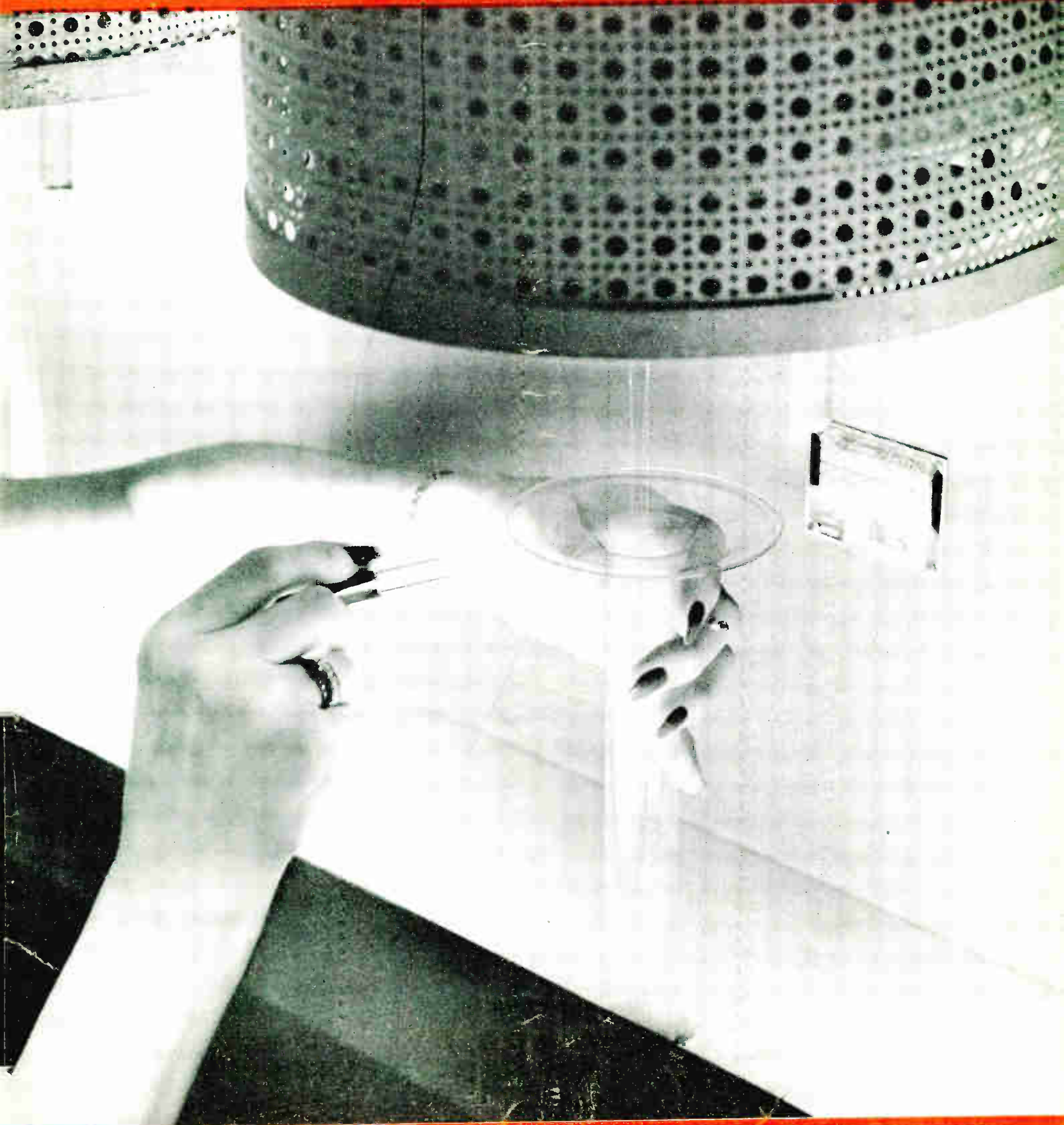
RADIO

OCTOBER, 1945

Design • Production • Operation



The Journal for Radio & Electronic Engineers

Available Types

Shielded • Saddle Plate • Chassis Lock
Bottom Mounted • Rubber Mounted
Shielded Rubber Mounted

As war-designed and tested improvements are freed for general use, Amphenol is proud to announce more and more new units to aid manufacturers of postwar electronics equipment.

Amphenol Miniature Sockets are typical of this policy. They're new, represent advanced engineering, possess many exclusive features, plus the famous Amphenol built-in perfection and performance.

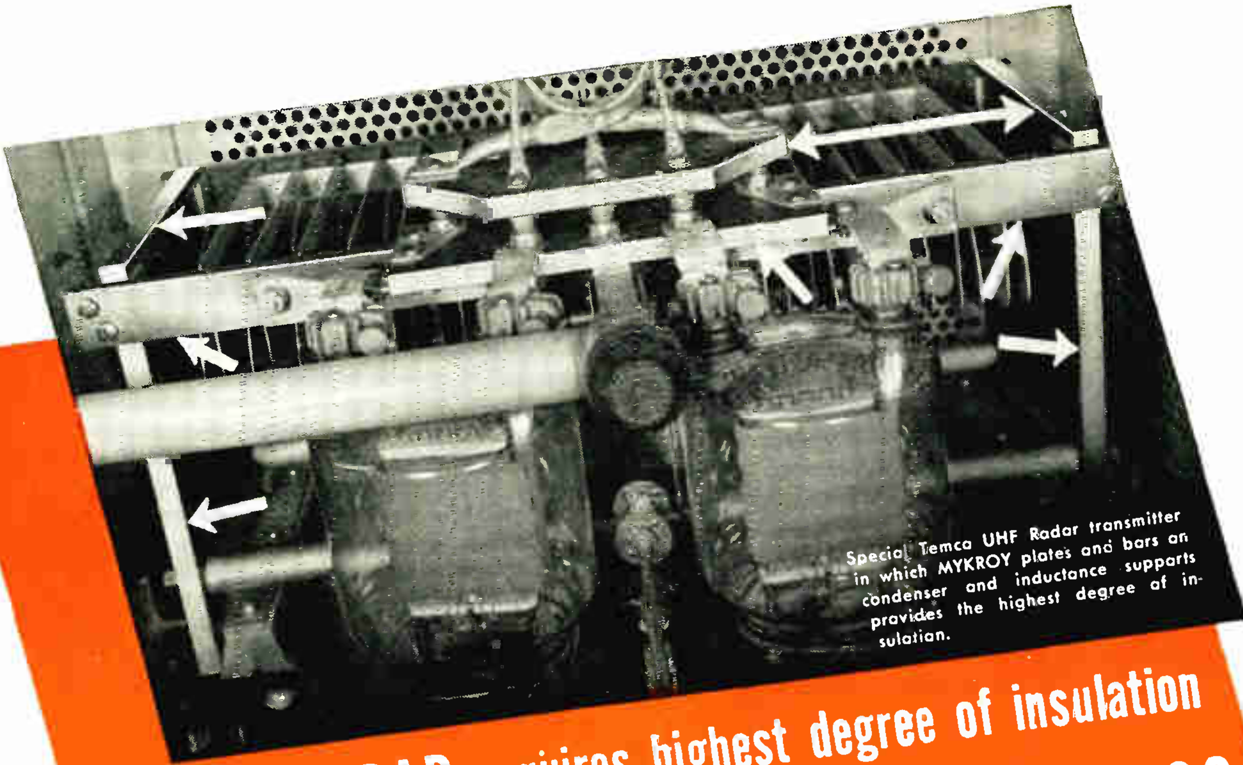
Think of them where space is limited or easy portability is an advantage—for use with handy-talkie radios, miniature and portable sets, electronic controls and endless industrial applications in the coming era of electronics.

How will they fit in with your products? Amphenol engineers are ready and glad to give you all technical data NOW . . . and any engineering assistance of help to you.

AMPHENOL
MINIATURE BUTTON SOCKETS
147 SERIES

Write for this free bulletin . . . It tells the story of Amphenol Miniature Sockets

AMERICAN PHENOLIC CORPORATION
Chicago 50, Illinois
In Canada • Amphenol Limited • Toronto


Special Temco UHF Radar transmitter in which MYKROY plates and bars on condenser and inductance supports provides the highest degree of insulation.

Because RADAR requires highest degree of insulation

MYKROY is specified at TEMCO

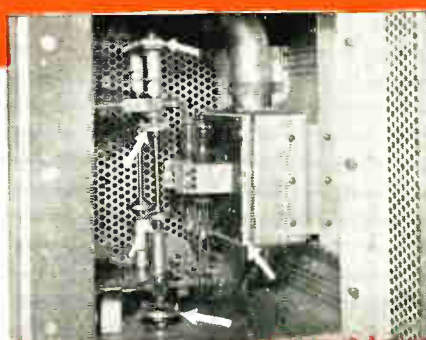
PERFECTED MICA CERAMIC INSULATION

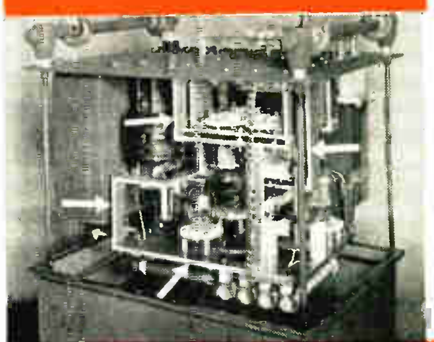
"WHEN insulation of the highest order is specified you can always depend on MYKROY to fill the bill," says Morton B. Kahn, President of Transmitter Equipment Manufacturing Company, designers and builders of advanced Radar equipment, "and insulation requirements for Radar set an all-time high for the industry."

Mr. Kahn's opinion is shared by leading engineers and manufacturers everywhere who have also discovered that MYKROY is one of the best and most usable insulating materials ever developed for general and high frequency applications.

Mykroy is a perfected Glass-Bonded Mica Ceramic made entirely of inorganic ingredients, hence it cannot char or turn to carbon even when exposed to continuous arcs or flashovers. Its electrical characteristics are of the highest order and do not shift under any conditions short of actual destruction of the material itself. Furthermore it will not warp—holds its form permanently—molds to critical dimensions and is impervious to gas, oil and water.

Although MYKROY is a new and superior type of insulation it costs no more than many standard dielectrics of lower electrical and mechanical properties. It will pay you, therefore, to investigate MYKROY now in planning your new products. Write for Bulletins 101-104.


High powered Temco VHF Radar unit operates over wide frequency range utilizing forced air cooled tubes. MYKROY is used at all points requiring maximum insulations


Temco 350KW Radar Pulse Modulator, all parts of which are completely immersed in oil, operates with a normal plate voltage of approximately 25000 volts. MYKROY is used at all critical high voltage points to assure maximum dependable insulation and particularly because it is impervious to oil.

MADE EXCLUSIVELY BY
ELECTRONIC MECHANICS INC.
70 CLIFTON BLVD., CLIFTON, N. J.
CHICAGO 47; 1917 N. Springfield Ave., Tel. Albany 4310
EXPORT OFFICE: 89 Broad Street, New York 4, New York

MYKROY IS SUPPLIED IN SHEETS AND RODS — MACHINED OR MOLDED TO SPECIFICATIONS

FOR THESE MARKS IN CHEMISTRY AND PHYSICS

This recent graduate of the Formica war-expanded laboratories has passed the following tests and is qualified for employment in many old and new applications.

It is made with melamine resins and glass fibre base and conforms to Navy Grade GMG.

It withstands 440 degrees F for a short period, and 390 degrees continuously.

Its arc resistance reaches a new level—by ASTM test D 495-42 it is rated at 185 seconds.

It is so strong it can take structural stresses when desirable. Test figures: Tensile strength 25,000 P.S.I.; Compressive strength (flatwise) 90,000 P.S.I.; Modulus of Elasticity in bending 3,000,000 P.S.I.; Izod impact, 12 ft. lbs. per inch of notch.

FORMICA

Here is a new combination of desirable properties not previously available in one material. Unlike various materials which possess some of these characteristics, FF-55 can be easily punched and machined. It is superior for rapid fabrication by production methods.

THE FORMICA INSULATION COMPANY, 4670 SPRING GROVE AVENUE, CINCINNATI 32, OHIO

YOU CAN TAKE THE SAME GRIP

BUT CAN YOU PITCH LIKE A CHAMP?

There is more to throwing curves than holding a ball a certain way—

And there is more to producing top-performance transformers than assembling coils, cores, etc. in an enclosing case.

Correct use of engineering—years of experience—control of quality and manufacture in everyday large scale production—and the selection of the appropriate type and design for each particular requirement—are all essential to successful operation.

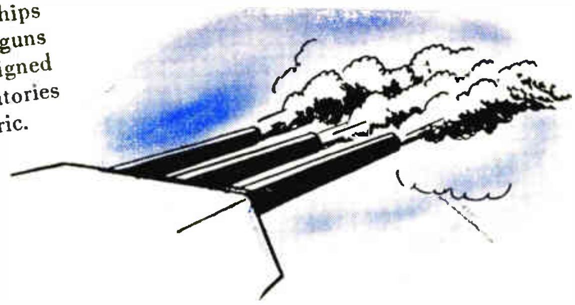
The hundreds of thousands of transformers regularly produced—are ample proof that leading manufacturers of equipment in electronic, lighting, radio and similar fields prefer Jefferson Electric Transformers. Recommendations concerning transformers made by the Jefferson Electric engineering staff can save time for you—and insure the performance you desire. JEFFERSON ELECTRIC COMPANY, Bellwood (Suburb of Chicago), Illinois. In Canada: Canadian Jefferson Electric Co. Ltd., 384 Pape St., Toronto, Ont.

JEFFERSON ELECTRIC

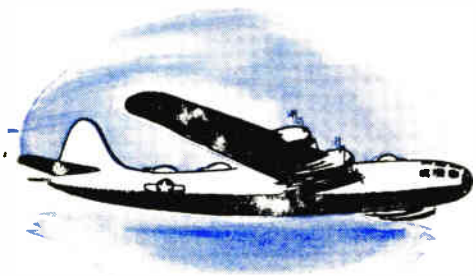
ELECTRONIC • RADIO • TELEVISION

TRANSFORMERS

All of the big guns on Navy ships and a majority of their smaller guns are directed by radars designed by Bell Telephone Laboratories and made by Western Electric.



What TEAMWORK



Bomb-directing radars used on B-29s were designed by the Laboratories and made by Western Electric.

This team developed and produced low altitude radar bombsights widely used against the enemy's merchant shipping.

Bell Telephone Laboratories and Western Electric were "naturals" for the leading part they played in the radar program. For years they've worked as a team in developing and producing complex electronic equipment.

Here are some unadorned facts about what their teamwork made possible.

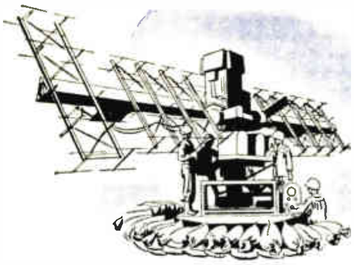
Up to the end of the war, Western Electric had furnished the Army, Navy and Air Forces with more than 56,000 radars of 64 different types, valued at almost $900,000,000.

In 1944 alone, Bell Laboratories worked on 81 different types of radar systems and Western Electric produced 22,000 radars of 44 different types — of which 20 were new in production that year.

Western Electric was the largest producer of the cavity magnetron and other essential vacuum tubes for radar. Number of tubes required for Western Electric radar systems varied from less than 100 to nearly 400 per system.

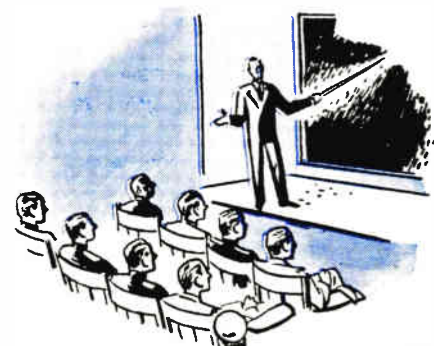
Complexity of radar manufacture is indicated by the fact that even a simple type may require 4,000 labor hours to manufacture and the larger types as much as 40,000 labor hours.

From the very beginning, ground radars made by Western Electric played an important role in all theatres of war.



did for RADAR

Bell Laboratories developed more than 100 different radar test sets. In 1944, Western produced over 40,000 test sets of 68 types.



A school to train military personnel to operate and maintain radar was established by the Laboratories. Over 100 courses were given to some 4,000 officers and men.

The same team is working for YOU!

The unique combination of brain power and manufacturing facilities that made Bell Laboratories and Western Electric the nation's largest source of radar, is now devoted to bringing you the best in communications equipment for a world at peace. In peacetime off-shoots of radar—and in FM, AM and television broadcasting—in radio telephone equipment for every type of mobile service—this team can be counted on to lead the way.

Western Electric built up a Field Engineering Force of more than 500 specialists. They served with all branches of the Armed Forces on all fighting fronts.

BELL TELEPHONE LABORATORIES
World's largest organization devoted exclusively to research and development in all phases of electrical communication.

Western Electric
Manufacturing unit of the Bell System and nation's largest producer of communications and electronic equipment.

THOUSANDS OF TESTIMONIALS

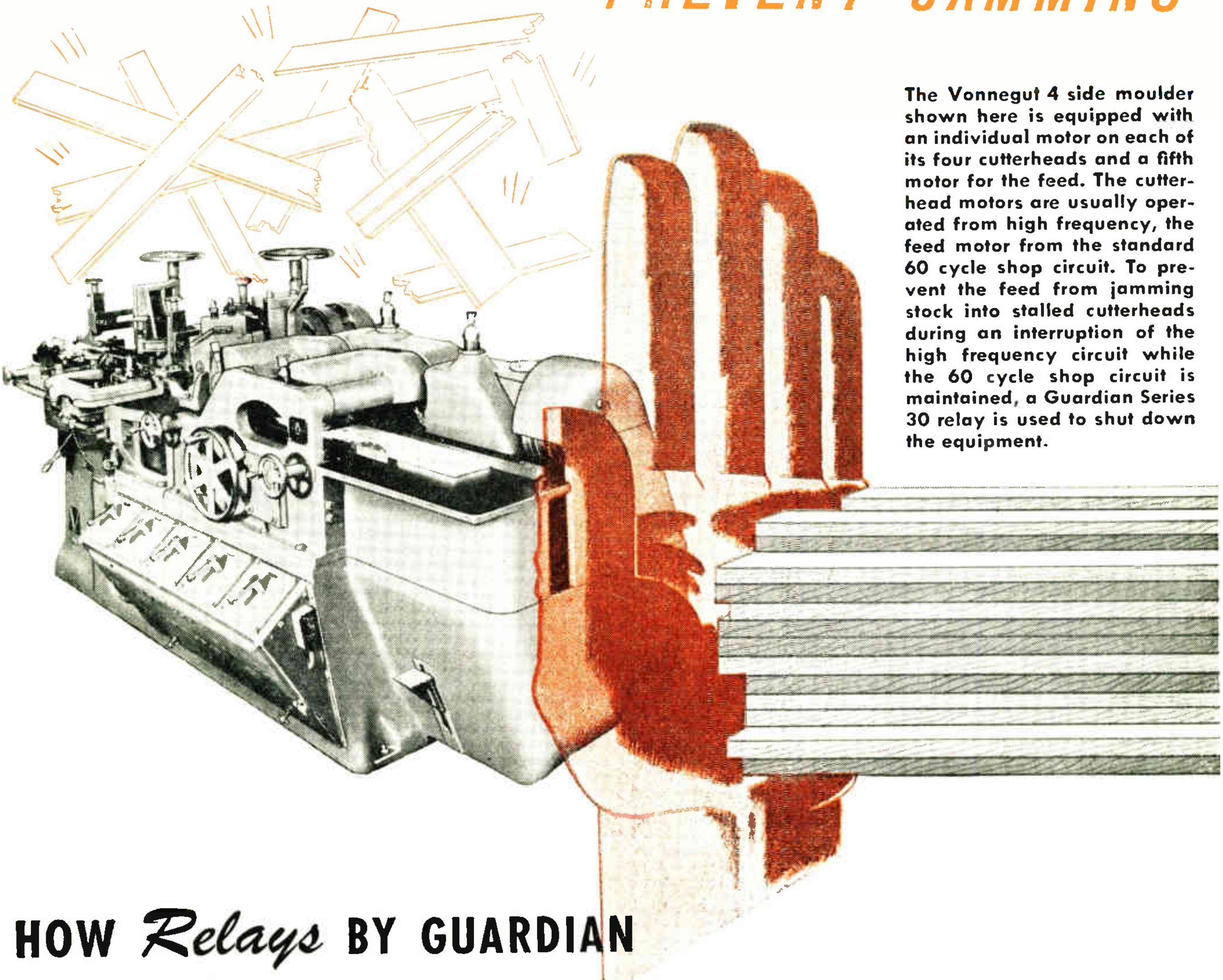
Thousands of testimonials are in the files at Hallicrafters. They are from members of the armed services all over the world. They tell how Hallicrafters-built communications equipment has performed dependably and brilliantly on all the battle fronts of the world. Many of these letters are signed by licensed amateurs who include their call letters with their signatures. A high percentage of the letters conclude with sentiments like these—we quote: *"If a rig can take it like the HT-9 took it in the Australian jungles, it's the rig for my shack after the war"*. . . *"When I buy my communications equipment it will be Hallicrafters"*. . .*"After we have won this war and I can get a ham ticket there will not be the slightest doubt as to the equipment I will use . . . it will be Hallicrafters"*. . .*"Meeting Hallicrafters gear in the service was like seeing someone from home . . . I used to have one of your receivers at W7FNJ . . . hope to have more after the war"* . . .*"being an old ham myself I know what went into the 299 . . ."* Thus does the voice of the amateur come pouring into Hallicrafters headquarters, providing information, guidance and further inspiration to Hallicrafters engineers. Amateurs will find in Hallicrafters peacetime output just the equipment they need—refined and developed in the fire of war and continuing to live up to the well earned reputation as "the radio man's radio."

BUY A VICTORY BOND TODAY!

hallicrafters RADIO

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

relays IN MACHINE CONTROL PREVENT JAMMING



The Vonnegut 4 side moulder shown here is equipped with an individual motor on each of its four cutterheads and a fifth motor for the feed. The cutterhead motors are usually operated from high frequency, the feed motor from the standard 60 cycle shop circuit. To prevent the feed from jamming stock into stalled cutterheads during an interruption of the high frequency circuit while the 60 cycle shop circuit is maintained, a Guardian Series 30 relay is used to shut down the equipment.

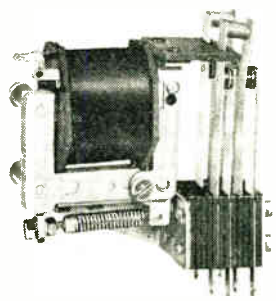
HOW *Relays* BY GUARDIAN

provide automatic SHUT-OFF . . . *conserving materials and equipment*

Wherever two or more independent sources of power are utilized to perform one operation, the failure of one power source presents a hazard to safety, materials and equipment. In such places Relays by Guardian are often employed to interrupt all other circuits when one circuit fails.

The Vonnegut 4 sided moulder, built by the Vonnegut Moulder Corporation of Indianapolis, uses a Guardian Series 30 relay in this application. This is a quiet, dependable relay with a laminated field piece and armature, a large contact switch capacity, and a wide operating range. It is available for operation on any frequency between 20 and 150 cycles.

But whatever your relay application may be, it will pay you to write. If you describe your application when writing, Guardian engineers will make recommendations.



Series 30 A.C. Relay

Also, iron clad and laminated solenoids, stepping relays, magnetic contactors, electric counters, snap and blade switches.

GUARDIAN G ELECTRIC

1605-L W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

JENSEN RADIO MANUFACTURING COMPANY • 6621 SOUTH LARAMIE AVENUE, CHICAGO 38, ILLINOIS
IN CANADA—COPPER WIRE PRODUCTS, LTD., 137 RONCESVALLES AVENUE, TORONTO

THE *Quiet* BALLENTINE RECORD CHANGER MOTOR

Has these four characteristics achieved by advanced design, skilled engineering and precision manufacturing.

- Lowest Rumble
- Highest Efficiency
- Most Compact Design
- Longest Life

The *Quiet Ballentine* Changer Motor is recommended to record changer manufacturers seeking to provide the ultimate in performance.

RUSSELL ELECTRIC CO.

370 West Huron Street
Chicago 10, Illinois

Manufacturers of

BALLENTINE RECORD CHANGER MOTOR

SYLVANIA NEWS

Electronic Equipment Edition

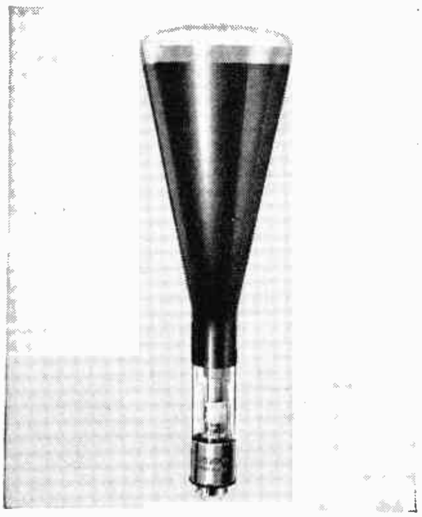
OCT. *Published by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. 1945

SYLVANIA CATHODE RAY TUBES NOW AVAILABLE

Ready for New Television Sets To Be Produced

Sylvania Electric announces the welcome news that cathode ray tubes are once more available for the manufacturers of television sets.

Constant research in this field, combined with wide experience in large-



Sylvania Electric precision built cathode ray tube now available to television set manufacturers.

scale production to meet war requirements, has placed Sylvania in a position to manufacture these tubes to a much higher standard than ever before.

This is an important factor to manufacturers of television receivers whose "plans" are rapidly becoming realities.

Check today with Sylvania Electric Products Inc., Emporium, Pa.

MANY MANUFACTURERS TO USE ELECTRICALLY SUPERIOR TUBE

Sylvania Lock-In Radio Tube Ideal For FM, Television, Radar

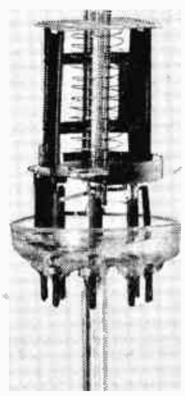
With the increasing trend toward higher frequencies—as shown by recent FCC decision assigning FM the band between 88 and 106 megacycles—set manufacturers will tend, more than ever, to use a tube ideally suited to the adoption of these very high frequencies.

The Sylvania Lock-In is *known* to be electrically and mechanically superior to any tube made.

Electrically, it is more efficient because the element leads are brought directly down through the low-loss glass header to become sturdy socket pins—reducing lead inductance—and interelement capacity.

Mechanically, it is more rugged because support rods are stronger and thicker—there are fewer welded joints and no soldered joints—the lock-in lug is metal, not molded plastic—the elements are prevented from warping and weaving.

Today, set manufacturers considering the many developments in the field of communications, are looking to the Sylvania Lock-In Tube as a perfect electronic unit—the tube built to handle ultra-high frequencies.



The Sylvania Lock-In Tube showing construction—electrical and mechanical—that makes it superior to any tube made.

SYLVANIA ELECTRIC

Emporium, Pa.

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

POWER

HIGH VOLTAGE POWER SUPPLY

This is the RA-38 power supply—another of the numerous valuable items in the group of government radio and electronic supplies offered for general distribution through the Hallicrafters Co., agents for RFC under Contract SIA-3-24.

Output voltage continuously variable from 0 to 15,000 volts. Can be easily adapted to deliver up to 6,000 volts at 1 ampere. Excellent power supply for laboratory work or can be used as power source for broadcast stations, induction heating equipment, vacuum tube life tests and many other industrial applications.

THESE VALUABLE ITEMS *Available Now*

or very soon. Write, wire or phone for further information

• head phones • test equipment • component parts • marine transmitters and receivers • code practice equipment • sound detecting equipment • vehicular operation police and command sets • radio beacons and airborne landing equipment.

CLIP THIS COUPON NOW

RFC DEPARTMENT 210, HALLICRAFTERS
5025 West 65th Street • Chicago 38, Illinois

☐ Send further details and price on RA-38 Power Supply
☐ Send listings of other available items

Especially interested in . . . .
NAME . . . .
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CITY . . . . ZONE . . . .
STATE . . . .

hallicrafters RADIO

HALLICRAFTERS CO., AGENT OF RFC UNDER CONTRACT SIA-3-24
MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT

COPYRIGHT 1945 THE HALLICRAFTERS CO.

WORLD'S FASTEST PLANE *uses* ANDREW COAXIAL CABLES!

Lockheed's sensational new jet-propelled super fighter, the P-80 "Shooting Star," is the world's fastest and highest flying plane.

★ It is highly significant that Andrew coaxial cables were chosen for the vital radio and radar equipment installed in the P-80. They were selected because they are much more resistant than ordinary solid dielectric cables to the high temperature encountered in the tail of the plane.

Andrew Co. is a pioneer manufacturer of antenna tuning and phasing equipment, including a complete line of ceramic insulated coaxial cables and all necessary accessories. *Write for catalog.*

ANDREW

ANDREW CO.

363 EAST 75th STREET, CHICAGO 19, ILLINOIS

TECHNICANA

VOLTAGE MEASUREMENT

★ The actual d-c working voltage across a circuit element is determined from two voltmeter readings, one with a series resistance equal to the voltmeter resistance, as in *Fig. 1.*

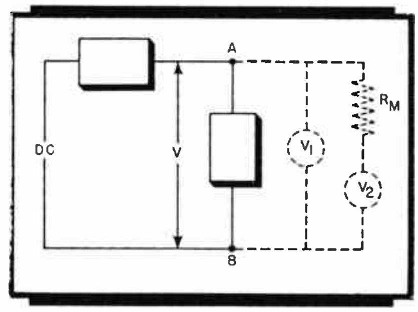


Figure 1

The actual voltage V across AB follows formula $\frac{1}{V} = \frac{1}{V_2} - \frac{1}{V_1}$, in which V_1 is the first meter reading, and V_2 the meter reading with series resistance R_m.

When taking repeated measurements V may be found easily by use of an alignment chart, *Fig. 2.*

The chart is prepared as follows: Take arbitrary values for V_1 and V, say 100 volts and 400 volts. Compute V_2 from the formula, so that $\frac{1}{100} + \frac{1}{400} = \frac{1}{V_2} = \frac{1}{80}$. From this value V_2 is laid off in terms of V_1-axis units. Draw a vertical line $V_1 = 80$ and divide the diagonal line V_2 into equal parts by constructing additional vertical lines from V_1.

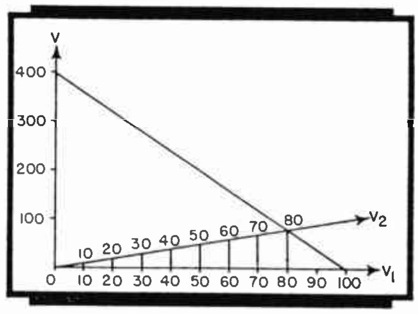
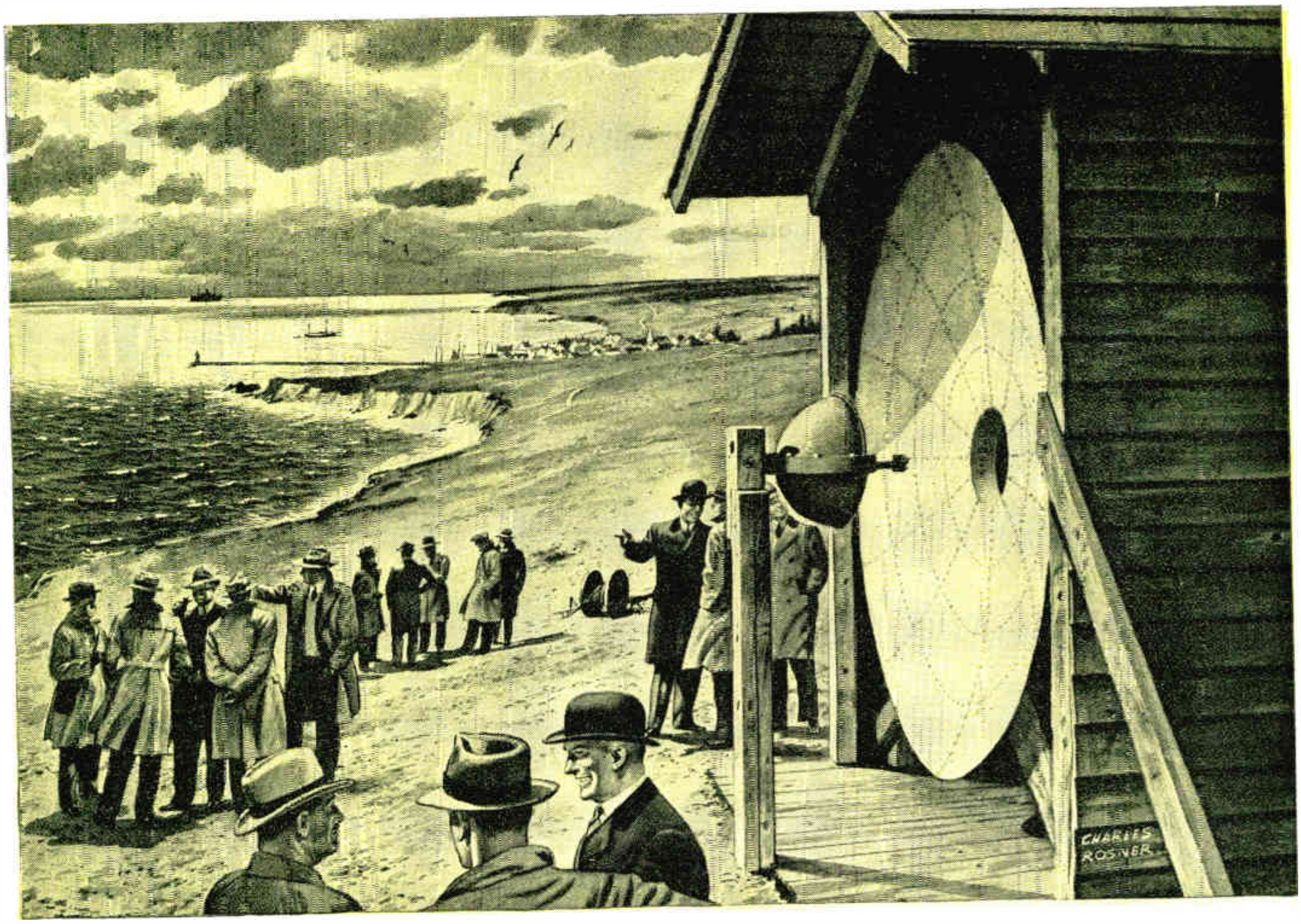


Figure 2

Now if a straight-edge is placed through the V_1 value, on the V_1 axis, and V_2 value on the diagonal, it will project the correct voltage reading, V, on the vertical axis.

