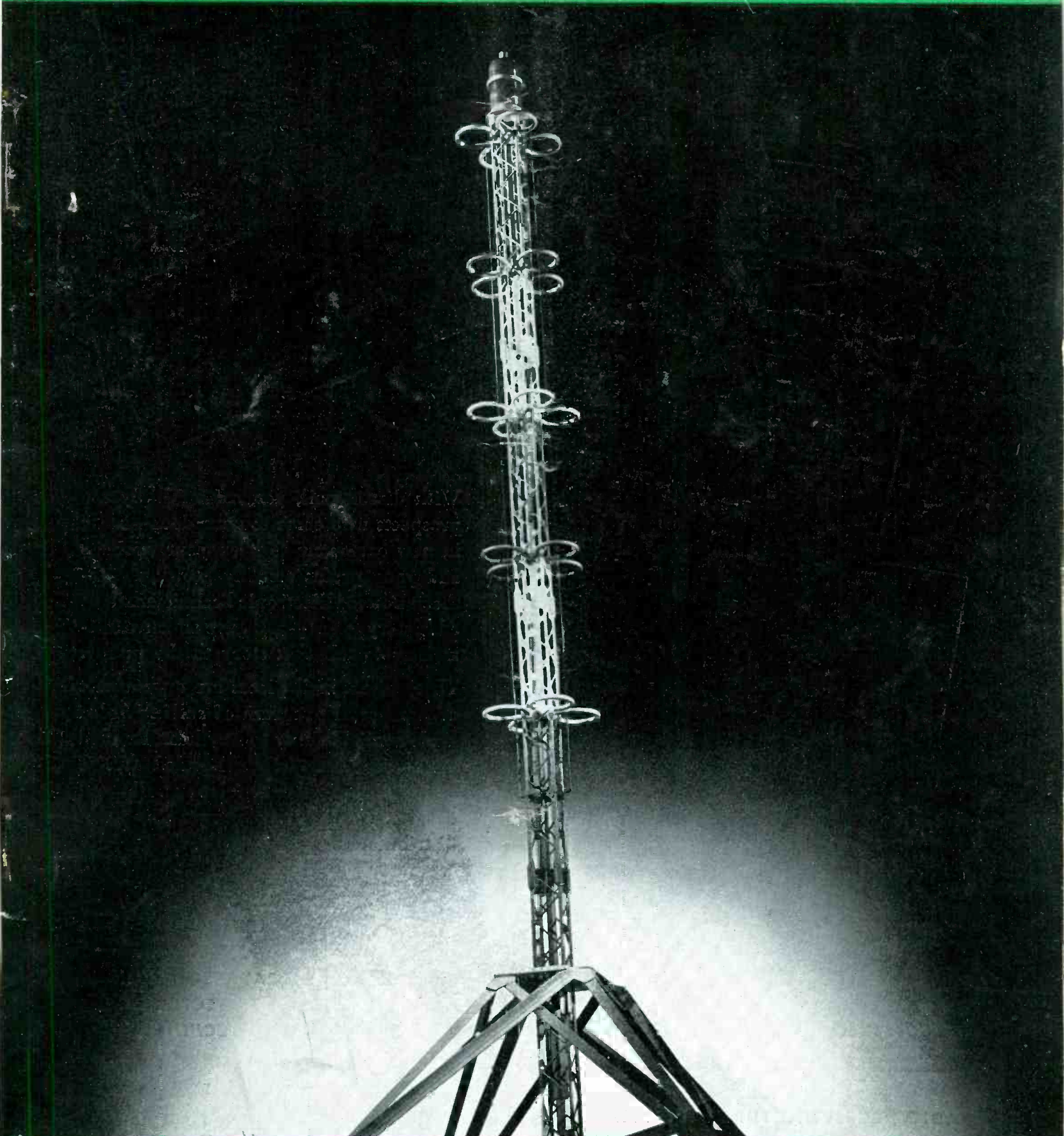
RADIO

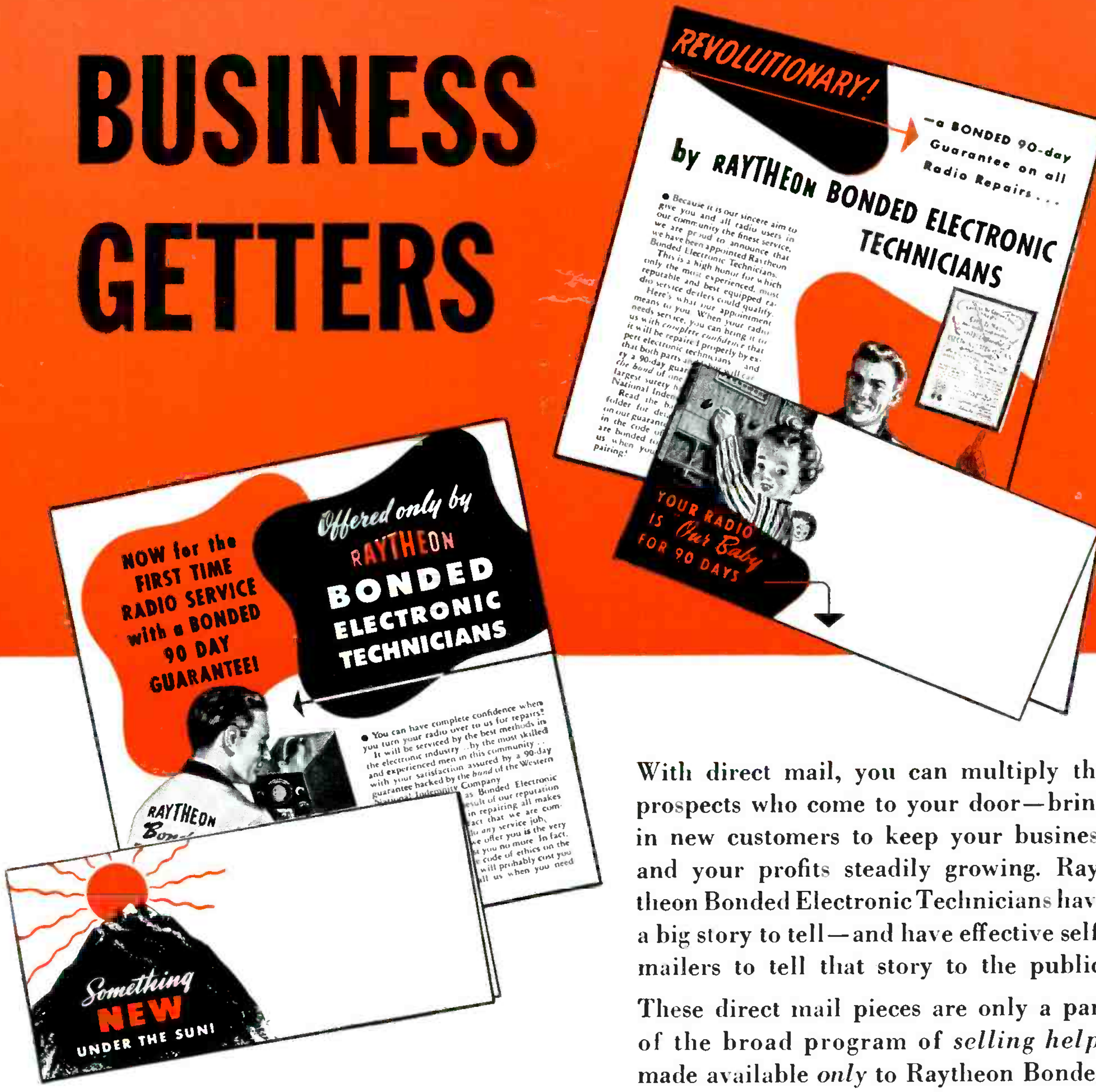
APRIL, 1946

Design • Production • Operation



The Journal for Radio & Electronic Engineers

BUSINESS GETTERS



With direct mail, you can multiply the prospects who come to your door—bring in new customers to keep your business and your profits steadily growing. Raytheon Bonded Electronic Technicians have a big story to tell—and have effective self-mailers to tell that story to the public.

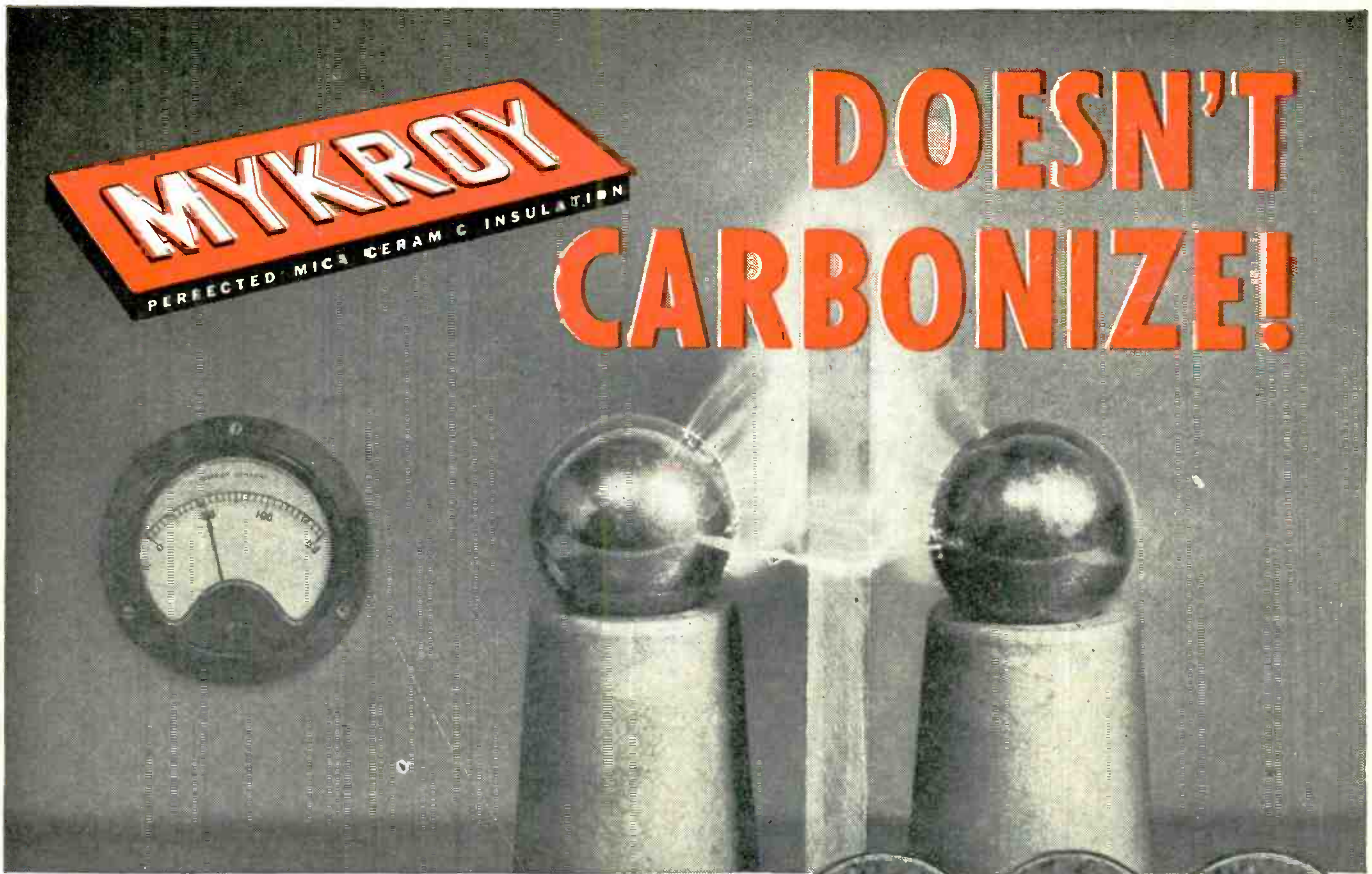
These direct mail pieces are only a part of the broad program of *selling helps* made available *only* to Raytheon Bonded Electronic Technicians. Bonded service means better customer relations. For full details to qualify, see your Raytheon distributor today.

RAYTHEON
MANUFACTURING COMPANY

Excellence in Electronics

ANOTHER REASON WHY IT PAYS TO QUALIFY AS A RAYTHEON BONDED ELECTRONIC TECHNICIAN

RADIO RECEIVING TUBE DIVISION
NEWTON, MASS. • NEW YORK • CHICAGO



This high frequency insulation will not carbonize under arc, yet it possesses dielectric properties of the highest order. Made entirely of inorganic materials, Mykroy cannot char or turn to carbon even when exposed to continuous arcs and flashovers.

The sheet of Mykroy in the photo was exposed to a 50,000 volt arc after which it was sectioned and carefully examined for signs of damage. None were found . . . not even the slightest excoriations were present, hence no low resistance paths formed to support breakdown.

Engineers everywhere are turning more and more to Mykroy because the *electrical characteristics of this perfected glass-bonded ceramic are of the highest order*—and do not shift under any conditions short of actual destruction of the material itself. Furthermore Mykroy *will not warp—holds its form permanently—molds to critical dimensions and is impervious to gas, oil and water.* For more efficient insulation investigate Mykroy. Write for copies of the latest Mykroy Bulletins.

Cross sections of the test sheet made at the point of exposure to the 50,000 volt arc (magnified 10 times) show no trace of damage.

MECHANICAL PROPERTIES*

MODULUS OF RUPTURE	18000-21000 psi
HARDNESS Mohs Scale 3-4 B-IN. BHN 500 K9 Load. 60-74	
IMPACT STRENGTH	ASTM Charpy .34-.41 ft. lbs
COMPRESSION STRENGTH	42000 psi
SPECIFIC GRAVITY	2.75-3.8
THERMAL EXPANSION	.000006 per Degree Fahr
APPEARANCE	Brownish Grey to Light Tan

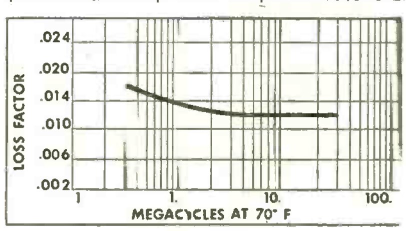
ELECTRICAL PROPERTIES*

DIELECTRIC CONSTANT	6.5-7
DIELECTRIC STRENGTH (1/8")	630 Volts per Mil
POWER FACTOR	.001-.002 (Meets AWS L-4)

***THESE VALUES COVER THE VARIOUS GRADES OF MYKROY**

GRADE 8 Best for low loss requirements.
GRADE 38. Best for low loss combined with high mechanical strength.
GRADE 51 Best for molding applications.

Special formulas compounded for special requirements.



Based on Power Factor Measurements made by Boonton Radio Corp. on standard Mykroy stock.

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

More Efficient Production—Better Finished Product

AMPHENOL

One of the latest Amphenol developments is a loop antenna wire insulated with low-loss Copolene. The production advantages and the electrical superiorities of this wire are many, and the cost compares favorably with that of conventional wire commonly used for the purpose.

The Copolene dielectric acts as a flux during soldering operations—no stripping is necessary. It remains flexible and is easily wound on coil-winding equipment. Best of all, it can be heat-treated for self-supporting coils and the finished coils may be heat-sealed to mounting boards—no cementing or stitching required. Copolene insulation is non-hygroscopic—saves labor and cost of impregnation with lacquer or waxes.

Radio set manufacturers and coil winders have found it profitable to take advantage of this new wire. Write today for complete information.

Other Special Properties of Amphenol Loop Antenna Wire:

Physical—Impervious to oil, solvents, moisture, sunlight • Remains flexible down to —70°F. • #24 solid wire, covered with Copolene in wall thicknesses of .005", .010", .015" and .020" • Other wire sizes and dielectric wall sizes in production or available on special order.

Electrical—Lower distributed capacity • Higher Q than cotton or paper covered wire • Every foot spark tested • Copolene has a power factor of .00035 to .00045 and a dielectric constant of 2.29.

Depend upon AMPHENOL *Quality*

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

COAXIAL CABLES AND CONNECTORS • INDUSTRIAL CONNECTORS, FITTINGS AND CONDUIT • ANTENNAS • RADIO COMPONENTS • PLASTICS FOR ELECTRONICS

MEMBER AUDIT BUREAU OF CIRCULATIONS

RADIO

Published by RADIO MAGAZINES, INC.

APRIL, 1946 Vol. 30, No. 4

CONTENTS

COVER

Model of Western Electric's "Clover-Leaf", FM broadcasting antenna. This antenna was designed by Bell Telephone Labs for FM stations on the new assigned carrier frequencies between 88 and 108 mc and at power levels up to and including 50 kw. Pattern measurements on accurately scaled models show that the distribution of energy in azimuth is circular (±0.2 db) and that the computed beam width is realized to ±1 degree in practice.

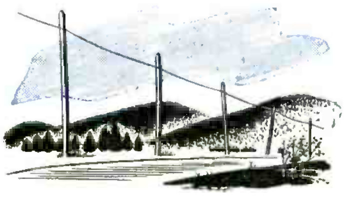
ARTICLES

MISCELLANEOUS

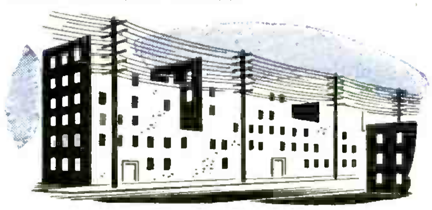
RADIO Magazine (title registered U. S. Pat. Off.) is published monthly at Boston Post Road, Orange, Connecticut, by Radio Magazines, Inc. Executive and Editorial Offices at 342 Madison Avenue, New York 17, N. Y. Subscription rates—United States, U. S. Possessions & Canada, $3.00 for 1 year, $5.00 for 2 years; elsewhere $4.00 per year. Single copies 35c. Printed in U.S.A. All rights reserved, entire contents Copyright 1946 by Radio Magazines, Inc. Entered as Second Class Matter May 10, 1945 at the Post Office at Orange, Conn., under the Act of March 3, 1879.

Why

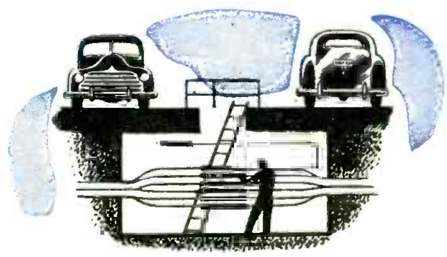
this team is a leader in VHF



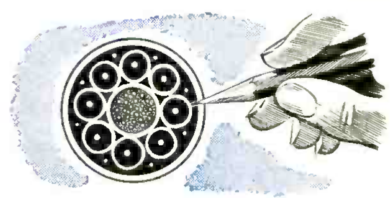
1. *First voice circuits were single iron wires with ground return. Frequency limitations, noise and high losses soon ruled them out.*



2. *Big improvement was the all wire circuit—a pair of wires to a message. Later came carrier which stepped up frequency and permitted several messages per circuit*

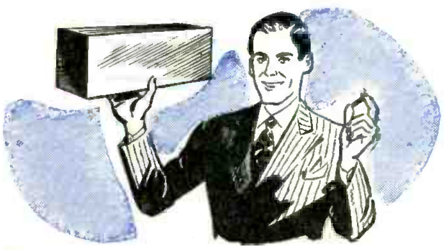


3. *Lead covered cable compressed many wire circuits into small space—took wires off city streets. But losses are prohibitive at very high frequencies.*

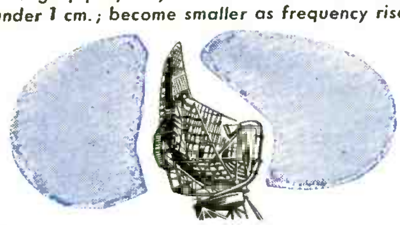


4. *Coaxial cable—a single wire strung in a pencil size tube—extended the usable frequency band up to millions of cycles per second and today carries hundreds of messages per circuit, or the wide bands needed for television.*

transmission



5. *Wave guides, fundamentally different in transmission principle, channel energy as radio waves through pipes; vary in size from several inches to under 1 cm.; become smaller as frequency rises.*



6. *Late model radar wave guides, similar to that used to feed the antenna above, can carry 3½ cm. waves at more than eight billion cps. Experimental guides for still shorter waves are being tested.*

Back in 1933, Bell scientists established an historic first when they transmitted very high frequency radio waves for hundreds of feet along hollow pipes called wave guides. For them it was another forward step in their long research to make communication circuits carry higher frequencies, broader bands and more messages per circuit.

Continuing Research showed the way

From the days of the single open wire line—through all-metallic circuits, phantoming, cable, carrier systems and coaxials—up to today's wave guides, every improvement has been the result of continuous fundamental study.

When Bell Laboratories started work on wave guides, there was no immediate application for the microwaves they guided. But the scientists foresaw that *some day* wave guides would be needed—so they kept on working until they had developed the wave guide into a practical device.

With the war came radar—and the problem of conducting microwave frequencies. Bell Laboratories had the answer—wave guides—without which radar at the higher frequencies would have been impractical.

What this means to YOU

Year after year, Bell Laboratories have continued to develop methods for handling higher and higher frequencies. Year after year Western Electric has provided equipment putting these scientific advances to work. This team has become the natural leader in the field.

When your requirement dictates the use of VHF—in mobile communications, broadcasting, or point-to-point radio telephony—depend on Western Electric to supply the latest and best equipment for your needs.

AMERICAN TELEPHONE & TELEGRAPH CO. AND ASSOCIATED COMPANIES — BELL SYSTEM

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.

Transients

RADIO BECOMES A.B.C. MEMBER

We are pleased to announce that RADIO Magazine has been elected to membership in the Audit Bureau of Circulation. This organization requires its membership to maintain the highest standards possible in the handling of paid circulation. We are proud to attain membership in this select group of A.B.C. members.

RAILROAD RADIOPHONE SERVICE

★ A hog riding smugly in a railroad car while a crestfallen traveler and his family looked on, was pictured during March in newspaper and magazine ads with the caption: "A hog can cross the country without changing trains—but YOU can't."

Under this needling the New York Central and Pennsylvania lines hastily arranged for through service between New York and the West Coast.

Further comparisons between hog and human accommodations may be made: Both remain incommunicado en route, and while this is matter of indifference to porcine guests, it is frequently a very serious handicap to business and professional men. With satisfactory railroad radio equipment now available, travelers deserve a better break. Why should this situation exist when those who sail have ship-to-shore phone service?

It cannot be said that phone service from train-to-central office is technically impractical. In Canada, such a system was used successfully for two or three years between Toronto and Montreal, and was finally discontinued for commercial reasons.

Persons traveling through Germany have reported that rail radiophone was available on more important lines for many years prior to the war. Others have evidently led in this public service, as England has led us in television.

Railways are in a highly competitive position, and with the public also traveling by automobile, bus, and plane, their owners would do well to make rail travel as attractive as possible. It appears that ship operators have been more alert and progressive in this instance than have railway interests.

Competition was met in former years by inauguration of streamline trains. The innovation was successful, and was largely responsible for revival of rail popularity. Since that time, however, no major improvements have been effected.

While the Bell System is at present concentrating efforts on mobile communication, already inaugurated in St. Louis, the company is willing to "play ball" with the railroads. In fact, officials report that they would be quite happy to undertake such extension of telephone service. But railroad executives have not approached the Bell System, and take the stand that it is the telephone company's job to inaugurate rail radiophone service. The position is scarcely tenable, since the phone equipment must be installed aboard train, and of course the telephone company owns no trains.

That railways required needling to inaugurate through passenger service is understandable, since the recent war has conditioned rail operators to a seller's market. The way of thinking which has resulted may continue from inertia alone, unless the public chooses to protest in sufficient volume to be heard, or until rail executives wake suddenly to find that planes, buses and private cars are doing the transportation job. Radio manufacturers can help the railroads as well as themselves by plugging for radiophone service.

ENGINEERS VS. TINKERNEERS

★ There are those within the ranks of radio engineers who are endowed with a certain allergy to mathematics and circuit analysis. Whereas the engineer formulates his design factors, makes any required assumptions, and pushes a development through to its conclusion, the tinkerneer has another approach. The latter visualizes the problem within wide limits, assembles components whose characteristics appear to lie within these limits, and proceeds to tinker.

Thus, a considerable amount of activity which passes for engineering would seem to be more properly classified as testing, mechanical layout, product designing, drafting, and sheet-metal working.

Those who work without benefit of circuit analysis are of course severely handicapped in development work, and become hopelessly lost in the vast majority of these projects. It is moreover a basic principle of analysis that unsuspected useful relationships and technical possibilities emerge as the analysis progresses.

It is true that mathematical analysis can be overstressed, becoming little else than a technical chess game. It is likewise true that some of the finest contributions to the art have come from the ranks of the tinkerers.

The classical example of the mathematician's prowess is of course Maxwell's formulation of electromagnetic radiation upon the basis of the experiments of Ampere, Faraday, and their contemporaries.

On the other hand, the art of frequency modulation admittedly was largely developed through tinkering techniques. The Edison effect, a basic radio principle, was evolved by a gifted tinkerneer.

And so there is a place for both the engineer and tinkerneer. It is when the tinkerneer is misplaced on the job that difficulties and misunderstandings arise.

TECHNICANA

CAPACITOR MACHINE

★ Fixed capacitors may be manufactured on a machine of German invention which the Department of Commerce believes may revolutionize production techniques. The machine will be brought to the United States and will be available for inspection on arrival. OPB estimates that present manufacturers of fixed paper capacitors could adopt the new process for an outlay of $25,000.

Several years ago the Bosch company of Stuttgart undertook development of fixed paper capacitors in which the usual metal foil is replaced by a very thin, vaporized metal coating, applied directly to the paper dielectric by atomization, spraying, or vaporization of zinc or cadmium. The film may vary from 0.001 mm to 0.0001 mm in thickness.

Contact difficulties were encountered in course of development, and a favorable solution was found as illustrated in *Fig. 1.* Successive layers of the metallized and non-metallized layers alternate with each other, alternate metallized layers being brought into contact with one another at one edge by folding over one edge of alternate metallized layers to contact the metal coating adjacent.

