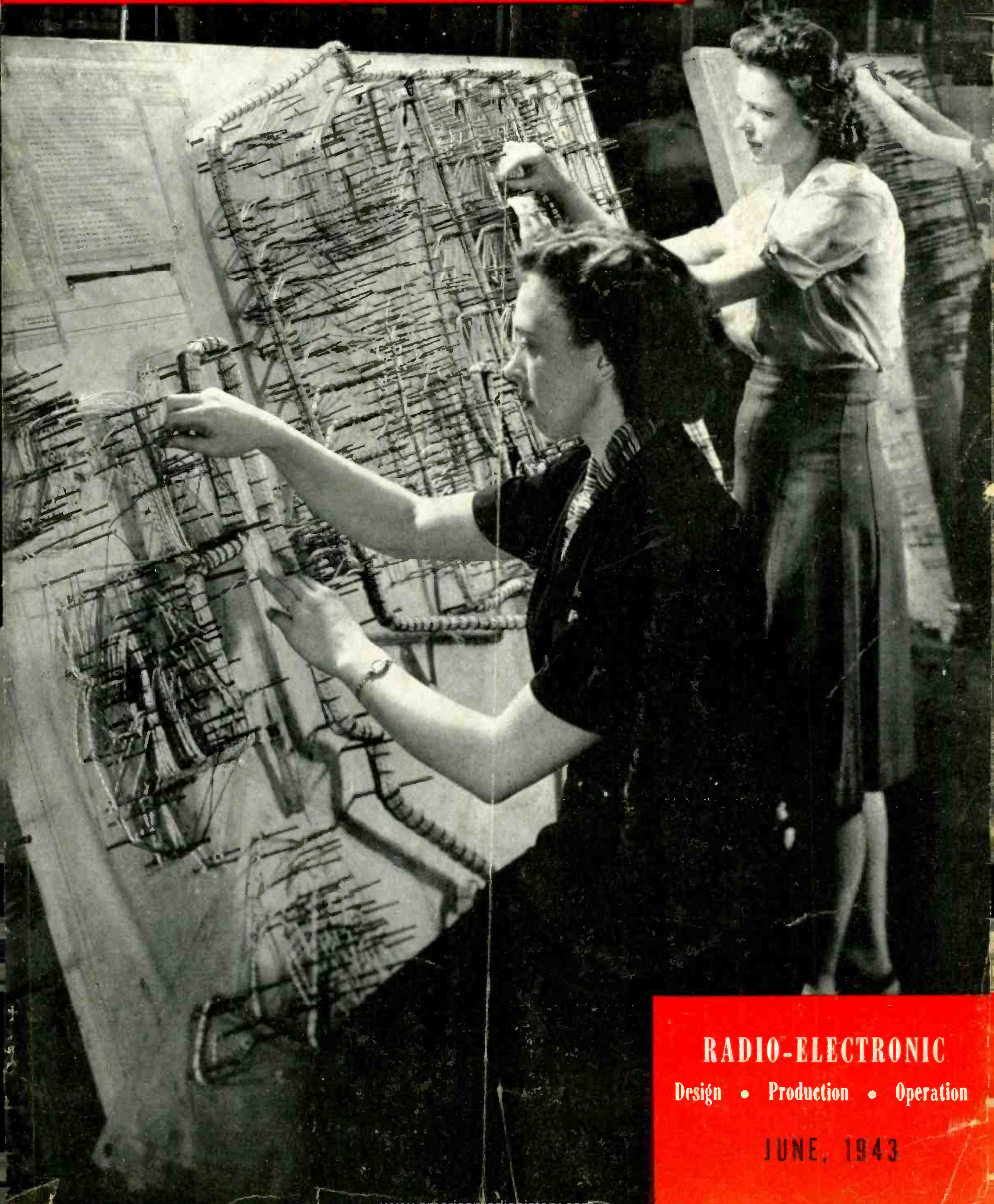
RADIO

ESTABLISHED 1917



RADIO-ELECTRONIC

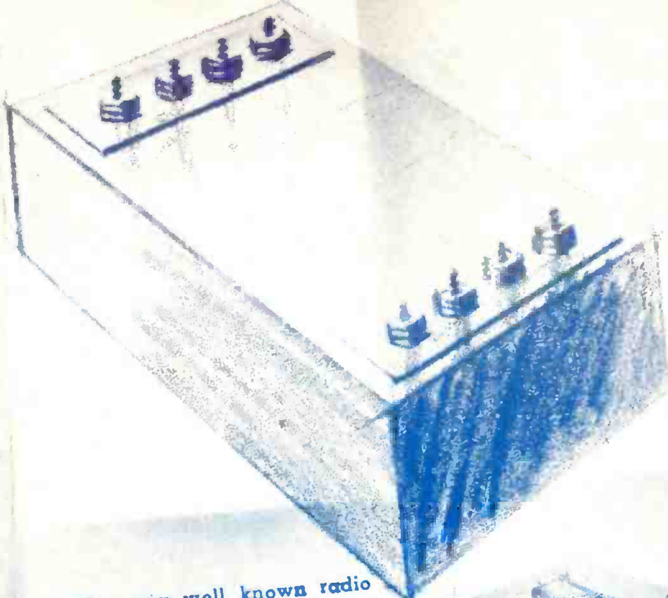
Design • Production • Operation

JUNE, 1943

FILTERS—
Designed for war

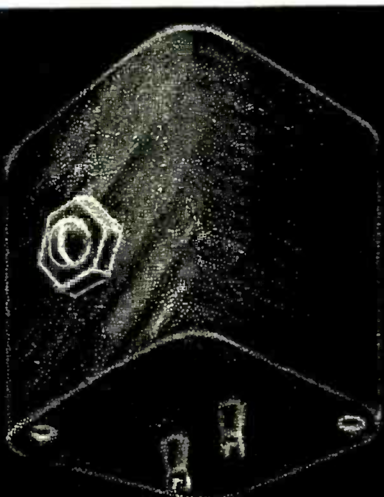
Unique characteristics of many UTC filters are the result of years of research on core materials and filter structures. We are proud of our part in the development of filters for wartime electronics. Here are a few typical elements, based on UTC design, which have led to UTC leadership in this field.

May we design a "Victory" unit to your application?



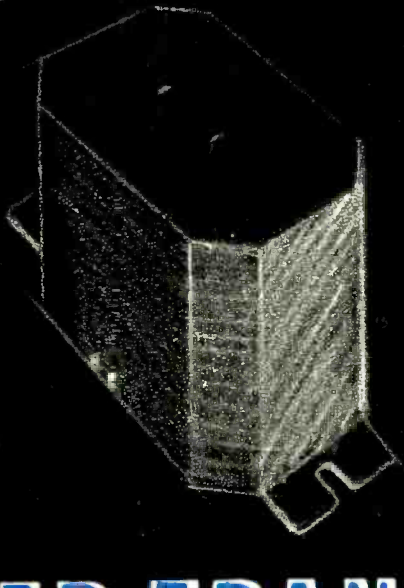
The now well known radio range filter weighed *36 pounds* when it originally was submitted to us.

Continuous refinement by UTC has resulted in the modern radio range filter weighing only *1.6 pounds* — a weight reduction of 95%.

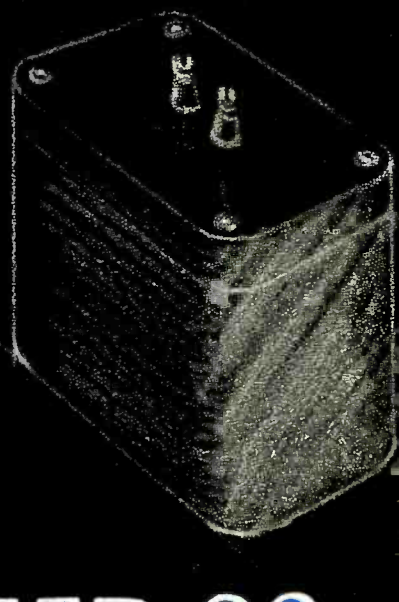


This UTC development is a tunable inductance, adjusted in the same manner as an I.F. trimmer.

Designed for high frequencies, the Q of this coil is 300 at 20,000 cycles.



. . . For medium frequencies, the Q of this coil is 210 at 1,000 cycles.



. . . For low frequencies, the Q of this coil is 80 at 100 cycles.

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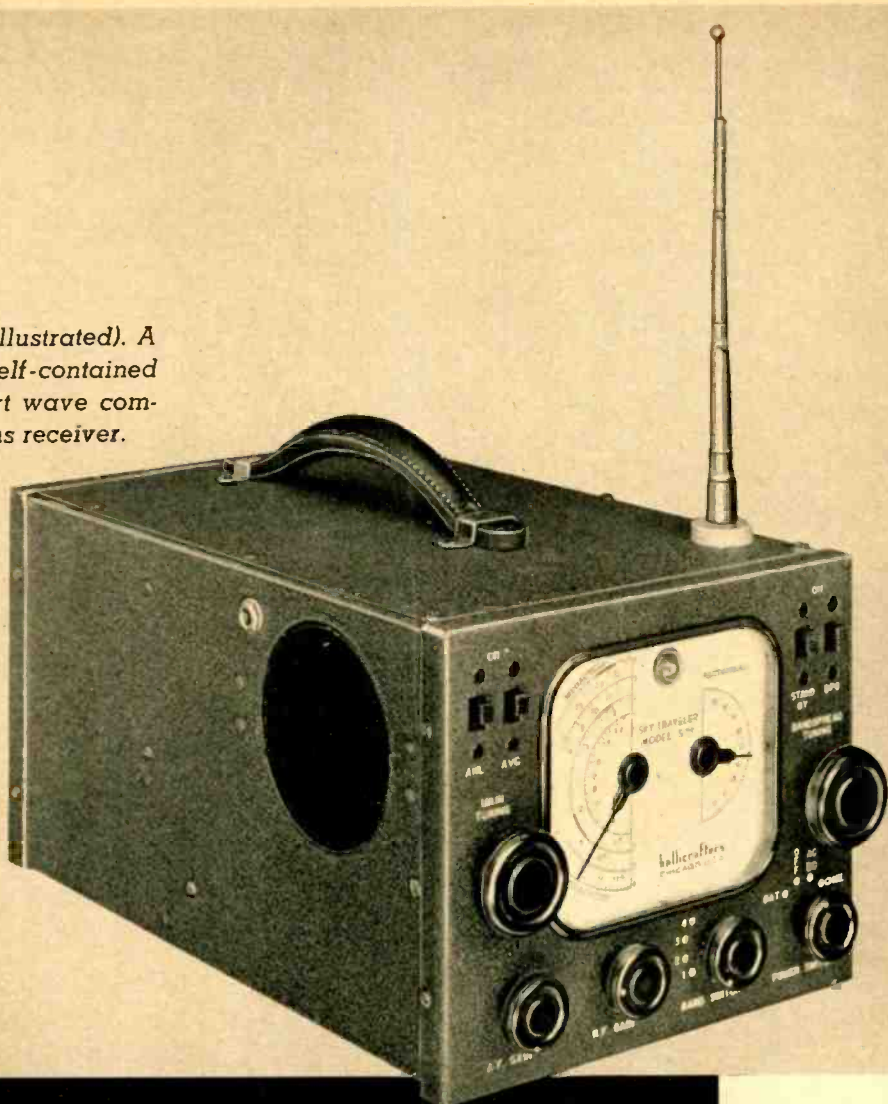

Model S-29 (illustrated). A completely self-contained portable short wave communications receiver.

RADIO

Published by RADIO MAGAZINES, INC.

Editor

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◆

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JUNE 1943 No. 281

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COVER

Peggy Wolsztyniak and Irene Sperka are shown forming cable at Western Electric's Hawthorne Works in Chicago. This type of work, seldom performed previously by girl workers, is a common operation in the manufacture of telephone exchange equipment, which was one of Hawthorne Works' principal products before the war.

ARTICLES

MISCELLANEOUS

RADIO (title registered U. S. Pat. Off.) is published monthly at 34 N. Crystal Street, East Stroudsburg, Pa., by Radio Magazines, Inc., Executive and Editorial Offices at 132 West 43d Street, New York 18, N. Y. Subscription rates—United States and Possessions, $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 1943 by Radio Magazines, Inc. Entered as Second Class Matter October 31, 1942, at the Post Office at East Stroudsburg, Pa., under the Act of March 3, 1879.

THE RADIO-ELECTRONIC FIELD

★ There is as much confusion over what constitutes the field of radio and the field of electronics as there is over who invented radar. But, by averaging the opinions on the former, it would seem that electronics is everything except radio, that radio is communications only, and that radar is a field apart. On the other hand, there is another school of thought supporting the assumption that electronics is radio, radar, television, and anything else using an electron tube.

None of this is really important so long as a popular definition of the word electronics does not make it appear that our editorial scope is limited to the field of communications. Since this possibility exists, we are using the appendage "radio-electronic" on our front cover as a means of more precisely defining the field we have covered from the outset. It means, simply, that RADIO concerns itself with the application of radio-frequency currents, and therefore naturally covers the fields of broadcasting, communications, television, radar, radiothermics, radiolocation, radiocontrol, and the many other applications of radio-frequency currents that are bound to develop in the future.