[*Continued on page* 16]



Federal's men know *Microwave*

On a gusty March day in 1931 . . . when man's voice was beamed across the English Channel from an antenna less than an inch long and powered by a mere half-watt . . . Microwave was born.

This was the inauguration of a new technique in the art of communication . . . blazing the trail for modern, high fidelity television, FM transmission, pulse time modulation, plurality of currents on a common carrier, and certain other commercial applications for this technique.

Many of the scientists now at work in Federal laboratories participated in that triumph and helped in its developement through the years. Now they are engaged in extending its application, opening vast and striking possibilities for the future of communications.

Pioneer in the field of microwave . . . a contributor to radio progress for more than 35 years . . . Federal stands for leadership in research, development and manufacture of equipment and components for every segment of the communications industry.

FEDERAL TELEPHONE & RADIO FTR

ARMY E NAVY

M

Federal Telephone and Radio Corporation

AN IT&T ASSOCIATE

Newark 1, N. J.

Communications WELL IN HAND

• *Transmitting equipment designed and manufactured by Wilcox Electric Company of Kansas City, Missouri.*

THE inclusion of Astatic's GDN Series Dynamic Microphone in this modern airline dispatching office installation speaks for itself. Present-day communications systems demand the finest possible equipment. Astatic products measure up to these high standards of operating efficiency.

SHOWN in the installation pictured above is a Dynamic, semi-directional, all-purpose Microphone of the Astatic DN Series, mounted on Grip-to-Talk Desk Stand. This stand embodies a relay-operating ON-OFF Switch for remote control of transmitters and amplifiers, the switch itself being operated by a slight pressure of the fingers upon a convenient grip bar.

Astatic Microphones, Phonograph Pickups and Cartridges are going forward daily in an ever-increasing volume to manufacturers of radio, phonograph, communications and public address equipment, and to authorized Astatic jobber outlets.

You'll HEAR MORE *from Astatic*

THE Astatic CORPORATION
CONNEAUT, OHIO
IN CANADA CANADIAN ASTATIC LTD., TORONTO, ONTARIO

TECHNICANA

[*Continued from page* 14]

This method is suggested in an article entitled "Correcting for Voltmeter Load" in the July, 1945, issue of *Electronic Engineering.*

In a second method the series resistance R_m is replaced by a variable resistance X. The V_1 is read when $X = 0$, and V_2 is set at a fixed value equal to $\frac{V_1}{2}$, by adjusting X.

It is shown that $V = V_1 \frac{X}{R_m}$, so that if the scale of X is calibrated in terms of the meter resistance, V can be found by multiplying the V_1 reading by the factor on the scale of X.

RESISTANCE-CAPACITY OSCILLATOR

★ Many types of circuits have been designed to incorporate in one oscillator as many desirable features as possible. Those include operation over a wide frequency band, good stability, constant output, low harmonic distortion, and inexpensiveness.

In the June, 1945, issue of *Electronic Engineering*, F. G. Clifford of the British Post Office Research Station describes a bridge-stabilized, resistance-capacitance oscillator which incorporates an amplitude stabilizing desire of the thermal element type.

The Wien bridge network is of the form of *Fig. 3.* This network is frequency sensitive so that there is zero phase shift when $\omega_0 = \frac{1}{\sqrt{C_1C_2R_1R_2}}$ and optimum feedback is provided.

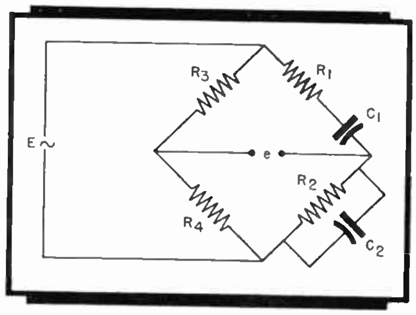
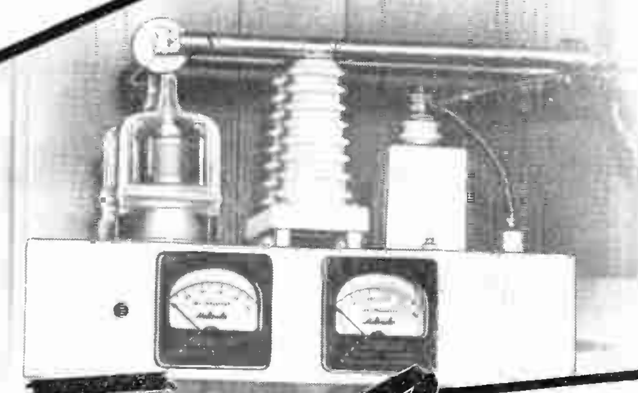


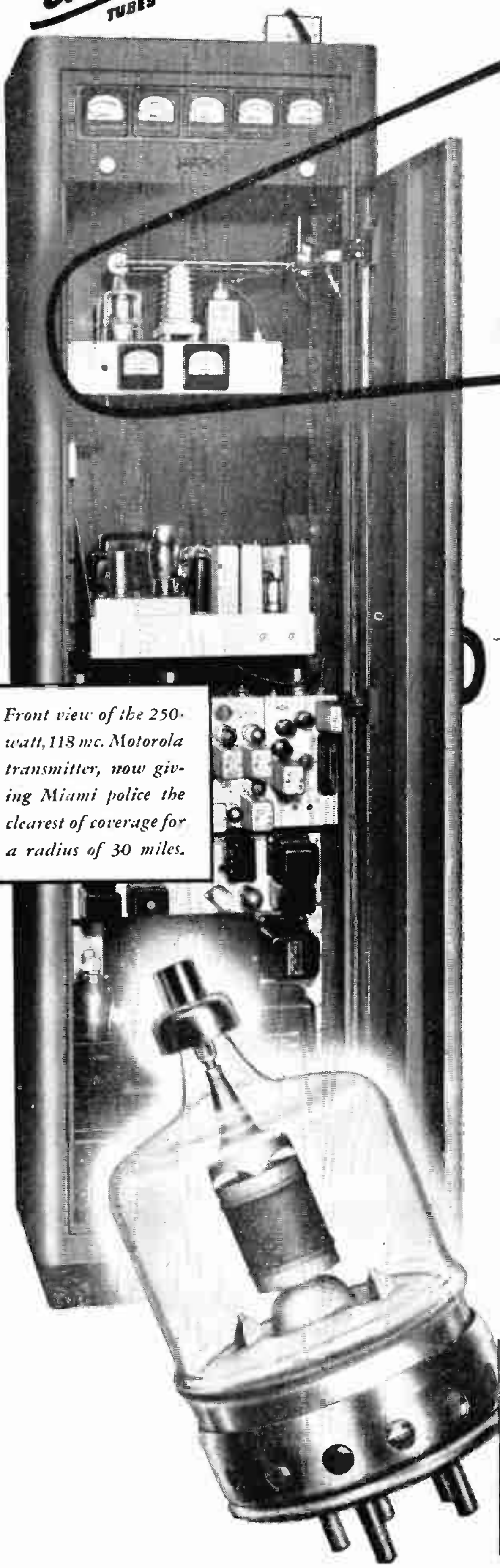
Figure 3

The bridge circuit with feedback amplifier added is shown in *Fig. 4.* This circuit will oscillate at frequency ω_0 if the attenuation of the bridge is less than the gain of the amplifier. As R_4 is in-

[*Continued on page* 18]

Eimac TUBES · THE COUNTERSIGN OF DEPENDABILITY IN ANY ELECTRONIC EQUIPMENT

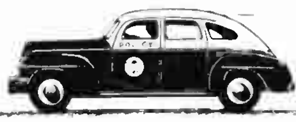




Front view of the 250-watt, 118 mc. Motorola transmitter, now giving Miami police the clearest of coverage for a radius of 30 miles.

Top Spot

IN FM POLICE SYSTEMS



EIMAC TETRODE 4-125A

Top honors to Galvin Manufacturing Corporation for building it, and a salute to the police and fire departments of Miami, Florida, for putting it to work in spite of the skeptics! It's the first two-way police radiotelephone system in the United States on frequencies *above 100 mc.* Twenty-four hours a day, 12 patrol cars in Miami's busy area tune in on signals as solid as a dinner-table conversation from this Motorola 250 watt, 118 mc. FM transmitter.

From the earliest experimental stages of FM broadcasting, Eimac tubes have been lending a hand. Naturally, there are Eimac 4-125A tetrodes (pictured above) in the vital power output stage of Galvin's new Motorola success. Eimac 4-125A's were a logical choice for this transmitter because of their superlative high frequency performance capabilities and their low driving power requirements.

FOLLOW THE LEADERS TO

Eimac REG. U. S. PAT. OFF. **TUBES**

Ask for your copy of Electronic Telesis, the 64-page booklet giving the fundamentals of electronics. It will help electronic engineers explain the subject to laymen. Available in English and Spanish. No obligation, of course.

EITEL-McCULLOUGH, Inc., 1074 San Mateo Avenue, San Bruno, Calif.
Plants located at: San Bruno, California and Salt Lake City, Utah
Export Agents: Frazar & Hansen, 301 Clay St., San Francisco 11, Calif., U. S. A.

1074

ELECTRICAL CHARACTERISTICS - 4-125A TETRODE

Filament: Thoriated Tungsten		Direct Interelectrode Capacitances (Average)	
Voltage	5.0 volts	Grid-Plate (Without shielding, base grounded)	0.03 μμfd.
Current	6.2 amperes	Input	10.3 μμfd.
Plate Dissipation (Maximum)	125 watts	Output	3.0 μμfd.

Transconductance (i_B = 50 ma., E_B = 2500 v., E_{C2} = 400 v.) . 2450 μmhos

40 DEGREE

Vertical

AREA OF DISTRIBUTION

The new amazing Altec Lansing multi-cellular Duplex Speaker provides up to 800% increased area of quality sound distribution. In the vertical plane, the Duplex delivers a forty degree angle of distribution, or eight times the area distribution at high frequencies as compared to single unit speakers of comparable size. Another reason why the DUPLEX is the SPEAKER that REVOLUTIONIZES the methods of sound REPRODUCTION.

SEND FOR BULLETINS

ALTEC LANSING CORPORATION

1210 TAFT BLDG., HOLLYWOOD 28, CALIF.
250 WEST 57 STREET, NEW YORK 19, N. Y.
IN CANADA: NORTHERN ELECTRIC CO.

TECHNICANA

[*Continued from page* 16]

creased the attenuation increases until oscillation ceases.

The author employs a phase-splitting tube between the amplifier and the bridge. This is tube V_2 in *Fig. 5*. Tube V_1 is the amplifier tube and V_3 is a buffer. The non-linear-resistance element, *L*, is a special lamp having a positive resistance-current characteristic.

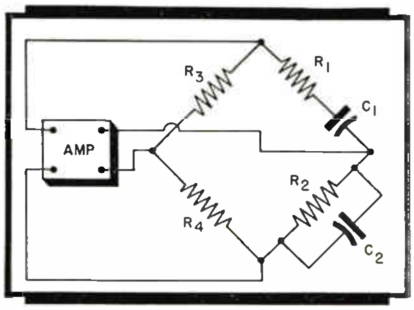


Figure 4

In order to preserve constant attenuation in the bridge at various frequencies, the ratio of the impedances of R_1C_1 and R_2C_2 must be constant. In particular the ratios R_1/R_2 and C_1/C_2 must be constant. Since R_3 and R_4 do not control frequency, the frequency is controlled by C_1 and C_2, which are equal and ganged, or by R_1 and R_2, in steps.

If the ratio of the impedance of R_1C_1 to the impedance of R_2C_2 is *N*, at frequency ω_0, then $R_1 = R_2(N-1)$. The author shows that the condition for maximum frequency stability is that $N = 1.67$ so that the optimum value for $\frac{R_1}{R_2}$ is 0.67.

The author operated between 25 cycles and 40 kc. The lower limit is imposed by the lamp. At below 25 cycles the lamp resistance will follow the frequency cycles sufficiently close to cause distortion. In this range the output was 6 mv, within 1 db, and between 200 cycles and 15 kc the output was constant.

Second and third harmonic contents were 0.2% maximum at 6 mw output between 70 cycles and 6 kc.

At 1000 cycles a 20% change in supply voltage produced less than .05 db change in output and less than 0.2 cycles frequency change.

The author believes that this oscillator could be designed to operate up to 5 mc, and has suggested that this device, amplitude stabilization and phase-splitting tube, may be useful with other types of feedback mechanisms.

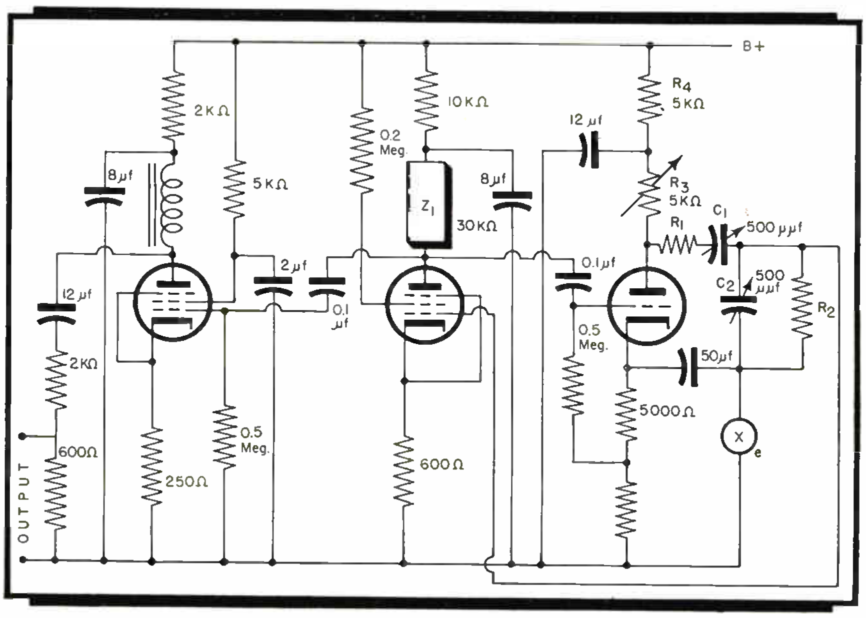


Figure 5

RATIO DETECTORS FOR F-M RECEIVERS

★ In a paper delivered before the New York Section of the Institute of Radio Engineers on Oct. 3, Stuart William Seeley, manager of the Industry Service Division of RCA Laboratories, described a new f-m detector designed to eliminate the need for a limiter stage.

In the conventional design of f-m receivers, a limiter stage is required because the usual type of f-m discriminator detects amplitude, as well as frequency, variations in the incoming signal. Mr. Seeley described discriminator circuits in which a fixed d-c voltage or current, split into two sections, is applied to the discriminator in such manner that the ratio of its amplitude is always equal to the ratio of the amplitudes of the two developed i-f voltages in the discriminator circuit. Such a circuit is stated to be immune to amplitude variations.

Fundamental circuits for ratio detection are illustrated in *Figs. 6, 7,* and *8.* In *Fig. 6,* E_1 plus E_2 equals the battery voltage and the meter indicates the d-c current flowing in the circuit. If the signals S_1 and S_2 are kept equal but increased in magnitude, the current

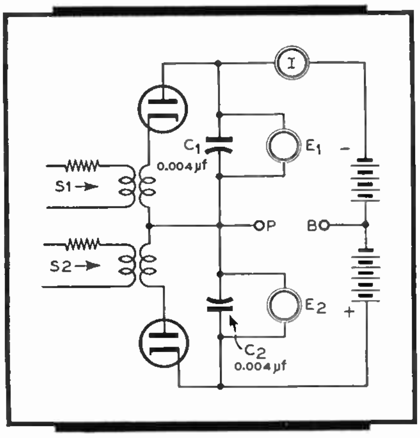


Figure 6

I will increase by an amount greater than the per cent increase in applied signal voltages. If the ratio of S_1 to S_2 equals ½, E_1 plus E_2 will still equal the battery voltage, but E_1/E_2 will equal S_1/S_2. This ratio will hold.

Fig. 7 shows a practical radio detector circuit, in which the battery

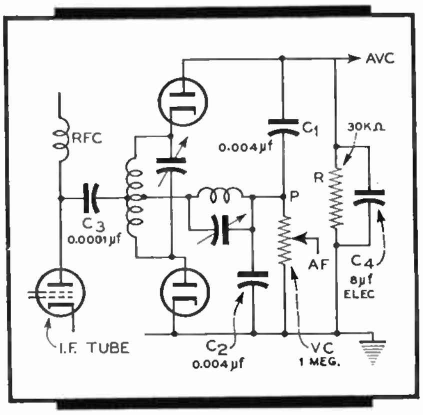


Figure 7

shown in *Fig. 6* is replaced by the resistor *R* and a by-pass capacitor. The capacitors C_1, C_2, and C_3 are used to secure normal de-emphasis. The time constant of the volume control plus C_1,

[*Continued on page* 20]

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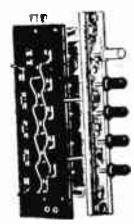

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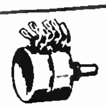

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[*Continued from page* 19]

C_2, and C_3 should be not less than .002 sec. without diode connection. No limiter stage is necessary and there is no threshold voltage. It requires but 10 to 20 mv i-f applied voltage. Although this circuit is in effect a voltage doubler for a-v-c voltages, the a-f output is less than that of a conventional discriminator. But it is stated that the loss in detection is not greater than that caused by the use of a limiter at threshold in comparison with full i-f gain.

Fig. 8 shows another ratio detector circuit which is designed to minimize

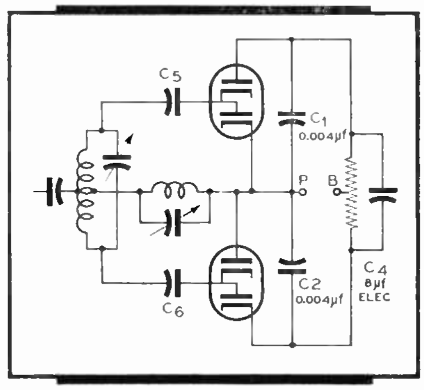


Figure 8

i-f harmonics. Resistor *R* is four times the value of that shown in *Fig. 7*.

Many variations of these fundamental circuits are possible. Design considerations include closer primary and secondary coupling of discriminator than conventionally used, and a completely balanced condition in both halves of network.

It is stated that discriminator linearity is not as easily obtained with ratio detectors as with the usual detector, and varation of transformer coupling cannot be readily used to secure linearity.

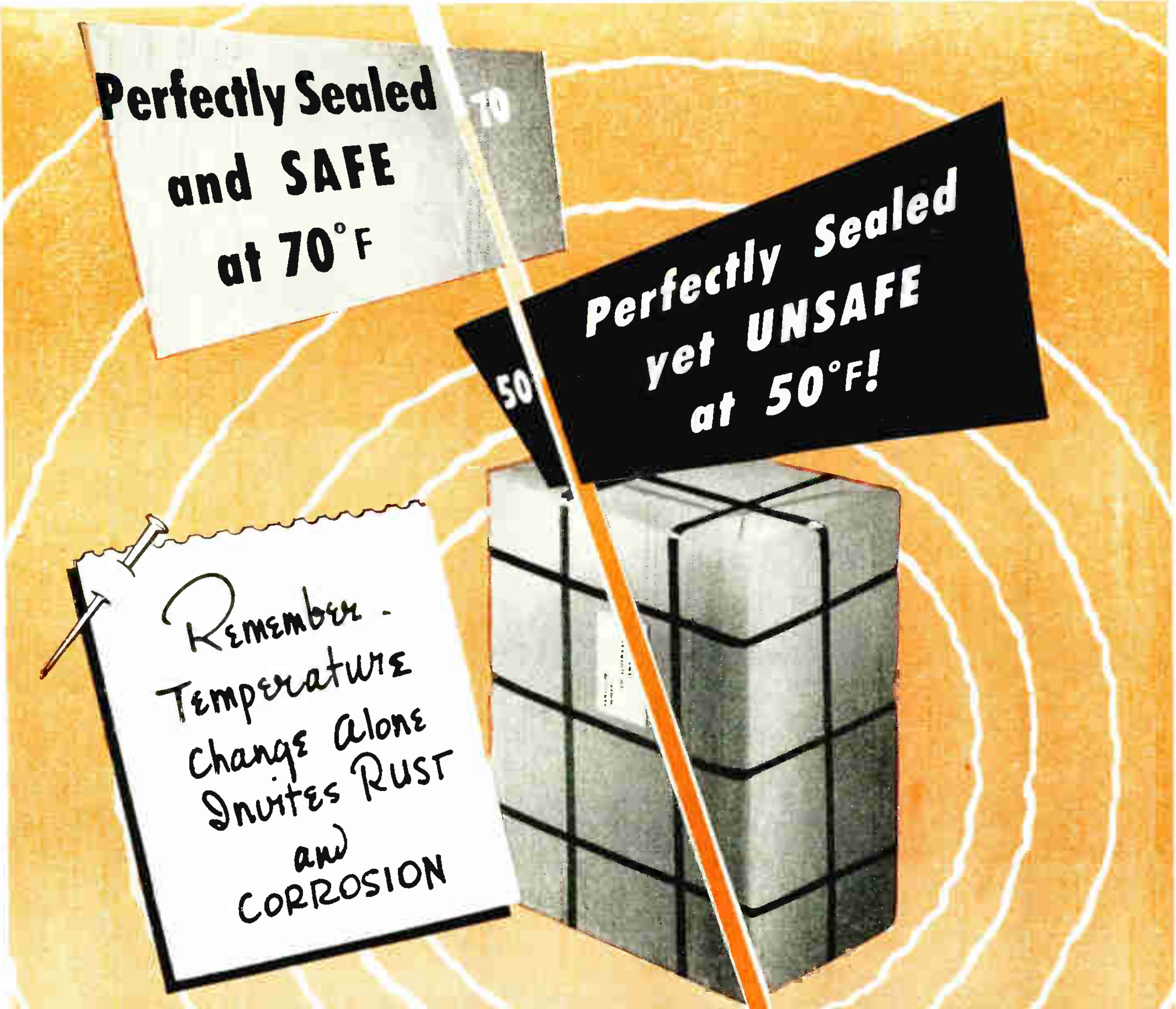
NETWORK DESIGN

★ When it is desired to match a load impedance to a source impedance, a reactive network may be employed. The matching of several circuits into a single load is also commonly employed in the broadcast industry.

The converse, that of matching a single source into *n* loads, and in particular, designing to minimize fluctuations in one outlet due to switching on and off the other outlets, is described in the July 1945 issue of the *A.W.A. Technical Review*, published by Amalgamated Wireless (Australasia) Ltd.

In addition, the attenuation must be

[*Continued on page* 22]



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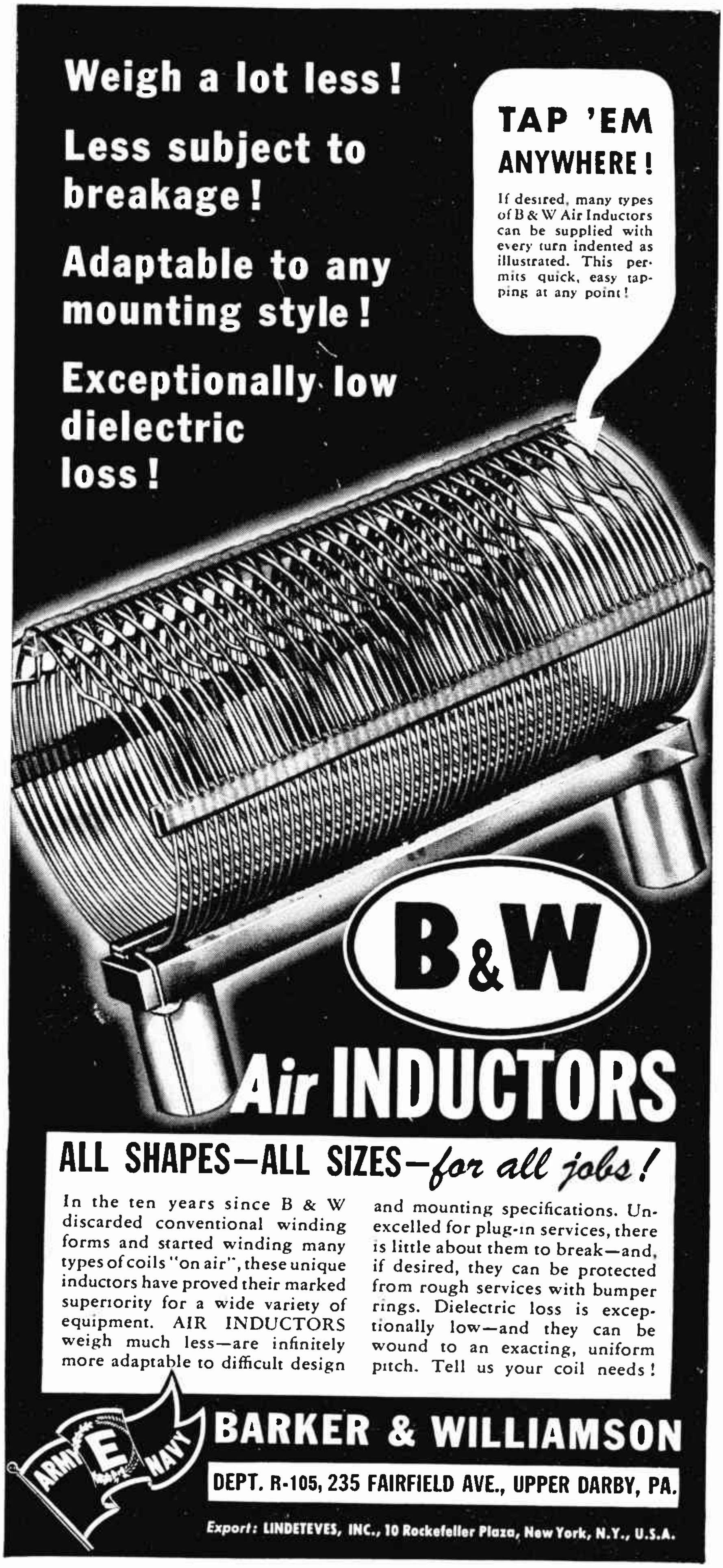

TECHNICANA

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a minimum in each circuit. The problem is stated in terms of a predetermined degree of isolation.

The circuit of *Fig. 9* illustrates the

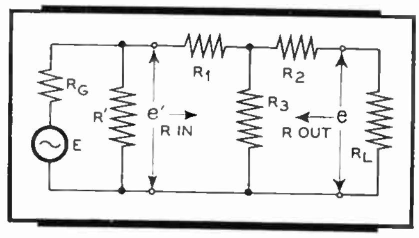

Figure 9

case at hand. The isolating network consists of resistance R_1, R_2, and R_3. The source E has an impedance of R_G, and the load impedance is R_L. R' represents $n-1$ identical networks paralleled at the source.

The author of the article, which is entitled "The Design of Isolating Pads" is J. K. Mackenzie. The per cent changes in output, from the normal condition, when the $n-1$ loads are all short-circuited or open-circuited simultaneously, are calculated. There is a direct relation between the degree of isolation and the attenuation in the network. The least attenuation is shown to occur when $R_2 = 0$ and the pads take the form of

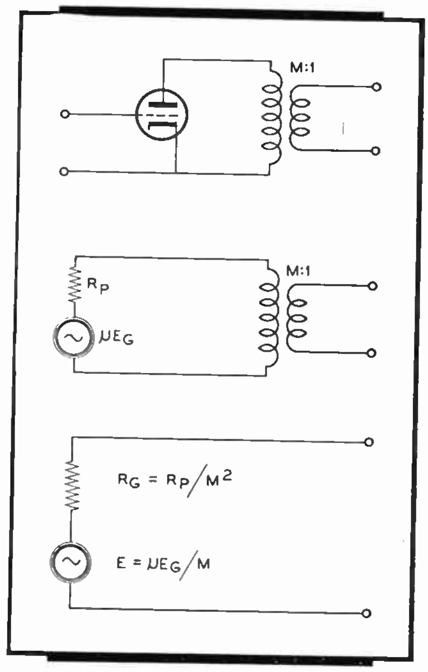

Figure 10

an inverted L section, with the load in parallel with the shunt arm R_3.

The author also determines the conditions necessary for the matching of

[Continued on page 24]

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each load to its generator impedance. These conditions are stated in terms of a working parameter, the value of which depends on the resistance values assigned to the networks, and the number of networks employed.

The fractional changes in output are slightly greater when all loads are open-circuited, so that this condition is employed in the calculations.

A transformer may also be employed between the source and the networks. With a suitably chosen turns ratio, lower attenuation can be obtained. In this case the value of $R_3 = \infty$ so that there is no shunt arm in the isolating pad.

If a triode amplifier is introduced into the generator circuit to make up for the losses in the isolating pads, transformer coupling is again desired in order to present an optimum load to the triode output. It is shown that when the optimum load is twice the plate impedance of the tube, the voltage attenuation is never more than 1.7 db greater than the minimum. The generator as a whole can be matched to its load through a transmission line, using a transformer, with a voltage loss of no more than 3 db above the minimum attenuation.

When a transformer is employed the values of E and R_o are obtained in terms of the equivalent circuit of *Fig. 10.*

VOLUME EXPANSION

★ One of the problems in sound reproduction concerns the audio frequency range necessary to provide reasonably faithful duplication of the original.

Reproduction of the original volume range presents an additional problem. The volume range of an orchestral performance may be as much as 70 db, for example, and if the peaks result in 100% carrier modulation the low levels may be obscured in the background noise of the receiver.

In broadcast work volume compression is ordinarily introduced by reducing the gain of the studio amplifier for loud passages, and increasing the amplification for softer tones. This may be accomplished manually by a studio operator.

It is now the problem of reproducing the original performance by introducing volume expansion in the receiver to offset the volume compression at the broadcast station.

This is discussed by J. G. White in an article entitled "Contrast Expansion", appearing in the Sept. 1945 issue of *Wireless World.*

It is claimed that volume expansion will result in a more pleasing reproduction, despite critics' claims that since the volume compression was introduced manually, no system of expansion can automatically make the proper corrections.

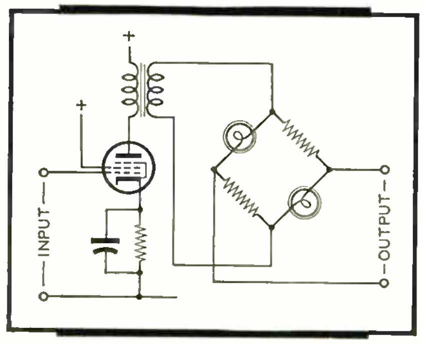

Figure 11

The expansion system should introduce minimum distortion; the degree of expansion should be controllable by the listener as desired for various types of music, and the expansion should be independent of the volume level.

The rate of volume increase, or de-

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crease, must also be considered. Usually the expansion should operate with little delay, but not so rapidly as to cause flutter.

Finally, because the background noise limits the volume reduction, the noise level should be reduced by the expander at the low end.