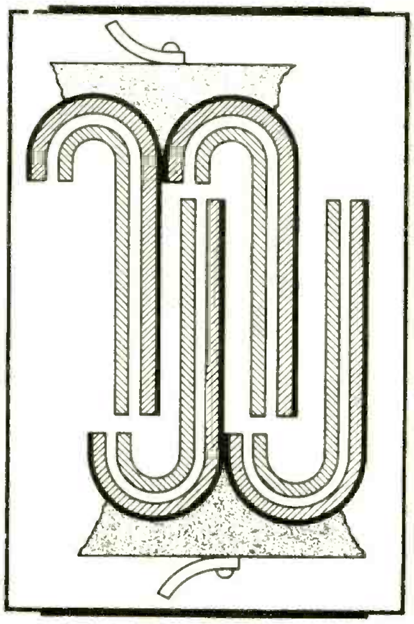


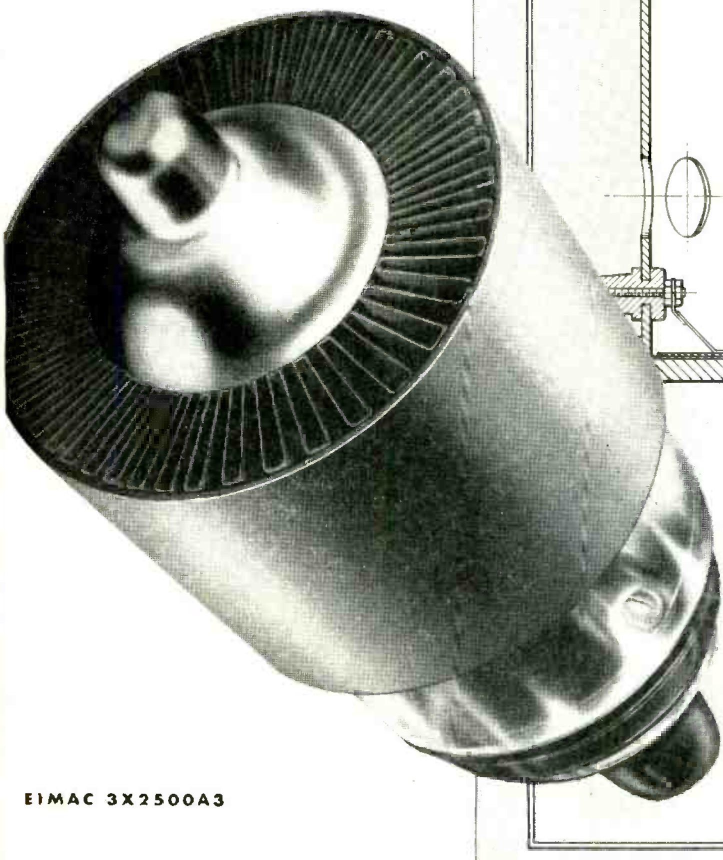
Figure 1

After assembly and compression, contacting layers are sprayed onto the folded edges as shown in *Fig. 1,* and terminal lugs attached. It is reported that when one section of the capacitor punctures, the resulting load ruptures the film, restoring the capacitor to working condition with capacitance accordingly reduced.

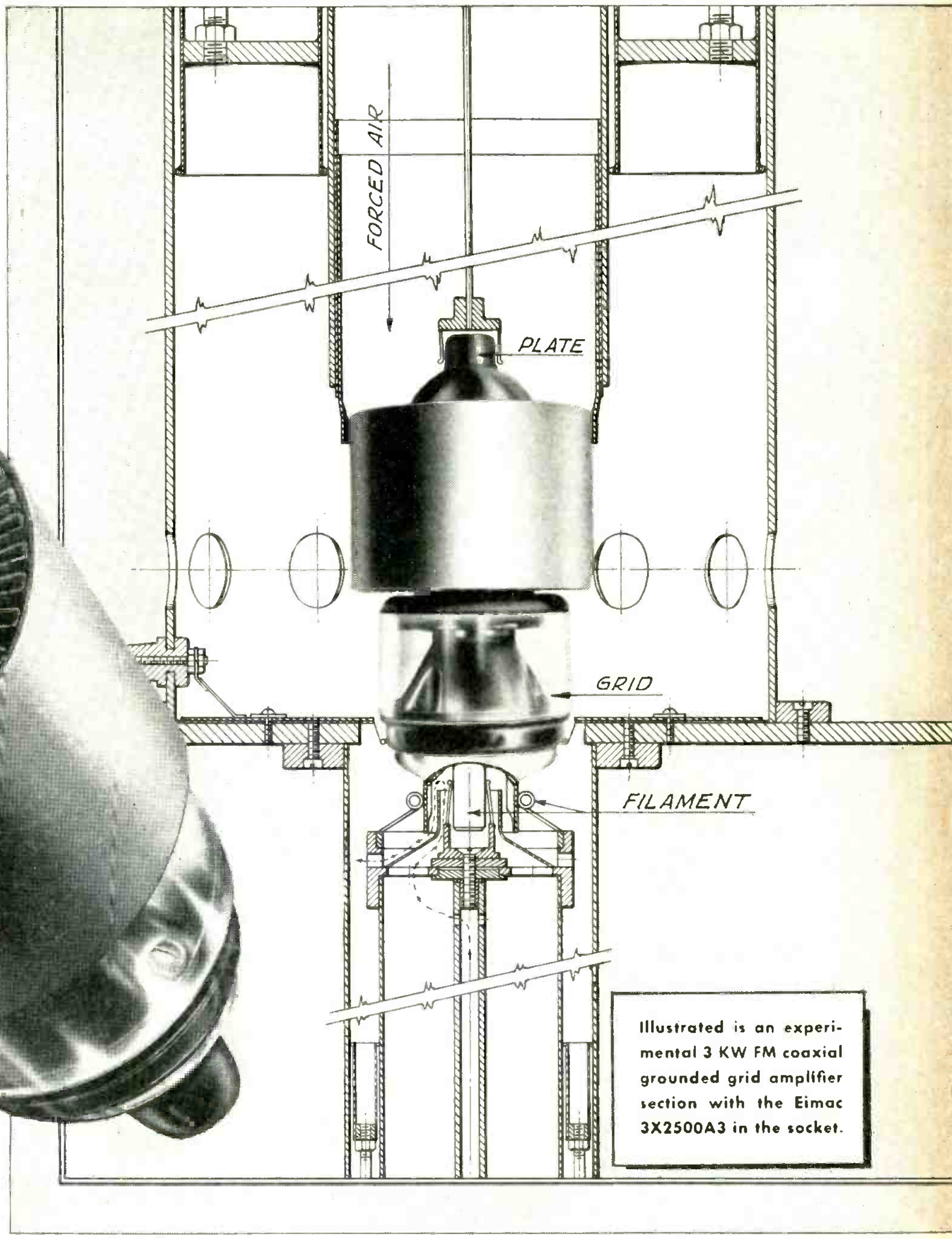
Frederic E. Henderson of the West-

Eimac TUBES

THE COUNTERSIGN OF DEPENDABILITY IN ANY ELECTRONIC EQUIPMENT



EIMAC 3X2500A3



Illustrated is an experimental 3 KW FM coaxial grounded grid amplifier section with the Eimac 3X2500A3 in the socket.

READY FOR FM NOW

3500 watts (useful*) output at 88 to 108 mc

The radical and efficient mechanical design of this new Eimac external anode triode makes it ideal for use in any type transmitter circuit. For example, note in the illustration above how well the arrangement of the terminals enables it to fit into a grounded grid amplifier. Its design features will be very much appreciated in the efficient layout of FM transmitters—grounded grid or neutralized. In typical grounded grid operation at 110 mc, the Eimac 3X2500A3 will provide 3½ KW of useful* output with only 3000 volts on the plate. Furthermore, only 800 watts (approx.) of driving power are required for such operation. To get your FM transmitter on the air quickly and efficiently, use the new Eimac 3X2500A3 tube—tried and proven for the job. Complete technical data is available now.

1151

** Power actually delivered to the load.*

Typical Operation (110 mc., 1 tube)

D-C plate voltage	3000 volts
D-C plate current	1.6 amps.
D-C grid voltage	−350 volts
D-C grid current	250 ma.
Driving Power (Approx.)	800 watts
Plate dissipation (Approx.)	1500 watts
Total power output (Approx.)	3800 watts
Useful power output	3500 watts

CALL IN AN EIMAC REPRESENTATIVE FOR INFORMATION

ROYAL J. HIGGINS (W9A10)...600 S. Michigan Ave., Room 818, Chicago 5, Illinois. Phone: Harrison 5948.

V. O. JENSEN, General Sales Co., 2616 Second Ave., Seattle 1, Washington. Phone: Elliott 6871.

M. B. PATTERSON (W5CI)...1124 Irwin-Kessler Bldg., Dallas 1, Texas. Phone: Central 5764.

ADOLPH SCHWARTZ (W2CN)...220 Broadway, Room 2210, New York 7, N. Y. Phone: Cortland 7-0011.

HERB BECKER (W6QD)...1406 S. Grand Ave., Los Angeles 15, California. Phone: Richmond 6191.

TIM COAKLEY (W1KKP)...11 Beacon Street, Boston 8, Massachusetts. Phone: Capitol 0050.

FOLLOW THE LEADERS TO

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

EITEL-McCULLOUGH, INC.
1151-G San Mateo Ave., San Bruno, Calif.
Plants located at: San Bruno, Calif. and Salt Lake City, Utah
Export Agents: Frazar & Hansen, 301 Clay St., San Francisco 11, Calif., U.S.A.

CAUTION!
Check serial numbers on Eimac tubes before you buy. Be sure you're getting newest types. Look for latest serial numbers.

[from page 10]

ern Electric Co. has issued a report (OPB PB 421; 6 pages, mimeographed, 10¢) available from the Department of Commerce.

CO-AX AND TV

★ Television transmission capabilities of the coaxial cable are reviewed and future possibilities predicted in an article abstract: Coaxial Cables and Television Transmission, by Harold S. Osborne in the *Bell System Technical Journal,* Vol. XXIV, Nos. 3-4, p. 463.

Development of carrier systems and technical features of the coaxial cable are discussed with an eye to the future. An extensive system of such cables, supplemented by radio relay, is seen as providing a good start for a nation-wide television transmission network.

Such a network is believed to be adequate to meet the requirements of the television industry.

FM WITH NON-LINEAR L

★ Frequency modulation is accomplished by means of a small coil wound on a permalloy core less than a quarter of an inch in diameter, as explained by L. R. Wrathall of the Transmission Research Department of Bell Laboratories in the Record for March, 1946.

The new technique eliminates the tubes previously used for modulation, and simplifies the stepping-up of frequency that results in a higher percentage modulation.

Frequency modulation by means of the non-linear inductance takes place as a result of the functional relation of current and magnetic flux as ideally depicted in *Fig. 2.* When the current

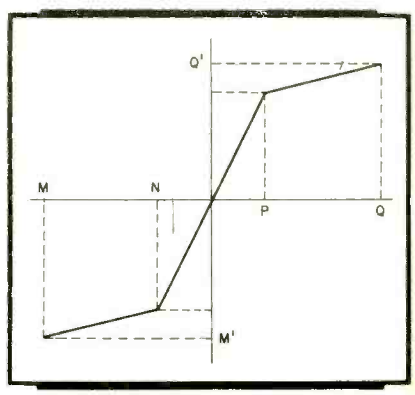
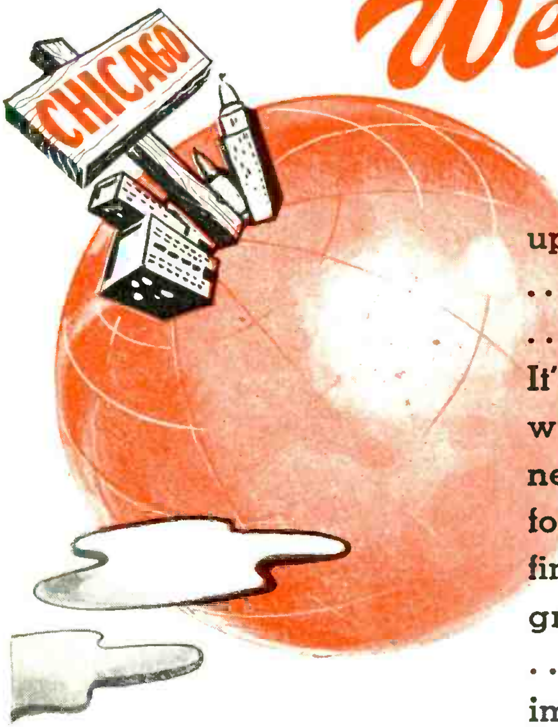


Figure 2

changes at a fairly uniform rate from the negative value M to the positive value Q, corresponding flux changes are seen at M' and Q'. A very large amount of flux change takes place between N and P on the diagram, which represents the unsaturated magnetic region.

With a negligible winding resistance,

We're coming in...



Astatic has made a lot of "pick-ups" along the line and here we are ... breezing through the azure blue ... headed for the Show ... and you. It's going to be fun ... shaking hands with the old gang again ... and the new-comers, too. We'll be holding forth at the Stevens, where you'll find Astatic Microphones, Phonograph Pickups and Cartridges ... including many new and improved models ... on display. We'll be seein' you!

Hotel Stevens

CHICAGO, ILL.
Headquarters for
Radio Parts National Trade Show
May 13, 14, 15 and 16

ASTATIC

THE Astatic CORPORATION

CONNEAUT, OHIO

In Canada: Canadian Astatic, Ltd., Toronto, Ont.

TECHNICANA

[from page 12]

the terminal voltage is directly proportional to the rate of change of flux in the core. In *Fig. 3* is shown the circuit for obtaining FM. L_1 and L_2 are resonated to the carrier frequency. The signal frequency is fed through L_1 into L. Thus the output current flows in pulses which are phase modulated, one pulse polarity being removed by means of the rectifier.

A Fourier analysis of the remaining pulses shows that effective frequency modulation is obtained from the filter output.

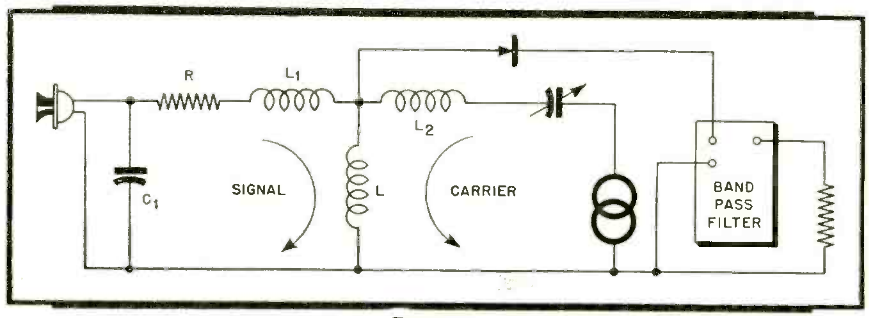


Figure 3

BOOK REVIEWS

Electronic Engineering Master Index, Electronics Research Publishing Company, 2 West 46th Street, New York, N. Y., one volume, two parts (1925-1935, 1935-1945), 320 pages, $17.50. (Part II, "Engineers" Edition, in one volume, 220 pages, $7.50).

This volume represents the first of a series, consisting of a master compilation of over 15.000 titles of texts and articles selected for their value to the research engineer, and covering the years 1925-1945.

Periodicals indexed by the editors include the Bell Laboratories Record, Bell System Technical Journal, Proceedings of the I. R. E., RCA Review, Journal of Applied Physics, Transactions of AIEE, Wireless Engineer, Wireless World, Journal of the IEE, Electrical Communication, etc. Selections have been made from a total of 65 engineering periodicals.

The Master Index will be followed by a volume of abstracts and a new edition of the Index in March 1947.

Considerable editorial effort has been expended in this project, and the result is commendable. Twenty years of research literature on any subject may be surveyed in a matter of minutes. The book is to be recommended to any engineer engaged in electronic development or research.

Transmission Lines, Antennas, and Wave Guides, by Ronold King, Harry Mimno, and Alexander Wing, published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, 345 pages, cloth binding, illustrated.

Developed on an engineering plane, this is a good book for the practicing engineer concerned with lines and antennas. Various topics heretofore sketchily treated have received extensive attention. The circle diagram is completely derived from a special solution of the general equation of the line. Familiarity with differential equations and elements of vector analysis is required for effective use of the book.

Chapter I, titled Nonresonant Lines, comprises work given in a series of 15 one-hour lectures on the dissipationless line and impedance-matching devices, with the addition of supplementary material.

Chapters II and III deal with transmission line constants and significant properties. While the authors have made a considerable attempt to avoid the use of higher mathematics, this background will nevertheless be required for basic understanding of the discussion.

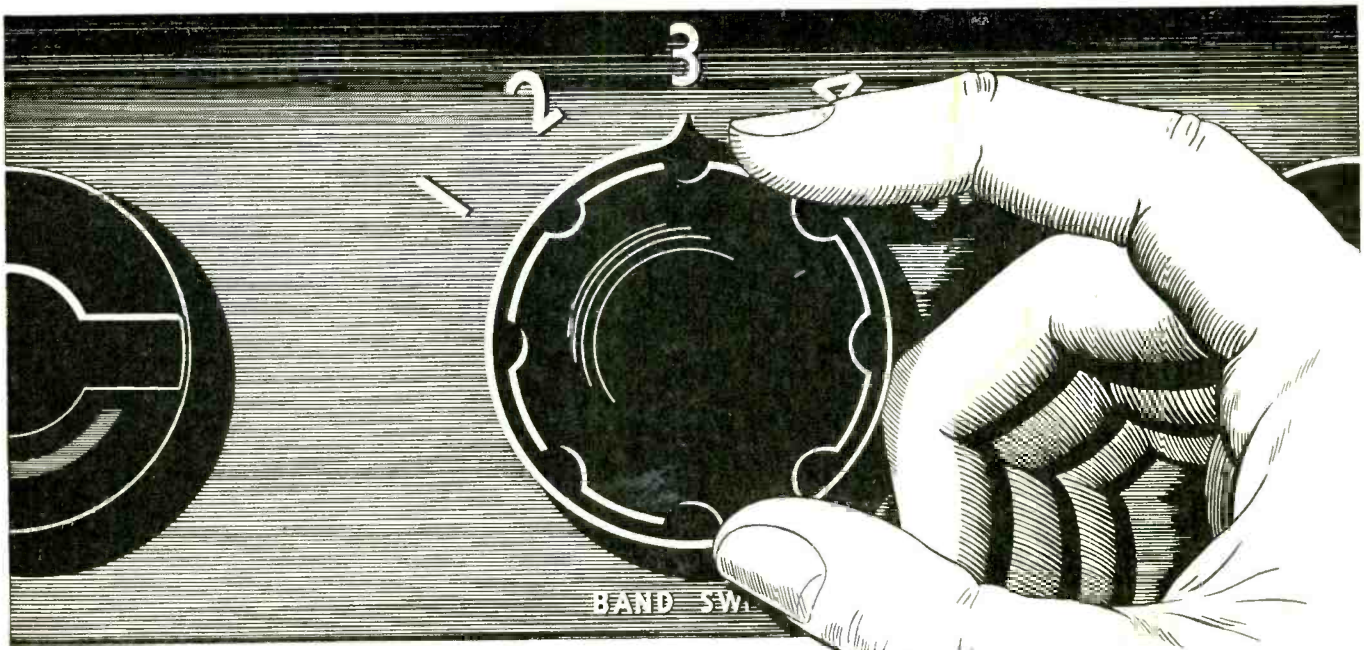
The second section of the book is concerned with antennas, the third with UHF circuits, and the fourth with wave propagation. It is competently written throughout, and represents a valuable addition to any technical library. Attention is given at various points to the problems of wide-band transmission and reception, and it is the opinion of the reviewer that this particular problem might have been further stressed. Wide-banding is a topic of increasing importance, and too much cannot be assembled for the benefit of the practicing engineer.

Numerous problems are given for practice and illustration, and the book is provided with a good index.

Electronics For Engineers, edited by John Markus and Vin Zeluff, published by McGraw-Hill Book Company, Inc., 330 West 42nd St., New York, 390 pages, cloth binding, $6.00.

This book represents a collection of high-grade engineering articles reprinted in handy bound form from Electronics magazine. It forms a valuable transition work for the busy engineer, who is usually unable to search the literature extensively.

Typical articles are charts are: Design Charts for Dissymmetrical T Pads,



For easier bandswitching use the 257B Gammatron!

MAX. PLATE DISSIPATION 75 WATTS

The HK-257B beam pentode, originated by Heintz and Kaufman engineers, facilitates the design, construction, and operation of multi-band transmitters since it requires very little driving power and no neutralization.

The wiring diagram below shows a transmitter capable of operating on all amateur bands from 10 to 160 meters. A single 6V6 metal tube in the oscillator circuit drives the r.f. amplifier to its full output. The precise internal shielding of the HK-257B makes neutralization unnecessary.

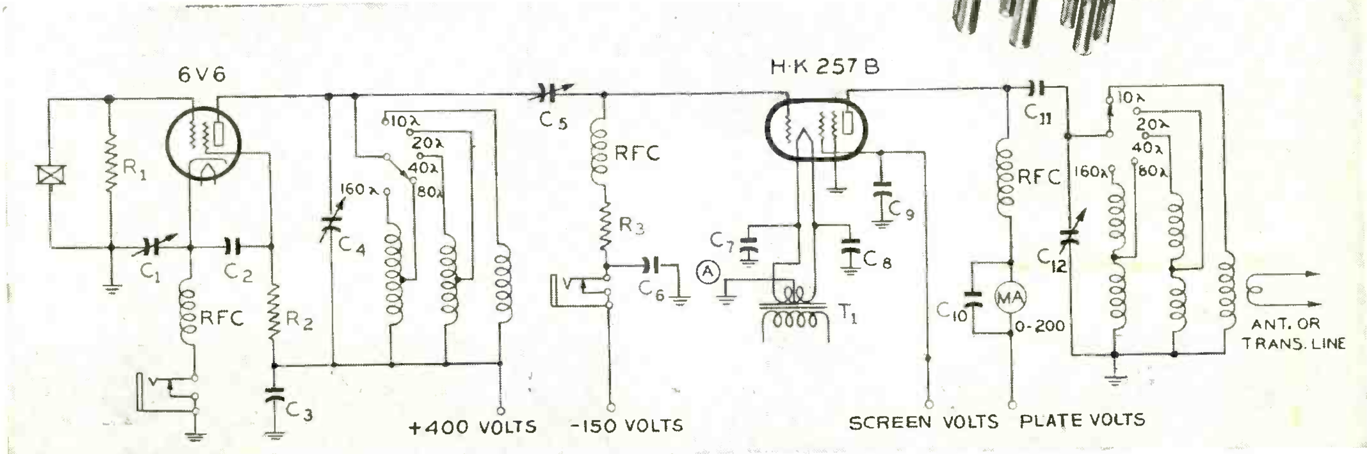
Write today for complete data on the 257B Gammatron, a versatile tube capable of very high frequency operation.

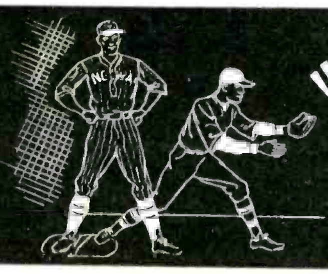
HEINTZ AND KAUFMAN LTD.

SOUTH SAN FRANCISCO • CALIFORNIA

Export Agents: M. Simon and Son Co., Inc.
25 Warren Street • New York City

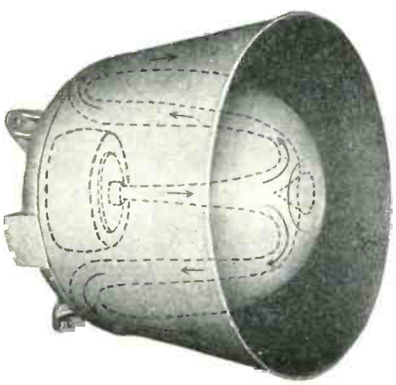
KEEP IT UP... BUY WAR BONDS





"PLAY SAFE"

A properly planned sound installation is a good investment and soon pays for itself. Practically all industrial firms use, or plan to buy, some type of P-A or paging installations. The majority want RACON speakers and driving units because they have proven to be the finest that money can buy. RACON receiver units are supplied with either metal or plastic diaphragms. RACONS outperform higher power-rated speakers of other manufacture, yet cost no more and afford peak efficient, dependable service over a longer period of time. Specify RACONS! There's a speaker, horn or driving unit for every purpose. Literature will be sent upon request. Hand prospective P-A buyers our catalog — they'll "OK" RACONS.



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

P.M. HORN
P.M. Horn units are available in operating capacities of 5 to 50 watts.

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

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

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

Again...**FEDERAL** *makes* **NEWS**...*with the*

FIRST TRIODE

EVER DEVELOPED THAT GIVES YOU

600 watts at 600 MC!

Now being used successfully in the powerful CBS color television transmitter operating at 490 MC carrier frequency with 10 MC bandwidth at 1 KW peak power output.

Federal's 6C22 is the *only* tube of this type ever to operate at this power output at such high frequency. It's *the* triode to use ... as oscillator, amplifier, or frequency multiplier.

Four years of Federal engineering effort were spent in its development for radar equipment. Now it's ready for commercial broadcast use . . . with features making it especially suitable in the UHF spectrum.

For example, Federal's 6C22 has ring-seal electrode construction which reduces lead inductance . . . and extremely close interelectrode spacings to lower transit time losses.

And with 37 years of tube-building experience behind all Federal tubes, you'll find "extras" of rugged mechanical design in the 6C22, in addition to trustworthy electrical performance. It has no internal spacers to break down. Built with solid copper anode block, and water cooled, it works at the high power levels with complete safety. Write for complete information.

ACTUAL SIZE

TENTATIVE MAXIMUM RATINGS AND TYPICAL OPERATION

Key-down conditions without amplitude modulation. Maximum ratings for frequency of 600 MC.

Typical operation—Self-excited oscillator

Frequency MC	Plate Voltage Volts	Plate Current Amperes	Power Output Watts
300	2500	0.70	900
400	2500	0.65	800
500	2200	0.70	680
600	2000	0.65	500

DC Plate Voltage . . . . 2500 Volts
DC Plate Current . . 0.75 Amperes
DC Grid Current . . . .075 Amperes
Plate Input . . . . 1875 Watts
Plate Dissipation . . . . 1000 Watts

Federal Telephone and Radio Corporation

Export Distributor:
International Standard Electric Corporation

Newark 1, New Jersey

AN IT&T ASSOCIATE — FEDERAL TELEPHONE & RADIO FTR

GROUP SUBSCRIBERS SAVE UP TO $1.50 Each

Form A Group Today!

