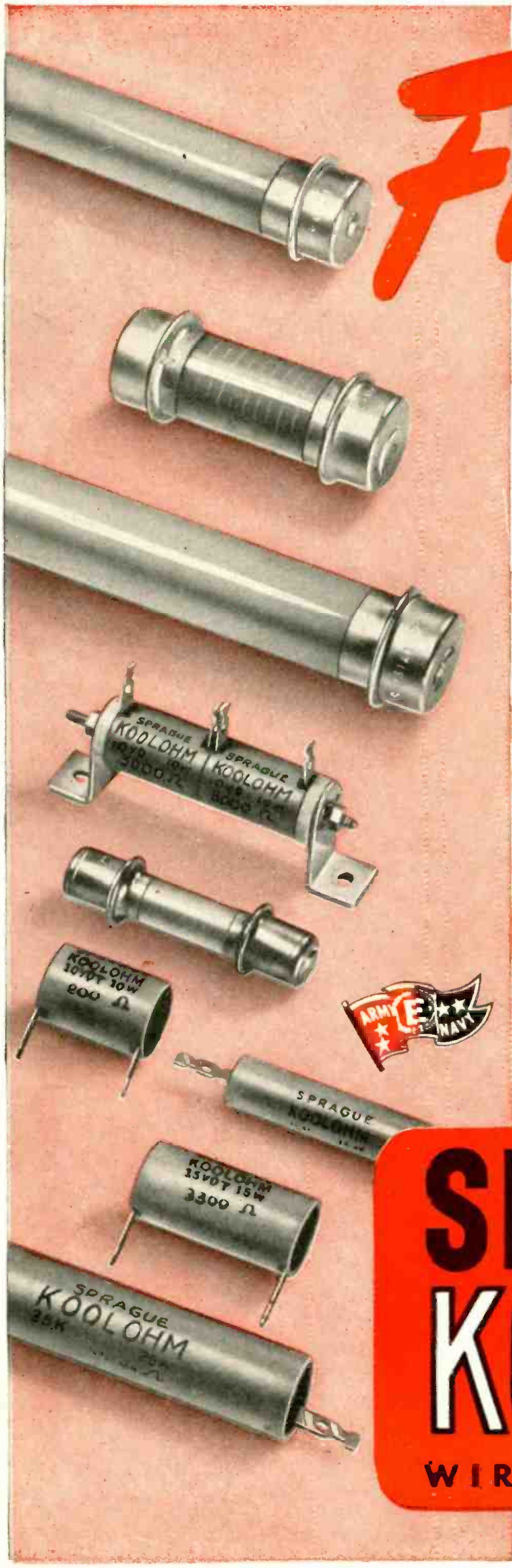


C -	Plate spacing	.125" - .500"
	Maximum frame dimensions	5½" x 5-13 32"
D -	Plate spacing	.080" - 250"
	Maximum frame dimensions	4½" x 4"
E -	Plate spacing	.045" - .125"
	Maximum frame dimensions	2⅝" x 2-19 32"
H -	Plate spacing	.030" & .080"
	Maximum frame dimensions	1½" & 1-9 16"

Type "F" single and dual condensers are stocked with plate spacings of .045 to .075" in 19 different models. Maximum capacity range is from 34 mmf. to 255 mmf. and the ratios of maximum to minimum run from 7:1 to 15:1. Maximum frame dimensions 2-1 16" by 2".

JOHNSON
a famous name in Radio

E. F. JOHNSON COMPANY • WASECA • MINNESOTA



First with GRADE 1, CLASS 1 RESISTORS

(First produced Dec. 1941—Millions made to date)

First **with RESISTORS WOUND with CERAMIC INSULATED WIRE**
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First **with GLASS-TO-METAL SEALED RESISTORS** (Pioneered by Sprague in 1941, now produced commercially at the rate of thousands of seals per day)

First **with GLAZED CERAMIC SHELLS and New Style End Seals for 5-, 10-, 25-, 50- and 120-watt resistors.** (One type of Koolohm—the *standard* type—does the job under any climatic condition, anywhere in the world)

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One after another, Sprague Koolohm Resistors have established new performance records as proved indisputably by the record. One after another Koolohm Resistors have revolutionized traditional limitations to wire wound resistor usage—because radically different Koolohm construction permits a higher degree of physical protection, better electrical characteristics, smaller sizes, and easier mounting arrangements than are possible with conventional resistor types. Write for catalog.

SPRAGUE KOOLOHM

(Trademark Reg. U. S. Patent Office)

WIRE WOUND RESISTORS

SPRAGUE ELECTRIC COMPANY
(Resistor Division) North Adams, Mass.

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GIVE *Exceptional Service!*

The high quality of RADIART VIBRATORS is well known to servicemen everywhere. That high quality has characterized all Radiart Products that have been and are being used by the Armed Forces on all fronts. As production for civilian users expands it will continue to increase the demand for RADIART VIBRATORS.

LIMITED SUPPLY UNTIL V-J DAY

While production for civilian users may increase gradually, by far the greater part of our production will continue to be required for U.S. Armed Forces. We must and will meet all of their schedules on time.

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By eliminating many little used types of vibrators Radiart has been able to increase production of all popular types. *Now the dozen or so types of RADIART VIBRATORS necessary for over 7/8ths of all replacements are more readily obtainable.*

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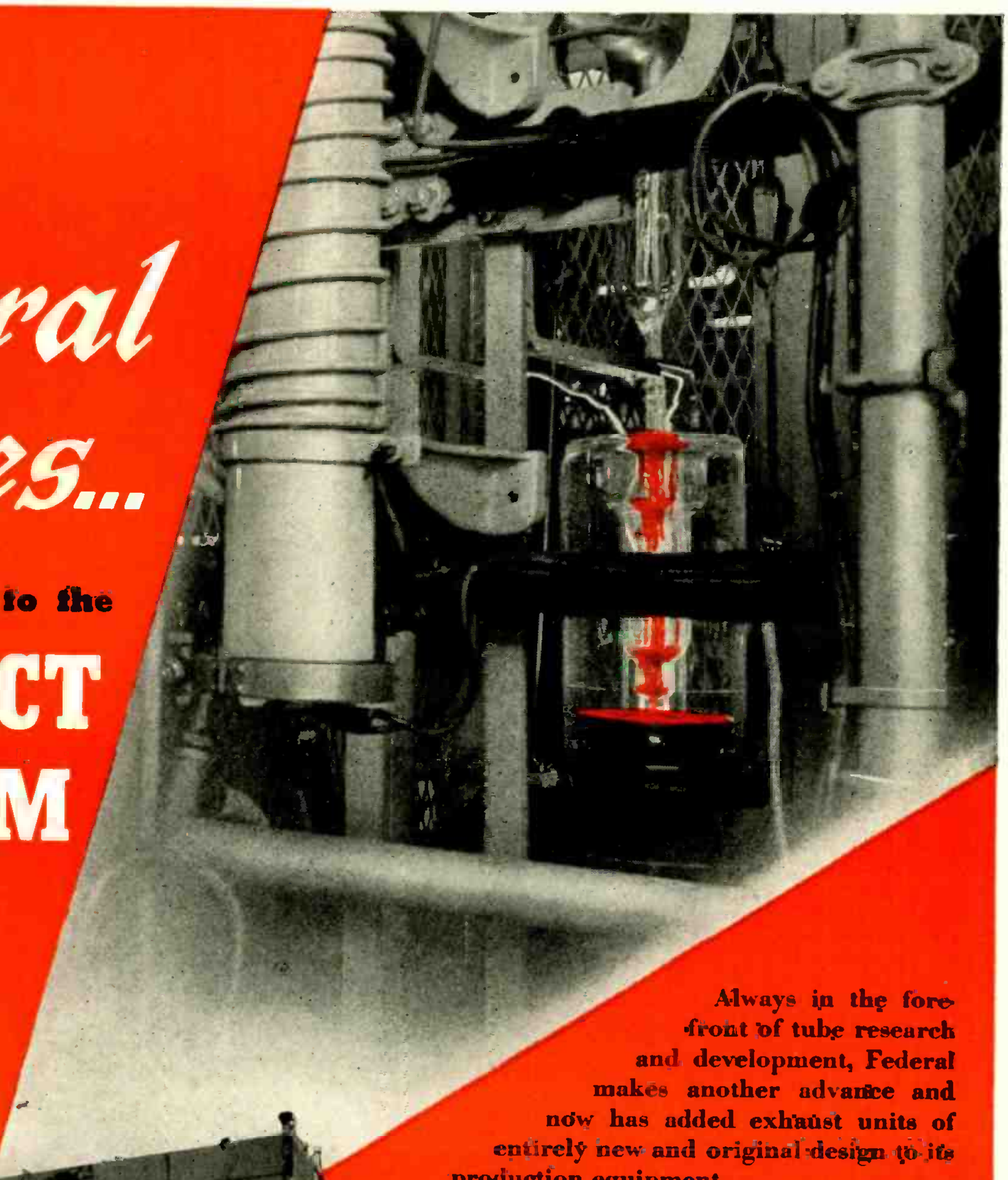
EXPORT DIVISION: 25 Warren Street • New York 7, N.Y.

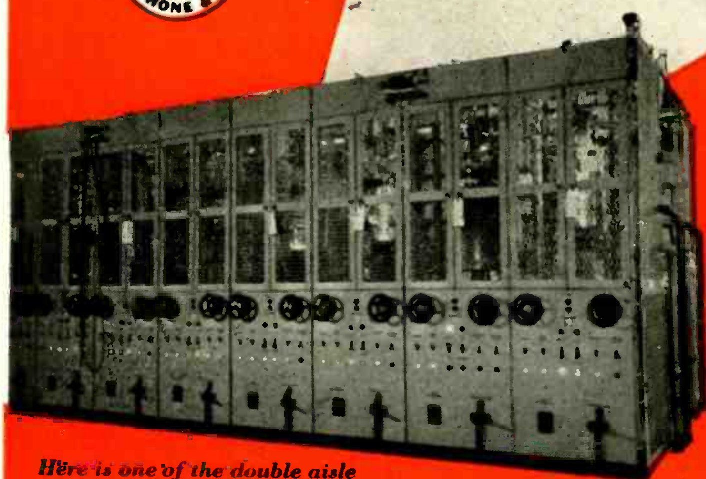
Federal Tubes...

come CLOSER to the

PERFECT VACUUM



FEDERAL FTR TELEPHONE & RADIO



Here is one of the double aisle exhaust banks where 16 high power tubes can be exhausted at one time, each with individual control.

Always in the forefront of tube research and development, Federal makes another advance and now has added exhaust units of entirely new and original design to its production equipment.

This latest Federal achievement produces a tube that is substantially closer to the perfect vacuum—a tube with greater efficiency and longer life.

Arranged in banks of eight and operated with identical control equipment, these units exhaust uniformly every size of Federal tube—assuring a consistent and high standard of quality.

For any communication and industrial power tube need, turn to Federal now—test its reputation that "Federal always has made better tubes."

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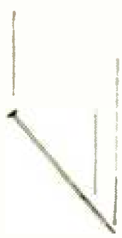
QUIET



In one expressive word you have the reason why so many phonographs will be powered by a BALLENTINE motor drive.

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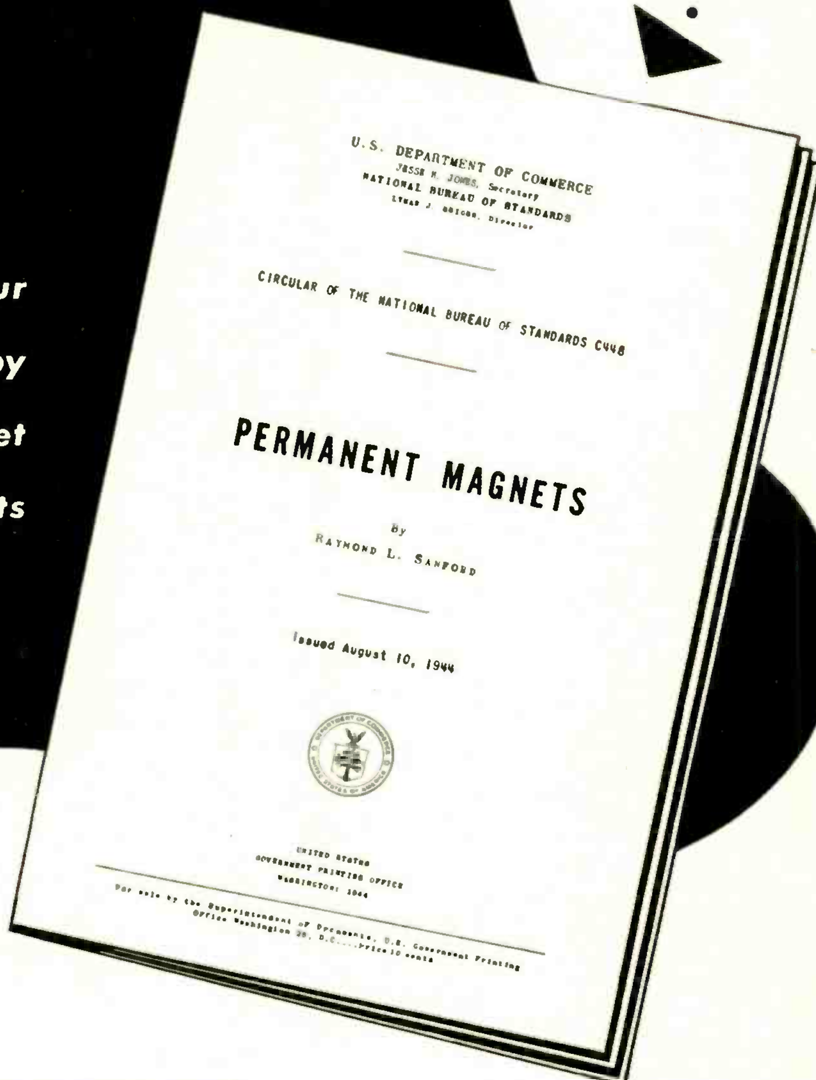
Just write us, on your letterhead, for your copy of this valuable booklet on permanent magnets


U.S. DEPARTMENT OF COMMERCE
JESSE H. JONES, Secretary
NATIONAL BUREAU OF STANDARDS
LYMAN J. BRIGGS, Director

CIRCULAR OF THE NATIONAL BUREAU OF STANDARDS C448

PERMANENT MAGNETS

By
RAYMOND L. SANFORD

Issued August 10, 1944

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON: 1944

For sale by the Superintendent of Documents, U.S. Government Printing Office Washington 25, D.C. ... Price 10 cents

● As a service to industry, The Arnold Engineering Company is "lending a hand" in the distribution of what Arnold engineers believe to be a very informative study on the subject of permanent magnets.

This 39-page book of permanent magnet theory, design data and references was published by the government. Arnold is pleased to make it available to you free of charge and without obligation. Write for it today!

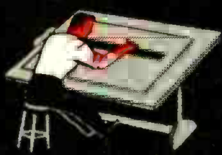
THE ARNOLD ENGINEERING COMPANY

147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS

Specialists in the Manufacture of ALNICO PERMANENT MAGNETS

An Original GUARDIAN *Development*

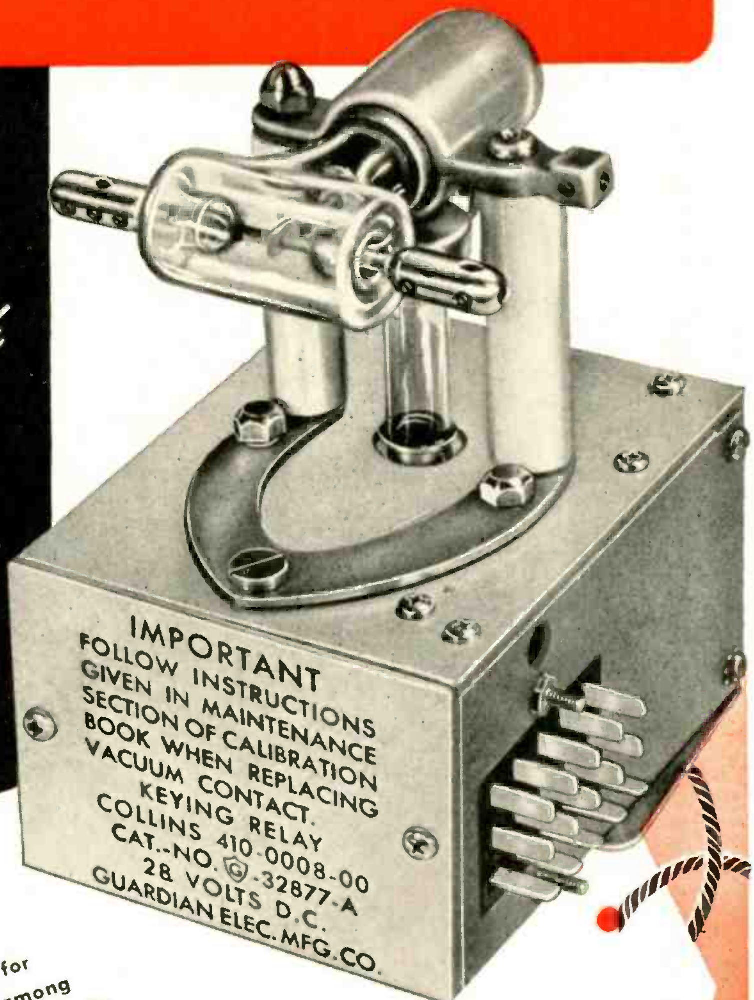
designed for and in conjunction with the Collins Radio Company



The New Vacuum Switch

KEYING RELAY

for High Frequency—High Voltage—High Altitude Applications



The confidential development of this vacuum switch keying relay involved design ingenuity and ability to produce immediate results. It called for cooperation and a meeting of minds among Guardian engineers and those of Collins Radio Co., the U. S. Navy, Sperti, and General Electric. Then quantity production and the responsibility of being the sole source of supply for many months followed successful development of the relay. The same confidential treatment, the same engineering ability on electrical control, the same production capacity is yours for the asking. Write.

GUARDIAN ELECTRIC
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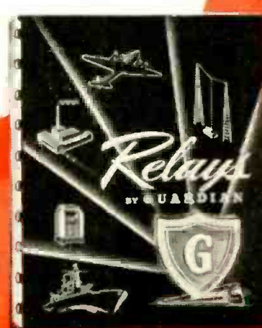

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SPECTRUM ANALYSIS

★ The radio spectroscope as a device for viewing on a single screen the composition of radio energy being received by an antenna is discussed in the May 1945 issue of *Wireless World*. The article is entitled "Radio Spectroscopy" and was written by Thomas Roddam.

Mr. Roddam presents the principles of radio spectrum analysis and does not discuss any specific circuit diagrams.

The simplest form of radio spectroscope consists of a radio receiver with a motor-driven tuning capacitor. A variable resistor ganged to the common shaft delivers the horizontal sweep voltage to a cathode ray oscilloscope. The vertical deflection is obtained from the detector stage output of the receiver.

The spectrogram appears in *Fig. 1*.

An improved arrangement employs a motor-driven variable capacitor with

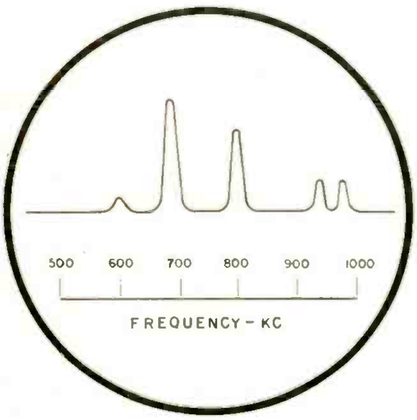

Figure 1

contacts on the shaft to provide synchronization with the cathode-ray sweep. The author describes the use of a magnetic strip rotating with the shaft, which passes near the gap of a magnetic pick-up and develops a triggering impulse for locking the sweep into the motor speed.

If the motor is truly synchronous the time base can be locked to the power line.

The author points out that the variable capacitor must be dynamically balanced and designed for 360° rotational coverage of the frequency band to be monitored.

For a truly electronic spectroscope a visual alignment test oscillator is employed in place of the rotating capacitor. The test oscillator has saw-tooth frequency modulation over a suitable range at a low audio rate.

The horizontal sweep of the cathode ray oscilloscope is synchronized at this

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[*Continued from page 25*]

same rate. The output of the detector stage of the receiver when the frequency-modulated test oscillations are applied to the mixer, forms the vertical deflection.

A block diagram is shown in *Fig. 2*.

The wide band amplifier delivers the r-f signal being monitored to the signal grid of the mixer tube #1. The lower chain of *Fig. 4* delivers the f-m voltage to the oscillator grid of the mixer tube #1. The swinging oscillator is driven over the range of say 10 ± 0.25 mc by the saw-tooth generator. The second oscillator, and mixer #2, are provided so that the range of the spectrum analyzer can be extended. Then a frequency (f_2 ± 10) ± 0.25 mc will be supplied to mixer #1.

The saw-tooth sweep rate is of importance and this rate should not exceed $M^2/3N$, where M is the band width of the i-f amplifier and N is the band width under investigation. For N = 500 kc and M = 10 kc, this a sweep rate of 67 cycles per second. The above formula is based on experience with television amplifiers which indicates that a signal lasting t seconds requires a band width of $3/t$ cycles for a reasonable amount of distortion.

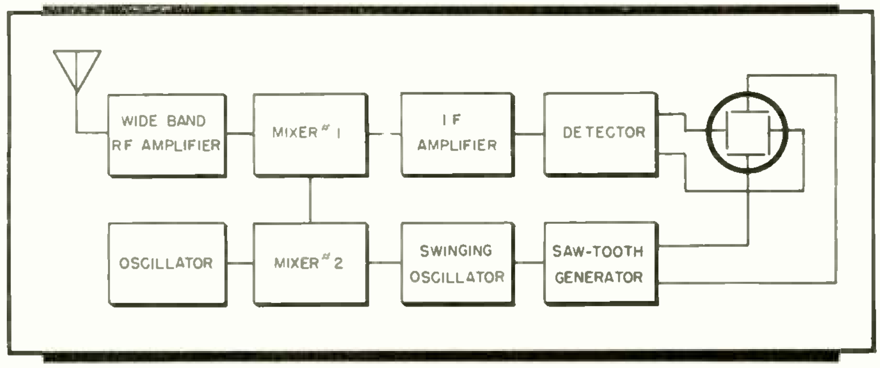


Figure 2

INK RECORDER AMPLIFIER

★ A new circuit for a power amplifier designed to operate an ink recorder consumes only 22½ watts of power with a 320 volt power supply. The static power consumption is 6½ watts and the equipment permits the use of a 3000 ohm per coil requiring only 0.3 watt. The amplifier frequency is 18%.

This amplifier is described by Mr. Donald Robinson, of Telephone Rentals, Ltd. The article, entitled "The Design of Power Amplifiers for Operating Ink Recorders" appears in the May 1945 issue of *Electronic Engineering*.

The pen recorder is suitable for medical work involving measurement of

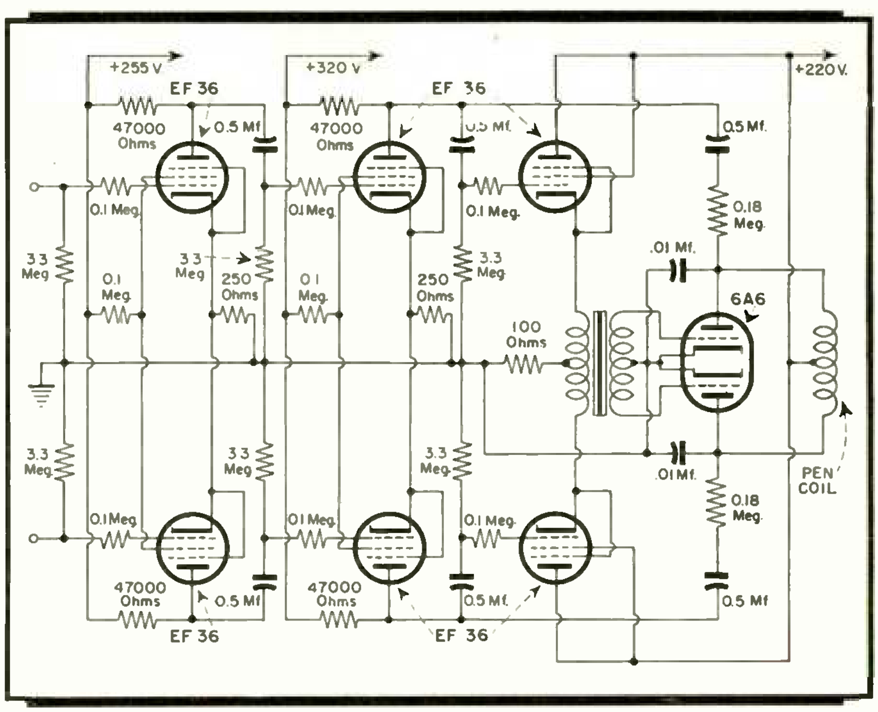
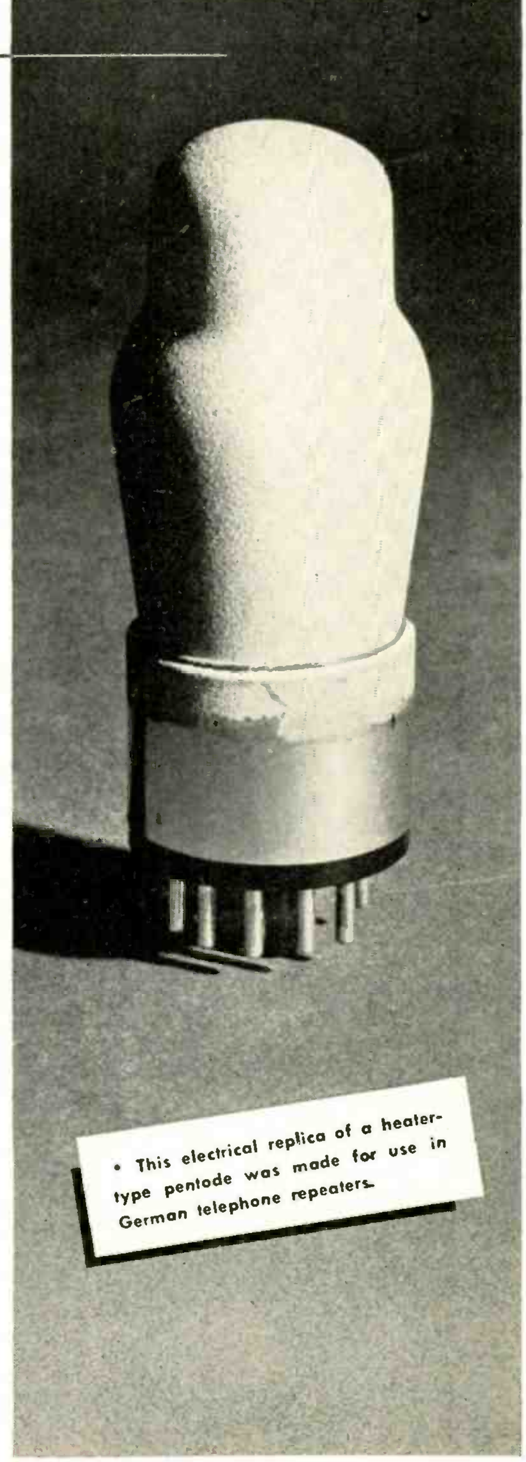


Figure 3

DUPLICATING A GERMAN VACUUM TUBE IN 3 DAYS



• This electrical replica of a heater-type pentode was made for use in German telephone repeaters.