U. S. RADAR

★ In the address delivered at the War Production Conference of the Radio Manufacturers Association by Ray C. Ellis, Director of WPB Radio and Radar Division, he remarked that the radio-radar equipment used by America's fighting services is much superior to captured German and Japanese apparatus. Combat experiences, with radar in particular, he said, have been such as to hold spellbound and speechless the most experienced and hardened military experts.

Complimenting the radio industry on its military production job, Mr. Ellis stated that through the remainder of this year and through the first half of 1944 some four billion dollars worth of radio and radar equipment must be produced, with constant changes in design.

"The enormity of our task is so great that it can hardly be conceived," said Mr. Ellis. "The production of one order for a single type of radar model exceeded in value the entire cost of the Boulder Dam hydro-electric project."

LONG-RANGE PLANNING

★ In his talk before the Annual Luncheon Meeting of the Radio Manufacturers Association, James L. Fly, Chairman of the FCC, made some very pertinent remarks regarding long-range planning for the post-war period.

Said Mr. Fly, "Before plunging into a post-war period we ought to pledge ourselves to ask the same questions we did when entering this present emergency period. The terms peace and war are merely reversed in the query. Sooner or later we must again ask ourselves: Can the radio industry survive the transition from war to peace? Can our post-war economy keep this vastly expanded industry, with its additional plants and its increased payroll, busy in the years to come? Can it meet the great potential public demand in a manner which will result in optimum benefits to the public? And, can the transitional period be bridged without undue dislocation?"

Mr. Fly's answer is long-range planning: "For twenty years this industry, just like every other industry, has been completely occupied with short-range planning—with getting ready for next year's model. Soon you will have an opportunity to plan—and to get off the endless treadmill of short-range planning. Ask yourselves 'Along what lines should radio develop over the next decade?'

"No group of producers and engineers have ever had placed upon them a more serious challenge. We must not plan anything that will fall outside the realm of sound engineering and good judgment. But if we can tell during the next year what general lines radio services should and will follow five or even ten years from now, we should be derelict in our greatest duty to ourselves and to the public were we to fail to plan now. This is an opportunity unparalleled in the history of the radio industry and paralleled in very few industries at any time.

"When peace comes these problems must be solved. Shall we run headlong into them and solve them on the spur of the moment, or shall we devote what time we can to lay a groundwork in advance? A look at the allocation pattern today should serve as a reminder that planning is well worth the effort. The sad experience of prior years resulted in more careful planning in the FM and Television bands. We laid out these bands with as much forethought and ingenuity as could be mustered. After this war, we must do better still, and insure that all phases of radio will be re-established on a firm and spacious foundation, broad enough and soundly enough designed to make possible indefinite advances along the lines of improved public service. At the same time radio services that can be unified must be unified. The public will not tolerate the idea of a heavy investment in each of several forms of regular radio service, or a living room full of radio boxes.

"Not the least challenging of our ultra-modern developments is the opening of the limitless ranges of the higher frequencies. Yet the development of varied and extensive uses of radio continues to keep demand ahead of supply. We cannot, in the foreseeable future come any nearer to the complete satisfaction of the frequency demand than the greyhound comes to the mechanical rabbit. Yet there is the problem and we must keep after it."

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Maximum Peak Plate Current . . . 2 amperes

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"A Rectifier with a Longer Life"

REBUILT TUBES

RCA Types 207, 891, 891-R, 892, and 892-R

As a wartime emergency service to help keep broadcast stations on the air, RCA offers a Tube Rebuilding Service on the types listed above. Actual use has proved the efficiency of these RCA Rebuilt Tubes beyond question. Ratings or characteristics are in no wise impaired. If your station uses any of the five listed types, write today for full details.

FOR DESIGN PURPOSES—

Now you can take advantage of the small size and outstanding dependability of the RCA 866-A/866 Half-Wave Mercury-Vapor Rectifier on high current applications—up to a peak inverse voltage of 2,000 volts maximum!

Improvements incorporated months ago make these new ratings just as conservative as the original lower current rating on which the reputation of this famous rectifier was built.

FOR REPLACEMENT PURPOSES—

Obviously, the higher current rating for the RCA 866-A/866 has no particular bearing on replacement applications of the tube where use is based on the old rating—but the improvements which make it possible do. They mean greater dependability, a greater margin of safety at the old ratings—and consequent longer life to the tune of hundreds of additional hours.

RCA RADIO-ELECTRONIC TUBES

RCA Victor Division, RADIO CORPORATION OF AMERICA, Camden, N. J.

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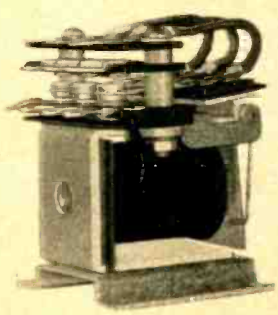
FROM "HAM" TRANSMITTER RIGS

RELAYS BY GUARDIAN

★ Today they are off the air . . . voices stilled . . . home-built rigs carefully covered. For most of yesterday's "hams" are lending their experience, knowledge, and ingenuity to the war effort . . . creating and perfecting new communication devices . . . the amazing new flight recorder, for instance . . . or Radar. But whether they work in a wartime lab or have their "office" in a Fortress, they are still close to one of their early friends—"Relays by Guardian".

One of the newer developments is a multi-purpose aircraft radio relay pictured at the right. It is built in contact combinations up to three pole, double throw. Coils are available in resistances from .01 ohm to 15,000 ohms. At 24 volts DC it draws 0.12 amperes. This relay is also built for AC with a contact rating of 12½ amperes at 110 volts, 60 cycles. Standard AC voltage is 92-125 volts but coils are available for other voltages.



Aircraft Radio Relay
DC Model—Bulletin 345
AC Model—Bulletin 340

Write on your business letterhead for these new bulletins: B-8, Six pages of Aircraft Contactors—195, Midget and Signal Corps Relays — B2A, Aircraft Relay — SC65, Solenoid Contactor.

GUARDIAN G ELECTRIC

1605-G WEST WALNUT STREET CHICAGO, ILLINOIS

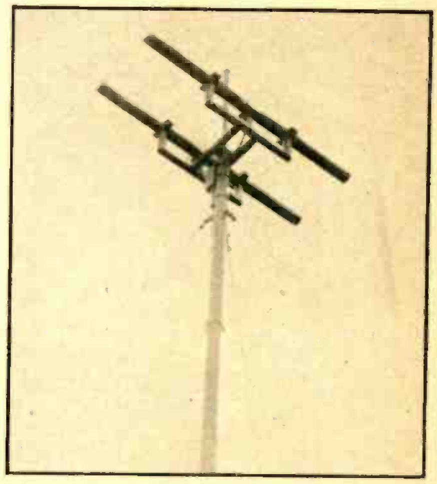
A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

TECHNICANA

RADIO RELAY ANTENNA

A NEW RADIO RELAY antenna for studio-to-transmitter service has been developed by engineers of the General Electric Electronics Department, Schenectady, N. Y. It is designed for relaying FM programs from studio to the main transmitter via any one of the 23 assigned channels centering on 337 megacycles. One of the new antennas is in operation at Schenectady where it is installed atop a building to relay programs of FM station W85A, with studios in the building, to the station's main transmitter in the Helderberg Mountains, 12 miles away.

According to M. W. Scheldorf, G-E electronics engineer, "The antenna concentrates its radiation in a narrow beam in the desired direction only, in accordance with well defined and narrow limitations of the Federal Communications Commission. The antenna consists essentially of five sets of simple dipole antennas, properly mounted



and connected electrically in a manner to achieve the necessary radiation pattern. The entire electrical system is mounted within a nonmetallic housing which protects it from rain, snow and ice. It is made to mount easily on a single metal pole."

★

BOMBER NOSE TEST CHAMBER

A SIMPLE ALTITUDE test chamber for aircraft radio and electronic equipment, in which engineers can now for the first time see the entire apparatus in operation under conditions duplicating

[Continued on page 15]

A new and distinctly *better* type of home radio combination was about ready to make its bow to the American public when war drafted the complete Motorola facilities. Had this *static and noise-free* F-M receiver been seen and heard by the general public, it would have aroused unqualified enthusiasm . . . whetted an appetite that will have to be satisfied when Peace once again releases electronic talents and skills war-sharpened for radio's greatest progress and achievement. In the interests of national defense, Motorola is now delivering the finest in F-M emergency broadcast and receiving equipment. You may look for notable scientific developments in F-M radios from Motorola engineers. We can't say *when* . . . but we *can* say that no one will be ready sooner.

Expect big things from Motorola!

THE ARMY-NAVY "E"—Awarded for excellence in the production of Communications Equipment for America's Armed Forces

Motorola Radio Communications Systems Designed and Engineered to Fit Special Needs

GALVIN MFG. CORPORATION • CHICAGO

TECHNICANA

[*Continued from page 12*]

the stratosphere seven and one-half miles up, has been developed by the RCA Victor Division of the Radio Corporation of America.

Built of transparent Plexiglas, the chamber is actually the unfinished nose of a bombing plane. Because of the transparent construction, it makes possible the complete testing and inspection of any piece of radio apparatus by several engineers at one time and materially speeds test work. This new construction has eliminated the difficulties found with standard test chambers which are constructed of metal and permit vision only through small portholes.

Defects in design, which normally would remain hidden until actual high altitude flights could be made, are now spotted at a glance. An entire complement of test instruments and meters may be connected to the apparatus under test and plainly viewed by the project engineers.

This chamber is cone-shaped, about four feet high and five feet in diameter at its base. It is just less than one-inch thick and capable of withstanding tremendous shocks and pressures. An airtight seal is accomplished by fitting a heavy platform, arranged for mounting radio apparatus under test, with a ring of soft rubber. The test chamber cone is then lowered until its base rests on the rubber ring. As the air is withdrawn by a powerful suction pump, the atmospheric pressure on the outside of the chamber forces it down into the rubber ring and creates a perfect air seal.

★

OSCILLOGRAPH RECORDS MUSCLE SPASMS

TREATMENT OF infantile paralysis victims, industrial and war cripples may be improved through data recorded by a twelve-element oscillograph developed in the Myodynamics Laboratory of the University of Rochester School of Medicine. Capable of recording all factors essential for the study of foot functions while walking, this instrument is the result of 17 years of research conducted under the direction of R. Plato Schwartz, M.D., head of the Division of Orthopedics.

Resistance disks are applied to six points on the bottom of each foot. Each disk is smaller, and slightly thicker than a dime, so that the records may be made either barefoot or with the

[*Continued on page 18*]

The revelations concerning RADAR and its part in the war came as no surprise to those whose job is to supply our fighting forces with modern electronic equipment. Since before Pearl Harbor these Americans have been working shoulder to shoulder with our armed forces in applying the power of electronics to the art of war. Out of this united effort have come fighting weapons never before known—on land, at sea or in the air. In this pioneering work it has been National Union's privilege to play a progressively increasing part. A greater National Union has been built to cope with vastly larger responsibilities. Today, National Union is ready to consult with and assist other manufacturers in the use of electronic tubes. Tomorrow, when peace comes—when the industrial usage of electronics gets the green light—engineers and production men will find at National Union unexcelled service and cooperation in perfecting new electronic applications for the production, testing and packaging of their products.

NATIONAL UNION RADIO CORPORATION • NEWARK, N. J. • LANSDALE, PA.

NATIONAL UNION
RADIO AND ELECTRONIC TUBES

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

TECHNICANA

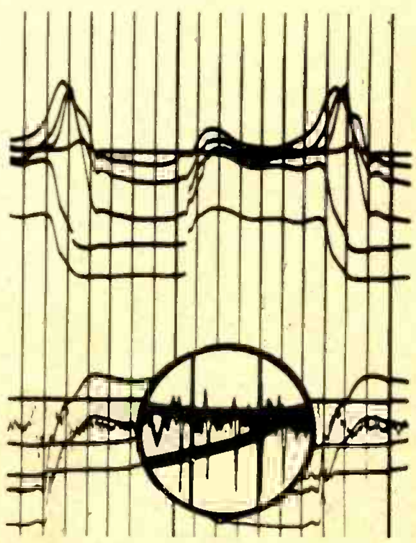
[*Continued from page 15*]

Ernest Barth records gait pattern of nurse with oscillograph.

subject wearing various types of footwear. The current passed by each of these disks varies in proportion to the pressure exerted upon it as the patient walks. By means of a suitable cable each disk is connected to one of the 12 high sensitivity General Electric galvanometer elements. A tiny mirror in each galvanometer reflects a pin point light beam as the galvanometers deflect in response to pressure changes on respective disks.

Focussed through an optical system, these beams strike a strip of photographic paper eight inches wide, 200 ft. long, which is moved past a slit aper-

[*Continued on page 52*]



Record obtained of walking characteristics. Portion in circle shows record of muscle action current.

THE *Ability* TO GO TO WAR!

In 1929, fourteen years ago, the first JENSEN Auditorium speaker was introduced. The first of its kind, it has during all the succeeding years faithfully served the public and professional need for a heavy duty, high quality loud speaker. We think it is undeniably the world's best known and respected loud speaker product. Now, this fourteen year old JENSEN product goes to war. Naturally it incorporates the refinements and improvements which have been steadily added, but the basic design and function remains the same. Many other JENSEN products are thus endowed with the ability to go straight to war.