You and your co-workers can now save up to half the regular cost of a RADIO subscription by using the Group Plan. The more men in a Group the more each saves, up to 50%.

Present subscriptions may be RENEWED or EXTENDED as part of a group.

The combination of exclusive, fine and timely articles plus this low-rate subscription offer makes RADIO a must-have publication. So fellows, form a Group today and send it to—

RADIO MAGAZINES, INC

342 MADISON AVENUE   NEW YORK 17, N. Y.

TEAR OUT—MAIL TODAY!

RADIO MAGAZINES, INC.
342 Madison Ave., New York 17, N. Y.

Kindly enter the following subscription to RADIO Magazine. Remittance of $........ is enclosed. (1 to 6 subscriptions may be ordered on this form).

- ☐ One 1-year subscription $3.00
- ☐ Two 1-year subscriptions $5.00
- ☐ Three 1-year subscriptions $6.00
- ☐ Four 1-year subscriptions $7.00
- ☐ Five 1-year subscriptions $8.00

Groups of 6 or more subscriptions in the U.S.A. and Canada will be accepted at the rate of $1.50 each. For Foreign groups add $.50 to each subscription ordered.

PLEASE PRINT

Name ....
Address ....
....
Position .... Company ....
Name ....
Address ....
....
Position .... Company ....

Name ....
Address ....
....
Position .... Company ....
Name ....
Address ....
....
Position .... Company ....
Name ....
Address ....
....
Position .... Company ....
Name ....
Address ....
....
Position .... Company ....

NOTE: If you do not wish to tear out this order blank, print or type a list giving each subscriber's name, address, employer's name and their respective positions. Mail it in today!

[*from page* 14]

Design Procedure for Ground Plane Antennas, Harmonic Analysis of Overbiased Amplifiers, Computing Reactive Attenuation, Capacitor Charge-Discharge Nomograph, Photographing Patterns on Cathode-Ray Tubes, Impedance Determinations of Eccentric Lines, Electronic Heating Design Chart, Grid Control of Industrial Gas-Filled Tubes, Design of Audio Reactors for DC Service, Chart for Determining Square Root of a Complex Number.

Twenty-seven chapters are included in the book, representing a good cross-section of engineering design in the electronic field. Some of the material has been integrated into textbook form by various writers, while much more is not available elsewhere. The 142 articles thus form a valuable addition to the design engineer's library.

The book is well printed and is apparently free from errata.

Television Simplified, by Milton S. Kiver, published by D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y., 375 pages, cloth binding, $4.75.

Television Simplified is a good book for the service man who wants to know in a general way how television circuits operate. It is entirely non-mathematical in treatment, and relies upon physical intuition to arrive at an understanding of the electrical sequences.

The book contains fourteen chapters, a glossary, and a good index. It is amply illustrated with typical circuits for which operating values are usually not given. Halftones and line illustrations are provided where required.

Topics range from antennas and wide-band circuit considerations through amplifier and synchronizing circuits. A discussion of cathode-ray tubes appears in the middle of the book, which terminates with chapters on color television and FM. A couple of very practical chapters are included on servicing of television receivers.

Service men breaking into the television field will find this a valuable introductory text, when supplemented with manufacturers' circuits and component values for specific models.

Television Show Business, by Judy Dupuy, published by General Electric Co., Schenectady, New York, 245 pages, paper bound, $2.50.

Miss Dupuy has gone very thoroughly into methods of televising dramatic productions, sports, various dance techniques, special forums and speakers, and those theater features which present special problems to the television producer. At the conclusion of each chap-

[*Continued on page* 51]

8 Features of DIEFLEX VARNISHED TUBING PRODUCTS that mean Money in Your Pocket . . .

The pictures tell dramatically the story of the economies and ease of handling and the many other advantages which modern Dieflex products bring to fast-moving production lines.

Plant men like the smooth inside bore and complete roundness of Dieflex tubings and sleevings which make them easy to thread and telescope and prevent snagging. They like the speed of assembly due to non-fraying qualities, the workability of the products in inaccessible spots . . . yes, they like Dieflex products!

Permanence in finished assembly is doubly assured in the Fiberglas grades which are thoroughly impregnated against moisture, oils, and chemicals, as are all Dieflex varnished tubing products.

All Dieflex products meet V. T. A. and A. S. T. M. standards, are available in standard sizes and grades, are all uniform.

DIEFLEX Products List

MADE WITH BRAIDED COTTON SLEEVING BASE

VTA Grade A-1 Magneto Grade Varnished Tubings
VTA Grade B-1 Standard Grade Varnished Tubings
VTA Grade C-1 and C-2 Heavily Coated Saturated Sleevings
VTA Grade C-3 Lightly Coated Saturated Sleevings
Heavy Wall Varnished Tubings and Saturated Sleevings

MADE WITH BRAIDED GLASS SLEEVING BASE

VTA Grade A-1 Magneto Grade Varnished Fiberglas Tubings
VTA Grade B-1 Standard Grade Varnished Fiberglas Tubings
VTA Grade C-1 Extra Heavily Saturated Fiberglas Sleevings
VTA Grade C-2 Heavily Saturated Fiberglas Sleevings
VTA Grade C-3 Lightly Saturated Fiberglas Sleevings
Silicone-Treated Fiberglas
Varnished Tubings and Saturated Sleevings

Distributed by

Insulation Manufacturers Corporation
CHICAGO · CLEVELAND · MILWAUKEE · MINNEAPOLIS · DETROIT · PEORIA

Insulation and Wires Incorporated
ST. LOUIS · ATLANTA · HOUSTON · DETROIT · BLUE FIELD · BOSTON · NEW YORK

Tri-State Supply Corporations
LOS ANGELES · SAN FRANCISCO · SEATTLE

Inductive Tuned Loop Circuits

W. J. POLYDOROFF

Inductive tuning techniques make possible a substantial reduction of man-made static

PART I

THE LOOP AND ITS CHARACTERISTICS for reception of electromagnetic waves (also magnetic induction) have been studied and thoroughly analyzed by physicists, mathematicians and engineers. Its application as a collecting device has been known for over fifty years and since then it has been applied with varying success for numerous purposes.

As compared with a vertical antenna a loop has very poor pickup properties, since a vertical antenna operates on the vertical gradient of electromagnetic field, while a loop operates on the phase difference observed at its extremities.

The effective height of a vertical antenna whose physical height is smaller than λ/4 is expressed:

$$h_{eff} = \frac{\lambda}{\pi \sin \frac{2\pi h}{\lambda}} \sin^2 \left(\frac{\pi h}{\lambda}\right) \ldots . (1)$$

Thus a vertical rod one meter in height at 1 mc (300 meters) will have an effective height of 40 cm.

The effective height of a loop is expressed as:

$$h_{eff} = \frac{2\pi AN}{\lambda} \ldots\ldots\ldots . (2)$$

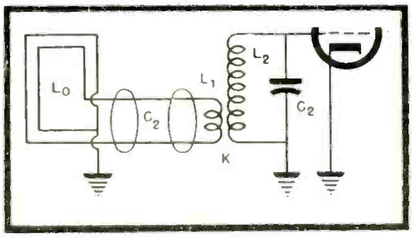
and in order to obtain equal sensitivity (same effective height) as with a rod antenna, a single-turn loop of 5 meters diameter, or a 100-turn coil of 50 cm diameter should be used at the same frequency.

It is only when a vertical antenna becomes extremely small as compared with the wavelength that loop sensitivity may approach that of a vertical antenna.

Signal-to-Noise Ratio

The above is true when *absolute sensitivity* is considered. In recent years this concept has been somewhat changed: what is measured is the ability to pick up and reproduce a signal, but not noise plus signal. Army and navy specifications during the war called for a certain signal-to-noise ratio, which for good intelligibility must be at least 4 to 1. Even this ratio is not good enough for comfortable broadcast reception where a 10 to 1 ratio would be more desirable. Some manufacturers set their goal in automobile receivers as 7 to 1 and even 10 to 1.

It is only with improved noiseless sensitivity of a receiver, in which grid input noise has been reduced to a fraction of a μv, that loop reception is really appreciated; having reduced the tube noise, we are now limited by thermal agitation noise of the input circuit. In the simplest case of a directly-tuned loop the pickup factor of the loop equals $h \times Q$, and this product determines the voltage delivered to the first grid. It is known that thermal agitation noise is proportional to $\sqrt{Q}$ and it is obvious that a relatively large coil employed in the loop may have a much higher Q than a conventional antenna input circuit into which the radiation resistance of the antenna is reflected.



Low impedance loop is matched to primary, with L_1 somewhat less than L_0

The loop may be further improved by the insertion of iron in which case $h_{eff} = h \times \mu_{eff}$ is increased and Q may be improved by a suitable selection of iron core. Thus, with normal small loops now used in aircraft and broadcast receivers (8″ for the air core and 3½″ for the iron core loop), the signal received is weaker. However, a reduction of thermal agitation noise produces an improved signal-to-noise ratio. It remains for the receiver itself to make up for the deficiency of signal.

The directional properties of a loop help considerably to get rid of atmospherics. Effective heights of the loop with respect to direction of the wave front is expressed as

$$h = h_{eff} \cos \theta \ldots\ldots\ldots\ldots (3)$$

which produce a figure-eight pattern.

The two null points theoretically reduce the signal to zero (when θ equal 90°) but in practice a reduction from maximum to minimum signal of the order of 40-90 db is obtainable, depending on shielding and balancing of the loop. Thus, if the loop is rotated against the source of atmospheric noise, quiet reception can be expected.

In city locations the main source of interference is man-made static which may originate in the direct vicinity of the receiver. This type of static may affect the antenna either by direct induction or through the radiation field. Due to inefficiency of a loop, and the absence of established wave motion, induction is hardly noticeable. Adequate shielding of the loop, or rotation of the loop to utilize its directive discriminating properties, will entirely eliminate direct pickup due to radiation. In a typical case of a large city police radio it has been found that the replacement of a whip antenna on the car by a loop has reduced man-made static to such an extent that signal-to-noise ratio has improved from 4 to 10 times.

The loop is mounted on the roof of the patrol car with its axis parallel to the direction of travel. The principal noise on the street comes from the trolley wire which is constantly excited by the street car's sparking. The described location of the loop practically eliminates this type of disturbance and good shielding prevents pickup of other electrostatic disturbances.

With the high sensitivity of existing police receivers, sufficient signal is received by a 6 inch dia. air core loop. This structure, however, looks unsightly and reduces clearance on the road, so that finally elongated iron core loops of the same sensitivity but of much smaller size were proposed. Such loops are housed in hermetically sealed plastic teardrops of 4 inches maximum diameter and 7 inches long, such as may be used for small aircraft.

Aircraft Applications

This is one example of advantageous employment of loop reception; another example may be taken from aircraft radio operation where static generated by the plane or encountered in the clouds may entirely blank out the reception on the vertical antenna, yet by switching on the loop communication may be easily maintained.

Here it must be emphasized that these

advantages of the loop are only apparent when the loop is thoroughly shielded or balanced, or both, in order to eliminate the so-called "antenna effect". This latter is so pronounced in unshielded or unbalanced loops that most of the good features of loop reception disappear, leaving only the features of compactness and portability. Unfortunately the majority of broadcast receiver designers, when striving for quiet local reception, entirely disregard this feature of the loop which can be restored at a small expense by rational circuit modification.

Levy shows (*Proc. I. R. E.*, Vol. 31, #2, p. 61) the effect of a vertical antenna which exists in an unbalanced or unshielded loop. One can see from the polar diagram that the antenna effect component may be of the same order as the electromagnetic component of the loop itself.

High and Low Z Loops

Before going into the constructional details of balancing or shielding of a loop we must consider separately two systems widely used for loop reception.

a. High impedance or directly tuned.

b. Low impedance loops.

In the first type the loop antenna is directly tuned to a resonant frequency so that the voltage generated across the circuit is applied to the grid of the first tube, located close to the loop itself. The voltage V_g delivered to the grid is equal to the voltage generated in the loop, multiplied by Q of the circuit. Thus if the field strength at a given point is e

$$E = e \times h_{eff} \text{ and } V_g = E \times Q \ldots (4)$$

Thus we can see that the received signal is directly proportional to the effective height and to the Q of the circuit. If we choose an antenna of customary high Q for this circuit (of the order of 100-200) the shielding should be of such nature as not to materially impair the Q of the loop.

In other words, the shielding must be sufficiently removed from the loop coil, and the type of shield known as a Faraday cage, consisting of a series of vertical wires, connected and grounded at the bottom of the loop, is preferred. If such a screen is made large enough to permit rotation of the loop, it can be easily used in broadcast receivers of console type. Flat-type pancake loops used in portable receivers can be likewise shielded without much increasing the overall dimensions of the loop. This can be accomplished by shielding cloth, or by suitable plastic sheets with shielding wires or metal spray embedded in the material.

In aircraft installations it has been found advantageous to shield the streamlined casing rather than the loop itself in order to preserve the high Q of the circuit.

A thorough shielding as above described will reduce the antenna effect to the point where the minimum signal (at null point) is attenuated by 20-30 db, as compared with unshielded loops where this attenuation is of the order of 4-10 db. In order to get still further attenuation the loop, in addition, must be electrically balanced. A true balance with juxtaposition of the coil will theoretically produce infinite attenuation without any shielding, but in practice, attenuation of the same order as of shielding, i.e., 20-30 db is obtainable. In order to get the sharpest null possible in direction finding, both shielding and balancing are employed, in which case 50-90 db attenuation of the null point, as compared with maximum signal, is possible.

High-Impedance Balance

There are two known ways to balance a high impedance loop, both requiring a ground connection brought to the center of the loop; consequently the tuning condenser has to be insulated from ground. Additionally two input tubes in push-pull should be used, or if a single tube is employed, only half of the voltage across the loop is utilized. In many cases of direction finding such systems have been in use; in practical cases of broadcast receivers the balancing of the loop is entirely disregarded so that the loop has a considerable vertical antenna component with the accompanying pickup of undesired noise. Only in a few exceptional cases have radio manufacturers employed shielded loops, which considerably improves reception.

In the low-impedance type, the loop of smaller inductance feeds into the primary of a transformer whose impedance should be matched to the impedance of the loop. In practice, this means that the inductance of the primary is somewhat lower than the inductance of the loop, in order to obtain maximum transfer of energy. There may be a cable of considerable length (up to 12 feet) between these two elements and the characteristic impedance of this transmission line would be of the same order as the above impedances. The secondary constitutes a tunable element and a variable condenser tunes the whole loop input system to resonance.

Bond (Radio Direction Finders, pp. 163-169) gives complete solution of the circuit. The gain

$$G = K \cdot \sqrt{\frac{L_2}{L_1}} \cdot Q' \ldots\ldots\ldots\ldots (5)$$

where Q' is a complex quantity depending on Q_1 of the primary circuit, Q_2 of the secondary circuit, coupling coefficient, resonant frequency of primary circuit and the degree of matching of the loop to the primary. While this Q' can be easily calculated, and gain computed, in practice the whole circuit can be measured on the Q meter by the following procedure:

The whole circuit being connected together, the Q of the secondary is measured; (it is interesting to note how the Q goes up when the loop is disconnected from the primary). Then the voltage is injected into the primary circuit — as it would be in actual operation — and the secondary is connected across the "condenser terminals" of the Q meter. This last reading gives the value of the gain of the complete circuit and when divided by the figure of the first measurement gives the degree of stepup of the transformer. Quite high values of Q' are often observed. The sensitivity of this system can be computed analogously with the formula (4) $V_g = E \times G$ and often affords sensitivity of the same order as obtainable with a directly tuned loop, but the signal-to-noise ratio is usually considerably lower, as will be later discussed.

Center-Tap

In such a system the balancing of the loop is obtainable by a center-tap in the loop winding, or in the primary, or both, the center-tap being grounded. Experience shows that in such a system without shielding, the loop will produce a null-point attenuation of 20-30 db, but for further attenuation shielding is required which will increase attenuation by the same amount, producing a total of 60-90 db, as compared with the maximum signal. The nulls become extremely sharp and static disturbance when in the sector of silence is practically eliminated. In such a loop the antenna effect is effectively suppressed, and reception becomes extremely quiet, since now the loop works on phase difference only.

Experience shows that man-made static is mostly of electrostatic nature and is also greatly reduced. One or two broadcast receivers of pre-war make employed a low-impedance loop system and several models are being designed for post-war receivers. In all such circuits, reduction of man-made static is a distinct feature.

In recent years permeability tuning has become quite a prominent factor in the construction of broadcast receivers. Its compactness, economy, absence of microphonics, and input circuit efficiency using a small antenna, made it particularly suitable for auto receivers, so that the majority of such receivers are and will be permeability tuned. This system also appeared in several household models employing pigtail or plate antennas in superheterodyne circuits, and has proven itself over years of service.

[*To be continued*]

USE OF MICROWAVES FOR INSTRUMENT LANDING

DONALD F. FOLLAND

Engineer, Sperry Gyroscope Co., Inc.

PART 2

The output of the microwave landing transmitter* feeds through a waveguide to a phase shifter, which serves to match the output klystron tube to the mechanical modulator. Its adjustment controls the wave shape of the transmitted power. The modulator is a mechanical unit which varies the transmitted amplitude of the microwave signals at predetermined audio frequencies.

This modulator consists basically of two metal discs mounted on a common shaft which rotates at a constant speed, being driven by a synchronous motor. Teeth are cut in the periphery of the discs and these teeth pass resonant slots in waveguide sections. When a tooth is in front of the slot about 30% of the microwave energy is passed, that is, giving 70% modulation. When the cutaway part of the disc is in front of the slot the maximum microwave energy flows to the antenna. The frequency of modulation depends on the number of the teeth and the speed of rotation of the discs. The frequencies used in this system are 600 and 900 cycles per second.

As can be seen on the glide path modulator, *Fig. 1,* a portion of the disc periphery has no teeth cut in it. When this section of the disc is in front of the waveguide slot, no energy passes to the antenna. Therefore, the modulator not only modulates the microwave energy but also switches it from one antenna to the other. By this means it is possible to transmit only one beam into space at a given time. Hence, problems of radio frequency interference from two sources at identical radio frequencies are minimized.

Fig. 2 shows the output of the glide path modulator which feeds the glide path antenna through two waveguides. *Fig. 3* shows the localizer modulator output which feeds the four localizer antennas through four separate waveguides. The modulator is placed as the last component between the transmitter and antennas. Locating the modulator in this position minimizes any unbalance in the transmitted beams forming the landing path.

The microwave energy from the output klystron can vary over a considerable range without affecting the precise position of the path since all beams will be affected alike. Sufficient microwave power is always transmitted so that a minimum line of sight range of 50 miles with an adequate safety factor is assured.

Antennas

The glide path antenna is a 12 foot by 3 inch cylindrical parabola fed by two waveguides; one whose effective source is slightly above the focus illuminating the parabola with 600 cycle modulated energy, and the other whose effective source is slightly below the focus illuminating the parabola with 900 cycle modulated energy. Phase shifters are inserted in these feeds between the modulator and the antenna. Proper adjustment of these phase shifters prevents feed-back from one waveguide to the other. If this feedback is present it allows 600 cycle modulated energy to be radiated by the 900 cycle waveguide and vice-versa.

The localizer antenna system consists of four separate antennas. Two halves of a 6-foot diameter paraboloid split vertically produce the two course forming beams while two 6 foot by 3 inch cylindrical parabolas form the side coverage beams. These antennas are fed by their respective waveguides. However, in the localizer it is not necessary to use phase shifters between the modulators and the antennas because no two waveguides feed a single antenna and therefore no feedback is experienced.

The difference between the glide path and localizer consists of the frequency modulators and antennas. The following table shows the various transmitting frequencies of the two units.

	Channel A	Channel B	Channel C	Channel D
Localizer	2640 mc	2639.5 mc	2639 mc	2638.5 mc
Glide Path	2617 mc	2616.5 mc	2616 mc	2615.5 mc

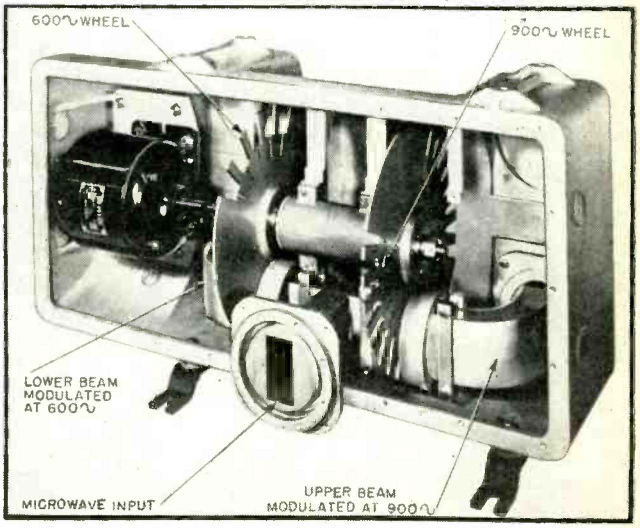
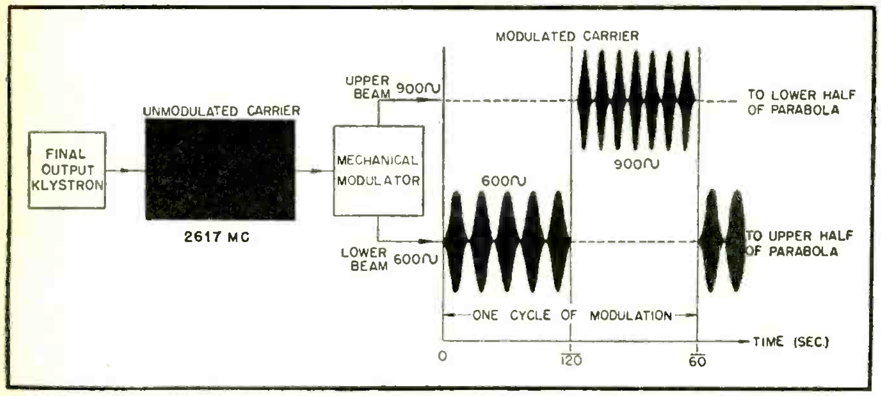
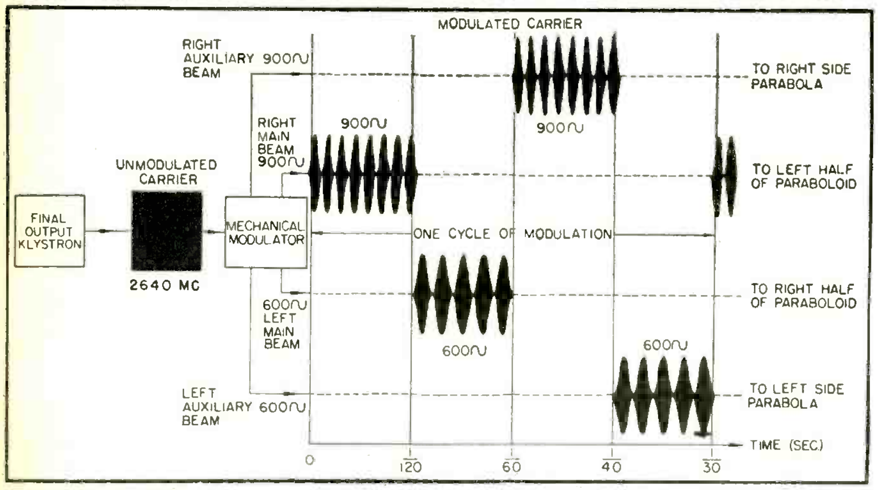
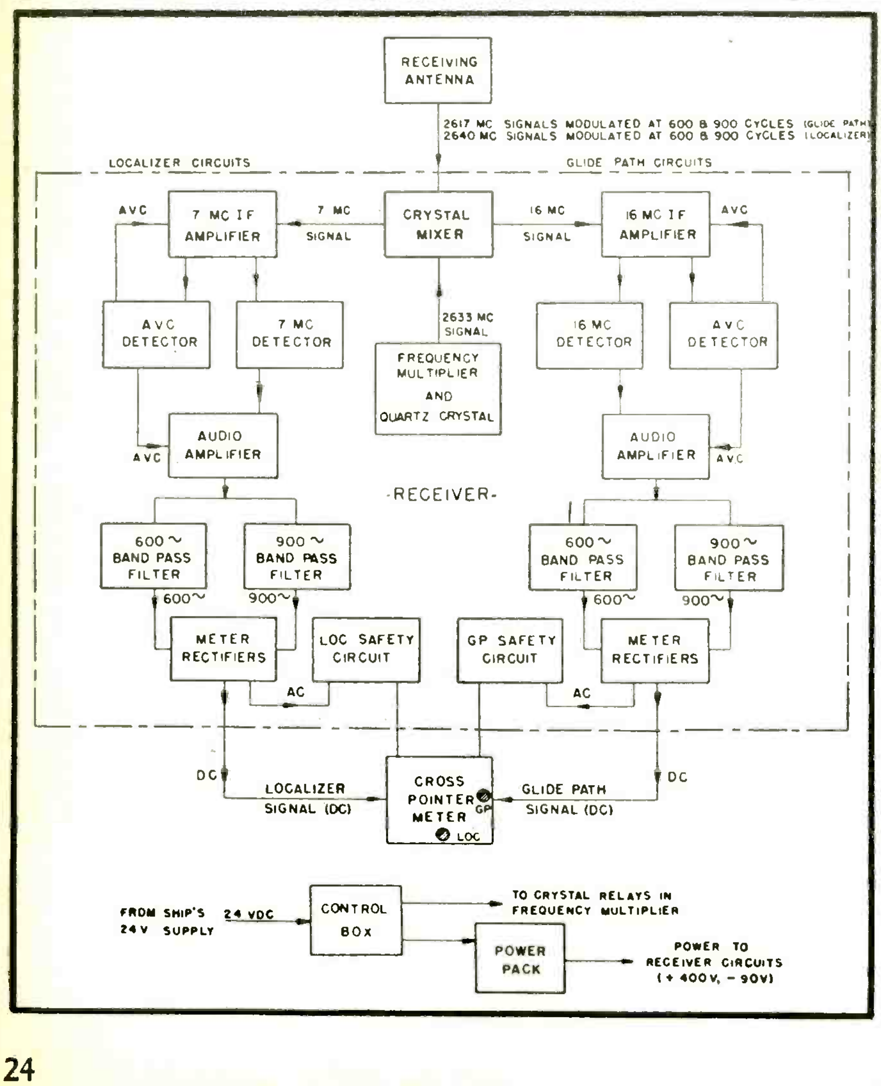


Fig. 1. Glide path modulator, showing 600- and 900-cycle modulating discs which rotate in the waveguide slots.