Just behind the battlefront, a telephone system lay dead. The retreating enemy, hoping to return, had not blown it up, but had taken with them its vacuum tubes. To put it back to work, the General ordered 1000 new tubes – spot delivery.

A sample tube was flown back to the United States and brought to Bell Telephone Laboratories. It was of German design, different from any American tube in both dimensions and characteristics. Could it be duplicated soon? The job looked feasible. Within three days, try-out models were on their way to Europe. Three weeks later, Western Electric Company had made and delivered every tube. They were plugged in; vital communications sprang to life.

Vacuum tubes are an old story for Bell Laboratories scientists. Back in 1912 they made the first effective high vacuum tube. Three years later, they demonstrated the practical possibilities of tubes by making the first radio talk across the Atlantic, pointing the way to radio broadcasting. Since then, they have developed and utilized the vacuum tube wherever it promises better telephone communication – there are more than a million in your Bell Telephone System.

Today, Bell Telephone Laboratories is solving many of the toughest tube problems faced by the Armed Forces. When the war is over, it goes back to its regular job—keeping American telephone service the best in the world.

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Having no grid element, this gauge is completely free from Barkhausen oscillations. Construction is simple, rugged, dependable—and, of course, economical to manufacture.

Here again is an example of the many contributions National Union engineers are making to the advance of electronics. For progress through research—count on National Union. *National Union Radio Corporation,* Newark 2, New Jersey.

N. U. IONIZATION GAUGE

Typical Operation

- Filament voltage—3.0 volts
- Filament current—1.8 A.
- Electron collector voltage—13 volts
- Electron current—20 Ma.
- Ion collector voltage—200 volts
- Sensitivity—Ten times the ion current in amperes equals the pressure in mms. of mercury.

It is possible to expose the hot filament of this gauge to air at atmospheric pressure and later have it function efficiently under vacuum conditions.

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Transmitting, Cathode Ray, Receiving, Special Purpose Tubes • Condensers • Volume Controls • Photo Electric Cells • Panel Lamps • Flashlight Bulbs

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[Continued from page 26]

heart and nervous system activity and can also be used with some systems of submarine telegraphy. It is suitable for use in a portable system.

The amplifier is claimed to have linear frequency response from ½ cycle to 6 kc and the response is only 3 db down at 10 kc.

The author first describes two types of amplifiers in current use, both of which consume a greater amount of power at less efficiency and higher voltages.

Class B operation, using a 6A6 dual triode for the output stage, permits low standing anode current. Inverse feedback of voltage is employed to reduce the source impedance and improve the damping factor of the pen, and reduce harmonic distortion to less than 5%.

The complete circuit is shown in *Fig. 3.*

The inverse feedback consists of feeding part of the output voltage back to the grids of the EF36 driver tubes through the 180,000 ohm resistors and the 0.5 μf capacitors. The percentage of feedback is determined by the relative values of the feedback resistors and the 47,000 ohm pre-drivers tube load resistors. The ratio is approximately 4:1, so that there is about 20% voltage feedback. There is no phase shift in the drivers stage so that feedback voltages are in the correct phase.

The introduction of feedback, however, increases the input voltage required by the driver stage from 83 volts to 122 volts (grid-to-grid, r.m.s.).

The driver stage is a transformer-coupled cathode follower which provides an output of 53 volts, r.m.s. at 0.2 watt and with good regulation.

A low resistance path from the 6A6 grids to ground is required to keep the grid near zero bias.

To meet above requirements a special pre-driver stage output transformer was developed.

The author also presents his design of the stabilized power supply.

CAPACITORS FOR SERIES HEATERS

★ There are some advantages in the use of capacitors instead of resistors in circuits consisting of several vacuum tube heaters in series. The capacitor offers longer life, low power consumption, and self compensation when the number of tubes is varied.

Mr. G. S. Light has reviewed these advantages versus the disadvantages in an article appearing in the April 1945

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[*Continued from page 30*]

issue of *Electronic Engineering*. The article is entitled "Condensers in Series-Heater Circuits".

The disadvantages in the use of capacitors are that only one frequency can be used with a given circuit arrangement, the capacitor has a slightly greater cost, and a special switching arrangement is necessary when using series pilot lamps. Furthermore, the warming-up period is increased.

The value of the capacitance required can be calculated as in the following example. For three 6.3 volt, 0.3 ampere tubes and two 25 volt, 0.3 ampere tubes, the voltage drop across the heaters is 68.9 volts. The voltage across the capacitor, with a 230 volt, 60 cycle, supply voltage is $V_c = \sqrt{230^2 - 68.9^2} = 219.5$ volts. The capacitance in $\mu f = \frac{10^6 \times 0.3}{2\pi \times 60 \times 219.5} = 3.63\ \mu f$.

The self-regulating action is good when the total heater voltage is less than approximately one-third of the supply voltage. This is apparent from

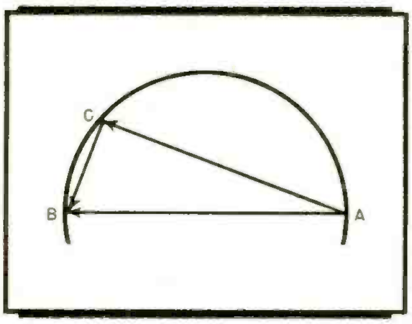
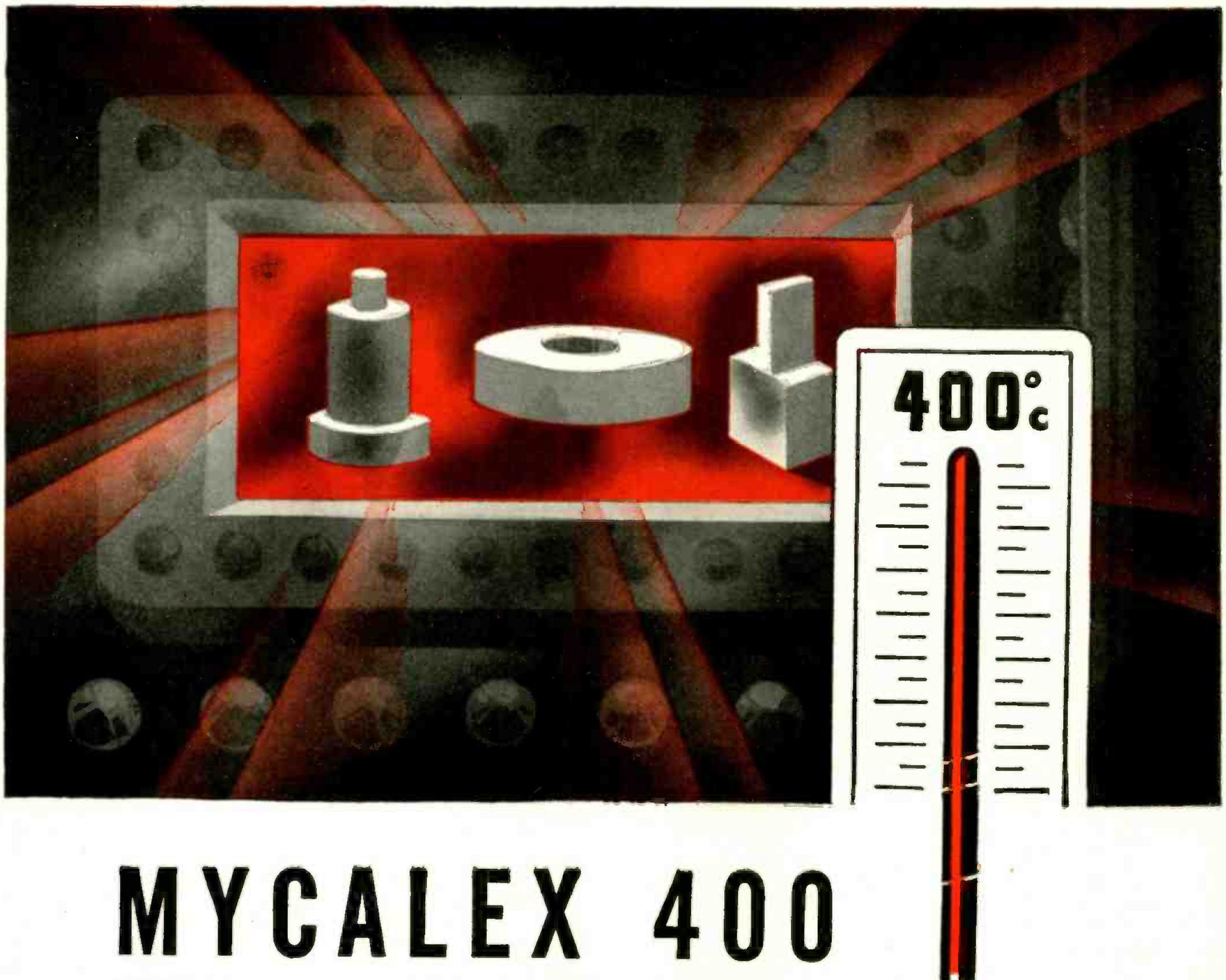


Figure 4

Fig. 4, in which AB = supply voltage, AC = capacitor voltage, and BC = total heater voltage. When BC is small compared to AB, then variations in BC do not produce substantial variations in AC, so that the current through the capacitor remains about the same. The current regulation with a resistor is not as good as this.

With indirectly heated tubes the warm-up period of the filaments is greater than the period of the transient current which occurs when the switch is first turned on. The warm-up period of a pilot lamp is shorter, and short life can be expected unless the pilot lamp is shorted out during the transient period. This can be accomplished with a delayed action switch, or by using a single switch to short out the heaters for "off". This latter method would mean that the capacitor would remain permanently in the line, but since there is no power consumption by the capacitor, this is permissible.


400°C

Audio-Carrier-Frequency R-C Oscillator

ROBERT C. PAINE

This oscillator covers a range of 20 to 20,000 cycles, using a direct-reading dial with but two logarithmic scales, and has other unusual features

THE resistance-capacity tuned type of audio oscillator has been widely accepted and valued for its stability, simplicity, and good wave form. The author has modified such an RC oscillator which has been previously described in RADIO[1] to obtain certain additional desirable features as shown in *Fig. 1.*

In this circuit a range of 20 cycles to 200 kilocycles is obtained, using a direct-reading dial calibrated in two scales, 20-70 and 60-210. By using an 8-position band switch and properly proportioning the resistors of the tuning circuit, these two scales are arranged to serve for the whole range and spread out the scale so that frequencies can be read very accurately for tests on filters or other equipment at audio and carrier frequencies. High and low output impedances are under control of an output switch. These impedances remain at an approximately constant value because the output control is placed in the grid of the output tube. A built-in diode rectifier permits checking the output with any convenient d-c voltmeter or milliammeter. A "Clipped Wave" switch modifies the feedback circuit to clip the sine wave peaks and so to produce a partial square wave useful for synchronization or other special purposes.

Oscillator Circuit

The operation of the oscillator circuit shown in *Fig. 1* depends on positive feedback from the plate of tube V_2 to the grid of tube V_1 through the frequency-determining network formed by the resistors R_{1-8}, R_{11-18}, and condensers $C_{1,2,3}$ and $C_{11,12,13}$. Negative feedback to the cathode of V_1 through R_{30} controls the output and maintains good wave form. The two 6-watt lamps in the cathode circuit control the amount of negative feedback. As the circuit tends to oscillate more vigorously the increased alternating current causes the resistance of these lamps to rise rapidly, increasing the negative feedback voltage to the cathode and tending to keep the output voltage at a constant level. The tube V_3 isolates the load from the oscillating circuit to prevent any frequency reaction.

The oscillating circuit consisting of the tubes V_1 and V_2 and the tuning

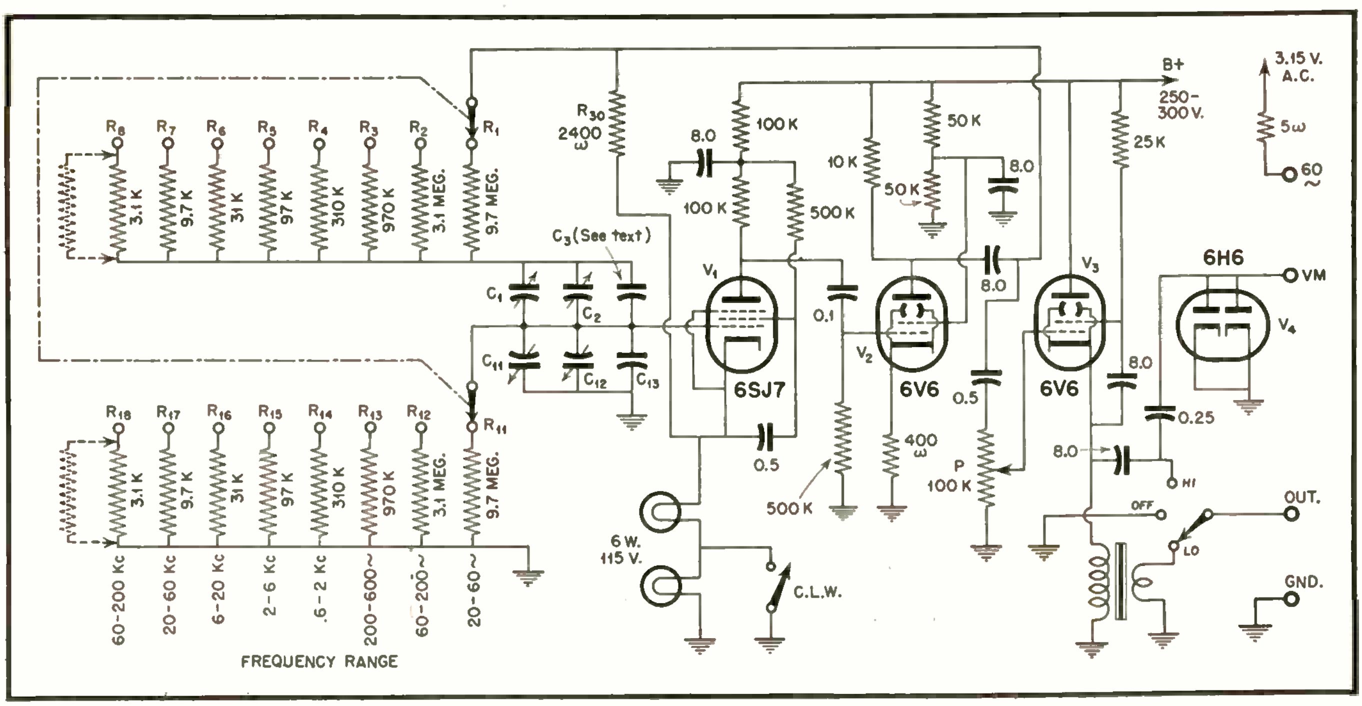


Fig. 1. Schematic of the oscillator tuned by R-C network with variable capacitors

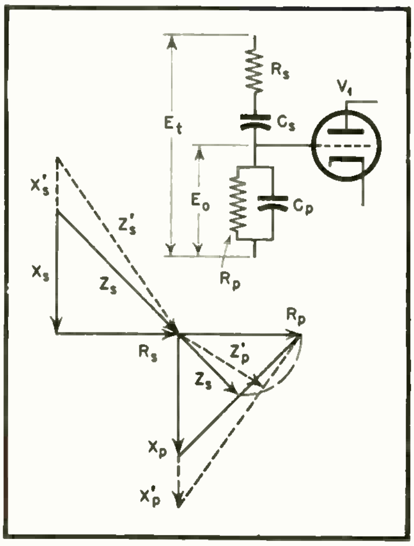


Fig. 2. Impedance vectors of R-C network, $R_s = R_p$ and $C_s = C_p$. Solid lines at oscillating frequency, dotted lines at lower frequency

network are well shielded from the power pack and the rest of the circuit to avoid hum pickup and undesirable feedback from the output stage. The power supply has not been shown as this can be of conventional design, operated from the power line. The 8 μf condensers are of the electrolytic type. C_3 and C_{13} are mica, and all others are of the paper type. The output control potentiometer is placed in the grid of the output tube V_3 so that an approximately constant output impedance may be presented to the load. Using an output transformer of about 10-to-1 ratio, the author obtains an output impedance of about 4 ohms on the "Lo" point and about 400 ohms on the "Hi" point. An "Off" position between the "Hi" and "Lo" points is convenient for cutting off output during tests.

The diode rectifier tube V_4 furnishes a convenient means of checking and adjusting the output to constant value when this is required. For output indications a d-c voltmeter, of 1000 ohms per volt, on the 50 or 100 volt scale, or a milliammeter in series with 50-100 thousand ohms, can be connected between the "Vm" binding post and ground, for such use the meter need not

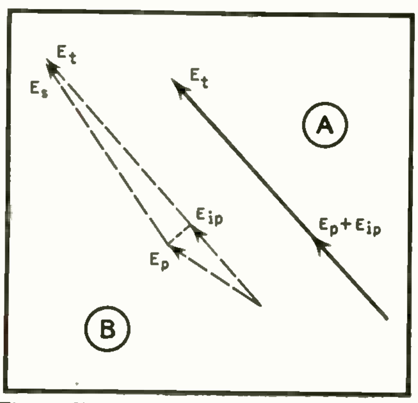


Fig. 3. Voltage vectors for Fig. 2; (a), at oscillating frequency, (b) at lower than oscillating frequency

be calibrated. The "CL. W." switch shorts out one of the 6-watt lamps to reduce the negative feedback. Since the amount of negative feedback is the principal factor in the production of a good wave form, this reduction of feedback results in the clipping the peaks of the waves somewhat so they approach a square wave. Such a wave is useful for synchronization and for various testing purposes. Operation of the "CL. W." switch changes the frequency somewhat, for which corrections should be made when required.

Theory of Tuning Network

The tuning network consists of a series combination R_{1-8} and $C_{1,2,3}$. and a parallel combination R_{11-18} and $C_{11,12,13}$. The impedance, Z_s, of the series combination is found graphically by the vector addition of the resistance, R_s, of resistors R_{1-8}, and the reactance, X_s, at a given frequency, of the capacity C_s formed by the condensers $C_{1,2,3}$. The

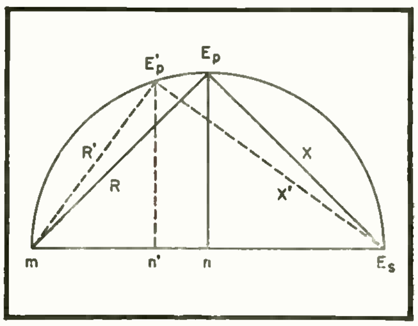


Fig. 4. Circle diagram of R-C network showing relative absolute voltages where $R_s = R_p$ and $C_s = C_p$

impedance, Z_p, of the parallel combination of the resistance, R_p, of the resistors R_{11-18}, and the reactance X_p, at the same frequency, of the capacity C_p formed by the condensers $C_{11,12,13}$ is also found in a vector diagram, perhaps less familiar, which has been previously described by the author[3].

These diagrams have been combined in *Fig. 2* in which values have been chosen so that $R_s = R_p$ and $C_s = C_p$. The dotted lines show impedances at a lower frequency where $X_s = R_s$ and $X_p = R_p$ and the phase angles of Z_s and Z_p are both 45° and equal. The dotted lines show impedances at a lower frequency where X_s and X_p are greater. It is seen that Z_p/Z_s is greater than Z_p'/Z_s' *Fig. 3(a)* and *(b)* show the corresponding voltage diagrams where E_t is the feedback voltage from the plate of V_2 and equal to the sum of the voltage E_p across Z_p and the voltage E_s across Z_s, these voltages being proportional to the corresponding impedances. Of the voltage E_p, only the "in-phase" component E_{ip} is effective in producing oscillation.

The maximum "in-phase" feedback voltage occurs at the frequency which makes the phase angle of the series combination equal to that of the parallel combination. If the values are so proportioned that $R_s/C_s = R_p/C_p$, the phase angles become equal (45°) and the circuit oscillates at a frequency such that $R_s = X_s$ and $R_p = X_p$. If $R_s = R_p$ and $C_s = C_p$ the relative values can be shown in a combined diagram, *Fig. 4*. Here the solid lines show the relative absolute values of the voltages nE_p and mE_s across the impedances Z_p and Z_s, respectively at the frequency of oscillation where $R_s = X_s$ and $R_p = X_p$. The dotted lines show values at another frequency at which $R_s \neq X_s$ and $R_p \neq X_p$. Although the scale of values for the dotted lines has been changed to accommodate the same semicircle, the relative values remain unchanged and it is seen that the ratio of voltage nE_p to mE_s is greatest at the oscillating frequency. Due to the fact that these voltages are no longer in phase at any frequency other than that shown by the solid lines, it can be shown also that the ratio of the in-phase component of nE_p (E_{ip} of *Fig. 3*) to the in-phase component of mE_s is relatively even less.

If the capacities are not in the same ratio as the resistors, or R_s/C_s is unequal to R_p/C_p, the maximum "in-phase" feedback voltage to the grid of V_1 still occurs at the frequency which makes the phase angles of Z_s and Z_p equal. Then it is not possible for R_s to equal X_s and R_p to equal X_p at the same frequency, so the phase angles become equal at a frequency which causes these angles to differ from 45°. This is shown in *Fig. 5* where, for example, $R_s/R_p = 2/3$ and $C_s/C_p = 3/4$ and the tangent of their phase angles is 1.4. However, in any practical design, it is desirable that the ratio C_s/C_p remain substantially constant over the tuning range to avoid variation in the feedback ratio and constant variation in output.

The oscillating frequency due to any particular combination can be calculated from the fact that the phase angles of Z_s and Z_p must be equal. The tangents of these angles must then be equal or

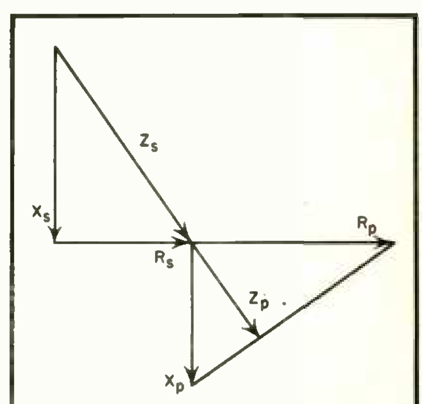


Fig. 5. Impedance vectors of R-C network tuning at oscillating frequency where R_s/C_s is not equal to R_p/C_p

$X_s/R_s = R_p/X_p$, then $1/R_s(1/2\pi fC_s) = R_p(2\pi fC_p)$. From this equation it is found that the frequency of oscillation, $f_r = 1/2\pi\sqrt{R_sR_pC_sC_p}$, or expressed in cycles, megohms, and micromicrofarads, $f = 15900/\sqrt{R_sR_pC_sC_p}$.

The circuit shown in *Fig. 1* as built by the author uses a four gang broadcast condenser for $C_{1,2}$ and $C_{11,12}$ with resistances R_s, (R_{1-8}), *and* R_p, (R_{11-18}), of equal value. The capacity per section is 380 $\mu\mu$f and the capacity shunt to ground, across $C_{11,12,13}$, of the condenser frame and common rotors, (which of course must be well insulated) is 30 $\mu\mu$f. The condenser C_3 has a capacity of 180 $\mu\mu$f and C_{13}, 150$\mu\mu$f, these values make C_s and C_p equal and also pads the condensers to reduce the frequency range as will be discussed later. The tuning condenser is driven by a vernier control dial which makes possible a very close setting of frequency.

It is possible to use a 3-gang condenser although this results in higher impedances and is less desirable. When a 3-gang condenser is used, a single section is used for C_s and correspondingly the value of R_s is made twice R_p. The oscillating frequencies then are the same as with the four-gang condenser, since $R_s = X_s$ and $R_p = X_p$, as before. The ratio of positive feedback voltage to the grid of V_1 is less and the negative feedback must be correspondingly reduced by increasing the value of resistor R_{30} sufficiently to permit oscillation, but not so much as to result in poor wave form.

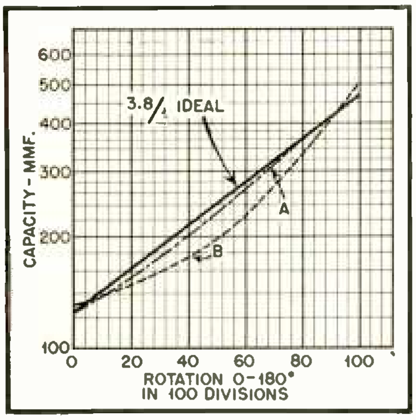


Fig. 6. Condenser capacity curves, the ideal logarithmic for a 3.8/1 range R-C oscillator. "A" a padded broadcast condenser suitable for this range, and "B" a condenser less suitable for this range

Frequency Scales

The ideal scale on the frequency dial is logarithmic, that is, the scale divisions are proportional to the logarithm of the corresponding frequency. This makes possible a constant percentage of accuracy in taking readings. Many test instruments have this type of scale and tests such as audio fidelity are usually plotted on logarithmic paper. Since it is usually necessary to use tuning condensers having capacity curves of conventional broadcast design, it is desirable to examine the possibilities of obtaining a logarithmic calibration with condensers which may be available.

The capacity curve for an ideal condenser can be readily calculated and this can be compared with curves of available condensers. With the capacities C_s and C_p equal and the resistances R_s and R_p equal, frequency is inverse proportional to capacity or $f = k/C$ and, for a logarithmic calibration, the capacity must vary logarithmically from minimum to maximum. To cover a given range the condenser must be padded by a fixed condenser shunt. For example, consider a 3.8/1 frequency range using a variable condenser of 380 —30 $\mu\mu$f. To cover this range the padded maximum and minimum capacities must have the ratio $3.8/1 = (380+X)/(30+X)$, or X, the shunt capacity, = 95 $\mu\mu$f. The maximum and minimum padded capacities are then 475 $\mu\mu$f and 125 $\mu\mu$f, these values are plotted on semi-logarithmic paper and a straight line drawn through them. This line defines the ideal capacity variation vs. degrees rotation for this frequency range.