Jensen
RADIO MFG. CO.

6601 SOUTH LARAMIE AVENUE
CHICAGO, U. S. A.

NONSINUSOIDAL WAVE GENERATORS

W. P. BOLLINGER
RCA Victor Division
Radio Corporation of America

★ With the advancement of the electronic sciences has come the increased application of waveforms other than sinusoidal. Three of the most common and important of these are the square wave, the pulse, and the sawtooth.

Square Waves

One method of producing a square wave is by successive amplification and clipping of a sine wave. For example, in *Fig. 1-A* if the sine wave is clipped at the dotted line and amplified, a wave with slightly slanting, nearly straight sides, as in *Fig. 1-B*, will be produced. Further amplification and clipping will give a square wave whose sides are nearly vertical. This clipping and amplification can be accomplished by an amplifier as in *Fig. 2*, whose input voltage is so high that saturation takes place. The sine wave is then clipped on the positive side by virtue of the grid drawing current and on the negative side by virtue of the grid voltage going beyond cutoff.

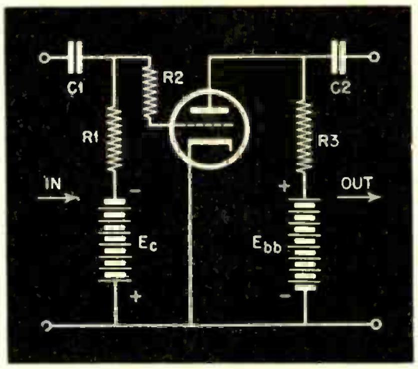


Fig. 2. Circuit for clipping sine wave.

Square waves can be generated more directly by use of the discharge circuit shown in *Fig. 3*. When the voltage is applied to this circuit one of the discharge tubes, which may be ordinary neon bulbs, becomes conductive. For purposes of analysis, let us assume that *V1* is the conducting tube. The capacitor *C1* will then start charging through *R2* with the result that point *(2)* will become positive with respect to point *(1)*. Since the potential of point *(1)*, with respect to the negative lead of the power source, is fixed by the drop of *V1*, point *(2)* will gradually rise in potential as *C1* charges until the discharge tube *V2* becomes conductive. When *V2* is conducting, point *(2)* is fixed in potential and since point *(1)* is negative with respect to point *(2)*, the voltage on *V1* will be lowered below that required to maintain a discharge. Capacitor *C1* will then begin charging in the opposite direction resulting in point *(1)* becoming positive with respect to point *(2)* and the cycle will be repeated. The discharge then oscillates between the two gas tubes in such a manner that one is always conducting but never both at the same time.

If the two gas-discharge tubes have identical characteristics and *R1* and *R2* are equal, the two tubes will conduct equal periods of time. If the resistances are unequal, the discharger tube connected to the lowest resistance will conduct the greater part of the time. Oscillation frequency is determined by the ignition and extinction voltages of the gas-discharge tubes and the values of *R1*, *R2* and *C1*. The larger *R1*, *R2* and *C1* are made, the lower will be the oscillation frequency. Square-wave output voltage may be obtained across small resistors *R3* and *R4*, the voltage across one being 180 degrees out of phase with that across the other. Synchronizing voltage, if used, may be applied across either *R3* or *R4*.

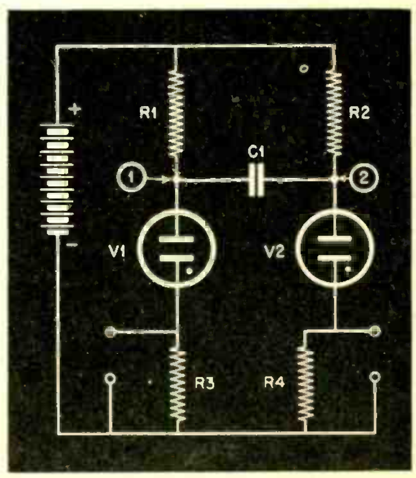


Fig. 3. Gas tube discharge oscillator.

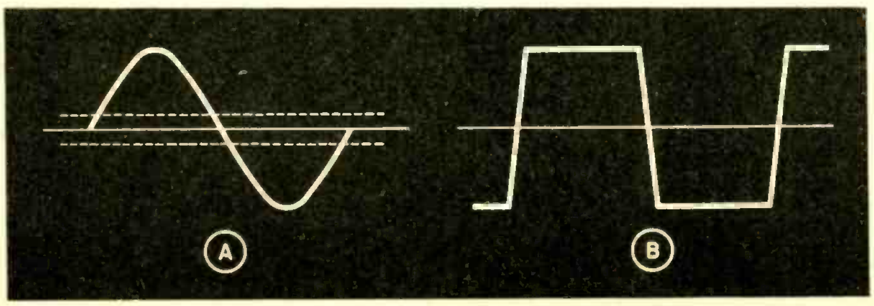


Fig. 1. Clipping of sine wave for production of square wave.

Another method of generating

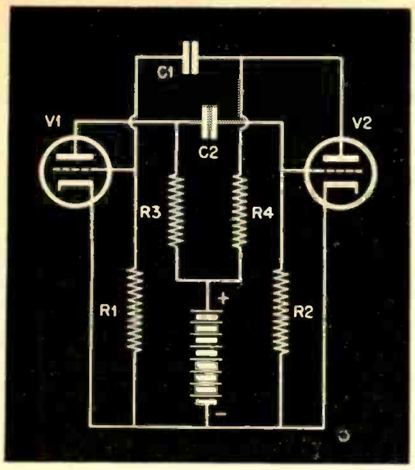


Fig. 4. Circuit of multivibrator.

square waves directly is by means of a multivibrator, the circuit of which is shown in *Fig. 4*. In this circuit only one tube at a time is conducting, the other being biased beyond cutoff. For example, if *V1* is conducting, the coupling capacitor *C2* has a charge such that the grid of *V2* is highly negative. This charge leaks off through *R2* until the grid voltage of *V2* is high enough that it begins to draw plate current. Now during the time that *C2* is discharging *C1* has been charging through *R4*, so that when *V2* begins to conduct, the grid of *V1* is driven highly negative, causing an abrupt transfer of plate current from *V2* to *V1*. The coupling capacitor *C1* now begins to discharge through *R1* until such time that *V1* begins to conduct and the plate current is transferred from *V2* back to *V1*. Oscillations are then set up the frequency of which depends principally on the values of *R1*, *R2*, *C1* and *C2*. If *R1* and *R2* are equal and *C1* and *C2* are equal, each tube will conduct half the time and a symmetrical square wave will be obtained. The higher the values of *R1*, *R2*, *C1* and *C2*, the lower will be the frequency of oscillation. If synchronization is desired, the locking voltage may be introduced in either grid circuit.

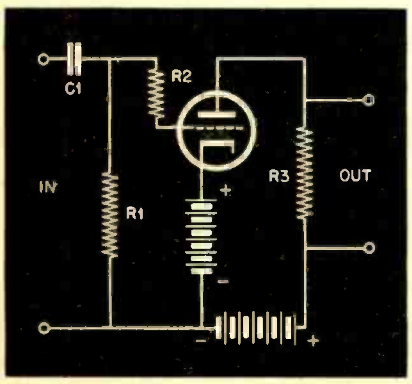


Fig. 5. Differentiator and clipper.

Producing Pulses

Pulses may be produced from a square wave through successive differentiation and clipping by means of circuits similar to that shown in *Fig. 5*. The input coupling capacitor *C1* is very small so that it charges completely during the first portion of the square-wave cycle. This is shown in *Fig. 6* where *A* is the input square wave and *B* is the current flowing through *C1* and consequently the voltage across *R1*. Note then that the current and consequently the grid voltage are present only for a short time immediately after a change in input voltage. The vacuum tube connected to the differentiation circuit *R1-C1* is biased to cutoff, so only the

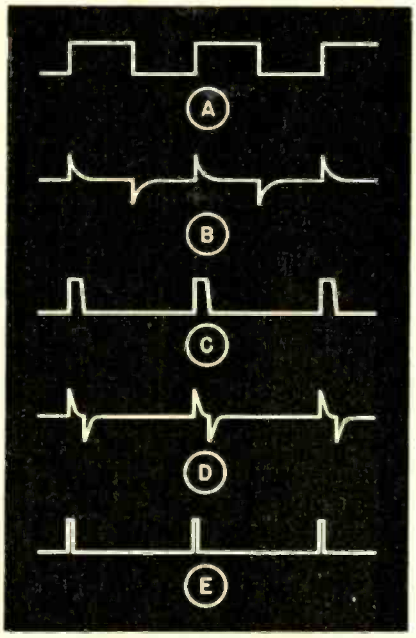


Fig. 6. Production of pulse by differentiation.

positive excursions are amplified and those are clipped at the voltage at which the amplifier begins to draw grid current. The purpose of *R2* is to offer a high-impedance circuit so that the clipping action may take place. The output voltage, *C* in *Fig. 6*, is then the positive excursions of wave *B* amplified and clipped and producing a nearly square pulse. This output pulse may be shortened still more by feeding it to a similar circuit, again differentiating as in *D* and amplifying and clipping as in *E*. The original square wave may, of course, be produced by any of the methods previously described.

A more direct method of producing a pulse is by means of the discharge oscillator circuit shown in *Fig. 7*.

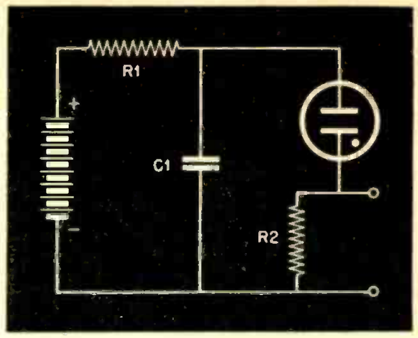


Fig. 7. Gas tube discharge oscillator.

When the voltage is applied *C1* charges through *R1* until the capacitor voltage is high enough that the gas discharge tube becomes conductive. This tube may be an ordinary neon bulb. As soon as the discharge tube becomes conductive, the capacitor is discharged very quickly through *R2* until the voltage is so low that the gas tube is extinguished. The capacitor then begins to charge again and the whole process is repeated.

The frequency of oscillations is determined by the values of *R1*, *C1* and the ignition and extinction voltages of the gas-discharge tube. The higher the product of *R1* and *C1*, the lower will be the frequency. Pulse voltage may be obtained across *R2*, or if power is desired, *R2* represents the load. With this circuit, pulses as short as 10 microseconds in length may be easily obtained. Synchronizing voltage may be applied across a small resistor connected in series with *C1*.

The Blocking Oscillator

The blocking oscillator shown in *Fig. 8* is well suited for producing pulses of short duration. This circuit is a conventional oscillator except that the value of grid leak *R1* is exceptionally high. As a result of this and the large amount of feedback, high

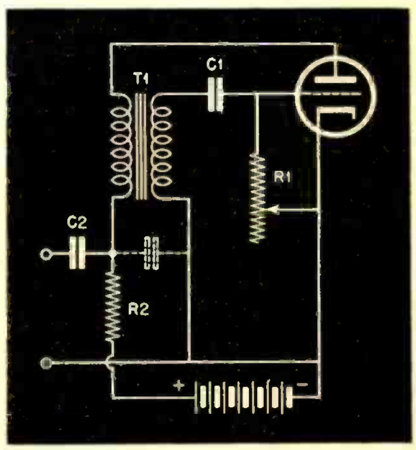


Fig. 8. Blocking oscillator circuit.

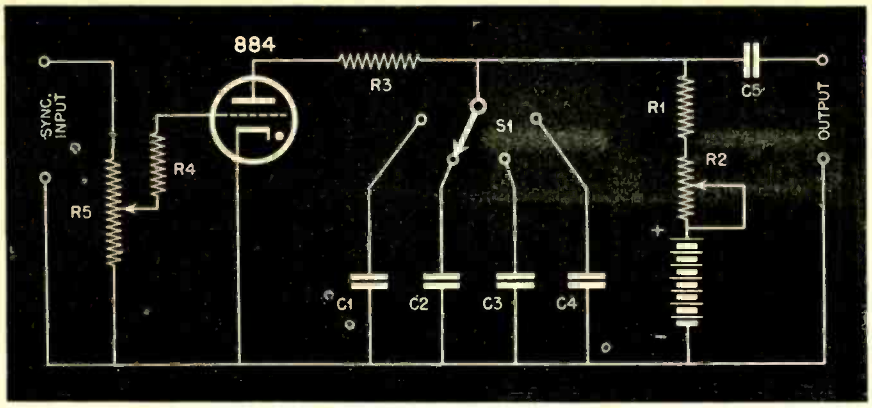


Fig. 9. Circuit of sawtooth generator.

negative bias is built up across *C1* very shortly after the circuit begins to oscillate. If this voltage is high enough the tube will be biased a great deal beyond cutoff and will cease to oscillate. The coupling capacitor, *C1*, will then begin to discharge through *R1* until the negative grid voltage has been reduced sufficiently so that oscillations may begin again. The entire process is then repeated.