*RADIO, March 1946







Due to the fact that both the glide path and the localizer courses are dependent only on the location of the antenna structures, it is possible to set up this equipment by optical means alone. For example, the localizer is set up by locating the transmitter on the end of the runway opposite to that on which the plane will land and so adjusting its position that the electrical center of the antenna system is exactly coincident with the center line of the runway. This is done using a telescopic type instrument. This instrument is also used to check the accuracy of the aircraft's flight when coming in on the beam, and it is found that a proficient pilot can fly this course to within ± two-tenths of one degree, while an automatic pilot such as the Sperry A-12 Pilot can fly the course with an accuracy of ± one-twentieth of a degree.

The accuracy of present equipment is such that it is possible to set up a localizer course so that at the opposite end of a 5000 ft. runway the course will lie within ± fifteen feet of the center of the runway. This accuracy can be maintained under all service conditions of varying weather, etc.

Aircraft Equipment

The aircraft equipment consists of a microwave antenna, a receiver, power supply, junction box, control box, interconnecting cables and a cross pointer meter. The receiving equipment detects the signals transmitted from the localizer and glide path ground station transmitters, and translates them into meter indications which the pilot uses to guide the aircraft toward the airport runway. The signals from the two ground stations are picked up by the receiving antenna and fed to the receiver through a flexible coaxial line. In the receiver the glide path and localizer signals are detected and amplified. Each is separated into its respective modulations. The output of the receiver operates the two needles of the cross pointer meter which shows the pilot his position in space with respect to the landing path.

The receiving antenna is normally mounted on top of the airplane. This antenna consists of an array of three triple dipoles mounted on a rigid coaxial line. The azimuth field pattern of the antenna is approximately circular; that is, it receives equally well from all horizontal directions. The elevation field pattern is fan shaped and ranges from 22½° below the horizontal plane to ap-

Fig. 2 (top) Glide path modulation patterns obtained at output of the glide-path modulator feeding the glide-path antenna. Fig. 3 (center) Localizer modulation patterns at localizer modulator output which feeds the four localizer antennas. Fig. 5 (lower) Block diagram of receiving equipment used in aircraft receiving installation.

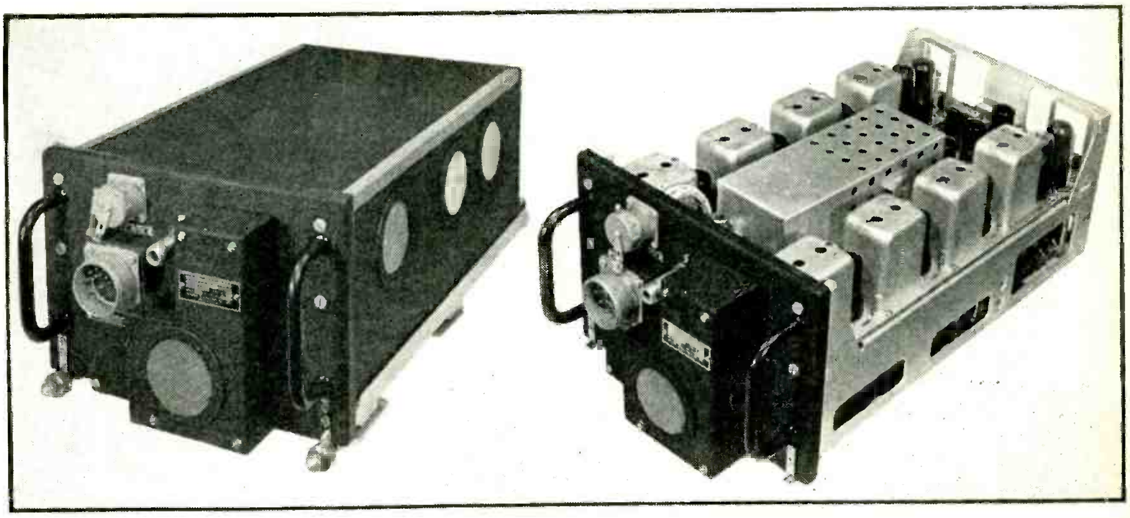


Fig. 4. (left) View of receiver and shock mounting. Dust cover also affords shielding from extraneous microwave fields. Fig. 6. (right) View of receiver with dust cover and microwave shield removed. Design stresses unusually high degree of isolation from external fields

proximately 22½° above (to the half power point).

The antenna has a gain of 3.1 or 5 db over an isotropic radiator. Within these limitations reception of the landing path signals is not affected by changes in attitude of the airplane unless some large surface of the airplane comes between the microwave beam and the antenna. This could occur when the airplane executes a steep bank away from the transmitting station causing the wing of the airplane to cast a shadow over the antenna, or in cases when the plane is flying away from the transmitter and the tail structure casts a shadow on the antenna.

The aircraft receiver is a superheterodyne type and is designed to receive both the localizer and glide path signals simultaneously. The microwave signals from the two ground stations are detected in a single resonant chamber mixer and amplified in separate i-f circuits. Provision is made in the receiver for reception of any one of the three possible frequencies which the ground transmitting station may have selected. The channel selector switch is located on the control box and operates relays in the receiver unit to switch in the proper crystal for driving the local oscillator at the correct frequency. *Fig. 4* shows the receiver in its shock mounting. The chassis is tightly closed in a removable dust cover which provides physical protection and electric shielding from extraneous microwave signals.

Operation of the receiving equipment is controlled by two switches on the control box which is located near the pilot's seat. After turning on the equipment and selecting the proper operating channels, the pilot has no further adjustments to make. The aircraft antenna, an array of three tripole elements, as described in the foregoing paragraphs.

The receiver as outlined in the block diagram, *Fig. 5*, consists of the following principal circuits:

1. Frequency Multiplier.
2. Crystal Mixer.
3. I-F Amplifier (2).
4. Audio Detectors (2).
5. AVC Detectors (2).
6. Audio Circuits (2).
7. Safety Circuits (2).

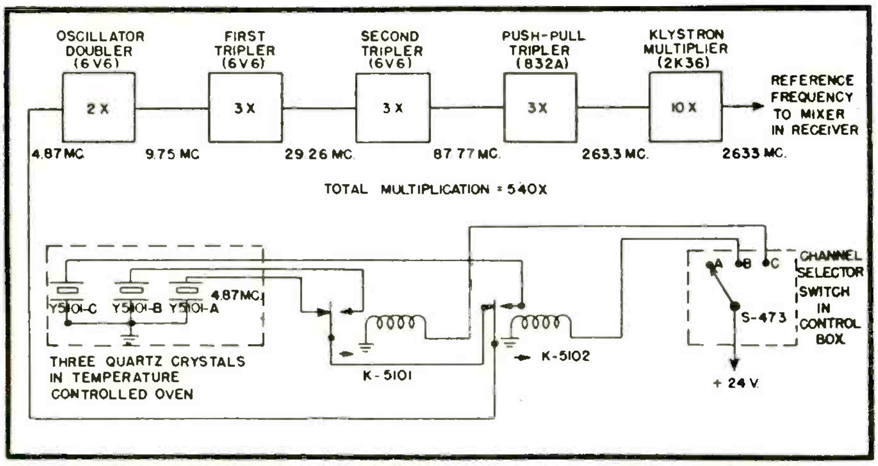
Fig. 6 shows this receiver with its dust cover and microwave shield removed. In the receiver as in the transmitter, it is very important that the unit be completely shielded from microwaves so that the only microwave energy reaching the receiver comes from the antenna. For this reason, in addition to shielding over the entire receiver, a microwave choke block has been designed through which all power supply and meter leads go into and out of the receiver.

The frequency multiplier supplies the reference frequency signals which are combined with the received signals to produce the intermediate frequency signals.

The unit has five principal circuits:

1. Crystal oscillator and frequency doubler.
2. 1st frequency tripler.
3. 2nd frequency tripler.
4. 3rd (push-pull) frequency tripler.
5. Klystron multiplier (Type 2K36).

Fig. 7 shows the schematic arrangement of the five stages. The oscillator stage contains three temperature-regulated quartz crystals. Each crystal is accurately cut to produce the desired frequency. A trimmer condenser is connected across each crystal to provide a small range of frequency adjustment. The accurately cut crystal and trimmer condenser give a reference frequency source which can be controlled within ±50 cycles, which is approximately 1 part in 100,000. [Continued on page 55]



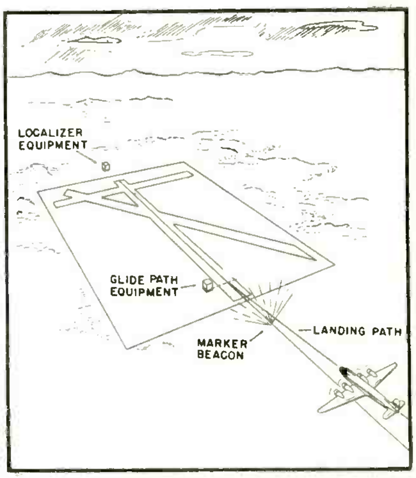


Fig. 7. (left) Schematic diagram of frequency multiplier unit. Selector relays are controlled by selector switch. Fig. 8. (right) Placement of transmitters on airport with respect to incoming aircraft.

Intermediate Frequency

Designers of communication equipment will find Dr. Jaffe's investigation of unusual interest

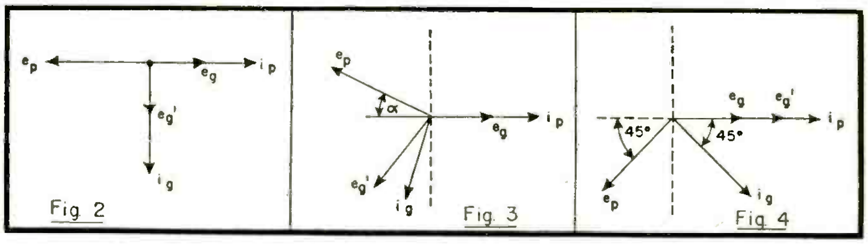


Fig. 2. Vector diagram with grid and plate circuits tuned to the same frequency. Fig. 3. Vectors with circuits tuned to f_0, but $f_1 < f_0$. Fig. 4. Diagram for inductive grid and plate circuits, with 45° phase angle

SUMMARY OF A STUDY OF INTERELECTRODE CAPACITANCES AND MAXIMUM STABLE GAIN OF VARIOUS TUBE TYPES

1. For Single Tuned Circuits
   Max. stable impedance $= \sqrt{2/(g_m \omega_0 C_{gp})}$
   Max. stable gain $= \sqrt{2 g_m/(\omega_0 C_{gp})}$
2. For Double Tuned Circuits Critically Coupled
   Max. stable impedance $= \sqrt{.79/(g_m \omega_0 C_{gp})}$
   Max. stable gain $= \sqrt{.79 g_m/(\omega_0 C_{gp})}$
3. Socket Capacities

Socket	For Tubes	C_{gp} mmf	Lead Length
Wafer	6SK7, 6SG7, 6SH7, etc.	.0125	5/8"
Ceramic	6SK7, 6SG7, 6SH7, etc.	.0126	3/4"
Loctal	7W7, 7H7	.00145	3/4"
Miniature	6AK5, 6AG5	.006	5/8"

4. Ceramic octal socket reduced maximum stable gain approximately 82 per cent from that of wafer socket.
5. Ceramic octal socket with shield wire #18 gage between pins 3 and 7 increased maximum stable gain approximately 10 per cent.

Stability of intermediate-frequency amplifiers is determined by the plate-grid capacitance of the individual tubes and wiring, overall gain and degree of coupling between input and output stages. It is assumed that interstage coupling due to common leads and ground paths has been eliminated or minimized to the point that it is of second-order importance.

The stability of an amplifier with gain less than 80 db is largely a function of the individual stages, and is determined by the plate-grid capacitance feedback path within the tube. The plate and grid wiring are extremely important contributors to this capacitance. For amplifiers with gain in excess of 80 db, the problem of input-output coupling becomes important and special precautions must be taken in layout to minimize such effects.

Interelectrode Capacitance Considerations

A single tuned i-f amplifier stage is illustrated in *Fig. 1.* The grid impedance Z_g and plate impedance Z_p are net values which include tube loading effects. The condition for oscillation of this stage is satisfied when, for a voltage e_g at frequency f injected into the grid circuit, a voltage e'_g is fed from the plate circuit into the grid, through C_{gp} such that:

$$e_g' \geqq e_g \qquad (1)$$

where e_g is the real part of the voltage fed back.

When both grid and plate circuits are tuned to the same frequency, the vector diagram is as shown in *Fig. 2.* We have assumed a constant-current pentode, and $X_{C_{gp}} >> Q_g X_g$. It will be seen that the feedback voltage e''_g is in quadrature with e_g and the circuit hence will not oscillate since there is no in-phase component fed back to the grid.

If the frequency is now adjusted to f_1 where $f_1 > f_0$, the tuned circuits remaining tuned to f_0, the vector diagram becomes that shown in *Fig. 3.* Note that as the frequency is raised the circuits become capacitive. The plate voltage lags its former position by the angle α. The grid circuit current due to voltage e_p also lags by this angle.

The feedback voltage lags i_g since the grid circuit is now capacitive. It will be seen that the feedback voltage is shifting in a direction so as *not* to produce an in-phase grid voltage.

If we now lower the frequency to f_2 so that $f_2 < f_0$, maintaining the tuning of the circuits at f_0, the feedback voltage is shifted in a direction to produce an in-phase component in the grid circuit. When the frequency is lowered so that the plate and grid circuits are inductive and introduce a phase angle of 45°, the grid feedback voltage is in phase with the grid input voltage and one of the conditions for circuit oscillation is satisfied.

If now $e_g' \geqq e_g$ the circuit will oscillate. (Note that the circuit oscillates at a frequency below that of resonance). The grid feedback voltage is

$$e_g' = g_m e_g Z_0^2/2X_{C_{gp}} \qquad (2)$$

The condition for oscillation is

$$g_m e_g \omega_0 C_{gp} Z_0^2/2 \geqq e_g \qquad (3)$$

$$g_m \omega_0 C_{gp} Z_0^2/2 \geqq 1 \qquad (4)$$

Solving for Z_0 we get, for an oscillatory condition

$$Z_0 \geqq \sqrt{2/(g_m \omega_0 C_{gp})} \qquad (5)$$

Thus the maximum grid and plate impedance to be used for single-tuned i-f transformers is given by the right-hand side of equation (5).

Stability Criterion for Double-Tuned Circuits

Where double-tuned transformers are used in i-f circuits, equation (5) is somewhat altered. For a double-tuned circuit, critically coupled, having iden-

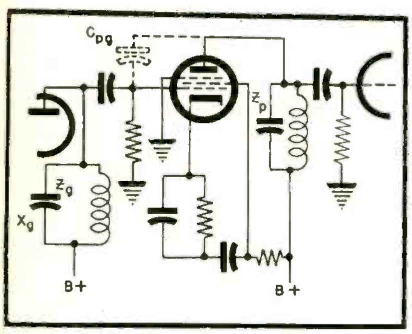


Fig. 1. Single tuned i-f amplifier stage, with notation used in text

Amplifier Stability Factors

D. L. JAFFE[1]
Polarad Electronics Co.

ACTUAL GRID-PLATE CAPACITANCES FOR SOME TYPICAL I-F STAGES

Tube	Socket Type	Tube C_{pg} mmf	Tube & Socket & Wiring C_{pg} mmf	Shield #1	Shield #2
6SK7	Wafer	.003	.078	.073	.063
6SK7	Ceramic	.003	.112	.097	.085
7W7	Loktal mica-filled	.0025	.061	.053	.045
6AK5	Miniature Ucinite	.01	.048	.048	.048
6AK5	Miniature Eby	.01	.047	.047	.047

Shield #1: Grounded length of #18 wire connected across socket, shielding plate from grid.

Shield #2: Grounded strip of ⅜ inch wide copper connected across socket, shielding plate from grid.

TABLE 1

tical primary and secondary elements, the primary impedance is given as[2]

$$Z_p = Q_x \frac{1 + jv}{12 - v^2 + j2v} \qquad (6)$$

where

$Q = \omega L/R$ or $1/\omega CR$

$x = 1/\omega C$

$C = C_g = C_p =$ tuning capacitance

$v = 2\Delta f Q/f_0$ for $\Delta f/f_0 < 1$

The phase angle of the impedance as given by equation (6) is

$$\phi_p = \tan^{-1} - v^3/(2 + v^2) \qquad (7)$$

The primary impedance will introduce a phase lag of 45° lag when $v = -1.7$. Note that for the double-tuned circuit the phase angle of the primary impedance also becomes inductive at lower frequencies. Since identical primary and secondary circuits were assumed, $Z_p = Z_g$, and the impedances as seen from primary and secondary sides of the transformer are identical. It therefore follows that unstable double-tuned circuit i-f transformers will oscillate at a frequency lower than that to which the resonant circuits are tuned.

For double-tuned circuits critically coupled, the primary impedance at resonance ($v = 0$) is [*Continued on page* 54]

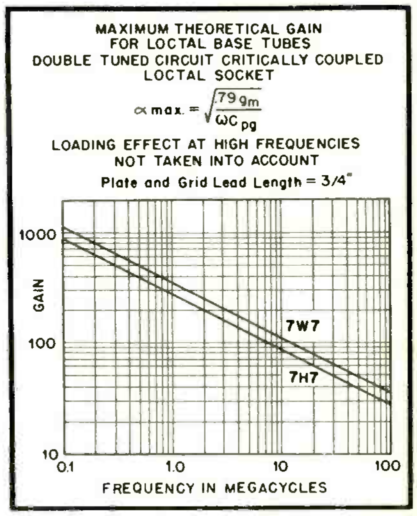


TABLE 4

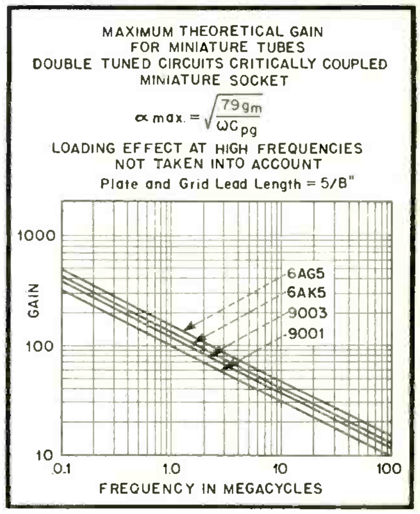


TABLE 5

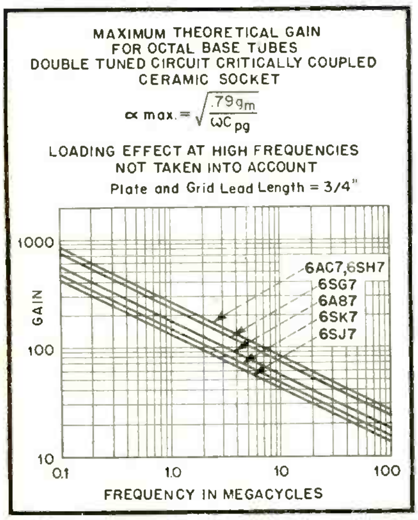


TABLE 2

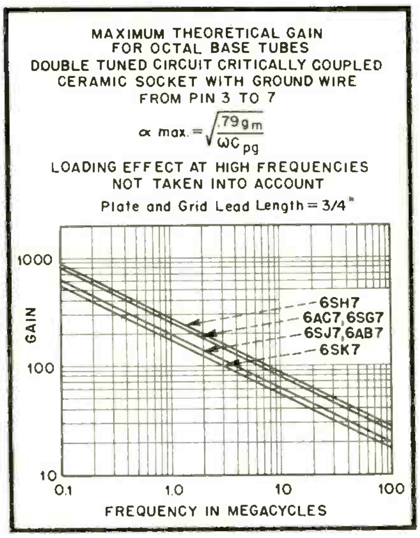


TABLE 3

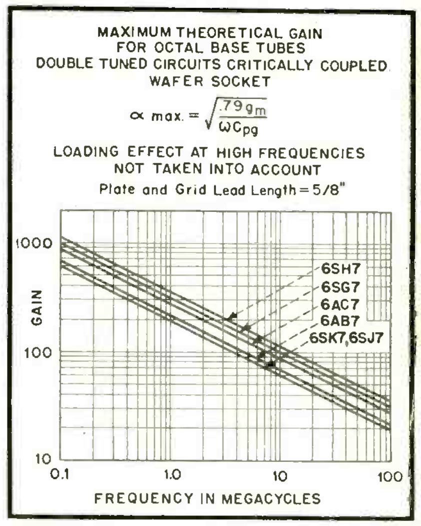


TABLE 6

Electro-Mechanical Analogy

Comparisons of mechanical and electrical phenomena facilitate thinking in design of intricate mechanical networks

THE CHIEF TOOL OF THE acoustical engineer in designing a speaker or a microphone, and one which may be used many times subconsciously, is the analogy of mechanical to electrical vibrating systems. Before much was known of electrical circuits, mechanical analogies were used to explain many electrical phenomena. During this period of development of the electrical art, more was known of mechanical vibrating systems than of electrical systems, and mechanical analogies were used to explain many electrical phenomena. Now that the electrical art has been developed to such a high degree, the opposite is true, and the application of this knowledge to mechanical systems has been mutually beneficial.

The fundamental relationships in the equations of electrical circuits all have their counterparts in analogous equations pertaining to mechanical or acoustical vibrating systems. In other words Ohm's law, Kirchhoff's law, the use of the *j* operator, the reciprocity theorem, Thévenin's theorem, and the fundamental differential equations can all be used in solving mechanical systems.

Fundamental Differential Equations

The analogy may be explained in either of two ways. Certain fundamental relationships in circuit theory may be compared to their analogues in a mechanical system, or a comparison may be made between the differential equations governing the actions of the two systems. The analogy is probably most easily explained by comparing the differential equations of the two systems. The equation for an electrical circuit containing a resistance *R*, an inductance *L*, and a capacitance *C* in series, and acted on by a voltage *e* producing a current *i* is

$$e = L\frac{di}{dt} + Ri + \frac{1}{C}\int i\,dt$$

Or

$$e = L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{q}{C}$$

where *q* is the charge. For a simple mechanical system containing a mass *M*, a stiffness *K*, a resistance *R*, and acted on by an alternating force *f*, producing alternating velocity *v*, the differential equation is

$$f = M\frac{dv}{dt} + Rv + K\int v\,dt$$

By using the term compliance *C* as the reciprocal of the stiffness *K*, this equation may be written in the same form as the electrical equation

$$f = M\frac{dv}{dt} + Rv + \frac{1}{C}\int i\,dt$$

$$f = M\frac{d^2x}{dt} + R\frac{dx}{dt} + \frac{x}{C}$$

where *x* is the displacement. From these equations we can set up the analogue where:

Mass is analogous to inductance.
Compliance is analogous to capacitance.
Mechanical resistance is analogous to electrical resistance.
Velocity is analogous to current.
Displacement is analogous to charge.
Force is analogous to voltage.

Electrical Equations and Analogies

These analogies may be seen more easily by some if they are explained in terms which are every-day language to every engineer and technician. We know that an inductance offers an impedance to a change in current when a voltage is applied, and that a mass offers an impedance to a change in velocity when a force is applied. So we can say:

Mass is analogous to inductance;
Force is analogous to voltage; and
Velocity is analogous to current.

In an electrical circuit we all remember the equation

$$q = Ce$$

where *q* is the charge on a condenser, *C* is the capacity, and *e* the voltage. We also know that in a mechanical system the displacement *x* in the case of a force *F*, acting on a spring, is proportional to the force and inversely proportional to the stiffness *K*. If we use the term compliance *C* as the reciprocal of the stiffness *K*, the analogy to the electrical equation may be written as

$$x = fC$$

Therefore we can say:

Displacement is analogous to charge
Compliance is analogous to capacitance.

In the case of resistance the analogy is very nearly obvious. The force required to overcome a resistance is proportional to velocity, therefore, we may write Ohm's law in an electrical circuit as

$$e = Ri$$

and in a mechanical circuit as

$$f = Rv$$

By this time we may start worrying about units. Our units in electrical systems such as ohms, henries, farads, volts, amperes, and coulombs are so well known that one may start thinking in terms of mechanical henries, mechanical farads, etc., but the fears are groundless. We could devise a system and call the units mechanical farads, mechanical henries, etc., and be perfectly correct, but it is much simpler to use the units with which we are already familiar in the metric system. Using the metric system Table 1 gives the electrical system with its quantities and units along with their analogous mechanical quantities and units.

Some electrical equations with which we are all familiar and their mechanical counterparts are shown in Table 2.