These values have been plotted in *Fig. 6* where the vertical scale represents capacity values of the padded condenser and the horizontal scale divisions of rotation, 100 divisions being equal to 180°. The solid line represents the capacity of the ideal condenser. The dashed line represents the padded capacity of condenser *A* used to obtain an approximately logarithmic scale over a range of 3.8/1. The dotted line represents the capacity curve of condenser *B*, properly padded for this range. Condenser *B* is less suited for a logarithmic scale in this range; its use would result in a crowding together of frequencies at the low frequency, or high capacity, end of the dial and a spreading out at the high frequency end, tending to approach a linear scale.

In *Fig. 7* is shown the ideal curve for a 10/1 frequency range. For this range condenser *A* requires only 9 $\mu\mu$f of padding capacity, it can be seen by the dashed curve that it is less suited for this range. Condenser *B*, also properly padded, is more suited for this range than it is for the 3.8/1 range, as seen by the dotted curve.

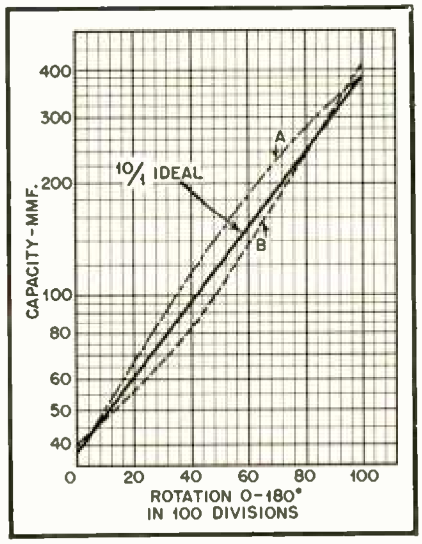


Fig. 7. Condenser capacity curves, the ideal logarithmic for a 10/1 range R-C oscillator. "A" and "B" curves of condensers shown in Fig. 6 but padded for a 10/1 range. Neither conforms closely to the ideal for this range

To divide a 10/1 range into two parts logarithmically, the square root of 10 or 3.16 is taken and the 10/1 range then becomes 2 ranges of 3.16/1 each. The required resistors then vary in steps of 3.16. It is convenient to select low values of 9.7 $\times$ 10^n ohms from resistors rated 10 $\times$ 10^n and high values of 3.1 $\times$ 10^n ohms from resistors rated 3 $\times$ 10^n. The tuning condenser has been padded by the author to give a range of about 3.5/1 instead of the exact value 3.16/1 in order to obtain a suitable overlap between ranges.

Calibration

The tuning condenser can be calibrated by the usual methods with an oscilloscope, using Lissajou figures with 60 cycles from the power line as a standard for the lower frequencies. Higher frequencies could use the 440 and 4000 cycles of the standard broadcasts from WWV or the harmonics of 60 cycles if a stable auxiliary audio oscillator is available on which to set up intermediate frequencies.

A convenient method of using WWV signals is to pick up the 5, 10, or 15 mc signal on a receiver and use the audio output to synchronize the CRO sweep.

[*Continued on page 74*]

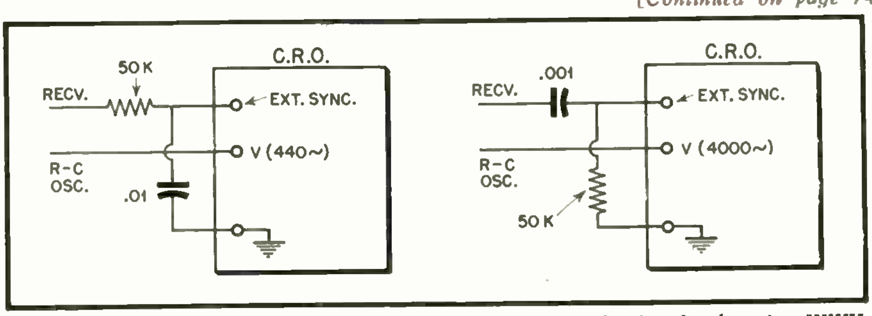


Fig. 8. Simple filter arrangements for using 440 and 4000 cycle signals of station WWV for calibrating the R-C oscillator

Application of METALS in RADIO

A. C. MATTHEWS

It is surprising to find in the radio engineering profession so many well qualified designers who have little knowledge of metals and their use in radio design. While it is true most radio engineers find such knowledge is not necessary, it is nevertheless an asset to be able to appreciate the metal problems encountered by the mechanical designer. Such understanding leads to better co-operation between groups and may often improve the quality of the overall design.

The object of this article is to explain for the radio engineer the various properties of those metals commonly employed in radio receiver design. Methods of fabrication and requirements for mechanical strength and prevention of corrosion will also be discussed. In an article of this length it is obviously impossible to cover the field in great detail; only the points with which the electrical design engineer should be acquainted will be considered. If the need arises, more comprehensive information is readily available in texts on the subject. For convenient reference, Table 1 has been prepared to show at a glance characteristics of metals commonly used in the majority of present-day designs. To simplify the picture, many of the infrequently used metals and alloys have been purposely omitted.

For convenience we will divide the metals and their alloys into two groups: ferrous and non-ferrous. But before we specifically consider these materials, let us define some of the terms commonly used in order to establish a common ground for further discussion.

Mechanical Properties

The *tensile strength* of a metal is determined by the force in pounds per square inch (psi) which will rupture the metal. This property is of little interest in the design of most radio equipment since the metals are seldom subjected to stresses of such large magnitude. Before the point is reached where rupture occurs the metal stretches or elongates. The degree of elongation is a measure of the stiffness or rigidity and is commonly known as the *modulus of elasticity*. The greater the modulus, the heavier the load a metal will withstand before bending occurs. As the force applied to a test specimen is increased, a point will be reached where the metal will permanently deform (not return to its original shape when the load is removed). When the permanent elongation reaches 0.5 per cent, the force applied in psi is a measure of the yield strength. This property together with the modulus of elasticity is important in choosing the material for levers,

TABLE 1

PROPERTIES OF SOME METALS AND ALLOYS

MATERIAL	MECHANICAL PROPERTIES: FORM	YIELD STRENGTH 1000 PSI	HARDNESS BRINELL	TENSILE STRENGTH 1000 PSI	PHYSICAL PROPERTIES: SPECIFIC GRAVITY	COEFF. LIN. EXPANSION 10^6"/"/°F	ELECTRICAL RESISTIVITY OHMS/CIR. MIL FOOT	MODULUS ELASTICITY 10^{-6} PSI
ALCOA 2S	COLD ROLLED [1]	21	44	24	2.72	13.8	17.6	10.3
ALCLAD 24S	ANNEALED [3]	41		62	2.77	13		10.3
COPPER	ANNEALED COLD ROLLED	10 48	30 120	31.8 60	8.92	9.8	10.4	16
BRASS (HIGH)	COLD ROLLED [1]	75	180	86	8.47	11.2	40	14
PHOSPHOR BRONZE	COLD ROLLED [1]	75	210	100	8.86	9.9	57	15
ZINC	COLD ROLLED [2]	21	40	36	7.15	16.5	36	12.4
CARBON STEEL SAE 1020	ANNEALED COLD ROLLED	40 75	130 146	58 81	7.86	6.7	60	29
STAINLESS STEEL 309	ANNEALED COLD ROLLED	50 110	165 275	100 150	7.90	8.3	470	29
INVAR	ANNEALED	42	130	70	8.09	0.6	480	21
SILVER	COLD ROLLED [1]	40	90	51	10.5	10.6	9.6	10.3
MAGNESIUM	CAST	12	48	28	1.83	15.5	69	6.25
DOWMETAL H	ROLLED		33	25				

1- HARD TEMPER 2-LONGITUDINAL TEST 3-HEAT TREATED AND AGED

RECEIVER DESIGN

Practical data on the use of metals in radio design

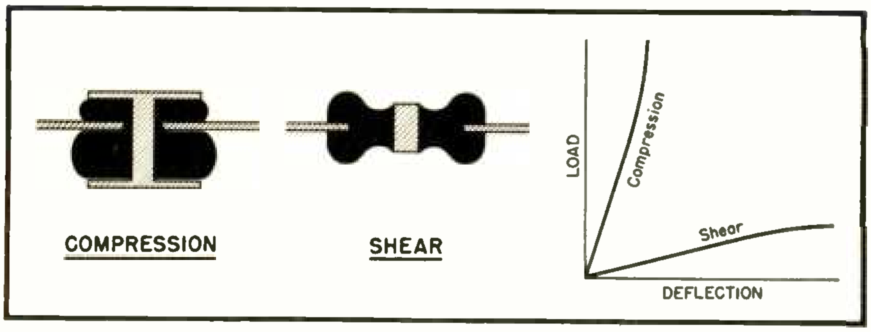


Fig. 1. Rubber shock mountings in compression and shear

springs, etc. The higher the modulus the stronger the part, or if size is a factor the smaller the part for a given strength or stiffness.

Another property that is important in some design applications is ***ductility***, because this is a measure of the ability of the metal to absorb sudden overloads or shocks; lack of ductility is brittleness. Two materials may have equal strength and hardness but different ductility and therefore one may be more suitable for bending, drawing or other cold working because it has the ability to "take it" without fracture. Obviously such a characteristic is important in the choice of the method of fabrication.

Hardness, although it is difficult to measure or define, is one of the three properties of a metal (ductility and toughness being the other two) to be considered where long life and wear are important requirements. Several methods of testing hardness are commonly employed depending upon the part to be measured. Since the Brinell and Rockwell methods are the most popular in most radio applications, only these two will be described.

The Brinell method consists of measuring the penetration of a standard hardened steel ball of 10 mm. diameter into a flat surface of the test specimen with a standard load for a prescribed length of time. (3000 kg for 15 to 30 seconds for hard metals. 500 kg from 30 to 60 seconds for soft metals). The diameter of the indentation is converted to a Brinell Hardness Number by referring to a special table supplied for the instrument.

The Rockwell hardness is determined from a measure of the depth of penetration into the material due to a steel ball or diamond cone under a fixed load. A preliminary load of 10 kg is first applied to obtain an initial zero setting. The major load is then applied (major load depends on the nature of the material to be tested) until penetration into the test specimen ceases. The latter penetration is a measure of the Rockwell Hardness and is indicated by a pointer on the instrument as a hardness number.

Fatigue is another term that has become increasingly important in the design of metal parts subjected to a dynamic load, shock or vibration. When a metal part is subjected to repeated loads, though none exceeds the elastic limit of the material, it may eventually fail due to fatigue. Whenever possible, accelerated life tests should be made on the part or parts in question. Such tests indicate the suitability of a particular design and are of great importance in determining safe operating conditions for such parts.

Physical Properties

Specific gravity, resistance, density, and the melting point are properties too well known to describe further. But the temperature characteristics are important because radio equipment designed for airborne use frequently must function at sub-zero temperatures. Not only are sub-zero temperatures encountered in such applications but usually they are accompanied by severe vibration and strains. If the metal becomes brittle and loses its toughness, failure is generally imminent.

Another effect of variations in temperature is the change in magnetic properties of a non-ferrous metal. Below a certain temperature, known as the Curie point, non-ferrous metals become magnetic. Such behavior often will result in undesirable effects and therefore this characteristic should be known before specifying a metal for a part whose operation is dependent upon definite non-magnetic properties.

Besides the above properties the *coefficient of expansion* is also of importance. This is particularly true where a change in physical dimensions will cause distortion of the part and either directly or indirectly cause the frequency of a tuned circuit to vary. The coefficient of expansion of a metal is determined by measuring the total expansion over a range of temperatures and dividing the expansion by the degrees change in temperature. It is expressed as parts per inch, per inch, per degree temperature. Frequently it is possible to choose metals having coefficients of expansion which, in a specific design, will compensate the effects of one another. This is especially true in the design of variable tuning condensers and coils.

Non-Ferrous Metals

Since copper, aluminum, magnesium, zinc and their alloys are the most commonly used non-ferrous metals in radio equipment design, we will confine ourselves to brief descriptions of these metals only.

COPPER has a tensile strength of

30,000 to 65,000 psi depending upon the treatment to which it has been subjected. It is fairly free from corrosive effects because in dry air a thin film of cuprous oxide is formed, and in moist air a green basic carbonate forms which is protective in nature. Copper is an excellent conductor of electricity and because it can be readily worked it finds many uses in radio, such as shields, wire and even castings if properly alloyed with other metals.

Copper alloys are divided into the brasses and bronzes. BRASS, an alloy of copper and zinc has excellent mechanical properties, is quite corrosion resistant and is readily machined. Its strength and toughness depend upon the percentage of zinc used and the mechanical and heat-treatment received.

BRONZE is an alloy of copper and tin and, like brass, its properties depend on the particular alloy and its treatment. It is chiefly used for castings, although it can be rolled satisfactorily. The addition of phosphorus to bronze greatly improves its characteristics especially in tensile strength, elasticity and fatigue resistance. It can be readily forged, drawn, cold rolled and cast, and since it is comparatively corrosion resistant, it is often substituted for steel in the manufacture of corrosion-resistant parts.

Because ALUMINUM is one of the lightest of metals and relatively strong and tough, possesses high electrical conductivity and under ordinary atmospheric conditions forms a protective oxide coating, it is widely used in the manufacture of radio equipment. Where lightness and extreme strength are required, as in airborne equipment, some of its alloys are particularly suitable. For instance, Alclad 24S when properly treated has a tensile strength of 62,000 psi. This is comparable with mild steel in strength yet only about one-third the weight.

MAGNESIUM is the lightest of the metals (approximately 0.7 that of aluminum) used in radio applications. Although its tensile strength is comparable to that of aluminum it is somewhat harder. It may be alloyed with aluminum, zinc, manganese, cadmium and copper; in fact, most metals with the possible exception of iron and chromium. These alloys are becoming increasingly important for use in airborne equipment since they can be rolled, extruded or cast.

ZINC is primarily used as a coating for other metals. It can, however, be rolled or cast satisfactorily and is therefore used for coil and tube shields, although it is not as satisfactory as aluminum or copper for this purpose. As an alloy with aluminum and copper, it is particularly suitable for die-castings. Its low cost and the fact that its dimensions can be held within plus or minus 0.002″ per inch of casting makes it suitable for many applications. As a die-casting it is quite tough and less likely to breakage in handling or service compared with some of the other alloys. Wherever an intricate piece is required a zinc alloy die-casting should be considered.

Ferrous Metals

There is a wide variety of steels to choose from in the design of radio equip-

TABLE 2

COMMONLY USED FINISHES				
TYPE (ELECTROPLATED)	PROTECTION	THICKNESS IN INCHES (MIN)	SALT SPRAY (HOURS)	REMARKS
CADMIUM	MILD EXPOSURE	0.0002	50	ON STEEL
CADMIUM	SEVERE EXPOSURE	0.0005	100	MEETS AN SPECS
CADMIUM	VERY SEVERE	0.001	200+	REQ'D ONLY FOR UNUSUAL CONDITIONS
ZINC	MILD	0.0002	35	NOT TO BE PAINTED OR SOLDERED
ZINC	SEVERE	0.0005	100	CAN BE PAINTED
ZINC (BRIGHT)	VERY SEVERE	0.0007 TO 0.0009	150	
ZN (OX BLACK)	MILD	0.0002	35	0.0002″ DEPOSIT BEFORE OXIDIZING
SILVER		0.00012 TO 0.00018		LOW ELECTRICAL RESISTANCE
SILVER		0.0003		LOW ELECTRICAL RESISTANCE CAN BE SOLDERED
NICKEL	SEVERE	0.0014	48	ON STEEL
NICKEL	SEVERE	0.0003		ON BRASS
BLACK NI.	SEVERE	ZN OR CD BEFORE NI.	50	RUST RESISTANT BLACK
WHITE NI		0.0012	50	ON BRASS
FLASH COPPER	NONE	0.00008		UNDERCOAT BEFORE NICKEL
COPPER	MILD	0.0002		
ANODIZED ON ALUMINUM	SEVERE			EXCELLENT FOR SALT SPRAY ELECTROLYTIC MEANS
BLACK ANODIZE	SEVERE			DURABLE BLACK FINISH

CHEMICAL FINISHES NOT ELECTROPLATED	
BONDERITE	TREATMENT FOR ZINC TO IMPROVE PAINT ADHESION
LITHOFORM	USED ON HOT GALVANIZING TO IMPROVE PAINT ADHESION
BONDERIZING	ON STEEL BEFORE PAINTING
PARKERIZE	ON STEEL BEFORE PAINTING
CRONAK	ON ZINC FOR ADDITIONAL PROTECTION
SHERARDIZE	ZINC IRON ALLOY COATING BY CEMENTATION

ment, but for most applications ordinary carbon steel is very satisfactory because it can be readily formed and finished and has excellent mechanical properties.The carbon content of a steel is extremely important and for this reason a method of classification or identification has been standardized by the Society of Automotive Engineers. Each carbon steel is assigned a series of four digits; the first digit for all carbon steel is 1, the second digit represents the type of carbon steel (0 for plain, 1 for free cutting, etc.) and the last two digits indicate the percentage carbon content in hundredths of one per cent. Thus SAE 1010 is plain carbon steel having approximately .010 per cent carbon content.

Steel alloys are used only where special characteristics are required, as for instance silicon electrical steel for transformer laminations, or some of the stainless steels where freedom from corrosion is desired. These special applications are outside the scope of this article and therefore will not be discussed.

A metal or alloy is made up of a great number of small crystals arranged at random. Their properties are dependent upon the treatment and working to which they are subjected. In the process of manufacture the rate of cooling determines to a large extent the size of the crystals formed. (Slow cooling will generally result in large crystals which produce a weak material. On the other hand, rapid cooling is likely to produce a less ductile material.)

The cold working of a metal will increase its hardness and strength at the expense of ductility. This can be seen by bending a piece of soft metal with the hands and then trying to straighten it out again. While it bends easily it is very difficult to straighten. Apparently the bending distorts the crystalline structure in some manner and a structural change occurs which increases its rigidity or hardness. If a piece of cold rolled or drawn metal which has been distorted is examined under a micoscope, the crystals or grain will appear to have fine parallel lines running through them. These lines are caused by a movement of the crystals and are known as slip planes. So long as the slipping occurs the metal will not fracture, but as soon as the limit of slipping is reached, the metal will break.

Once the metal has been hardened by cold working, the crystals remain in their distorted condition until the metal is heated to a high temperature, known as the annealing point. At this point the crystals are relaxed and regain their symmetry. (An annealed part must be allowed to cool slowly). Annealing makes the metal soft and more workable, at the expense of its hardness and strength.

Hot working is a combination of annealing and cold working, wherein the grain size is decreased but the crystals retain their symmetry and no strain is apparent. This results in some hardening and strengthening without loss of ductility.

Design Notes

Chasses and other metal parts for radio equipment are generally fabricated from steel, although aluminum is widely used for airborne equipment where weight is an important factor. As mentioned previously there are many grades of steel available and accordingly it might seem difficult to choose the correct type. The requirements, however, are fairly well defined; that is, a metal is required that has a good surface for finishing, is capable of being easily formed, and low in cost. Many companies specify half-hard cold rolled automobile body steel. This has an excellent finish and is not too hard for working. In general, cold rolled steel is specified rather than hot rolled because the former takes a smoother finish or plating. Very few companies specify the actual composition of the metal they purchase, but they do specify what it will be used for and leave the details as to composition etc., to the supplier.

Aluminum, magnesium, brass, bronze and copper are specified in the B & S gage while steel is specified in the U.S.S. gage. The gage or thickness varies of course with the size of the part to be fabricated. In general, small chasses or parts use 0.037" material, medium sized 0.050" and the larger chasses 0.062". This of course varies with the actual design of the part. For example, if the chassis has large cutouts, which obviously would weaken the unit, then it would appear that a heavier gage material should be used than if the cutouts were small. Unfortunately this is not always the case; it may be much more economical to fold and weld the corners or add strengthening ribs at the weak spots rather than use a heavier material. While it is true such designs necessitate extra operations which add to the piece price, nevertheless the dies for blanking and forming the lighter material are not quite as expensive and will produce more parts before wearing out.

No hard and fast rules are available with which to make this decision as each design must be considered individually. An experienced cost estimator, in collaboration with a qualified tool designer and a representative of the purchasing department, usually make such decisions. Where the design is quite similar to a previously produced part the mechanical design engineer can of course rely on his past experience for the answer.

The cost of a unit can often be reduced by eliminating extra brackets. Separate mounting brackets which must be riveted or welded on the chassis can, in many cases, be eliminated by piercing and folding a suitable piece of metal from the chassis. Of course, the opening in the chassis must be such that it does not materially weaken the unit and it should be so placed that Underwriters requirements are not violated, where these restrictions apply. Furthermore, in designing a substitute bracket of this type the folding or forming should require no additional operations as these would practically offset any savings.

Where it is necessary to use separate brackets or super-structures on a chassis a saving in the mounting time can often be made, particularly when the bracket is not subject to handling, by omitting one of the mounting holes and substituting a locating dowel in its place. The dowel only positions the bracket and contributes nothing to holding the part so this can only be used where the strength requirements are low.

Another important consideration when designing brackets, particularly where two are required and one must be right-handed and the other left handed, is to make the design such that only one part will be needed. This eliminates extra die cost, the cost of handling an extra part and the avoidance of confusion in production since

TABLE 3

CORRODED END (ANODIC, OR LEAST NOBLE)
MAGNESIUM MAGNESIUM ALLOYS
ZINC
ALUMINUM 2S
CADMIUM
ALUMINUM 17ST
STEEL OR IRON CAST IRON
CHROMIUM IRON (ACTIVE)
NI-RESIST
18-8 STAINLESS (ACTIVE) 18-8-3 STAINLESS (ACTIVE)
LEAD TIN SOLDERS LEAD TIN
NICKEL (ACTIVE) INCONEL (ACTIVE)
BRASSES COPPER BRONZES COPPER-NICKEL ALLOYS MONEL
SILVER SOLDER
NICKEL (PASSIVE) INCONEL (PASSIVE)
CHROMIUM IRON (PASSIVE) 18-8 STAINLESS (PASSIVE) 18-8-3 STAINLESS (PASSIVE)
SILVER
GRAPHITE GOLD PLATINUM
PROTECTED END (CATHODIC, OR MOST NOBLE)

the parts are usually quite similar in appearance.

Separate spacers to hold parts in position can often be eliminated by a so-called "embossing" operation on the main chassis. These are relatively easy to include in the die and give very satisfactory results. They cannot, however, be placed too close to a hole in the chassis as the embossing operation tends to pull the metal in such a manner that nearby holes become distorted and very likely would run out of tolerance. The embossing is usually done during the piercing operation.

Another design feature which reduces costs is the use of extrusions or punch-formed holes. These have a variety of applications. For example, where it is necessary to provide a hole in the chassis for lead wires, cables or power cords it is customary to insert a metal or fiber grommet to eliminate the raw metal edge which might otherwise abrade the insulation. An extruded or punch-formed hole can be specified to provide a smooth surface for the wires and thereby eliminates the chances of failure from this cause.

Another use for punch-formed holes is where the mounting of a part would ordinarily require a machine screw, lockwasher and nut. By providing a punch-formed hole, a hardened drive screw can be employed with a saving in both time and material costs. If the part to be mounted requires frequent removal during the life of the apparatus, a self-tapping drive screw can be used, or the punch-formed hole can be tapped and a regular machine screw employed. Punch-formed holes provide extra material for tapping purposes; the engagement of the thread should never be less than its major diameter, even in non-ferrous materials.

Sharp corners on brackets, etc., are to be avoided because of the danger of injury to production personnel. Some designers cut the corners at a 45° angle, which is a compromise between safety and cost. A small radius usually increases the die cost while cutting the corners at a 45° angle is relatively inexpensive.

Chasses are usually fabricated from sheet metal by stamping, piercing and folding. Sometimes mounting feet and

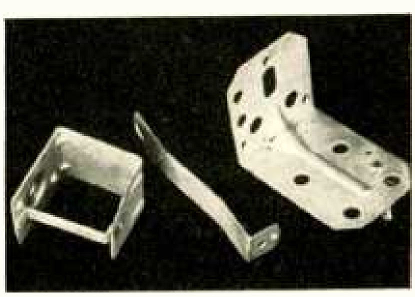


Fig. 3. Examples of strengthening ribs, dowels, spot welds, etc.

(*Courtesy Oak Mfg. Co.*)

Fig. 2. Silver plating on wave switch contact. Cross-sectional view shows silver deposit of .0001", indicated as a white line at top of photo. Magnification 750.

brackets are formed during the same operations but these cases are limited because of the complexity of the dies. It is therefore usually necessary to rivet several metal parts together to make a complete assembly. For this reason, complicated designs may lend themselves to die-casting. Shields, coil mountings, brackets, and mounting feet can then be made as one integral part without additional assembly operations. Zinc die-casting alloy is ideal for such purposes as it is tough and will withstand rough handling in service, and dimensions can be held extremely close so that very little machining is required.

The material cost of zinc die-castings is slightly higher than steel, but in some designs a cost saving may be apparent because of the fewer operations required to obtain a finished products.

As mentioned previously, riveting is the most common method of assembling a unit, although spotwelding is often employed where the material of the parts to be joined are approximately equal in thickness. Spotwelding or two parts that differ appreciably in thickness is not recommended.

When specifying spotwelding it is important that adequate space be available for performing the operation. Inaccessible spotwelds often require special jigs or fixtures and require additional time which defeats its main purpose, that is, speed in production and decreased cost. Dowels, stamped in the part at the same time the original stamping operation is performed, often can be used in place of holding fixtures thereby saving both time and equipment.

There is no set rule for determining the minimum number of spotwelds required. This is usually left to the judgment of the designer, but it should be clearly specified because of the cost involved. Flanges to be spotwelded should be at least one-half inch wide to avoid coming too close to the edge of the material.

The matter of tolerances is probably one of the most misused details in mechanical design (particularly by radio engineers). Because it is practically impossible to fabricate a part in production quantities to exact dimensions, it is necessary to specify allowable limits or tolerances. This can often be in the form of a general statement as, for instance. "All fractional dimensions are ± 1/64", all decimal dimensions ± 0.005", all angles ± 1° unless otherwise specified". The assignment of general limits depends upon the function of the part and the interchangeability required.

Tolerances should be as liberal as possible. They should be determined by taking the tightest permissible fit and the greatest allowable clearance, keeping in mind necessary clearances between parts, particularly where such parts are shock-mounted or subject to movement during normal operation, where it is necessary to insert or remove plugs etc. or adjustment may be necessary after assembly. In other words, tolerances are applied to obtain the greatest permissible variation between parts which will allow proper functioning of the assembled unit.