The frequency of the feedback oscillations is determined by the natural resonant frequency of the feedback transformer and may be made any convenient value. If the frequency is made high, several cycles of oscillation may take place before the grid blocks. However, if it is relatively low, the grid may block before a fraction of a cycle of the oscil-

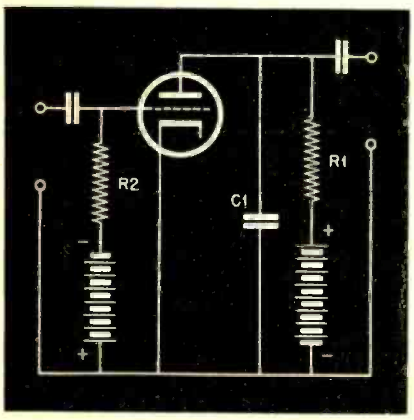


Fig. 10. Sawtooth generator.

lations is completed. The frequency at which the blocking takes place may be controlled by varying either *C1* or *R1*. The higher the product of these two values, the lower will be the blocking frequency. Every time the circuit begins to oscillate, a large value of plate current is drawn while the remainder of the time the plate current is zero, since the tube is biased beyond cutoff. Pulse voltage may then be obtained across *R2*. Pulse voltage may also be obtained by connecting the grid of an amplifier directly to the grid of the blocking oscillator. This amplifier will then also be biased beyond cutoff except when the circuit begins to oscillate, at which time it is momentarily driven positive, resulting in a high peak output voltage of short duration. Pulses as short as 5 microseconds may be easily obtained from this circuit. Synchronizing voltage, if used, may be introduced across a resistor connected in series with the ground lead of the feedback transformer.

Sawtooth Waves

The third type of common non-sinusoidal wave, the sawtooth, may be produced by the previously discussed gas tube discharge oscillator of *Fig. 7*. Since the action of this circuit is a gradual charging of the capacitor *C1*, followed by an abrupt discharge through the gas tube, a reasonably good sawtooth voltage may be obtained across the capacitor. A common application of this circuit is for the oscilloscope sweep generator shown in *Fig. 9*. The discharge tube is a gas triode whose grid is used for the introduction of a synchronizing signal. The charging capacitors *C1, C2, C3* and *C4* are selected by the coarse frequency switch *S1*, while the fine frequency is controlled by *R2*. The purpose of *R3* and *R4* is to limit respectively the plate and grid peak currents to safe values. The potentiometer *R5* is used to control the amplitude of the synchronizing voltage.

The blocking oscillator of *Fig. 8* is also well suited for producing sawtooth waves. If a rather large capacitor is connected between the junction of the transformer and *R2* and ground, as shown by the dotted symbol, this capacitor will charge slowly through

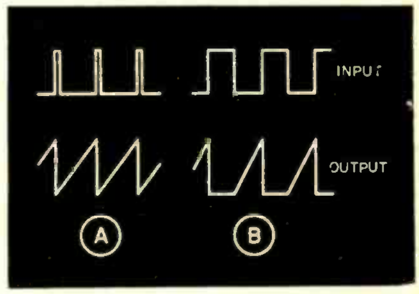


Fig. 11. Waveforms for circuit of Fig. 10

R2 during the time the circuit is not oscillating and then will partially lose its charge abruptly when the circuit oscillates and draws plate current. A sawtooth of voltage will then be obtained instead of the original pulse. A sawtooth of voltage may also be obtained from the grid of the blocking oscillator tube. However, the waveform is usually not satisfactory

Other Means

Sawtooth voltages may also be produced from pulses and square waves. A circuit for accomplishing this is shown in *Fig. 10*. The triode is biased

[*Continued on page 56*]

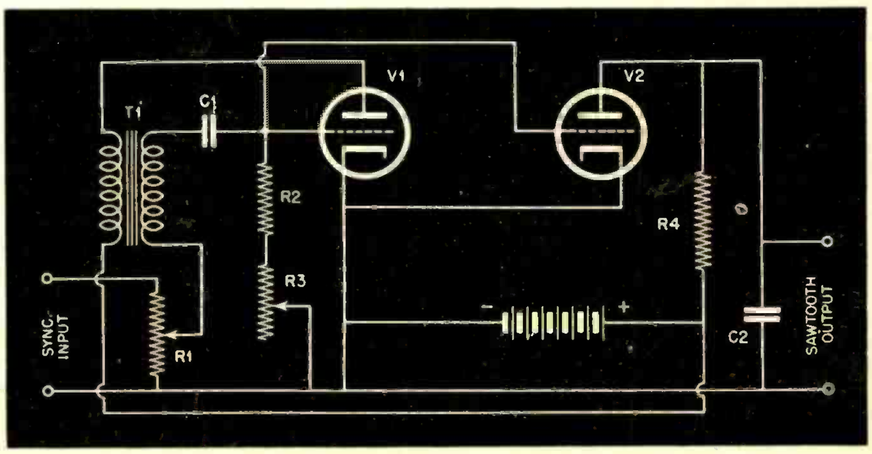


Fig. 12. Sawtooth generator using a blocking oscillator.

DESIGN OF

LINE-CONTROLLED U. H. F. TRANSMITTERS

HAVING CRYSTAL STABILITY

S. YOUNG WHITE
Consulting Engineer

Experimental Development of Compact 5-Watt Unit Free of Spurious Frequency Modulation, Using Standard Tubes

★ Just before the war it was a pleasure to come across any signal at all in the region of 100 to 250 megacycles. However, it is safe to predict great activity in this region immediately after the war, and undoubtedly very disciplined performance will be required of our receivers and transmitters. Any transmitter that puts out energy in any channel but its own will be unusable.

Scope of Project

A project was set up by the writer to investigate all forms of line-controlled transmitter circuits, as well as all available tubes to be used with them, to determine the most stable, compact and economical combination to give out at least five watts. Both battery and power line were to be used. It was desired that 100% amplitude modulation be obtained with complete freedom from spurious frequency modulation.

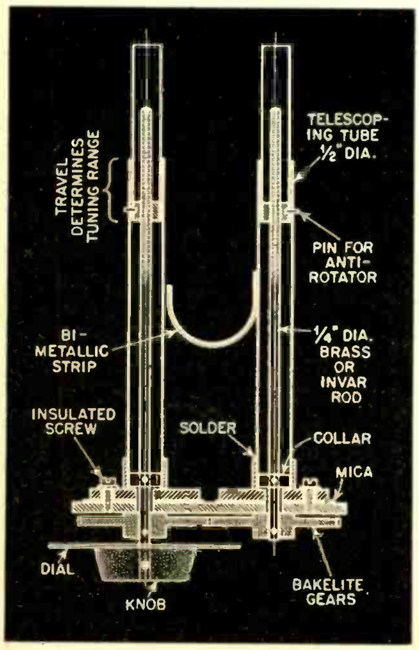


Fig. 1. Details of universal tunable parallel line.

A very full investigation was made at a frequency of 150 mc., as it represented a medium u.h.f. that most tubes could easily reach. The initial research revolved around parallel lines, and a number were constructed and their Q measured by the method described in the April issue of RADIO.

It was quickly ascertained that by far the most important thing about a parallel line is the spacing. If the line is not shielded the radiation resistance rises rapidly as the spacing is increased, and since the copper losses in the line are much less than the radiation losses, a lowered Q resulted even if larger conductors were used. For instance, lines made of ¼-inch tubing spaced one inch gave a Q of 970, while a line made of half-inch tubing spaced 2½ inches gave a Q of only 780. When the latter line was shortened to a frequency of 250 mc. the Q fell to 560, as of course the spacing became a much larger fraction of a wavelength, and radiation increased.

Spacing is of equal importance in a line enclosed in a copper box; the box prevents radiation, of course, but at the same time the line has an appreciable field due to the spacing, and consequently sets up eddy currents in the box, giving rise to eddy-current losses. This is of great practical importance

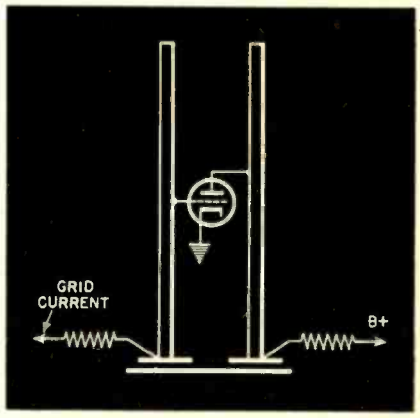


Fig. 2. Tunable parallel line used with single triode.

in two respects. Since the frequency of the line is affected by the dimensions of the box, which in turn is subject to change with temperature, the box introduces thermal instability. It is also very difficult to design a box of sufficient strength as to be unaffected by vibration and stresses met with in mobile work; so if the box warps, or if the sides of the box resonate mechanically, it will be reflected as frequency instability in the line.

Some of the lines were mounted an inch above a wooden base on the usual standoff insulators, and erratic effects noted at times. It was found that the wood in the field of the line lowered the Q to less than half, even with the wood very dry. This was overcome by covering the wood with copper foil. In some other work it was found that an antenna mounted one inch off a wooden

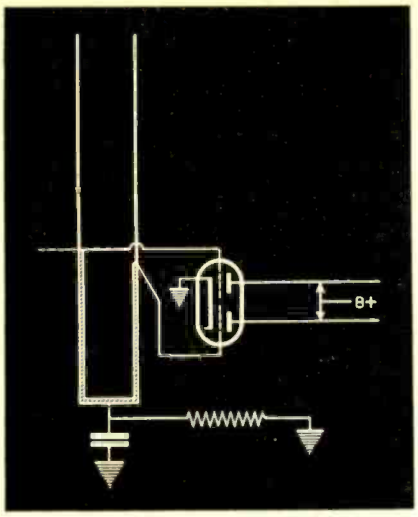


Fig. 3. Parallel line used with double triode.

2"x2" support radiated nearly half its energy into the wood, which suggests that all u.h.f. antennae should be self-supporting.

Mechanical Aspects

Fig. 1 shows the mechanical construction of a very convenient parallel line for general use as an oscillator in the laboratory, or as a transmitter. It can be used with a single or double triode, or with a double beam tube such as the 815, as in the circuits shown in *Figs. 2, 3,* and *4.* The capacities at the bottom of each line are very convenient as they are at r.f. ground potential, and can be used as grid and shunt plate feed capacitors.

The lines themselves can be of half-inch telescoping tubing, mounted on a flat brass plate about 3/16 inch thick, by means of the bushings shown. The capacitors are formed by mica washers between the plate and the bushings. Since these capacities need to be as large as possible, both the bushings and the plate should be made quite flat by polishing them with fine emery cloth backed by a piece of plate glass.

The threaded ¼-inch rods are used to tune the lines through a range of frequencies by extending the telescoping sections of the line. If these rods are made of Invar, they will serve to hold the length of the line constant with temperature changes. Since the rods are at different d.c. potentials, bakelite adjusting gears are used to insulate one from the other.

Choice of Tubes

There are a number of considerations that determine the choice of a tube used with a parallel line. Of the filament type tubes the Gammatron 24 and the 316A come to mind. Both have bad frequency modulation when the filament supply is a.c., apparently due to magnetic modulation of the electron stream. The 24, because of its coiled filament, will "splash" about 200 kc at 150 mc if operated on a.c., and the 316A about 125 kc.. With storage-battery supply for the transmitter they must still be watched carefully, as with a vibrator power supply and common leads from the battery the vibrator drop will show up as a few kc of frequency modulation, so separate leads should be used. Heater types, such as the Hytron 615 and the Acorn 955, have less of this effect, of course, but even the Acorn heater on a.c. will develop some frequency modulation due to the magnetic effect of the heater

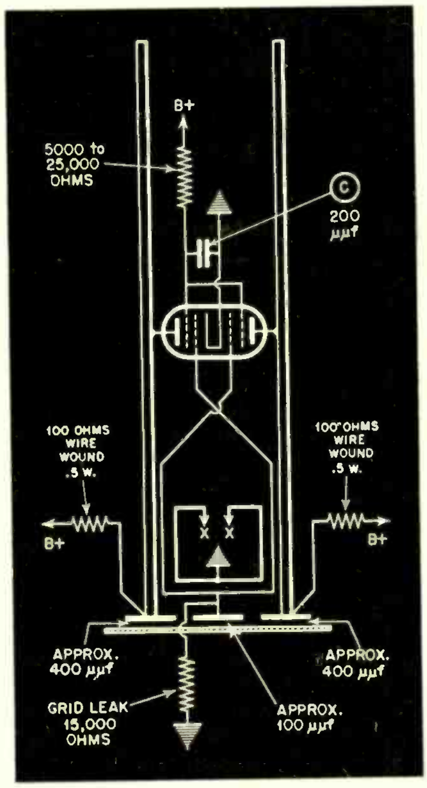


Fig. 4. Double beam tube used with parallel line. Leads X-X connect to twisted pair transmission line for driving buffer or load. Capacitor C is 200 mmf for 815 tube, built in types 828 and 832.

winding, which is noticeable above 150 mc. It is also advisable, when using a.c., to choose a circuit in which the heater and cathode are grounded, to eliminate heater-to-cathode effects which also give rise to frequency modulation.