TABLE 1

MECHANICAL			ELECTRICAL		
Quantity	Unit	Symbol	Quantity	Unit	Symbol
Velocity	Cm./Sec.	v	Current	Ampere	i
Force	Dyne	f	Voltage	Volts	e
Displacement	Centimeter	x	Charge	Coulombs	q
Mass	Gram	M	Inductance	Henry	L
Compliance	Cm./Dyne	Cm	Capacitance	Farad	Ce
Resistance	Dyne/Cm./Sec.	Rm	Resistance	Ohms	Re
Reactance	Dyne/Cm./Sec.	Xm	Reactance	Ohms	Xe
Impedance	Dyne/Cm./Sec.	Zm	Impedance	Ohms	Ze

in Acoustic Design

Resolution of Mechanical System into its Electrical Equivalent

A. M. WIGGINS
Electro-Voice, Inc.

TABLE 2

ELECTRICAL	MECHANICAL
$e = Ri$	$f = Rv$
$q = Ce$	$x = Cf$
$X_L = j\omega L$	$Xm = j\omega M$
$X_C = \frac{1}{j\omega C}$	$X_C = \frac{1}{j\omega C}$
$Z_E = R + j\,(\omega L - \frac{1}{\omega C})$	$Z_M = R + j\,(\omega M - \frac{1}{\omega C})$
$fo = \frac{1}{2\pi\sqrt{LC}}$	$fo = \frac{1}{2\pi\sqrt{MC}}$
$e = \frac{q}{C}$	$f = kx = \frac{x}{c}$
Kinetic Energy $= \frac{Li^2}{2}$	Kinetic Energy $= \frac{Mv^2}{2}$
Potential Energy $= \frac{Ce^2}{2}$	Potential Energy $= \frac{Cf^2}{2}$
$e = L\frac{di}{dt} = L\frac{d^2q}{dt^2}$	$f = Ma = M\frac{dv}{dt} = M\frac{d^2x}{dt^2}$
$e = \frac{1}{C}\int i\,dt = \frac{q}{C}$	$f = \frac{1}{C}\int v\,dt = \frac{x}{C}$
$i = C\frac{de}{dt}$	$v = C\frac{df}{dt}$

Acoustical Analogies

Nothing has been mentioned about acoustical systems. These are, of course, modifications of the mechanical system, and are mechanical vibrations in gases or liquids. To avoid getting involved in another set of equations and units, we can treat an acoustical system as a mechanical system. Mass, compliance, and resistance may not be so readily recognizable in acoustical circuits as in mechanical circuits. If sound must go through a restricted enclosure, such as a tube or pipe, it must move a mass of air through the tube. The mass can be calculated by calculating the volume in the tube and multiplying by the density of air or whatever the fluid may be.

The velocity of this vibrating column of air will be proportional to the cross sectional area of the tube. Therefore, to obtain the effect on a diaphragm of the mass of this vibrating column of air, the mass of the air must be multiplied by the ratio of the square of the area of the diaphragm to the square of the cross-sectional area of the column of air. This is similar to a transformer in an electrical circuit where the reflected impedance is proportional to the ratio of the square of the number of turns.

A stiffness in an acoustical system usually takes the form of a volume of air or other fluid which, if acted on by a pressure, offers an impedance to being compressed. The compliance acting on a diaphragm, due to a volume of enclosed air or other fluid back of it, may be calculated by the equation

$$C = \frac{v}{\rho c^2 A^2}$$

where ρ is the density, c is the velocity of sound in the medium, V is the volume, and A is the area of the diaphragm. The effect of a mass or compliance is the same whether it is of a solid or a fluid form, so long as its dimensions are small compared to the wave length of sound. In an acoustical or mechanical circuit as in an electrical circuit, the parameters cannot be treated as lumped constants when the wave length is proportional to the dimensions of the parameters, and must be treated as distributed constants. The velocity of sound is very low compared to the velocity of electrical waves, therefore the wave lengths are very short for comparatively low frequencies. The wave length of 5000 cycles, for example, is less than three inches. This corresponds to a frequency of more than 4000 megacycles in an electrical circuit.

A very familiar and concrete example of the similarity between electrical and acoustical problems can be seen in the unidirectional microphone whose operation is analogous to the operation of a unidirectional antenna using a combination of vertical and loop antennae. In the microphone this is accomplished by using a combination of bi-directional and non-directional microphones.

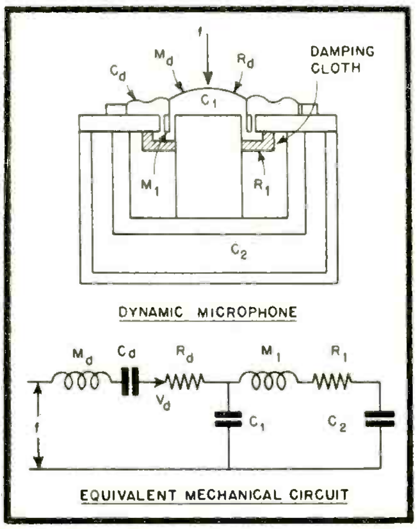


Fig. 1. Equivalent mechanical and electrical networks for microphone assembly

It is sometimes difficult for one not skilled in the art to draw the analogous circuit of a mechanical system. A microphone is shown in *Fig. 1* with the various mechanical and acoustical parameters labeled, and the equivalent mechanical circuit drawn. The force on the diaphragm due to a sound pressure is f. The diaphragm is represented by a mass M_d, a resistance R_d, and a compliance C_d. The volume of air C_1, back of the diaphragm must be compressed before any air will flow through the air gap; so it is analogous to charging a capacitance. This is then represented by a capacitance to ground. After the volume of air is compressed, the mass of air in the air gap must be moved; this is represented by M_1. This air must go through the damping cloth behind the air gap. This presents a resistance R_1 to the flow of air. After the air flows through this resistance, it has nowhere to go, so the remaining force is used to compress the volume C_2. From this diagram it is seen that the volume of air C_2 adds its stiffness to the stiffness of the diaphragm. Since the response of the microphone is proportional to the velocity of the diaphragm, the response may be calculated by calculating V_d as shown in the equivalent circuit. For a flat response the resistance R_1+R_d must be the controlling factor in the circuit, in other words R_1 must be large compared to the total mass reactance (ωM) or the reactance of the total compliance $(1/\omega C)$ in the circuit. Resonances of the reactive components may be utilized to extend the range or modify the frequency response.

Mechanical analogy is an indispensable tool for determining the kind of mechanical impedance which is desirable for certain applications such as speakers, microphones, vibration control, phonograph pickups, servo mechanisms, etc. There are so many ramifications to this subject that it would take a text book to cover it completely. Some good books on this subject are listed below from which much of the subject matter in this article was borrowed.

Bibliography

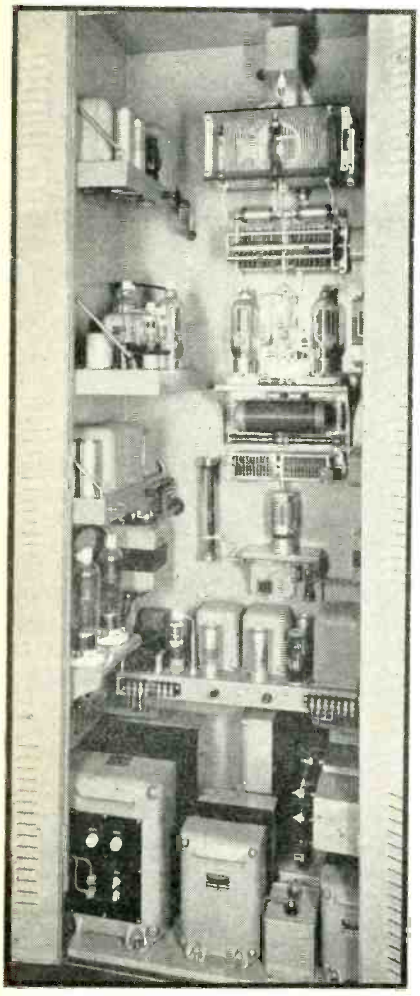
Olson, *Elements of Acoustical Engineering*, D. Van Nostrand Co., New York
Olson, *Dynamical Analogies*; D. Van Nostrand Co., New York
Olson and Massa, *Applied Acoustics*; P. Blakiston Son & Co., Philadelphia
Everitt, *Communication Engineering*; McGraw-Hill, New York.
Stewart and Lindsay, *Acoustics*; D. Van Nostrand Co., New York

Modern AM TRANSMITTER DESIGN

With flat frequency response from 30 to 10,000 cps, this transmitter uses precision remote tuning of triode RF and PA stages

W. E. PHILLIPS and CHARLES PROBECK
Raytheon Mfg. Co.

During the past five years, interest has been focused upon the increase in transmitter fidelity made possible by frequency modulation. At this same time, although little has been said about it, substantial progress has been made in improving the performance of conventional amplitude modulation transmitters. In fact, for nearly ten years, the performance of the best broadcast transmitters has far exceeded the fidelity possible with average broadcast receivers until, at the present time, the performance of truly modern a-m broadcast transmitters, with regard to fidelity, is practically equal to the performance standards of fm.



Interior of 250-watt AM transmitter. Silent natural draft ventilation is used

Improvements in a-m transmitter performance have been along the lines of greater dependability and freedom from program interruptions, savings in power consumption, wider frequency response, lower distortion and lower noise level. Carrier frequency stability has also steadily improved until most standard broadcast stations, having modern equipment, are able to maintain their carrier frequency with an error of only one or two parts in a million.

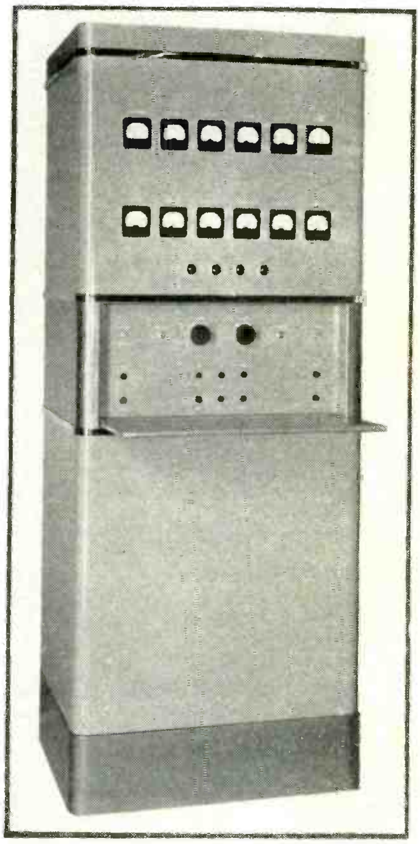
Dependability has been greatly increased by the use of better and more conservatively rated components. For example, the development of oil-impregnated capacitors has produced a marked decrease in failures due to punctured capacitors. Improvements in wire-wound resistor construction have nearly eliminated failures due to resistors becoming open-circuited. Experience has led designers to use resistors and capacitors well below maximum rating in the interest of long life and freedom from failure.

Modern transmitters are much more efficient and require less power input for given output than before. The use of a-c operated filaments and the use of mercury-vapor rectifiers for plate supply have practically eliminated rotating equipment.

High-Level Modulation

The design trend is away from low level modulation systems and toward systems using high level modulation of the final amplifier with Class B modulators. The substantial decrease in operational cost produced by transmitters of better efficiency has gone hand in hand with longer tube life and a decrease in cost per hour for tubes.

The frequency response of broadcast transmitters has been greatly improved because of better transformer design, wider appreciation of the selectivity requirements of tuned circuits and the use of inverse feedback. The best modern broadcast transmitters now have uniform response from 30 to 10,000 cycles within about 1 db which is considerably better than any commercially available receiver and loud speaker.



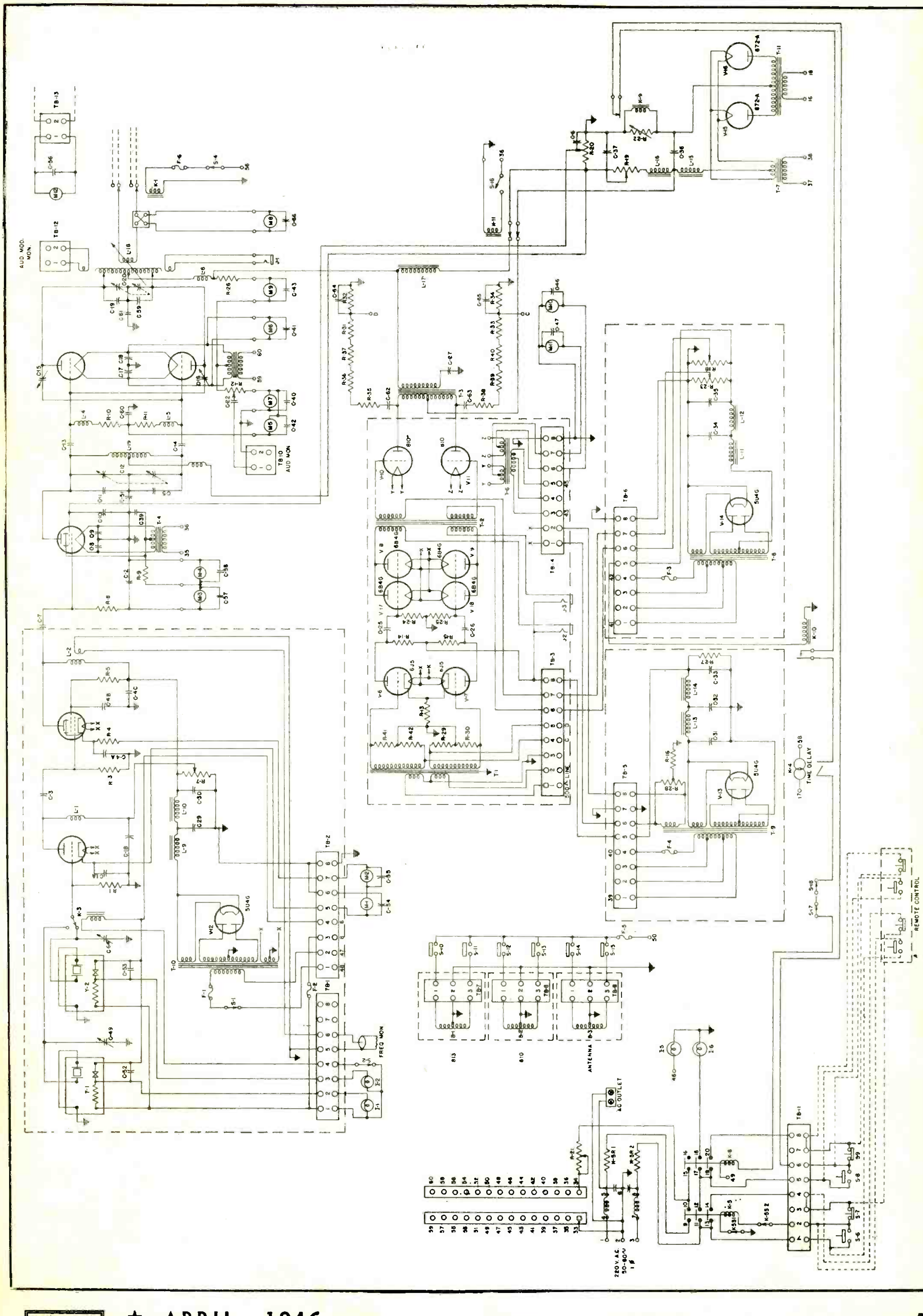
Front view of transmitter. Micrometer tuning control is obtained from push buttons on control panel

Marked reduction in harmonic distortion has been the most significant improvement in broadcast transmitters. The use of high level modulation systems has contributed materially to the reduction in distortion by eliminating the necessity for complex and critical adjustments of linear amplifiers. Better design of modulation transformers and reactors has reduced distortion particularly at low frequencies. Use of inverse feedback has considerably lowered distortion levels. The best present-day practice is to keep the distortion below 2½ per cent at 100 per cent modulation.

Polyphase Filament Operation

Lower noise level has been attained by better design in filter circuits, by

[*Continued on page* 52]



Schematic diagram of transmitter. Adjustment of two tuned circuits puts transmitter in operation on a given frequency

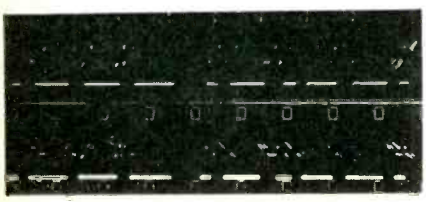
D-F FOR STATIC PULSES*

Origin of storms 2000 miles away can be determined by radio, using "Sferics" technique

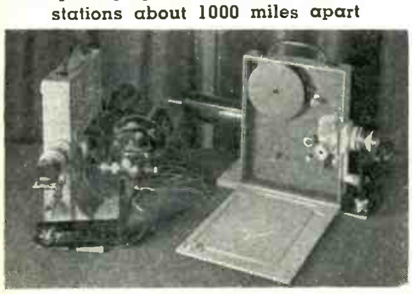
Static 2,000 miles distant writes its own autograph on the face of a cathode-ray tube. The incoming noise signal draws a straight-line flash, and the angle of this disturbing outburst points to the direction of origin of the particular crash of static.

This direction finder, war born and a lip-sealed secret until recently, is the brain child of at least three organizations — the University of Florida, the Army Air Forces Center at Orlando, and the Evans Signal Laboratory in Belmar, New Jersey. Locating severe tropical storms by this so-called "Sferics", or static, apparatus, as a weapon of war, it intercepted storms in the Pacific theater of flying and thus minimized aircraft losses. Information deduced from the straight-line flashes on the cathode-ray tube was regarded as invaluable in calculating conditions for navigating bombing machines over enemy areas and in directing airplanes around territory of turbulence caused by electrical storms — the foster mother of static. Eighteen of these storm locators were employed during the war and they proved their worthiness as reliable storm-locator systems.

***See also "Radio Weather Forecasting," Ferrell, RADIO, August 1943**

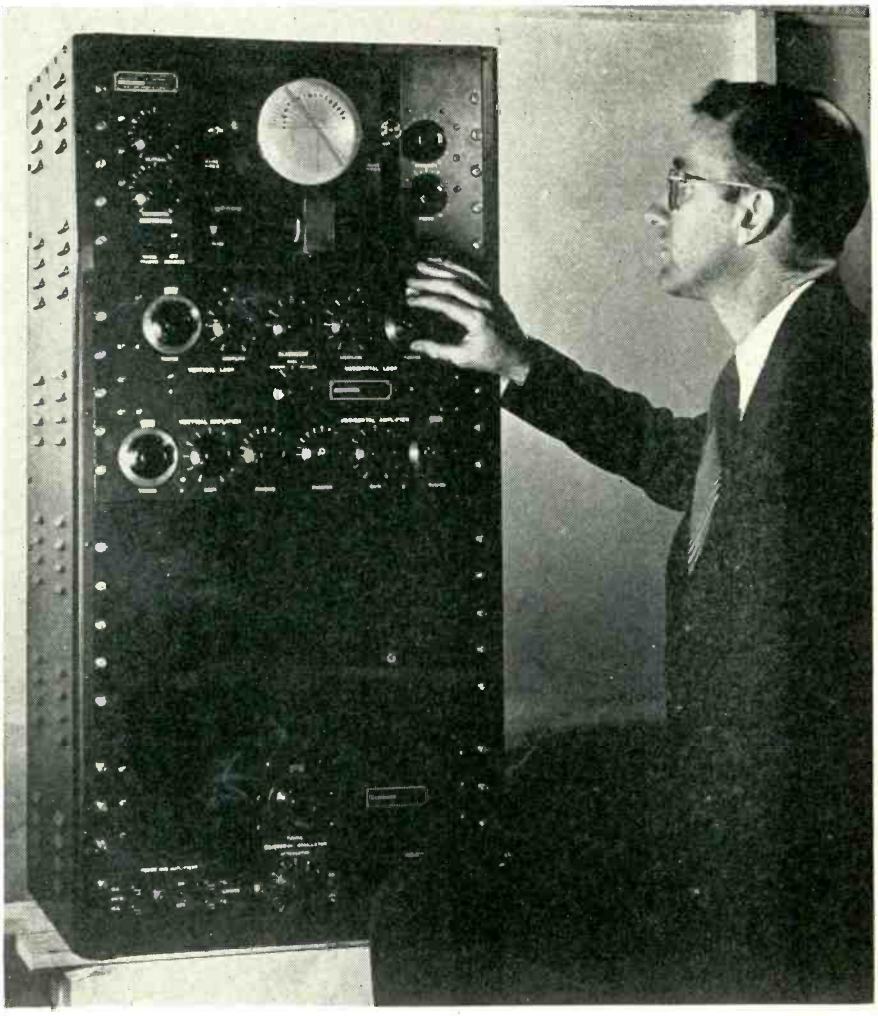


Static photographed simultaneously at two stations about 1000 miles apart



Special camera constructed for photographing static at Univ. of Florida

Photograph of accumulative static during fifteen-second intervals



Dr. H. L. Knowles of the physics department of the University of Florida tests 'Spherics' equipment built in the engineering experiment station

As a weapon of peace, this direction finder holds promise for use by commercial airlines, as well as private airplanes, in fixing the position of an impending storm and then steering clear. Static is a common nuisance to the average radio listener — an annoyance about to be squelched by the ultimate licensing of 2,000 static-free FM broadcast stations — but to aircraft and their passengers it is a bugaboo of menacing proportion. That's why the weather bureau is interested in this novel direction finder — another ally in forecasting weather conditions along the routes of our peace-time expanding passenger airlines.

Meteorologists had been for some time familiar with the phenomenon that certain weather conditions were attended by violent electrical disturbances. These outbursts are responsible for the crackling and grinding noises — the bugaboo of all radio fans. This static direction finder gives a "picture" of a storm's direction — and it can determine the origin, although 2,000 miles away, within a few minutes. This is possible through a network of static-finding stations which take observations on the same electrical flashes at the same time.

Although this storm-locating system was first used as an instrument of war, the science of "Sferics" was introduced as a well-planned project about eleven years ago at the University of Florida.

The work at the University of Florida was carried on under the direction of Dean Weil, Dr. P. H. Craig, and Dr. H. L. Knowles, all of Gainesville. Laboratory engineers who developed the device were William J. Kessler of Lakeland, Ovid R. Gano of Gainesville, C. A. Moreno of Palo Alto, Wallace Zetrouer of Rochelle, Ralph Tygert of Jacksonville, Prof. R. A. Thompson of Miami, Dr. R. C. Williamson and Dr. A. A. Bless of Gainesville. Mechanical work was also done by R. A. Keens, John C. Henry, E. E. Bailey, all of Gainesville, and R. G. Beasley of Bradenton.

Major General H. C. Ingles, Chief Signal Officer, recently wrote Dr. John J. Tigert, president of the University of Florida, thanking the University for its contribution to the war effort. The laboratory developed and constructed units of the direction finder and also established a network of stations, instructing Army Air Forces Center personnel in use of the equipment.

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

Method for Neutralizing Static Charges on Aircraft

★ Recently Gilbert J. C. Andresen was awarded a patent on a system that allows an airplane to get rid of an unwanted electric charge by causing more or less charge of the desired polarity to be discharged as ions in the exhaust gases. This arrangement is needed because air friction and the operation of the engine often produce a static charge on the airplane which sometimes causes corona discharge from metallic surfaces and interferes with the operation of the aircraft radio equipment.

One form of the invention is shown in the diagram. Exterior to the airplane and in the slip stream of the propeller is mounted a test plate, electrically insulated from the metallic body of the airplane. This plate is connected to one arm of a vacuum-tube bridge circuit and any small voltage difference between the plate and the body of the aircraft unbalances the bridge. When the aircraft is flown under conditions which would normally cause a static charge and a potential above that of the surrounding atmosphere, both the body of the aircraft and the test plate become charged to a voltage of the same polarity. Because of the differences in geometry, the potentials differ, and consequently the bridge becomes unbalanced. The direction of the unbalance depends upon the polarity of the charge and operates a sensitive relay. As the relay moves away from its neutral position, contacts are made which connect a battery between the body of the airplane and an insulated section of the exhaust line. If the airplane has a positive charge relative to the surrounding atmosphere, the unbalance currents cause the relay to connect the positive terminal of the battery to the exhaust pipe section. This positive voltage draws negative ions out of the exhaust gases and returns them to the body of the airplane by way of the battery and leaves the exhaust gases with a net positive charge which is blown out with the exhaust gases.

When the airplane acquires a negative voltage charge, the relay moves the other way and creates a negative polarity so as to capture positive ions while the excess negative ions are eliminated with the exhaust.

The patent, No. 2,386,647, is unassigned.

Radio Receiver

★ A receiver which does not employ a.v.c. but is nevertheless able to avoid extreme noise conditions is described in a patent issued to Howard Corey Lawrence recently. The system is applicable only to the reception of i-c-w code signals and is presumed to be of particular value in applications where it is desired to measure relative signal strengths so that an a-v-c circuit is precluded.

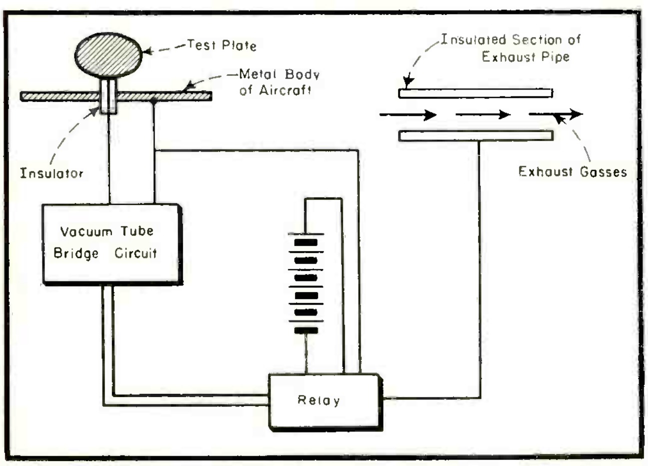
The accompanying drawing illustrates the principles of the invention. The output from the last i-f stage of the receiver is mixed with a signal from a local oscillator to produce a 1000-cycle audio note whenever the carrier is present.

In the present invention this mixture of frequencies is applied to the detector with a gaseous discharge tube shunted across the i-f signal input. This tube limits the strength of the signal to a degree determined by the magnitude of a resistor connected in series with the tube.

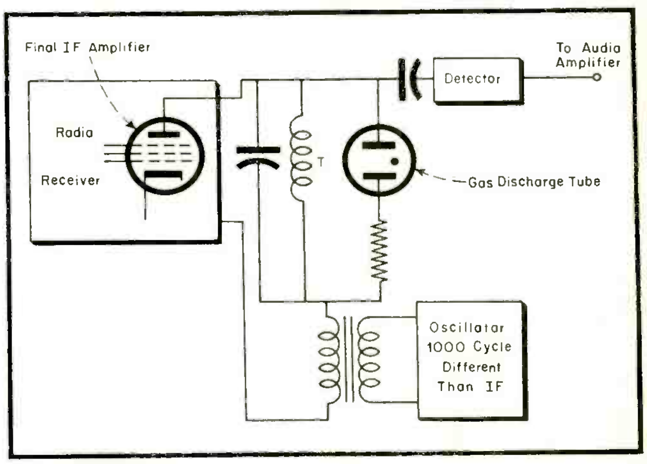
The patent, No. 2,387,666, is assigned to RCA.