Tolerances should permit ready interchangeability of production parts with a minimum loss in time due to fitting, again keeping in mind that narrow limit are usually costly. After limits are decided question whether, considering the cost of the piece, if a part 0.003" or 0.005" outside of tolerance should be scrapped. Remember close tolerances are expensive and should only be specified when absolutely necessary. If possible the tolerances should be specified in the direction which permits reworking of the part should it be outside specified limits.

Shock Mountings

In radio equipment design it is often necessary to provide some isolating medium between certain parts to prevent them from periodically changing value so as to cause undesirable microphonism. Sometimes it is necessary only to isolate a single stage or a single part, as for example the variable tuning condenser. In general, however, the entire unit is isolated from its cabinet or case. Considering the problem from a structural standpoint, where heavy parts such as power transformers, speakers and chokes are mounted in the center of a chassis, some means of isolation between chassis and cabinet may be necessary to prevent excessive vibration from causing structural failures.

Adequate mountings spaced well apart will go a long way in reducing vibration effects. Ribs, flanges, embossings and welded sections as

[*Continued on page* 66]

THE FCC REPORT ON FM

So much controversy has arisen regarding the action of the Federal Communications Commission in changing the FM frequency allocations that we believe this statement by the Commission deserves careful consideration

On May 25, 1945, the Commission made public its final report of allocations above 25,000 kilocycles, except for the region of the spectrum from 44 to 108 megacycles. With respect to this region, the Commission proposed three alternative allocations for FM, television, facsimile non-government fixed and mobile services, and the amateur service. In its report, the Commission stated that the final decision among the three alternatives could be made with a great deal more assurance if more factual data were available. The Commission also pointed out that a program of experimentation during the summer months designed to collect further data was possible, since the War Production Board had assured the Commission that the radio industry would not resume production of AM, FM, and television transmitters and receivers in 1945 or even in the first part of 1946 unless Japan capitulated, and that the War Production Board would give the Commission 90 days' advance notice in the event of any change in its production estimates.

However, in view of the fact that the War Production Board subsequently advised the Commission that the manufacture of AM, FM, and television transmitters and receivers might commence at an earlier date than was originally indicated to the Commission, and that it would probably not be possible for the War Production Board to give 90 days' advance notice to the Commission before production was resumed, the Commission on June 5, 1945, ordered a further argument and hearing in order that a final decision might be reached at the earliest possible date. Such a hearing was held on June 22 and 23, 1945, marking the culmination of an extended series of hearings and oral arguments which began in September, 1944.

As the Commission noted in its report of May 25, 1945, its primary concern in making allocations between 44 to 108 megacycles is that FM shall be assigned the frequencies best adapted to its needs. All of the other services for which provision is made in this portion of the spectrum, have allocations in other portions of the spectrum, so that they are not wholly dependent upon their assignments here. FM, on the other hand, is receiving assignment only in this portion of the spectrum, and accordingly it is essential that it receive an allocation which will give a permanent locus, as free as possible from interference and other shortcomings.

The three alternatives proposed for FM are:

(1) 50- 68 megacycles
(2) 68- 86 megacycles
(3) 84-102 megacycles

There was unanimity that alternative No. 2 (68-86 mc) is completely unfeasible. Accordingly, the choice lies between alternatives Nos. 1 and 3.

The primary objection to alternative No. 1 is the amount of skywave interference which will result among FM stations if FM is placed in the 50-68 megacycle region. The nature and extent of this anticipated interference was set forth in great detail in Section 8 of the Commission's report of May 25, 1945 (pp. 49-72). The tables showing such interference are reproduced at the end of this report. For example, interference among 50 kilowatt FM stations at 58 mc from sporadic E transmissions alone, assuming a 10/1 ratio of desired to undesired signal and full occupancy of the channel, might be expected for 140 to 480 hours per year at the 50 microvolt contour from stations 900 and 1000 miles distant, respectively. At 84 mc, in contrast, interference under these conditions would be anticipated for only 6.5 to 25.5 hours per year. It should be noted that the 140-148 hours per year of anticipated interference would not be spread out evenly throughout the entire year but that the great bulk of it would be concentrated in two or three summer months.

The existence and extent of such sporadic E interference is not merely a matter of abstract calculation. In addition to the measurements of such interference made by the Commission, there is the experience of the amateurs, who have heretofore utilized both the 56-60 mc and the 112-116 mc bands. Mr. Grammer of the American Radio Relay League stated that there have been thousands of communications via sporadic E in the 56-60 mc amateur radio band but that there have been no recorded instances of such transmission in the 112-116 mc band (Cl, Tr. 144).

The amount of sporadic E interference will vary with the particular frequency involved, the power of the transmitters, the distance between transmitters, the number of transmitters on a channel, and other factors; but regardless of these factors, the region of the spectrum above 84 mc is markedly superior to the region below 68 mc with respect to sporadic E.

In addition to this interference from sporadic E transmissions, interference from F2 transmission at 53 mc may be anticipated for as many as 470 hours per sunspot cycle—concentrated in a period of three years—in the case of a sunspot cycle the same as the last one, or interference may exist for as much as 2,650 hours per sunspot cycle if the next sunspot cycle is as severe as the highest on record. These figures for F2 transmission, it should be noted, assume only two stations on a channel; more than two stations on a channel would double or treble the number of hours during which F2 interference would be expected at 53 mc. In contrast, no F2 interference whatever is to be anticipated above 84 mc.

For listeners buying FM receivers in reliance on a belief that FM is an interference-free service, these figures are extremely serious. They mean, for example, that a listener tuned to a station which is carrying the program of his choice may suddenly find, either that the program to which he has been listening is being interfered with by a station hundreds or even thousands of miles away, or else that control of his receiver has been seized altogether by a distant station completely obliterating the desired program of the local station. These distant transmissions, moreover, are sporadic in nature, with the

[Continued on page 58]

TROPOSPHERIC EFFECTS

Height of Transmitting Antenna (ft.)	Height of Receiving Antenna (ft.)	Power in Kilowatts	Frequency in Megacycles	Separation in Miles For Ratio of Desired to Undesired Signal Shown 2/1	10/1
500	30	300	58	257	290
500	30	300	66	259	295
500	30	300	104	276	306
1000	30	300	58	271	312
1000	30	300	66	272	313
1000	30	300	104	281	319
500	30	1	58	98	170
500	30	1	66	100	176
500	30	1	104	104	193
1000	30	1	58	121	183
1000	30	1	66	123	187
1000	30	1	104	132	213

TABLE I

APPROXIMATE HOURS PER YEAR OF INTERFERENCE AT THE 50 µV/M CONTOUR FROM SPORADIC E LAYER TRANSMISSIONS*

mc.	2:1 ratio, one co-channel station (hours)	2:1 ratio, full channel occupancy (hours)	10:1 ratio, one co-channel station (hours)	10:1 ratio, full channel occupancy (hours)
A. 50 kw stations with an antenna power gain of 6 (300 kw effective radiated power)				
43	132-298	660-1490	166-482	830-2410
58	22-56	110-280	28-96	140-480
48	75-166	375-830	95-280	475-1400
66	8.9-23	44.5-115	11-38	55-190
84	1.1-3.1	5.5-15.5	1.3-5.1	6.5-25.5
104	0.1-0.32	0.5-1.6	0.13-0.52	0.65-2.6
B. 1 kw stations with no antenna gain				
43	0.58-0.87	2.9-4.35	57-86	285-430
58	0.1-0.16	0.5-0.8	9.7-15	48.5-75
48	0.33-0.51	1.65-2.55	33-49	165-245
66	0.03-0.07	0.15-0.35	3.8-6.1	19-30.5
84	less than 1 min.	less than 1 min.	0.5-0.87	2.5-4.35
104	less than 1 min.	less than 1 min.	0.05-0.087	0.25-.43

*Based upon measurements and methods previously described.

TABLE II

APPROXIMATE HOURS PER YEAR OF INTERFERENCE AT THE 100 µV/M CONTOUR FROM SPORADIC E LAYER TRANSMISSIONS*

mc.	2:1 ratio, one co-channel station (hours)	2:1 ratio, full channel occupancy (hours)	10:1 ratio, one co-channel station (hours)	10:1 ratio, full channel occupancy (hours)
A. 50 kw stations with an antenna power gain of 6 (300 kw effective radiated power)				
43	95-173	475-865	157-429	785-2145
58	16-32	80-160	27-81	135-405
48	54-100	270-500	90-247	450-1235
66	6.4-13	32-65	10-33	50-165
84	0.75-1.7	3.75-8.5	1.2-4.5	6.0-22.5
104	0.07-0.18	0.35-0.9	0.12-0.46	0.6-2.3
B. 1 kw stations with no antenna gain				
43	Negligible	Negligible	18-22	90-110
58	Negligible	Negligible	3.1-4.1	15.5-20.5
48	Negligible	Negligible	10-13	50-65
66	Negligible	Negligible	1.2-1.7	6-8.5
84	Negligible	Negligible	0.15-0.23	0.75-1.15
104	Negligible	Negligible	0.013-0.024	0.065-0.120

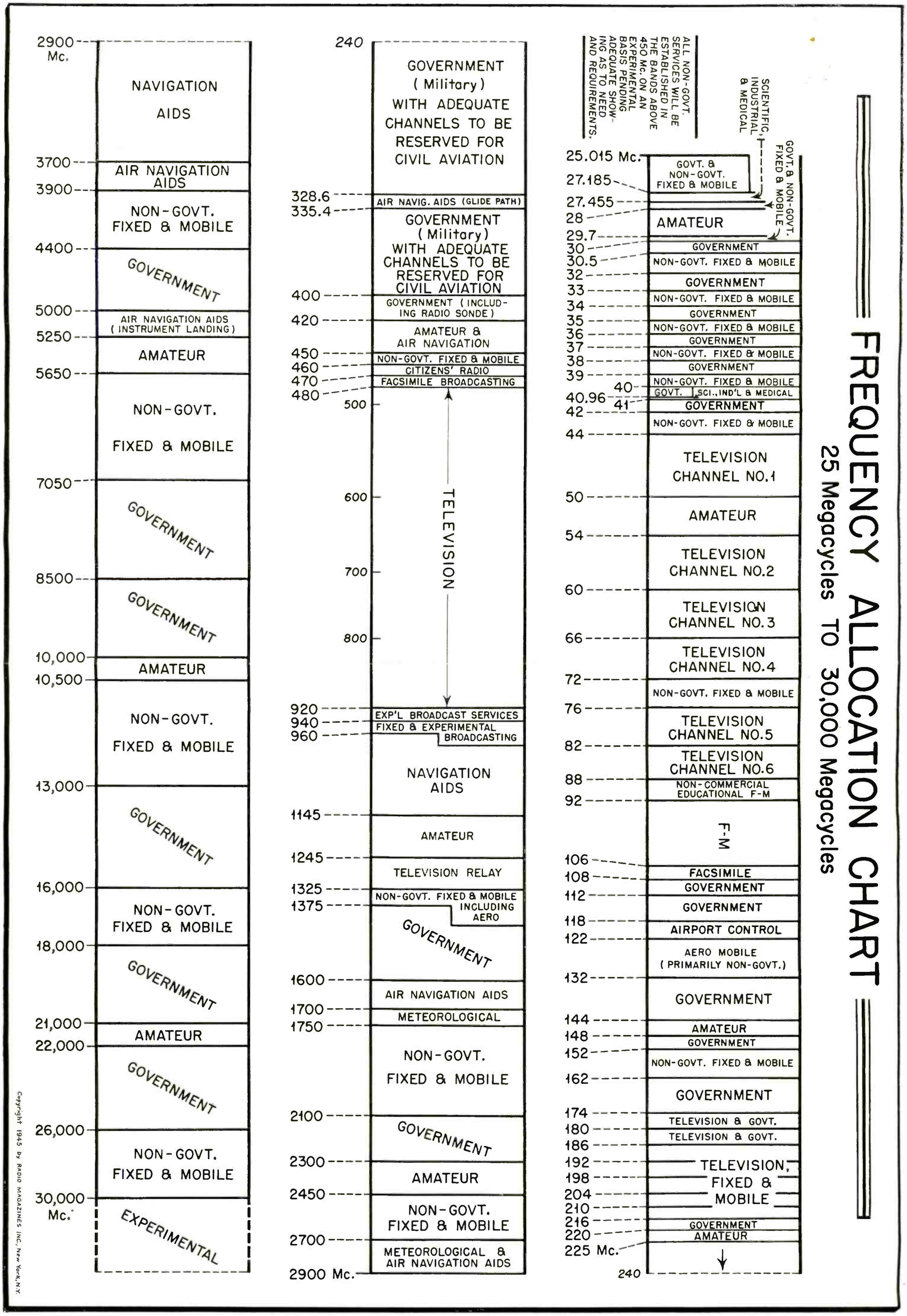
*Based upon measurements and methods previously described.

TABLE III

APPROXIMATE HOURS PER YEAR OF INTERFERENCE AT THE 200 µV/M CONTOUR FROM SPORADIC E LAYER TRANSMISSIONS*

mc.	2:1 ratio, one co-channel station (hours)	2:1 ratio, full channel occupancy (hours)	10:1 ratio, one co-channel station (hours)	10:1 ratio, full channel occupancy (hours)
A. 50 kw stations with an antenna power gain of 6 (300 kw effective radiated power)				
43	47-70	235-350	139-333	695-1665
58	8-13	40-65	24-63	120-315
48	27-40	135-200	80-192	400-960
66	3.2-5.3	16-26.5	9.4-25	47-125
84	0.38-0.7	1.9-3.5	1.1-3.5	5.5-17.5
104	0.03-0.07	0.15-0.35	0.1-0.36	0.5-1.8
B. 1 kw stations with no antenna gain				
43	Negligible	Negligible	1.8-2.5	9-12.5
58	Negligible	Negligible	0.3-0.45	1.5-2.3
48	Negligible	Negligible	1-1.4	5-7
66	Negligible	Negligible	0.12-0.19	0.6-0.95
84	Negligible	Negligible	0.015-0.02	0.075-0.1
104	Negligible	Negligible	0.0013-0.002	0.0065-0.01

*Based upon measurements and methods previously described.


FREQUENCY ALLOCATION CHART
25 Megacycles TO 30,000 Megacycles
25.015 Mc. GOVT. & NON-GOVT. FIXED & MOBILE
27.185
27.455
GOVT. & NON-GOVT. FIXED & MOBILE
SCIENTIFIC, INDUSTRIAL & MEDICAL
ALL NON-GOVT. SERVICES WILL BE ESTABLISHED IN THE BANDS ABOVE 450 Mc. ON AN EXPERIMENTAL BASIS PENDING ADEQUATE SHOWING AS TO NEED AND REQUIREMENTS.
28 AMATEUR
29.7
30 GOVERNMENT
30.5 NON-GOVT. FIXED & MOBILE
32 GOVERNMENT
33 NON-GOVT. FIXED & MOBILE
34 GOVERNMENT
35 NON-GOVT. FIXED & MOBILE
36 GOVERNMENT
37 NON-GOVT. FIXED & MOBILE
38 GOVERNMENT
39 NON-GOVT. FIXED & MOBILE
40 GOVT.
40.96 SCI., IND'L & MEDICAL
41 GOVERNMENT
42 NON-GOVT. FIXED & MOBILE
44 TELEVISION CHANNEL NO. 1
50 AMATEUR
54 TELEVISION CHANNEL NO. 2
60 TELEVISION CHANNEL NO. 3
66 TELEVISION CHANNEL NO. 4
72 NON-GOVT. FIXED & MOBILE
76 TELEVISION CHANNEL NO. 5
82 TELEVISION CHANNEL NO. 6
88 NON-COMMERCIAL EDUCATIONAL F-M
92 F-M
106 FACSIMILE
108 GOVERNMENT
112 GOVERNMENT
118 AIRPORT CONTROL
122 AERO MOBILE (PRIMARILY NON-GOVT.)
132 GOVERNMENT
144 AMATEUR
148 GOVERNMENT
152 NON-GOVT. FIXED & MOBILE
162 GOVERNMENT
174 TELEVISION & GOVT.
180 TELEVISION & GOVT.
186
192
198
204
210
TELEVISION, FIXED & MOBILE
216 GOVERNMENT
220 AMATEUR
225 Mc.
240
240 GOVERNMENT (Military) WITH ADEQUATE CHANNELS TO BE RESERVED FOR CIVIL AVIATION
328.6 AIR NAVIG. AIDS (GLIDE PATH)
335.4 GOVERNMENT (Military) WITH ADEQUATE CHANNELS TO BE RESERVED FOR CIVIL AVIATION
400 GOVERNMENT (INCLUDING RADIO SONDE)
420 AMATEUR & AIR NAVIGATION
450 NON-GOVT. FIXED & MOBILE
460 CITIZENS' RADIO
470 FACSIMILE BROADCASTING
480
500
600
700
800
TELEVISION
920 EXP'L BROADCAST SERVICES
940 FIXED & EXPERIMENTAL BROADCASTING
960 NAVIGATION AIDS
1145 AMATEUR
1245 TELEVISION RELAY
1325 NON-GOVT. FIXED & MOBILE INCLUDING AERO
1375 GOVERNMENT
1600 AIR NAVIGATION AIDS
1700 METEOROLOGICAL
1750 NON-GOVT. FIXED & MOBILE
2100 GOVERNMENT
2300 AMATEUR
2450 NON-GOVT. FIXED & MOBILE
2700 METEOROLOGICAL & AIR NAVIGATION AIDS
2900 Mc.
2900 Mc. NAVIGATION AIDS
3700 AIR NAVIGATION AIDS
3900 NON-GOVT. FIXED & MOBILE
4400 GOVERNMENT
5000 AIR NAVIGATION AIDS (INSTRUMENT LANDING)
5250 AMATEUR
5650 NON-GOVT. FIXED & MOBILE
7050 GOVERNMENT
8500 GOVERNMENT
10,000 AMATEUR
10,500 NON-GOVT. FIXED & MOBILE
13,000 GOVERNMENT
16,000 NON-GOVT. FIXED & MOBILE
18,000 GOVERNMENT
21,000 AMATEUR
22,000 GOVERNMENT
26,000 NON-GOVT. FIXED & MOBILE
30,000 Mc. EXPERIMENTAL

A Circuit For PHASE MODULATION

BERNARD GROB

This article describes a new phase modulation circuit which has proved sucessful in a commercial transmitter

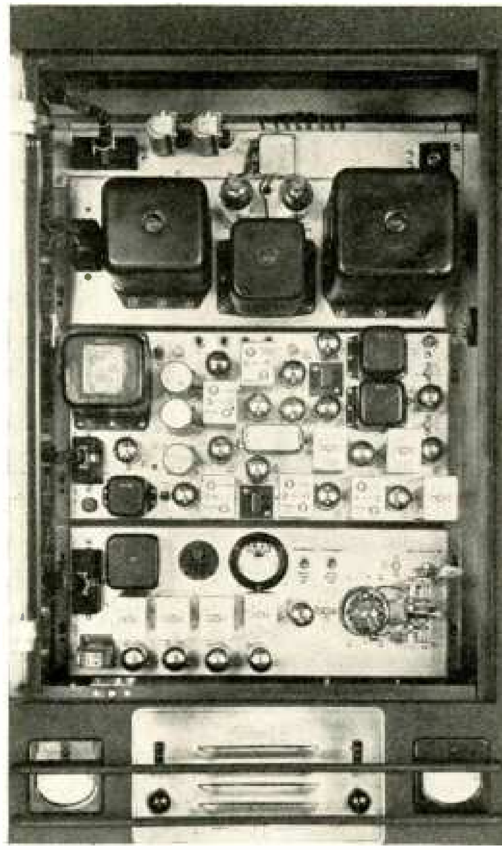


Fig. 1. Link Type 1498 FM Relay Station, 50-watt transmitter-receiver using crystal frequency control

As the use of frequency modulation has increased, new and interesting methods for accomplishing frequency modulation have been developed. One of these is the phase modulator circuit employed in the transmitter component of the Fred M. Link Model 1498 Relay Station. The equipment is shown in *Fig. 1*, the complete unit consisting of an f-m transmitter, f-m receiver, and transmitter power supply, all mounted on a relay rack in one cabinet. In *Fig. 2* is shown the remote control unit that can be used to control the equipment from a remote position.

The schematic diagram of the phase modulator circuit is illustrated in *Fig. 3*. One section of the 7F7 twin triode is used for the modulator, the other triode section, (not shown), serving as a crystal controlled oscillator. T_1 is the microphone transformer. L_1 and C_2 form

Fig. 2. Remote control desk unit

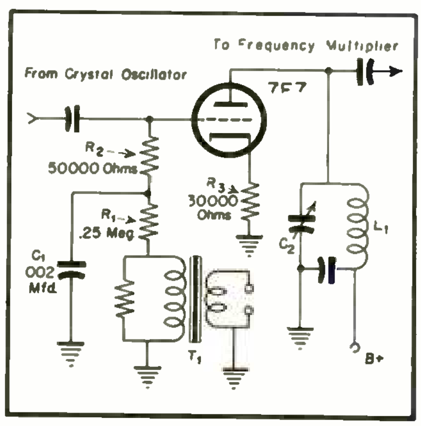


Fig. 3. Schematic of phase modulator circuit

the plate tank circuit, tuned to the oscillator frequency. R_2 is the grid load resistor, and R_3 is the unby-passed cathode resistor. C_1 and R_1 make up an audio corrector circuit whose function will be explained later. This compact circuit has the advantage of simplicity plus the frequency stability of crystal control, in addition to the many advantages inherent with frequency modulation.

In this circuit the radio-frequency signal from the crystal oscillator is shifted in phase by an amount proportional to the audio modulation voltage, resulting in a phase modulated output. This phase modulation is accomplished by means of an output voltage across the plate tank circuit which is the resultant of two voltages of different phase. One is due to the amplification of the tube, and the other is due to the inter-electrode capacitance between grid and plate. The phase of this latter voltage is shown in the simplified diagram of *Fig. 4*. Here, the grid voltage acts as a generator, E_g, the grid-plate capacity as C_{pg}, and the plate load is the resistance, R_L, since the tank circuit is tuned to resonance. In this a-c circuit the capacitive reactance due to C_{pg} will result in a capacitive current, I_c, that leads the generator voltage. Let this leading phase angle be 30 degrees. The voltage across R_L is in phase with the current I_c. Therefore the voltage across the plate load due to the grid-plate capacitance, E_c, leads the grid voltage by 30 degrees. Since the plate load is resistive, the voltage across R_L which is due to the amplification of the tube, E_a, will be 180 degrees out of phase with the grid voltage E_g.

Plate Tank Voltage

The actual voltage across the plate tank, E_r, is the resultant of E_a and E_c, which are 150 degrees out of phase with each other. With the vector lengths for E_a and E_c shown in *Fig. 5a*, the resultant, E_r, leads E_a by 60 degrees. This is true so long as E_a is of constant amplitude. However, when an audio modu-

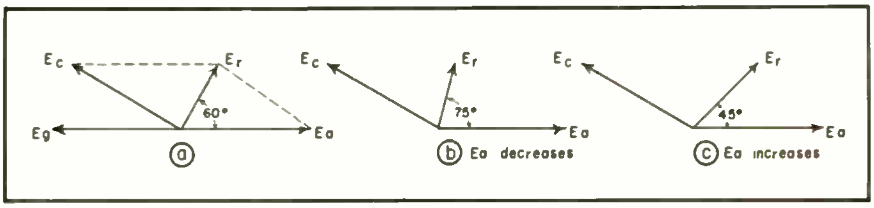


Fig. 5. Vector diagrams of plate tank voltage. See text

lating voltage is impressed on the modulator grid, varying the grid voltage, the amplitude of E_a is also varied at the audio rate. The resultant voltage, E_r, will then change in phase as the magnitude of E_a varies, as illustrated in *Figs. 5b* and *c*. In order to produce degeneration, and thereby reduce the magnitude of amplitude variations of E_a, the cathode resistor is not by-passed. This minimizes the amount of amplitude modulation in the output.

The output radio-frequency signal, then, is phase modulated because its phase with respect to the fixed reference, E_a, changes in direct proportion to the audio modulating voltage. As shown in *Fig. 6*, at the positive peak of the audio voltage there is the maximum amount of phase change in one direction. At zero audio voltage there is no change in phase. At the negative audio peak there is the maximum change of phase in the opposite direction. The fixed phase angle "at rest", where ϕ equals 60 de-

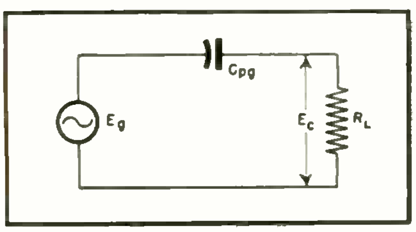


Fig. 4. Phase shift due to tube capacitance

grees, contributes nothing to the modulation, but is merely the starting point for the phase modulation.

Mathematical Analysis

This voltage of varying phase can be described by the equation

$$e_r = E_r \sin(\Omega t + \alpha) \quad (1)$$

where e_r = the instantaneous value of the r-f signal voltage.
Ω = the angular velocity of the r-f signal voltage.
α = a varying phase angle whose value depends on the audio modulating voltage.

As shown in *Fig. 6*, this varying phase angle is equal to the fixed angle ϕ plus or minus any change in angle due to modulation. The amount of the change in angle "follows" the audio voltage, and the maximum change in angle is $\Delta\phi$. Therefore α may be written

$$\alpha = \phi + \Delta\phi \sin \omega t \quad (2)$$

where ϕ = the fixed phase angle "at rest"
$\Delta\phi$ = the maximum change in phase angle, which occurs for maximum audio voltage
ω = the angular velocity of the audio signal

Substituting equation 2 in equation 1

$$e_r = E_r \sin[\Omega t + (\phi + \Delta\phi \sin \omega t)] \quad (3)$$

Equation 3 completely describes this phase modulated radio frequency voltage, with angular velocity Ω, maximum amplitude E_r, initial phase ϕ and a varying phase corresponding to the audio modulating voltage.