When any of the single triodes are used in the circuit of *Fig. 2,* it will be found that the circuit is not symmetrical. The grid loading is very heavy, and the voltage on the side of the line connected to the grid is less than half that developed on the plate side. It will often be found that the plate line should be about 2% to 4% longer than the grid line.

A full investigation was made of all triodes as to their effect on stability if they were operated somewhat down the line from the end. All tubes vary in their loading effects on the line. For instance, an unloaded line at 150 mc is about 18½ long. A 316A at the end of the line will shorten it to 14½ inches, a 6A6 to 8½ inches, and all other tubes to some intermediate value. The tube is obviously a very poor tuning element, and should be coupled as loosely to the circuit as possible so that its variations will have a minimum effect on the frequency. This is accomplished by sliding the tube down the line in somewhat the same way as we vary the L/C ratio in a concentrated tank circuit. If it is moved too far down, however, sufficient impedance is not developed to match into the tube.

Striking Voltage

A very significant point to observe in the performance of any oscillator circuit is the "striking voltage"; that is, the plate voltage at which the system begins to oscillate. If an Acorn strikes at 8 volts, or a 316A strikes at 15 volts it means the impedance and phase angles are extremely favorable, and we almost invariably have an oscillator which is not affected by small changes in voltage when operated at 100 volts or more. If it takes 50 volts to strike the tube, the oscillator will be unstable. By sliding the tube down the line until the striking voltage increases by 25% or so, the minimum coupling point is found. With the Acorn it will be about 4½ inches up from the bottom. At the same time, it is necessary to increase the line length to make up for the tube loading removed, to maintain frequency, and to determine how much longer the plate

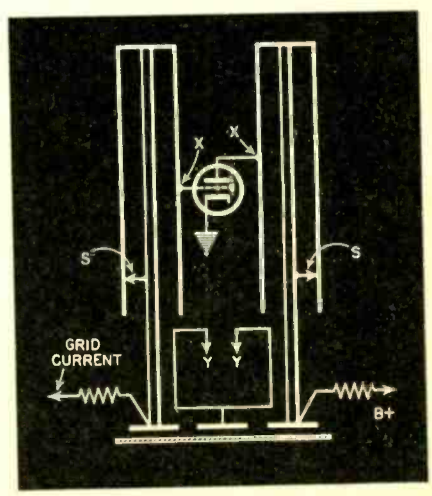


Fig. 5. Halving length of parallel line by slipping concentric tubes over their ends. Tuning over the whole range can be accomplished by moving the shorting contacts S.

line must be for minimum striking voltage.

By careful measurement with all tube types, it was found that the best point at which to attach the tube to the line was not critical, and in every case about one-third up from the bottom is satisfactory.

The value of grid leak and grid capacitor was likewise measured with every tube and at all frequencies and positions on the line, and found not to be critical. This was done with the grid capacitor right at the grid, and not at the bottom of the line, as in *Fig. 2*.

An unexpected observation was made with the tuned grid, tuned plate circuit of *Fig. 3,* with the two lines uncoupled. Only the portion of the grid lines shown in heavy lines were doing any work, these portions acting as a simple inductance and the top portions acting as a slight capacity load. The frequency was determined almost entirely by the plate lines. This is a common effect at u.h.f., where the grid loading is so heavy that the Q of the plate circuit is much higher than that of the grid, since plate loading is only about one-third that of grid loading. In fact, in the case of a tickler oscillator with a concentrated tank circuit, a grid tickler should be used. If a plate tickler is used the tube will often shift over to parisitic oscillations at the plate frequency, but with a grid tickler it will never shift over to grid frequency.

The double beam 815, 828, and 832 tubes work well in the circuit of *Fig. 4.* The plates are strapped to the line, and a grid tickler couples each grid to the opposite line. The grid capacitor is formed by means of a flat plate screwed on the base plate and insulated with mica in the same manner as the bushings on the lines. The tickler can be any self-supporting wire. The plates are about two-thirds of the way up the line, and the tickler spaced about 1/4 inch from the line, the dimensions not being critical.

This assembly makes a very useful laboratory oscillator, the 815 giving over 25 watts at 400 plate volts, if desired. The length of the lines is about 15 inches for 150 mc, and the arrangement works well up to 220 mc.

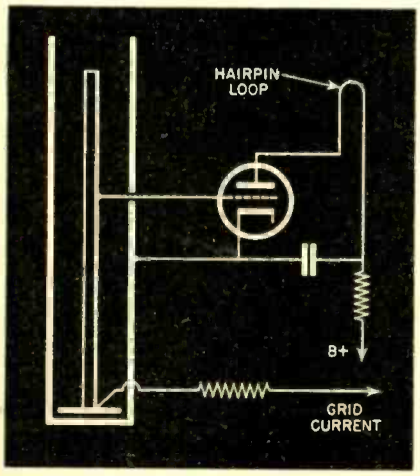


Fig. 6. Simple circuit offering advantages of grounded cathode.

Variable-Frequency Line

At lower frequencies, such as 100 mc, a line assumes an awkward length, being about 30 inches at this frequency. Attempts to shorten this markedly with a capacitor lowered the Q with capacitors that were available. For this reason the assembly of *Fig. 5* was developed, and has interesting characteristics.

If the tube is connected at points *X-X*, and if the length be 15 inches, the frequency will be 92 mc. By sliding the short circuit *S* which connects the inside of the outer shell with the inside line, the frequency can be smoothly varied between 92 and 151 mc. This circuit is difficult to analyze, but has several advantages, the obvious one being a shortening of the line by nearly half. Moreover, it provides a current point at the bottom to which a buffer or other load may be coupled, with reasonably constant output.

The concentric line oscillator has several practical advantages. The outer tube is at ground potential and if it actually is a tube it forms a mechanically rigid structure which is thermally and mechanically indifferent to any movement of the housing. Its Q is also higher, since it has no radiation.

The circuit of *Fig. 6* offers the advantages of simplicity and a grounded filament or cathode. The plate hairpin is not at all critical; at 150 mc the spacing may be one inch and the length 3 to 7 inches. The oscillations, however, result from the phase angle of the plate being inductive, which tends to make the frequency sensitive to both voltage and load. The Q of a 2-inch line is about 1800, however, and it has about the same voltage stability as the parallel line of half the Q. The grid can be as little as one-quarter the way up the inner conductor, but it is quite sensitive to load.

The circuit of *Fig. 7* depends in practice upon how the leads come out of the tube, the difficulty being to obtain sufficient distance between the plate and cathode taps to develop a reasonably high impedance between them. For example, if a lead were run to the top of the inner element, as shown by the dotted line, the lead would assume the same potential as the part of the line it was opposite, inch for inch, and at the point of connection to the plate would be at the same potential at that point as though it were directly connected there. The same would apply if the grid and plate leads were interchanged. If an attempt is made to run these leads outside the outer conductor there would be introduced a large leakage inductance in series with the element, and a phase angle would result, again giving instability.

Power Level

The power level at which the oscillator is operated is of great importance. The oscillator must drive the buffer grids at from 15 to 40 volts. This buffer load has a pronounced resistive component made up of the circuit losses, the grid leak, and the transit time and other losses in the tube. The writer believes the manufacturers of the double beam tubes are a little optimistic on their ratings as to driving power, which they give as being only the grid leak wattage dissipation. These tubes require appreciable power to drive even below the grid current point, and this load reflects into the oscillator, lowering its Q and stability. Obviously the more power put into the oscillator, the lower the percentage of this power drawn by the buffer, and the more stable the oscillator.

A real effort was made to drive an 815 buffer with an Acorn oscillator, but the power requirements were too great. In the writer's experience in using Acorns in receiving circuits, it is a mistake to run the plate voltage on the triode type much above 100 volts, as at the 250-volt rating either the grid current was down to one-third, or the frequency shifted more than 100 kc at the end of ten hours of such operation in more than 25% of the tubes tested. The little Hytron 615 is somewhat better, but at least in the earlier production shifted characteristics rather rapidly if run at two watts. For a.c. on the filament, about the only

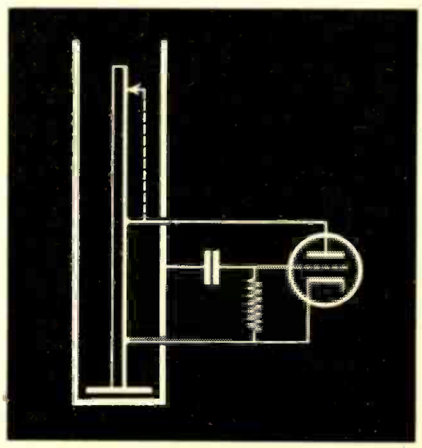


Fig. 7. Interesting circuit, but offers difficulties in obtaining high impedance between plate and cathode.

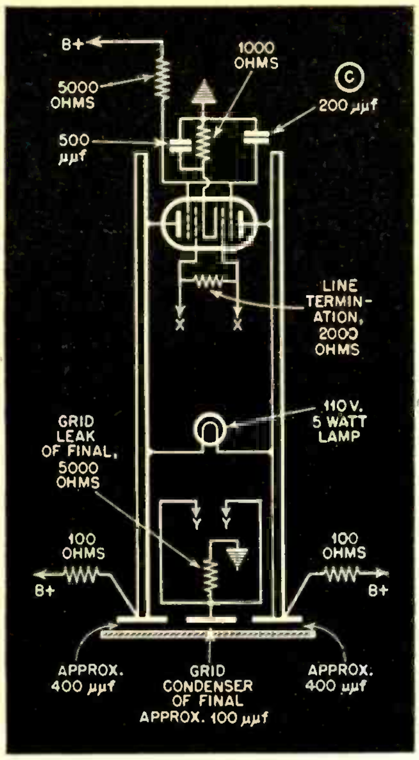


Fig. 8. Circuit of buffer stage with beam tube. Leads Y-Y to grids of final. Capacitor C is 200 mmf for 815, built in 828 and 832.

tube left is the 815, which will run at 4 watts input for a long time. The 316A has a good life also at 8 watts input.

When attempts were made to make a transmitter of this type with only an oscillator and final stage, it was not successful. Remember, the goal was crystal stability as far as "splash" is concerned, and on 100% modulation the spurious frequency modulation was about 90 kc wide at 150 mc. This was due to insufficient shielding inside the tube, and when neutralization was attempted proved to be too critical to be practical.

When a double beam 815 or 832 was used as buffer in the circuit of *Fig. 8*, it was noted that it was not necessary to drive to grid current at all. Plate power was limited to about five watts to conserve on overall power supply, and no increased efficiency resulted from high grid currents; and, of course, the load on the oscillator was less.

The double beam final of *Fig. 9* required somewhat more drive for linearity of modulation, of course. It was found practical to detune the buffer plate to control the grid drive on the final, and also to place a one-watt lamp load on the buffer, permanently mounted at a suitable point down its plate line. This is definitely makeshift, but it is an easy way to lower the Q of the plate circuit of the buffer to limit its reactive effect through the interelectrode capacity, and allowed the final to be well modulated and yet emit 99% of its energy at all times within a 10-kc channel.

Since the transmitter was to work into a 72-ohm line, it was found very convenient to build in a short length of such line terminated in a 72-ohm lamp load at five watts. Such a load can be easily made up of three 6.3-volt 250-ma dial lamps debased and connected in series. By shifting from the antenna line to this inbuilt line and load, the power and modulation can be quickly and visually checked.

Loop Coupling

In laying out a compact assembly of the transmitter, it will be found very convenient to couple from plate to grid of the succeeding stage by a twisted pair line, coupled to the plate line by a small loop. Considerable care should be used to make this line symmetrical to ground. Remember, 1μμf has an impedance of only about 90 ohms at 150 mc. It will also help to equalize the drive on each grid by terminating this line right at the grid with a 2000-ohm resistor of the type made by depositing colloidal carbon on a glass thread.

The modulator for this transmitter can be a three stage Class A ending in a 6L6 giving about five watts out. Usual precautions should be taken to insure that r.f. does not get into the audio system.

The power supply was a 12-volt double vibrator giving 300 volts at 180 ma, with single section filter. From this it can be seen that the stability of the power supply was not very good, but nevertheless adequate for this job. The plate voltage for the oscillator was stabilized at 150 volts, and drew 30 ma. The whole transmitter was housed in an HRO receiver cabinet.

It will be understood that when we discuss 100% modulation at 150 mc there are a number of assumptions being made that might not be true. An oscilloscope is useless at this frequency, and measurement with diodes has limitations also. The region between 85 and 100% modulation is still uncertain.

The variation of frequency with variation of supply voltage from 10 to 14 volts at 150 mc was about 45 kc. As the plate supply was stabilized, this was due to the change in dimensions of the tube by the variation in wattage dissipation in the filament.

Although the assembly was rebuilt several times to strengthen it against mechanical vibration, it was never able to pass an aircraft vibration test. For moderate shocks, as encountered in an automobile over normal roads, it was adequate.