Among existing types of volume expansion systems is the lamp-operated circuit, of *Fig. 11*. The resistance of the

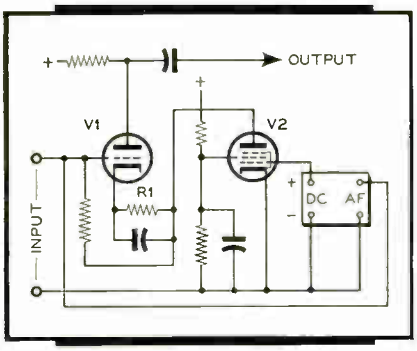

Figure 12

lamp increases as the filament temperature rises, throwing a greater proportion of the energy into the output. This system must be operated at a high volume level, requires pre-selected lamps, and in general operates over a narrow volume range.

The popular variable gain amplifier stage permits the use of independent volume and expansion controls and adjustment of the rates of volume increase or decrease. It has the disadvantage of introducing harmonic distortion.

In a third type of circuit the impedance of one type of tube may be made to vary by changing the potential of the control grid with respect to cathode. The variable-impedance tube is thus made one arm of a potentiometer in the output to the next stage.

This system may be used at a higher signal level than the variable gain system, and harmonic distortion will be less if the circuit constants are such

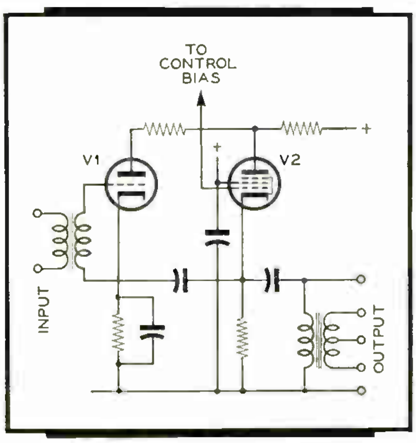

Figure 13

that the impedance of the controlling tube, reflected to the prior stage, is not so low as the introduce distortion.

Variable negative feedback has been employed for volume expansion. The negative feedback varies inversely as the volume input. It has the advantage of reducing harmonic distortion to a minimum.

Variable feedback may be employed with a lamp-operated, or with a tube expansion system.

In one form of tube circuit, *Fig. 12*, the tube V_2 has an impedance which varies with the signal amplitude. The feedback voltage developed across R_1, due to the current through V_2, varies inversely with the applied signal. This circuit has a high output impedance, and high a-f attenuation will occur at low signal levels. This effect can be overcome by use of the circuit of *Fig. 13*.

Here voltage feedback is provided from part of the potential-dividing network and variable feedback produces volume expansion. This circuit cannot be readily used without the output transformer which may introduce increased hum.

This discussion is to be continued.

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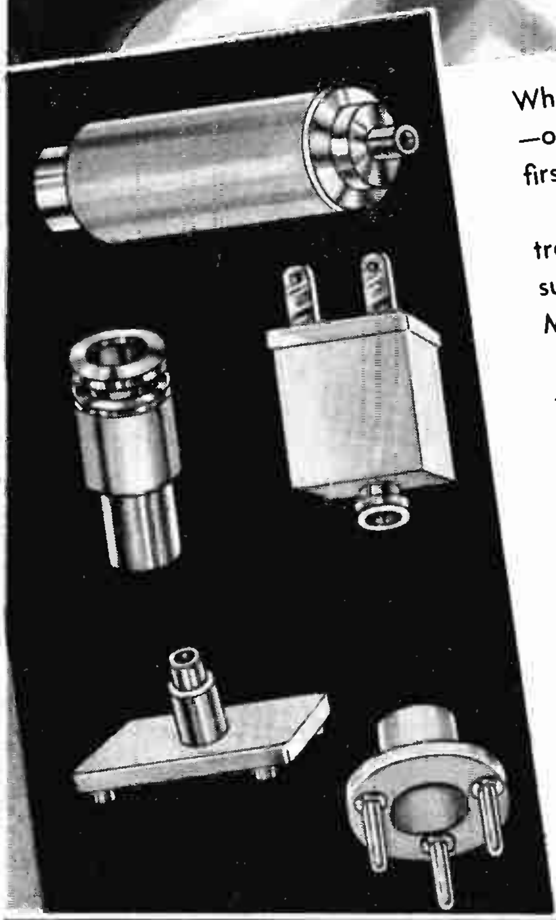

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A Comparison of Push-Pull and Parallel Tube Amplifiers With Practical Design Data For a Low Distortion Parallel Output Tube Amplifier

THE EVER-GROWING DEMAND for a simple and economical high-fidelity audio amplifier for use in the home is responsible for the development of a parallel tube circuit by the writer, after considerable research was devoted to push-pull operation. The relative simplicity of a two-stage parallel tube amplifier as compared to a three-stage push-pull system, including a phase inverter stage, became immediately apparent. It was found that a reduction in amplitude, harmonic and cross-modulation distortion could be obtained from the parallel tube system at relatively large values of audio power output.

The myth of second harmonic distortion cancellation can be literally exploded insofar as push-pull amplifiers with commercially available output transformers and "unmatched" tubes are concerned. A lower percentage of second, third, fourth and fifth harmonic distortion was measured in parallel tube amplifiers with feedback than in similar push-pull circuits. Less hum and motorboating were likewise found in the two-stage parallel system.

Push-Pull vs. Parallel Tube Amplifiers

Two tubes operated in push-pull, i.e. with the grids excited by equal voltages 180° out of phase, and the outputs combined in a conventional output transformer, have been accepted as an almost universally standard method of operation in power audio amplifier circuits. The advantage of this form of operation is the high power output which is obtainable with relatively low distortion. This is an excellent method for modulators, or for public-address systems, but it does not appear to be the best possible solution for high-fidelity amplifiers in which harmonic distortion, amplitude distortion, and, particularly, cross-modulation distortion are extremely important considerations.

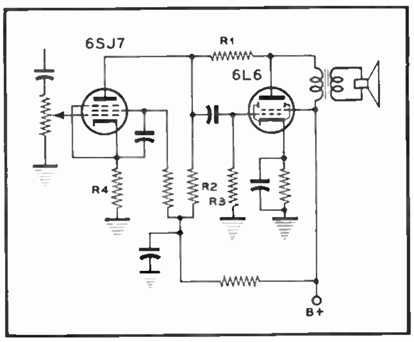

Fig. 1. A method of applying negative feedback across a single output tube

For a high-fidelity amplifier for FM reception, or for phonograph record reproduction in an ordinary living room, only a few watts of power will be required. The major problem is a reduction of all forms of distortion to a value lower than provided by any of the present-day systems. Class AB or B push-pull amplifiers always introduce greater distortion than a pure Class A amplifier. Probably 95 per cent of all push-pull amplifiers are biased to a point far above pure Class A operation. Push-pull circuits are supposedly a magical means for balancing-out the even order harmonics, but this method is of no help for the odd harmonics which are even more objectionable to the ear than are the even harmonics, in most cases.

The cross-modulation effect is increased when an amplifier is biased beyond the mid-point of its Class A characteristic. Cross-modulation is produced when the non-linear operation of any part of an amplifier produces added beat notes, for example when a 1000-cycle and a 700-cycle note are present a new tone of 300 cycles and 1700 cycles is produced by cross-modulation—and this tone should not be present. These tones are audible down to values lower than 2 per cent of the fundamentals, and are consequently far more serious than harmonic distortion.

If a push-pull amplifier is operated strictly Class A, the output is only twice that of a single tube. The same output can be obtained by operating the two power tubes in parallel. Actually, with output transformers listing for less than $15.00 to $20.00 more output can be obtained from parallel operation than from a push-pull Class A amplifier. If a single tube amplifier produces its lowest distortion at normal power output when working into a 5000 ohm load, it is evident that for pure Class A operation in parallel this load should be 2,500 ohms—*and 20,000 ohms for push-pull.* When 2,500 ohms is transformed down to a voice coil load of perhaps 4 ohms, the result will be an impedance ratio of 625 for parallel tubes and 5,000 for push-pull tubes.

The impedance transfer of 5,000-to-1 over the audio-frequency range is an extremely difficult accomplishment and requires a transformer with a large iron core and special windings. When attempted with conventional high-class output transformers, the power loss usually amounts to 30 per cent to 50 per cent. If half of the output power is lost by reason of poor impedance match, copper or iron losses, etc., the effective output will be reduced to that of a single tube with a perfect transformer. When the output tubes are operated in parallel it is possible to secure output transformer efficiencies ranging from 70 to 90 per cent at moderate cost. The net result will be a parallel tube amplifier which will deliver more "undistorted" power to the voice coil of a loud speaker than is possible from a push-pull amplifier. Many measurements with a harmonic analyzer have proved this assertion. The writer made comparisons with three types of push-pull amplifiers (biased for Class A), then converted these circuits for parallel operation—and secured from 25 to 50 per cent more audio power into the voice coil load for a given maximum distortion of 2 or 3 per cent.

Measurements for push-pull amplifiers operated at Tube Handbook voltages usually indicated far higher values of third and fifth harmonic distortion, and always more cross-modulation, than when the plate and grid bias voltages were set for pure Class A operation. In some instances the second harmonic was excessive, due to tube or transformer unbalance. It would appear that no justifiable reason can be given for the use of push-pull Class AB, AB_1, AB_2 or B amplifiers for high-fidelity

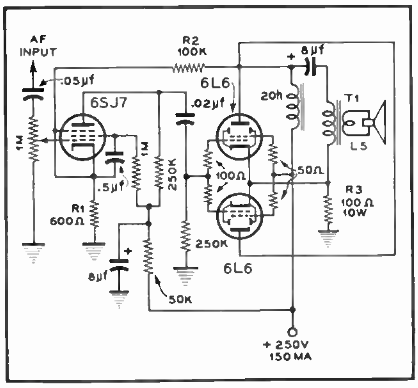

Fig. 2. Negative feedback applied over two stages

service in the home. A single 6L6 tube will deliver sufficient power for most practical purposes, and a pair of 6L6s in parallel will deliver ample peak power to handle symphonic reproduction in a large living room at values of sound level above normal requirements. Triode tubes such as 6A3s will not deliver sufficient power in parallel or push-pull pure Class A, since the plate dissipation will limit the applied plate voltage to aproximately 250 volts. At this voltage a pair of tubes will deliver approximately the same output as a single 6L6. Operation at higher plate voltage will result in higher than Class A grid bias in order to limit the plate dissipation. The net result is an increase in distortion, as shown by the harmonic analyzer tests.

Feed-Back Amplifiers

High undistorted output power can be obtained from beam power tetrodes if sufficient inverse feedback is applied. A loudspeaker load is not a constant load, having a tremendous peak at a low frequency and a gradually rising value at high frequencies. This means that there will be an excessive amount of false bass and high-frequency reproduction unless the amplifier has such a low internal plate resistance as compared to the load impedance that the load can change appreciably without effect. A triode such as a 6A3 has a low plate resistance and functions very well for this purpose, but the useful output is only about half that of a 6L6 at the same plate voltage. The 6L6 has a high plate resistance, but it can be reduced to a value comparable to a 6A3 triode by applying inverse feedback, particularly when applied over a two-stage amplifier. The effective output impedance of a two-stage amplifier is:

$$R_o = \frac{R_p}{1 - \mu A_1 \beta}$$

where R_p = normal plate resistance of output tube
μ = amplification factor of output tube
A_1 = amplification of first stage
β = feedback factor

The inverse feedback reduces the overall amplification and distortion. The resultant amplification is:

$$M = \frac{A}{1 - A\beta}$$

where A = overall amplification in the absence of feedback
β = feedback factor

$$\text{Distortion with feedback} = \frac{\text{Distortion in absence of feedback}}{1 - A\beta}$$

For regenerative feedback, β is positive and increases the amplification, distortion and effective output imedance. For inverse feedback, β is negative and the term $1-A\beta$ is always greater than unity.

There are many circuits for obtaining voltage feedback over one or more stages. For inverse feedback the voltage fed back must be 180° out of phase with the signal voltage at the point of feedback connection. In *Fig. 1,* feedback is applied across the output tube and the feedback factor β is equal to the ratio of the parallel resistance of R_2, R_3 and the 6SJ7 plate resistance, to this and the sum of the feedback resistor R_1. If the latter is 800k and the total plate resistor load is 200k, then

$$\beta = \frac{200k}{200k + 800k} = .20$$

If the 6L6 has a normal gain of 12, the gain with feedback would be

$$M = \frac{12}{1 - (-.2)12} = \frac{12}{1 + 2.4} = 3.5$$

If the 6SJ7 stage has an effective gain of 60 with an un-bypassed cathode resistor R_1, then the overall gain would be $60 \times 3.5 = 210$.

The output resistance in this case would be

$$R_o = \frac{R_p}{1 - \mu\beta} = \frac{1}{\frac{1}{R_p} - \beta G_m}$$

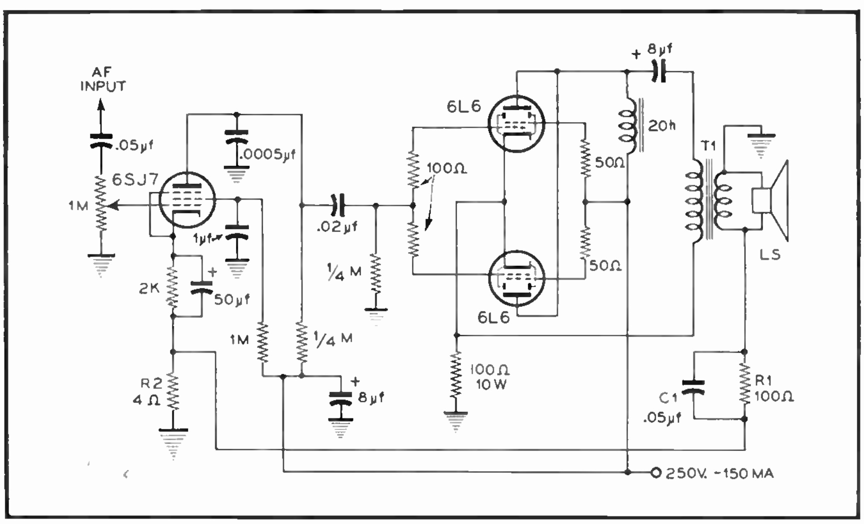

Fig. 3. Circuit diagram of parallel tube amplifier with negative feedback

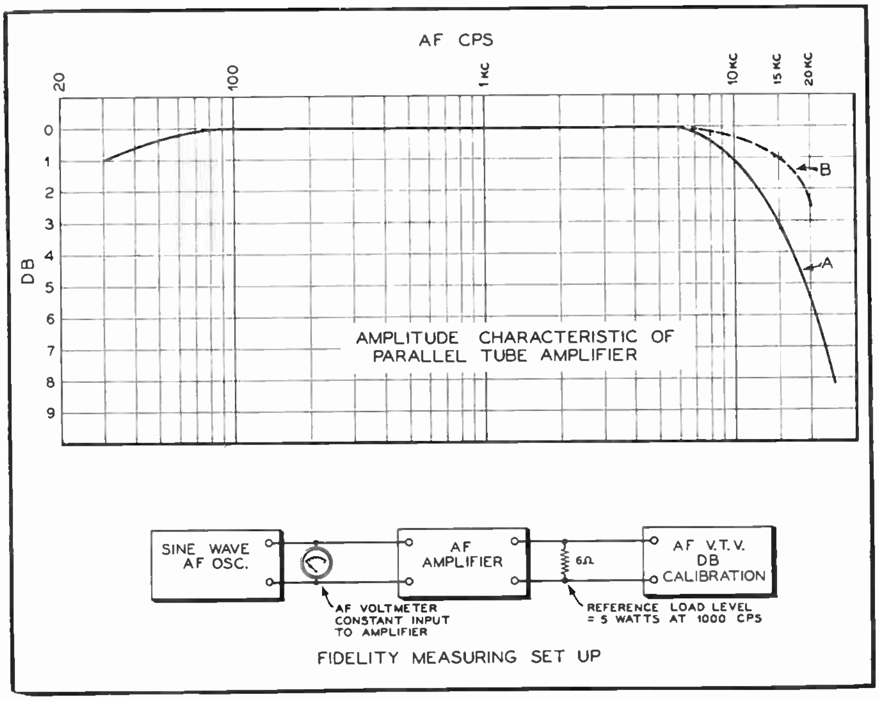

Fig. 4. Fidelity measuring setup and amplitude characteristic of parallel tube amplifier

$$R_o \cong \frac{1}{\frac{1}{25000} + .2 \times 5500 \times 10^{-6}} \cong 880 \text{ ohms}$$

When the feedback is applied over two stages, as in *Fig. 2*, the output resistance and overall gain would be the same if R_1 was 333 ohms and R_2 was 100,000, making β = .00333. The advantage of applying it over two stages is that the distortion in both amplifier stages is reduced. With the values shown in *Fig. 2*, $\beta \cong .006$.

$$M = \frac{720}{1 + .006 \times 720} = 135$$

$$R_o \cong \frac{25{,}000 \times .5}{1 + 137.5 \times 60 \times .006} \cong 245 \text{ ohms}$$

The negative current feedback across R_3 in *Fig. 2* is practically zero since the load is connected directly from plate to cathode of the parallel tube amplifier. The amplification of the 6SJ7 stage is approximately halved by the un-bypassed cathode resistor R_1. This resistor cannot be by-passed since it would short-circuit the inverse feedback voltage from R_2.

Fig. 3 shows another feedback system which permits practically full gain in the 6SJ7 stage. The overall gain from the grid of the 6SJ7 to the plate of the 6L6 can be made as high as 250 or 300 for the same distortion values as those obtained in *Fig. 2* at half the gain. This feature is sometimes needed in connection with high-quality equalized phonograph pickups when the generated voltage in the pickup unit is relatively low.

Due to the phase characteristics of the conventional output transformer over the range of from 30 to 15,000 cps, the feedback resistor R_1 should be shunted by a capacitor C_1 of approximately .05 μf and the 6SJ7 tube plate shunted by C_2 to ground, the value of the latter being from .0003 to .001 μf. A value of .0005 functions satisfactorily with most output transformers. These capacitors were tried in several different varieties of parallel tube feedback amplifiers while observing the wave-form on an oscilloscope when square-wave voltage was applied to the input. An oscilloscope is a necessity when building feedback amplifiers in order to determine the optimum constants for each particular layout of parts, or type of parts.

The amplitude characteristics of the amplifier shown in *Fig. 2* are illustrated by the curve "A" in *Fig. 4*. Applying the feedback across the output transformer together with the equalizing capacitors, improves the high-frequency response of the amplifier shown in *Fig. 3*. The curve "B" of *Fig. 4* was obtained from the amplifier circuit of *Fig. 3*.

Harmonic analyzer measurements for these amplifiers indicated values of second harmonic distortion of 2 per cent, and third harmonic of 1 per cent into a 1,500-ohm plate load with 8.5 watts output into the voice coil load resistance. Connecting two sine wave audio oscillators into the input, as shown in *Fig. 5*, gave cross-modulation values of 2 per cent at 4 watts output, 3 per cent at 6 watts, 7 to 8 per cent at 8.5 watts, and about 10 per cent at 10 watts output. The harmonic distortion with an r-m-s output of 10 watts of fundamental gave values of 2.5 per cent second harmonic and 5 per cent third harmonic. In general, the cross-modulation effects, as proved by measurement, were from two to three times as high as the harmonic distortion. Very few loudspeakers are capable of handling more than 5 or 6 watts into the voice coil without generating very high degrees of distortion. The given values of output were those measured into a 6 ohm resistor, and consequently the actual tube output will be greater.

One push-pull amplifier rated at 10 watts output actually gave about 5 watts from the tubes with 5 per cent distortion, and less than 2 watts into the voice coil at the same distortion values. The low-priced output transformer working out of high-impedance 6V6 tubes caused more power loss than was applied to the loudspeaker voice coil.

Power supplies for the amplifiers shown in *Figs. 2* and *3* should be adequately filtered. A choke input filter with two sections of 15 to 20 henry chokes, and considerable filter capacitor capacity will satisfy these requirements. The hum voltage across the voice coil was measured at .001 volt for the amplifier of *Fig. 3*, with two chokes and a two-capacitor-filter of 20 and 40 μf. This hum voltage is far below normal for a push-pull audio amplifier system.

One disadvantage of push-pull amplifiers not mentioned previously is to find a phase inverter stage which is really low in harmonic and cross-modulation distortion. Either a phase inverter or push-pull input transformer is required for driving a push-pull amplifier. Most circuit engineers have ignored or overlooked this problem: a few simple measurements will prove its seriousness.

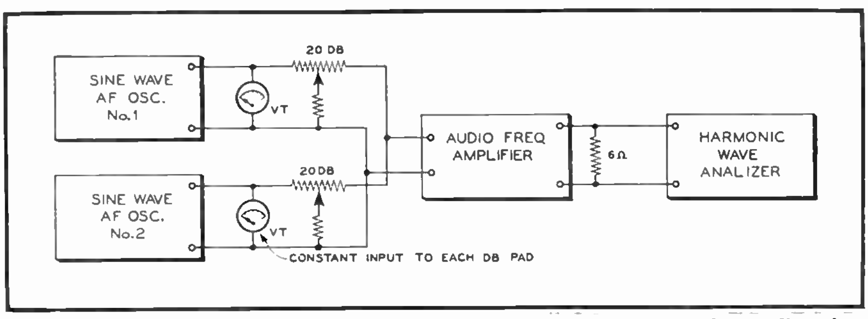

Fig. 5. Block diagram of method of measuring audio amplifier cross-modulation distortion

Microwave Transmission

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IN ORDER TO GIVE a discussion of radio wave communication in general and of microwave transmission in particular, we shall incidentally need to establish certain conventions which are by no means new and repeat some definitions which are necessary to keep clearly in mind. We shall also speak of the balance sheet method of computation which we shall use and which is a convenient way of establishing the feasibility of transmission over a projected link. This last refers to a way of setting up db gain and db loss in separate columns. If all the factors are known, it is then obviously necessary that the db gain column equal or exceed the db loss column in order that transmission be successful. If one item in either column is unknown, then a symbolic addition with the sums of the two columns equated, will allow us to solve for a db gain or loss figure which must be bettered by the unknown factor, if the arrangement is to be a success.

The complete list of items which may enter into a transmission is shown in the following blank balance sheet. Generally speaking, it is not always necessary to include all these items and it is sometimes desirable to combine some of them. The word available is in all cases used to mean the power delivered to a matched load. When perfect matching is not used, additional losses are incurred.

BALANCE SHEET

GAIN	LOSS
(1) Oscillator Power-----db	(2) Trans. Cable Loss-----db
(4) Trans Antenna Gain---db	(3) Isotropic Trans. Antenna--db
(7) Rec. Antenna Gain---db	(5) Propagation Loss-----db
(8) Perfect Rec. Sensitivity--db	(6) Isotropic Rec. Antenna--db
	(9) Receiver Noise Figure---db
	(10) Receiver Cable Loss----db
TOTAL GAIN	TOTAL LOSS

The meanings of these items are as follows:

1. *Oscillator Power.* The power available from the transmitter oscillator as compared to one watt.
2. *Transmitter Cable Loss.* The power available from the transmission line to the antenna as compared to the power available from the oscillator.
3. *Isotropic Transmitting Antenna.* The power passing through one square meter one meter away from an isotropic antenna as compared to that available into the antenna.
4. *Transmitting Antenna Gain.* The power in one square meter at one meter as compared to what would be had in an isotropic antenna. This is equivalent to the usual definition.
5. *Propagation Loss.* The field strength at the receiving antenna as compared to that one meter from the transmitting antenna.
6. *Isotropic Receiving Antenna.* Power available from receiving antenna as compared to that passing through one square meter in the neighborhood of the antenna.
7. *Receiving Antenna Gain.* Power available from antenna as compared to that from an isotropic antenna under the same condition. This is equivalent to the usual definition.
8. *Perfect Receiver Sensitivity.* The sensitivity of a perfect receiver measured in db below one watt.
9. *Receiver Noise Figure.* The sensitivity of the receiver compared to a perfect receiver.
10. *Receiver Cable Loss.* The power available into the receiver antenna connection as compared to that available from the receiving antenna.

The Perfect Receiver

Any radio receiver can be made only so sensitive. A certain definite amount of signal strength must be inserted into the receiver antenna connection in order that reception be successful, and no matter how much gain the receiver is capable of nor how well the receiver is constructed, no signal weaker than that can be successfully used to obtain intelligence from a radio transmission. So far as the radio art in general is concerned, this is of course an unfortunate situation inasmuch as it imposes a definite range limit beyond which no particular radio transmitter can be heard. For propagation calculations, however, it has its advantages since it allows us to put down as receiver sensitivity a certain definite number of db below one

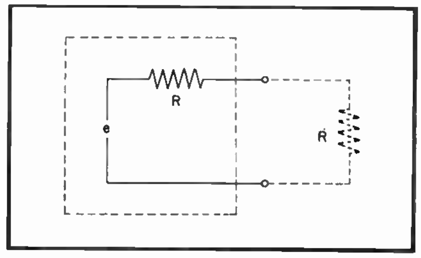


Fig. 1. Equivalent circuit for noise generation in the resistive component of the input impendence of a radio receiver

watt on the credit side of the ledger and place a number on the debit side ot denate the amount by which a given receiver misses the ideal.

The threshold sensitivity of a good receiver is determined by the thermal noise in the resistive component of the input impedance of the receiver. This may mean the input impedance of the antenna, the first mixer, or what is more likely, of the first i-f stage of a microwave receiver. At lower frequencies it is the first r-f stage which usually is the place where the noise contribution is most important. Since, as will be seen presently, the exact value of that resistance does not need to be known in calculating the performance of an ideal receiver, it is not necessary here for us to locate its position. We only have to recognize that it exists. To build an ideal receiver is quite another matter and the struggle to use proper components in a proper arrangement so as to come as close to the ideal as possible is continually being aided by further research. The number of db by which a practical receiver misses the performance of an ideal receiver is called the noise figure. Modern microwave receivers have noise figures down to as little as 6 db, but even a 10 db receiver is considered to be a good one.

The crux of the situation, so far as thermal noise is concerned, is that any resistance contains electrons which in the presence, or even in the absence, of a current have random motions in addition to any systematic movement occasioned by the desired signal. These

Power Requirements

A comprehensive discussion of the factors involved in determining the power needed from a microwave transmitter to assure successful operation under specified conditions. A simple balance sheet method of calculating required transmitter power is presented

random motions cause the resistor to act like a source of power and furnish noise signals to the receiver in addition to the desired signal. Such noise is well known to anyone who has operated sensitive receivers. Even with the antenna disconnected, noise can be heard in the earphones or loudspeaker if the volume control is turned up sufficiently. A very weak signal can be made to yield intelligence only if it bears a definite relation in strength as compared to the strength of the unavoidable noise. In exceptional cases it may be possible for a signal to yield information even when its amplitude is less than that of the accompanying noise but generally speaking, it is demanded that the ratio of signal to noise be at least unity. For the sake of definiteness, we shall take that as our criterion of acceptable reception.

The difference between a body which is hot and one which is cold is the amount of molecular, atomic, and subatomic motion which is going on inside the body. This sheet of paper which is seemingly quite stationary is nevertheless made up of many atomic particles which are in constant vibration or rotation. If the paper is made colder the motion is reduced, and only if we could make the paper very cold indeed (—273° Centigrade) would the motion cease entirely. At higher temperatures the motion increases in amplitude and in the case of tungsten, the electrons even get to moving so fast at sufficiently high temperatures that they leave the metal entirely and act as they do in tungsten filament vacuum tubes. Even at room temperature the charge in a resistor moves about in a perfectly random way with sufficient amplitude so that a voltage of completely arbitrary wave form appears across the ends of the resistor. This voltage is of course very small in terms of volts, but it is nevertheless finite and it is large enough so that it does place an end limitation on the performance of a radio receiver.

Fortunately, by virtue of many careful measurements which physicists have made during the last hundred years or so, we can write down an expression for this noise voltage of a resistor with good accuracy. The equation giving the value is

$$e^2 = 4\,kRT\Delta f$$

where e is the voltage, k is a constant called Boltzmann's constant after the man who made early measurements of the phenomenon, R is the resistance, T is the temperature in degrees Kelvin, and Δf is the bandwidth over which the noise component is to be evaluated. In more detail if e is to be in volts, k is equal to 1.374×10^{-23} joules per degree Kelvin. R is expressed in ohms and T is the approximate temperature of the resistor measured, according to a temperature scale which uses degrees of the same size as those of the Centigrade scale but whose zero is coincident with an absolute zero temperature as measured on the Centigrade scale.

The symbol Δf is a little bit more complicated to explain but just as easy to use. In practice it is normally the bandwidth of the i-f amplifier expressed in cycles. The idea is that, since the wave form of the noise voltage generated in a resistor is perfectly random, it contains all frequencies in equal amounts. If an actual plot of the voltage across a resistor could be made against time and then the jagged curve

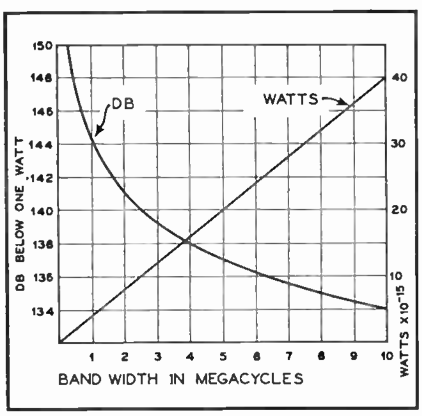


Fig. 2. Power in watts, and in db below one watt, needed at an ideal receiver to produce unity signal-to-noise ratio

which results duplicated by adding up very small amounts of sine waves of many frequencies, it would be found that sine waves of all frequencies would be needed. This is no more than an explanation of random motion. Since the resistor charge moves about in a way which is not systemized, a voltage peak may appear at any point in time and consequently a voltage wave of any frequency may be needed to simulate that peak. Stating it all more simply, noise contains components of all frequencies, and to find the amount which lies in a given bandwidth as specified by the band pass width of the receiver, it is necessary to multiply by the width of that pass band, which is here symbolized by Δf.

In *Fig. 1* is shown an equivalent circuit for the noise generation of a resistor. A voltage source e is imagined to be impedanceless and capable of generating the noise voltage in series with a resistor R. Across the combination, a connection to the outside world is made and specifically to the input to the receiver. It is there that the desired signal first appears from the antenna and also that noise from the necessary input resistance is present. The job is to find the power which is available from that resistor and hence know the power which must be obtained from space in order to even theoretically obtain unity signal to noise ratio.

Maximum power will obviously be delivered from the circuit of *Fig. 1* if a matched load is used. A matched load is of course approximately needed not to get maximum noise but to get maximum useful signal which also must pass through the receiver input impedance. In the present case matching is obtained by connecting another resistance, R, across the terminals of *Fig. 1*. Now, in this circumstance, the generator impresses only half its voltage across the external resistor. The voltage there is $E/2R$ and the power into the external load is given by

$$\text{Power} = \frac{e^2}{4R} \text{ watts}$$

Substituting for e, its value obtained in terms of Boltzmann's constant yields

$$\text{Noise power} = N = KT\Delta f \text{ watts}$$

Thus the minimum number of watts

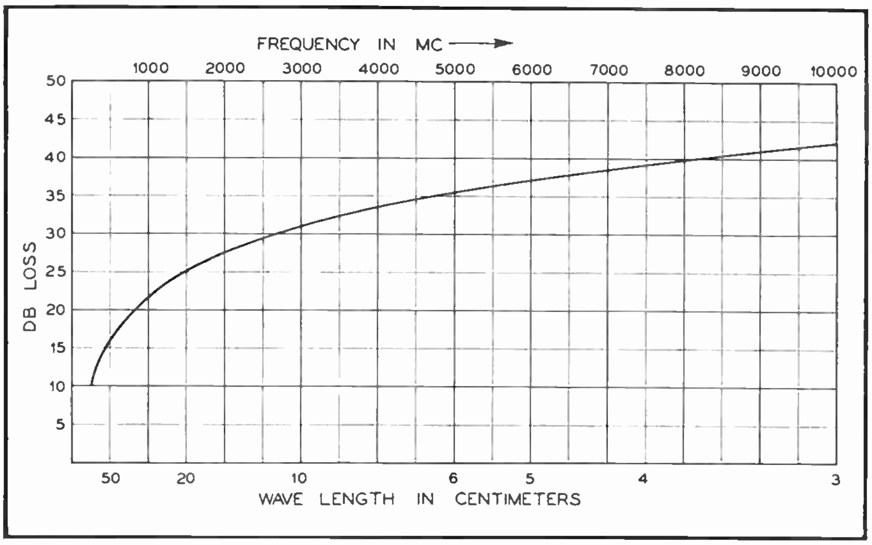


Fig. 3. Isotropic receiving antenna cross-section factor

which must be available to the receiver in order to produce an acceptable signal (unity signal to noise ratio) even in a perfect receiver is

$E_0 = 1.374 \times 10^{-23} \times 291 \times \Delta f$ watts

This assumes the resistor to be at normal room temperature (18°C = 64°F). A plot of this against various bandwidths is shown in *Fig. 2*.