This continuous change in phase is equivalent to a change in frequency because there can be no change in one without a change in the other. Further examination of equation 3 will show the connection between phase modulation and the equivalent f.m. Since the general equation for a sine wave is $e = E \sin \theta$, the quantity $[\Omega t + (\phi + \Delta\phi \sin \omega t)]$ must equal θ where θ is the instantaneous angle through which the vector E_r has turned, including any change in phase angle. Also, since in general, $d\theta = \Omega dt = 2\pi F_t\, dt$, then $F = \frac{1}{2\pi}\frac{d\theta}{dt}$. Therefore, in order to find the instantaneous frequency due to the changing angle θ, it is only necessary to differentiate θ with respect to t.

$$F_t = \frac{1}{2\pi}\frac{d\theta}{dt} = \frac{1}{2\pi}\frac{d}{dt}[\Omega t + (\phi + \Delta\phi \sin \omega t)]$$

$$= \frac{1}{2\pi}[\Omega + \omega\, \Delta\phi \cos \omega t]$$

$$= \frac{\Omega}{2\pi} + \frac{\omega}{2\pi}\Delta\phi \cos\ t$$

$$F_t = F + f\, \Delta\phi \cos \omega t$$

center frequency; change in instantaneous frequency due to modulation

Note that the change in frequency is proportional to f, the audio modulating frequency. Therefore, for audio signals of the same amplitude, higher frequencies will give more frequency deviation. In order to correct for excessive frequency deviation at high audio frequencies, and to allow use of the usual f-m detector, an RC circuit is used as an audio corrector circuit to provide an audio modulating voltage that is inversely proportionnal to the modulating frequency. This RC circuit cancels the f factor in $f\, \Delta\phi \cos \omega t$, making the frequency deviation dependent only on the amount of phase change, which is pro-

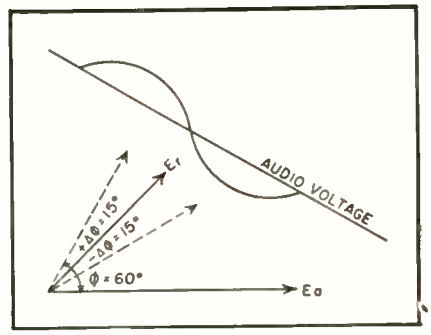


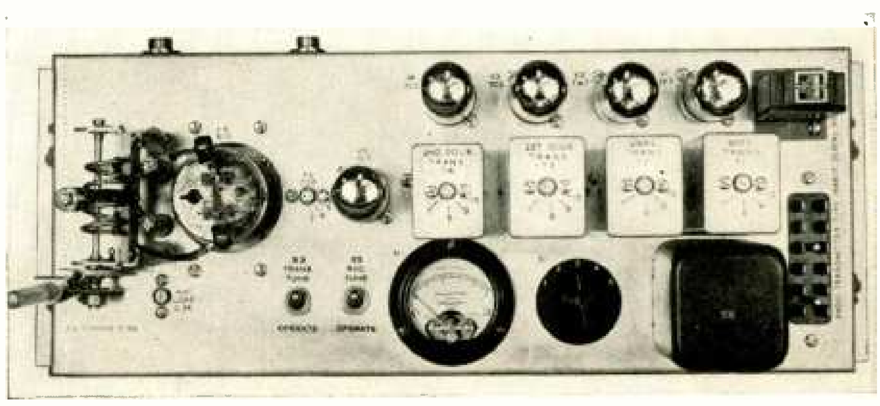
Fig. 6. Phase change is a maximum for positive and negative peaks of audio voltage

portional to the amplitude of the audio voltage.

Audio Corrector Circuit

R_1 and C_1 form the RC audio corrector circuit. They are connected as a voltage divider across the secondary of T_1, with C_1 in series with the modulator grid resistor R_2 to ground. Since the small reactance of C_1 at radio frequencies grounds R_2 for radio frequencies, but not for audio, the audio voltage across C_1 is the modulation voltage applied to the grid tin series with the radio frequency voltage across R_2 from the crystal oscillator. This audio voltage is inversely proportional to the audio frequency f, thus correcting the frequency deviation of the radio frequency signal.

In conclusion, then, this phase modulation circuit provides an f-m signal, with crystal control. In actual operation in the field it has given trouuble-free service, with all the advantages of f.m. The equipment has been used in a radiotelephone network with excellent results —stable in operation and free from interference.



Top view of Link power amplifier chassis, type 1498-T

A Direct Reading C-R-L Impedance Bridge

ATHAN COSMAS, Engineer, Station WQXR

Design and constructional data on a useful laboratory instrument

Because of the difficulty of obtaining commercal bridges, such as the General Radio Type 650-A, the author undertook last year the design and construction of a simplified instrument for measuring capacity, resistance, and inductance. This bridge was designed around components which were low in cost and not subject to priorities. Considering these limitations, the results secured were very satisfactory. This instrument was described elsewhere.*

The instrument to be described utilized the same basic bridge circuits but has greatly improved accuracy and convenience of operation, adapting it to the exacting needs of laboratories. It includes an internal d-c supply, 1000-cycle signal source, and null indicator. Provision is made for using an external null indicator, d-c power, or signal source, by means of switches.

The following bridge circuits are provided:

1. Capacity Bridge (low power factor)
2. Capacity Bridge (high power factor)
3. Wheatstone Bridge
4. Maxwell Inductance Bridge (low Q)
5. Hay Inductance Bridge (high Q)

These fundamental bridge circuits are illustrated in *Fig. 1*. By means of a selector switch, any one of these five circuits may be rapidly chosen.

*"An Inexpensive Impedance Bridge", Athan Cosmas, *QST*, July, 1944

Photos for this article by Robert E. Cobaugh.

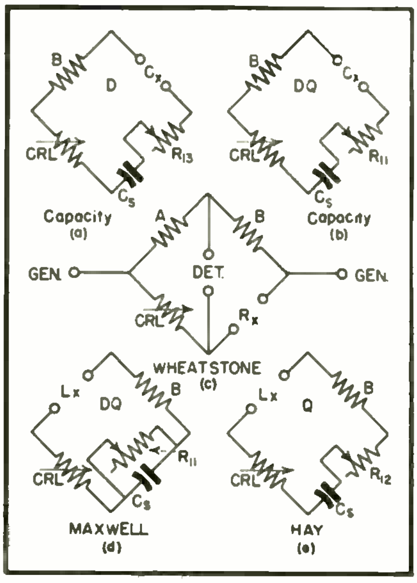
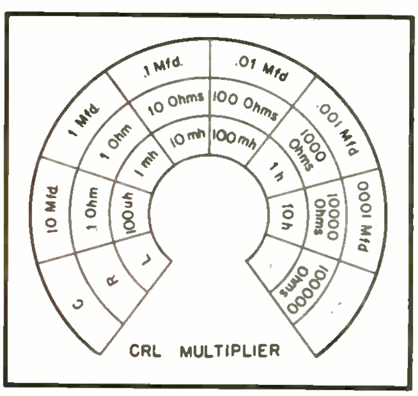
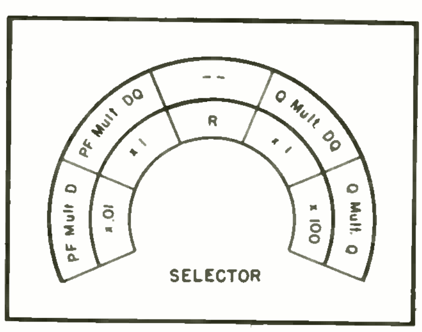


Fig. 1. Fundamental circuits used in impedance bridge





Layout for CRL multiplier (left) and (above) selector dials

The complete schematic of the bridge is shown in *Fig. 2*. The switch S_2 is used to select the desired bridge circuit. With this switch in the *CD* or CDQ position, the circuit is that of a standard capacity bridge. In the *R* position, it becomes a conventional Wheatstone bridge. The LDQ position provides a Maxwell bridge arrangement for measuring apparent inductance for Qs up to 10. The final position, *LQ* connects the necessary bridge components to form a Hay bridge, to measure apparent inductance of components with Qs up to 1000.

The range of the CRL Bridge is as follows:

Selector switch	Minimum	Maximum
CD (low p.f.)	1 μμf	100 μμf
CDQ (high pf.)	1 μμf	100 μμf
R	1 milliohm	1 megohm
LDQ (low Q)	1 μf	100 h
LQ (high Q)	1 μf	100 h

Resistance Measurement

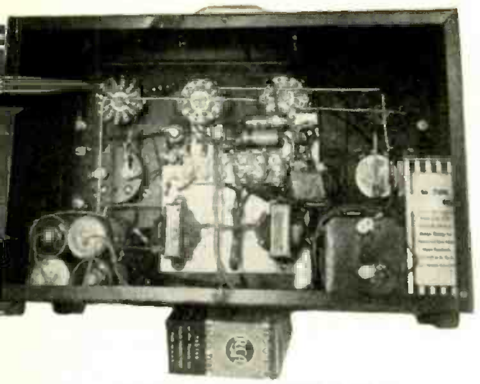
Referring to *Fig. 1* (*c*), the basic circuit for the Wheatstone bridge consists of four resistance arms, the unknown resistance being connected in the R_x arm. Fixed resistors are employed in two arms, *A* and *B*, the values of which are selected by the dual tap switch S_1 (*Fig. 2*). The third arm is the calibrated variable resistor *CRL*. A galvanometer (*G*, in *Fig. 2*) is used as a null indicator. At balance,

$$A/B = \text{"CRL"}/R_x$$

whence

$$R_x = B\,\text{"CRL"}/A$$

In operation, the unknown resistor is connected to the lower left-hand binding posts, S_3 is set at Galv. Shunt. and the generator switch S_4 at DC. The CRL multiplier tap is then adjusted to the proper range, if known. Then press the



Bottom view of CRL bridge

push-button (S_5), competing the galvanometer circuit. Adjust the CRL dial for zero reading. Then set S_3 to "Galv." and re-adjust the CRL dial for precise balance. The value of the unknown resistance is read directly from the *CRL* dial (times the *CRL* multiplier factor, see Table 1).

Capacity Measurement

Referring to *Figs. 1* (*a*) and (*b*), the reactance of an unknown capacitor C_x is determined from the expression for bridge balance

$$\frac{B}{1/C_x} = \frac{\text{"CRL"}}{1/C_s}$$

whence

$$C_x = \frac{B}{\text{"CRL"}} C_s$$

The standard capacitor is C_s (C_2 in *Fig. 2*). Table 1 shows the multiplying factor, as determined by the setting of the CRL Multiplier for direct reading of capacity on the CRL dial.

Power Factor

A close approximation of the power factor of a capacitor is given by the ratio R/X, which is known as the dissipation factor. R is the equivalent series resistance of the unknown capacitor and X is its reactance. Assuming the standard to have negligible losses, resistance introduced into the C_s arm sufficient to afford a sharp balance serves as a means of determining the dissipation factor. When the resistance in the C_s arm equals that of the C_x arm, the losses in each arm are equal and the amount of resistance introduced into the C_s arm is

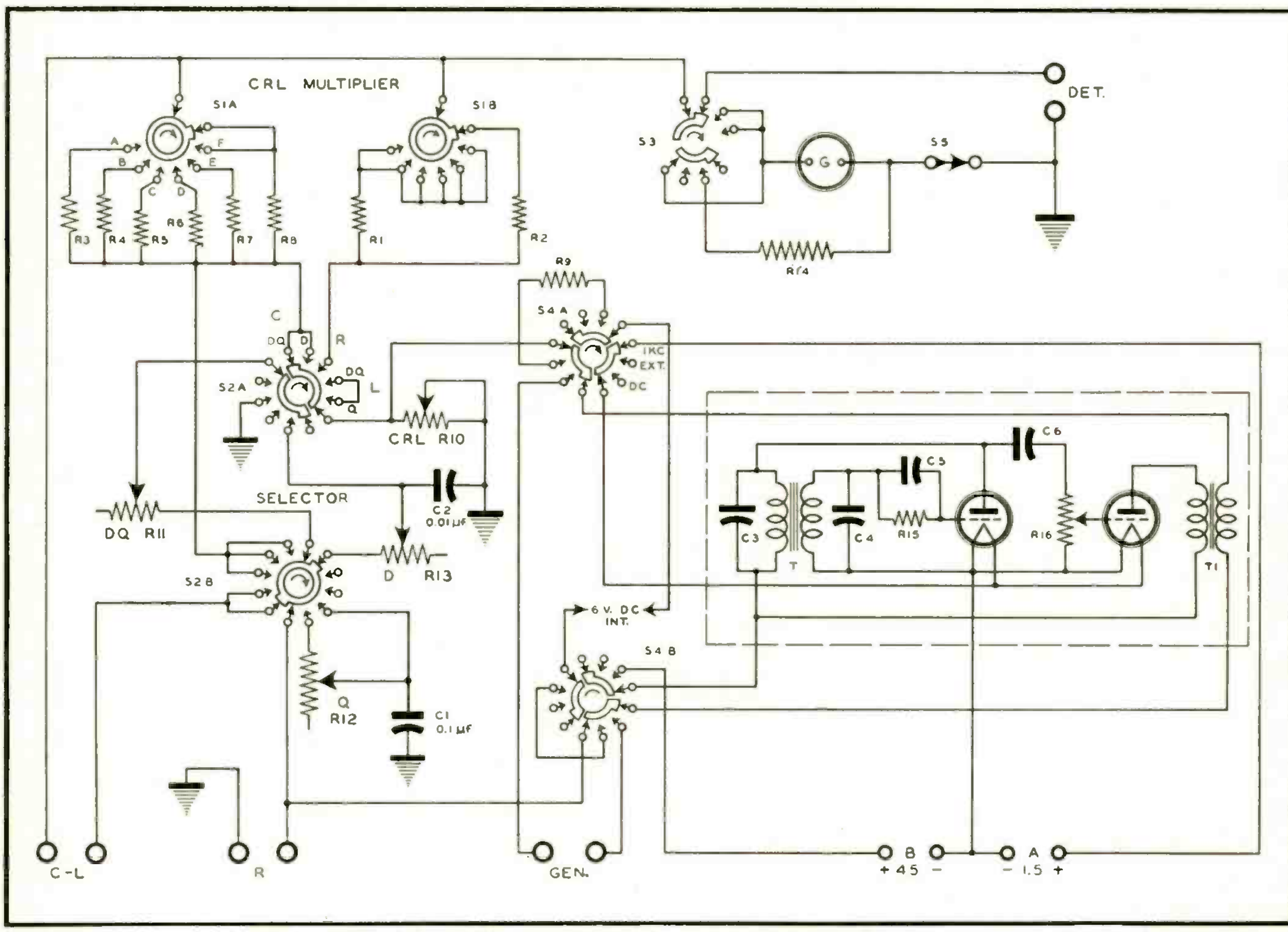


Fig. 2. Complete schematic of the CRL Impedance bridge

PARTS LIST

R_1 10,000 ohms (#8119)
R_2 1,000 ohms (#8111)
R_3 1 ohms (#8102)
R_4 10 ohms (#8103)
R_5 100 ohms (#8106)
R_6 1,000 ohms (#8111)
R_7 10,000 ohms (#8119)
R_8 100,000 ohms (#8131)
(R_1–R_8:) Ohmite Riteohm Type 81 Precision (1%) Wirewound (Noninductive) See text
R_9 60 ohms
R_{10} 10,000 ohms, General Radio Type 371-T (See text)
R_{11} 20,000 ohms (Linear taper—wirewound)
R_{12} 200 ohms (Logarithmic taper—wirewound)
R_{13} 2,000 ohms (Linear taper—wirewound)
(R_{11}–R_{13}:) Centralab, Clarostat or equivalent
R_{14} Galv. Shunt (Will depend upon type of Galv. used.)
R_{15} 1 megohm ½ watt.
R_{16} .25 megohm pot.

C_1 .1 μf "Bridge selected" (Stacked micas)
C_2 .01 μf "Bridge selected" Mica
C_3 .25 μf
C_4 .015 μf mica
C_5 250 μμf mica
C_6 .1 μf (paper)
T Stancor "Victory Model" (Core removed)
T_1 UTC S-14 (With 500 ohm output)
S_1 2 Gang, 2 pole, 7 position rotary (Centralab #(1413)
S_2 2 Bang, 4 pole, 5 position rotary (Centralab #2515)
S_3 1 Gang, 2 pole, 3 position rotary (Centralab #1405)
S_4 2 Gang, 6 pole 3 position rotary (Centralab #1417)
S_5 Push button, Utah-Carter Type 1s-13
Cabinet: 7 x 9 x 15 Bud # CU-882
Galv.: (Presently using an "offset" Gruen Microammeter, 150 microamps full scale deflection) See text

TABLE ONE			
	CRL MULTIPLIER		
	C (µf)	R (ohms)	L
A	10	.1	100 µh
B	1	1	1 µh
C	.1	10	10 µh
D	.01	100	100 µh
E	.001	1,000	1 h
F	.0001	10,000	10 h
G	——	100,000	——
PF	CD	MULTIPLY BY .01	D
	CDQ	MULTIPLY. BY .1	DQ
Q	LDQ	MULTIPLY BY 1	DQ
	LQ	MULTIPLY BY 100	Q

equivalent to the series resistance of the unknown capacitor in the C_x arm. This is done by means of the variable resistors *CD* (R_{13})—2,000 ohms and CDQ (R_{11})—20,000 ohms. The dissipation factor is then determined by substitution in the following formula

Dissipation factor $= (2\pi fC)R_s$

where

f = frequency in cycles of applied voltage

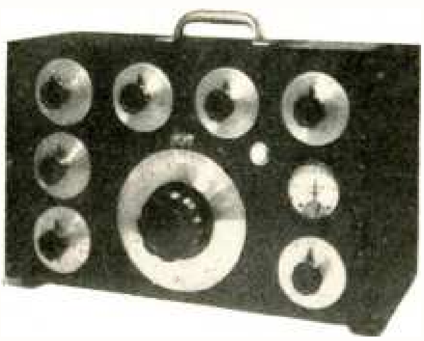
C = capacity of capacitor in farads

R_s = series resistance in ohms

Inductance Measurements

The Maxwell and Hay bridges differ principally in the range of Q which may be measured.

Because the impedance of a coil is proportional to its inductance while the



Panel of Impedance Bridge

reactance of a capacitor is inversely proportional to its capacity, the condition for balance for either bridge circuit is

$$\frac{L_x}{B} = \frac{\text{"}CRL\text{"}}{1/C_s}$$

Therefore

$$L_x = B(\text{"}CRL\text{"})C_s$$

Thus the product of $B \times$ "*CRL*" is the factor by which the numerical value of C_s must be multiplied to determine the value of the unknown inductance.

As in the case of capacity measurements, it will be found necessary to balance resistive as well as reactive components in the non-resistive arms. The amount of resistance which must be added in the capacitive arm to obtain a sharp balance serves as a means of measuring *Q* (or *X/R*) of the coil under test.

$$Q = 1/2\pi fCR$$

The range of *Q* which may be measured with the Maxwell bridge is up to 10 and for the Hay bridge, to 1000. It should be remembered that all values of *CR* and *L* are direct reading on the *CRL* dial by applying the unit multiplying factors indicated in Table 1.

Construction

Obviously one of the most important parts of the bridge is the CRL calibrated resistor. The General Radio potentiometer Type 371-T is recommended since it has the required taper by which the low end of the CRL calibration can be opened up. If this is unobtainable a 15,000 ohm Clarostat (Type W) wire-wound potentiometer, shunted by a 41,000 ohm resistor will provide a taper in which the low end can be opened up. This will be adequate but not as desirable as the 371-T. A Clarostat 15,000 ohm Type V might be used without the shunting resistor. Then, too, it is possible to substitute a four section resistance decade for the CRL pot.

The absolute accuracy of measurements made with the bridge will naturally depend upon the accuracy of the fixed resistors and capacitors used as standards, as well as the accuracy of calibration.

In this instance, "bridge selected" condensers and Ohmite Riteohm Type 81 1% resistors were used. The resistors were checked on a bridge and fortunately averaged much closer than one per cent.

If precision resistors are unobtainable, they can be made with a little effort. Study of the wire tables will show that ordinary copper wire magnet wire may be used in constructing the low ohm standards, while meter multipliers might be used for the higher values.

For example, the wire table shows that #28 wire has a resistance of 66.2 ohms per 1000 feet, or 0.0662 ohms per foot. Therefore a length of 16 feet will have a resistance of 1.0392 ohms.

The resistances R_1 through R_4 must be of the non-inductive type. *Fig. 3* shows how the low ohm (1, 10 and 100) resistors can be made. The two ends of the wire are first soldered to the terminals at the end of the strip. The two

TABLE THREE THIS TABLE SHOWS HOW THE DQ, D AND Q DIALS SHOULD BE MARKED TO BE DIRECT READ-ING FOR EACH RESISTANCE SETTING OF R_{11}, R_{13} AND R_{12} RESPECTIVELY:					
DQ (R_{11})		D (R_{13})		Q (R_{12})	
DIAL	OHMS	DIAL	OHMS	DIAL	OHMS
0	0	0	0	0.10	165
0.1	160	0.1	16	0.12	138
0.5	800	0.2	32	0.14	113
1.0	1600	0.4	64	0.16	103
1.5	2400	0.6	96	0.18	92.5
2.0	3200	0.8	128	0.2	83.0
3.0	4800	1.0	160	0.25	66.3
4.0	6400	2.0	320	0.3	54.3
5.0	8000	3.0	480	0.35	46.6
6.0	9600	4.0	640	0.40	40.3
7.0	11200	5.0	800	0.45	35.6
8.0	12800	6.0	960	0.5	32.0
9.0	14400	7.0	1120	0.6	26.8
10.0	16000	8.0	1280	0.7	23.0
—	—	9.0	1440	0.8	20.1
—	—	9.5	1520	0.9	17.7
—	—	10.0	1600	1.0	16.1
—	—	—	—	1.5	10.8
—	—	—	—	2.0	8.1
—	—	—	—	3.0	5.95
—	—	—	—	4.0	4.1
—	—	—	—	5.0	3.27
—	—	—	—	10.0	1.7

half-lengths of wire are then close wound in opposite directions. The looped end is pulled through the holes at the left of the bakelite strip. The one ohm "standard" is then connected to the R_x terminals of a Wheatstone Bridge — pre-set to the correct value. Insulation is removed from the loop end and the wire is twisted (reducing the total value of resistance) until a balance is indicated. When this point is reached, the junction is soldered and the excess wire cut away.

The 1000 and 10,000 ohm standards can be made by turning down some ½" bakelite rods in pies. In the first model of this bridge some 80-ohm-per-foot wire, with about 250 ohms per pie for the 1000 ohm resistors, were used. Direction of winding reverses in each pie. The 10,000 ohm standards require 2500 ohms per pie. Slightly more than the required amount is placed in the last pie. This permits trimming to precise value by means of a bridge. Two 50,000 ohm 1% meter multipliers were used for the 100,000 ohm standard.

Calibration

It is suggested that the *R* portion of the bridge be wired up first. The wiring

[*Continued on page 62*]

TABLE TWO THIS TABLE SHOWS HOW THE CRL DIAL CONTROLLING R_{10} SHOULD BE CALIBRATED											
CRL	OHMS	CRL	OHMS	CRL	OHMS	CRL	OHMS	CRL	OHMS	CRL	OHMS
0	0	1.0	1000	2.0	2000	4.0	4000	6.0	6000	8.0	8000
0.05	50	1.05	1050	2.1	2100	4.1	4100	6.1	6100	8.1	8100
0.1	100	1.1	1100	2.2	2200	4.2	4200	6.2	6200	8.2	8200
0.15	150	1.15	1150	2.3	2300	4.3	4300	6.3	6300	8.3	8300
0.2	200	1.2	1200	2.4	2400	4.4	4400	6.4	6400	8.4	8400
0.25	250	1.25	1250	2.5	2500	4.5	4500	6.5	6500	8.5	8500
0.3	300	1.3	1300	2.6	2600	4.6	4600	6.6	6600	8.6	8600
0.35	350	1.35	1350	2.7	2700	4.7	4700	6.7	6700	8.7	8700
0.4	400	1.4	1400	2.8	2800	4.8	4800	6.8	6800	8.8	8800
0.45	450	1.45	1450	2.9	2900	4.9	4900	6.9	6900	8.9	8900
0.5	500	1.5	1500	3.0	3000	5.0	5000	7.0	7000	9.0	9000
0.55	550	1.55	1550	3.1	3100	5.1	5100	7.1	7100	9.1	9100
0.6	600	1.6	1600	3.2	3200	5.2	5200	7.2	7200	9.2	9200
0.65	650	1.65	1650	3.3	3300	5.3	5300	7.3	7300	9.3	9300
0.7	700	1.7	1700	3.4	3400	5.4	5400	7.4	7400	9.4	9400
0.75	750	1.75	1750	3.5	3500	5.5	5500	7.5	7500	9.5	9500
0.8	800	1.8	1800	3.6	3600	5.6	5600	7.6	7600	9.6	9600
0.85	850	1.85	1850	3.7	3700	5.7	5700	7.7	7700	9.7	9700
0.9	900	1.9	1900	3.8	3800	5.8	5800	7.8	7800	9.8	9800
0.95	950	1.95	1950	3.9	3900	5.9	5900	7.9	7900	9.9	9900
—	—	—	—	—	—	—	—	—	—	10.0	10000

RADIO DESIGN WORKSHEET

NO. 38—IMAGE SUPPRESSION; CONSIDERATIONS INVOLVED IN CHOICE OF INTERMEDIATE FREQUENCY

IMAGE SUPPRESSION

One of the early difficulties of double detection receivers was that due to undesired responses. One of the most troublesome of the undesired responses was the so-called "image frequency." *Fig. 1* illustrates a first detector fed by an antenna. Let the incoming desired signal be 40 mc. The frequency of the oscillator might be 42 mc. This would produce beat notes of 40 plus 42, or 82 mc, which would be eliminated by the fixed tune i-f filters, and 42 minus 40, or 2 mc, which would be accepted by the i-f filters. However, an interfering signal of 44 mc applied to the antenna would be attenuated by the antenna tuned circuit but that part of the interference which did reach the grid of the first detector would likewise produce a beat note of 2 mc. Thus 44 plus 42 = 86 mc would not be accepted by the i-f filter but 44 minus 42 would be accepted. This is the so-called image frequency, which differs from the desired signal by twice the intermediate frequency.

One method of reducing this type of interference is to use two or more tuned circuits between the antenna and the first detector, as in *Fig. 2*. This method attenuates the undesired interfering frequency reaching the first detector grid by something more than the square root of that reaching it in *Fig. 1*. This might also have been accomplished by using an amplifier between the tuned circuits as in *Fig. 3*. In the case of *Fig. 2*, the desired signal reaching the first detector grid is reduced 6 db or more over that of *Fig. 1*. The circuit of *Fig. 2* remedies this situation and correspondingly improves the signal-to-receiver-noise ratio. The circuit of *Fig. 3* represents one of the best methods of reducing undesired response from an interfering r-f signal. Cheaper methods were sought, however, and a number of well-known image suppression circuits came into being.