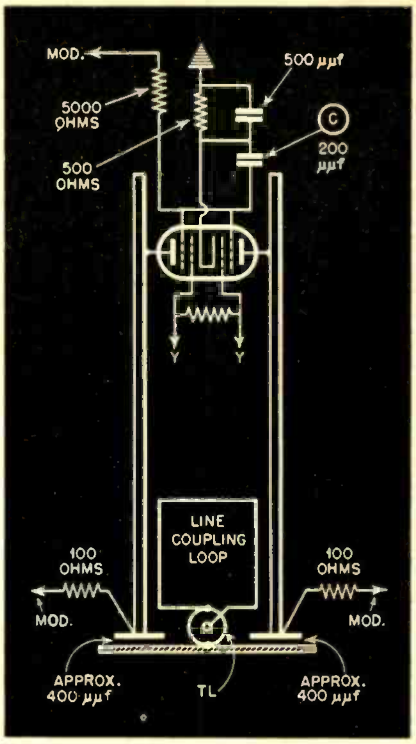


Fig. 9. Circuit of double beam-tube final. Y-Y twisted-pair leads to buffer. TL is a concentric line. Loop is about 4 inches long for 150 mc. Value of C same as previously given.

Thermally the stability was no more than fair. To stabilize it for a range of 100 degrees F. (not C.) it was necessary to fasten a very heavy bi-metallic strip on one line, and have the end close to the other line, as shown in *Fig. 1*. This brought the frequency excursion down to one kc per degree F. after a lot of cut and try. The line held length well because of the Invar rod in the center of each line, but compensation was necessary because of a change in the dimensions and conductivity of the housing with temperature.

Checking Modulation

The modulation capabilities were quite good. These were checked by modulating 100 percent at 5000 cycles and observing the output by means of a very sharply tuned receiver incorporating a beat-frequency oscillator. As the first step, the unmodulated carrier was heterodyned and the output read on an output meter. As the second step, modulation was applied and the true sidebands individually heterodyned and measured. In the event of spurious frequency modulation, spurious sidebands will appear at multiples of the modulation frequency. These were looked for at 10 kc, 15 kc and 20 kc either side of the carrier. The strongest was found at 10 kc, and amounted to 5 percent of the amplitude

[*Continued on page 56*]

DISSIPATIVE LOSSES

V. J. YOUNG

★ Over relatively short distances of twenty feet or less ultra-high frequencies can easily be transmitted through coaxial lines—with small losses. Not only can the loss due to mismatching in the line be reduced to a small amount by very careful adjustment[1], but with proper design the dissipative losses generating heat in the line and radiation out into space may be kept within bounds.

Disposition of Charge

If at any instant it were possible to take a snapshot which would show the position of all the charge on a high-frequency coaxial line, it would be found to be mostly either on the inner surface of the shield or the outer surface of the center wire. If we think in terms of a line operating in its fundamental mode, which is essentially the only one that can be present when the shield diameter is sensibly smaller than a wavelength, it is quite easy to see in part why this is true. The source always adds positive charge to the center conductor as it adds negative charge to the shield, and vice versa. Thus as these disturbances, which we usually call waves of current and voltage, travel down the line there always remains a symmetry of charge between the center and outer conductor.

Fig. 1 shows diagrammatically what is meant. Any charge on the outer conductor is at any instant just balanced by an equal amount of charge of opposite sign on the inner conductor. The attractive force between these unlike charges tries to hold the charge to the inner surface of the outer conductor and to the outer surface of the inner wire. This static picture of charge is not the whole story by any means. Actually, with microwaves, the charge moves as a current and reverses its direction twice as many times a second as the frequency of the energy transmitted. To discuss the so-called skin effect as a function of frequency and material, it is necessary to consider the facts more carefully. We need to do so and deduce what we can about the depth of penetration of energy outward through the outer conductor for two reasons: First, to arrange the dimensions so that no energy penetrates the shield and escapes as radiation; second, to determine the effective volume of metal through which the currents flow so that it will be possible to calculate effective resistance and then the I^2R loss generating heat in the line.

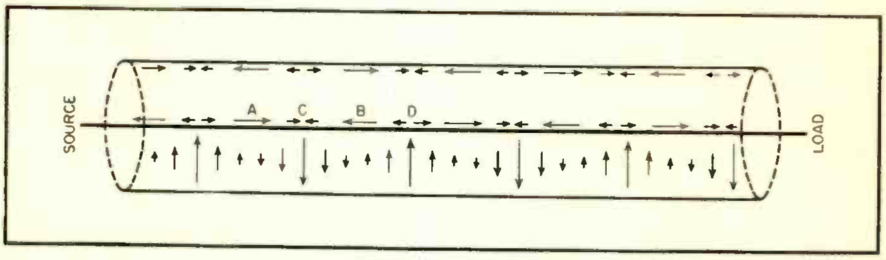


Fig. 2. The horizontal arrows show direction and magnitude of currents flowing in the coaxial line at some instant. The vertical arrows indicate voltage between adjacent points on the center wire and shield at the same instant.

Line Losses

Before going into this, however, let us consider some actual lines to illustrate the magnitude of the effect.[2] For example, with a line made of copper and using an optimum ratio of size for the inner and outer conductor, the dissipative losses will be 5 db per mile for a line having a sheath with an inner radius of 0.6 inch and operated at 20 megacycles. A loss of 5 db per mile means that only one-half of one percent of a given input energy is lost in a 20-foot length.

It is important to understand that line losses are best expressed in db per unit length because the loss is always a given fraction of the input

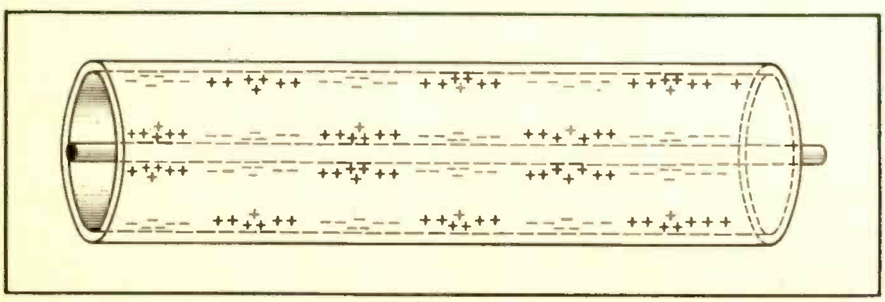


Fig. 1. An "instantaneous" view of a section of a coaxial transmission line showing that the charge active in the transfer of energy is primarily on the inner surface of the shield and the outer surface of the center wire.

[1] Losses due to mismatching are really losses only to the line and not necessarily to the system. They represent energy reflected back into the source. See "Mismatching in Coaxial Lines," RADIO, April, 1943.

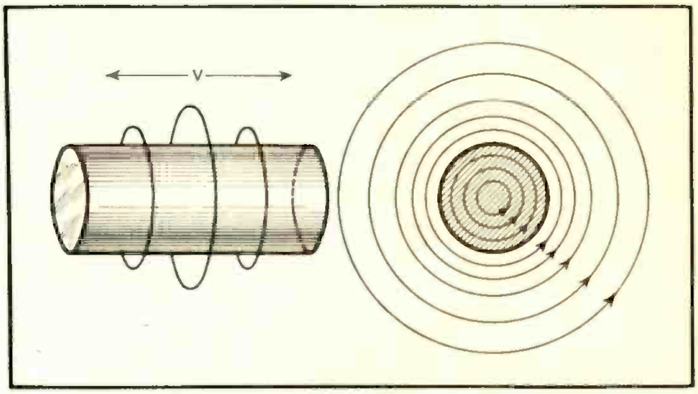
[2] Calculated values of attenuation coefficients for various size coaxial lines are shown in a paper by Sturba and Feldman in *Proc. IRE* 20, 1163 (1932).

IN COAXIAL LINES

power. This means that with the 20-foot line just mentioned, 0.5 watt would be lost if 100 watts were put in and proper termination arranged. If 99.5 watts were put in, the loss would be only 0.497 watt; with a 50-watt input, it would be only 0.25 watt. If the line is lengthened, the absolute value of energy lost per 20-foot unit of length will gradually decrease as we move along the line, always being one-half of one percent of that delivered from the preceding section. A convenient way of denoting this type of attenuation is by stating a coefficient in terms of db per unit length. The energy lost per unit length varies, but the db loss per unit length remains the same throughout.

To find the fraction of power passed through a mile of 5 db per mile line, we need only to take the reciprocal of the number whose logarithm is this coefficient expressed in bels. Thus, since the log of 3.17 is .5, a little less than a third of the input energy will be transmitted a mile. If the coefficients were 3 db per mile, then, since log 2 equals .303 about one-half the energy could be carried a mile. If from the 5-db per mile value it is desired to find the loss in 20 feet, it is first necessary to adjust the coefficient. Multiplying 5 by 20 and dividing by 5280, results in an equivalent coefficient of about 0.02 db per 20 feet. Since the log of 1.005 is .002, the transmission fraction is the reciprocal of 1.005 or 99.5%. The db losses are proportional to the length of the line. Power or percentage power losses are not.

Fig. 4. When a cylindrical conductor carries current, the magnetic field is something like that shown. The instantaneous voltage, V, gives rise to a current distributed in some fashion over the cross section which gives rise to a circular magnetic field.



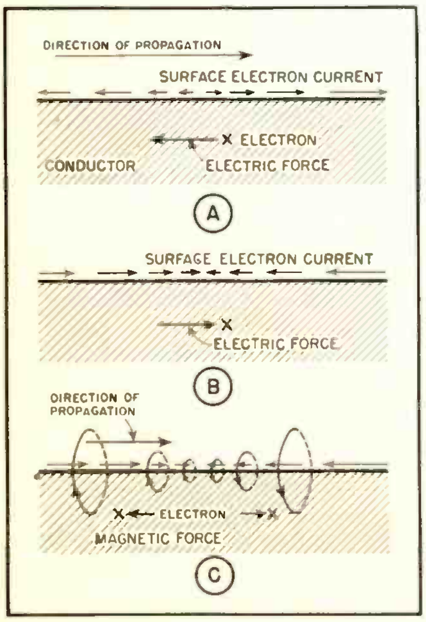


Fig. 3. Here the forces on an electron in a conductor carrying high frequency energy are illustrated. The horizontal arrows indicate electron currents along the conductor at some instant. Arrows pointing to the left are hence equivalent to positive currents to the right. In C it should be remembered that it is the rate of change of magnetic field that exerts a force on the charge.

Electronics as Basis

To improve the physical picture of electrical phenomenon it is very helpful to explicitly realize that all electrons are precisely alike. To visualize a current we need not think of a certain electron or group of electrons moving along, but only of the motion of a region in which there is an excess of electrons. Since the days of Franklin we have found it useful to talk of two kinds of charge, positive and negative. This is always true in fact and with ionic solutions the mobility of the two kinds of charge may well be of the same order of magnitude so that each kind does its share of the job in the transfer of energy. In metallic conductors, however, the charge in practically all cases is carried by electrons. The electrons are so much smaller than the positive ions that they have a much greater mobility and account for practically all the motion of charge. An uncharged metal ball is one which has an equal number of positive and negative charges. A negatively charged ball is one to which electrons have been added; a positively charged ball is one from which electrons have been removed. A current which for convenience we might call one of positive charge flowing from left to right is in reality one of negative charge flowing from right to left.

Thinking then in terms of electrons, the problem of deciding how deeply energy will penetrate the shield is simply one of finding how deeply an electron need be buried to be unaffected by the current and voltage waves traveling down the line.

In a perfectly uniform line terminated with a perfect match to the source and load, the way in which the current and voltage change with time is very simple. In *Fig. 2*, the current in the wire and shield and the voltage between the wire and shield are indicated for a certain instant of time. This assumes that the source is supplying a single frequency voltage. As time progresses the whole pattern simply shifts toward the load with a velocity equal to the propagation velocity of the wave which, in practical cases, will be nearly equal to the velocity of light.

In terms of an electron picture this means that in regions such as *B* in *Fig. 2* the electrons in the shield are

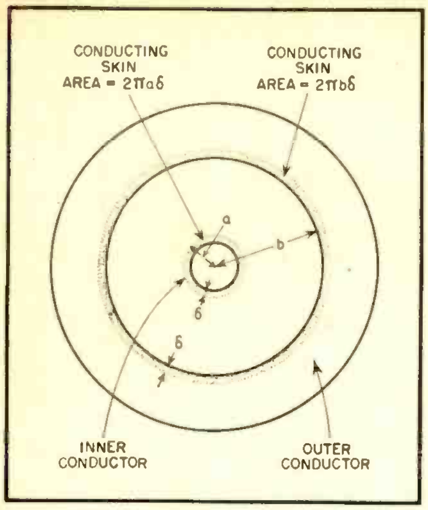


Fig. 5. Endwise view of a coaxial line shows how for some purposes we can think of current as flowing in a skin of perfectly definite thickness.

moving to the right while those in the wire are being displaced to the left. At a point such as *A*, the electrons are moving in the opposite direction. At a certain time later when the pattern has shifted so that point *B* on the line has a pattern like that shown at *A*, the electrons at *B* will have reversed their direction of displacement. Similar remarks may be made about the voltage. At *D* the wire is positive with respect to an adjacent point on the shield. At *C* the reverse is true. After the pattern has shifted a correct amount the voltages at *D* will be as they now are at *C*.