Radio Control Unit with Interference Suppression

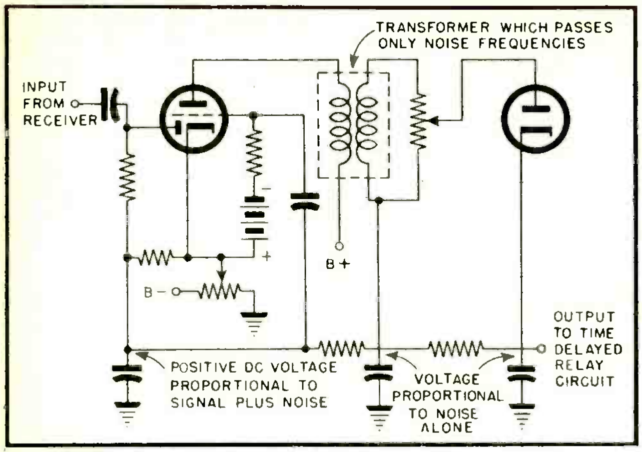
★ The remote control of radio equipment is considered in a patent issued to Carleton D. Haigis recently. According to the letter of patent it is often desired to remotely open or close



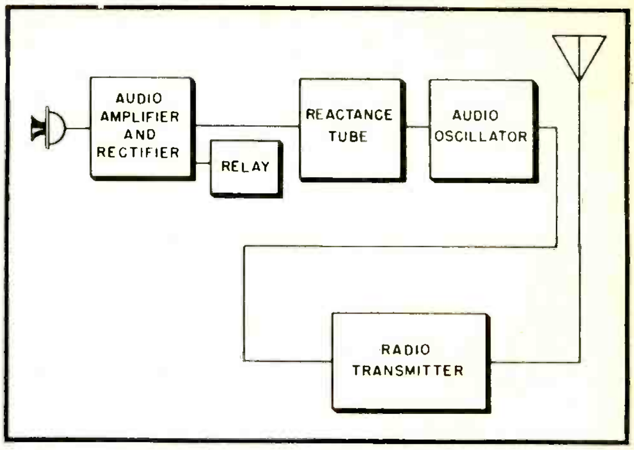
Patent No. 2,386,647



Patent No. 2,387,666



Patent No. 2,379,799



Patent No. 2,382,557

a set of relay contacts in accord with the presence or absence of a radio signal as for example in an unattended radio relay transmitter which is to be tuned to a given channel in accord with the reception of a signal on a particular radio frequency through one of several radio receivers tuned to various frequencies.

In performing such an operation it is normally difficult to insure that such control signals will not be falsely received because of noise received on an unused channel. Especially because a system of this sort is frequently used at times of poor reception conditions in order to search for the most satisfactory channel, it is important that relatively weak carrier signals shall be able to maintain control and yet that the control shall be insensitive to noise or to changes of noise level.

The invention, which meets the above requirements, is primarily based upon the fact that practically all noise signals which cause interference have frequency components which are spread evenly throughout the frequency spectrum. Because of this it is impossible to separate signal from noise by methods of frequency filtering, but conversely it is possible to select a portion of the spectrum which will give a noise signal and be relatively free of the transmission signal even though intelligence is present in other frequencies in the same receiver. After rectification the present invention balances the d-c voltage arising from such a frequency band against a d-c voltage obtained from the whole frequency band. No matter what noise level is present, the two voltages approximately cancel each other unless the carrier is present so that one is sensibly larger than the other. The present invention, which is in part shown in the accompanying diagram, uses such an unbalanced voltage to close a relay whenever such an unbalanced condition persists for several seconds.

The patent, number 2,379,799, is not assigned.

Obstruction Warning Device

★ It has long been thought that some advantage, such as cloudy and stormy weather operation, would be incurred by the use of radio transmitters in the place of lights as a warning to aircraft of obstructions. Many of the usual objections to such a scheme have been removed in a system described by Elmer E. Frazier in a patent issued recently. For one thing, radio marking of obstructions requires the airplane to carry a receiver which is kept constantly tuned to the frequency of the transmitter located at the obstruction. Since the obstruction in which a given airplane is interested is not known, this necessarily requires that all such obstruction warnings be done on a single frequency and that all aircraft carry a special receiver constantly sensitive to that one frequency.

This is also necessary in order to keep the weight of the aircraft equipment to a minimum and insure that the pilot will not accidentally set up a wrong frequency. Such a system, however, gives rise to interference from adjacent obstruction markers unless some intermittent arrangement such as the one recommended in the present invention is used. Also a strong argument in favor of intermittent operation is contained in the power requirements and life of such radio warning beacons.

Because of the necessity of locating the radio transmitters at relatively inaccessible places such as mountain tops, the equipment must run unattended for considerable periods of time. In the present invention the power vacuum tubes are turned on only when an aircraft comes within a certain range of the obstruction in question.

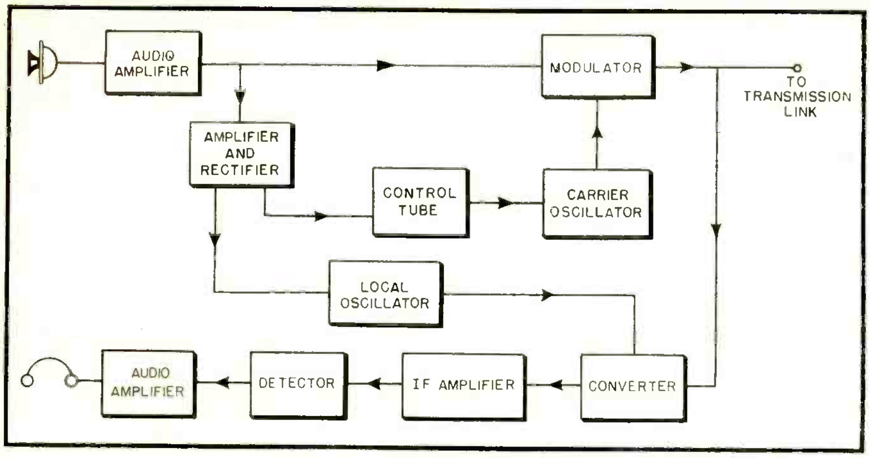
As may be seen by the block diagram which is included with this summary, the obstruction warning equipment includes a microphone and an audio section as well as a small standard transmitter. Whenever an airplane comes near the warning device, the sound of the aircraft motors is picked up by the microphone and amplified so as to close a relay and hence energize the radio transmitter. Special filters may be included so that noises which do not have the general character of an internal combustion engine will not operate the relay. The carrier frequency of the transmitter is modulated by an audio oscillator and the frequency of the transmitter is modulated by an audio oscillator and the frequency of that audio oscillator is controlled by a reactance tube which in turn is operated in accordance with the loudness of the audio signal received by the microphone.

Thus when an aircraft approaches an obstruction, the noise of the motors will first close the relay and cause its pilot to hear a characteristic warning tone. If the airplane continues to approach the obstruction, the pitch of that tone will rise because the louder sound at the microphone will provide a higher voltage input to the reactance tube. Upon noting such a rise in pitch, the pilot will alter the course of the aircraft until the noise is found to remain constant or decrease in frequency, indicating that his separation from the obstacle is no longer decreasing.

The patent, number 2,382,557, is assigned to the Bendix Aviation Corporation.

Two-Way Carrier Wave Signal Transmission System

★ A patent on automatic switching of radio equipment from receiving to transmitting arrangement was issued to Leland K. Swart recently. During transmission, an ocsillator forms the carrier wave frequency, and plate amplitude modulation of that signal is obtained in a modulator tube. During reception, an oscillator beats with the carrier frequency to produce an intermediate frequency which is amplified and detected as in any superheterodyne receiver. When not in use, both terminal equipments are left in a receiving condition but any word spoken into either microphone causes that particular terminal unit to become a transmit-



Patent No. 2.386.515

ter. This is accomplished either by causing the voltage generated by the voice to change the frequency of a local oscillator so as to make it serve as a carrier source, or, alternatively, the voice currents may turn off a local oscillator and energize a carrier oscillator in its place. Other features are that the changeover is made so rapidly that no appreciable portion of the first word is lost, yet smoothly enough to avoid unwanted noises.

In the preferred embodiment shown, two separate oscillators are used with the receiver local oscillator tube normally biased to permit oscillation but with the carrier oscillator biased to cutoff. Signals from the microphone are amplified and then applied to the grid of another amplifier tube as well as to the modulator. The output from the extra amplifier is divided into two parts, each of which is rectified and connected across a condenser which becomes negatively charged when the microphone is used. One of these negative voltages is used to turn off the local oscillator by biasing its grid into the cut-off region and the other biases off a control tube whose resulting increase in plate voltage overcomes the cut-off bias on the carrier oscillator.

The patent, No. 2,386,515, is assigned to the Bell Telephone Laboratories.

High Frequency Receiver

★ George G. Young was awarded a patent recently for a receiver which automatically adjusts its gain characteristics for code or voice reception conditions. Any receiver, no matter how well made, can supply only so much amplification before thermal noise in the input circuits is so greatly amplified that weaker radio signals are undecipherable.

If a receiver is built to produce maximum amplification for voice signals without obtaining intolerable thermal noise amplification, then when it is switched over for code reception, the amplification is increased and the noise components of the signal become too great. The present invention is a method of reducing the gain of the receiver during telegraphic reception so that thermal noise is never amplified to an objectionable level.

As shown in the diagram, the invention uses a superheterodyne receiver and is shown in block form except for the final stage of the intermediate frequency amplifier and oscillator. During code reception the oscillator inserts a signal into the last i-f stage to beat with the i-f signal and form an audio tone. During voice reception the oscillator is biased so as to become inactive and the final i-f stage then acts only as an amplifier. Whether or not oscillation is obtained depends upon the position of a switch. This switch is the only adjustment necessary to change from code to voice reception.

The present invention is contained in the fact that when the switch is closed, the bias of the oscillator tube is not only adjusted so as to allow oscillation, but also that oscillation causes the average level of the control grid of the final i-f amplifier stage to become more negative so that the overall gain of the receiver is held constant rather than being increased because of the increased simplicity of the wave form to be received.

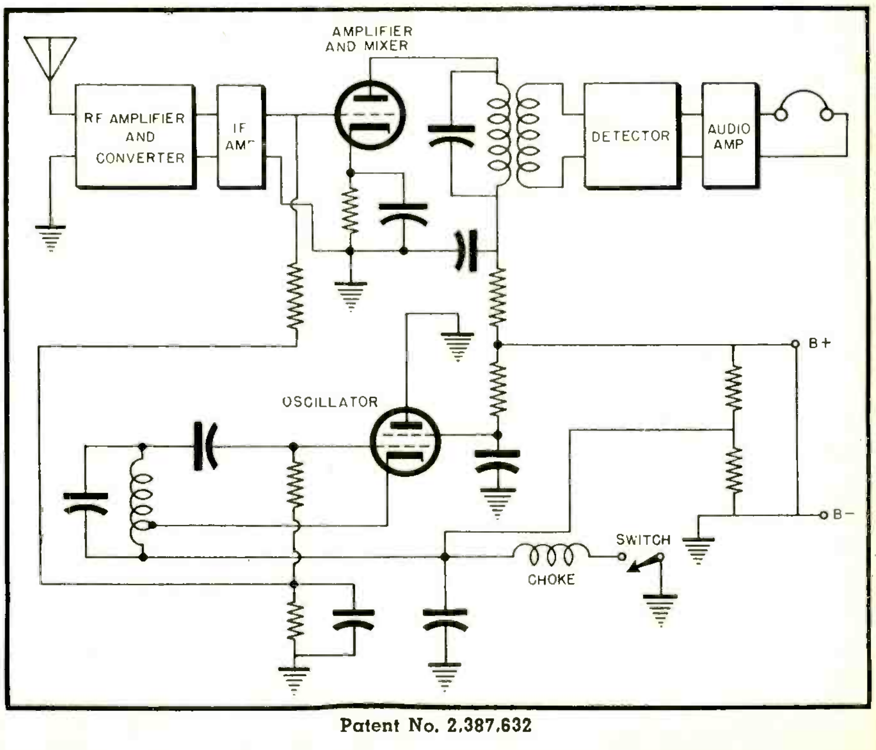
The patent, No. 2,387,632, is assigned to the General Electric Company.

Signal Transmission System

★ Alton C. Dickieson has been awarded a patent recently relating to volume compression and expansion. The chief advantages claimed for his system include the use of but a single variolosser circuit, no need to match the loss of two elements, and lower cost. A two-to-one compression ratio is obtained. This is the same ratio as has been realized in previously known arrangements where a so-called marginal detector is used in conjunction with two variolosser circuits.

The generic operation of this type of volume compressor may be stated as follows: Two identical units of controllable loss characteristics, which are called vario-lossers, are connected in series and controlled together. At the input to the first unit a signal having a normal variation of volume is applied. Because of the control of the lossers, the output of the second unit has essentially no volume variation. The desired degree of compression is half-way between these two extremes and is obtained by making a connection at the point where the two vario-lossers are connected together. The present inven-

[*Continued on page* 52]



Patent No. 2.387.632

RADIO DESIGN WORKSHEET

NO. 47 — BRIDGED T AND H ATTENUATORS; DIODE CONDUCTION

BRIDGED T AND H ATTENUATORS

Let Z = terminal impedance in ohms, pure resistance
db = attenuation in decibels
K = voltage or current ratio
R_1 = series arm resistance in ohms
R_3 = shunt arm resistance in ohms
R_4 = bridge arm resistance in ohms

Then $K = 10^{db/20}$
$db = 20 \log_{10} K$
$R_1 = Z$
$R_3 = Z/(K-1)$
$R_4 = Z(K-1)$

Example: Z = 450 ohms and attenuation = 20 decibels. R_3 = 50 ohms, R_4 = 4050 ohms.

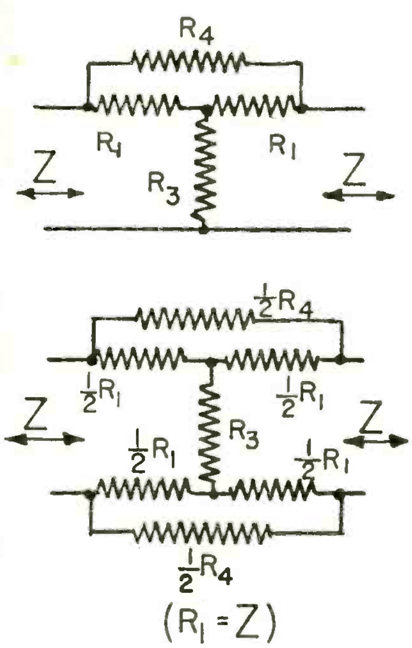


Figure 1

DIODE CONDUCTION

When the diode terminal characteristic, $i = kv^{1.5}$, is expanded in a Taylor's series, the effect of successive terms is to cause the tangent at the operating point to curve inwardly until it finally assumes the same shape as the characteristic itself. Thus the first three terms of this series are:

$i = I_b + (v-E_b)\,di/dv + \frac{1}{2}(v-E_b)^2 d^2i/dv^2 + \ldots$

all derivatives being evaluated at the operating point E_b, I_b. *Fig. 2* illustrates the significance of these terms: I_b is an ordinate intersecting the characteristic in the operating point; $I_b + (v-E_b)\,di/dv$ is the tangent to the characteristic at the operating point, and the sum of the three terms yields a curve situated between the tangent and the characteristic.

When Taylor's series is applied to the diode characteristic, it is accurate for the portion of the curve in the neighborhood of the operating point. It is not valid to extend Taylor's series over a point where the derivatives are discontinuous, such as 0, 0. As shown in *Fig. 3*, $i = kv^{1.5}$ has two branches in the real plane and two branches in the complex plane. Mathematically, negative voltage corresponds to imaginary current, but physically, negative voltage corresponds to zero current. Mathematically, current is a two-valued function of positive voltage; physically, positive voltage corresponds to positive current.

This situation frequently arises in radio engineering when empirical curves are employed. Child's law is an empirical equation, which has been selected because it expresses in a simple fashion what the relationship is between positive voltage and positive current. But it would be rash to overlook the fact that in the engineer's attempt to achieve simplicity, the empirical equation implies more than it should, and hence must be used with reservations. In using

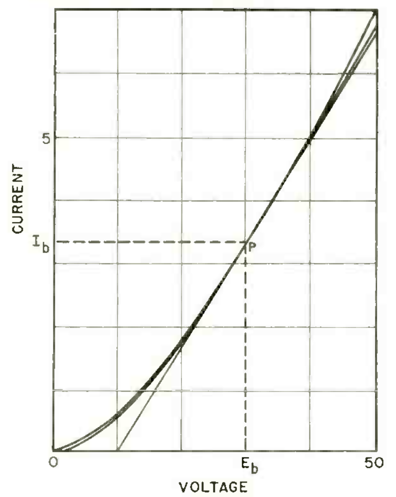


Figure 2

Child's law, it is understood that negative currents are discarded, and that it is forbidden to apply negative voltages. A diode is non-reactive, and imaginary currents are meaningless.

Sometimes a "force fit" is attempted by the substitution method, explained later and it has certain justification.

To analyze the diode characteristic past the point of zero plate voltage, or to operate over the wide range indicated by the heavy curve of *Fig. 3*, a Fourier series may be applied to obtain an analytical relationship free from objection. Fourier's series is written:

$$f(x) = 1/2a_0 + a_1\cos x + a_2\cos 2x + a_3\cos 3x + \cdots + b_1\sin x + b_2\sin 2x + b_3\sin 3x + \cdots$$

Where $$a_0 = 1/\pi\int_{-\pi}^{\pi} f(x)\,dx;$$

$$a_n = 1/\pi\int_{-\pi}^{\pi} f(x)\cos nx\,dx; \quad b_n = 1/\pi\int_{-\pi}^{\pi} f(x)\sin nx\,dx.$$

It is now desired to express i in terms of v, within operation limits which may may be defined as $+E$ to $-E$. To do this conveniently, let $v = \phi E/\pi$. Then when $v = E$, $\phi = \pi$. Accordingly,

$$i = 1/2\,a_0 + \sum_1^{\infty} a_n \cos n\phi + b_n \sin n\phi,$$

Where
$$a_0 = 1/E \int_0^E kv^{1.5}\, \pi/E\, dv,$$

$$a_n = 1/E \int_0^E kv^{1.5}\left(\cos \frac{n\pi v}{E}\right)(\pi/E)\, dv,$$

$$b_n = 1/E \int_0^E kv^{1.5}\left(\sin \frac{n\pi v}{E}\right)(\pi/E)\, dv.$$

Since i is zero from $-E$ to $v=0$, the limits of integration are from E to 0. To find the coefficients of the terms in the Fourier series, it is necessary to integrate the foregoing expressions for all non-negligible values of a_n and b_n. A coefficient may be considered negligible when less than 1% of the fundamental coefficient.

It is not possible to integrate by parts, since the exponent is not an integer. However, integration may be effected by series substitution for the sin and cos. This involves considerable labor, as a series must be evaluated for each coefficient of the Fourier series. A result is then obtained of the form:

$$i = \tfrac{1}{2}a_0 + a_1 \cos v + a_2 \cos 2v + a_3 \cos 3v + a_4 \cos 4v \ldots + b_1 \sin v + b_2 \sin 2v + b_3 \sin 3v + b_4 \sin 4v \ldots$$

This equation gives the current corresponding to any voltage within the operating limits from $-E$ to $+E$. By carrying out the series sufficiently far, the analytical relationship may be determined to any required degree of accuracy.

To determine the harmonics present in the current when a sinusoidal voltage operates over this characteristic, $E_1 \sin \omega t$ is substituted for v in the series defining the characteristic. The various harmonics are evaluated by expanding the trigonometric terms in Bessel functions.

Remainder in Taylor's Series

When $i = kv^{1.5}$ is expanded in a Taylor's series:

$$i = I_b + \left(\frac{di}{dv}\right)_{E_bI_b}(v-E_b) + 1/2\left(\frac{d^2i}{dv^2}\right)_{E_bI_b}(v-E_b)^2 + \cdots + \frac{1}{n!}\left(\frac{d^ni}{dv^n}\right)_{E_bI_b}(v-E_b)^n$$

it has been noted that E_bI_b is the operating point on the diode characteristic, the second term is the tangent to the characteristic at the operating point, and successive terms define functions which are situated closer and closer to the curve $i = kv^{1.5}$.

It is desired to find what error in the value of i is involved by using a certain number of terms, rather than the original function. For this purpose, the remainder of Taylor's series is employed:

$$R = \frac{(x-a)^{n+1}}{(n+1)!} f^{(n+1)}(\xi)$$

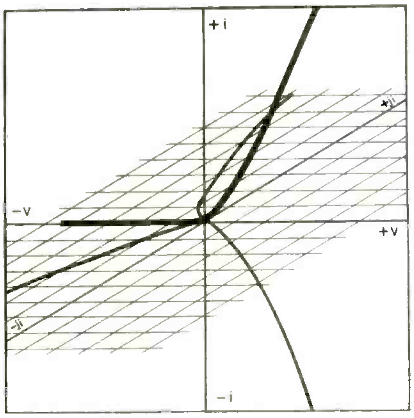


Figure 3

where the standard series is written with the notation:

$$f(x) = f(a) + (x-a)f'(a) + \frac{(x-a)^2}{2!} f''(a) + \frac{(x-a)^n}{n!} f^n(a) + R$$

and ξ represents the largest value between x and a; actually, this value of xi yields too large an error, but since the exact value of xi is unknown, this safety factor must be employed.

As an example, let $i = kv^{1.5}$ be expanded to five terms, and the error evaluated. Then:

$$R = \frac{(v-E_b)^5}{5!} f'''''(kv^{1.5})_{(\xi)}$$

When an alternating voltage is applied, which is usually the case in such an analysis, $v = E_1 \sin \omega t$, and goes through both positive and negative values; the maximum value of xi is then

$$|-E_1 - E_b|.$$

$$f'''''(kv^{1.5}) = -\frac{45}{32}kv^{-3.5}, \text{ and evaluated at xi,}$$

Equals
$$f'''''(\xi) = -\frac{45}{32}k(-E_1-E_b)^{-3.5}$$

If $k = 2\times10^{-5}$, $E_b = 3$ volts, $E_1 = 2$ volts, then $\xi = 0.065$ milliampere.

This figure represents an error that cannot be exceeded by employing five terms of a Taylor's series, when operating with arbitrary voltages indicated. An underlying assumption is that the diode characteristic is accurately expressed by Child's law, which is usually justified.

Power Series by the Substitution Method

When appreciable departures from Child's law occur, and the empirical equation (or measured data) must be worked up, a power series may be assumed:

$$i = a_0 + a_1v + a_2v^2 + a_3v^3 + a_4v^4 + \ldots$$

with the condition that the series will not be used for any regions of the curve which possess discontinuous derivatives.

As many i-v pairs of data may then be selected as there are unknown coefficients in the series, and each pair successively substituted into the equation, which gives a set of equations linear in the coefficients, to be solved simultaneously.

Having determined the coefficients by simultaneous solution, the power series for the terminal characteristic may be written.

When a linear resistance is employed in series with a non-linear resistance as shown in *Fig. 4*, the amplitudes of harmonics in the current flow are less than without the linear resistance. This is because the linear resistance "straightens out" the terminal characteristic of the circuit.

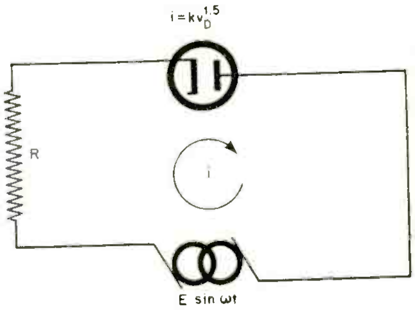


Figure 4

This terminal characteristic may be expressed as a Fourier series by the method which was discussed earlier, but it should not be forced into a power series. The terminal characteristic is discontinuous at the operating point 0, 0 and it is not valid to force a fit by the substitution method.

On the other hand, the circuit of *Fig. 5* may be fitted with a power series

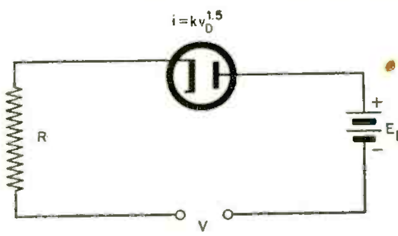


Figure 5

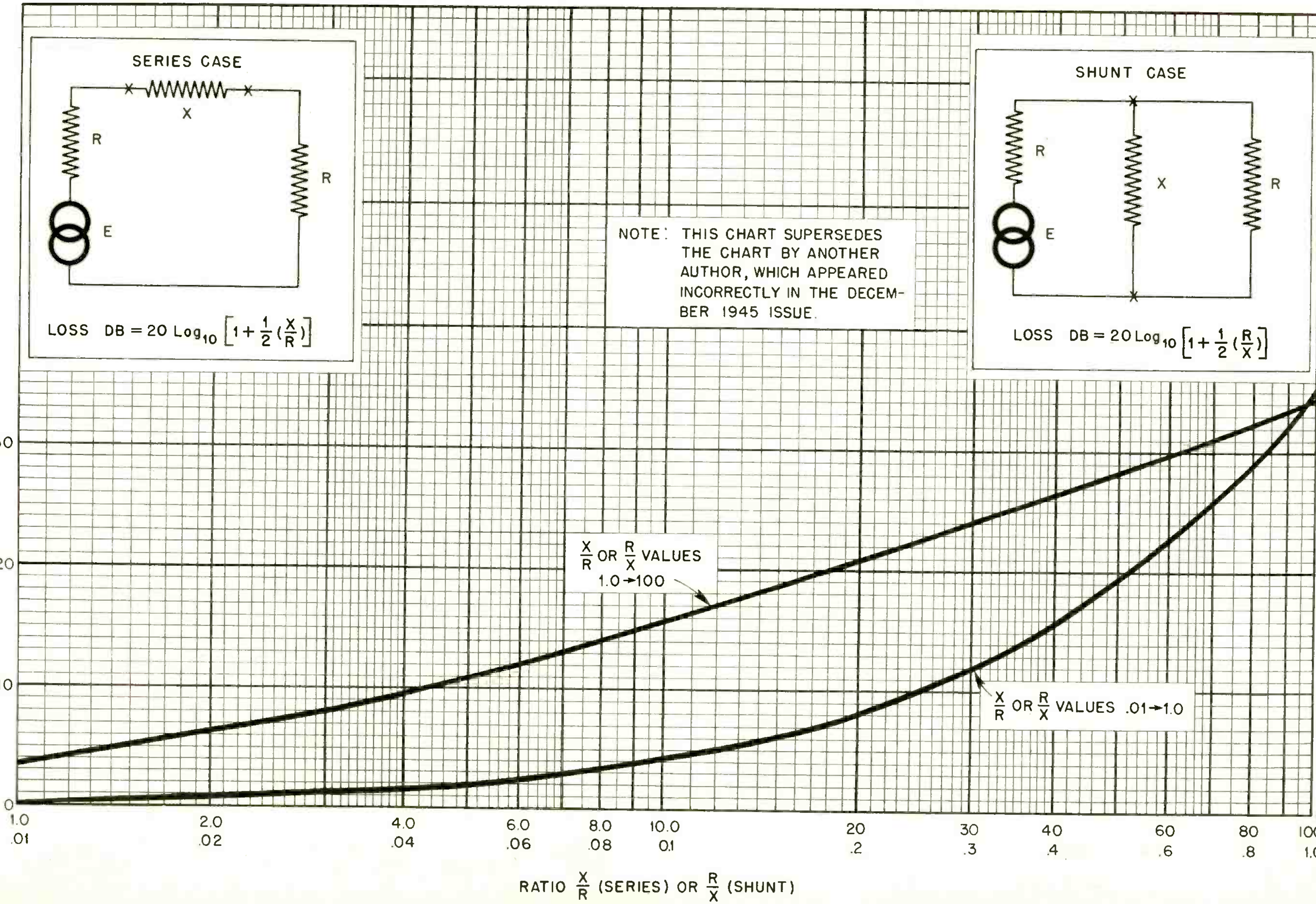
by the substitution method, with the condition that v is less than E_b. A sufficient number of i-v measurements may be made to obtain the required number of simultaneous equations.