DB Noise Figures and Practical Receivers

It is generally most convenient to use db in calculating the various factors which enter into propagation problems. At the receiver and at the transmitter we make the final and first computation with respect to a power of one watt. Elsewhere we simply calculate db gain or loss in comparison with a standard or ideal arrangement. Thus, using the usual equation for defining db, namely,

$$db = 10 \log a/b$$

we will, in the calculation of performance of an ideal receiver use one watt as a reference standard and the actual watts needed as the other quantity. In calculating gain of an antenna, we will compare actual signal strength to that which would come from an isotropic antenna. The advantage of using db for such calculations and doing them in this way is that the units drop out because of the ratio and the values obtained are more closely proportional to the real discrepancies of operation which accompany them.

In the case of the ideal receiver working with a 250 kc bandwidth, for example, our above equation for power shows that just about exactly 10^{-15} watts are needed. Converting to db, this means that with an ideal receiver ance of an ideal receiver, use one watt are receivable. The second curve in *Fig. 2* gives the threshold sensitivity of a receiver in terms of db below one watt. As a separate entry we may give a db comparison of the signal needed for an actual receiver to that needed for an ideal receiver. A combination of the two db figures will of course give the actual sensitivity in db below one watt, but for the flexibility of computation it is generally more convenient to keep the two entries separate.

The methods of measuring noise figures of actual receivers is not easy although, as in most electrical measurements, the difficulties are primarily those of setting up proper equipment. What is wanted is to find the ratio of the signal to noise at the input as compared to that at the ouput. If, as is usually the case, the noise introduced in the antenna itself may be neglected, the problem is simply one of connecting a signal generator to the receiver input and under known conditions of signal-to-noise input, measure the same thing at the receiver output. Fesults may have to be extrapolated to small signal values, or better yet, inserted into the receiver through calibrated attenuators which supply the receiver with very weak but accurately known microwave signals. As we have said before, the best obtainable microwave receivers are, generally speaking, those with a noise figure of 6 to 10 db.

Receiving Antenna Cross Section

Now an isotropic point receiving antenna is effectively able to make available to its connecting transmission line all the energy which passes by at a distance closer than the fraction of a wave length which is represented by one radian. That is, if a very small non-directional antenna is mounted at a point in space and radio waves from a remote transmitter pass through the neighborhood of the antenna, some of the space born energy is absorbed by the antenna. That which passes closest to the antenna is absorbed most efficiently and that which is further and further away is less and less well absorbed. The total absorption of a point isotropic receiving antenna is sufficient so that an amount of energy equivalent to all that which passes within $\lambda/2\pi$ (one radian) of the antenna is available from the antenna. To calculate the energy involved, we may assume the antenna acts as if it had a capture cross section of area equivalent to that of a circle $\lambda/2\pi$ cm in radius. The cross sectional area of a poiot isotropic receiving antenna is therefore

$$\sigma = \frac{\lambda^2}{4\pi}$$

If W watts are passing through one square meter of area near the receiving

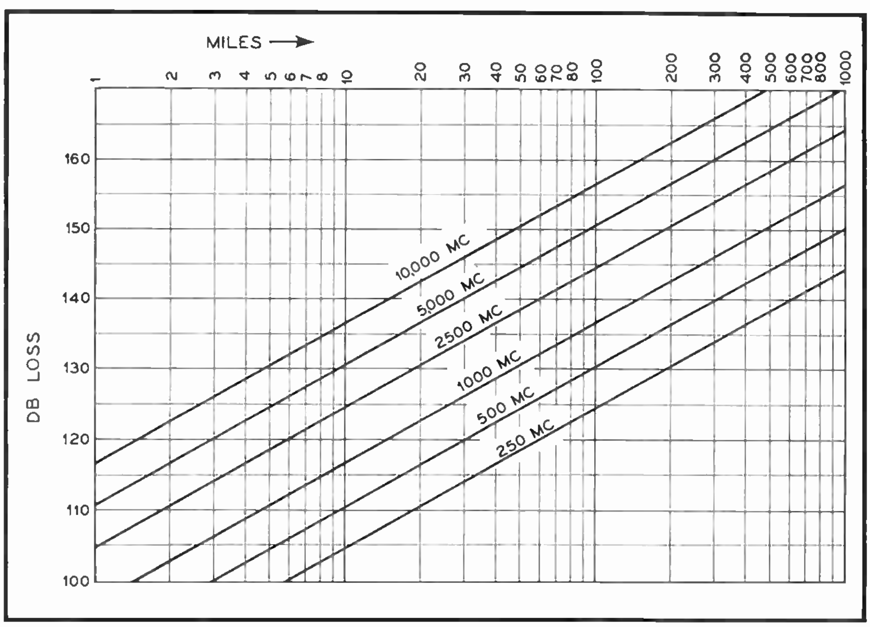


Fig. 4. Free space attenuation from power into isotropic radiator to power available from receiving antenna

antenna, there will, therefore, be $W\lambda^2/(4\pi)$ watts available from the receiving antenna. The db relation will be

$$\text{db loss} = 10 \log \frac{W}{W\lambda^2(4\pi)}$$

This is the factor which, in the balance sheet, we call isotropic receiving antenna loss.

Fig. 3 shows this loss as a function of frequency or wave length. It should be borne in mind, however, that the lower frequencies shown are not so superior to the high frequencies as this graph alone might lead one to think. The reason is that much greater antenna gains are possible in the true microwave region than can ever be realized at longer wave lengths.

Fig. 4 is a plot of three of our balance sheet items taken together. When values are taken from it, a single entry in the balance sheet will cover what we have called Isotropic Transmitting Antenna factor, Propagation Loss, and Isotropic Receiving Antenna factor. It must be strongly emphasized that *Fig. 4* can only be used for free space calculations.

Example. Computation of minimum transmission power needed for 100 mile free space transmission at 5000 mc with a 250 kc bandwidth using an isotropic radiator and an isotropic receiving antenna feeding a 10 db receiver.

BALANCE SHEET

GAIN		LOSS	
Trans Power	X db	Receiver Noise Figure	10.0 db
Perfect Rec Sensitivity	150 db	Isotropic Receiving Ant	35 5 db
		Propagation Loss	104 0 db
		Isotropic Trans Ant	11 0 db
TOTAL	150+X db	TOTAL	160.5 db

150 + X = 160.5 db
X = 10 5 db
Transmitter power (minimum) = 10 5 db above 1 watt
= 11.2 watts

Here we have no antenna gain so those items do not come into the computation. Also, we have assumed that there are no cable losses and have left them out and renamed oscillator power as transmitter power which means we have computed the energy it is necessary to actually deliver to the transmitting antenna.

The item called Isotropic Receiving Antenna Loss may be taken directly from *Fig. 3* but the entry for isotropic transmitting antenna loss needs further explanation. It is a quantity which is always the same and serves to separate the problems of the antenna from those of propagation.

As defined, the isotropic transmitting antenna loss is the db difference between the power inserted into an isotropic transmitting antenna and that which passes through a square meter of area located one meter away. If W is the power into the antenna, then one meter away that energy will be spread over a spherical area of 4π square meters. The energy passing through any square meter of that spherical surface will be the same as that going through every other unit area so $W/(4\pi)$ watts is the amount in the square meter area which we require. Calculating the db loss in the usual way gives 11 db.

The propagation loss item of the balance sheet is usually the most difficult one to evaluate but in this particular example it is very simple because free space operation is specified. Each watt of power emerging from the transmitting antenna spreads out in all directions and at a 100 mile range the energy is distributed over the surface of an expanding spherical wave with a density that is equivalent to covering each unit area of the surface of a 100 mile radius sphere with the same fraction of the original transmitted energy. The propagation loss is a db loss which compares the energy in a meter area at one meter away from the transmitting antenna to that in a meter area 100 miles distant. For free space it is shown in *Fig. 5*. Thus, if W is the watts of power from the transmitter, the energy density at 100 miles will be W/A, where A is the area of the spherical surface at that distance. In the case of a 100 mile range

$$A = 4\pi r^2 = 4\pi \times 256 \times 10^8$$
$$= 32 \times 10^{10} \text{ meters}^2$$

The power density at 100 miles is therefore $W/(32 \times 10^{10})$ watts per square meter. The power density at one meter is $W/(4\pi)$ watts per square meter as we pointed out before. The propagation loss in db is therefore

$$10 \log (32 \times 10^{10})/(4\pi) = 104 \text{ db}$$

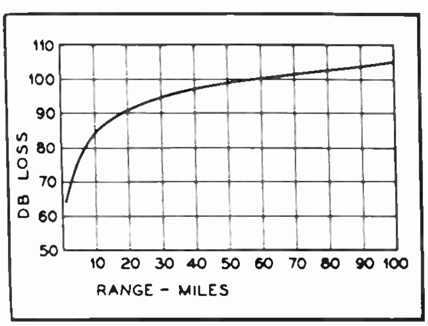


Fig. 5. Free space values of the propagation loss factor

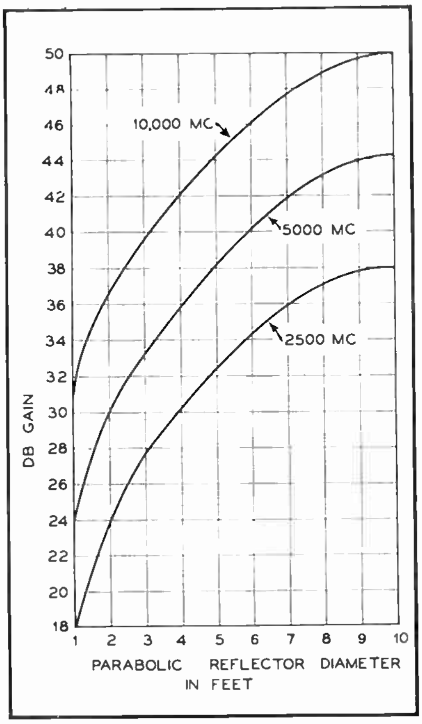


Fig. 6. Theoretical gain of a parabolic reflector antenna

Antenna Gain

Antenna gain is encountered whenever an antenna having directional properties is used. With a half wave dipole antenna, for example, the gain in a direction perpendicular to the antenna length is 1.5. In db this means that a dipole has a gain of about 1.8. If such an antenna radiates a given number of watts, the resulting field strengths in the direction of optimum power transmission will be half again greater than when the dipole is replaced with a point isotropic radiator. In general, the term antenna gain means gain in the direction of maximum radiation, although the term may of course be used to tell of the relative strength or sensitivity of an antenna in a direction other than that. Good practice calls for specific mention of direction when antenna gain is used for radiation directed in a manner other than toward the maximum pattern contour.

In radar applications particularly and in fixed communication links as well as to a certain extent in mobile communication, high gain antennas can be

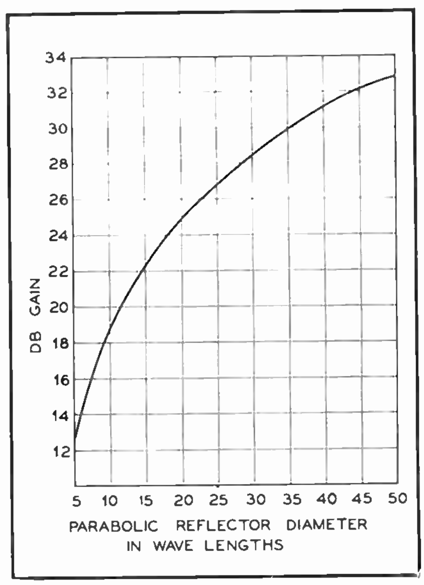


Fig. 7. Parabolic reflector antenna gain (diameter in wave lengths)

very valuable and in general can only be realized at true microwave frequencies. In radar, the problem is to direct a beam so accurately that when a reflection signal is obtained the direction of the target will be accurately known. In other words, the angular resolving power of a radar set depends upon concentrating essentially all the transmitter energy into a very small solid angle. The use of conical beams whose angle of divergence is less than a degree is not unusual.

In communication applications, the argument for high gain depends upon the number of db that are realized to benefit the system. A little manipulation of balance sheets with various antenna gains will show what a large reduction of transmitter power can be accomplished by increasing antenna gain. In general, the maximum sharpness of the beam which can be obtained depends entirely upon the antenna size as measured in wave lengths. This is true regardless of whether the antenna uses a parabola or some other kind of beam shaping surface. Only at microwave frequencies are the wave lengths short enough so that the antennas are of reasonable size. For example, a 2 degree beam at 6000 mc requires only about a 6 foot parabolic reflector. To get the same beam width at 300 mc would require the reflector to be 120 feet in diameter.

With parabolic reflector antennas very high gains may be easily obtained. *Fig. 6* shows the gain which is obtainable with dishes of various practical sizes at three different microwave frequencies. *Fig. 7* shows antenna gain as a function of reflector size alone where the size is measured in terms of wave lengths. In those units the gain is independent of frequency although the

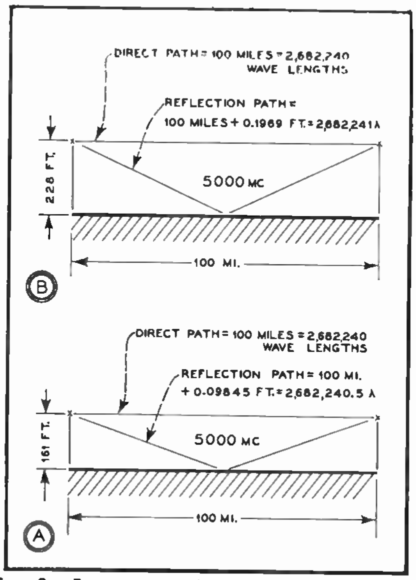


Fig. 9. Antenna positions for transmission under conditions of maximum interference and reinforcement from ground reflection

wave length is not. Both figures are based on the relation

Parabolic Antenna Gain $= 4\pi A/\lambda^2$

Where A is the aperture area of the reflector and λ is the free space wave length of the radiation.

As an aid to transmission and as a method of obtaining dependable transmission over a fixed link while still using low power in the transmitter, high gain antennas are very valuable. For mobile operation they are of very much less use since horizontal gain spoils the "all around looking" properties of the array, and the amount of vertical gain that can be managed without causing reception to be too sensitively dependent on tilt is practically limited to about 6 db. *Fig. 8* shows the gain of such a communication antenna as a function of elevation beamwidth. In fixed installations, too, antenna gain is generally somewhat limited by the stability with which the support will allow alignment to be maintained and besides, it is always limited by the antenna bulk which will be tolerated.

The parabolic antenna gains which are given here, assume that the feed is very small in comparison with the size of the reflector. This is only strictly true with very large reflectors and is not at all true with wave lengths longer than those that are plotted. The effect of finite size in the feed is to lower the gain below the values that are given.

Example. Computation of minimum transmitter power needed for 100 mile free space transmission at 5000 mc with a 250 kc band width using a dipole transmitting antenna and a dipole receiving antenna feeding a 10 db receiver.

BALANCE SHEET

GAIN		LOSS	
Trans. Power	X db	Rec. Noise Figure	10.0 db
Perfect Rec.	150.0 db	Isotropic Rec. Antenna	35.5 db
Trans Ant. Gain	1.8 db	Propagation Loss	104.0 db
Rec. Ant Gain	1.8 db	Isotropic Trans. Ant.	11.0 db
TOTAL	153.6 + X db	TOTAL	160.5 db

153.6 + X = 160.5 db
X = 6.9 db
Transmitter power (minimum) = 6.9 db above 1 watt
= 4.9 watts

Example. Same as in previous example except with a 12 db transmitting antenna and a 6 db receiving antenna.

BALANCE SHEET

GAIN		LOSS	
Trans. Power	X db	Rec Noise Figure	10.0 db
Perfect Rec.	150.0 db	Rec Insert Loss	6.0 db
Trans Ant Gain	12.0 db	Distance Loss	150.5 db
Rec Ant Gain	6.0 db		
TOTAL	168.0 + X db	TOTAL	160.5 db

168.0 + X = 160.5
X = −7.5 db
Transmitter power (minimum) = 7.5 db below 1 watt
= 0.17 watts

Reflection Interference

So far we have made no mention at all of what is perhaps the most troublesome factor of all those which go into determining the feasibility of a given communication link. We have avoided all reference to the effects of reflection by carefully specifying in each example that the calculation is made for free space. In actual transmission cases energy proceeds from the transmitter to the receiver not only by the direct route but also via reflection from the earth. At the receiver these separate energies may reinforce each other and cause a further gain entry to be made in the balance sheet or, what is unfortunately also possible, the energies may interfere so that a serious loss is encountered. It is beyond the scope of the present article to give detailed coverage computations. In general, these reflection losses need to be checked up experimentally. The essential point here is that no matter how this loss or gain is evaluated, it plays a very important

[Continued on page 64]

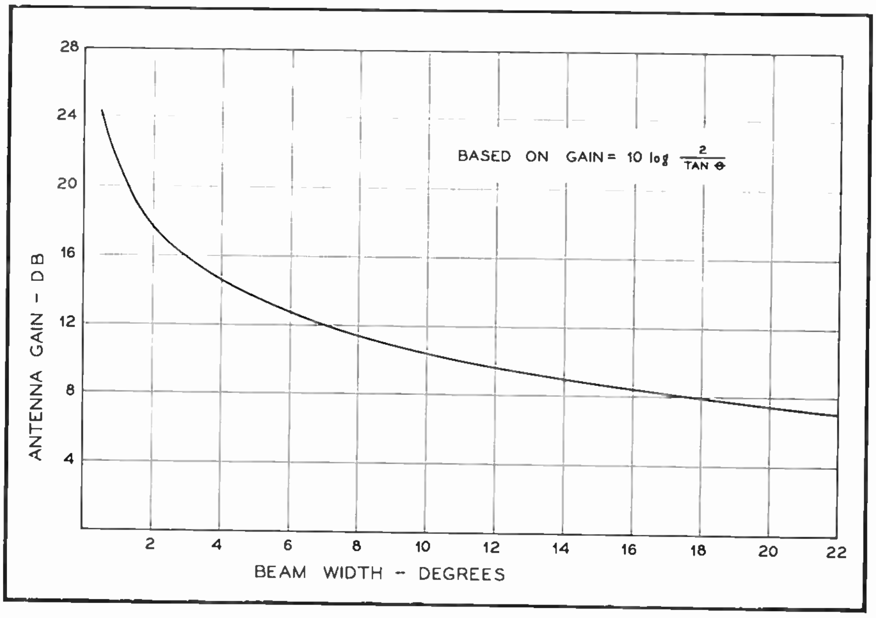


Fig. 8. Antenna gain when only vertical directivity is used

Graphical Determination of the Horizon

W. H. ANDERSON

This practical method of determining the optical horizon when topographic irregularities are present is a valuable aid in solving certain v-h-f problems

THE VARIOUS MATHEMATICAL methods of computing the optical horizon are all based on the assumption that the earth is a perfectly smooth sphere. While the results so obtained will be useful in a general sense, it is obvious that they cannot be relied upon when examining any *particular* case, due to the fact that the topographic irregularities cannot be taken into account. Because of the relatively insignificant height of such objects as compared to the radius of the earth, it is extremely difficult to set up any formulae that will adequately express the path between any two points, at least so that its solution will permit seeing at a glance whether an optical path exists or not.

Recourse must therefore be made to graphical means of solution. The first step in this direction is to obtain from the Geological Survey, Dept. of Interior, Washington, D. C. (in Canada, the Surveyor General, Dept. of Mines and Resources, Ottawa, Ont.) a chart which shows the various maps available of the general district in question. Maps with a scale of not less than one or two miles to the inch with a contour interval of 25-50 feet will be required for the route being surveyed. An 8 or 16 mile to the inch map of the area is also handy for laying out the route, etc., after which the path may be marked on the one or two mile to the inch maps by reference to landmarks on the larger map.

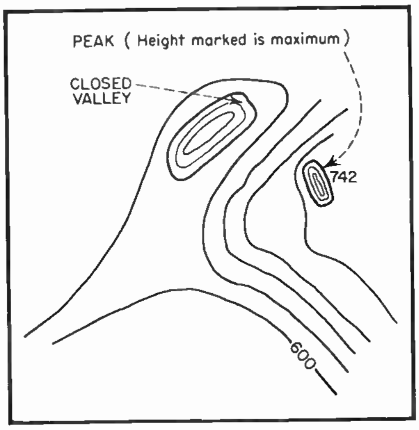


Fig. 1. Contours of hills and valley

Preparation of Profile

The second step will be to employ the information on the maps in the preparation of a suitable profile of the path. Now merely reproducing the earth to scale will not suffice as the difficulty mentioned above will be encountered, namely for any reasonable scale on the circumference, the height of objects above the earth becomes so minute that accurate calculations cannot be made. Since only a small arc of the earth's surface is under consideration, arbitrarily decreasing the radius of this arc, while retaining its scale and length would appear to have the effect of increasing the scale of elevations above the earth. It will be shown in the appendix following this paper that, providing the angle subtended by the arc is small (i.e. less than 10°) dividing the radius by "x" expands the scale above the surface by the factor "x."

Accordingly, the base diagram may be drawn by following these steps:

1. Multiply the number of miles per inch that is the desired scale for the earth's surface by 63,360. (Employing 5 or 8 miles per inch or fractions thereof will simplify later steps.)

2. Divide this quantity into 250,000,000. (The radius of the earth in inches.)

3. If a suitable vertical (elevation) scale is x feet per inch,

$$\text{Find } \frac{\text{Figure found in step 1}}{12x}$$

4. Divide figure found in step 2 by figure found in step 3—this will be radius of circle in inches.

One convenient set of dimensions has a 5 mile to the inch scale on the circumference, 500 feet per inch vertical scale and an arc radius of 15 inches.

After drawing the arc it should be laid off in fairly small intervals. An error will of course be introduced by measuring with an ordinary scale and thereby actually measuring the chord rather than the arc, but if the units are an inch or less, this discrepancy will be negligible. The vertical scale should also be carefully laid off at frequent intervals for convenience in plotting. Then the line on the map should be marked off in similar intervals to those on the arc.

Plotting of Profile

With the arc considered as sea-level, dots should be placed on the drawing to represent the various heights of land encountered on the path being examined. Any sharp peaks that may fall between the plotting points should then be noted.

[*Continued on page 62*]

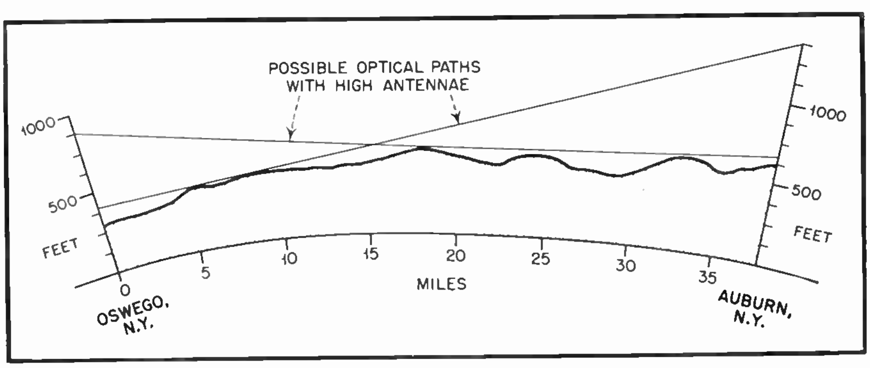


Fig. 2. Profile of direct path from Oswego, N.Y., to Auburn, N.Y.

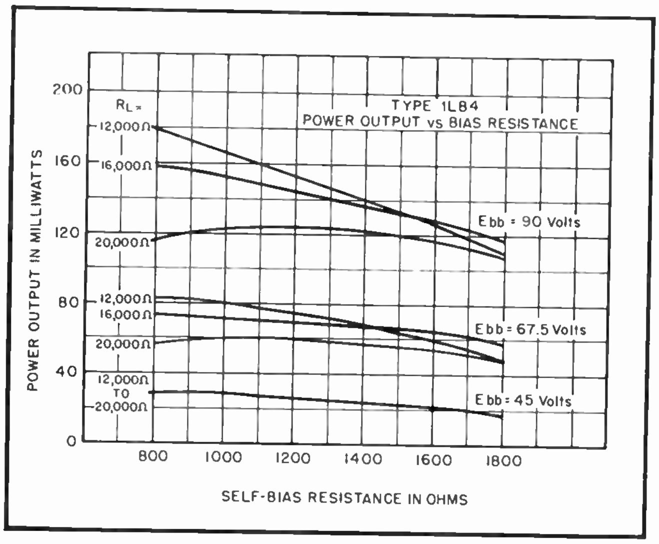


Fig. 1. Effect on power output of changes in load and bias resistances

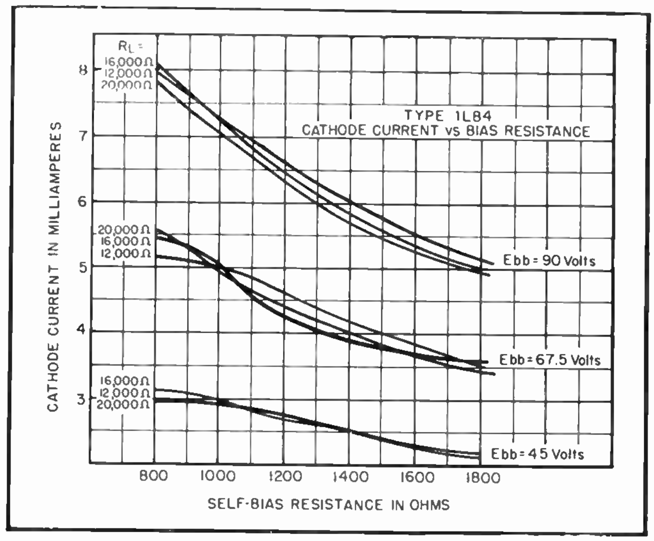


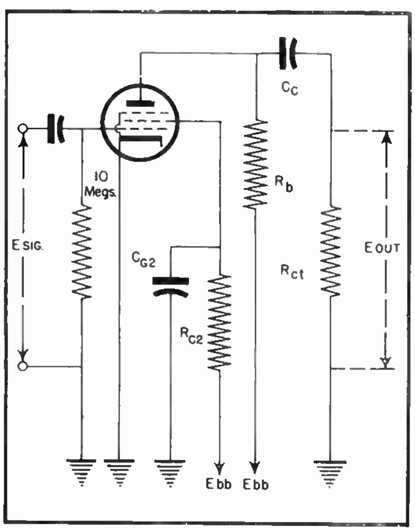
Fig. 2. Effect of bias resistance on cathode current

Audio Section Design Data for

Practical information for the designer of battery-operated portables

In portable receivers battery economy may be obtained either by use of a maximum supply of 45 volts or by use of a 90 or 67½ volt supply allowed to drop in service below the usual end-of-life voltage. By making use of tubes optimized for low voltage conditions it is possible to design units having high efficiency over a longer operating range of battery voltage. Types 1LB4, 1LD5, 1LC6 and 1LC5 have been designed for this service.

This article will consider only the design of the audio section using a Type 1LD5 resistance coupled to drive Type 1LB4.



Representative resistance-coupled amplifier stage. Function of components designated by symbols is tabulated on opposite page

Values Chosen

Since the optimum values of load and bias resistors differ for the three rated operating conditions, and since it is not practical to change these values when in service, compromise values must be selected to give satisfactory operation over the desired voltage range. *Fig. 1* shows the effect on power output of changes in load and bias resistances. The data shown are with the maximum signal which gives 10% total distortion. The values selected for best average performance, considering the plate current drain, are 1500 ohms for biasing, and 12,000 to 16,000 ohms load. As shown by the curves the value of load resistance becomes less important at the lower voltage but the lower values of bias resistance cause a disproportionate increase in current drain for a small additional power output, as shown in *Fig. 2*. Values of output power shown include that lost in the output transformer, as the test circuit used a choke having 100 ohms resistance which approached ideal conditions.

Filament voltage was maintained at 1.4 volts so another variable would not be introduced.

Fig. 3 shows a signal run for a typical detector-amplifier circuit considering the signal at the driver grid. The distortion shown is thus the *total distortion in the audio system.* The small difference between the outputs with 12,000 ohms and 16,000 ohms load is clearly shown. Similarly *Fig. 1* shows variation of power output, current drain and maximum input signal for 15% distortion with values of plate voltage from 90 down to 45.

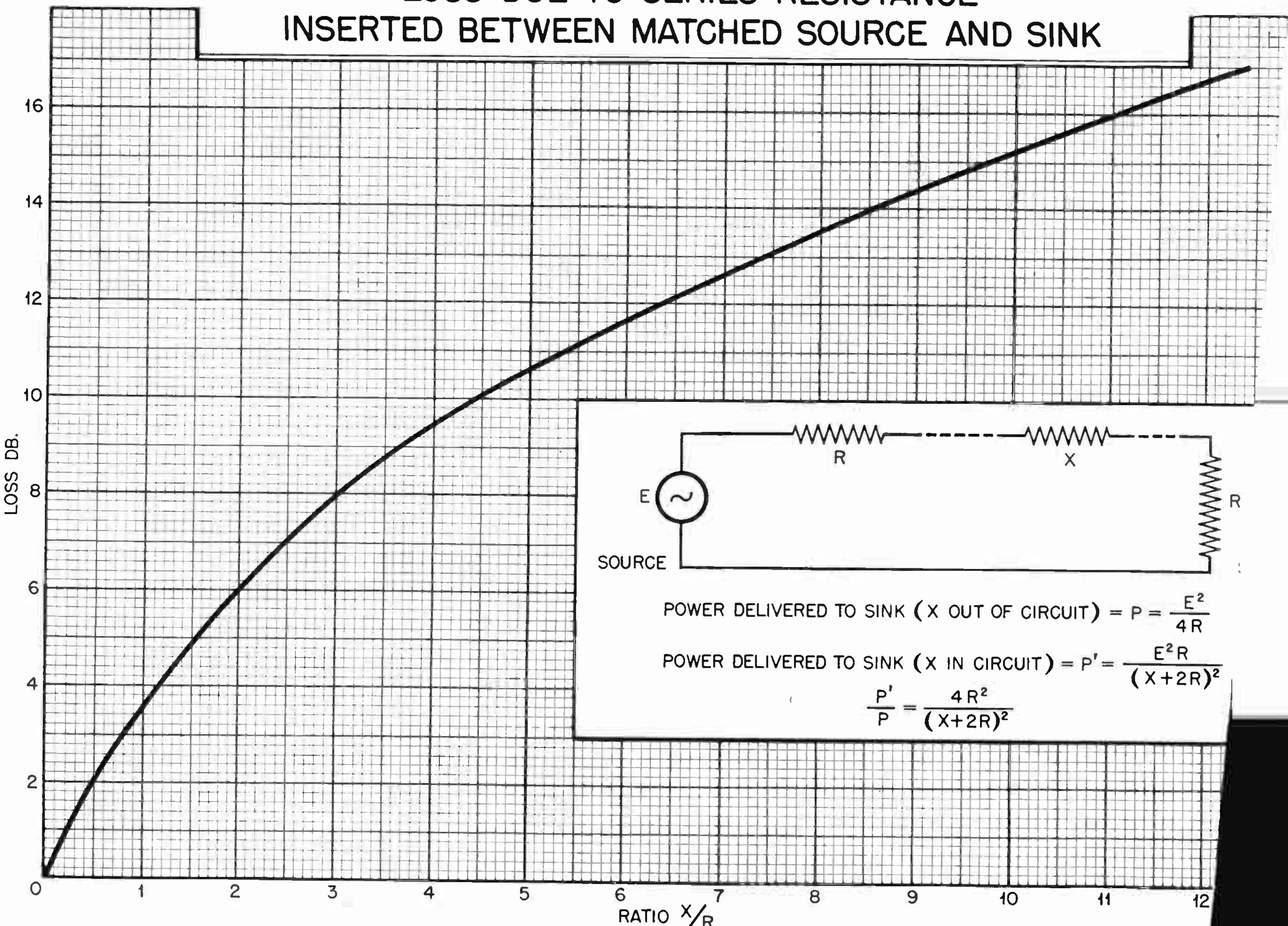
These data show that Type 1LD5 provides a low distortion driver tube for any audio system requiring a gain of 60 to 100 times.

Table Data

The table following *Fig. 1* is included so that design engineers may have the necessary information for using Type 1LD5 as a driver for other power output tubes where the limitations of battery supply do not require the use of Type 1LB4.

(The Table of resistance-coupled amplifier data on the opposite page is copyrighted by Sylvania Electric Products, Inc.)