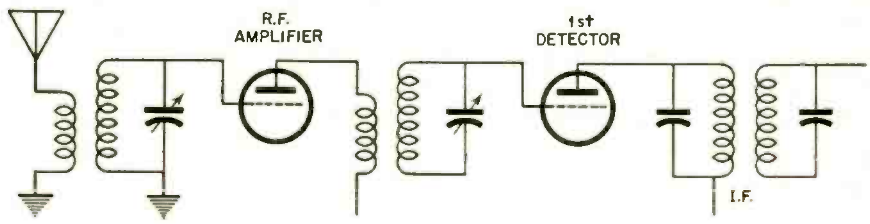


Figure 3

One of these is illustrated in *Fig. 4*. In this circuit the first detector grid is connected to a suitable tap on the tuned circuit secondary winding. This causes a corresponding reduction in desired signal voltage and first circuit noise as well that reaches the grid of the first detector. The tap is properly chosen in this case so that L_2C is resonant (or nearly so) at the image frequency. This forms a shunting series resonant circuit at the image frequency which greatly attenuates it. The shunt resonant circuit $(L_1 + L_2)C$ is, however, tuned to the desired frequency, which is lower than the interfering image frequency. Thus, in the case cited above, $(L_1 + L_2)C$ would be resonant at 40 mc, while L_2C would be series-resonant at 44 mc.

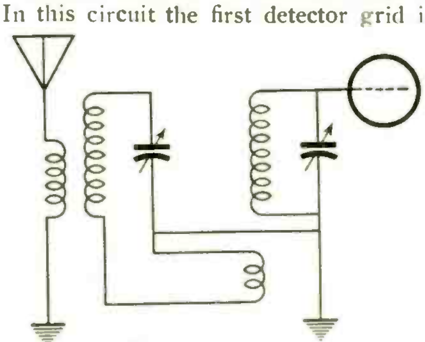


Figure 2

Fig. 5 illustrates another image suppression circuit which has been quite popular. In general, this circuit is not as effective as the circuit of *Fig. 4*. In this arrangement the signal frequency, the oscillator frequency, and the image frequency appear in the feedback cathode circuit coil, and are fed back into the antenna circuit. The voltage transferred to the antenna primary will be greater for the higher frequencies than for the lower signal frequency. Consequently more of the image frequency will be fed back than signal frequency. All the voltages thus fed back are phased so that they will subtract from the voltage induced in the antenna. As a result, there is some reduction of signal voltage which will reduce the signal to first circuit noise ratio. This did not occur in the arrangement of *Fig. 4*, where signal and thermal noise are reduced in like amount and their ratio is unaffected. Probably the greatest disadvantage of the circuit of *Fig. 5* lies in the practical difficulty of adjusting the circuit constants to function properly over the whole tuning band. This results partly from the fact that the selectivity of the antenna tuned circuit decreases as the frequency increases and partly from the fact that the phase angle of the tuned circuit varies more rapidly than the attenuation. This is illustrated by *Fig. 6*.

This figure may be computed as follows:

At resonance $I_o = E/R$

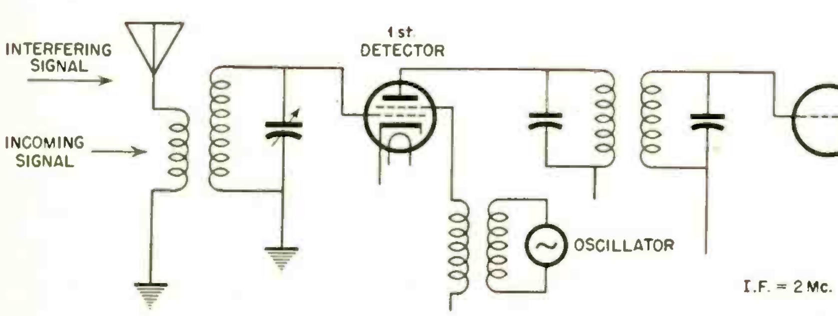


Figure 1

At any other frequency

$$I = \frac{E}{\sqrt{R^2 + X^2}}$$

Let

$$K = \frac{I}{I_0} = \frac{R}{\sqrt{R^2 + X^2}} = \frac{1}{\sqrt{1 - \tan^2 \theta}}$$

$$\text{phase angle} = \phi = \pm \tan^{-1} \frac{\sqrt{1-K^2}}{K}$$

where

$$X = \omega L - \frac{1}{\omega C}$$

From *Fig. 6* it will be noted that

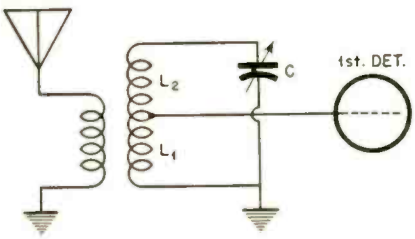


Figure 4

when the phase angle is 45° the signal amplitude is still seven-tenths that at resonance. This illustrates the practical difficulties of keeping the circuits of *Fig. 5* properly phased over a wide frequency band without manual adjustment.

The best circuit arrangement from the standpoint of performance is probably a single tuned circuit coupling the antenna to the r-f amplifier, followed by a double tuned coupled circuit coupling the amplifier to the first detector. Such a circuit is shown in *Fig. 7*.

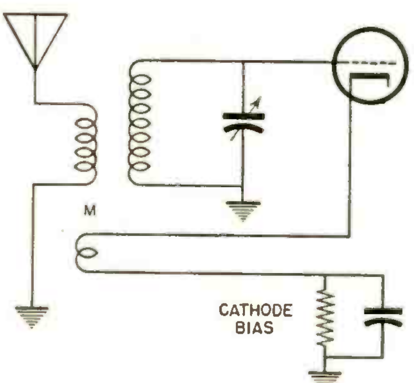


Figure 5

This arrangement obviously yields optimum antenna step-up, optimum signal-to-thermal-noise ratio and has an image response which is the cube root of that for *Fig. 1*.

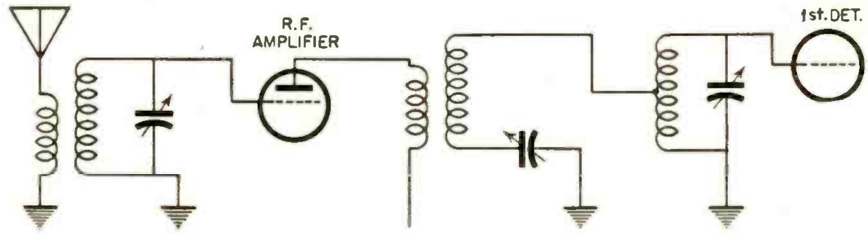


Figure 7

CONSIDERATIONS INVOLVED IN CHOICE OF INTERMEDIATE FREQUENCY

The choice of the proper intermediate frequency for superheterodyne broadcast receivers has at various times in the past come up for much discussion. It is now pretty well settled at 465 kc and the F.C.C. has cleared this part of the spectrum to prevent interference. However, the first intermediate frequency to be widely used was 30 kc. Later 50 kc became popular, then 175 kc was used for many years. It would appear instructive to inquire into some of the important considerations involved in the choice of the optimum intermediate frequency.

Some of the boundary conditions are:

1. The intermediate frequency must be at a sufficiently high frequency that two incoming signals differing in frequency by an amount equal to the intermediate frequency cannot feed through the radio-frequency circuits and cause audible interference (see *Fig. 8*). This is obviously influenced by the r-f attenuation embodied in the receiver.

2. The intermediate frequency must be sufficiently high to permit the radio frequency circuits to offer about 60 db attenuation to the image frequency.

3. The intermediate frequency must not be so high that good sensitivity and selectivity at moderate cost cannot be attained.

4. The intermediate frequency must not be so high that its second or third harmonic falls in the band to be received. Such harmonics may be generated by the intermediate frequency tubes or by the second detector and fed back to the first detector through coupling in the wiring.

5. The intermediate frequency should not fall on or too near the frequency of any nearby transmitters which might be strong enough that some of the signal from such transmitters would feed through the radio-frequency circuits or be picked up by exposed wiring in circuit elements and thus be amplified to cause interference.

6. The intermediate frequency should be chosen to reduce all modulator products that fall in the intermediate-frequency or radio-frequency band to a minimum. While there are an unlimited number of possible combinations, some of the most important are:

Oscillator frequency beating with second harmonic of signal

Second harmonic oscillator beating with signal

Oscillator frequency beating with third harmonic of signal

Third harmonic of oscillator beating with second harmonic of signal

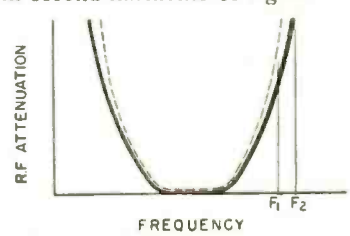


Figure 8

Second harmonic of oscillator beating with third harmonic of signal

Third harmonic of oscillator beating with signal

Such a list could be extended to perhaps 30 undesired responses for the broadcast band alone. When the spectrum of the broadcast and international short wave bands is considered, the number of important responses may number several thousand.

It is of utmost importance that sufficient radio-frequency circuits be used. However such circuits are much more expensive than the fixed tuned intermediate frequency circuits, so that economy dictates that no more of them than required be used. Let the Q of the radio frequency circuits vary from 50 which represents a poor circuit to 200 which is extremely good. The table below illustrates the attenuation in decibels at 1%, 5% and 10% of turns for one tuned circuit.

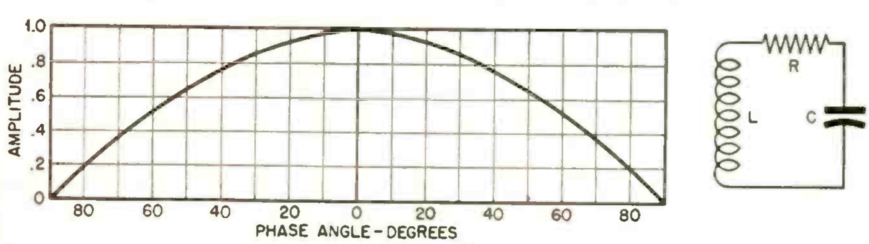


Figure 6

ADJACENT CHANNEL ATTENUATION FOR SINGLE TUNED CIRCUIT, VARYING Q

Q	1%	5%	10%
50	3 db	13.5 db	20 db
100	7 db	20 db	26 db
150	10 db	23 db	28 db
200	12 db	26 db	32 db

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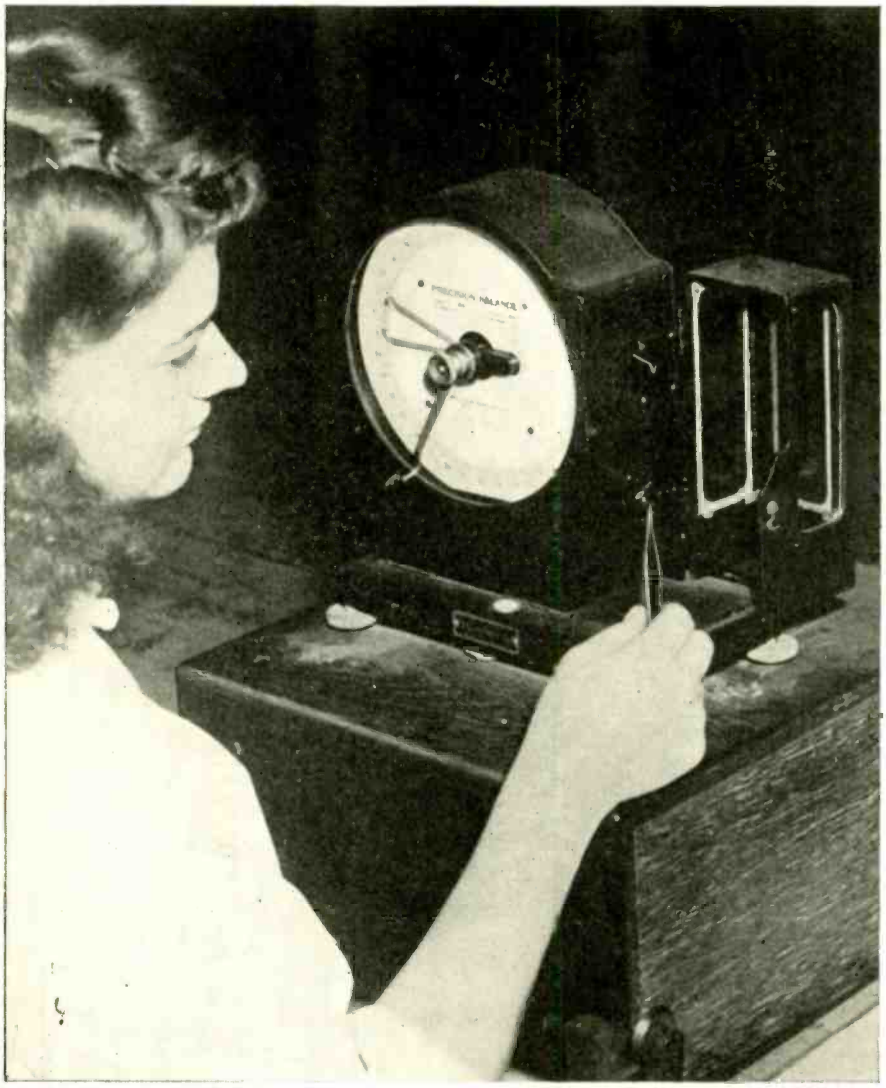
This Month



Measuring fine wires for electronic tubes at the Dobbs Ferry, N. Y., plant of the North American Philips Company. A unit-length sample is weighed on an accurate torsion balance. From the density of the wire and its weight, the diameter can then be computed

30 PER CENT PRICE INCREASE ON RADIOS FORECAST AFTER WAR

Due to increased labor and materials costs, postwar radio receivers will sell for about 30 per cent more than they did in 1941, according to Mort N. Lansing, of the Specialties Unit, Bureau of Foreign and Domestic Commerce.

Writing in the April issue of "Domestic Commerce" on "Television and its Postwar Outlook," Mr. Lansing forecast a rising volume in postwar sales of radio and television sets for the first four years after V-E Day, reaching a retail value of $1,870,000,000 in the fourth year, compared with the 1941 volume of $460,000,000.

Mr. Lansing's article predicted that FM broadcasting and television on a broad scale will open new markets. The development of the walkie-talkie in the war has paved the way for widespread civilian use of this radio service. Mr. Lansing also said. "Many factors were considered in making these estimates," he wrote. "Weight is given to the fact that AM-FM receivers and television receivers will represent an increasingly larger proportion of total sales each year. This in turn will result in increased average receiver prices each year.

"However, it is believed that at least on a short-time basis, FM will be much more important than television on account of its more general utility and the fact that sound broadcasting techniques have already been developed. As television broadcast techniques are perfected, television sales will become increasingly larger."

Copies of the April issue of "Domestic Commerce" may be obtained at ten cents from the Government Printing Office, Washington, D. C.

Direct-Viewing Cathode-Ray Tube Receiver

THIS merits of direct-viewing television systems were set forth by Allen B. Du Mont, who heads his own company engaged in the development and manufacture of cathode-ray tubes and equipment, including television receivers and transmitters, before the June 15th meeting of The Institute of Radio Engineers, in New York. Stated Dr. Du Mont:

"In the past, and also at the present time, the direct-viewing cathode-ray tube has been used almost universally in all oscillograph, television and radar applications with very satisfactory results. The tubes that have been used previously for television ranged in size from 5" in diameter to 14" in diameter. Because of the desire on the part of television viewers for a larger picture, a 20" tube has been developed with a reasonably flat face. This tube utilizes a pressed face in order to economize on manufacture and insure uniformity of product. It is possible with this tube to obtain a picture 13½" x 18", which our experience has shown is of a satisfactory size for any ordinary home living room.

"The principal advantages obtained with the direct-viewing cathode-ray tube are: high light brilliance, better contrast range, wide angle viewing, lower accelerating voltage, longer life, better resolution, less alignment difficulty, and simplicity of the focusing system. It would seem from this list of advantages of the direct-viewing cathode-ray tube as compared with projection systems, that there should be very little question as to which is the most satisfactory providing any picture larger than 13½"x18" is not desired.

"The disadvantage of the direct-viewing cathode-ray system is a slight curvature of the screen and the need for a special mounting arrangement to reduce the depth of the television receiver in the larger bulb sizes. For instance, the length of the 20" tube is 31", but by using a mechanical arrangement so that the tube is only in a horizontal position when being used, the depth of the cabinet can be held to 24".

"Taking up the various characteristics of the direct-viewing cathode-ray tube television receiver in detail, we find that the highlight brightness of the 20" tube is in the order of 20 foot lamberts as compared with approximately 3.5 foot lamberts for the most efficient projection system now in use. In both cases the size of the picture is considered to be 13½" x 18".

"One of the big advantages of the higher light brilliance is the fact that the 20" tube receiver can be used satisfactorily in a quite brilliantly illuminated room and an ambient light level as high as 5 foot lamberts can be tolerated without seriously impairing the picture quality. On the other hand, with the projection system only about .5 foot lambert average ambient light can be tolerated. It is interesting to compare the brilliance of the 20" picture with that of the normal commercial 35 mm screen, which averages between 6 and 10 foot lamberts.

"As regards the brightness ratio, or contrast range, the 20" tube has a contrast range of approximately 35 as compared with a contrast range of 17 for the projection system. This is an extremely important characteristic of the television picture and in many cases the lack of contrast range gives people the impression of poor resolution.

"As to directivity (maximum viewing angle from the normal-angle at which the apparent brightness decreases to 50% of its value in normal direction) we find that the 20" tube can be viewed from ± 80° whereas the projection system screen can only be viewed from ± 15°. It is of course possible to widen this angle somewhat in the projection system but in so doing the highlight brightness will decrease from its already low value.

"In making these comparisons we have assumed an accelerating voltage on the 20" tube of 15 kilovolts and 30 kilovolts on the 5" flat face tube of the projection system. It is obvious that the lower accelerating voltage of the direct-viewing tube effects certain economies in the manufacture of the receiver.

"The anticipated life of the 20" direct-viewing tube should run considerably above 1,000 hours, whereas the present tubes used in the projection system the anticipated life is from one-half to one-third that of the direct-viewing tube. This is because of the higher accelerating voltage as well as the much greater concentration of energy per unit of area in the projection tube.

"With the 20" direct-viewing tube, the spot size is sufficiently small to resolve any 525-line television pattern or even higher with a well-designed deflection yoke, whereas care must be taken with the 5" tube used in the projection system to obtain full 525-line resolution.

"Forgetting about the size of the spot for the moment, we have noticed that the resolution on the 5" projection tube is considerably reduced by light scattering on the fluorescent surface as well as on the translucent projection screen. With the direct-viewing tube, all the elements are aligned within the glass envelope, whereas with the projection system the tube and optical system have to be very carefully lined up and any slight inaccuracy of this line-up will seriously interfere with the resolution of the picture.

"In order to focus the picture on the direct-viewing tube, it is only necessary to make an electrical adjustment, whereas with the projection system both electrical and optical adjustment are necessary. Furthermore, the lenses and translucent screen of the optical system, and in some cases a mirror, are not encased in vacuum and the picture is subject to deterioration with age unless the mirror, translucent screen, and lens surfaces are carefully kept clean.

"As regards the cost between the two systems, at the present time there seems to be very little to chose between. In the one case we have the cost of the 20" tube and its special mechanical arrangement for putting it in the horizontal position during use, and in the other case we have the cost of the 5" projection tube, its optical system, usually a mirror, and a translucent screen.

"As previously mentioned, the voltage on the direct-viewing tube is 15 kilovolts as against 30 kilovolts with the projection system, so that there is a saving here in the case of the direct-viewing tube.

"As regards the design of the cabinet, with the 20" tube it can be somewhat lower than with the projection system although the maximum depth is slightly greater as compared with the projection receiver.

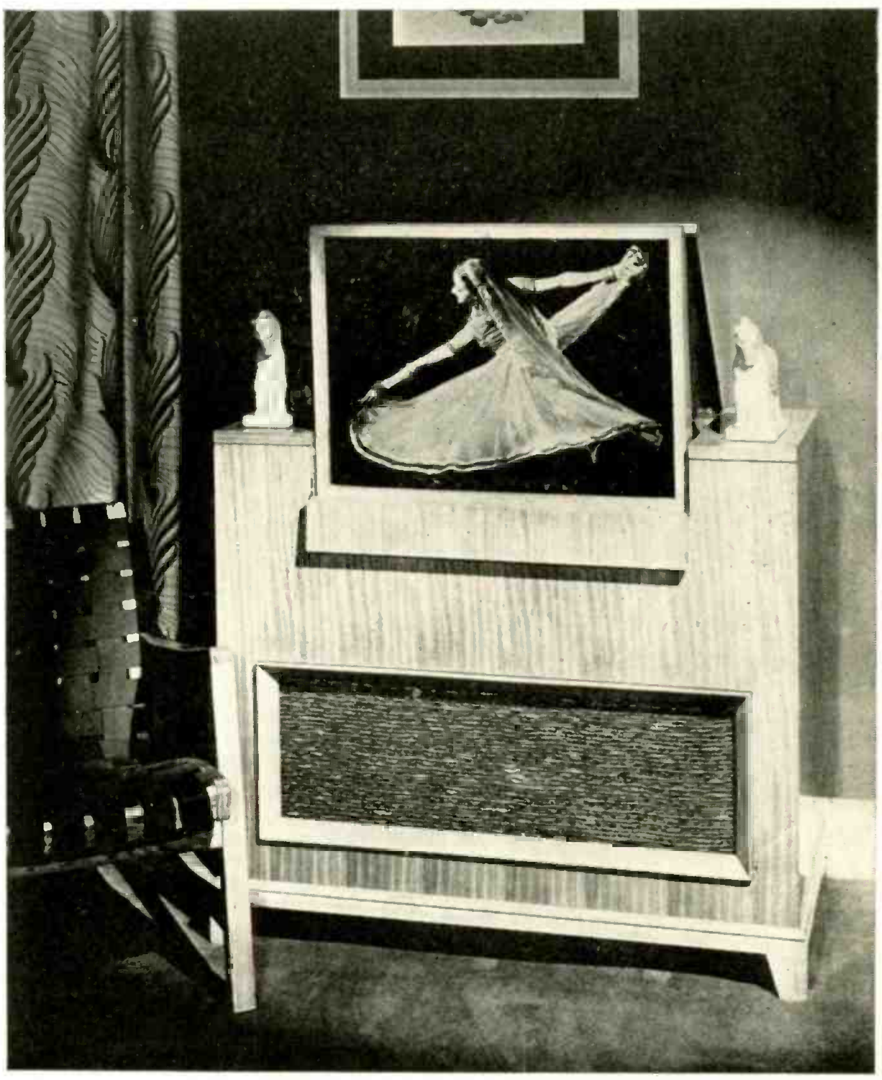
"This comparison has been made mainly taking into consideration the actual results obtained to date with the two systems. Undoubtedly improvements will be made in the projection system but it is also reasonable to assume that improvements will be made in the direct-viewing tube. If we desire to go to a larger picture than 13½" x 18", as previously pointed out, some type of projection system is imperative."

RAYTHEON RADIO-TELEPHONE STATIONS

The Raytheon Manufacturing Co. announced recently that it has filed applications with the Federal Communications Commission for construction permits to install five coastal harbor radio-telephone stations in New England at Eastport, Rockland, Portland, Maine; and Gloucester and New Bedford, Massachusetts.

Included with Raytheon's application were statements from eighty-nine import-

New General Electric large-screen television receiver, to be manufactured as soon as war conditions permit. Screen measures 16 by 22 inches. This receiver was recently shown for the first time, in New York City



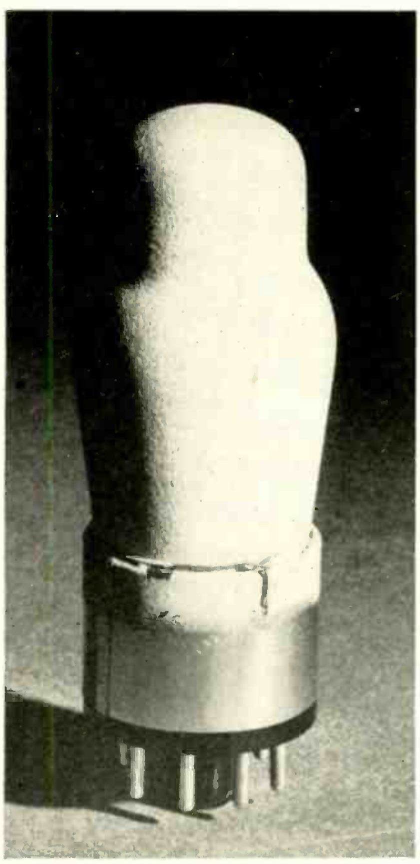
ant potential useds testifying as to the vital need for the proposed service. At present only one coastal harbor radiotelephone station is in operation in this part of the country. This is the Boston station operated by the New England Telephone and Telegraphy Company.

One of the most important users of the proposed service would be the fishing industry. New England represents 16.2% of the total yearly volume in pounds of the United States fishing industry, and 19.7% in dollar value. The New England proportion of the entire United States is 626 million pounds, or 20 million dollars.

It is proposed to introduce for the first time in the coastal harbor service frequencies in the newly allocated 152-162 mc band. The engineering report discloses that an average satisfactory service range of some 45 miles is estimated for the 160 mc operation at each of the five points.

In addition to the 160 mc frequencies Raytheon requests the assignment of 2, 4, 6 and 8 mc for servicing vessels in the area beyond the range of the 160 mc channels. The application pointed out that the most efficient operation would be obtained by the assignment of exclusive 2, 4, 6 and 8 mc frequencies for the five stations, but in the event the Commission found it impossible to make such assignments, the application requested shared use of 2550, 4282.5, 6470, and 8585 kc now allocated by the Commission to Great Lakes Coastal Harbor stations.

Raytheon discloses that its survey indicates that fishing vessels require communications service at distances as great as 800 miles from New England.



The Bradley tube, duplicate of German-made repeater, made by Western Electric for Belgian telephone systems

Proposed Raytheon coastal harbor radio telephone stations

The proposed coastal harbor radio-telephone rates employ a basis quite different from those offered by existing coastal harbor stations. A rate of $1.00 for three minutes is offered when the 160 mc frequencies are employed, and a rate of $1.50 for three minutes when the frequencies in the 2-8 mc band are employed with an additional per minute charge of 35c and 50c respectively.

In its application a power of 2,000 watts was specified on the 2-8 mc operation and 50 watts on the 160 mc operation. Three frequencies are requested in the newly allocated 152-162 mc band with one channel for calling purposes and the other two channels for traffic operations. Two traffic frequencies are requested in order to meet peak traffic loads and to avoid interference between stations when a vessel is located in a position within the over-lapping service area of two stations.

The rates proposed are for the radio link of the circuit only, to which would be added the regular Bell System land-line rates for communications with telephone subscribers ashore.

Raytheon proposes to transmit on a scheduled basis free of charge. United States Weather and Hydrographic reports. Repetitions of these reports will be furnished upon request at a rate of 50c when 2-8 mc frequencies are employed and 35c when 160 mc facilities are employed. A similar differential is used for message forwarding and position reporting services.