Forces on Electron

The question now is, how all this will affect an electron at a depth δ in either the shield or the center wire. This electron may feel two types of forces urging it to move, one electric and one magnetic. *Fig. 3-A* shows that as a positive current wave approaches (and a negative wave leaves) it will, because of its opposite polarity, be attracted back toward the source, being thus equivalent to a further advance of the positive current wave. In *Fig. 3-B* a negative wave is approaching and the electron is urged to move in the opposite direction, becoming a more advanced part of that negative wave. In *Fig. 3-C* it is shown that the magnetic forces have the same sort of effect. Other electrons at different depths in the shield cause changing magnetic fields as they accelerate. The lines of force from these magnetic fields run transversely through the conductor and as they change exert a force which tends to move the charge one way or the other along the line. This magnetic force on the electrons is in part such as to oppose the motion dictated by the electric field.

It is clear from *Fig. 4* how the competition between these electric and magnetic forces give rise to a skin effect. Here a single conductor is carrying a rapidly changing current, as it will if operated at very high frequency. Because of this current there will be a changing magnetic field which will be circular in form and surround the wire. The exact distribution of the field, expressed by how close together the lines of force are drawn at various radial distances from the axis of the wire, will depend upon how the currents are allocated throughout the cross-section of the wire; but whatever it is the center of the wire will be surrounded by more magnetic lines than the surface. This means that the electric field will have greater difficulty in moving the charge in the center of the wire and we will there find smaller currents than at the surface. It also means that the current will be shifted in phase as we go deeper into the conductor.

Penetration Factors

It turns out that it may be pretended for many calculations (especially when the frequency is very high) that all the current flows in a skin of thickness δ where

$$\delta = 2\pi \sqrt{\rho / f}$$

in which ρ is the specific resistance of the material expressed in electromagnetic units, and f is the frequency of the energy being transmitted. Actually, of course, this is not true. Currents do not flow uniformly for just this depth and then suddenly cease. Instead they fall off exponentially with penetration. It is just that we have calculated δ as the depth at which the current falls off to the proper value (about 0.6) so that all currents flowing at greater depths added to those at lesser depths gives the equivalent of the average current flowing in the skin alone.

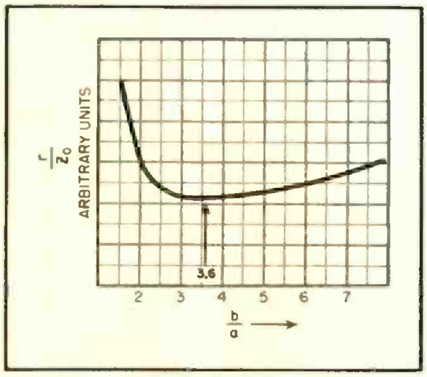


Fig. 6. This plot shows how the power loss depends on the relative size of the inner and outer conductor.

It is interesting to notice how δ depends on ρ and f. At higher frequencies the current is more and more concentrated at the surface. This fits in with the picture since higher frequencies mean more rapid changes in the magnetic field and hence stronger magnetic forces. δ also becomes small if the conductivity of the material is very high. This seems reasonable since a high conductivity material allows a skin of a certain physical thickness to be electrically equivalent to a thicker tube of higher resistance.

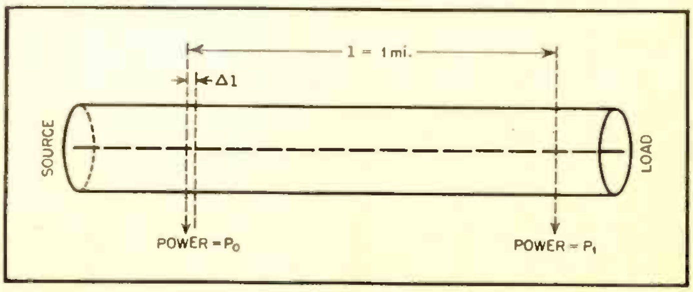
It must be pointed out here that the expression for the skin thickness, δ, has actually been calculated for a plane surface instead of a wire. For good conductors and high frequencies, however, δ is such a small number that this is a good approximation. Even a quite small wire may have a large radius of curvature as compared to δ.

Calculations

Returning now to the general problem of obtaining the best possible transmission in a line, it is found that this skin effect will influence the dimensions chosen. The problem is to make the loss of energy in the line as small a fraction of the power transmitted as possible. Since the quantity, Z_0, which we call "characteristic impedance," is the actual impedance of a properly matched system when the line is cut at any point and the impedance measured in either direction, it is apparent that i^2Z_0 is a measure of the power being transmitted at any instant. Likewise i^2r is the same sort of

[*Continued on page 55*]

Fig. 7. To calculate the db loss per mile it is convenient to first find it for a very short distance △l. Over such a short length we are usually justified in assuming a constant current.



CHARACTERISTICS OF

RADIO-ELECTRONIC COMPONENTS

A. C. MATTHEWS

A Resumé for Electrical Engineers, Production Men, and Technicians Now Concerned with Developments in the Ever Expanding Radio-Electronic Field

FOREWORD

A chain is no stronger than its weakest link; likewise it is true that a radio or an electronic device is no more reliable than its weakest component part. Failure of a device due to temperature and humidity effects can be greatly reduced by applying the knowledge obtained from a careful study of the individual component parts.

The problem is largely one of insulation or dielectric changes with respect to varying temperature and humidity, although the normal expansion and contraction of materials must not be overlooked. In making a study it is first necessary to devise a test procedure and then develop a technique of measurement. Too much data can never be taken during a study of this type. A record of ambient temperature and relative humidity throughout any tests may save hours of rechecking and quite possibly prevent an erroneous conclusion from the results. Another primary rule is always to check a "standard" part along with any unknown. By "standard" is meant any part that has been repeatedly found to have certain characteristics under the conditions of the test. Thus if the "standard" behaves normally one can be reasonably sure that the test has been properly made.

★

PART 1—RESISTORS

Like most other component parts, resistors might be discussed in great detail; however, a generalized treatment of the more important design features with appropriate curves will be sufficient to demonstrate their characteristics.

The resistance of a conductor is directly proportional to its length and inversely proportional to its cross section. Thus,

$$R = \rho \frac{l}{A} \qquad (1)$$

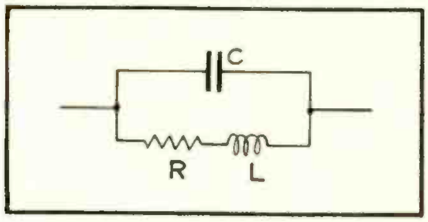


Fig. 1. Equivalent circuit of a resistor.

where ρ = specific resistance of the material
l = length of conductor
A = cross sectional area

The specific resistance of several commonly used materials is shown in Table 1 and is ordinarily specified in ohms per circular mil foot. Material and dimensions, however, are not the only factors determining the resistance. Temperature variations are also important and within normal limits can be determined by the equation,

$$R_{t2} = R_{t1} [1 + \alpha(t_2 - t_1)] \qquad (2)$$

where R_{t1} and R_{t2} are resistance at temperatures t_1 and t_2 respectively and α is the change in resistance per ohm per degree rise in temperature. (See Table 1).

Another factor to be considered when operating at other than d.c. is the "skin effect." This is a function of the following factors,

$$t\sqrt{\mu f/\rho} \qquad (3)$$

where t = thickness of the conductor
f = frequency of current
μ = permeability of the conductor
ρ = specific resistance of the conductor

The resistance is at a minimum when the current density is uniformly distributed over its cross section. This condition exists only when d.c. is applied to the conductor. When a.c. is applied a non-uniform current distribution is caused by the magnetic flux lines inside and outside the conductor. Imagine the wire to be made up of a number of conductor elements in parallel. Then the inner conductors being surrounded by more lines of flux than the outer, will have more reactance. Therefore the current in the inner conductors will be less than that in the outer conductor, producing a non-uniform current density. As a result of this, the resistance increases with frequency and is commonly known as the "skin effect."

TABLE 1.

Material	Specific Resistance at 20°C. Ohms per circular mil foot	Coefficient of Temperature per °C. 20°C. — 100°C.
Silver	9.75	0.0040
Copper	10.75	0.0040
Zinc	38.0	0.0040
Manganin	270.0	0.00002
Constatan	294.0	0.00002
Nichrome	660.0	0.00023

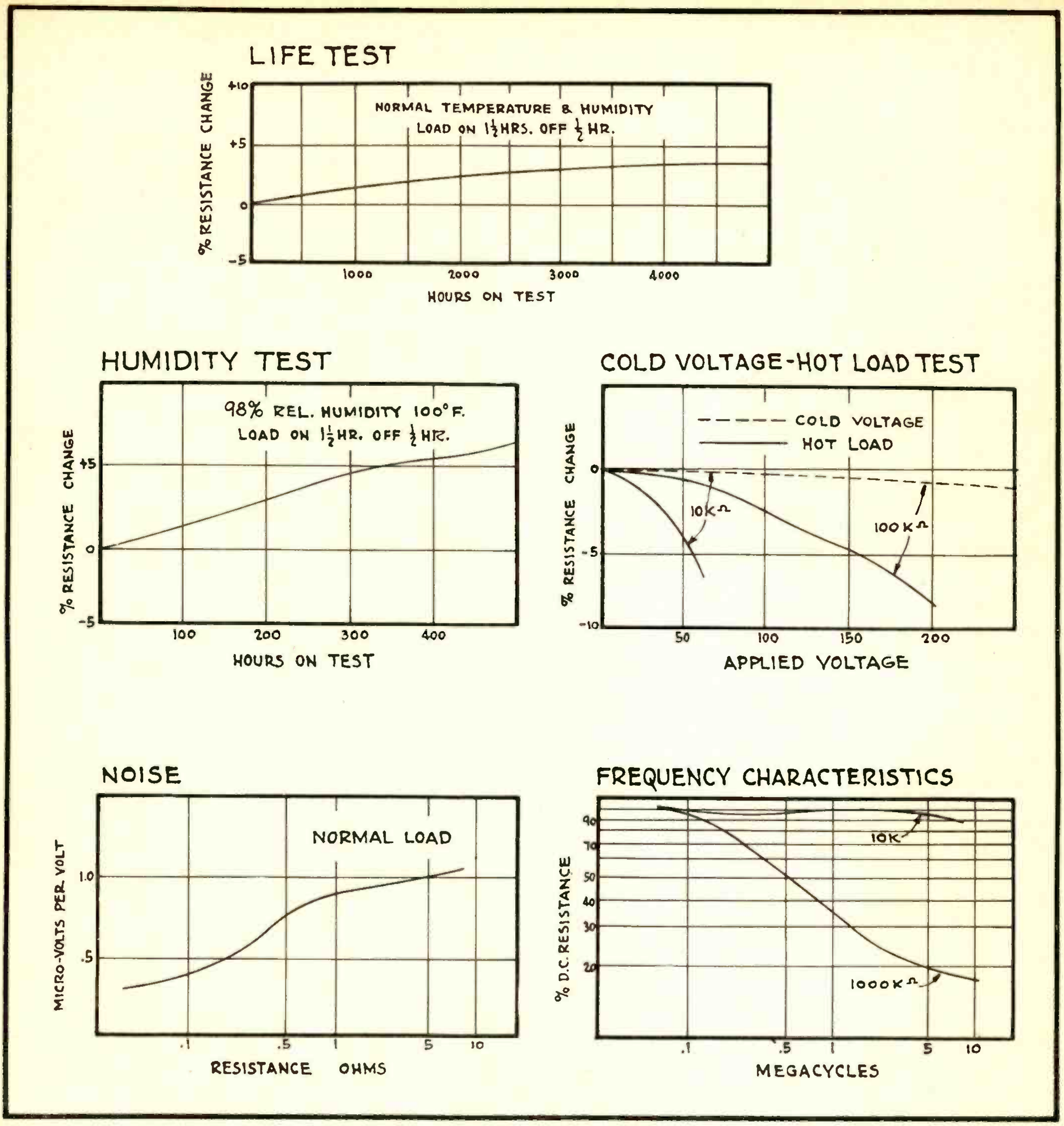


Fig. 2. Typical characteristics of a ½-watt composition-type resistor.

A resistor can be represented by the equivalent circuit of *Fig. 1*, where R = actual resistance of the conductor, L = inductance produced by the magnetic flux due to the current in the conductor, and C = distributed capacity, plus the capacity between terminals. The residual inductance is primarily determined by the area surrounded by the current and number of turns of wire. It is therefore important to keep the area of the turn small and to use wire having as high a specific resistance as possible. The effect of the inductance and capacity is to give the resistor an impedance which is either leading or lagging. By properly proportioning the L and C it is possible to maintain a nearly constant effective impedance-to-resistance ratio.[1]

Wire-Wound Resistors

Fixed wire-wound resistors are commonly employed where high wattage dissipation is required. The arbitrary full rating of a wire-wound resistor is the load in watts which will produce a 250°C (450°F) temperature rise at the hottest spot of a two terminal resistor when suspended in air at least one foot away from the nearest object. The temperature of the surrounding air should not exceed 40°C (104°F). If the conditions of ventilation are not as good as those specified, a temperature rise of 250°C will be reached at a correspondingly lower rating. Component parts in the vicinity of a resistor may be injured by a temperature rise which is much

[*Continued on page 57*]

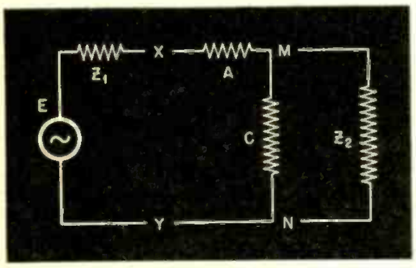
[1] *General Radio Experimenter*, January, 1939.