LOSS DUE TO SERIES RESISTANCE INSERTED BETWEEN MATCHED SOURCE AND SINK



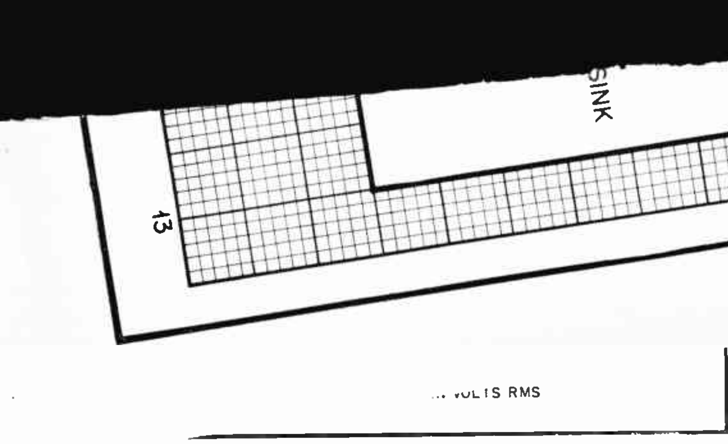


Fig. 3. Signal run for a typical detector-amplifier circuit

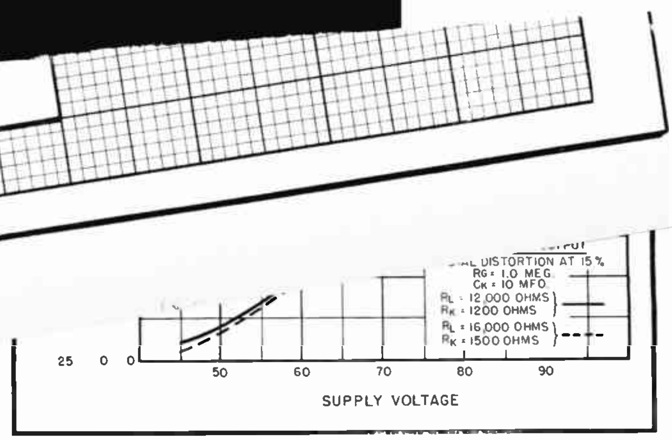


Fig. 4. Power output vs. signal voltage for Type 1LB4 driven by Type 1LD5

Battery Operated Receivers

ENGINEERING DEPT.

Sylvania Electric Products, Inc.

RESISTANCE COUPLED AMPLIFIER DATA (Zero Bias Operation)

	Ebb = 45 VOLTS								
Rb	0.27			0.47			1.0		
Rc_2	1.5			2.7			5.6		
Rcf	0.47	1.0	4.7	1.0	4.7	10.0	2.2	4.7	10.0
Ib (1)	0.066	0.066	0.066	0.043	0.043	0.043	0.023	0.023	0.023
Eb	27.2	27.2	27.2	24.8	24.8	24.8	22.0	22.0	22.0
Ic_2	0.0142	0.0142	0.0142	0.009	0.009	0.009	0.0048	0.0048	0.0048
Ec_2	23.7	23.7	23.7	20.7	20.7	20.7	18.1	18.1	18.1
Esig	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Eout	1.46	1.75	2.10	2.0	2.54	2.62	2.47	2.97	3.24
Gain	29.2	35.0	42.0	40.0	50.8	52.4	49.5	59.4	64.8
% Distortion	2.2	1.9	1.5	2.4	2.0	1.7	3.1	2.2	2.1
Esig (2)	0.11	0.11	0.12	0.09	0.1	0.1	0.07	0.08	0.08
Eout	3.06	3.80	4.75	3.5	4.83	5.03	3.37	4.66	4.93
Gain	27.8	34.5	39.6	39.0	48.3	50.3	48.2	58.4	61.6
% Distortion	4.7	4.2	4.6	4.5	4.7	4.5	4.3	4.7	4.3

	Ebb = 67.5 VOLTS								
Rb	0.27			0.47			1.0		
Rc_2	1.5			2.7			5.6		
Rcf	0.47	1.0	4.7	1.0	4.7	10.0	2.2	4.7	10.0
Ib (1)	0.125	0.125	0.125	0.077	0.077	0.077	0.04	0.04	0.04
Eb	33.7	33.7	33.7	31.3	31.3	31.3	27.5	27.5	27.5
Ic_2	0.0259	0.0259	0.0259	0.0159	0.0159	0.0159	0.0082	0.0082	0.0082
Ec_2	28.6	28.6	28.6	24.5	24.5	24.5	21.6	21.6	21.6
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	4.05	4.82	5.50	5.45	6.8	7.05	6.85	8.4	8.9
Gain	40.5	48.2	55.0	54.5	68.0	70.5	68.5	84.0	89.0
% Distortion	2.3	1.8	1.6	3.1	2.3	2.2	4.0	3.2	2.8
Esig (2)	0.17	0.18	0.20	0.14	0.16	0.17	0.11	0.13	0.13
Eout	6.50	8.35	10.3	7.36	10.1	11.1	7.47	10.6	10.9
Gain	38.2	46.3	51.5	52.5	63.2	65.4	68.0	81.6	84.0
% Distortion	4.7	4.8	4.9	4.9	4.7	4.9	4.6	4.9	4.7

	Ebb = 90 VOLTS								
Rb	0.27			0.47			1.0		
Rc_2	1.5			2.7			5.6		
Rcf	0.47	1.0	4.7	1.0	4.7	10.0	2.2	4.7	10.0
Ib (1)	0.189	0.189	0.189	0.114	0.114	0.114	0.059	0.059	0.059
Eb	39.0	39.0	39.0	36.4	36.4	36.4	31.0	31.0	31.0
Ic_2	0.0385	0.0385	0.0385	0.023	0.023	0.023	0.012	0.012	0.012
Ec_2	32.2	32.2	32.2	27.9	27.9	27.9	22.8	22.8	22.8
Esig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Eout	4.9	5.7	6.75	6.65	8.45	8.75	8.55	10.4	10.8
Gain	49.0	57.0	67.5	66.5	84.5	87.5	85.5	104.0	108.0
% Distortion	1.1	0.9	0.7	2.0	1.2	1.2	2.4	1.7	1.7
Esig (2)	0.24	0.27	0.28	0.19	0.22	0.22	0.15	0.17	0.18
Eout	10.9	14.3	17.1	11.9	16.9	17.5	12.4	16.3	18.2
Gain	45.4	53.0	61.1	62.7	77.0	79.6	82.8	96.0	101.0
% Distortion	4.7	4.7	4.8	4.7	4.8	4.7	4.9	4.8	5.0

Note (1) Grid return to pin No. 8.
Note (2) Maximum signal for 5.0% distortion.

SYMBOLS USED

Symbol	Function	Unit
Rb	Plate Load Resistor	Megohms
Rc_2	Screen Dropping Resistor	Megohms
Rcf	Grid Resistor of following tube	Megohms
Ebb	Plate Supply Voltage	Volts
Eb	Plate Voltage at plate	Volts
Ec_1	Grid to Neg. Filament Voltage	Volts
Ec_2	Screen Grid Voltage	Volts
Esig	Input Signal	R-M-S Volts
Eout	Output to following grid	R-M-S Volts
Ib	Plate Current	Ma.
Ic_2	Screen Grid Current	Ma.
Cc	Coupling Condenser	mfd.
Cc_2	Screen By-Pass Condenser	mfd.

Values of capacity are not specified since these are dependent mostly on frequency characteristics required in each individual case.

$$\text{For low frequency limit} = f_1 \quad Cc_2 = \frac{1.6 \times 10^6}{f_1\ Rc_2}\ \text{mfd.} \quad \text{and} \quad Cc = \frac{1.6 \times 10^6}{f_1\ Rcf}\ \text{mfd.}$$

Some text books show a more complicated method for calculating these by-pass condensers, but this method is quite rapid and gives conservative values. The loss due to incomplete by-passing will be less than 1%. The size condenser may be halved where economy is essential unless stages are cascaded and highest quality is required.

RECENT RADIO INVENTIONS

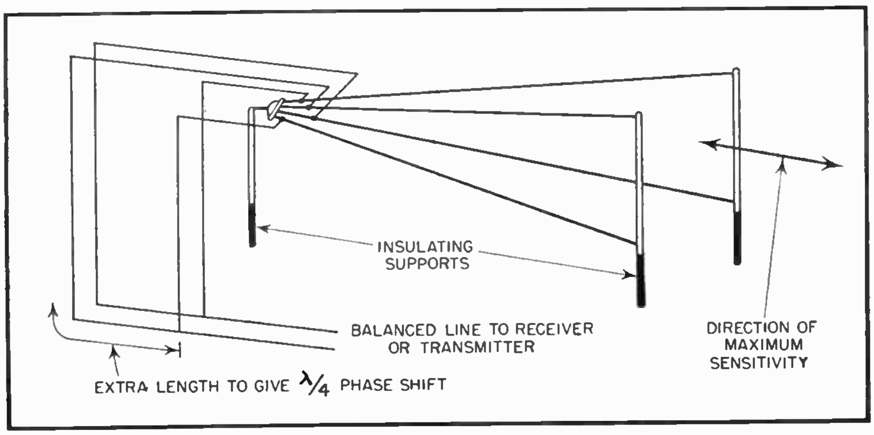
These analyses of new patents in the radio and electronic fields describe the features of each idea and, where possible, show how they represent improvements over previous methods

Antenna

★ The combining of V or diamond shaped antenna arrays to produce the advantages of the directivity normally associated with such antennas while yet retaining moderately broad-band characteristics are claimed by Clarence W. Hansell in a patent issued July 3, 1945. It is well known that an antenna in the shape of a V which is fed from a balanced line produces a directional pattern that allows signals sent or received in a given direction to be greatly enhanced. Maximum signal strength is obtained along a line which bisects the angle of the V. The balanced transmission line to the antenna is connected so that one wire is fastened to each side of the V. This causes the antenna currents in the two antenna wires to be just 180 degrees out of phase.

Simple V antennas have optimum operation characteristics only when the angle of the V and the length of the wires bear a particular relation to the wave length of the signal to be transmitted or received. For example, if it is decided to use wires three times as long as a wave length of the desired signal, the angle of the V should be 60 degrees. After such an antenna is built, if it is desired to receive other wave lengths, poor results will be obtained unless they happen to be harmonics of the original frequency.

The present invention removes some of this need for design to a single frequency by using a pair of V antennas arranged in planes at right angles to each other and with their bisectors coincident. The two V's are phased 90 degrees apart so that the incidence of a wrong frequency will at any given time cause compensating effects in the two V's and thus allow good operation under conditions that would be intolerable with a single V. The patent is assigned to RCA and is number 2,379,706.

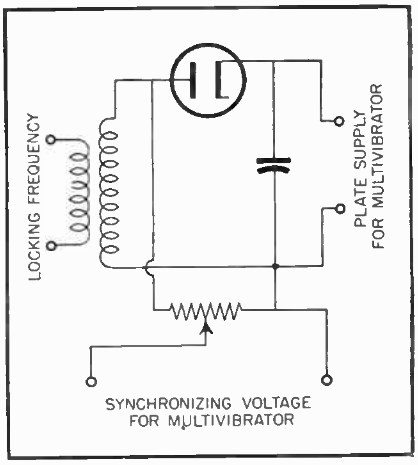


Patent No. 2,379,706

Automatic Control for Locked Oscillator

★ In a patent issued June 12, 1945, William A. McCool shows a circuit in which a multivibrator is supplied with a d-c plate voltage derived from a locking signal. An a-c part of the locking frequency voltage is also applied to the multivibrator in the usual way and causes the multivibrator frequency to synchronize with a desired submultiple of the locking frequency.

One object of the invention is to provide a method of frequency division



Patent No. 2,377,894

which is more stable against incidental changes of locking frequency amplitude than has been known before. The idea is, for example, that if a crystal controlled frequency of 10,000 is available and it is desired to obtain 1000 cycles from it, a multivibrator arranged to oscillate at about 1000 cycles is connected in such a way that its cycle changes precisely every tenth cycle of the 10,000 cycle locking source. Such a method of frequency division has long been common practice and it is well known that in general the multivibrator frequency will depend upon the amplitude of the locking signal. If the locking signal increases, the multivibrator will start synchronizing with the 9th instead of the 10th cycle of the locking frequency. If the locking voltage is lowered the 11th subharmonic will begin to appear.

The present invention depends upon the fact that the harmonic number chosen by the multivibrator also is dependent upon the plate voltage of the multivibrator. By deriving that plate voltage directly from the locking signal the plate voltage is made to change whenever the locking voltage changes. The two effects compete in their influence on the subharmonic chosen and result in increased stability against locking voltage change.

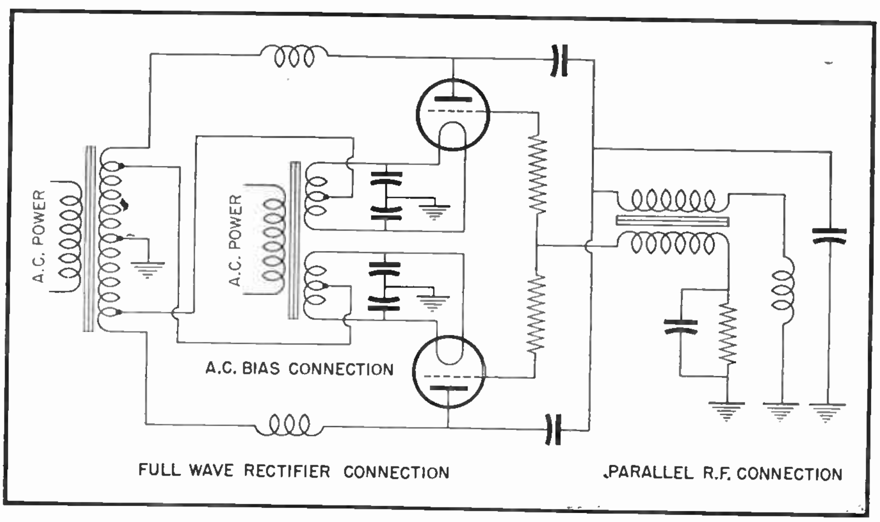
In the accompanying figure is shown a diode circuit capable of producing the multivibrator plate voltage from the locking frequency voltage. Its operation is essentially self-explanatory. A potentiometer allows one to choose a given fraction of the locking voltage to be used for synchronization and a diode causes rectification to produce a d-c plate voltage. The patent which is unassigned is number 2,377,894.

High Frequency Oscillator System

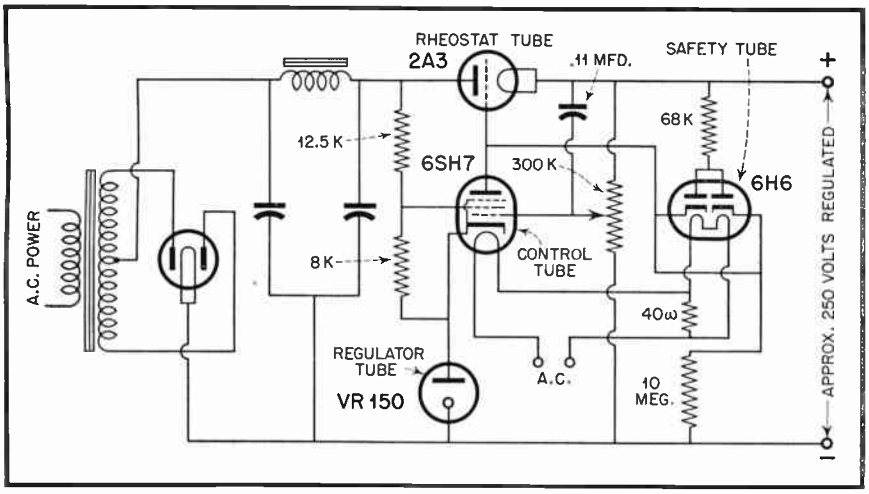
★ In high-frequency induction heating equipment used for industrial purposes or for diathermy treatments, it is often convenient to operate directly with alternating current and dispense with the usual rectifying and filtering system. When this is done, difficulty with grid current during the reverse half of the cycle may be encountered. In a patent issued June 5, 1945, Edwin E. Spitzer describes an invention which alleviates this difficulty.

The practice of operating a radio-frequency oscillator with raw alternating current normally involves the use of two vacuum tubes which are connected in parallel so far as the radio-frequency oscillator circuit is concerned but which at the same time are connected like a full-wave rectifier arrangement so that one tube or the other is always receiving a positive anode voltage. During one-half of the cycle, one oscillator tube refuses to pass current because its plate is negative. At that time, that tube is entirely inactive so far as the oscillator circuit is concerned but the other tube is operating in the normal fashion by virtue of the positive voltage on its anode. During the next half cycle, the second tube acts as a part of the oscillator and the first tube becomes inactive. The tubes alternate in their function in this way, but since the primary limitation on their ability to generate radio frequency is determined by their average power dissipation, the rest periods do not indicate loss in efficiency and it is still possible to arrange the circuit so that the power generation is approximately as much as could be obtained with two tubes operating continuously from a direct current power source.

During the period in which a tube is inactive, the anode is negative with respect to the cathode but it may often happen with the normal connection that the grid becomes positive. Grid current and unwanted heating effects then follow and frequently become cumulative because the grids get hot enough to start emitting electrons themselves. The present invention involves the application of an alternating current component to the normal grid bias so that the grid is carried to a strong negative voltage curing the inactive portion of the cycle. Several ways of doing this are shown in the patent and one is indicated in the accompanying sketch. The patent is assigned to RCA and is number 2,377,456.



Patent No. 2,377,456



Patent No. 2,377,500

Voltage Regulator

★ A safety circuit to be used in conjunction with a series regulated power supply is covered in a patent issued to Lambert L. Johnson, on June 15, 1945. The problem arises because the series rheostat tube which controls the output voltage of such a power supply is required to carry a large current and is logically of the directly heated cathode type while the pentode control type is necessarily of the indirectly heated sort. Because of this the rheostat tube is ordinarily without control when the supply is first turned on. The directly heated cathodes of the rectifier and rheostat tubes start to operate immediately but the operation of the control tube is delayed while that tube heats up. During this delay the rheostat tube presents little or no resistance and the load voltage may easily build up to a point that is harmful to components in the load circuits. The present invention removes this difficulty by adding a safety tube and circuit which keeps the grid of the rheostat tube at a reasonable level during the heating period, but which has no influence on the circuit operation after that period has passed.

Reference to the accompanying circuit will aid in the explanation of the operation. Because the heaters of the control tube and of the safety tube are connected in series with a shunt resistor across the safety tube heater, it is certain that the safety tube will not reach an operable temperature before the control tube does. Until the heating is accomplished both of these tubes represent essentially open circuits between their plates and cathodes and the only connection to the grid of the rheostat tube is through a high resistance to ground. This connection is sufficient to keep the resistance of the rheostat tube high and prevent excessive current into a load that is used with the power supply. When the heating is complete, the safety tube no longer presents an open circuit, and the high resistance in its cathode connection becomes a part of a potential divider which causes a relatively high voltage to appear at the grid of the rheostat tube. The control tube then proceeds to control this voltage in the usual way and consequently regulates the output of the power supply.

The patent, No. 2,377,500, is assigned to RCA.

Frequency-Measuring System

★ Harold O. Peterson received a patent on July 31, 1945 for a system of producing any radio frequency up to 30 megacycles with the accuracy that can be obtained from a carefully ground and mounted quartz crystal. This may be presumed to mean an accuracy of better than one part in 10 million. The method used is a straightforward one inasmuch as all frequencies are made to be dependent on one or two accurate crystal oscillators at one megacycle and at 10 kilocycles with filters, converters, and multipliers used to combine the harmonics in various ways. Also, a considerable amount of novelty is involved in the systematic way the arrangement is made. It is clear that much persistence and ingenuity were necessary to procure and arrange all of the many tuned circuits that are required.

It is not strictly true that the present invention has only one set of terminals from which the proper setting of simple decade switches will make any desired frequency emerge. It is, however, nearly true. In one arrangement using a 10 kc crystal, any frequency up to 200 kc is available in this way. In another scheme involving more complexity than the first arrangement, three additional output connections are provided and, in accord with decade switch positions, these respectively are capable of producing any frequency from 1 to 10, from 10 to 20, or from 20 to 30 megacycles.

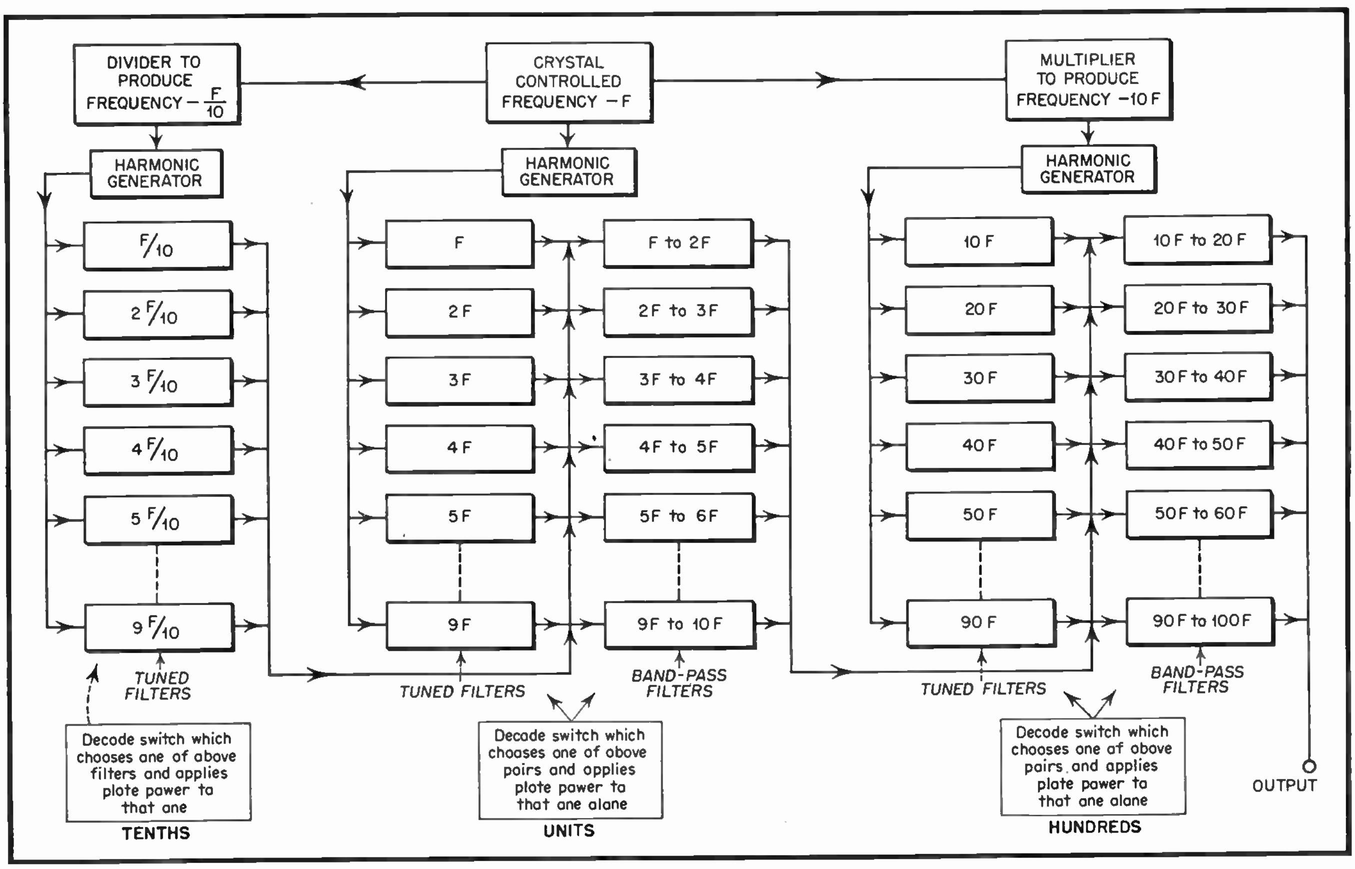
In the accompanying block diagram an attempt is made to show the general scheme of the patent in a simplified form. What is shown is a system capable of producing any frequency from $F/10$ to $100F$ in steps of $F/10$ where F is the frequency of the crystal standard chosen. Thus if a standard of 100 kc is chosen, any frequency such as 10 kc, 20 kc, 30 kc, etc., up to 100 kc can be obtained at will by turning three decade switches to proper positions. Study of the drawing, moreover, will indicate that the method is capable of extension to any frequency at which simple filters and other components can be made to operate.

First, the standard frequency source is connected to frequency multipliers and dividers so that stable frequencies of $F/10$ and $10F$ are obtained in addition to the standard, F. Oscillators operating at each of these frequencies are then connected to harmonic generators. There oscillations at each of the frequencies are maintained but with a distorted wave form so that a signal is produced in each one that contains not only a fundamental frequency but also all multiples of that frequency up to a factor of 10. The outputs of the harmonic generators are each connected in parallel to nine tuned circuits which are capable individually of responding with reasonable amplitude to only a particular one of the 10 harmonics. The connections are actually made through vacuum tubes to which plate current is allowed to flow only when the corresponding decade switch picks that frequency. Thus, by setting three decade switches, particular harmonics of frequencies $F/10$, F, and $10F$ are chosen. With the aid of band-pass filters and converters, these are added and a final frequency obtained that is the sum of any chosen harmonics of $F/10$, F, and $10F$.

The patent, No. 2,380,868, is assigned to RCA.

Instrument Landing Guide System

★ In order to produce a radio beam path inclined to the surface of the earth so that an airplane can successfully fly down the path to land at an airport, it is generally considered most advantage-

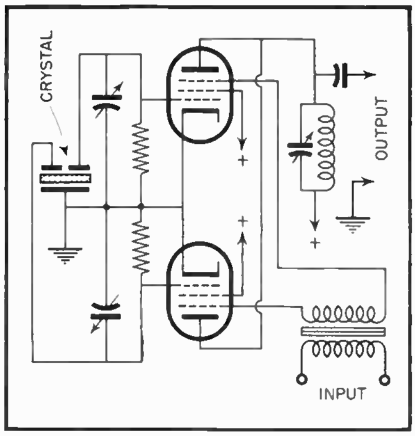


Patent No. 2,380,868

ous to radiate two distinctive signals that predominate respectively when the airplane is too high or too low and have equal strength when the correct glide path is obtained. In a patent issued July 3, 1945, Armig G. Kandoian shows a method of obtaining such a distribution of radio energy. He uses a modulation frequency such as 150 cycles per second to represent the "high" signal and 90 cycles per second to indicate a "low" position. Both modulations are applied to the same carrier frequency.

The unmodulated output of a transmitter is divided into two equal parts and 90 cycle amplitude modulation is applied to one-half while 150 cycle modulation is imparted to the other. This results in two signals which are respectively made up of a carrier having plus and minus 150 cycle side-bands and a carrier with plus and minus 90 cycle side-bands. These two signals are combined in a double bridge which is so arranged that three signals are obtained that may be respectively applied to three loop antennas. Two of them are made up of side-bands alone and the third contains a carrier as well as a single set of side-band information. All side-bands are either in phase or 180 degrees out of phase. In the accompanying sketch the side-bands which are in phase with each other are marked with the same sign (either + or —) and those of opposite phase are shown with opposite signs.

The loops are mounted horizontally at various heights above the ground and are so located and dimensioned that they produce antenna patterns approximately like the ones shown. Above the glide path the +90 cycles from the center radiator approximately cancels the —90 cycles of the upper antenna so as to leave a preponderance of 150 cycle signal. Below the glide path, it is the 150 cycle signal which cancels between the two lower antennas and the 90 cycle signal is left to tell the airplane that it is flying too low. The patent is assigned to Federal Telephone and Radio Company, and is number 2,379,442.



Patent No. 2,375,527

Wave Length Modulation

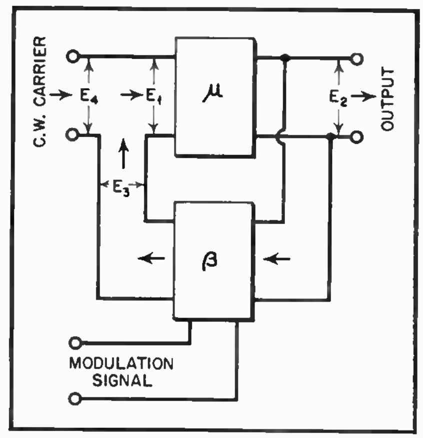
★ The problem of obtaining crystal control of a frequency-modulated transmitter is one which has been partially solved in a number of ways. The solution offered by Murray G. Crosby in a patent issued May 8, 1945 is a direct one in that it offers a method of influencing the crystal oscillation frequency. The contradictory requirements of producing a crystal oscillator which is very stable as to center frequency but which still may be easily varied in the neighborhood of that point in accord with intelligence applied through modulation is overcome by the use of three electrodes in the crystal holder.

The circuit and general arrangement may be visualized by looking at the accompanying schematic. If either of the two vacuum tubes is removed from its socket, it will be recognized that which remains is a crystal controlled oscillator of a usual type which makes use of the common crystal electrode and one-half of the split electrode. It will also be noticed that these two crystal electrodes have a small variable condenser connected across them. As is well known, the frequency of oscillation may be adjusted within limits by changing the capacity loading on the crystal.

To adjust the circuit for use the two oscillators are adjusted separately, each with the other out of operation, so that one is above the desired center frequency and the other below by the same amount. When both are run simultaneously and at the same level, the crystal is forced to choose a frequency midway between the values desired by the oscillators individually. When intelligence in the form of a voltage wave is aplied to the third grids of the tubes in the way shown, one or the other of the oscillators is made to reduce its level at various times because of the grid's ability to reduce the current flow. Any change in the relative plate current of the two tubes also changes the relative influence that the oscillators have on the crystal frequency. This means that the desired change of frequency with modulation voltage is obtained. The patent is assigned to RCA and is number 2,375,527.

Modulator

★ On June 26, 1945, Robert C. Shaw was granted a patent on a high-fidelity system of amplitude modulation which makes use of changing attenuation in a feedback loop to produce the necessary change in level. A steady continuous wave carrier is fed through an amplifier which is supplied with a feedback loop. The modulation signal is arranged to vary the attenuation in that loop and hence change the overall gain of the amplifier system in accord with the modulation. The principle involved is more completely explained by reviewing some of the theory of feedback circuits and by referring to the accompanying diagram.



Patent No. 2,379,042

The block marked with the Greek letter μ is the amplifier which alone has an amplification factor of μ. By definition this means that $E_2 = \mu E_1$. Similarly the block marked β is an attenuator which reduces the strength of the feedback voltage so $E_3 = \beta E_2$. Both μ and β may be complex numbers to account for phase shift as well as change in signal magnitude. Now $E_1 = E_3 + E_4$

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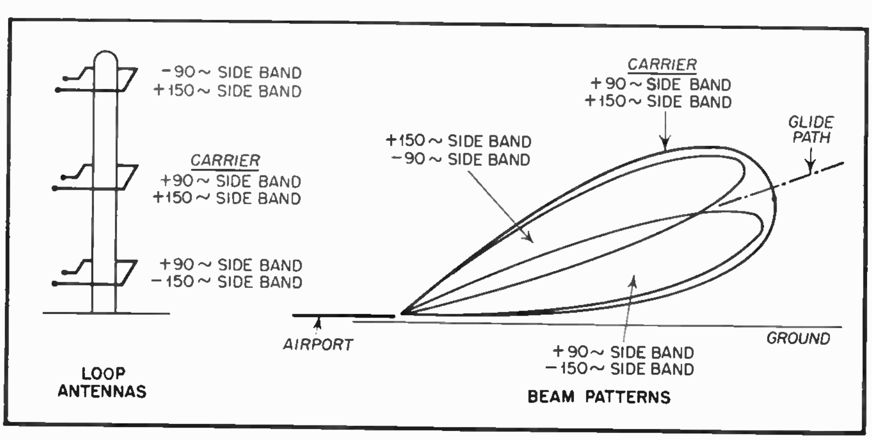

Patent No. 2,379,442

RADIO DESIGN WORKSHEET

No. 41 — SUPER-REGENERATION; RADIO NETWORK PROBLEM

SUPER-REGENERATION

SUPER-REGENERATION was described by its inventor, Major E. H. Armstrong, in a paper before the Institute of Radio Engineers on June 7, 1922. This paper, which is a classic, was published in the August, 1922 issue of the Proceedings of the I.R.E.

Super-regeneration is a special type of regenerative amplification resulting when the effective resistance of a tuned circuit is varied from positive to negative at a frequency rate relatively low with respect to the resonant frequency of the circuit but the average value of the circuit resistance remains positive.

Before launching into the subject it is important to consider a few fundamentals of tuned circuits. Consider first the parallel resonant circuit of *Fig. 1*. This circuit presents to the tube a high resistance at resonance equal approximately to the product of the inductive reactance of the coil and the Q of the circuit. Parallel resonance as used here may be defined as that frequency at which the inductive and capacitive reactances are numerically equal. Parallel resonance is sometimes defined as the frequency of maximum current flow in the circuit and sometimes as the frequency at which time impedance Z looking into the circuit is a pure resistance. While all three of these definitions yield different frequencies, these frequencies differ by less than 1% when the Q of the circuit is in the range normally used in radio circuits.