The application also stated that it would offer service to land mobile units, such as trucks and buses when within the 160 mc service area range, if such service was requested.

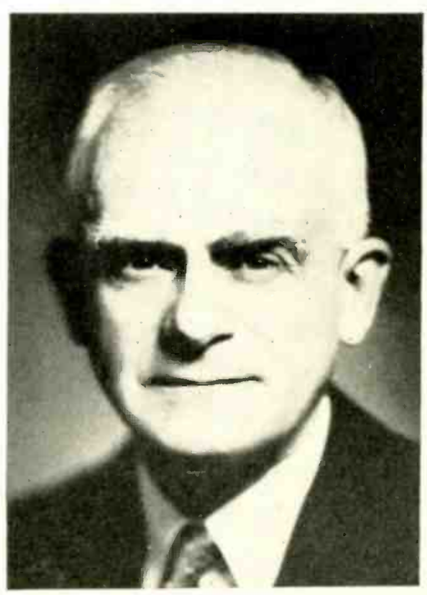
I. T. & T. APPOINTS KOHLHAAS

Herman T. Kohlhaas, editor of Electrical Communication, technical journal of the International Telephone and Telegraph Corporation and associated companies, has been appointed an assistant vice-president of the Corporation. He has had a long career in the I. T. & T. System.

Mr. Kohlhaas received a B.S. degree in electrical engineering from Cooper Union in 1907. Later he was awarded. E.E. degrees by both Cooper Union and Brooklyn Polytechnic Institute.

From 1905 to 1922, he served in the Bell Telephone Laboratories as an engineer, a section head, and finally as a division head in the Physical Laboratory. In 1922, he was appointed executive personnel assistant to the system's engineer of the Bell Labs. He was transferred to the Western Electric Company headquarters in 1924.

In 1925, Mr. Kohlhaas was transferred to the International Western Electric Company to make statistical studies and to start his responsibility as editor of Electrical Communication. Through the purchase of that Company, he became a member of the staff of the International Telephone and Telegraph Corporation. During 1937-39, he edited Electrical Communication from London, serving also as publicity representative of the I. T. & T. and International Standard Electric Corporation.



Herman T. Kohlhaas

New Products

NEW REPRODUCER

Specially designed for railroad use in intercommunication, the new Type NJ-300 Reproducer, announced recently by Jensen Radio Mfg. Co. of this city, is arousing widespread interest among railroad signal engineers and builders of intercommunication equipment.

Type NJ-300 Reproducer was originally designed for Navy use as a loud speaker and microphone (talk-back) but has been developed for all types of railroad use in locomotives, cabooses, signal towers, and outdoors in railroad yards. In tests made on trains and in locomotive cabs, Jensen engineers found that this speaker, because of its frequency range, over-rode the surrounding high noise levels and delivered clear, crisp, intelligible speech.

Because of correct case design, wind noise pickup, when used as a microphone, shows a reduction up to 6 db as compared with the conventional type of loud speaker. Voice coil impedance is 12 ohms nominal value; power handling capacity for speech is 10 watts.

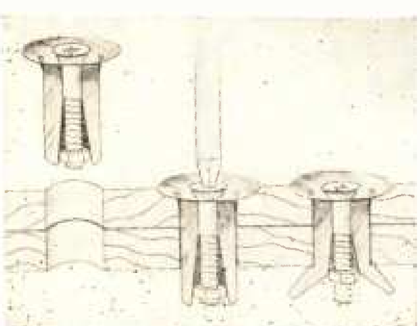
Type NJ-300 is in production and available on properly rated priority orders showing suitable end use.

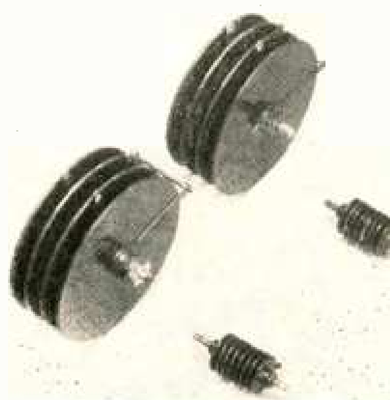
BLIND BOLT ASSEMBLY

The "Des-Bolt", another of the plastic fastening devices developed by Victory Manufacturing Company, has recently been announced. The complete unit is composed of a molded plastic expansion sleeve and any standard nut and bolt assembly of the correct size to match the sleeve. The sleeve is the important element of the design and makes possible the simplicity of the device. The sleeve is composed of three thin fingers with an inside taper extending approximately three-fourths of their length from the flanged head. The head is a flange with a cored hole to accommodate the bolt shank and countersunk to receive standard countersink type of bolts, with three sharp ribs attaching the flange and sleeve. These thin ribs wedge into the work and prevent the sleeve from turning.

Advantages of the "Des-Bolt" unit are many. When used in small assembled units, such as electronic and radio equipment, improved fastening is accomplished in locations highly inaccessible to hold the nut by normal methods.

For complete information, write to Engineering Dept. 2-E, Victory Manufacturing Company, 1105 So. Fairoaks Ave., So. Pasadena, Calif.





NEW SELENIUM RECTIFIER

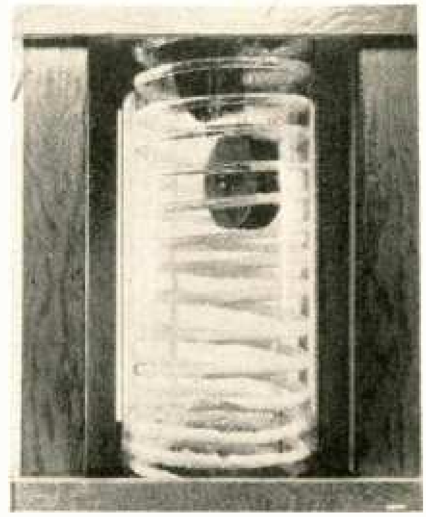
A newly developed selenium rectifier for applications on sea and at high humidity has been perfected by the Selenium Corporation of America, 1719 West Pico Blvd., Los Angeles 15, California, according to Mr. Carl Holmes, Project Engineer. The new unit featuring a raidcally different assembly method and coating technique does not show any effect of salt spray after 100 hours of operation at 50°C. Type designation of the new rectifier is "K".

Results of testing thus far, according to Mr. Holmes, prove conclusively that two-way protection of the selenium plates has been achieved. This new coating protects the selenium barrier layer from within and preserves its rectifying properties indefinitely. It also protects the selenium barrier layer from exterior attacks by salt spray, fungi, mercury vapor and other corrosive fumes.

The recently completed test of a 3-minute spraying of the selenium rectifiers with 20% salt solution at 55°C., followed by a 3-minute air blast at 55°C., the cycle being repeated continuously throughout the entire 100-hour test.

A strong ultra-violet light was continuously played on the rectifiers during the length of the test.

After extended production runs, with many units already subjected to test, there have been no instances of corrosion nor have electrical characteristics varied in any way. As a result, concludes Holmes, the new coating not only provides the armed forces with proved dependable rectifying units, but also opens new fields for the industrial application of selenium rectifiers.



NEW DECADE UNIT

To meet the demand for a line of flexible circuit components, Harvey-Wells Electronics, Inc., Southbridge, Massachusetts, has developed a decade unit which makes immediately available almost any desired value or combination of values covering capacitance, inductance, resist-

[*Continued on page 62*]

FM REPORT

[*Continued from page 42*]

result that his enjoyment may be further destroyed by an alternation of first one program and then another as transmission vagaries decree. The effect may well be to render FM receivers useless to many listeners for substantial periods of time.

It has been argued that the bulk of the interference anticipated will be found in outlying rural areas which rely upon low-intensity signals for their radio reception and that if these areas be excluded, FM service will be more than 99 percent perfect. The tables make it clear that urban as well as rural service will be subject to substantial interference on the lower frequencies. This Commission, moreover, is under a statutory duty to make available to *all* the people of the United States an efficient nationwide radio service. The Commission's duty is not fulfilled if its provision for FM service is such as to make it impossible for rural areas to enjoy satisfactory FM service.

The tables and data upon which the Commission's interference predictions are based were set forth in full in the May 25 report and were the particular topic for the oral argument on June 22 and 23. Practically without exception all persons appearing at the hearing stated either that they agreed with the Commission's predictions or that in determining the best allocation for FM they were willing to assume that the predictions as to interference contained in the Commission's report were accurate. In those cases where exception was taken, no substantiating data were offered. Indeed, the testimony at the June 22-23 argument indicated that the Commission's predictions might understate in at least one respect the number of hours of interference to be anticipated at particular contours. The Commission's predictions were based upon the assumption that receivers will be generally available which are capable of rejecting an undesired signal one half as strong as the desired signal. Manufacturers generally appearing at the hearing were unwilling to state that their postwar receivers would meet this standard. With inferior receivers, an even greater number of hours of interference can be anticipated. The issue, accordingly, is whether the freedom from long-range interference which FM will enjoy at the higher frequencies is to be sacrificed by reason of other considerations.

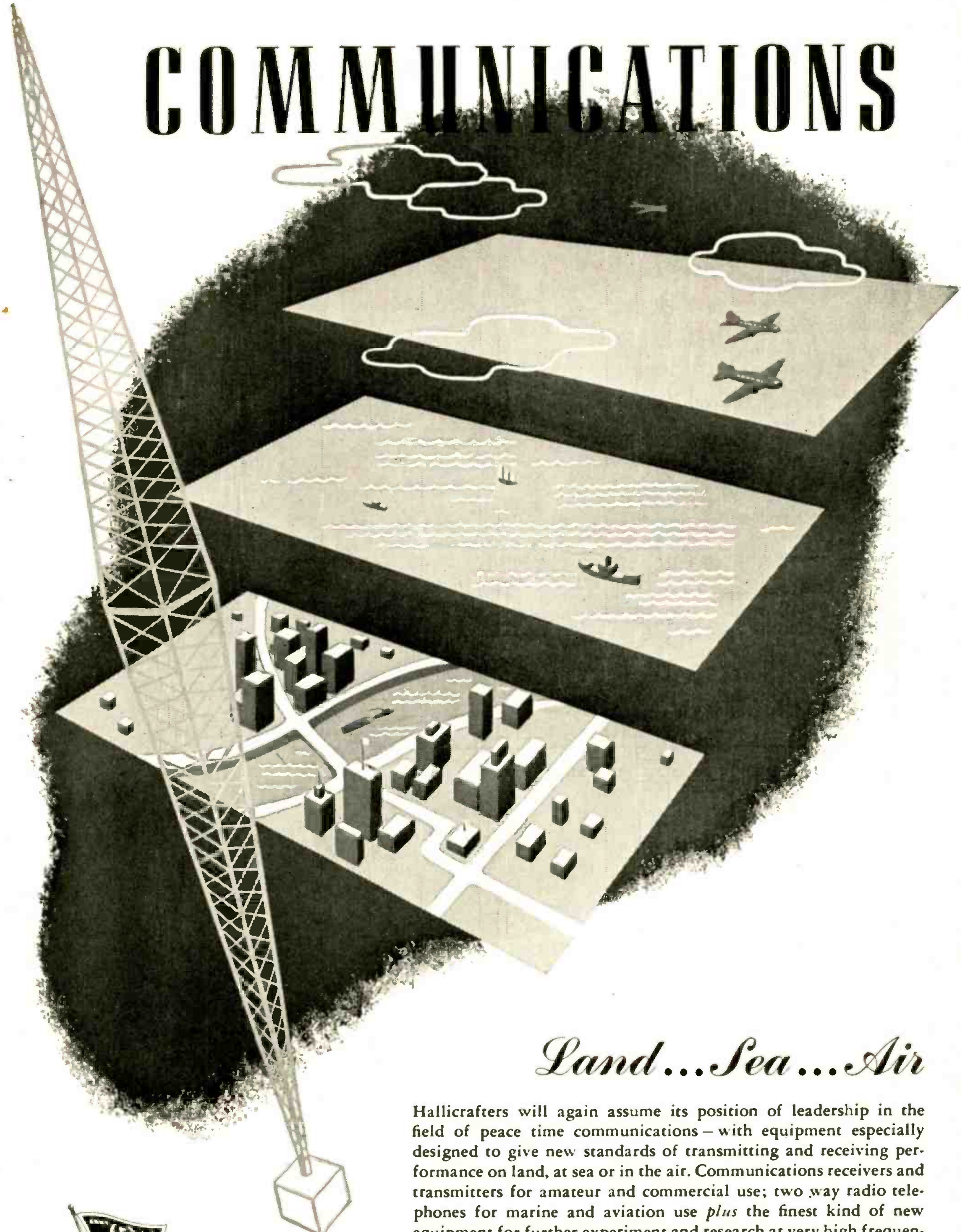
Various objections to assigning the higher frequencies to FM have been raised in this record. For example, it has been alleged that tropospheric interference may be worse in the vicinity of 100 mc than in the 50 mc region. The Commission in its report of May 25, 1945, specifically pointed out that there would be some difference in tropospheric propagation; but this difference would be only slight and that tropospheric interference at the higher frequencies could be eliminated by slightly increasing the geographical separation between stations. This evidence was not controverted at the oral arguments on June 22 and 23, 1945, and Dr. Beverage, one of the propagation experts chiefly relied upon by persons favoring alternative No. 1, testified that tropospheric effects change slowly and that they would not be greatly different throughout the range of frequencies under consideration (Tr. 5583).

The point has also been made that equipment for use in the vicinity of 100 mc will cost more than equipment for use in the vicinity of 50 mc. This will no doubt be true at least temporarily, but it seems equally clear that competition will reduce the differential substantially, and that the benefit to the public resulting from an interference-free service will more than outweigh the slight increase in initial cost for service in the 100 mc region.

At the earlier hearings, some contended that FM might be delayed for two years or even longer if FM were assigned to the higher frequencies. At the time of the oral argument, June 22-23, 1945, the estimates of delay were reduced to four months. It may well be that competition will markedly reduce even this four-month estimate. Moreover, this report makes it possible for manufacturers to begin at once their planning and design for the higher frequencies. The War Production Board has not yet authorized construction of AM, FM, or television equipment for civilian use; and some months may still elapse before manpower or materials become available in sufficient quantities for such production to begin. If so, the planning and design of equipment for the higher frequencies can be completed before civilian production of any AM, FM, and television equipment is authorized.

Manufacturers, of course, are desirous of

COMMUNICATIONS



Land... Sea... Air

Hallicrafters will again assume its position of leadership in the field of peace time communications – with equipment especially designed to give new standards of transmitting and receiving performance on land, at sea or in the air. Communications receivers and transmitters for amateur and commercial use; two way radio telephones for marine and aviation use *plus* the finest kind of new equipment for further experiment and research at very high frequencies will all be included in Hallicrafters postwar production plans.

BUY A WAR BOND TODAY!

hallicrafters RADIO

THE HALLICRAFTERS CO., WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF SHORT WAVE RADIO COMMUNICATIONS EQUIPMENT, CHICAGO 16, U. S. A.

marketing FM receivers at the earliest possible moment; and the Commission, too, is concerned that FM receivers shall be freely available to the public early enough to supply the immediate post-war demand. However, the Commission has a duty to consider the long range effects of its action as well as the effects during the months immediately ahead, and it does not propose to provide an inferior FM service during the decades to come merely because of the transitory advantages which may be urged for an inferior type of service.

Earlier in these proceedings, much emphasis was placed on the presumed hardship which would result to the approximately 400,000 persons who had purchased FM receivers before the war. Most of these receivers are combination AM-FM and the AM part of the receiver will continue to be used. There is now substantial agreement that the band (42-50 mc) for which these receivers were made is wholly inadequate and unsuited to FM reception. Accordingly, no one today argues that post-war FM should be degraded to the point necessary to accommodate these receivers. However, interim operation in the present band from 42 to 44 mc is being provided until such time as equipment for the higher frequencies is freely available to the public and until owners of existing receivers have had equal opportunity to convert them to the new band. In this connection, a converter was demonstrated to the Commission which would make existing FM receivers capable of tuning to the higher frequencies and which should retail for approximately $10.00.

For the foregoing reasons and upon the basis of data set forth in Section 8 of the report of May 25, 1945, the Commission is adopting alternative No. 3 with certain modifications. The allocation between 42 and 108 mc is as follows:

Freq. Band (mc)	*Proposed Allocation*
42-44	Non-Government Fixed and Mobile
44-50	Television—Channel No. 1
50-54	Amateur
54-60	Television—Channel No. 2
60-66	Television—Channel No. 3
66-72	Television—Channel No. 4
72-76	Non-Government Fixed and Mobile
76-82	Television—Channel No. 5
82-88	Television—Channel No. 6
88-92	Non-commercial educational FM
92-106	FM
106-108	Facsimile

This allocation is essentially the allocation proposed as alternative No. 3 of the earlier report, except that the non-government fixed and mobile services have been moved from 104-108 mc to 72-76 mc, and FM and television have been adjusted accordingly. The advantage of this change is that it makes possible immediately the use of all 13 television channels below 300 mc. Under alternative No. 3 as originally proposed, the entire 6 mc television channel between 72 and 78 mc could not be used until the aviation markers centering on 75 mc were moved. The non-government fixed and mobile services are not under the same disability. They can use the entire band

between 72 and 76 mc at once, with the exception of approximately one-half mc in the vicinity of 75 mc to protect the aviation markers. This shift of the non-government fixed and mobile services from 104-108 mc to 72-76 mc also results in a possible increase in the number of channels available to the non-government fixed and mobile services, since a 40 kc channel is adequate in the 72-76 mc portion of the spectrum, whereas a 50 kc channel was proposed in the 104-108 mc region.

NEW PRODUCTS

[*Continued from page* 57]

ance, transformer ratios, etc., over a wide range.

So far as is known, this is the only decade unit available with circuit components that will dissipate heat and power and stand up indefinitely under actual operating conditions. The various components of this decade unit may be included in actual circuits necessary for testing equipment of all natures by research and experimental laboratories, classrooms, power companies, electrical repair and maintenance shops, and especially by industrial manufacturers for testing refrigerators, motors, insulated wire, appliances, etc.

The electrical circuits for the various components were engineered in the Harvey-Wells Research Laboratories. The unit is purely functional in design and occupies a minimum of space. Complete information and technical data is available from the manufacturer.

IMPEDANCE BRIDGE

[*Continued from page* 49]

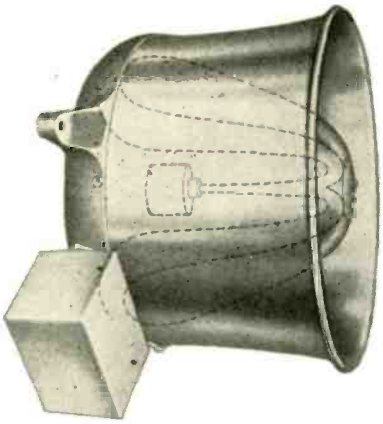
should be rigid and it is suggested that #10 or #12 tinned copper bus be used.

The CRL dial should be as large as possible. A six inch diameter dural or aluminum disc will provide enough space for the calibrated points as indicated in Table 2. This dial can be calibrated very simply by use of a G-R or equivalent 1 to 10,000 ohm resistance decade. For example, the decade ("unknown resistance") is set at 50 ohms and the CRL dial is adjusted for balance. This point is then marked on the dial. The "unknown" is then set to 100 ohms and the CRL dial again adjusted for balance, with this point marked on the dial. This step is followed in order for all the values of R indicated in Table 2.

The first markings can be made in pencil and later carefully cut in with a scriber. The cuts should then be filled in with india ink. Lettering and numbering can be engraved or stamped in.

Once the CRL dial is calibrated it is a relatively simple matter to calibrate R_{11}, R_{12} and R_{13} in accordance with the values indicated in Table 3, by simply connecting them to the "R" terminals of the bridge. After these pots are calibrated, the bridge wiring can be completed.

The "Detector" switch S_3 (*Fig. 1*) provides means of picking up an ex-



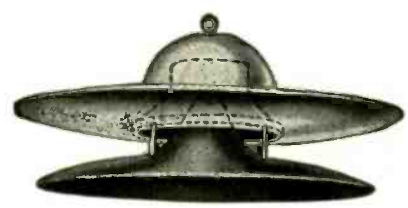
Left—MARINE SPEAKER; approved by the U. S. Coast Guard, for all emergency loudspeaker systems on ships. Re-entrant type horn. Models up to 100 watts. May be used as both speaker and microphone.

Right—RE - ENTRANT TRUMPET; available in 2½-3½-4½-6 ft. sizes. Compact. Delivers highly concentrated sound with great efficiency over long distances.

Left—RADIAL HORN SPEAKER; a 3½' re-entrant type horn. Projects sound over 360° area. Storm-proof. Made of RACON Acoustic Material to prevent resonant effects.

Right—AEROPLANE HORNS; super-powerful and efficient P. A. horns for extreme range projection. 9-4 and 2 unit Trumpets available.

Left—PAGING HORN; extremely efficient 2' trumpet speaker for use where highly concentrated sound is required to override high noise levels. Uses P.M. unit.



Right—RADIAL CONE SPEAKER; projects sound over 360° area. Cone speaker driven. Will blend with ceiling architecture. RACON Acoustic Material prevents resonant effects.

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ternal detector at the upper right hand binding posts. This permits substitution of another galvanometer on d-c measurements or suitable null indicator on a-c measurements. The center position connects up the internal galvanometer (with shunt) for rough adjustments and the third position provides the galvanometer alone for fine adjustments.

Galvanometers for use in the bridge can be obtained with different values of internal resistance. Those having an internal resistance of approximately fifty ohms will give a very sharp balance indication when measuring low values of resistance. However, they become less sensitive as higher values of resistance are being measured. Since one

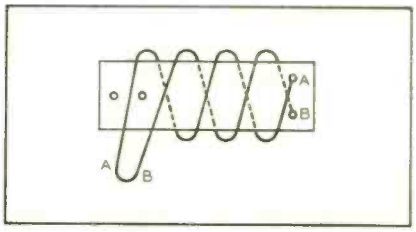

Fig. 3. Method of winding non-inductive resistance standards

cannot have everything in a general purpose instrument, a compromise is in order. The trend is toward a galvanometer with an internal resistance of approximately 1000 ohms, as this type will have a greater sensitivity over a wider range of resistance measurement. By means of the switch S_3 it is a simple matter to connect an external "low ohm" galvanometer on low ohm measurements. To increase the sensitivity on the high ohm range an external battery of 22½ volts may be used.

The "Generator" switch S_4 adds greatly to the flexibility of the bridge. In the "1 KC" position the oscillator A+ and B+ circuits are completed and the 500-ohm output of the oscillator is connected to the bridge. In the center position, provision is made for use either of an external battery for d-c measurements or an external signal source for a-c measurements. The third position "DC" picks up an internal source of six volts. "Generator" binding posts are at the lower right.

1000-Cycle Oscillator

In balancing a bridge it is desirable to obtain a complete null balance for only by so doing can the maximum precision of balance be realized. Since the balance depends to a greater or lesser extent on the wave form of the signal source, the presence of harmonics will prevent a complete null balance.

General Radio uses a "microphone hummer" as a signal source in the GR 650-A Bridge. This is an electromechanical oscillator whose frequency is determined by a tuned reed. A microphone button mounted near the reed

FOR A JOB *Well Done . . .*

THIS button, soon to be worn by thirteen million men and women—honorably discharged members of the Armed Forces of the United States—is a symbol of honor, an insignia of respect.

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picks up energy for continuing the oscillations.

A carefully adjusted high frequency buzzer with filtered output can also be used. The buzzer frequency can be checked with sufficient accuracy by matching it up with the second B above middle C on a correctly tuned piano.

The "hummer" or buzzer presented sound insulation problems, so a tube oscillator was employed.

The oscillator shown in the photograph is not the one now in use. This one tube oscillator was rejected for two reasons: leakage and insufficient signal after filtering. The present oscillator (*Fig. 1*) uses two 1S4s, triode connected, as an oscililator-amplifier. This arrangement provides sufficient gain to permit adequate filtering. The transformer T is a Stancor "Victory" Model" interstage type with the core removed, while the output transformer is a UTC S-14, the 500 ohm output going to the bridge through S_4. The entire oscillator is placed in a metal box but left floating, i.e. not grounded in any way to the bridge ground.

METALS

[*Continued from page* 40]

strengthening for the chassis where large parts are mounted are also highly recommended; they permit making the chassis from a lighter gage material.

The effects of vibration can be minimized by the use of materials such as rubber, cork and even steel (springs). Rubber becomes harder as the load increases, cork becomes softer under similar conditions and steel springs deflect linearly with load.

The most promising of these appears to be rubber (for our specific applications) since it provides a fair degree of isolation under normal conditions and, when subjected to a severe shock, the deflection is not greatly magnified. In other words, it behaves somewhat like a limiter stage in an FM type receiver. Similarly, cork can be likened to a square law amplifier, while springs behave as a linear amplifier since the greater the load, the greater the deflection. Therefore large deflections must be provided for to afford protection against severe shocks.

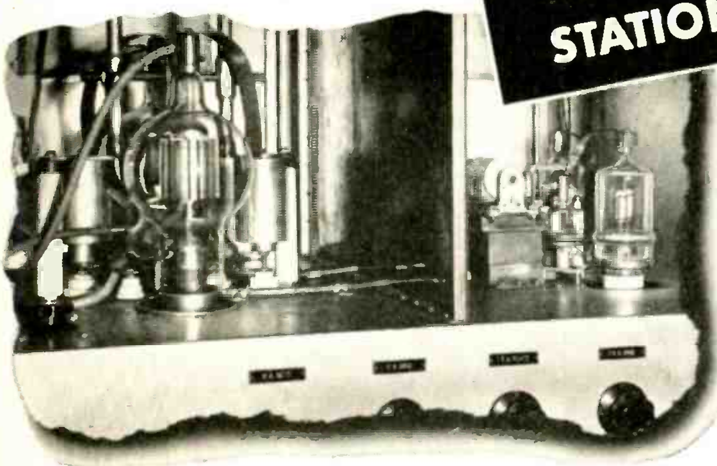
Rubber may be used either in shear or compression (see *Fig. 1*) depending upon the load, required efficiency and the physical space available. It is generally used in compression (grommets) in most home radio applications since it requires little physical space. While the efficiency is not as high as rubber-in-shear it is satisfactory for most purposes.

Rubber will bulge when in compression so allowances must be made for

IT'S EIMAC AGAIN! FIRST CHOICE FOR THE KEY SOCKETS AT TELEVISION STATION WBKB

A. H. Brolly . . . Chief Engineer of Television Station WBKB, Chicago, adjusts the grid circuit of the Eimac 304-TL's in the Class B linear stage of the video transmitter.