An alternate analytical method is to employ the circuit equation in terms of Child's law:

$$i = k(v + E_b - iR)^{1.5}$$

since $v_D = (v + E_b - iR)$, squaring both sides to obtain a cubic equation, and solving for i with $v = 0$, which gives I_b. E_bI_b is the operating point, and with the required number of derivatives of the circuit equation, Taylor's series may be written for this R-diode-E_b circuit.

LOSS DUE TO SHUNT OR SERIES RESISTANCE INSERTED BETWEEN MATCHED SOURCE AND SINK



— C.W. Vadersen, Bell Tel. Labs.

What DOES Make a BETTER Loud Speaker?

WILL the possession of physical facilities and desire create a better product? No, because for all of their importance, these possessions are certainly not unique. All institutions have them to some degree. Is it fanciful claims and fluent use of superlatives in product description that make a product better? Obviously not. Is it the achievement of theoretically perfect performance in the laboratory? No, not that either, for perfection in such respects does not necessarily create the *practical ideal.*

The simple truth is that no product can be better than *know how* and the honest application of that *know how* as the product is created and its virtues described.

What is the yardstick of these ingredients in a product? The record of achievements and the list of contributions to the advancement of science and art is one good measurement. The First PM Speaker, the Bass Reflex Principle, the Hypex Formula are just a few of the advancements contributed to the industry by JENSEN. There is also the endorsement by those users and connoisseurs of Loud Speaker performance whose first and last emphasis is always on superiority. JENSEN Loud Speakers and Reproducers are the overwhelming choice of such people. Finally, and perhaps most important of all, there is the established custom of the manufacturer to make honest statements as to the *real ability* as well as *limitations* of the product. Here at JENSEN this has always been a fixed policy, an absolutely essential ingredient in *honesty of purpose,* even though by some standards it is called "selling down."

And so, a better Loud Speaker is created because of *know how,* achievement as shown by the record, significant endorsement and integrity of purpose from start to finish. JENSEN Loud Speaker Products, personnel and policy meet these requirements.

For those interested in the proper appraisal, selection, use and operation of Loud Speakers, JENSEN is publishing a series of Technical Monographs—of which five issues are now in print. Note the titles listed below and write for one or all of them.

5 MONOGRAPHS AVAILABLE

1. Loud Speaker Frequency-Response Measurements
2. Impedance Matching and Power Distribution
3. Frequency Range in Music Reproduction
4. The Effective Reproduction of Speech
5. Horn Type Loud Speakers

FREE to the Armed Forces, Colleges, Technical Schools, Libraries — **25c** Each

JENSEN RADIO MANUFACTURING CO.
6615 SO. LARAMIE AVENUE, CHICAGO 38, ILLINOIS
In Canada: Copper Wire Products, Ltd., 137 Oxford Street, Guelph, Ont.

Specialists in Design and Manufacture of Fine Acoustical Equipment

This Month

Intermodulation analyzer with its companion dual RC sine-wave oscillator, demonstrated by John Hilliard, Altec-Lansing engineer. Equipment to be tested receives its complex-wave input from the oscillator, delivering its output to the analyzer. Higher order components are recorded

UTAH EXPANDS TRANSFORMER DIVISION

Utah Radio Products, Chicago, a division of International Detrola Corporation, announces the expansion of its transformer division, particularly in the jobber and industrial fields. The number of types of transformers available from stock will now be more than double that before the war.

In addition to adding many new models to their post-war line, Utah has now established a special transformer division to manufacture special type transformers for specific applications. Included will be hermetically sealed types as well as the new hypersil transformers which Utah engineers helped to develop during the war.

Utah's new 1946 radio parts catalog covering the complete line of transformers not only for radio sets but for public address equipment, radio transmitting equipment, and other industrial uses, is now available.

MEASUREMENTS CORPORATION OPENS CHICAGO OFFICE

Frank M. Murphy has opened a Chicago Office at 21 East Van Buren Street and will serve as the sales representative of Measurements Corporation, Boonton, N. J., manufacturers of signal generators and precision test equipment.

Prior to his present position Mr. Murphy was associated with Mechtronics Corporation and the General Electronic Industries, Greenwich, Conn.

PLYMOLD PLANT

Quite recently the Plymold Corporation of Lawrence, Mass., announced the formation of a molded plywood division. The company has recently acquired additional buildings into which machinery and equipment to handle the increasing molded plywood business is being installed.

The company maintains a corps of engineers, each of whom is thoroughly experienced and versed in the technique of molding plywood into parts suitable for furniture, the manufacture of radio cabinets, and components for other fabrications in which solid wood and metal have heretofore been used.

G-R APPOINTEES

Ivan G. Easton has been appointed manager of the New York Engineering and Sales Office of the General Radio Company, succeeding Martin A. Gilman, who returns to the sales engineering staff at the Cambridge office.

Kipling Adams becomes manager of the Chicago office, succeeding Lucius E. Packard, who has resigned.

Personal Mention

Jack Siegel

★ Stamford Electric Products Company announces the appointment of Jack R. Siegel of White Plains, N. Y., as vice-president in charge of sales and advertising. Mr. Siegel, until April first of last year, was West Coast Manager of Philharmonic Radio Corporation of New York, which recently withdrew from the home receiver field. Jack Siegel brings practical sales and technical experience to his new appointment with Stamford Electric Products Company Inc.

The transformer division of Stamford Electric Products Company Inc. is launching a nation-wide national advertising and sales promotion program for its complete line of radio transformers, which will be sold through radio jobber organizations as well as to manufacturers of radio sets and electronic equipment.

Irving C. Brown

★ Irving C. Brown has been appointed sales manager of the industrial electronics division. Raytheon Manufacturing Co., Waltham, Mass., it was announced recently by John M. Cage, manager of the division.

D. W. Gunn

★ Transferred from the company's New York office, D. W. Gunn will now make his headquarters at Cleveland, Ohio, for the Radio Tube Division of Sylvania Electric Products. Working in the East Central Division he will cover the states of Michigan, Ohio and Indiana.

Mr. Gunn, who has been with the company since 1932, will work with equipment

D. W. Gunn

manufacturers in the radio field. His offices will be at 295 Union Commerce Building in Cleveland. He is a graduate of Northeastern University and a member of the Institute of Radio Engineers.

Richard E. Mathes

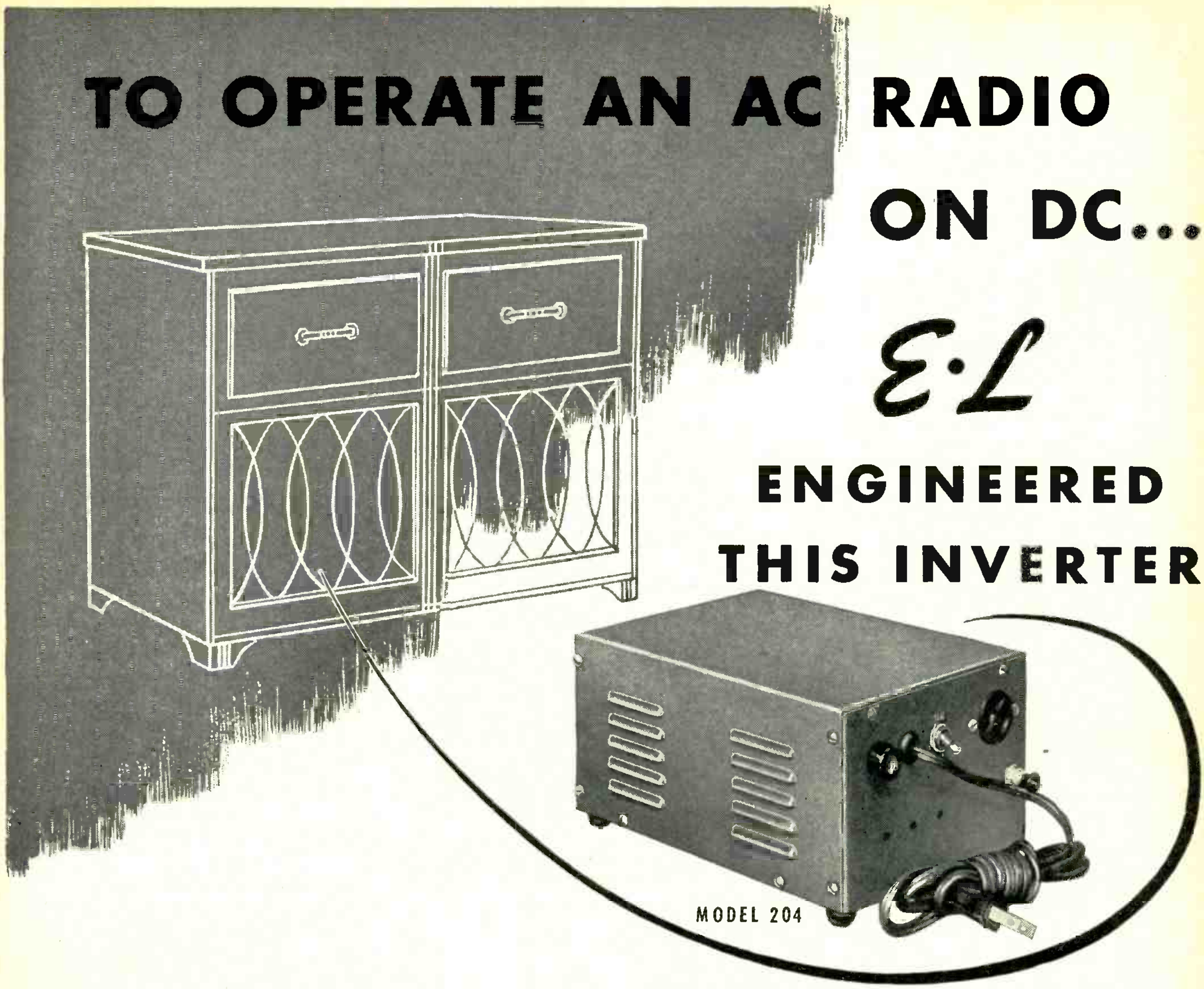
★ Capt. W. G. H. Finch, recently reelected president of Finch Telecommunications, Inc., of Passaic, N. J., specialists in facsimile equipment, has announced that Lieut. Commander Richard E. Mathes, USNR, has joined the company in the capacity of chief engineer and plant manager.

Mr. Mathes has recently been released from active duty in the Navy's Bureau of Ships, where he assisted Capt. Finch in

[*Continued on page* 47]

TO OPERATE AN AC RADIO ON DC...

E·L ENGINEERED THIS INVERTER



● Retailers and distributors of radios, appliances and similar products can now use to better advantage the storage and floor space once needed for special DC models.

And manufacturers can now say goodbye to the time-wasting labor once required in providing special models for the limited "DC market".

These great benefits are made possible and *practical* by E·L 's complete line of Vibrator Inverters . . . *efficient* DC to AC conversion units that give longer service and increased capacity at lower cost.

Proved in thousands of applications in war and peace, E·L Vibrator Inverters are extremely simple in design, have only *one* moving part, and are precision-constructed in every detail. The absence of brushes, armatures and bearings eliminates lubrication and other routine maintenance.

Get all the facts on E·L Vibrator Inverters! For products with new or unusual requirements, E·L engineers are equipped and ready to design special power supplies.

DC-AC INVERTERS

Electronic

LABORATORIES, INC.

INDIANAPOLIS

OFFICES IN 22 CITIES

There is an E·L VIBRATOR INVERTER *for each important application*

involving radios, appliances, communications equipment, electric motors, coin-operated equipment, public address systems, neon signs, electric razors and other products.

(Typical of 26 E·L Models available to meet your requirements)

MOD. NO	INPUT VOLTS DC	OUTPUT VOLTS AC	OUTPUT WATTS	LOAD P.F. (%)	DIMENSIONS (in.)	WT. (lbs.)	PRINCIPAL APPLICATIONS
307	6	115	100	80-100	10¾"x7½"x8¼"	23½	Radio Receivers, Appliances
507	12	115	150	80-100	10¾"x7½"x8¼"	25	Radio Receivers Transmitters, Appliances
146	32	115	350	80-100	16"x10"x8⅜"	48	Receivers, Transmitters, Coin Phonographs
204	115	115	150	80-100	3⅜"x6⅓"x4⅝"	12½	Radio Receivers, Appliances
268	115	115	750	80-100	20⅛"x11¾"x7½"	66	Motors, Communications Equipment

VIBRATORS AND VIBRATOR POWER EQUIPMENT FOR LIGHTING, COMMUNICATIONS, ELECTRIC AND ELECTRONIC APPLICATIONS

New Products

RADIO BROADCASTING EQUIPMENT — 1 KW FM TRANSMITTER, TYPE 503B-1
The Western Electric 1 kw FM Radio transmitter employs the Frequency "Watchman" Circuit for accurately controlling the carrier frequency of the transmitter. This unique system of synchronized frequency modulation makes possible the complete separation of the two functions of modulation and mean frequency stabilization, permitting the use of push-pull reactance control tubes for modulating the oscillator, so that ripples in bias or plate supplies do not modulate the frequency. The balanced circuit employed, together with other refinements in design, permits a frequency excursion of hundreds of kilocycles with very low distortion for all signal frequencies between 30 and 15,000 cycles. The transmitters are housed in modern cabinets styled by the well-known designer, Henry Dreyfus

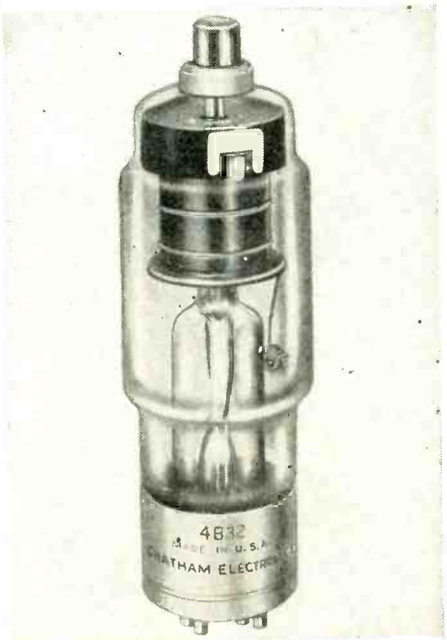
MASTER TESTER

A two-hundred-billion-to-one ratio in resistance measurements is available in the new comprehensive master tester by Reiner Electronics Co., 152 West 25th St., New York. Model 456 handles both laboratory and production testing, and features an unusually large number of measurements and ranges. The Reiner Master Tester is equivalent to 61 individual single range meters, with eight types of testers in one instrument: insulation tester, capacity meter, ohmmeter, a-c voltmeter, d-c voltmeter, a-c ammeter, d-c ammeter, impedance-inductance meter.

NEW RECTIFIER

This new 4B32 rectifier meets the expanding need for a rectifier having low voltage drop, high current capacity and ability to function in exposed locations without auxiliary heaters and controls.

Xenon filled, the 4B32 performs perfectly in ambient temperature from —70° to +90°C. There is no trouble from flashback throughout this temperature range provided ratings are not exceeded.



The tube is a product of Chatham Electronics, 475 Washington Street, Newark 2, New Jersey.

NOISE & FIELD INTENSITY METER

This 100-400 mc. instrument is useful in locating and indicating in microvolts, the amplitude of radio noise causing disturbance to radio reception in aircraft, landcraft, seacraft and other receiver locations, in determining the effectiveness of filtering and shielding electrical apparatus which produces radio noise at ultra high frequencies, and for indicating and recording in microvolts per meter the field intensity of A.M., F.M. and television transmitters.

The r-f amplifier, mixer and oscillator circuits use butterfly circuits.

These circuits maintain a high degree of stability and nearly constant value of resonant impedance which provides for substantially uniform calibration. Stability of calibration is determined by "shot noise" developed in the plate circuit of the r-f amplifier.

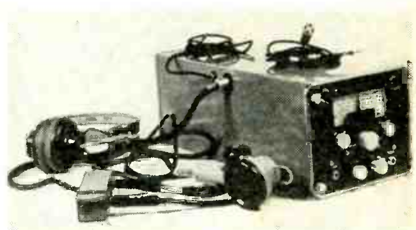
Voltage range is from 1 to 100,000 microvolts; field intensity range 5 to 100,000 microvolts per meter. Manufactured by Stoddart Aircraft Radio Co., 6644 Santa Monica Boulevard, Hollywood 38, California.

RAYTHEON RADIOPHONE

An entirely new two-way personal plane radio designed to utilize the outstanding features of both low frequency and very high frequency (VHF) airways facilities has just been announced by Raytheon Manufacturing Co. The new aircraft units are being manufactured by Raytheon's Belmont Radio Corp. division.

Total weight of the transmitter and receiver is 14 pounds. Dimensions are 5 inches high; 5¼ inches wide; and 14¼ inches deep.

By incorporating a fixed tuned VHF channel on 75 mc for receiving Fan and Z markers, and continuous tunable coverage from 195 to 410 kc and 540 to 1600 kc, the most satisfactory communications and navigation are available in one unit. A loop antenna may be added to provide radio d-f navigation. Transmitter operation is on the standard itinerant private aircraft frequency of 3105 kc.



Transmitter and receiver are combined in a single compact unit. The entire unit may be installed or removed in a matter of minutes. Installation initially is simple

and includes such conveniences as built-in loading coils and built-in power pack.

The radiophone is noteworthy for its simplicity of operation. Receiver performance is comparable to commercial airline standards. The superheterodyne circuit incorporates a stage of radio frequency amplification providing extremely high sensitivity to weak signals.

Optimum performance on both tunable bands is afforded by a volume control circuit controlling the r-f sensitivity on the range band, and the audio gain in the broadcast band.

Incorporated in the receiver is a range filter permitting filtering out of voice transmissions from "A" to "N" quadrant identification signals when using the standard simultaneous type CAA radio ranges. This is a particularly valuable feature when reading scheduled weather broadcasts sent out on almost all range stations.

The transmitter circuit has unusually high output — 14 watts is available — to insure communications over extended ranges and adverse radio conditions. No separate loading unit is required. Self-contained in the transmitter are all necessary loading circuits for use on any type aircraft radio antenna. A further feature is the use of an ingenious circuit that provides perfect indications on 75 mc without the use of a separate antenna.

Push-to-talk control of the transmitter is provided by a push-button on the microphone. At the same time the transmitter is turned on, the side-tone circuit is completed, enabling the pilot to monitor his own transmission and check the operation of the transmitter. Radiation and modulation are continuously indicated on the front panel.

Facilities are provided for a loop antenna which is available as additional equipment at a slight additional charge.

This radiophone will be available in three different models to operate from a d-c input of either 6, 12, or 24 volts. Two independent vibrators are included with a selector switch on the front panel in the event of failure of either unit.

MULTIMETER

This new instrument, Model 203, is designed to perform more functions than most volt-ohm-milliammeters. It measures wide ranges of capacity, resistance, a-c and d-c current and voltage. Inductance measurements are also possible.

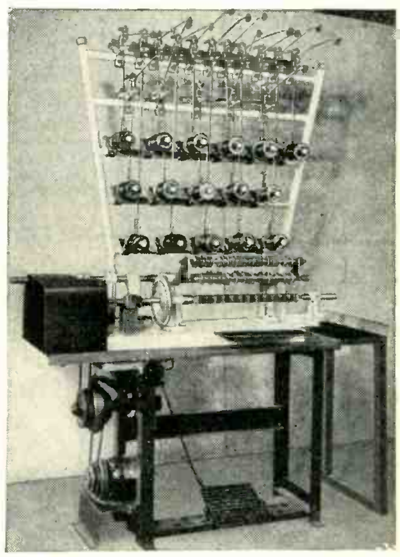
A high input impedance minimizes loading when making voltage measurements. Its electronic ohmmeter circuit permits measurements from 1.0 ohm to 10,000 megohms. Its capacity measuring circuit utilizes low voltage for measurements.

For further data, write the Hickok Electrical Instrument Co., 10532 Dupont Ave., Cleveland 8, Ohio.

COIL WINDING MACHINE

An improved coil winding machine is announced by Connecticut Specialties Co. This Multiple Winding Machine is a light compact unit. Quick adjustment and versatility are featured.

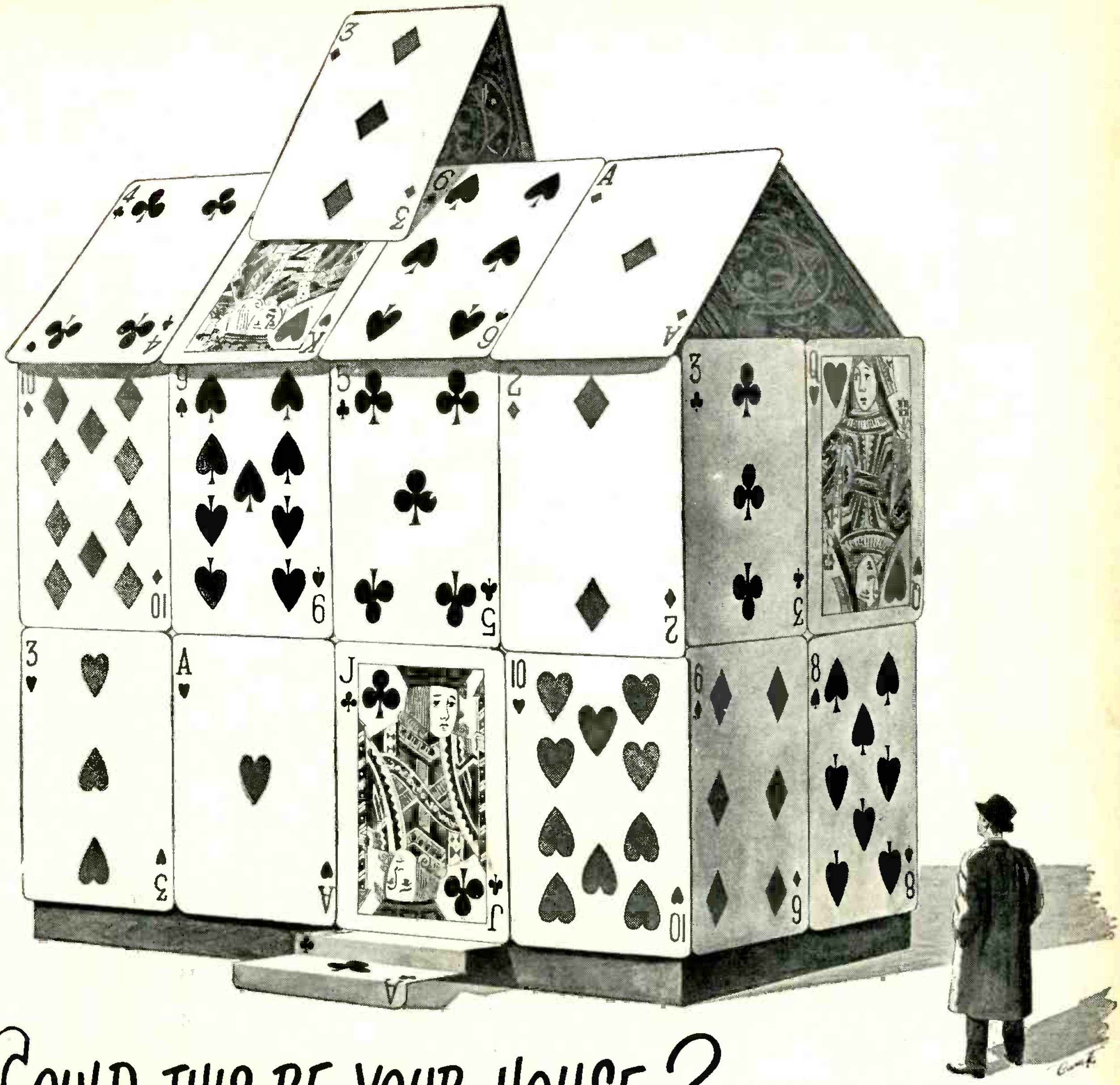
Winding capacity is 200 coils per day, in wire sizes ranges from 20 to 44. Coil ca-



pacity ranges from the smallest to 6". The only electrical component of the multiple coil winder is a 1/8 h.p. motor, with 800 to 2500 RPM.

NEW TRIODE

The new 4C36 by Lewis of Los Gatos is a general purpose triode in the 125 watt class. This versatile triode has a 37.5 watt thoriated tungsten filament (5 volts, 7½ amps.) which gives ample and long lasting emission life. Power output under typical operating conditions, Class B audio frequency amplifier, two tubes, 500 watts; Class C radio frequency power amplifier



COULD THIS BE YOUR HOUSE?

Now that the war's over and a lot more civilian goods are on the market, it's a big temptation to spend just about all you make, and not put anything aside.