The voltage across a parallel resonant circuit is shown in *Fig. 2* as a function of frequency. The bandwidth of the circuit or, as it is sometimes called, the pass band may conveniently be taken as the frequency band 3 db down from resonance or at the frequencies at which the voltage is 70% of maximum.

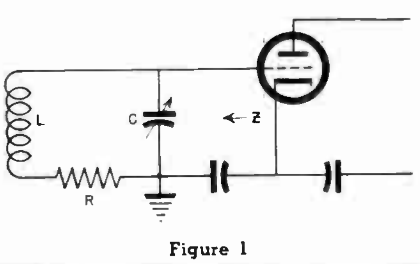

Figure 1

If a resistor and capacitor is connected by a switch to a source of voltage the capacitor will charge exponentially, and if the voltage is then removed and the resistor connected across the charged capacitor terminals, it will discharge similarly.

This is illustrated in *Fig. 3*. The curve shows the effect of charging the capacitor by closing the switch *A*, with switch *B* open, and the shape of the discharge curve secured by closing switch *B*, with switch *A* open.

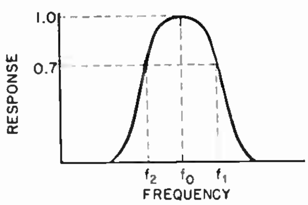

Fig. 2

If the battery in *Fig. 3* were replaced with a generator of alternating current and an inductance introduced in the circuit in series with *C* sufficient to resonate the circuit at the frequency of the generator then it could be shown that a transient is formed which builds up and decays in similar manner.

Fig. 4 shows a regenerative circuit. As the voltage fed back into the tuned circuit is increased, it has the effect of reducing the resistance of the tuned circuit. When the feedback is sufficient to reduce the tuned circuit resistance is zero, critical regeneration has been attained. Any increase in regeneration beyond this point will cause the circuit to oscillate. For extremely weak signals an enormous increase in amplification may be achieved but with larger signals correspondingly less amplification can be obtained, even at critical regeneration.

If means is provided for varying the amount of regeneration periodically, either by varying the plate or grid bias or by other means so that the circuit of *Fig. 4* varies beyond critical coupling on positive half cycles of the variation and to less than critical coupling on the negative half cycles so that over one full cycle of the bias variation the average effective resistance of the tuned circuit is positive, then the circuit of *Fig. 4* becomes super-regenerative. The bias variation is generally called the quench frequency. As a rule it is about 1/10th the frequency to be received.

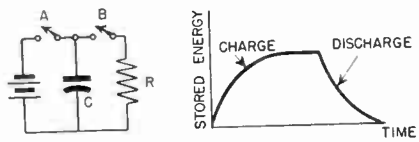

Figure 3

When this occurs, a transient train of oscillations builds up during the positive half cycle of the quench frequency and decays in similar manner over the quench frequency negative half cycle. The growth and decay curves may be represented as in *Fig. 3*. This is illustrated in *Fig. 5* where *A* is 1 cycle of the quench frequency and the dotted curve is the rate of build up and decay of the wave train of the transient oscillation. It is this succession of oscillations of the tuned circuit that carries the intelligence of the signal and is responsible for the function of the super-regenerative circuit. Actually the oscillations usually build up to a maximum determined by the damping or hunting of the tube and circuit and continues for an appreciable period before decay starts, as illustrated in *Fig. 6*.

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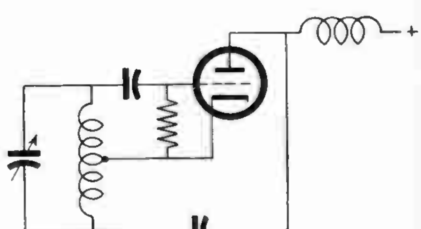


Figure 4

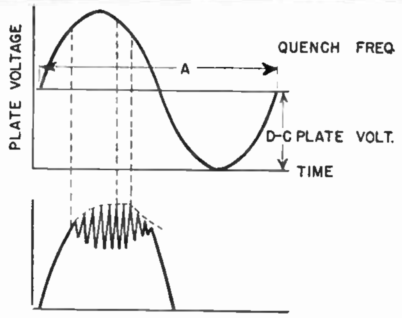


Figure 5

In general, there is for every super-regenerative circuit a particular quench frequency which will give maximum sensitivity. If the quench frequency is increased, a value is finally reached at which the oscillation does not have time to reach maximum build up before decay starts. Conversely, the lower the quench frequency the longer the oscillation will continue at its maximum amplitude before decay starts. The optimum quench frequency depends also on the Q of the circuit. There are other considerations involved, of course, in choice of quench frequency such as:

1. It should be well above the audible range, not only so the quench frequency will not appear in the receiver output along with the signal but to prevent the audio amplifier from being overloaded by quench voltage.
2. The higher the quench frequency the simpler is the by-passing.
3. If the quench frequency is too high, its harmonics may fall within the tuning range of the receiver, causing interference.

Just as super-regeneration increases the sensitivity of a receiver, it also greatly increases the selectivity.

When no signals are being received by a super-regenerative receiver this receiver produces a continuous noise due to the super-regenerative action on circuit noise such as shot effect, thermal agitation, etc. When a strong signal (whether modulated or not) appears, this characteristic noise practically disappears. As a matter of fact, a strong undesired carrier on an adjacent frequency sometimes renders a weak desired signal inaudible. Since circuit noise is a random phenomenon, the oscillations built up by noise will sometimes be in phase and sometimes out of phase with that caused by a strong signal, with the result that the noise voltage tends to balance out over a given time interval of sufficient duration to produce a few audio cycles.

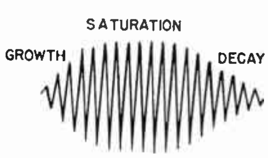


Fig. 6

Fig. 7 illustrates schematically a common type of super-regenerative receiver. The super-regenerative detector is supplied plate voltage by the quenching oscillator superimposed on the common supply. The frequency of the super-regenerative detector might be 30 mc up and that of the quenching oscillator 25 to 50 mc.

Another common type of super-regenerative circuit is the self-quenching type illustrated in *Fig. 8*. In this circuit the grid leak resistor-capacitor combination is properly chosen so that interrupted oscillations are produced. The rate of interruption is the quench frequency. In this circuit the quench frequency will not be constant but will, by the nature of the circuit, be a function of the strength of the incoming signal. This is partly due to the fact that a strong signal will cause the build-up time to be advanced over the

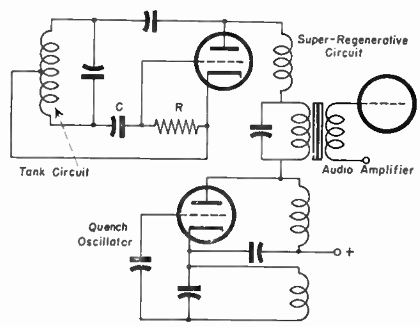


Figure 7

oscillations caused by a weak signal or those caused by circuit noise. This causes the quench frequency to increase, since the oscillations caused by the strong signal will reach a maximum more quickly than those caused by a weak signal or circuit noise.

Super-regenerative receivers may be designed to operate at any radio frequency but have found their chief usefulness at ultra-high frequencies. At such frequencies, this type of circuit provides a simple means of obtaining high sensitivity, whereas a relatively involved circuit might often be required for the conventional tuned radio frequency or double detector receiver. In a forthcoming data sheet some of the details of operation and design of super-regenerative receivers will be discussed at length.

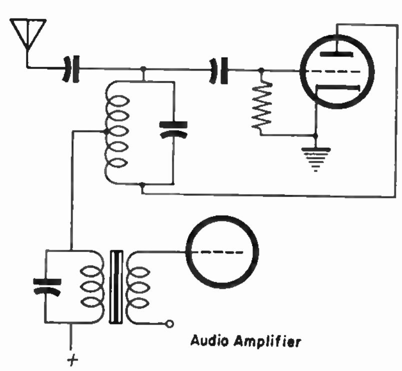


Figure 8

RADIO NETWORK PROBLEM

Fig. 9 shows an equalizer circuit which is often used in audio and radio frequency work. It consists of a resistor

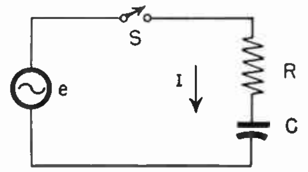


Fig. 9

and capacitor in series, to which is applied an alternating current voltage. Let the applied voltage be:

$$e = E \sin(\omega t + \phi)$$

The differential equation of the circuit of *Fig. 9* is:

$$e = RI + g/c$$

where g is the charge on capacitor C

$$E \sin(\omega t + \phi) = RI + \int I dt/c$$

Differentiating to eliminate $\int I dt$ yields:

$$\omega E \cos(\omega t + \phi) = \frac{I}{C} + R\frac{dI}{dt}$$

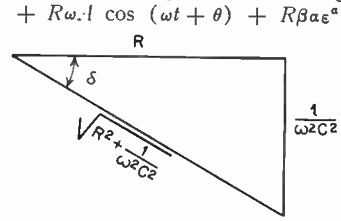
The solution of equation (1) will have the form:

$$I = A \sin(\omega t + \theta) + \beta \varepsilon^{at}$$

$$\frac{dI}{dt} = \omega A \cos(\omega t + \theta) + \beta a \varepsilon^{at}$$

Substitute equation (2) in equation (1) to obtain:

$$\omega E \cos(\omega t + \phi) = \frac{A}{C}\sin(\omega t + \theta) + \frac{\beta}{C}\varepsilon^{at} + R\omega A \cos(\omega t + \theta) + R\beta a \varepsilon^{a}$$



Vector Diagram of Circuit

Equate exponential and trigonometric terms to zero

$$\beta \varepsilon^{at}\left(\frac{1}{C} + Ra\right) = 0$$

$$\beta \varepsilon^{at} \neq 0$$

$$a = \frac{1}{RC}$$

Multiply by:

$$\frac{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}}{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}}$$

$$E \cos(\omega t + \phi) = \frac{1/\omega C}{\sqrt{R^2 + 1/\omega^2 C^2}} A\sqrt{R^2 + 1\omega^2 C^2} \sin(\omega t + \theta) + \frac{R}{\sqrt{R^2 + 1/\omega^2 C^2}} A\sqrt{R^2 + 1/\omega^2 C^2} \cos(\omega t + \theta)$$

$$= A\sqrt{R^2 + 1/\omega^2 C^2} \cos(\omega t + \theta - \delta)$$

$$A = \frac{E}{\sqrt{R^2 + 1/\omega^2 C^2}} \frac{\cos(\omega t + \phi)}{\cos(\omega t + \theta - \phi)}$$

Whence:

$$I = \frac{E}{\sqrt{R^2 + 1/\omega^2 C^2}} \sin(\omega t + \theta) + \beta \varepsilon^{-t/RC}$$

This Month

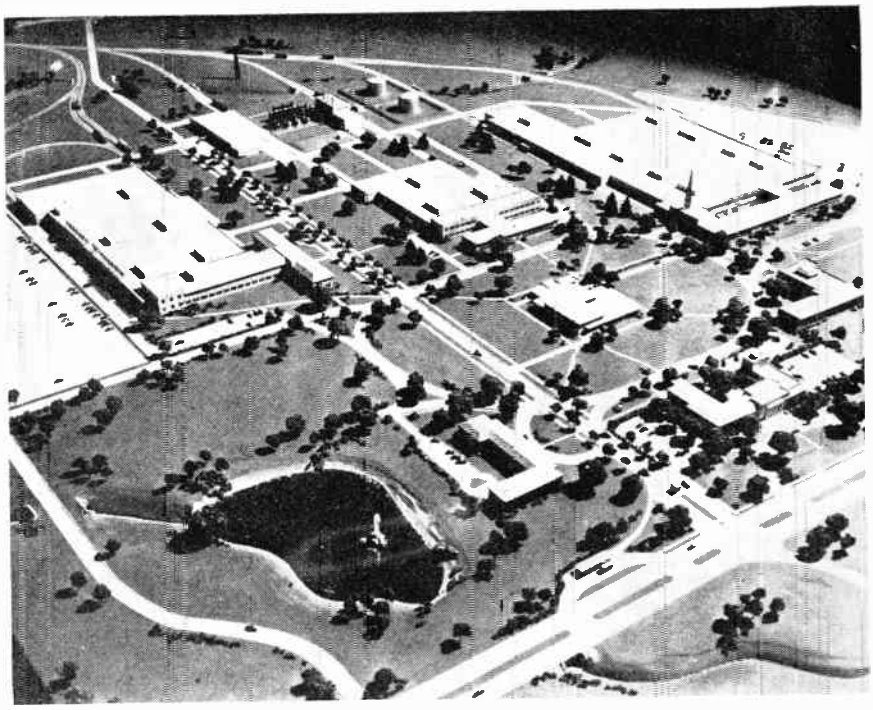
G.E. ELECTRONICS PLANT

A university of industry will begin to rise shortly on 155 acres of ground outside Syracuse, N. Y., as the General Electric Company begins the construction of its new $10,000,000 electronics headquarters plant.

Laid out and landscaped like a college campus, the new plant will be known officially as General Electric's "Electronics Park." Every modern facility for safe and efficient manufacturing operations also will be available. Floor area involved will be in excess of one million square feet. Buildings to be constructed include reception, administration, laboratory, transmitter, receiver, specialty, restaurant, service, boiler house and a substation.

The new plant will house the main manufacturing units of the G.E. Electronics Department. Other manufacturing units of the department will continue operating at Buffalo, Utica and Schenectady, N. Y.; at Wabash, Indiana; at Owensboro and Bowling Green, Ky.; and Tell City, Indiana.

Electronics has a bright future, Dr. W. R. G. Baker, G.E. vice president, explains, because it is a branch of science like chemistry. As chemistry is not limited to plastics or synthetic rubber, neither is electronics limited to radio, communications or radar. It will contribute to numerous fields and in some cases create new industries, like television, for example.



Plan of new G-E electronics plant at Syracuse, N. Y.

FCC ACTIONS

A proposed plan whereby all interested parties would be given an opportunity to apply for licenses of broadcast stations which are offered for sale was announced recently by the Federal Communications Commission.

Under this plan, the Commission would grant the transfer of license to the applicant best qualified to operate the station in the public interest.

The Commission's plan was included in an opinion issued with respect to its approval on August 2 of the sale of the Crosley Corporation radio interests to Aviation Corporation of America.

Under this plan, the Commission and the seller would publish the terms and the conditions of the proposed sale, and the name of the prospective buyer who has met the seller's price. Other persons desiring to apply for the station would be invited to do so on the same terms and conditions. The Commission would consider all applications on their merits, with a view to granting the transfer on the basis of public interest. A public hearing will be held on this proposal.

To strengthen its transfer procedure further, the Commission will recommend that Congress consider the desirability of adopting a yardstick for measuring the appropriate value of a station so that the Commission's field of choice will not be unreasonably restricted by permitting sales of stations at artificially high prices.

Congress will also be asked to consider the advisability of further defining the qualifications of licensees and particularly to determine as to what extent holding companies, investment banking groups, large industrial empires, large manufacturing companies and other businesses should be permitted to control radio stations.

"A basic infirmity of the Communications Act, which this case serves to highlight, is the fact that under the Act, as it has been administered up to this time, a man retiring from the radio business has, for all practical purposes the power to select his successor," the Commission statement pointed out.

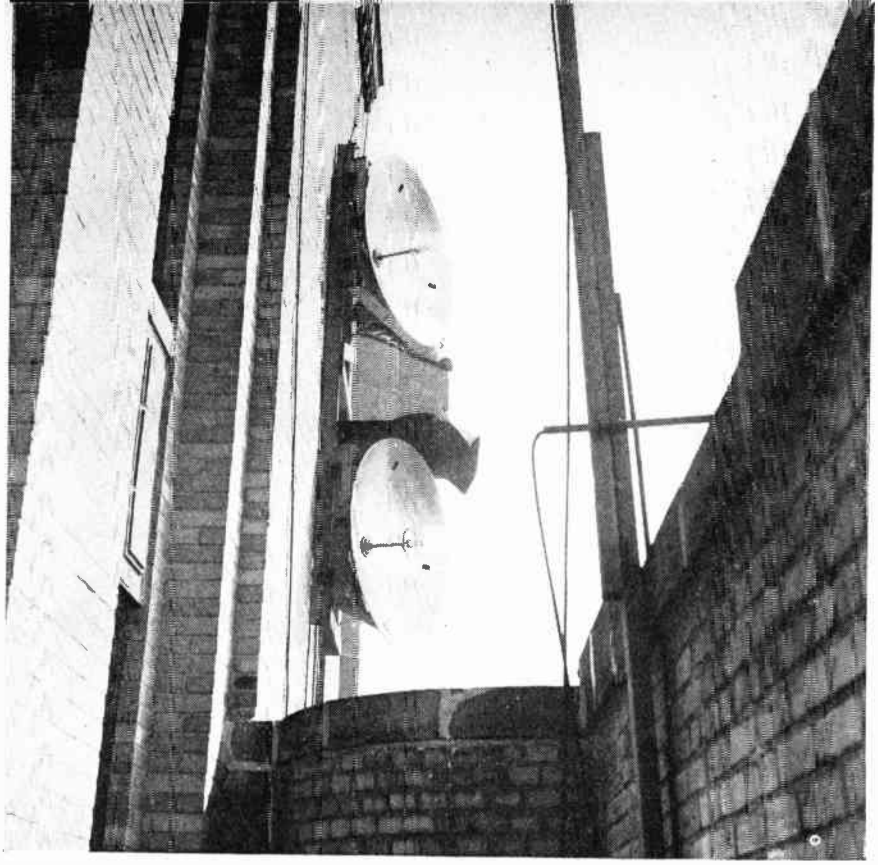
"Under the interpretation which has prevailed, his selection is final except in the very rare cases where he elects to sell to a party who is found not to be qualified. This is obviously a deficient procedure because a person retiring from the broadcast business is, in selecting a purchaser, likely to be influenced by many considerations which are quite unrelated to the question which should be paramount — namely, who is best qualified to continue to operate the station in the public interest."

". . . The procedure which has prevailed in transfer cases is in sharp contrast to that prescribed by Congress for the consideration of applications for new stations although the standards prescribed by the Act are identical. In the case of licensing new stations the procedure followed insures that everyone who is interested in applying for a particular broadcast frequency shall have the opportunity to do so. This usually results in a competitive situation where the Commission has a choice between applicants."

Approval of the transfer of the Crosley Corporation on August 2 was voted by a majority of the Commission consisting of Commissioners Paul A. Porter, Chairman; E. K. Jett, Charles R. Denny and William H. Wills. Commissioners Paul A. Walker, Ray C. Wakefield and Clifford J. Durr dissented.

With respect to its approval of the transfer of Crosley's station WLW to The Aviation Corporation, the Commission majority said that it had "no alternative but to grant the application unless the uniform precedents of 17 years of radio regulation are to be ignored and a complete reversal of administrative policy is to be adopted." The majority took the view that administrative agencies such as the Commission "have an obligation to adhere to uniform policies, and when developments dictate change, adopt after appropriate notice a rule of general application so as to avoid the color of discrimination in a particular case". Moreover, the majority pointed out that to deny the WLW transfer on the ground that Avco has substantial business interests in other fields would create a chaotic situation in the broadcast industry since doubt would be cast upon the status of scores of present radio licensees who, like Avco, has extensive non-broadcast interests.

The majority further found that Avco meets the citizenship requirements of the Communications Act, is financially qualified and is technically qualified. While the



Receiving and transmitting 1200 mc Multi-channel link antenna installation atop the International Telephone and Telegraph Corporation building, New York City, for the Pulse Time Modulation System developed by the Corporation's associate, Federal Telephone and Radio Corporation

parties to the transfer did not segregate the price paid for the radio properties from the price paid for the Crosley manufacturing properties, the Commission said that there was no evidence of trafficking in licenses and the record showed that the price paid would not adversely affect Avco's financial responsibility or the station's program structure.

A dissenting opinion issued by Commissioners Walker and Durr objected to the transfer on the grounds that Aviation Corporation is a large holding company of a type which has been traditionally a matter of concern because of their use as an instrumentality for gaining control over large segments of the economy of the country without corresponding responsibility; that Aviation Corporation has failed to give the Commission a valuation on the broadcast properties, has not demonstrated even minimum qualifications by acquiring a knowledge of the duties and responsibilities of a licensee and that the Commission should not be bound by its precedents when such precedents conflict with public interest and statutory responsibilities.

Commissioners Walker and Durr agreed that the procedure recommended by the majority for future transfer cases will remedy some of the deficiencies in the Commission's present procedure They objected that the proposal to limit competition to those who are willing and able to meet the contract terms and conditions of the highest bidder seems "without warrant in the Act". Such competition, their opinion asserted, should not be in terms of ability to pay the highest price but in terms of public service to be rendered. In view of the decision to adopt a new transfer procedure and to submit certain questions to Congress, action on all "questionable applications" should be deferred until Congress and the Commission have acted, the opinion declared.

Commissioner Ray C. Wakefield's separate dissenting opinion opposed the transfer primarily on the ground that the transferee, on the basis of the record, is less qualified than the transferor, and hence the Commission could not properly make the finding required by Section 310(b) of the Communications Act that the public interest would be served by the transfer. Commissioner Wakefield stated that the same public interest which is inherent in the privilege of using a portion of the public domain free of charge requires that a transferor select a successor who will possess not only the bare qualifications to assume the duties incumbent upon licensees as required by the Act, but also the qualifications which will assure at least a comparable standard of service.

Commissioner Wakefield cited precedents in which the Commission had heretofore denied transfer applications where it appeared that the public interest would be better served by leaving control in existing hands. He noted that according to the evidence adduced at the hearing, Avco was not originally interested in the purchase of radio stations, considering the purchase of the properties involved in this case as "a package of equities", and that those assuming control were unacquainted with the needs of the community to be served, the bare essentials of the program structure, and the nature of their public and legal responsibilities as broadcasters. He stated that the burden of overall management, as distinguished from mere day-to-day operations, should not be shifted to paid employees, and that to look to employees rather than to those in control for qualifications would render moot the statutory requirement of Section 310(b). He noted that there was adequate time in this case to find a fully qualified transferee.

Commissioner Wakefield's dissent noted that there was an absence of full information with reference to such fundamental issues as the price being paid by the transferee, the future program and financial policies of the transferee, and generally.

Commissioner Wakefield stated that on the basis of the record here, the Commission's authority appears clear without further legislation; and that some "such procedure as that proposed by the majority to be instituted hereafter should have been instituted in the present case". The dissent concludes: "I agree with the majority view that this case illustrates the deficiencies of the Communications Act with respect to the broader phases of some of the issues raised herein. The Commission should formulate specific proposals for submission to Congress".

Commissioners Walker and Durr, in addition to the grounds for denial set forth in their own dissenting opinion, expressed agreement with the grounds for denial set forth by Commissioner Wakefield.

FM LICENSES

The FCC has received inquiries from men now in the military service regarding the possibility of filing applications for FM facilities at this time with engineering data to be submitted at a later date upon their discharge from the service.

In a public notice of September 4, 1945, the Commission announced that it proposes to make "conditional grants" of FM applications, affording the applicants a period of ninety days in which to file engineering details of the proposed operation. It is believed that this procedure will facilitate the filing of applications by service men, and will enable them to qualify for FM licenses.

The Commission recognizes the difficulties confronting military personnel in completing their applications for broadcast facilities, and, accordingly, consideration will be given to requests by applicants in the armed services for reasonable extensions of time to submit engineering data.

Since it is not possible to reserve FM channels for future assignment, service men planning to enter the broadcast business are urged to submit their applications promptly.

IRE WINTER MEETING

The Institute of Radio Engineers will hold its annual Winter Technical Meeting at the Astor Hotel in New York, January 23 to 26, 1946, it was announced today by Edward J. Content, Chairman of the Meeting Committee.

"Because this is to be the first postwar meeting to be held by the Institute of Radio Engineers, it promises to be one of the most significant the Institute has ever held," Mr. Content declared.

With the end of the war, restrictions on information of a technical nature have been relaxed so that many papers on radar and other devices formerly of a confidential nature will be read. In addition to the many features that have always characterized the Institute of Radio Engineers' meetings, Mr. Content announced an unprecedented number of electronics and radio companies—approximately 150—will have commercial exhibits in which will be displayed their first postwar civilian products.

Mr. Content also announced the appointment of the various committees who will serve with him in handling all details of the meeting. The general committeemen are: Austin Bailey, Howard Frazier, William B. Lodge, Stuart L. Bailey, George W. Bailey and Miss Elizabeth Lehmann.

Sub-committee chairmen in charge of the various activities are: Frank Marx, Arrangements; C. M. (Buck) Lewis, Banquet; H. F. (Hank) Scarr, Exhibits; Raymond F. Guy, Finance; Will Whitmore, Publicity; A. E. Harrison, Papers; Dorman D. Israel, Printed Program; Harold P. Westman, Registration; Don H. Miller, Special Features; George B. Hoadley, Sections Committee Activities; William H. Crew, Technical Committees Activities; Philip F. Siling, Hospitality; Helen M. Stote, Women's Activities, and George T. Royden, Standing Committees Activities.

PERSONAL MENTION

Paul H. Thomsen

★ Paul H. Thomsen has been appointed chief engineer in charge of special electronics at the Los Angeles plants of the Hoffman Radio Corp., according to announcement from Walter S. Harmon, vice president of engineering.

He had been four years with the Air Track Mfg. Corp., College Park, Md., as vice president in charge of engineering and six years with the Jenkins Television Corp. in New York and Washington, D. C.

He was also a consultant for the National Radio Institute, Washington, D. C., for seven years.

Captain Finch

★ Captain W. G. H. Finch, USNR, has returned to inactive duty at his own request and will assume the presidency of Finch Telecommunications, Inc., Passaic and Clifton, N. J., developers and manufacturers of facsimile communications equipment. In addition to his work with Finch Telecommunications, Captain Finch also expects to resume construction of FM Station WGHF, New York, within the next few months.

Captain Finch is well known to industry, especially in the field of facsimile, where he personally holds over 100 patents. He was formerly Assistant Chief Engineer for the Federal Communications Commission in Washington, D. C.

Reporting for active duty as a Lieutenant Commander on December 1, 1941, six days before Pearl Harbor, he was assigned as head of the Countermeasures Section in the Bureau of Ships. As head of this section, he was responsible for large-scale research and development of a highly classified nature in the field of electronics, and

Capt. W. G. H. Finch

is credited with many basic and important equipments and systems now in extensive use.

Captain Finch was a member of both the Joint and the Combined Countermeasures Committees of the Joint and Combined Chiefs of Staff from the beginning of their organization.

In 1942, 1943 and just before DE Day in 1944, Captain Finch served tours of duty for the Navy in the European Theatre, his last trip resulting from a special request for his presence in England to assist in DE Day preparations.

Hugh S. Knowles

★ Mr. Hugh S. Knowles, vice-president and chief engineer of the Jensen Radio Manufacturing Company, of Chicago, was recently honored by his election as president of the Acoustical Society of America. This society comprises educators, research and development workers in all fields of acoustics including recording and reproduction of sound, electroacoustic devices, architectural acoustics, speech and hearing, noise abatement and vibration control, musical instruments, sonar and ultrasonics. Mr. Knowles has been further recognized by the Fellowship Award of the Institute of Radio Engineers for "Outstanding Contribution to Acoustics," and the chairmanship of Committee on National Defense, Electroacoustics Standards of the I. R. E., and Sound Equipment Standards of the R. M. A. He has also represented the I. R. E. and R. M. A. on various electroacoustical committees of the American Standards Association, and served as chairman of the Chicago Section of the I. R. E. He appears as associate editor of the John Wiley Engineering Handbook Series, and of Henney's Radio Engineering Handbook, 3rd edition, published by McGraw-Hill Book Co.

Mr. Knowles began his service with the Jensen company in 1931 as chief engineer

[*Continued on page 57*]

Tower at the Telegraph Hill Field Station with the antenna installation for the PTM Multiplex Radio Relay System developed by the Federal Telephone and Radio Corporation

New Products

This tiny 6AK5 pentode, manufactured by the Western Electric Company, is only 1½ inches high and ¾ inch in diameter. It played a vital role in high-frequency military equipment and promises an even bigger role in the FM and television equipment of tomorrow

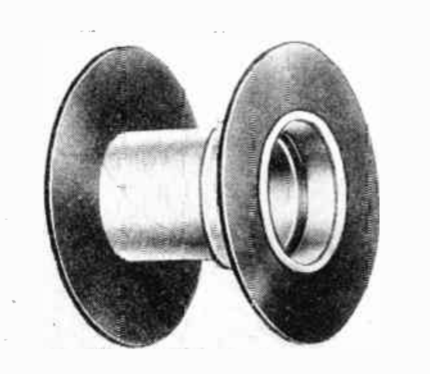
BOBBIN COIL FORM

Closer tolerances, stronger construction and much increased efficiency with ultimate lower cost, are among the advantages embodied in the new die-formed Bobbin Coil Form for speaker field coils now made available by Precision Paper Tube Company, 2023 West Charleston Street, Chicago 47, Illinois.

The new coil form comes in complete strong one-piece assembly, ready to go on mandrel of coil winding machine.

This construction, more dependable in every way, supersedes the old practice in which bobbin flanges were serrated and coil base glued to the flanges. By Precision process the entire coil base is now shaped by die in one piece from the spirally wound, heat-treated dielectric materials used in Precision bobbins and tubes. With this construction the voice coil fits more closely and securely, insuring far better functioning.

Precision Paper Tube Company is prepared to make these new coil forms to shapes, measurements and other special specifications to meet any requirement with prompt delivery in any quantity. Full details may be had by addressing the manufacturer.



NEW V-T VOLTMETER AND AMPLIFIER

This new product of the Reiner Electronics Co., Inc., offers many advantages for laboratory work, in industry, universities and like institutions. It is especially suitable for measuring amplifier gain, network response, output level at audio and radio frequencies, and has proven invaluable in the television and broadcasting field.

Its 25 millivolts a.c. on the lowest range, and 1000 volts on the highest range, as well as its 10 cps to 700 megacycles frequency range, and the 7 micro-microfarads input capacity gives this unit a sensitivity, voltage range, and capactiy matched only by very few of the high priced units. In addition, it permits comprehensive current and resistance measurements.

To make production testing time saving, and the operation simple, the following features have been incorporated into the unit: single linear scale for all voltage and current scales—single zero adjustments for all a-c and d-c ranges—voltage regu-

lated supply—stable operation—accuracy 2% of full scale values—large overvoltage capacity—fuse located on panel of meter.

The model 451 is manufactured with the following ranges: *AC Volts*: 0-.025-1-.25 (with amplifier)-2.5-10-25-100-250-1000—*DC Volts*:0-2.5-10-25-100-250-1000—*DC Current*: 0-2.5-10-25-100-250-1000—Ohms: 1 ohm to 1000 megohms—*AC Frequency Range*:10 to 5000 cps (with amplifier) 50 cps to 700 megacycles. DC Volt, ohm and current accuracy 2% on full scale. AC volt, accuracy 2%, 50 cps to 50 megacycles. AC frequency entire range 5% accuracy. The weight of the unit is 20 lbs., the size is 10¾" x 9" x 8".

For further information, write Reiner Electronics Co., Inc., 152 West 2t5h Street, New York 1, N. Y.

COMMUNICATIONS RECEIVER

Development of a radio receiver which in mechanical design is a "revolutionary departure" from existing types of construction was announced by the National Radio Company which has a $15,000,000 contract to supply the receivers to the Navy.

The receiver, which reaches into the ultra-high frequencies, represents months of work by National engineers, in collab-

oration with the Navy Research Laboratory, to simplify construction design and thus facilitate maintenance problems.

The set is mounted on a drawer-slide, which does away with the necessity of removing the receiver from the cabinet. With the receiver pulled out on this drawer-slide, the set can be tilted in three different positions so that all components can be reached easily.

Another new feature is that the front of the receiver is equipped with lock-handles, which eliminate the necessity of using screws to fasten the front panel to the cabinet. With a twist of the wrist, the panel can be detached and tilted into the required position for inspection or repairs. For reasons of security, no other details were disclosed, although it was said than the new mechanical features could be readily adapted to commercial models, including wall-flush home sets.

The new-type receivers will be installed by the Navy aboard fleet units and at shore stations.

POWER FACTOR CORRECTION CAPACITORS

A diversified line of oil-impregnated, oil-filled capacitors, embodying the electrical and mechanical design features which have been found best suited to requirements of fluorescent lamp service, is announced by the Tobe Deutschmann Corporation of Canton, Mass.