Mr. Brolly calls attention to the Eimac 1000-T's in the final stage of the Audio FM Transmitter which operates at 65.75 megacycles. It is a very stable amplifier of good efficiency.



The video transmitter operates at 61.25 megacycles; peak power output is 4 KW which provides a television service throughout metropolitan Chicago and reaches suburbs out to 35 miles or more.

Eimac 152-T's are used in the modulated stage and 304-T's in the first Class B linear amplifier of the video transmitter.

E. F. Cawthon and W. R. Brock are operating the station which has been broadcasting television programs with the present equipment since 1942 and began operation on a commercial schedule in October, 1943.

Grid modulation is employed at WBKB and a broad band of frequencies must be passed in all stages following the modulated amplifier. Multiple-tuned resistance loaded coupling circuits are used between stages.

Performance, stability, dependability are good reasons why Eimac tubes are to be found in the key sockets of the outstanding new developments in Electronics. Balaban & Katz, owners of television station WBKB of Chicago, offer potent confirmation of the fact that Eimac tubes are first choice of leading Electronic Engineers the world over.

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this in the design. This presents no problem with the use of rubber grommets since allowances must be made for clearances in assembly which ordinarily will take care of any bulge effect.

Without question, a rubber-in-shear type mounting will give the most satisfactory results, but because of the additional cost and physical space required it is very seldom used for home radio equipment. Where these factors are not too important, such as in communications equipment, the rubber-in-shear type mounting is recommended.

Underwriters Requirements

Certain requirements have been set down by the Underwriters Laboratories, Inc., which, when followed, make the operation of a radio appliance fairly safe from a shock or fire hazard standpoint. Since these requirements have a bearing on the mechanical design of the equipment, a brief summary of the applicable points will be given.

All live or current-carrying parts which involve shock or fire hazard, other than cords or cables shall be suitably protected. The enclosure shall be substantially constructed and in the case of metal enclosures shall be suitably corrosion resistant. Metals of at least 0.015″ in thickness, asbestos of at least 1/32″ or molded phenolic of 1/8″ may be used for the enclosure provided the part has adequate mechanical strength.

In the case of parts conductively coupled to the power line through less than 120,000 ohms impedance, the part or parts must not be exposed within three times the minor axis of irregular holes or within three times the diameter of holes larger than ¼″. When the current exceeds 5 ma with a 1500 ohm load, parts connected to secondary circuits of over 25 volts are also considered shock hazards and must be protected with suitable barriers or enclosures.

Openings are permitted for ventilation if protected by a fine mesh metal screen. Openings may be provided for cables or other conductors if they are small in size and few in number. Circuit adjustment holes are allowable if their diameters are less than 9/32″ and the adjustment screws are not more than ¼″ behind the openings. Openings may be provided for manufacturing purposes if they do not exceed 3/16″ diameter or equivalent area. (Slots having a width of 1/16″ or less are excepted.)

For complete information on Underwriters requirements see the latest edition of "Requirements for Power Operated Radio Receiving Appliances", published by the *Underwriters Laboratories, Inc., N. Y.*

Finish — Resistance to Corrosion

The specification of finish or protective coating on metal radio parts depends upon their function, what climatic conditions they must withstand, and to what degree protection from corrosion is desired.

It is practically impossible to apply a finish to a component which will withstand a severe salt spray test without some evidence of discoloration or other deleterious effects so unless these effects interfere with the actual operation of the part, either mechanically or electrically, it is common sense to tolerate them. The following discussion is based on this premise, since designers are interested in reliable operation and not theoretical considerations.

First, let us consider what constitutes corrosion. It is well known that most metals and alloys are attacked by climatic conditions, particularly when water or other aqueous solutions are present. Such corrosion, as it is called, is a result of the formation of an oxide, carbonate, sulfide or other corrosion product of the metal. Usually the newly formed product is insoluble in the environment under which it was formed and sometimes will act as a protective coating which inhibits further corrosion. Such a protective film must be very thin and complete in order to passify the metal. Should the film grow due to high temperatures and/or humidity, it is likely to crack or scale which permits further oxidation and corrosion with time. It is this protective air-formed film which accounts for the relative permanence of some metals under dry atmospheric conditions. Unfortunately these ideal conditions do not often exist and for this reason an artificial protective coating is required.

Table 2 shows most of the commonly used electroplated and chemical finishes ordinarily specified on radio equipment. The extent of protection each affords, together with recommended thickness has been given. This table does not take into account corrosion caused by electrochemical action (galvanic corrosion).

It is this galvanic effect (similar to the generation of current in an ordinary dry cell battery) that increases the corrosive action over its normal rate. The metal which is attacked is called the anode while the metal which is "protected" is called the cathode. These in conjunction with the aqueous solution complete the galvanic couple or cell. The extent of the reaction or corrosion when the two dissimilar metals contact one another in the presence of an aqueous solution may be determined from the position of the two metals in the galvanic series and the relative areas of each metal.

For example, if stainless steel is to be in contact with aluminum or any other metal above stainless steel in the electromotive series, the corrosion products formed would attack the aluminum or other metal and protect the stainless steel. Likewise, if silver or any metal more noble than the steel were to be in contact with one another the corrosion product would form on the stainless steel. This effect can be minimized by the choice of a plating which lies between the two dissimilar metals in the series. See Table 3.

In other words, any metal above another in the series will be anodic or less noble to the lower metal and the greater the separation between the metals in the series the more serious the likelihood for corrosion. It should be noted that the various metals are arranged in groups within the series. Metals within the same group are relatively free from corrosion when in contact with one another, unless the areas of the two metals are substantially different. In fact, the ratio of the areas is nearly proportional to the intensity of the corrosion if the area of the more noble (cathodic) metal is much larger than that of the less noble (anodic). It is therefore wise to avoid couples wherein a metal that is low in the series (copper, for instance) has a much greater exposed area than that of a higher metal such as aluminum, because corrosion will be accelerated since the anodic metal which is always attacked is small.

The following general rules should be followed to lessen the effects of galvanic corrosion:

1. Do not join metals far apart in the galvanic series, especially with threaded fastenings. If it is necessary to use materials widely separated in the series, the joint should preferably be made by brazing, in which case the brazing material should be more noble than at least one of the materials no joined.

2. Designs should use the less noble metals for the large areas with all small fastenings of a more noble material.

3. Whenever practical insulate the dissimilar metals by coating both the anodic and cathodic elements. This increases the resistance between the couple and results in less current flow and consequently less corrosion.

Three general classes of coatings are used: metallic, inorganic, organic or combinations thereof. A metallic coating may be produced by electroplating, hot-dipping, spraying and cementation to mention a few of the more common methods. A common non-metallic protective coating is known as "anodizing" and is formed by electrolytic means on aluminum. The organic coatings are represented by the paints, enamels and lacquers.

Since fewer metals are used in fabricating radio components than there are protective coatings or finishes, only those commonly employed on the metals with which we are interested will be discussed.

Steel

Parts made of steel are usually electroplated with cadmium and zinc. If the surface is to be painted (no electrical contact required) zinc is ordinarily used and supplemented by a Bonderizing (phosphate) treatment. When the part requires no painting, a chromate finish, Cronak, or Iridite is sometimes applied. The chromate acts as a protection to the underlying plating and will usually withstand at least 200 hours of salt spray before any corrosion products appear. When a chromate finish is applied over cadmium or zinc the initial finish need not exceed a thickness of 0.0002". The electrical resistance of both Cronak and Iridite is negligible.

In applications where steel is in contact with aluminum, cadmium is recommended instead of zinc. Both are anodic toward iron and steel and therefore give galvanic protection to any exposed base metal. Cadmium has a lower electromotive potential difference and will not give as much galvanic protection as zinc, although the difference is relatively small. This galvanic protection is very desirable, because small breaks in the plating caused by staking operations or scratches due to handling do not seriously impair the protective coating. A disadvantage to cadmium

plating is its tendency to grow "whiskers" when in contact with phenolic materials having traces of free organic acids.

Nickel is rather unsatisfactory on steel because it is more noble and is quite porous unless a very heavy coating is applied.

Brass — Phosphor Bronze

These metals seldom require plating, unless sulphur or ammonia are present, the parts are to be soldered or a better electrical contact is required. Another reason for specifying plating is because both brass and phosphor bronze are negative with respect to most metals in the electromotive series. Thus, if brass or phosphor bronze are to contact cadmium plated steel for instance, severe corrosion products are likely to be formed on the latter while the brass will remain relatively clean.

Nickel is probably the most common plating used on brass, although cadmium, zinc and tin can be employed. As with steel, if the brass is to contact aluminum it is preferable to cadmium plate rather than use zinc. The plating of brass parts with cadmium must be carefully specified otherwise the plating will gradually tend to be absorbed into the brass. For this reason the plating should be over 0.0002" thick.

An exception to cadmium plating is where phosphor bronze is used for springs. For such applications, tin is recommended.

Aluminum

Silver-plated parts should not be used in contact with aluminum or its alloys, depending upon the requirements at hand. Anodizing, which produces a very hard layer of aluminum oxide by electrolytic means, is extremely corrosion resistant. Its main disadvantage lies in the fact that aluminum oxide is a particularly good insulator electrically and therefore cannot be used where a good electrical contact is required.

A chemical oxide finish on the other hand does not impair the electrical conductivity of the aluminum and when properly applied will withstand over 200 hours salt spray without aluminum corrosion products being formed. Unfortunately this method does not result in a very durable finish and is easily damaged by scratching, etc. It makes an excellent base for the application of organic coatings however, and is therefore extensively used when the exterior surface is to be painted.

Organic Coatings

Before any of the commonly used organic coatings such as paint, enamel or lacquer can be applied to a part, the

[*Continued on page* 74]

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METALS

[Continued from page 72]

surface of the part must be suitably prepared. This is particularly true where the surface to be coated has a tendency to oxidize. The preparation of the surface should result in a fine etch which allows the organic coating to obtain a "grip" on the surface. Several methods for readying the surface are used, such as Bonderite for zinc, Parkerize or Bonderize for steel, Lithoform on hot galvanized parts and chemical oxide chromodizing or phosphatizing on aluminum.

Conclusion

The finishing of metal is a very exacting procedure and it is not the intention of this article to present a detailed description of the process. It is hoped however that the above will provide sufficient information for the radio engineer to fulfill his requirements.

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OSCILLATORS

[Continued from page 35]

This eliminates the fuzzy figures due to noise and the combined 440 and 4000-cycle frequencies when the receiver output is viewed directly. The 440 cycle and the 4000 cycle signals can be separated by a simple filter arrangement as shown in *Fig. 8*. Separation of these frequencies can also be partially accomplished by tuning, when the receiver is tuned to the carrier frequency the 400 cycles predominates, if tuned "off center" the 4000 cycles can be made to predominate.

If necessary a complete calibration can be made from the 60 cycle power line as standard. This can be used to synchronize the oscilloscope sweep circuit with the unknown frequency on the vertical plates. The author finds the resulting figure less confusing than the regular Lissajou patterns. The ratio of the unknown frequency to the 60 cycle sweep equals the ratio of the number of "peaks" to number of "tails" as shown in *Fig. 9*, which shows the figure for 90 cycles, or 3/2 of 60. *Fig. 10* shows a table of ratios and corresponding frequencies covering points on two ranges 60-210 and 200-700. In observing the higher ratios it is difficult to count the "peaks" and this need not be done if the "tails" are counted; the number of peaks can be deduced from the position of the dial, which will have already been marked for the major points indicated by the lower ratios as shown in the second and sixth columns of the table. Of course if difficulty is experienced

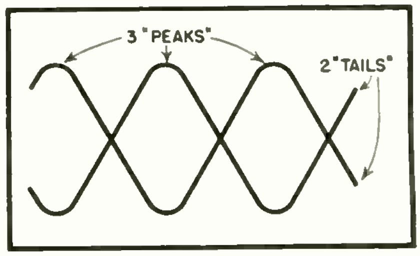

Fig. 9. Oscilloscope figure with the horizontal sweep at 60 cycles and an oscillator frequency equal to 3/2 of 60, or 90, on the vertical plates

with the higher ratios, intermediate points can be interpolated fairly accurately with draftsman's dividers.

If other ranges do not quite conform to the calibration of the above two ranges, corrections can be made by varying the resistors R_{1-8} slightly by means of shunts of high resistance or low series resistances. The slight changes necessary to correct the scale extremities do not upset the rest of the scale appreciably and it is generally not necessary also to adjust resistors R_{11-18}

FREQ.	RATIOS			FREQ.	RATIOS	
60	1	—	—	220	11/3	—
65	—	—	13/12	230	—	23/6
70	—	7/6	—	240	4	—
75	—	—	15/12	250	—	25/6
80	4/3	—	—	260	13/3	—
85	—	—	17/12	270	—	27/6
90	3/2	—	—	280	14/3	—
95	—	—	19/12	290	—	29/6
100	5/3	—	—	300	5	—
105	—	—	21/12	320	—	16/3
110	—	11/6	—	340	—	17/3
115	—	—	23/12	360	6	—
120	2	—	—	380	—	19/3
125	—	—	25/12	400	—	20/3
130	—	13/6	—	420	7	—
135	—	—	27/12	440	—	22/3
140	7/3	—	—	460	—	23/3
145	—	—	29/12	480	8	—
150	5/2	—	—	500	—	25/3
155	—	—	31/12	520	—	26/3
160	8/3	—	—	540	9	—
165	—	—	33/12	560	—	28/3
170	—	17/6	—	580	—	29/3
175	—	—	35/12	600	10	—
180	3	—	—	620	—	31/3
185	—	—	37/12	640	—	32/3
190	—	19/6	—	660	11	—
195	—	—	39/12	680	—	34/3
200	10/3	—	—	700	—	35/3
210	—	21/6	—	720	12	—

Fig. 10. Table of oscilloscope figures for frequencies calibrated against 60 cycles. Ratios shown are for vertical peaks to horizontal tails (or horizontal peaks for Lissajou figures)—see Fig. 9

except perhaps on the highest frequency range. The highest frequency range does not readily conform to the scale for the other ranges and it is generally necessary to use a table of correction for this range.

The terminal marked 60 cycles is a convenient source of voltage for spot checking calibration at any time. By connecting a low voltage a-c voltmeter between this terminal and the output (set at "Lo") "beats" can be observed when the oscillator is set close to the principal harmonics and sub-harmonics of 60 cycles. These two terminals can also be connected in parallel for the observation of beats on a vacuum tube voltmeter or other grounded indicator.

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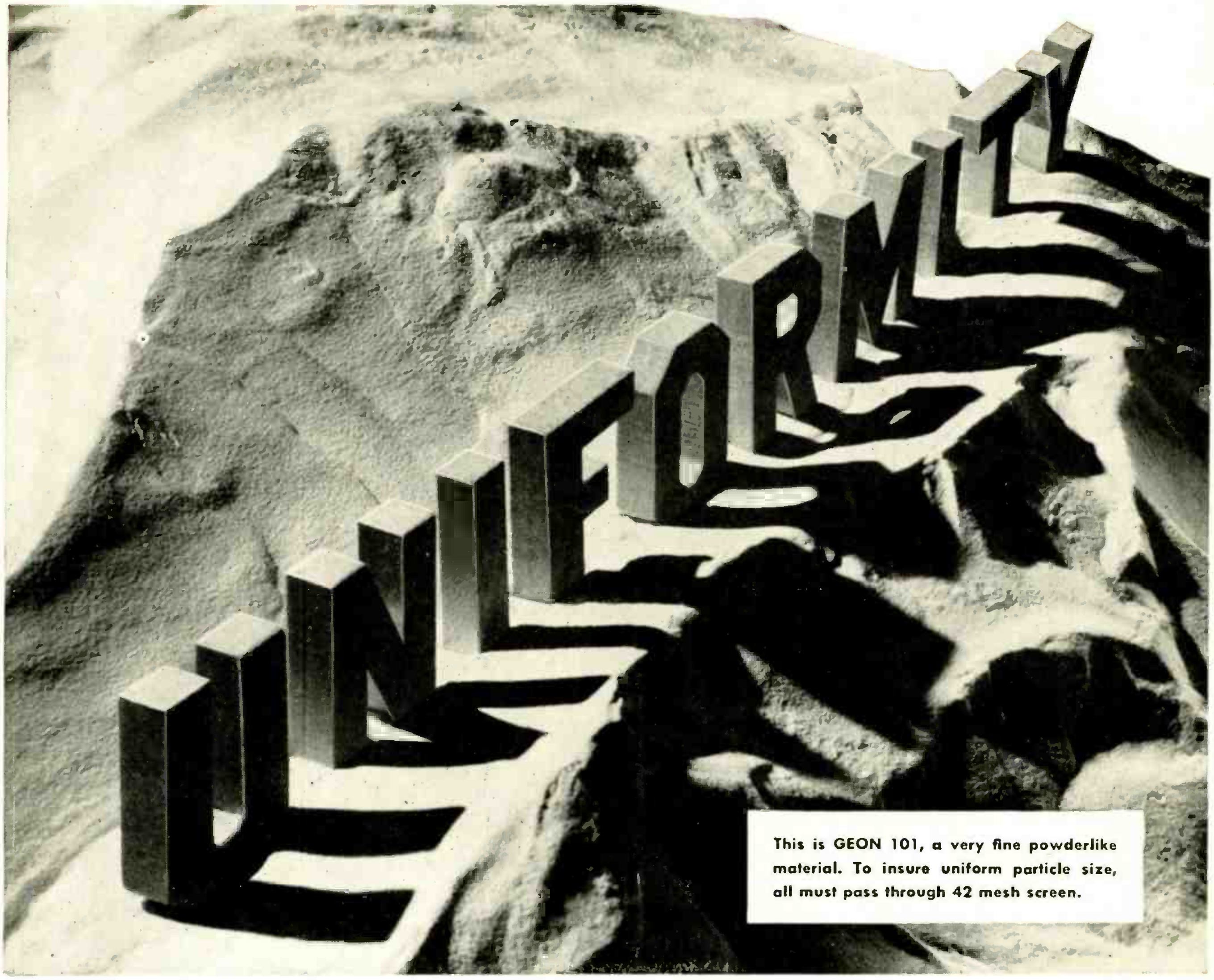

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An important advantage offered by GEON polyvinyl resins for electric wire and cable insulation

NEW users of GEON polyvinyl materials are invariably delighted to discover that these resins provide definite processing advantages resulting directly from the *uniformity* of the raw material. This basic uniformity means that foot after foot, mile after mile of wire insulation made from GEON will be of continuous high quality.

With GEON resins it isn't necessary to mix several batches together in an effort to get uniformity in the base material. Nor is there any need to adjust processing machinery frequently to compensate for batch-to-batch variations of the plasticized product. The formula used yesterday with one batch of GEON can be used today and tomorrow with new batches. And the finished insulation will be uniform—electrical and all other properties always the same. That means satisfied customers, fewer rejects.

All this is true because manufacturing methods for GEON result in a material that is *uniform*—batch after batch after batch are all alike within close tolerances controlled by rigid specifications. For example, specific viscosity limits for GEON 101 are .52—.57. To control particle size, 100% must pass through 42 mesh screen.

Another important advantage of GEON is that the right *combination* of properties for your insulating material can be selected to meet the specific conditions of end use. These properties include resistance to water, heat, cold, aging, wear, abrasion, sunlight, chemicals, and many other normally destructive factors. For more information write Department WW-7, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

Geon
Polyvinyl Materials

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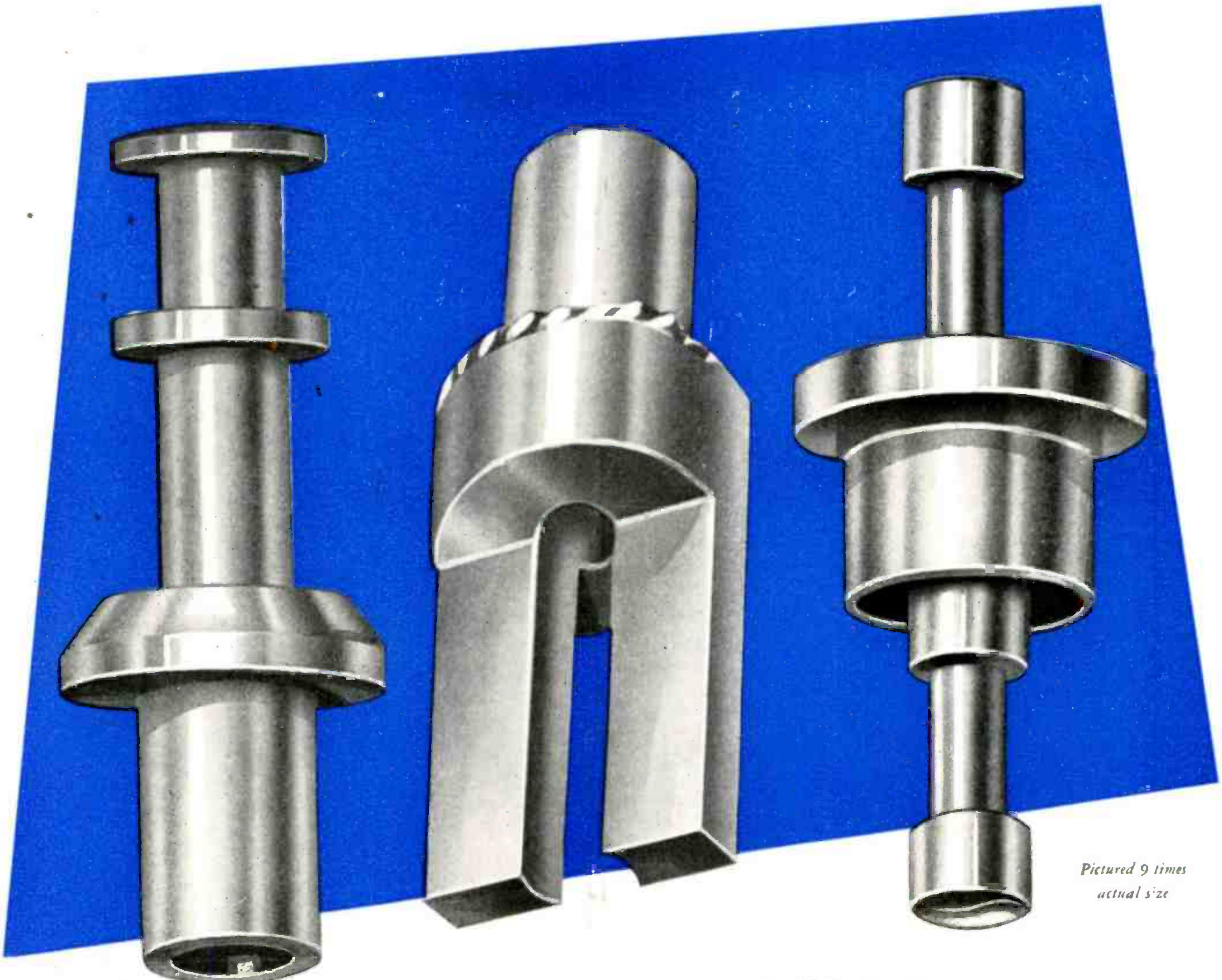

Pictured 9 times actual size

MEET THREE "BIG" LUGS

Reading from left to right they are C.T.C.'s Turret Terminal Lug, C.T.C's Split Terminal Lug and C.T.C.'s Double End Terminal Lug and we're willing to wager that once you've made their acquaintance you'll be very glad you've joined their ever-widening circle of friends who find in them a better, faster, more economical way to get firm, quick soldering terminal posts.

C.T.C. TURRET TERMINAL LUGS are firmly anchored to terminal boards by a simple swaging operation. Two soldering spaces permit two or more connections without superimposing wires — insure good contact, neat appearance. Made of brass, heavily silver plated, to fit 1/32", 2/32", 3/32", 4/32", 6/32" and 8/32" terminal board thicknesses.

C.T.C. SPLIT TERMINAL LUGS have a .050" hole through their shaft which makes them ideal for use on transformers or other potted units that require soldering after potting and on terminal boards that should be wired from top or bottom side of board without drilling. Made of heavily silver plated brass to fit 3/32" terminal boards.

C.T.C. DOUBLE END TERMINAL LUGS provide twin terminal posts in one simple swaging operation. They may be wired from top or bottom and electrical connection is perfect because both posts are part of the same lug. Stocked in 3/32" terminal board thicknesses.

CTC

THE NEW C.T.C. CATALOG NO. 100 contains complete information on C.T.C. LUGS, *All-Set* TERMINAL BOARDS, SWAGING TOOLS, X-RAY ORIENTED CRYSTALS and I-F TRANSFORMERS. Get your free copy.

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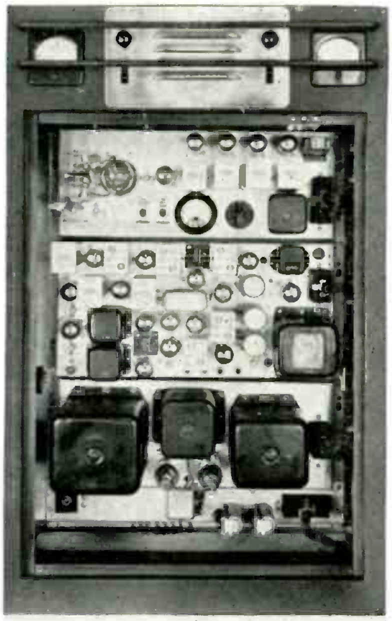

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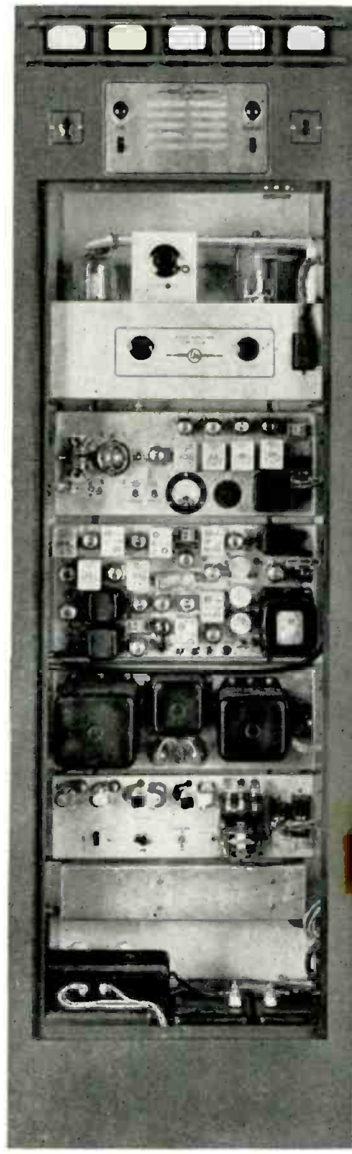

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