But to fall for that temptation is plenty dangerous. It's like trying to live in the house above—a house that might come tumbling down about your ears at the first little blow of hard luck.

Right now the best possible way to keep your finances in sound shape is to save regularly—*by buying U. S. Savings Bonds through the Payroll Plan.*

These Bonds are exactly like War Bonds. Millions of Americans have found them the safest, easiest, surest way to save. The U. S. A. protects every dollar you invest—and Uncle Sam gives you his personal guarantee that, in just ten years, you'll get *four dollars back for every three you put in!*

If you stick with the Payroll Savings Plan, you'll not only guard against rainy days, you'll *also* be storing up money for the really important things—like sending your children to college, travelling, or buying a home.

So—anyway you look at it—isn't it smart to buy every single U. S. Bond you can possibly afford!

SAVE THE EASY WAY... BUY YOUR BONDS THROUGH PAYROLL SAVINGS

RADIO MAGAZINE

★ *This is an official U. S. Treasury advertisement—prepared under auspices of Treasury Department and Advertising Council* ★

and oscillator, single tube, 480 watts. Driving power necessary to obtain above output as a Class "C" radio frequency power amplifier, 18 watts. Like the 3C28, the 4C36 has a dual grid lead which affords better symmetry in push-pull amplifier design. Upper frequency limit of the 4C36 at full power rating, 60 megacycles; maximum plate dissipation, 125 watts; maximum plate voltage, 4000 volts. Amplification factor, 29. Direct interelectrode capacitances—grid-plate, 3.0 $\mu\mu f$; input, 3.2 $\mu\mu f$; output, .4 $\mu\mu f$.

The 4C36 has a jumbo 4-pin metal sleeve bayonet base. Maximum dimensions, overall strength, 7.5"; bulb diameter, 2.75; maximum dimension along grid lead axis, 5". The convection type of cooling is used.

FM ANTENNA

The problem of good reception over the new FM band is more complicated because of the higher frequencies and other contributing factors. There are two antenna requirements that should be met to solve this problem:

1. That of the listener whose location is such that he will want to receive programs from many directions.
2. A listener who lives substantially outside a metropolitan area and will want reception from one general direction.

This FM dual purpose antenna is supplied in 2 kits:

Kit #1 for non-directional use includes:

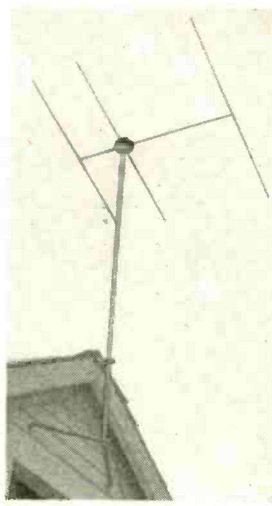
Mast (no guy wires are necessary), a unique mounting arrangement for the edge of any type of roof, 60 feet of low loss transmission line — completely wired ready for assembly, 4 aluminum elements that are firmly supported in the rugged plastic head.

This kit is a complete antenna in itself, ready to be installed, and satisfies the non-directional application.

Kit #2 for high gain directional use utilizes all the component parts in Kit #1 and, by means of simple assembly, converts the non-directional antenna into a high gain directional array using the well known principle of a dipole with reflector and director.

Exhaustive tests have been made to check ice loading and ability to withstand high winds. The mounting arrangement is rugged and versatile and can be adapted to the side of any structure. This device eliminates the necessity of drilling holes down through the top of the roof.

The non-directional antenna has a gain in any direction that is 7/10 that of a standard dipole in its optimum direction.



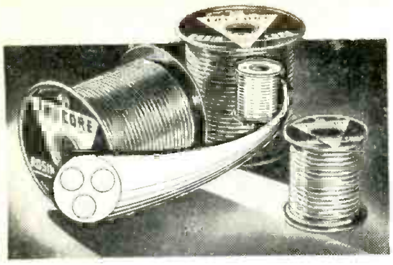
FM Dual Purpose Antenna

Tests have shown that this slight change in gain is not perceptible to the listener, particularly where this type of antenna will be used in a metropolitan area where the signal to noise ratio is high. The elements are of ½" diameter and are cut to size and require no further tuning. Tests have shown that they give a very good response over the entire new band. The standing wave ratios are reduced to a minimum by means of a carefully chosen matching section, requiring no further adjustment. When changing from the directional type antenna to the non-directional type, it is merely necessary to disconnect or cut the two leads of the phasing loop.

VOLT-OHM-MILLIAMMETER

Where extreme sensitivity is required, Triplett Model 2405 with d.c. volt ranges at 25,000 ohms per volt will provide for voltage, current and resistance analyses.

Model 2405 ranges are: d.c. volts: 0-10-50-250-500-1000, at 25,000 ohms per volt; a.c. volts: 0-10-50-250-500-1000, at 1,000 ohms-megohms; 0-4000-40,000 ohms-4-40 amperes: 0-0.5-1-5-10; d.c. milliamperes: 0-1-10-50-250; d.c. microamperes: 0-50; ohm-megohms: 0-4000-40,000 ohms, 4-40 megohms; output: condenser in series with a.c. volts.



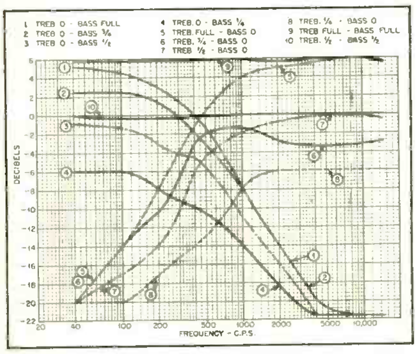
3-CORE SOLDER

Tri-Core, the solder with three independently filled cores of pure rosin flux, is a new development of Alpha Metals. Inc., Brooklyn, N. Y. This new product offers users faster soldering and elimination of dry joints, in addition to substantial savings in tin.

Tri-Core solder exceeds A.S.T.M. Class A specifications and is available in all alloys, all flux percentages and all gauges. Bulletins and Engineering Test Samples are available from Solder Development Division, Alpha Metals, Inc., 369 Hudson Ave., Brooklyn 1, N. Y.

ERRATUM

As noted in the caption for *Fig. 8*, p. 51. of the March issue. curve 9 should have appeared approximately flat at 6 db. The corrected diagram appears below. Total variation is ±13 db.



THIS MONTH

[*from page* 40]

the development and design of special electronic equipment for ships and aircraft of the fleet.

Mr. Mathes has had extensive experience in the development of facsimile equipment, having engaged in this and related research and electronic activities with the RCA Laboratories since 1925. He has written a number of technical articles on facsimile and radio multiplex.

Howard L. Richardson, formerly manager of personnel administration, will become director of industrial relations.

Ernest L. Ward

★ Ernest L. Ward, formerly a partner of the Boston investment banking firm of F. S. Moseley and Company, has recently joined the executive staff of the Sprague Electric Company, North Adams, Massachusetts.

Mr. Ward was one of the partners in Moseley's Chicago office and specialized in surveys and planning in connection with the setting up, purchase and sale of original issues of industrial securities. His wide-spread experience will add considerable strength to the Sprague organization, and admirably fits him for a variety of executive duties.

Edwin Norman Clark

★ Appointment of Edwin Norman Clark, former deputy assistant chief of staff for supply, supreme headquarters, Allied Expeditionary Force, as managing director of the RCA International Division, has been announced by Brigadier General David Sarnoff, President of Radio Corporation of America.

A member of the law firm of Robb, Clark and Bennitt from 1929 until 1938, Mr. Clark accepted a commission as major in the U. S. Army Reserve in 1940 and rose

E. N. Clark

to the rank of colonel. He was a member of the United States North African Mission, which in January, 1942, prepared for the American forces supporting Marshal Montgomery's British Eighth Army. In this connection he served as commanding officer of the Delta Service Command, which later became the Middle East Service Command, the Eritrea Service Command, and the Libyan Service Command. Mr. Clark then was transferred to England and was with SHAEF from its formation in 1944. He was principally concerned with supplies for the Allied invasion forces in Europe.

Before United States' entry into the war, Mr. Clark served as adviser to Lauchlin Currie, executive assistant to the late President Franklin D. Roosevelt, and was for a time expert consultant to Secretary Robert P. Patterson, then Under Secretary of War. He also has served as special adviser to the Chinese government on supply problems and as adviser to several other foreign governments.

A native of Parkersburg, Iowa, Mr. Clark attended the University of Wisconsin and was graduated from the United States Military Academy at West Point in the class of 1922. He studied at Harvard Law School.

Walter A. Bowers

★ Walter A. Bowers has been elected vice-president and treasurer of the Aireon Manufacturing Corporation, R. C. Walker, president, announced.

Mr. Bowers was formerly vice-president and treasurer of the Lawrance Aeronautical

W. A. Bowers

Corporation of Linden, N. J. Prior to joining Lawrance in May, 1944, he had fifteen years in executive and administrative positions in government service.

George T. Royden

★ George T. Royden, technical member of the radio engineering and sales division of the Federal Telephone and Radio Corpora-

George T. Royden

tion, was recently elected a director of the Institute of Radio Engineers.

Mr. Royden possesses a varied and extensive experience in the engineering and communications fields, having joined a predecessor company of Federal Telephone and Radio in 1916. Federal is the domestic manufacturing affiliate of the International Telephone and Telegraph Corporation.

Harold Gilpin

★ Sylvania Electric Products Inc. has announced the appointment of Harold P. Gilpin to assistant general sales manager

Harold Gilpin

of the radio division in New York City. Mr. Gilpin, who has been with the company since 1932, was formerly manager of equipment tube sales. He is a graduate of Temple College and is a member of the sales executive club.

Henri Busignies

★ Henri Busignies, director, Federal Telecommunication Laboratories, affiliated with the Federal Telephone and Radio Corporation, both associates of the International Telephone and Telegraph Corpora-

Henry Busignies

tion, was made a Fellow of the Institute of Radio Engineers at their recent winter meeting held in New York. The honor was conferred on Mr. Busignies "for his accomplishments in the field of radio direction finders, particularly pioneering work on instruments having automatic indicating features".

Mr. Busignies has long been active in the development of automatic direction finders for aerial navigation and was granted French and United States patents on such as early as 1926. Chairman of the Sub-Committee on Instrument Landing, Aeronautical Committee, Radio Manufacturers Association, and 1926 winner of the Lakhovsky Award, conferred by the Radio Club of France, he has been connected with the IT&T System since 1928.

Albert Preisman

★ E. H. Rietzke, President of the Capitol Radio Engineering Institute of Washington, D. C., announces the election of Mr. Albert Preisman to Vice President of the Institute in charge of engineering. Mr. Preisman has been associated with Capitol Radio Engineering Institute for three years, where he has been in charge of radio engineering activities, lesson text revision and development of new lesson material. He is a graduate of Columbia University with A.B. and E.E. degrees. Prior to his association with Capitol Radio Engineering Institute, he was senior engineer at Federal Telephone and Radio Corporation.

To C. C. N. Y.

Arthur Schach, formerly radar instructor at Western Electric Co., is now instructor in logic at C. C. N. Y.

CONSULTING RADIO ENGINEERS' DIRECTORY

RADIO Magazine announces the inauguration of a consulting radio engineers' directory service for the convenience of its readers.

Professional card listings in this directory are available at $16.50 per insertion for six consecutive insertions; $15.00 per insertion for twelve consecutive listings.

Address all inquiries to

Advertising Sales Department
Radio Magazines, Inc.
342 Madison Ave., New York 17, N. Y.

ADDRESS CHANGES—

Subscribers to RADIO should notify our Circulation Dept. at least 3 weeks in advance regarding any change in address. The Post Office Dept. does not forward magazines sent to a wrong address unless you pay additional postage. We cannot duplicate copies of RADIO sent to your old address.

RADIO Circulation Dept.
Radio Magazines Inc.
342 Madison Ave., New York 17, N.Y.

BOOK REVIEWS

[*from page* 19]

ter is a compact working outline which points out the "do's" and "don'ts" of producing a television show.

Television people with limited production budgets, laymen, and those with experience in this new field will find useful information which will eliminate many of the trial-and-error methods from production of television features.

The book is well illustrated, and is provided with a good index.

Radar, by Orrin E. Dunlap, Jr., published by Harper & Brothers, 49 East 33rd Street, New York, N. Y., 208 pages, price $2.50.

This is a well-written popularized treatment of radar, for persons who wish to know "what goes on" without becoming involved in waves, circuits, and electrons. It accomplishes what it sets out to do.

The writer is former radio editor of The New York Times, and author of ten other popular treatises. Mr. Dunlap is now a member of the executive staff of RCA.

He traces the history of radar from the early reflected wave experiments of Hertz and Marconi up to the termination of hostilities; a bright peacetime future is likewise envisioned in the latter portion of the book.

Topics contained in the book are:

- The Genesis of Radar
- Revelation of a Secret
- Amazing Wartime Performances
- How Radar Works
- Who Invented Radar?
- Radar in Peace
- Glossary
- Suggested Reading

The book is provided with a good index, although a list of the numerous illustrations has not been included.

"Radar" can be recommended to the large group of executives and planners who wish to acquire an authentic knowledge of the new technique.

New RCA Review

RCA Review was first published as a quarterly journal in July 1936 by RCA Institutes Technical Press. In the next six years, until April 1942 (Volume VI, No. 4) when publication was suspended due to war-time security restrictions, RCA Review gained international recognition as one of the leading engineering journals, presenting a continuous record of the latest developments in radio, electronics and related fields.

After a four-year war-time "blackout," publication of the RCA Review was resumed in March 1946 commencing with Volume VII, No. 1, and continuing thereafter on a quarterly basis. The new RCA Review is similar in most respects to the old, containing between 100 and 130 pages in the average copy, and is entirely devoid of advertising.

The purpose of RCA Review is to present a record of the latest available information for all scientists, engineers and others concerned with technical matters in the interest of radio and electronics as a science, an industry and a service. As before, RCA Review will contain papers prepared by scientists, engineers and executives of the Radio Corporation of America, its various divisions and subsidiary companies, and will include: important reports on status and progress of television (including color); articles on all phases of broadcasting; papers covering the improvements in radio tubes; progress reports on microwave radio-relay work; latest technical information on status, progress, new techniques and developments in frequency modulation, radar, electron optics, acoustics, navigational systems for all applications, facsimile transmission and reception, sound recording and reproducing, antennas of all types, marine — aviation — high power — and ultra-high-frequency communications; reports concerning results of propagation studies; articles on technical education requirements and problems; description of various new applications of the electron tube; and a variety of other subjects covering the entire fields of radio, electronics and their associated arts.

Papers appearing in RCA Review are carefully selected by the board of editors which is composed of men who are recognized authorities in their fields. Particular attention is given to appropriateness, significance and timeliness. For this reason, RCA Review is a source of new and advanced information and provides important reference material of the greatest value to all those who must keep abreast of the latest technical developments.

Handbook of Dry-Plate Rectifier Applications, by G. A. Culbertson, 3608 Angelus Avenue, Glendale 8, Calif. 16 pages, illustrated, paper binding, distributed through 'Culco', Box 122, Montrose, Calif., 50c.

This is a handy booklet, useful to the practicing engineer. It presents in organized form the essential factors to be considered when designing dry-plate rectifier installations.

Topics are: power applications, cooling, circuit applications, applications, relay control, and circuit-breaker control. The booklet is somewhat brief: however, the author announces his intention to expand the volume in the future.

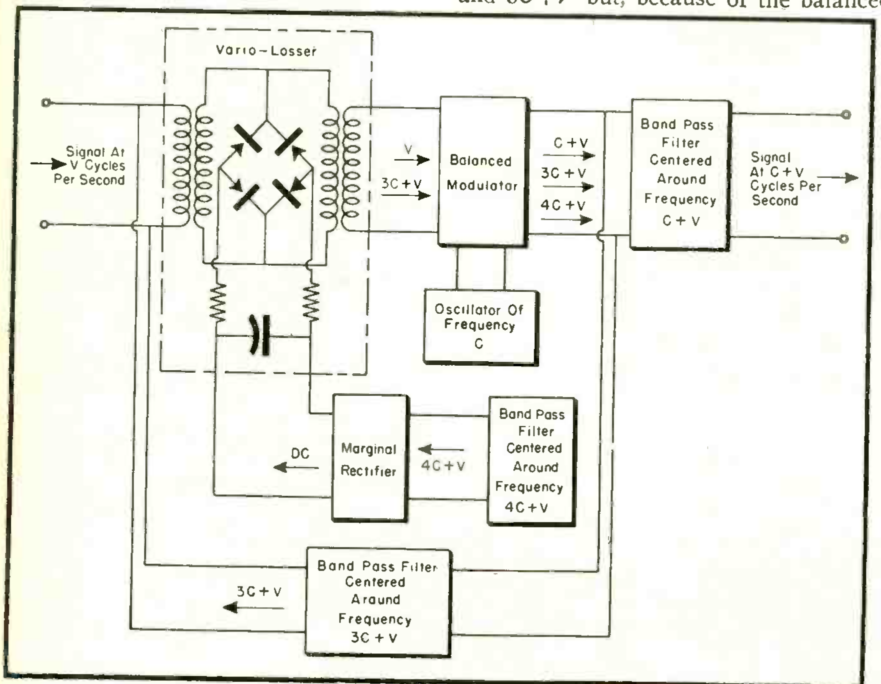
It is a useful addition to the design engineer's file.

INVENTIONS

[*from page 36*]

tion is of this general type, except that only one vario-losser circuit is used and the signal is passed through that unit twice.

As shown in the diagram, the input audio signal of variable volume is inserted as a straight audio-frequency voltage. The center frequency of these audio components is labeled as V. This signal passes through the vario-losser and into a balanced modulator where it produces a signal of frequency $C+V$ and $3C+V$ but, because of the balanced



Patent No. 2,387,652

character of the modulator, no frequency component at $2C+V$ or $4C+V$ is obtained from the original audio signal. The $3C+V$ component is carried back to the original input point and again inserted into the vario-losser. When the $3C+V$ signal enters the modulator, it produces a $4C+V$ component which is used to control the lossers so as to hold the $4C+V$ component at essentially constant volume. The $C+V$ component is therefore the center point of the double trip through the vario-losser. It has a volume variation that is compressed by a two-to-one ratio over the normal signal.

The patent, No. 2,387,652, is assigned to Bell Telephone Laboratories.

TRANSMITTER DESIGN

[*from page 30*]

polyphase operation of filaments and by the use of inverse feedback. Present practice is to maintain noise levels 60 db or more below 100 per cent modulation.

Greatly improved crystals have been made available, having extremely low temperature coefficients, which permit maintaining the carrier frequency to within very narrow limits using temperature control of very simple design.

The transmitter to be described can

be considered a typical example of present-day design features. It incorporates, so far as possible, all the improvements enumerated above which have contributed to greater dependability and improved performance. The transmitter selected is typical of the kind used in 250-watt stations serving hundreds of communities in the United States. It is enclosed in a modern cabinet with a color scheme which is pleasing to the eye and which blends with the architecture and surroundings used in modern stations. The designers have kept in mind that even a small broadcasting station can be made a showplace by proper attention to detail.

Dead Front Controls

Safety of operating personnel has been carefully safeguarded by providing dead front controls and safety interlocks protecting against contact with high voltage circuits. A high degree of operating dependability has been achieved through careful selection of components which are rated well above the maximum requirements likely to be imposed upon them.

Through a great deal of experience gained in making equipment to meet military requirements, improvements in plating and finishing to resist corrosion have been made. Although the requirements of broadcast equipment are not so severe, such design contributes greatly to operating dependability.

It is an old axiom that "the parts which are left out never make any trouble". While this axiom cannot be followed too literally, it is usually true that the simplest circuit arrangements which will produce the required performance is the best one. Everything else remaining equal, the circuit with the fewest components can be expected to have the least failures. This thought has been carried out in the design of the circuit in this transmitter by the use of a minimum number of tuned circuits and amplifier stages.

Theory of Operation

Referring to the schematic on page 31, note that the 6J5GT crystal oscillator is followed by a type 807 buffer amplifier, connected as a normal shunt-peaked video amplifier. The high frequency cutoff of this amplifier is somewhat above 1.6 mc so that it provides adequate excitation to the type 813 r-f driver without the use of tuned circuits. The r-f driver stage uses a split condenser output circuit to provide balanced excitation to the final amplifier. The final amplifier is connected in push-pull, its plate circuit being tuned with a capacitor. Thus there are only two tuned circuits to adjust to put the transmitter in operation on a given frequency. As an operating convenience, the two tuned circuits and the output coupling control are driven by back-geared motors and controlled by a pair of push buttons on the control panel.

Although broadcast transmitters require very little tuning adjustment in normal operation, it requires but a moment to check the tuning by depressing the appropriate button and observing meter indications. Metering of all important circuits is provided by 12 front panel instruments which are conveniently read at a glance.

Protection of the tube complement against abnormal operation is insured by the use of overload relays to prevent application of plate voltage before proper filament temperature has been reached.

Because of limited personnel, many small broadcast stations find it convenient to make announcements from the operating room. With this requirement in mind, the transmitter has been designed to operate as quietly as possible, and without ventilating fans, by the use of conservatively rated components and adequate natural ventilation. This may be accomplished in a transmitter of this power rating though it becomes increasingly difficult in higher powered transmitters. Power and modulation transformers have been given special silencing treatment by proper clamping of the cores.

The quality of the signal produced by such a transmitter leaves very little to be desired. It is a great satisfaction to a broadcaster to know that the signal which enters the listener's home is transmitted with fidelity considerably better than the performance standards of the best modern receiver. He is thus assured that, insofar as quality is concerned, he can compete on an equal basis with even the largest stations.

I-F AMPLIFIER

[*from page 27*]

$$Z_{po} = QX/2 \qquad (8)$$

When $v = 1.7$, the primary impedance is

$$Z_p = QX/1.78 \qquad (9)$$

and

$$Z_p = 1.12\, Z_{po} \qquad (10)$$

Since the primary and secondary elements of the double tuned circuit are identical, let $Z_o' = Z_{po} = Z_{so}$. The voltage across the primary of the transformer is, when $v = -1.7$

$$e_p = g_m e_g (1.12) Z_o' \qquad (11)$$

The feedback voltage is

$$e_g' = e_p (1.12) Z_o' \omega C_{gp} = (1.12 Z_o')^2 g_m \omega C_{gp} \qquad (12)$$

The stability requirement is given by equation (1) so that for stability in double-tuned critically coupled transformer circuits

$$(1.12Z_0')^2 g_m \omega C_{gp} \geqq 1$$

$$Z_0' \geqq \sqrt{1/(1.245 g_m \omega C_{gp})}$$

$$\geqq \sqrt{0.79/(g_m \omega C_{gp})} \qquad (13)$$

Practical Design Considerations For I-F Amplifiers

The grid-plate capacitance of an i-f amplifier stage is practically a function of tube socket and wiring capacitance. In Table 1, grid plate capacitances are given for both tube and socket wiring for various i-f amplifier stages. The exposed plate and grid leads were one-half inch in length. It will be seen that the tube grid-plate capacitance is practically negligible compared with the socket and wiring capacitance.

The variation in maximum theoretical gain vs. frequency for various tubes is illustrated in *Tables 2, 3, 4, 5* and *6*.

[1]This investigation was made while the author was chief research engineer at the Templetone Radio Co., New London, Conn.

[2]Aiken, C. B., "Two-Mesh Tuned Circuit Filters," *Proc. I.R.E.*, Feb. 1937. Vol. 25, p. 230.

MICROWAVES

[*from page* 25]

The crystals are connected to the contacts of two selector relays as shown in *Fig. 7*. Any one of the three crystals may be connected by setting the selector switch in the control box to the desired channel.

The multiplier stages of the frequency multiplier are Class C amplifiers tuned to a harmonic (second or third) of the preceding stage.

The tank circuit in the double output is tuned to the second harmonic (9.75 mc) of the crystal by a variable inductor. The range of the inductor is such that the resonant circuit can be tuned only to the second harmonic. The first tripler stage is similar to the doubler stage and is inductively tuned to the third harmonic (29.26 mc). The second tripler increases the frequency to 87.77 mc which is transformer-coupled to the third tripler.

The third tripler is an 832-A beam power amplifier operating in push-pull. The plate circuits of the 832-A are terminated in a short-circuited two wire line which is tuned to 263.3 mc. Some of the energy in the short circuited line is coupled to a balanced line and fed to the input resonator of the 2K36 klystron multiplier. Excitation of the klystron is adjusted to the proper amount by varying the screen voltage on the 832-A. The output resonator of the klystron is tuned to the 10th harmonic (2633 mc) of the input signal; this frequency is the reference used in the mixer on Channel A.

ADVERTISING INDEX

PRESS OF THE WILSON H. LEE CO.
ORANGE, CONN. PRINTED IN U.S.A.

SYLVANIA NEWS

CIRCUIT ENGINEERING EDITION

APRIL *Prepared by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. 1946

ANNOUNCING!

EFFICIENT, NEW SYLVANIA R.F. AMPLIFIER TUBE

TYPICAL OPERATING CONDITIONS

Heater voltage	6.3 volts
Heater current	0.150 ampere
Maximum plate voltage	250.0 volts
Maximum plate dissipation	2.0 watts
Maximum screen grid voltage	250.0 volts
Minimum external negative grid voltage	1.0 volt
Maximum screen grid dissipation	0.75 watts
Maximum heater-cathode voltage	90.0 volts

Here's a new sharp cut-off r-f pentode amplifier designed especially for 6.3 volt and a-c/d-c series service in Television and Frequency Modulation receivers.

The tube may be operated with full plate voltage on the screen grid to produce high input resistance as a result of reduced electron transit time. Identical voltage requirements for plate and screen grid also eliminate the need of screen grid filter resistors and by-pass capacitors in some circuit applications.

TYPICAL OPERATING CHARACTERISTICS OF TYPE 7AG7 AS A CLASS A1 AMPLIFIER

Plate current	6.0 Ma.
Plate resistance	0.75 megohm
Screen grid current	2.0 Ma.
Mutual conductance	4200 micromhos

Direct Interelectrode Capacitances

Grid to plate	.005 micromicrofarad Max.
Input	7.0 micromicrofarads
Output	6.0 micromicrofarads

Inquiries concerning the new Sylvania Type 7AG7 r-f pentode amplifier tube are invited. Write Sylvania Electric Products Inc., Emporium, Pa.