Contained in hermetically sealed metal cases, these capacitors are impregnated and filled with pure mineral oil, the character-

[*Continued on page* 50]

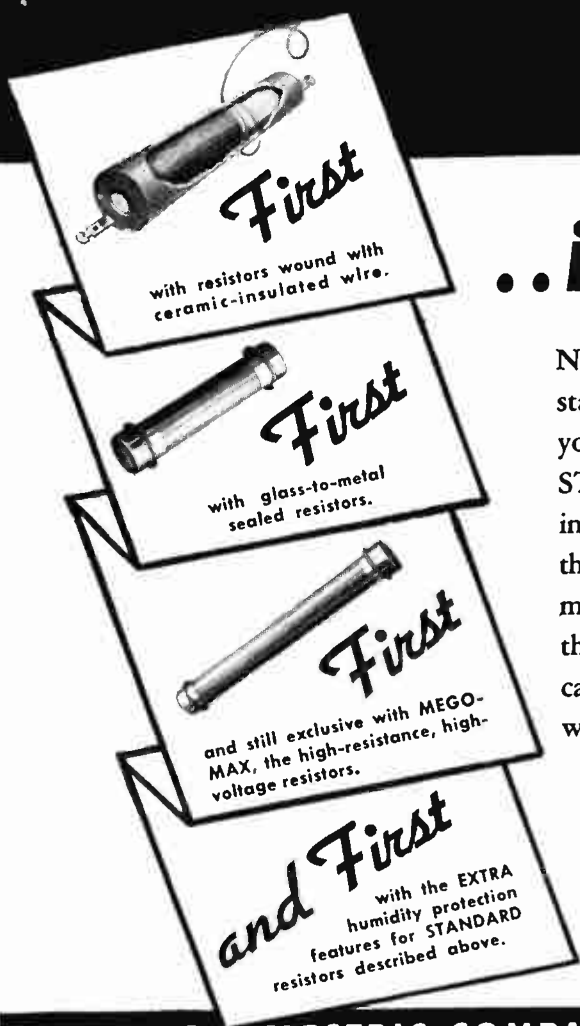
ONE STANDARD TYPE

does the job...

NEW type end seal for extra humidity protection.

WOUND WITH CERAMIC INSULATED WIRE 1000°C. HEAT-PROOF!

NEW glazed ceramic shell to withstand thermal shock, humidity and corrosive conditions.



..in ANY climate!

No more "special orders" to obtain suitable resistors to withstand the extreme thermal and humidity conditions to which your product may be subjected in many parts of the world! STANDARD Sprague Koolohm Wire-Wound Resistors now incorporate these extra protection features — and this means that you can count on STANDARD Sprague Koolohms for maximum dependability in ANY climate, ANYwhere on the face of the globe. Write for new catalog of Sprague Koolohm wire-wound types for every requirement.

ARMY E NAVY

SPRAGUE KOOLOHM

TRADEMARK REGISTERED U.S. PAT. OFF.

WIRE-WOUND RESISTORS

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

NEW PRODUCTS

[*Continued from page 48*]

istics of which render the units particularly applicable to use where a wide range of operating temperatures may be encountered; operating temperatures range from minus 67° to plus 185°F. Oil-tight terminals are insulated with sturdy phenolic bushings and provided with tinned copper soldering lugs.

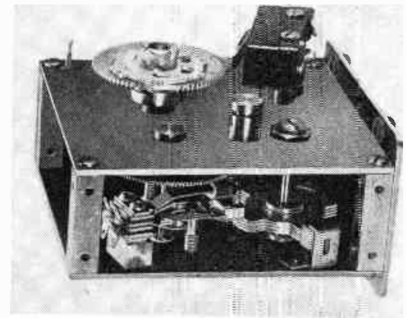
Available sizes include capacitances from 2.0 to 5.25 μfd and working voltages from 165 a-c to 440 a-c. The standard capacitance tolerance of Tobe capacitors for fluorescent lamp service is minus zero plus 20 per cent.

Detailed data are available on request to Tobe Deutschmann Corporation. Capacitor Division. Canton, Mass.

CONSTANT SPEED D-C MOTOR

Small enough to be held in the palm of the hand, a new Constant Speed d-c Motor has been developed by the Amglo Corporation of Chicago to supply a-c motor performance to the d-c market. The new motor is especially adaptable to synchronous operation formerly possible only through the use of alternating current.

It is simple in design and ruggedly constructed for land, aircraft, or marine use. According to test under actual working conditions. the Amglo Constant Speed D.C. Motor maintains a constant set speed re-



gardless of wide variations in voltage. It is self-starting and builds up full speed almost instantly. Current consumption is extremely low (from .6 to 1 watt), and shaft speeds may be geared from 1 revolution every 24 hours up to 600 r.p.m. It provides the same "time keeping" accuracy with direct current that A.C. motors give with alternating current.

Description and complete literature covering this new Constant Speed D.C. Motor can be received by writing direct to the Amglo Corporation, 4234 Lincoln Ave., Chicago.

CRYSTAL CATALOG

Of interest to amateur radio engineers and to "hams" is the new comprehensive catalog just released by Crystal Research Laboratories of Hartford. Conn.

This catalog shows interesting views of plant personnel at work in crystal production. One entire page is devoted to the facsimile of a movie film depicting the consecutive production steps from the raw quartz to the finished crystal. The entire catalog is clear and concise and various types of crystals are fully illustrated and described both as to operation and use.

Crystalab points out, however, that many other types and varieties of crystals can be produced by them in addition to those described herein. They specialize in making close tolerance crystals to order in any quantity. Those interested in securing a free copy are asked to write Crystal Research Laboratories, Inc., 29 Allyn Street. Hartford 3, Conn.

NEW FM MAST KIT

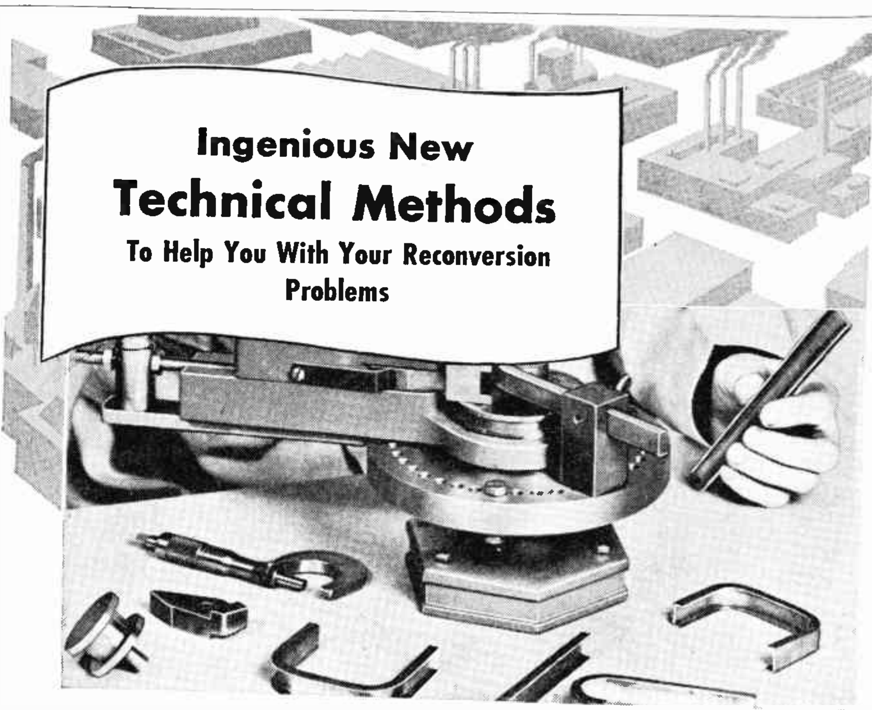
Plymold Corporation of Lawrence, Massachusetts, announces the development of a new mast for use with FM and television radio receivers.

The mast is made from Plytube and has unique fittings for attachment atop a roof or side of a building. In conjunction with the mast, they have developed a complete antenna system. The mast, antenna system, and all fittings are offered as a kit.

Production on the entire unit has already started and deliveries are promised to be reasonably prompt.

SUPER-SENSITIVE IONIZATION GAUGE

In their search for greater precision, greater accuracy and more uniform production of all their high vacuum electronic tubes, the Research Laboratories of Na-



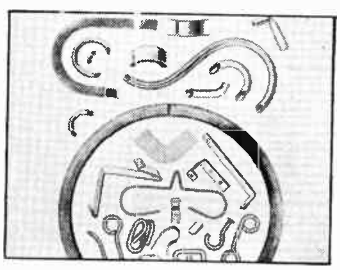
"Die-Less Duplicating" Eliminates Time Loss and Die Expense!

The DI-ACRO Bender is a precision unit, designed to form and duplicate an unlimited variety of parts and pieces—eliminating, in many cases, the need for special dies. Tubing can be accurately formed with the DI-ACRO Bender to a center line radius as small as 2½ times the outside diameter of the tube without distortion. Shapes and outlines, impossible to obtain with regular production dies, are easily formed with the DI-ACRO Bender. These include round, half-round, hexagon, and square rod, tubing, angle, channel, moulding, strip, stock and bus bar.

Stops may be set and material guides mounted for production work in excess of 1000 operations per hour. The Bender is compact and portable, ideal for temporary or permanent work. There are no extra parts to purchase, as the DI-ACRO Bender has been built to cover a wide working range, with simple conversions.

Peacetime production for industry, forecasts the return of Wrigley's Spearmint Gum—that favorite "help on the job," for workers everywhere. But Wrigley's Spearmint will be back only when conditions permit its manufacture in quality and quantity to meet your needs. Until that day, we ask you to remember the famous Wrigley's Spearmint Wrapper shown at right, as your guarantee of the finest chewing gum that can be made.

You can get complete information from O'Neil-Irwin Manufacturing Co., Minneapolis 15, Minn.



Typical Shapes Formed by the DI-ACRO Bender

Remember this wrapper

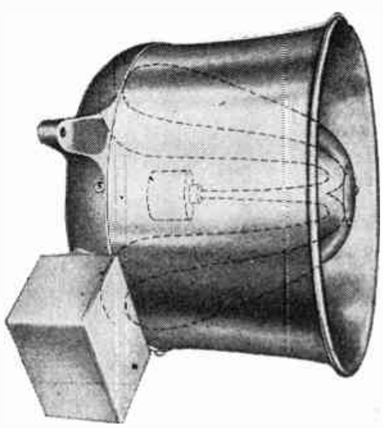
Z-86

RACON's . . . the leading speaker line . . . for all types of sound installation!

Most of the best industrial p. a. installations in use are RACON speaker equipped. They are the finest speakers made and there is a type for every conceivable application.

For Marine p. a. installations, too, RACON leads. Approved by the U. S. Coast Guard, RACON speakers are used aboard Army and Navy vessels. Only RACON can supply, when needed, patented Weatherproof, Stormproof Acoustic Material which is impervious to any weather condition and prevents resonant effects.

Most manufacturing plants will soon order sound installations. Specify RACON Speakers!



Left: MARINE HORN Speaker, approved by the U. S. Coast Guard. Several sizes available, Stormproofed, of the re-entrant type, suitable for indoor or outdoor use — may be used as both speaker and microphone.
Right: RE-ENTRANT TRUMPET; available in 3½', 4½' and 6' sizes. Compact. Delivers highly concentrated sound with great efficiency over long distances.

RACON ELECTRIC CO. 52 EAST 19th ST. NEW YORK, N. Y.

tional Union Radio Corporation of Newark, New Jersey, have developed a new high vacuum Ionization Gauge.

This new gauge is capable of recording pressures well below one billionth of an atmosphere. A new accuracy is possible in attaining uniform high vacuum, heretofore impossible with conventional gauges. Economical design and simplicity contribute significantly to its low cost.

Wherever high vacuum processes are involved in product manufacture the NU Ionization Gauge will be found to be an interesting improvement over most gauges now in common use.

Detailed information available on request to National Union Radio Corp., Dept. SE., 15 Washington St., Newark 2, New Jersey.

NEW SOUND EQUIPMENT CATALOGS

Concord Radio Corporation, of Chicago and Atlanta, have just published two new folders presenting complete listings of "available now" sound equipment units and sound accessories. Featuring illustrations and detailed descriptions of the complete Concord line of Amplifiers, Intercommunication Systems, Recording Equipment, and Accessories, these folders are up-to-the-minute catalogs of available equipment covering every requirement.

In Amplifiers and Boosters, the presentation covers models ranging in output ratings of 17 watts to 75 watts A.C.—includes 6-volt units with and without built-in phonograph. Intercommunication Systems covering all requirements are also listed—master and substation combinations for every purpose from 2 to 100 stations—and including push button control, universal operation, "busy signal" and "call waiting light" features.

The presentation of recording equipment lists professional-type units for microphone recording, radio recording, transcription and public address.

A separate listing offers a complete line of sound accessories covering microphones, speakers, and all essential needs. Copies of these important listings may be had without cost or obligation, by writing to either of the Concord Radio Corporation's offices—901 W. Jackson Boulevard, Chicago 7, Ill. Or 265 Peachtree St., Atlanta 3, Ga.

Our Hat Is Off . . .

Our hat is off to those radio men, both military and civilian, who contributed so much to the successful completion of the war. Too, our hat is off to those radio servicemen and jobbers who were patient and understanding of the shortage of Rider Books caused by wartime restrictions, now removed. Our hat is off (and our coat too), ready to tackle the peacetime radio problems in the civilian field. In the light of our wartime experiences we have planned a five year program which is right now developing in our own laboratories. From this research will result many innovations—and one of the most ambitious publishing programs we ever scheduled. It will bring to the student, the amateur, the serviceman, yes even the radio engineer the very information each must have if he is to understand, and work in radio and the new fields of television and microwaves that will be commonplace in coming years. This is not a program of the future, it is functioning today. Next month will witness the publishing of the first of these new Rider Books. Announcements will carry complete details. Yes, our hat is off—and it's great to be back!

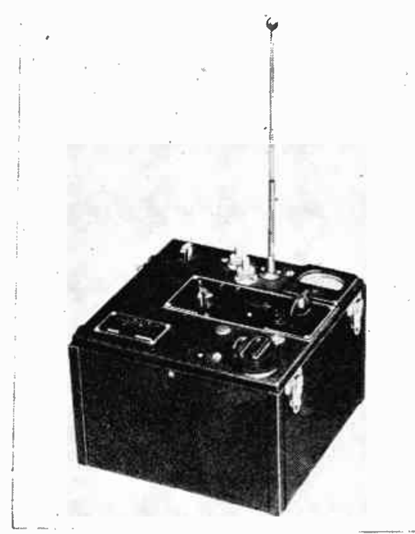
John F. Rider

JOHN F. RIDER PUBLISHER, INC., 404 FOURTH AVE., NEW YORK 16, N.Y.

"Publishers of Radio Technical Books Exclusively"

NEW OSCILLATOR

Type 291 is a portable, battery operated oscillator especially and primarily designed for checking HF aircraft radio receivers. As such, all features and equipment not relating to checking aircraft receivers have been omitted, resulting in a specialized, good quality checking oscillator at an exceptionally low cost. This new instrument



has a frequency range from 49 to 154 megacycles with modulation frequencies of 70, 90, 400, 1300, and 3000 cycles. It contains an easily extended, collapsible antenna and two coaxial terminals for low and high level outputs.

For further information, write Andrew Co., Chicago 19, Ill., manufacturers of coaxial transmission lines and accessories, radio broadcast equipment and antenna tuning units.

IMPROVED STEEL WORK BENCH

Streamlined design, sturdier construction, and numerous available extras are the features of the improved Equipto 12-gauge steel work bench announced by Equipto Division of Aurora Equipment Co., Aurora, Illinois. It may be furnished without back and side railings for use as a packing bench.

All four flanges of the bench are formed into a boxed edge for utmost rigidity. A

THESE *Gammatron* TUBE TYPES ARE NOW AVAILABLE!

Gammatron tubes, famed for the past 18 years for their ability to stand up under heavy overloads, and for their efficiency even at very high frequencies, are again available for civilian use! Look for the "HK" before the type number—your assurance of the best in tantalum-element tubes.

STANDARDIZED *Gammatron* TYPES

Electrical and physical characteristics guaranteed to meet currently high standards. These tube types will always be readily available.

14 TRIODES

TUBE TYPES	PLATE DISSIPATION	TUBE TYPES	PLATE DISSIPATION
HK-24	25 watts (Grid lead to base)	**HK-454L**	250 watts (Low Mu)
		HK-454H	250 watts (High Mu)
HK-24G	25 watts (Grid lead through envelope)	**HK-654**	300 watts
		HK-854L	450 watts (Low Mu)
HK-54	50 watts	**HK-854H**	450 watts (High Mu)
HK-254	100 watts	**HK-1054L**	750 watts
HK-354C	150 watts (Low Mu)	**HK-1554**	1000 watts
HK-354E	150 watts (High Mu)	**HK-3054**	1500 watts

1 PENTODE

HK-257B Plate Dissipation, 75 watts (Beam pentode)

4 RECTIFIERS

HK-253	Inverse Peak Volts, 15,000	**HK-953D**	Inverse Peak Volts, 75,000
HK-953B	Inverse Peak Volts, 30,000	**HK-953E**	Inverse Peak Volts, 150,000

3 IONIZATION GAUGES

VG-2 **VG-24G** **VG-54**

REPLACEMENT *Gammatron* TYPES

The following Gammatrons are being made available primarily for replacement use. Designers of new equipment are asked to consider recommended standardized types.

REPLACEMENT TUBE TYPE	DESCRIPTION	RECOMMENDED STANDARDIZED TUBE TYPE
HK-354	Triode, grid lead to base pin, ratings same as HK-354C	HK-354C HK-454L HK-454H
HK-354D	Triode, Medium Mu	HK-354C or E HK-454L or H
HK-354F	Triode, High Mu	HK-354E
HK-257A	Beam Pentode	HK-257B
HK-153	High Vacuum Rectifier, inverse peak volts, 5000	HK-253
HK-545	Triode. Same as HK-54 except fil. current is 3.35 instead of 5 amps.	HK-54
HK-2054A	Triode	
HK-2054B	Triode	

AWARDED FOUR TIMES

HEINTZ AND KAUFMAN LTD.

SOUTH SAN FRANCISCO • CALIFORNIA

Gammatron Tubes

Export Agents: M. SIMON & SON CO., INC., 25 WARREN STREET, NEW YORK CITY, N. Y.

Can You "*Measure Up*"
to a good paying radio electronics job with a secure peacetime future?

"Post-War" is NOW! Don't be caught unprepared! Add CREI home study training to your present experience and step ahead of competition

What's ahead for you in the field of Radio Electronics? One thing is certain. Now that peace is here, Radio-Electronics will surge forth as one of America's foremost industries, offering promising careers for radiomen with modern technical training.

NOW is the time to take the time to prepare yourself for the important, career jobs in radio-electronics engineering. You will find the knowledge gained from your CREI course useful almost from the beginning. Student C. Whitehead writes: "Your course has been of great value to me in that the knowledge I have gained has enabled me to meet technical situations satisfactorily and has given me the confidence to accept greater responsibility."

In our proved home-study course, you learn not only *how* . . . but *why!* Easy-to-read-and-understand lessons are provided you well in advance, and each student has his personal instructor who corrects, criticizes and offers suggestions on each lesson examination. This is the successful CREI method of training for which more than 10,000 professional radiomen have enrolled since 1927.

Your ability to solve tough problems on paper and then follow up with the necessary mechanical operation, is a true indication that you have the *confidence* born of *knowledge* . . . confidence in your ability to get and *hold* an important job with a secure, promising future. Investigate now the CREI home-study course best suited to your needs, and prepare for security and happiness in the New World of Electronics! *Write for all the facts today.*

WRITE FOR FREE 36-PAGE BOOKLET

"Your Opportunity in the New World of Electronics"

If you have had professional or amateur radio experience and want to make more money, let us prove to you we have something you need to qualify for a better radio job. To help us intelligently answer your inquiry — PLEASE STATE BRIEFLY YOUR BACKGROUND OF EXPERIENCE, EDUCATION AND PRESENT POSITION.

CAPITOL RADIO ENGINEERING INSTITUTE

Home Study Courses in Practical Radio-Electronics Engineering for Professional Self-Improvement

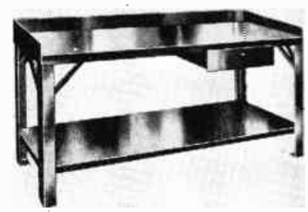
Dept. RA-10, 3224 - 16th Street, N.W., Washington 10, D. C.

Contractors to U. S. Navy—U. S. Coast Guard—Canadian Broadcasting Corp. Producers of Well-trained Technical Radiomen for Industry.

Member: NATIONAL COUNCIL OF TECHNICAL SCHOOLS

second 12-gauge steel plate may be tack welded onto top for vise reinforcement. The bench is highly suitable for both work bench use and for supporting light machine tools. The four feet have holes to permit fastening to floor if desired. It is available in 42 inch and 6 foot lengths, 34 inches high and 28 inches deep on short deliveries and without priority.

It can be furnished as a plain work bench with 12-gauge steel top and with bottom tray, back and side railings, drawers



with padlock attachment, adjustable 3-compartment tray for drawer. Benches may be used side by side and back to back forming larger working surfaces in a minimum of floor space.

TUBE TESTER

A new Tube Tester with a flexible test circuit provides for "tube value" test, short and open element test—plus a Transconductance Comparison check for matching tubes.

Three-position lever switching makes this one of the speediest and most flexible of all tube testers—provides simplicity in operation and still gives individual control for each tube element.

The long scale instrument carries the Triplett Red-Dot Lifetime Guarantee against defects in workmanship or materials. The multi-color scale makes it easy to quickly determine the condition of all tubes.

Instructions and test chart have simplified arrangement for quick reference and large easily read printing.

Write for circular to The Triplett Electrical Instrument Co., Bluffton, Ohio.

ELECTRO-VOICE CATALOG

A new Electro-Voice catalog, with a simplified Reference Level Conversion Chart, which marks the first attempt in the history of the industry to standardize microphone ratings, has been published by the Electro-Voice Corporation, 1239 South Bend Avenue, South Bend 24, Indiana.

Basic operating principles of microphones are explained in the new Electro-Voice Catalog, offering a guide to the proper selection of types for specific applications. New types of special purpose microphones developed for voice and sound transmission, featured in the catalog, make it a valuable hanadbook for sound men.

Poly-directional, dynamic, velocity and carbon microphones in various Electro-Voice models are completely described from applications to specifications. Diagrams, giving mechanical dimensions and photographs on every page illustrate each model.

Copies are available by writing on business stationery to the Electro-Voice Corporation, 1239 South Bend Ave., South Bend 24, Indiana.

HIGH-VACUUM RECTIFIER

A new, high-vacuum, half-wave rectifier tube which has been put into production and is presently ready for distribution, is announced by Taylor Tubes, Inc., 2312 Wabansia Avenue, Chicago, Ill. The tube bears the number TR-40M and is 9⅞ inches high with a maximum diameter of 3 13/32 inches. It is equipped with a 4-pin jumbo (50-watt) base and the glass is Nonex. The filament is thoriated tungsten assuring long life and trouble-free service. Plate lead is at the top, and filament leads are brought out to pins Nos. 2 & 4.

Electrical characteristics: Filament power—5.0 volts at 10.5 amperes; Peak forward volts—25,000; Peak inverse volts—60,000; Average plate current—.25 amperes.

Special design features insure complete safety against voltage breakdowns.

E-L CAR RADIO VIBRATORS

A drastic stock simplification plan through which 95% of the existing demand for auto radio vibrators may be met by four vibrator models has been announced by Walter Peck, vice president in charge of sales, Electronic Laboratories, Indianapolis. Use of the new E-L Auto Radio Vibrator Replacement line will enable radio distributors, dealers and servicemen to reduce their inventories of vibrator types as much as 92%, Mr. Peck said.

Recent surveys indicate that there will be more than 8,000,000 car radios in need of repair by the time replacement parts become available.

A program to promote the E-L Auto Radio Vibrator Replacement plan through advertising, publicity and related activities has already been initiated by Electronics Laboratories.

HIGH TEMPERATURE CAPACITORS

Plasticon Type AS, silicone impregnated plastic film dielectric capacitors, capable of continuous operation at 256 F, have been offered to radio and industrial users by Condenser Products Co., Chicago, Illinois.

Since paper capacitors have proven unsatisfactory at temperatures in excess of 205° F, this new capacitor fills a long-felt need of designers of high temperature equipment.

CATHODE RAY TUBES FOR INDUSTRIAL USE

A simple solution to the problem of installing and accurately positioning electronic equipment interconnecting cables has been devised by engineers of the Tool Division of The Glenn L. Martin Company, Baltimore, Md.

The new procedure is particularly valu-

able for facilitating critical cable assemblies and installations, since a large majority of electronic equipment troubles are traceable directly to cable failure.

Solution to the problem is obtained by merely painting two indicating marks on each cable which locate the cable with respect to the nearest structural clamp, thereby determining the location of the connector in the plane; and also establish the orientation of the right angle connectors, which eliminates twisting and possible breaking of wires when the cable is later connected to the equipment.

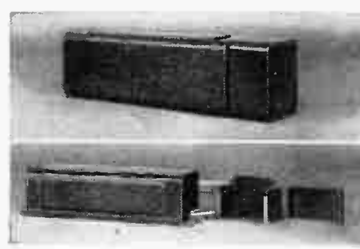
The indicating marks are applied to the cables prior to the installation of any wires by means of a special jig. One of the most important features is that wire flow is established once and for all at the assembly point. With this method, the operator always knows definitely which way the wires are to flow, even before the plug is attached.

Prior to the adaptation of the indicating system, the operator did not have this information and as a result many wires were kinked or otherwise damaged within the cable.

COLD CATHODE BALLAST WITH ATTACHABLE JUNCTION BOX

To fit their Cold Cathode Ballasts, Jefferson Electric Company, Bellwood, Illinois, has developed a junction box which can be easily attached with the bolts used for mounting the standard ballast.

The box is made in two pieces, and is shown, separately and attached, in the accompanying illustration. One piece is designed to slide over guides on one end of the ballast case while the other forms



the cover which is secured by one screw. Suitable knock-outs are provided in sides, ends and bottom. Thus the standard ballasts requiring no junction box as in the case of fixture installation, also serve where boxes are required.

These devices are listed as standard by Underwriters' Laboratories.

SELENIUM RECTIFIERS

As an addition to their array of industrial electrical equipment, Radio Receptor Company, Inc., 251 West 19th Street, New York City, announces a line of selenium rectifiers which meet every requisite for a modern a-c to d-c conversion unit.

This new line embraces a wide range of units—from 25 mils up to capacities of hundreds of amperes—thus offering an efficient unit for every industrial application, for all combinations of voltage and current outputs and for various types of circuits. To name only a few specific applications, selenium rectifiers are used extensively for battery charging, relay circuits, welding, electroplating, magnetic devices, telephony and railway signaling.

Selenium rectifiers, as compared with other types of dry-disc converters, have the advantage of enabling efficient operation at higher ambient temperatures, of being less susceptible to moisture, more stable, and displaying improved aging characteristics. Units that have been in service for more than a decade give evidence that type rectifier will serve at least fully as long as other circuit components.

Inquiries relative to the more unusual

applications of these units, together with complete information on their intended uses, are invited.

THIS MONTH

[Continued from page 47]

and was elected in 1940 to the position of vice-president in charge of product research and development. He is inventor of many of the Jensen engineering innova-

Hugh S. Knowles

tions and heads a department of capable development and design engineers with that firm. Mr. Knowles is also an independent consultant in the electronic and acoustic fields.

Raymond K. McClintock

★ Raymond K. McClintock, a Sylvania Electric engineer since 1936 has been ap-

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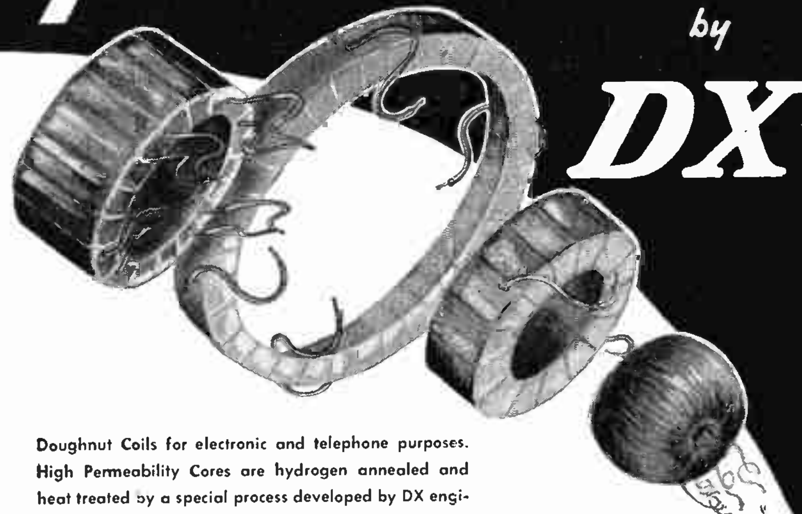

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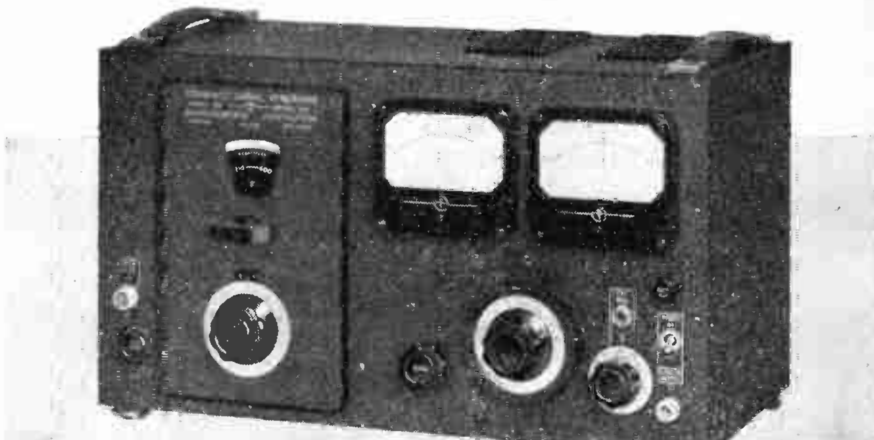

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INVENTIONS

[Continued from page 42]

or $E_1 = E_1 - E_3$, so substituting the values of E_1 and E_3 in terms of β and μ we obtain

$$E_1 = \frac{E_2}{\mu} - \beta E_2$$

Solving this for E_2 gives

$$E_2 = E_1 \frac{\mu}{1 - \beta\mu} = E_1 \frac{1}{-\beta} \frac{(-\mu\beta)}{(1 - \mu\beta)}$$

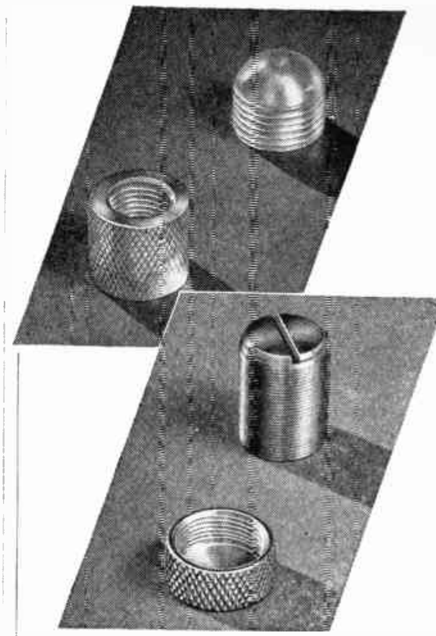
According to the invention, the circuits are so constructed that $|\mu\beta|$ is very large in comparison with unity. Under this condition the last factor of the above expression is substantially equal to unity and the output E_2 may be written as proportional to the reciprocal of β. Furthermore, if E_1 is held constant the output depends upon nothing else, since the expression then becomes simply

$$E_2 = -E_1 \frac{1}{\mu}$$

The patent, No. 2,379,042, is assigned to Bell Telephone Laboratories.

Balanced Frequency Modulation System

★ An invention which consists of a new way to cause a frequency modulating phonograph pickup to yield more efficiently the proper audio signals from that modulation is described in a letter of patent issued to Alexis Badmaieff on March 13, 1945. The advantages of having a phonograph pickup consist of an inductance or a capacitance whose value is changed in accord with needle



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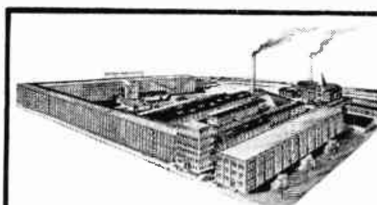

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movements caused by a record, had been previously disclosed. Such a variable reactance is made to vary the frequency of an oscillator in accord with the audio tones recorded in either lateral or vertically cut records. The resulting frequency modulation is converted to audio by means of a frequency discriminator.

As is common practice in FM radio, the frequency modulated signals are made to pass through a tuned stage which has its peak tuned to one side of the FM band. The stage consequently discriminates in frequency by supplying amplification in proportion to the instantaneous frequency of the signal. As the result of using such a system, greater freedom in the mechanical design of the pickup is obtained and it becomes possible to use lighter construction and lower inertia so as to reduce record wear and scratch noise arising from that wear.

The present invention makes use of this principle but the pickup is so arranged that when it increases the frequency of the co-operating oscillator, it also decreases the resonance frequency of the resonant curve which furnishes frequency discrimination. When the oscillator swings to a lower frequency, the discriminator resonance is increased in frequency.

Two main advantages of the present invention are claimed: because of the dual swing of oscillator and discriminator, double amplitude of the audio voltage from the discriminator is obtained. This reduces the required audio gain by a corresponding amount. Also the use of a dual function pickup system allows the advantage of even harmonic elimination, which is commonly found in push-pull circuits.

The accompanying figure shows a schematic diagram of one form of the invention. An LC oscillator operates with a fixed inductance and a capacitance which is varied by motion of the pickup needle. For example, if the arrow represents the phonograph needle and it is actuated by a lateral motion, then every time a movement to the left occurs, the oscillator capacitance will

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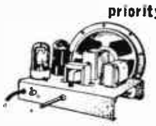

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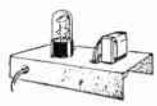

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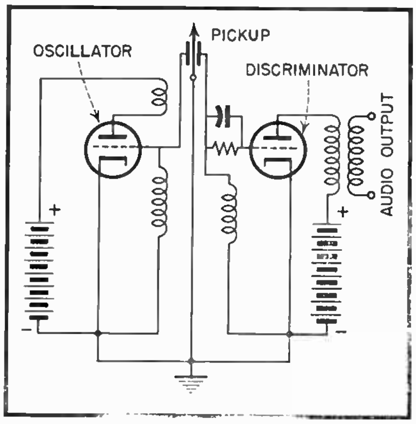
be increased and its frequency lowered. Conversely, motion to the right causes a rise in the frequency. Moreover, because the needle also actuates a second condenser which is part of the resonant circuit of the discriminator, the resonant frequency of that circuit is also



Patent No. 2,371,373

changed. Because a given mechanical motion has an opposite effect on the two resonant circuits, the changes in the discriminator are just 180 degrees out of phase with those controlling the oscillator, and this gives the desired effect.

The patent, No. 2,371,373, is assigned to RCA.

Super-Regenerative Radio Receiver

★ In a patent issued on July 3, 1945 to George E. Banks of Chelmsford, England, a super-regenerative receiver which operates at u-h-f or microwave frequencies and requires only a single vacuum tube is described. As in all super-regenerative devices, an arrangement which of its own accord would like to break into oscillation at the frequency which it is desired to receive, is provided. Also, a quenching oscillation is made to occur with a considerably lower frequency which is nevertheless still well above the audible spectrum. As oscillation in the high-frequency part of the device starts to build up, the peak values of the quenching frequency periodically destroy the attempt, so that real high-frequency oscillation is never realized. In fact, in the complete absence of an input signal, oscillation is not reached by a large margin. In accord with the instantaneous depth of the amplitude modulation present on the input carrier wave, however, the build-up toward oscillation is aided by a greater or lesser amount of signal at a frequency very near the desired oscillation frequency. Thus, during each quenching cycle, oscillation is more or less closely reached in accord with the carrier modulation. This causes

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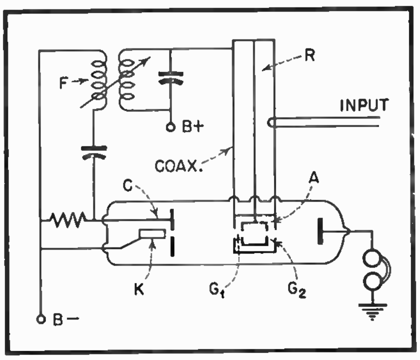
a corresponding level of d.c. in the earphones or other audio circuit connected to the device.

In the accompanying figure is shown one embodiment of the present invention. Neglecting for the moment the control electrode C and the accompanying circuits F, it may be understood that what is left is a velocity modulation oscillator. Electrons leaving the cathode K pass through the gap G_1 and because of their time of flight pass through gap G_2 at a time later which almost exactly corresponds to one cycle of the desired frequency. If there is even a trace of energy in the resonator R coupled to the volume A, this situation may give rise to oscillation. It will, in fact, if R and A considered together are tuned so as to resonate at the desired frequency. The electromagnetic field of the resonator causes periodic acceleration or deceleration of electrons passing through G_1, and because of the resulting variation in electron velocity, the electron beam reaches G_2 in bunches and is



Patent No. 2,379,673

therefore able to give up energy to the oscillating field of the resonator.

In the present invention, this velocity modulation oscillation is interrupted by the application of a quenching voltage which occurs by virtue of oscillation in circuit F, which is connected to the control electrode C and other electrodes in the tube, just as if a common triode was involved. The rapidity with which an approach to velocity modulation oscillation gets under way is reflected in the anode current which passes through earphones or some other audio device.

The patent, No. 2,379,673, is assigned to the Marconi Wireless Telegraph Co.

Device for Maintaining a Fixed Bias

★ Orville I. Thompson received a patent on May 15, 1945, which covers a system for utilizing alternating current voltage already available for the heater of a vacuum tube so that a steady source of bias voltage for the grid of the tube is also supplied. It is claimed that the

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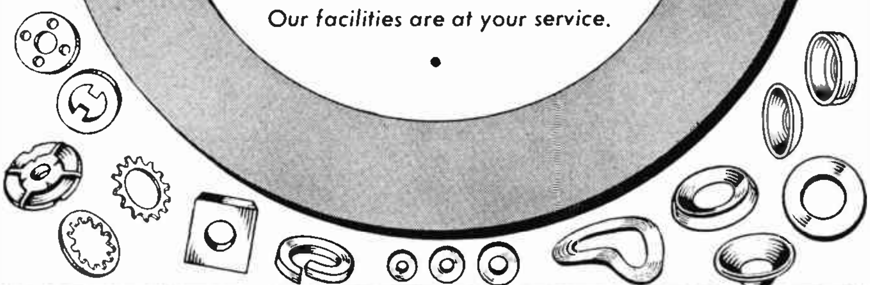

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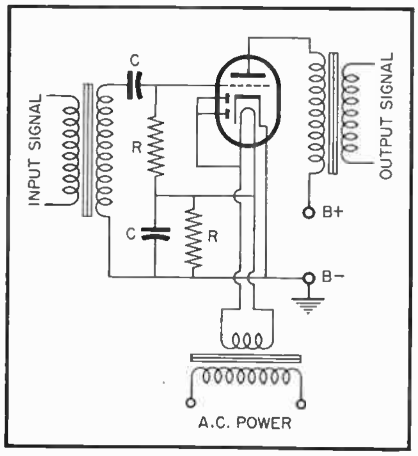
system is more economical in cost, manufacture, and service than are bias batteries or a bias voltage obtained from a separate rectifier. Since the bias voltage obtained by the method of the invention is independent of signal level, it is said that the scheme is often su-



Patent No. 2,375,877

perior to self-bias methods which are necessarily dependent on cathode current.

As can be seen in the schematic, the vacuum tube which is used must contain one or more auxiliary diode plates as well as the main cathode, grid, and plate assembly. In conjunction with the cathode and diode plates the heater voltage is rectified and filtered by a condenser connected between ground and what would normally be the ground end of the grid-leak resistor. The patent is assigned to DeForest's Training, Inc., and is number 2,375,877.

HORIZON

[*Continued form page 35*]

particularly if they lie in the central portion of the route. Joining these dots will then provide the required profile.

Possibly the only rather ambiguous point as regards the interpretation of contour lines on maps may arise in a case such as *Fig. 1.* Here it is only necessary to remember that the convention is to designate the heights of peaks rather than the depths of valleys. Accordingly, any unmarked nest of contours may be assumed to represent a valley.

Fig. 2 is a profile of the direct route from Oswego, N. Y., to Auburn, N. Y., prepared according to the above method. Obviously, extreme antenna heights would be required at both ends to provide an optical path. This also illustrates the rather paradoxical situation whereby less bending would be required for a signal to travel from Auburn to Oswego than in the opposite direction.

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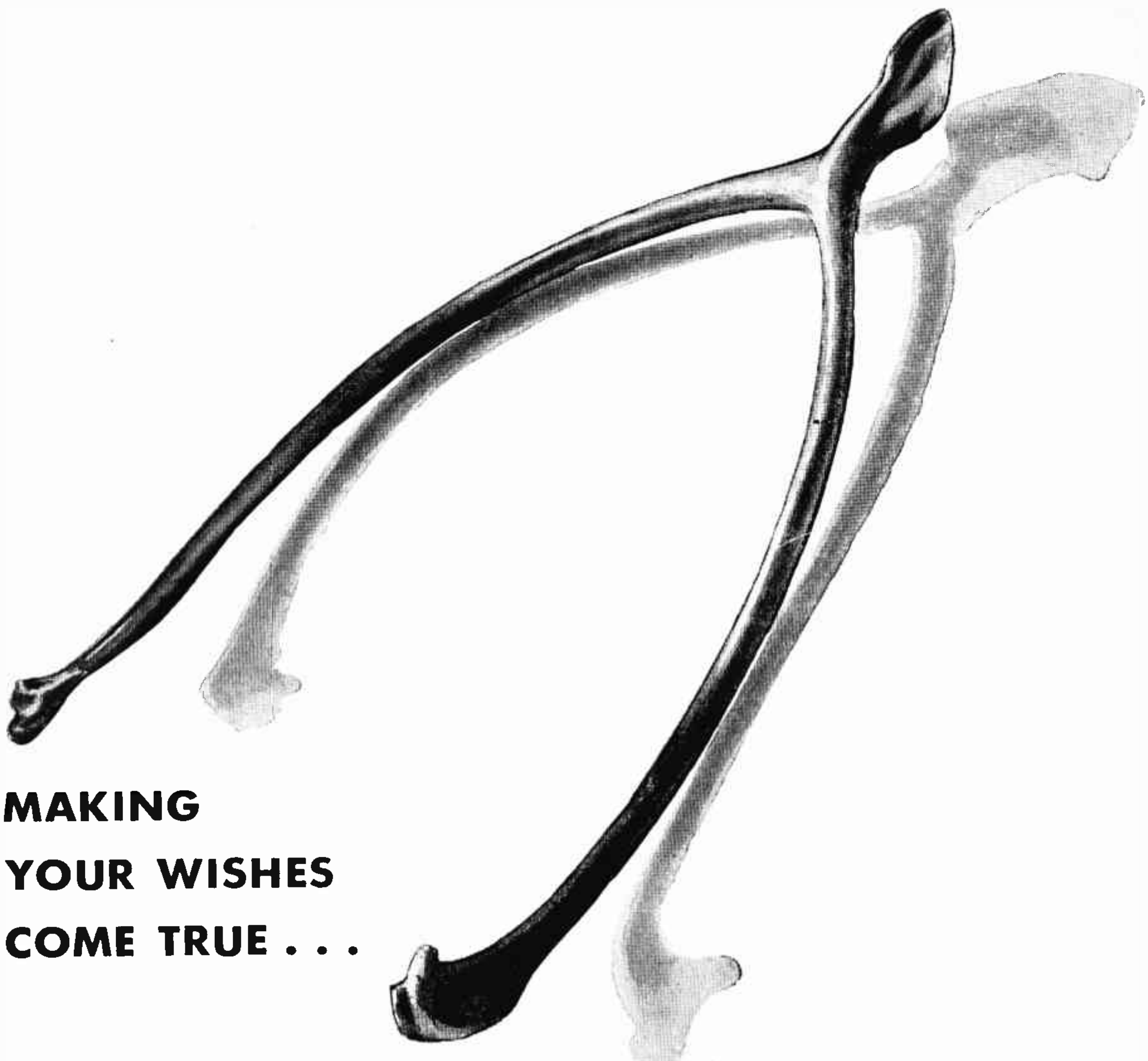

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path be established over this route, the proportions of the actual height of the optical path above a station compared to its actual sea level altitude reveals the factor by which the earth's radius may be increased in order to account for refraction.

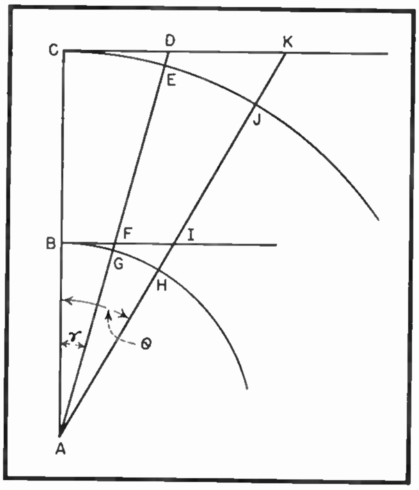

Fig. 3. Geometrical construction for proof in appendix

Appendix

From *Fig. 3*: arc BE = arc BH

$$\text{therefore } \frac{\theta}{\gamma} \text{ (radians) } = \frac{AC}{AB}$$

$$\frac{AE+ED}{AC} = \frac{AG+GF}{AB} = \sec\gamma$$

$$\text{or } \frac{AC+ED}{AC} = \frac{AB+GF}{AB}$$

Cross-multiplying—$ABAC + ABED = ABAC + ACGF$ Hence $\frac{ED}{GF} = \frac{AC}{AB} = \frac{\theta}{\gamma}$

$$\text{Similarly } \frac{KJ}{IH} = \frac{AC}{AB} = \frac{\theta}{\gamma} \quad \ldots\ldots\ldots(1)$$

$$\sec\theta = \frac{AJ+JK}{AC} \text{ or } AC\sec\theta = AC + JK$$

$$JK = AC\sec\theta - AC$$

$$\sec\gamma = \frac{AE+DE}{AC} \quad AC\sec\gamma = AC + DE$$

$$DE = AC\sec\gamma - AC$$

$$\text{Therefore } \frac{JK}{DE} = \frac{\sec\theta - 1}{\sec\gamma - 1} = \frac{\frac{1-\cos\theta}{\cos\theta}}{\frac{1-\cos\gamma}{\cos\gamma}}$$

$$\text{but } \frac{1-\cos\phi}{\sin\phi} = \tan\tfrac{1}{2}\phi$$

$$\frac{1-\cos\theta}{\cos\theta} = \tan\tfrac{1}{2}\theta \quad \tan\theta = \theta\tfrac{1}{2}\theta$$

(provided θ is small)

$$\text{Accordingly } \frac{JK}{DE} = \frac{\theta\tfrac{1}{2}\theta}{\gamma\tfrac{1}{2}\gamma} = \frac{\theta^2}{\gamma^2}$$

$$\text{whence } DE = JK\frac{\gamma^2}{\theta^2}$$

$$\text{From (1) } IH = KJ\frac{\gamma}{\theta}$$

$$\frac{IH}{DE} = JK\frac{\gamma\,\theta^2}{\theta\,JK\,\gamma^2} = \frac{\theta}{\gamma}$$

MICROWAVE

[Continued form page 34]

part in the determination of the item which we have called propagation loss.

We will now illustrate by two examples which are not entirely correct since they omit refraction (bending of the energy path due to variation in air density) and the curvature of the earth. In *Fig. 9*, the two cases we wish to discuss are illustrated. In *Fig. 9A*, the antenna heights and separations are so chosen that maximum reinforcement between the two signals are obtained while in *Fig. 9B* the most interference is found.

In *Fig. 9A* it will be noted that a half-wave difference in path length is obtained. This in conjunction with the 180° phase change at reflection causes the energy traveling over the two paths to reach the receiving antenna in phase. Now, in general, energy will be lost in reflection so the reflected beam will not be as strong as the one transmitted directly. In calculations over shorter ranges this must be taken into account and even some difference in reflection, depending upon polarization, will be found. In the present case, however, only a negligible reflection loss occurs. The reflection loss is very small at low

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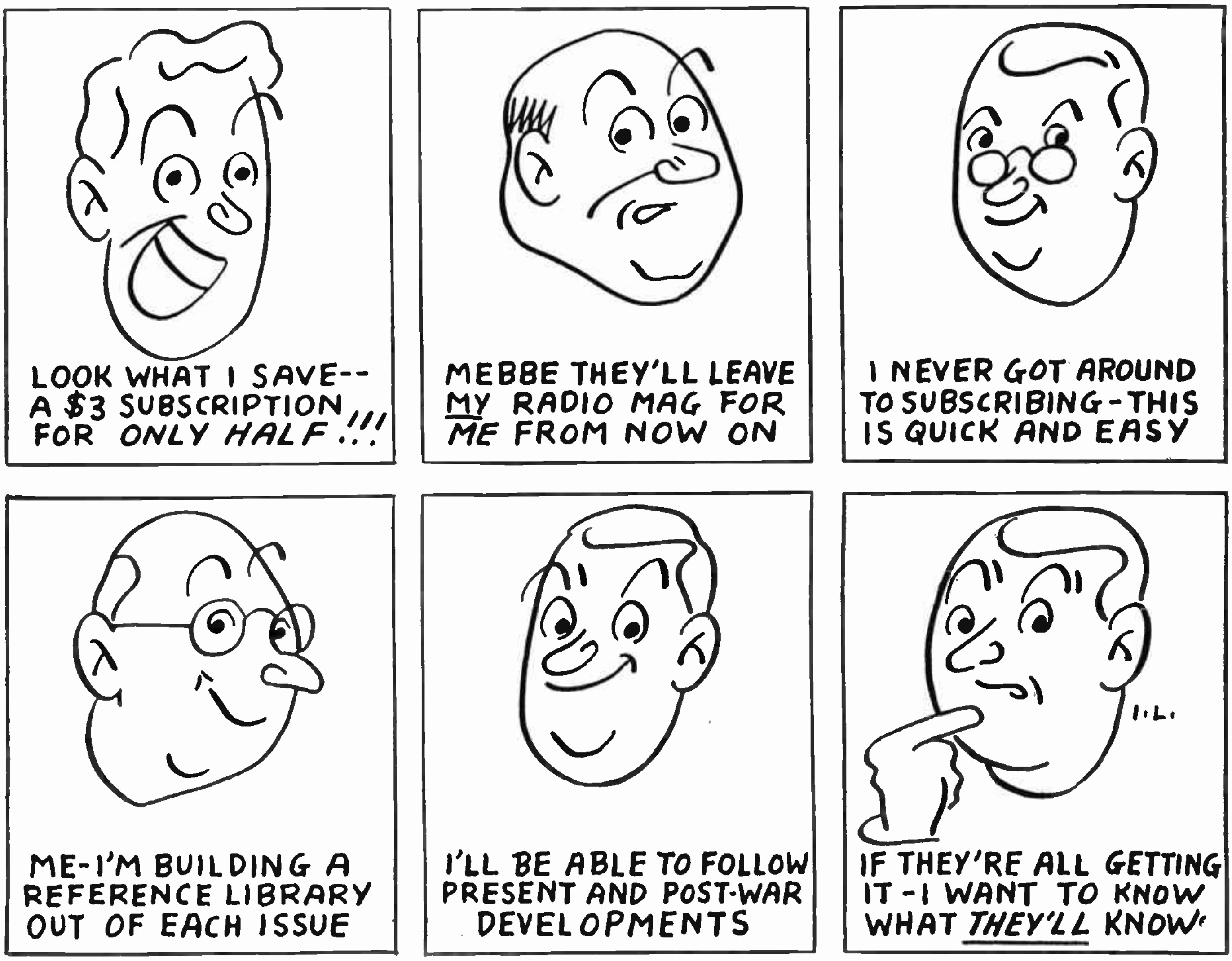

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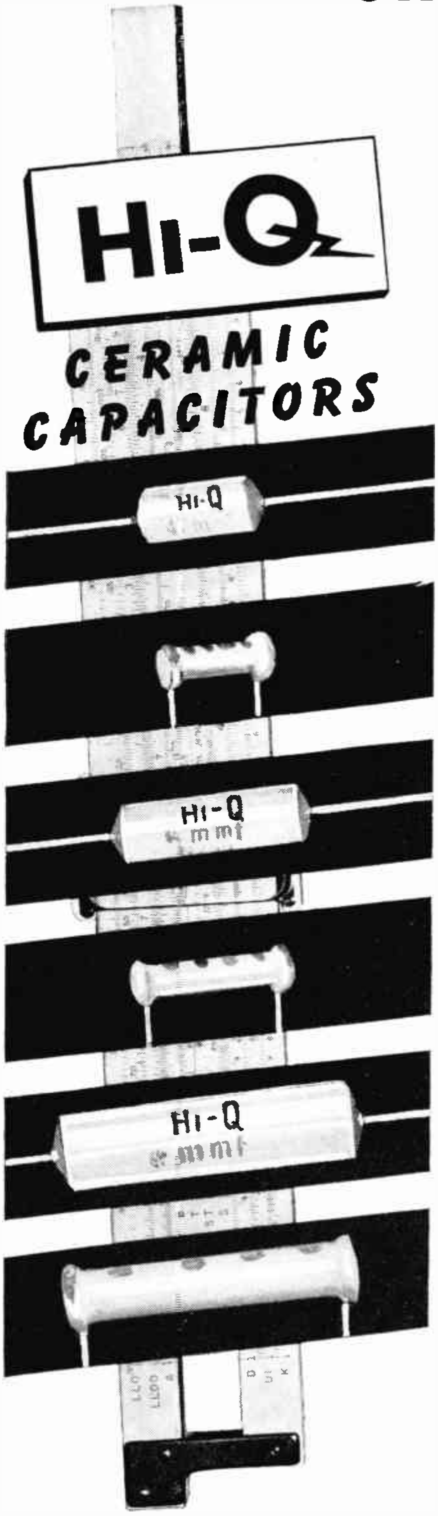

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angles of reflection such as we have here and increases at larger angles. All this assumes a perfectly flat surface such as calm sea water. The reflection gain in *Fig. 8A* is therefore 6 db.

It may not be entirely clear that the reflection gain, in the case just mentioned, is 6 db rather than 3 db. A 3 db gain, corresponding to a doubling of the energy at the receiver, would mean that the equal powers over the two paths add directly. This is not the case. Instead, it is the strengths of the electric fields and of the magnetic fields which add. At the receiving antenna both the electric field and the magnetic field are doubled in strength and their product, which is a measure of the energy, is consequently increased by a factor of 4, or raised by 6 db. The fact that the energy flowing over two paths is 4 times that which comes over one is not in disagreement with the conservation of energy. The flow over both paths is doubled by the additional loading which the constructive interference provides. The impedance of space is a constant 376.6 ohms) and doubling the voltage multiplies the power by a factor of 4 because power in a resistor is given by E^2/R.

In *Fig. 9B*, a whole wave length path difference is incurred and, in connection with the phase shift reflection, this causes almost total interference between the energies reaching the receiving antenna over the two paths. The electric and magnetic fields cancel each other so there is no field strength at all in the neighborhood of the receiving antenna. The reflection factor in this case would be considered as loss and for all practical purposes would be infinite.

Our statement concerning the 180° phase shift at reflection from the surface of the earth must also be qualified in order to be entirely correct. Not only does it suppose a smooth earth surface which is not actually present but also according to theory it is not true even then unless horizontal polarization is used or unless only glancing angles of reflection are incurred. In the present example we have been very careful to see that only extremely small angles are encountered.

To draw up a balance sheet for the cases of *Fig. 9*, about the best we can do is establish minimum transmitter power for the optimum case of *Fig. 9A* and say that for other antenna heights more power will be needed. Specifically, we may add that at the heights shown in *Fig. 9B*, communication will be virtually impossible no matter what the transmitter power.

Example. Computation of minimum transmitter power needed for 100 mile transmission over a link of flat earth that is like the one in Figure 9A. Isotropic antennas are used in conjunction with a 10 db receiver.

BALANCE SHEET

GAIN		LOSS	
Trans Power	x db	Receiver Noise Figure	10.0 db
Perfect Rec	150.0 db below 1 watt	Isotropic Receiving Ant.	35.5 db
		Propagation Loss	98.0 db
		Isotropic Trans Ant.	11.0 db
TOTAL	150.0 + x db	TOTAL	154.5 db

150.0 + x = 154.4
x = 4.5 db
Transmitter power (minimum) = 4.5 db above 1 watt
= 2.8 watts

Line of Sight Transmission

Because the earth is not flat but has a definite curvature, direct beam trans-

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933

of RADIO, published monthly at Orange, Connecticut, for October 1, 1945.
State of New York }
County of New York } ss.:

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Sanford R. Cowan, who, having been duly sworn according to law, deposes and says that he is the Publisher of RADIO, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit:

1. That the names and addresses of the publisher, editor, managing editor and business manager are: Publisher, Sanford R. Cowan, 1620 Ocean Ave., Brooklyn 30, N. Y.; Editor, John H. Potts, 98-50 67th Ave., Forest Hills, N. Y.; Managing Editor, None; Business Manager, S. R. Cowan, 1620 Ocean Ave., Brooklyn 30, N. Y.

2. That the owners are: Radio Magazines, Inc., 342 Madison Ave., New York 17, N. Y.; John H. Potts, 98-50 67th Ave., Forest Hills, N. Y.; and Sanford R. Cowan, 1620 Ocean Ave., Brooklyn 30, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities, are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock, and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

(Signed) SANFORD R. COWAN, Publisher.

Sworn to and subscribed before me, this 14th day of September, 1945.

(Seal.) WALTER J. KOPP, Notary Public.
Kings County, Kings Co. Clk's No. 401; N. Y. Co. Clk's No. 85,
Reg. No. 96-K-7. Commission expires March 30, 1947.

mission can be accomplished over only a certain distance. That distance is increased when either or both antennas are raised off the ground. For example, to obtain 100 mile line of sight transmission it is necessary that one or the other of the antennas be elevated 5000 feet or that they both be up some 1600 feet.

Refraction and Super Refraction

The numbers just given for 100 mile line of sight transmission are not enough to allow a straight line to be drawn from transmitter to receiver without passing through the intervening bulge in the earth. They are rather effective line of sight heights which take refraction into account. As a radio signal leaves the transmitter and goes to higher and higher altitudes, the reduced air density has the effect of bending the beam back toward the earth. This makes it possible to transmit over greater line of sight distances than would naively be expected. It is common practice to take this effect into account by assuming that the earth's radius is 1/3 larger than it is and then treat the problem as if refraction were not present.

Occasionally transmissions over much greater distances than would be expected are observed. These are due to air strata which give much stronger bending than would be expected from normal refraction. Such phenomena are known as super-refraction. Obviously such transmission is not dependable and is therefore rarely of any use.

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ADVERTISING INDEX

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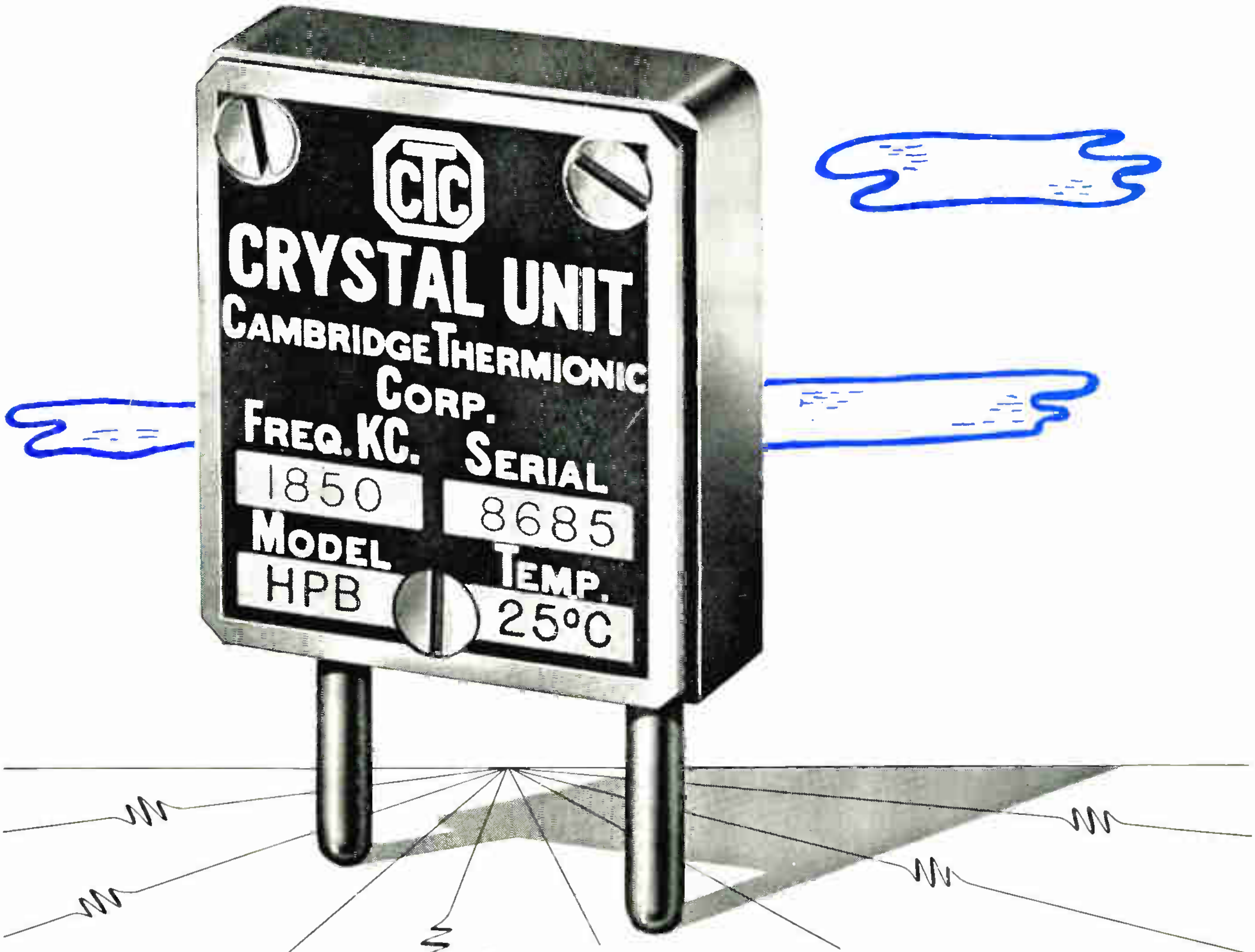

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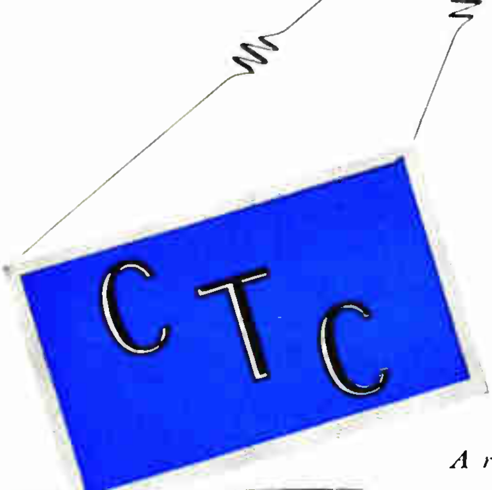

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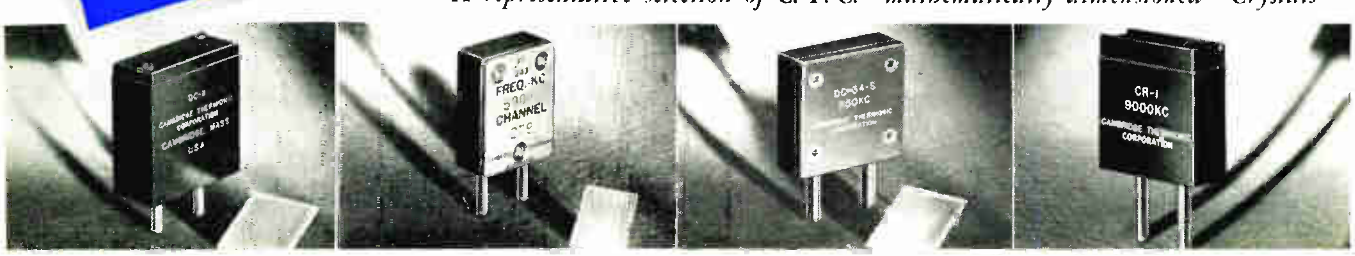

The Reader's Digest, in its Aug., 1941 issue, ran an article saying that investigators on its staff found that radio service-dealers cheated the public on 64 out of 100 repair jobs. After citing several examples, the article ended with a warning that radio owners should "beware" of the repair man.

N. Y. HERALD TRIBUNE
JANUARY 24, 1945

City License Law Urged For Radio Repair Men

Magistrate James A. Blanchfield declared yesterday in Flatbush Court that he would ask the City Council for a law requiring ... bonded in order to do business.

SHOULD RADIO SERVICE DEALERS BE LICENSED?

THE NEW YORK TIMES
JANUARY 24, 1945

RADIO RACKETEERS ASSAILED BY COURT

Says Repair Men Should Be ... Licenses

N. Y. WORLD-TELEGRAM
JANUARY 23, 1945

Irked Magistrate Lashes at Racket in Radio Repairs

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