RADIO DESIGN WORKSHEET

No. 14—NETWORK LOSS; AMPLIFIER PHASE SHIFT

NETWORK LOSS

Problem: *Apply Thevenin's Theorem to determine loss due to network shown in the accompanying diagram.*



Solution: Let Z_1 be source resistance and Z_2 be sink resistance. Let L-type pad AC be interposed between source and sink.

Thevenin's Theorem was stated in Radio Design Worksheet No. 6 (page 23, October 1942 issue) for a network containing a single source of voltage as follows: Any network with a load impedance connected across two terminals may be replaced so far as the load impedance is concerned by a voltage connected in series with an impedance. This voltage is the one which would appear across the load terminals with the load removed, and the impedance is that looking into the load terminals with the source of voltage short circuited.

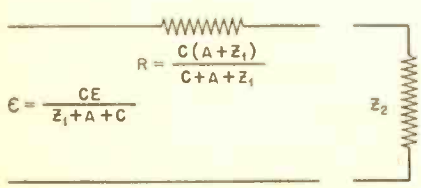
If the load impedance Z is removed the voltage appearing across the load terminals MN is:

$$\epsilon = \frac{CE}{Z_1 + A + C}$$

If E is short circuited the impedance looking into the load terminals MN is:

$$R = \frac{C(A+Z_1)}{C+A+Z_1}$$

Whence the equivalent circuit is:



The current which would flow through load impedance Z_2 is:

$$I_o = \frac{\epsilon}{R+Z_2} = \frac{CE}{Z_1+A+C} \times \frac{C+A+Z_1}{C(A+Z_1)+Z_2(C+A+Z_1)} = \frac{CE}{C(A+Z_1)+Z_2(C+A+Z_1)}$$

The power dissipated in Z_2 is:

$$P_o = I_o^2 Z_2 = \frac{Z_2C^2E^2}{[C(A+Z_1)+Z_2(C+A+Z_1)]^2}$$

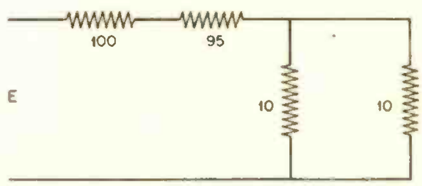
If the network were removed and Z_2 were connected across terminals XY then:

$$I_1 = \frac{E}{Z_1+Z_2} \text{ and } P_1 = I_1^2 Z_2 = \frac{Z_2E^2}{(Z_1+Z_2)^2}$$

The ratio of power dissipated in Z_2 with the network in circuit and with the network removed would be:

$$\frac{P_o}{P_1} = \frac{Z_2C^2E^2}{[C(A+Z_1)+Z_2(C+A+Z_1)]^2} \times \frac{(Z_1+Z_2)^2}{Z_2E^2} = \frac{C^2(Z_1+Z_2)^2}{[C(A+Z_1)+Z_2(C+A+Z_1)]^2} \qquad (1)$$

This can be checked easily by assigning some probable values to the circuit resistances. Thus let $Z_1 = 100$; $A = 95$; $C = 10$; $Z_2 = 10$.



Whence the total current flowing from source E would be:

$$I = \frac{E}{100+95+5} = \frac{E}{200}$$

Since the current will divide equally between Z_2 and C, the current flowing in the load will be:

$$I_o = \frac{I}{2} = \frac{E}{400}$$

$$P_o = I_o^2 Z_2 = \frac{10E^2}{160{,}000} = \frac{E^2}{16{,}000}$$

If the network AC were removed:

$$I_1 = \frac{E}{110},\ P_1 = I_1^2 Z_2 = \frac{10E^2}{12{,}100} = \frac{E^2}{1210}$$

$$\frac{P_o}{P_1} = \frac{E^2}{16{,}000} \times \frac{1210}{E^2} = \frac{1210}{16{,}000} = .0755 = 11.1 \text{ db}$$

Substituting in (1) the impedance values we have:

$$\frac{P_o}{P_1} = \frac{100(100+10)^2}{[10(95+100)+10(10+95+100)]^2} = \frac{100(110)^2}{[1950+2050]^2} = \frac{100(110)^2}{[4000]^2} = \frac{1{,}210{,}000}{16{,}000{,}000} = \frac{1210}{16{,}000} = .0755 = 11.1 \text{ db}$$

It is obvious, therefore, that Thevenin's Theorem may be applied to networks and by simple algebra network loss may be determined. If the network or source or sink impedances contain reactive elements then separate computations must be made for each frequency and complex algebra used.

AMPLIFIER PHASE-SHIFT MEASUREMENT

Problem: *Phase shift can be measured by a number of methods, one of which is to compare the magnitudes of the sum and difference of two vector quantities. Before the cathode-ray oscilloscope came into general usage, the circuit of Fig. 1 was commonly used for this purpose. This arrangement was explored in Radio Design Worksheet No. 12 (page 24, April issue) for a passive (attenuating) network. It is the purpose of this problem to establish the relation between sum and difference currents out of the unknown network and attenuator, and phase angle when the unknown network is active (amplifying).*

Solution: Let the output current of the network be a, and the output current of the attenuator b. The phase angle of b is identical to the input current to the network since it is assumed that no phase shift occurs in the attenuator. If I_1 is the vector sum of

[*Continued on page 34*]

a and b and I_2 their vector difference, then:

$$I_1^2 = a^2 + b^2 + 2\,ab\cos\theta$$
$$I_2^2 = a^2 + b^2 - 2\,ab\cos\theta$$

If: $K_1 = a/b$

Then: $I_1^2 = b^2\,(K_1^2 + 1 + 2K_1\cos\theta)$
$I_2^2 = b^2\,(K_1^2 + 1 - 2K_1\cos\theta)$

If: $K_2 = I_1/I_2$

Then: $K_2^2 = \dfrac{K_1^2 + 1 + 2K_1\cos\theta}{K_1^2 + 1 - 2K_1\cos\theta}$

And $\cos\theta = \dfrac{(K_1^2+1)\,(K_1^2-1)}{2K_1\,(K_2^2+1)}$

And $\theta = \cos^{-1}\dfrac{(K_1^2+1)\,(K_2^2-1)}{2K_1\,(K_2^2+1)}$

This is the desired relation.

If the unknown (amplifying) network has an attenuator inserted in its output in place of Z_1 then it can always be adjusted so that $a = b$ or $K_1 = 1$.

Whence:

$$\cos\theta = \frac{K_2^2 - 1}{K_2^2 + 1}$$

or:

$$\theta = \cos^{-1}\frac{K_2^2 - 1}{K_2^2 + 1}$$

And if attenuator *1 Fig. 1* is set at zero the setting of the new attenuator will equal amplifier gain. The same result can be achieved by adjusting attenuator *2* in *Fig. 1*, to adjust for differences in I_1 and I_2, the sum and difference frequencies. If attenuator *1* is set at predetermined values, say N_1, N_2, etc., then the setting of attenuator *2* may be plotted vs. phase angle of a and b, as shown in *Fig. 2*.

The ordinates of *Fig. 2* do not differentiate between quadrants. Thus the input and output currents of the network may lead or lag by an angle of 30° or 150° and the circuits of *Fig. 1* give the same indications. It is possible, however, to determine whether the angular difference between a and b is greater or less than 90° or $\pi/2$ radians. For the case in which:

$$a = b \text{ or } K_1 = 1$$

If $I_1 > I_2$ the angle θ lies in the first or fourth quadrants (see *Fig. 3*). If $I_1 < I_2$ the angle θ lies in the second or third quadrants.

For the case in which $a > b$ exactly the same situation holds. That is, if the series aiding current exceeds in magnitude the series opposing current, the angle θ will be less than 90° lag or lead. It can be shown that if θ is 90° lag or lead, then $I_1 = I_2$.

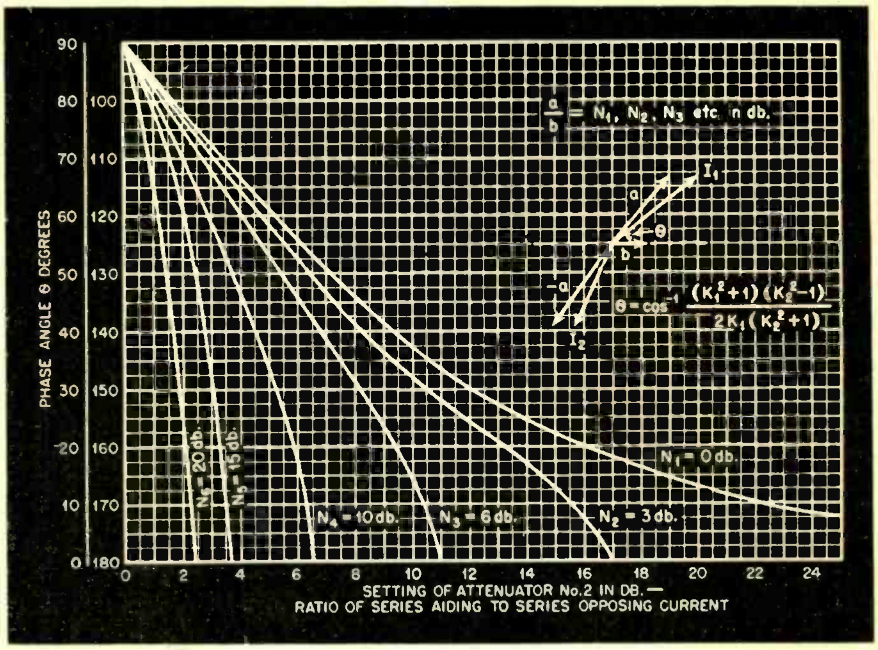


FIG. 2

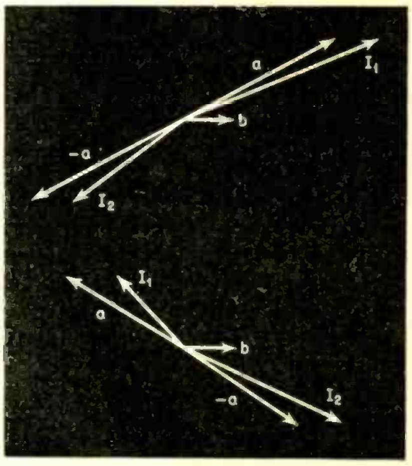


FIG. 3

This can be seen by reference to *Fig. 2*. It will be observed that for any ratio of a/b the ratio of $I_1/I_2 = 1$ or 0 db for $\theta = 90°$.

Whence:

$\theta = \pm 90°$ if $I_1/I_2 = 1$ (0 db)
$\theta < \pm 90°$ if $I_1 > I_2$
$\theta > \pm 90°$ if $I_2 < I_1$

If it is necessary to determine whether θ is positive or negative, this can be accomplished by shifting the angle of vector b slightly in a positive or negative direction by the insertion of a small positive or negative reactance in series with resistance ($Z_0 - Z_2$). This will serve as a quick check.

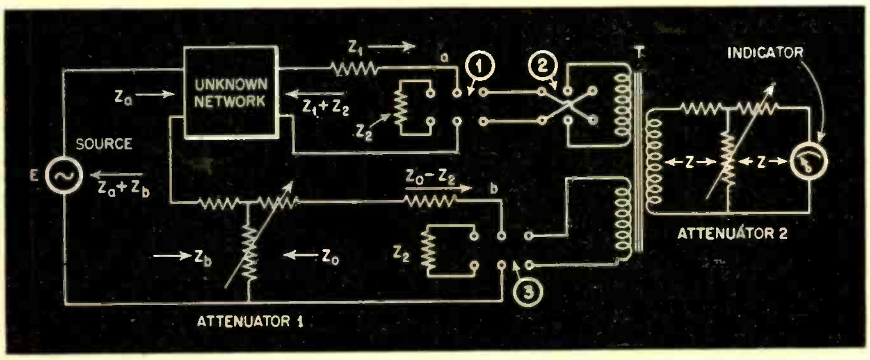


FIG. 1

Q. & A. STUDY GUIDE

C. RADIUS
RCA Institutes

A-F AMPLIFICATION—II

Resistance Coupling in Voltage Amplifiers

9. Draw a simple schematic circuit showing a method of resistance coupling between two triode vacuum tubes in an audio-frequency amplifier. (II-97).

In *Fig. 1*, R_L is the plate load resistor; R_g is the grid circuit resistor; C_g is the coupling condenser; C_s is the shunt (stray) capacitance; E_{bb} is the d-c power supply.

10. What circuit and electron tube factors influence the voltage gain of a triode audio-frequency amplifier stage? (II-143) Note: This question will be discussed with reference to a resistance-coupled stage.

As was pointed out in the answer to *Question 5*, the amplification of a triode with a plate load resistance R_L is given by—

$$\text{Amplification} = \mu \frac{R_L}{r_p + R_L} = \mu \frac{1}{1 + r_p/R_L}$$

It is apparent from this expression

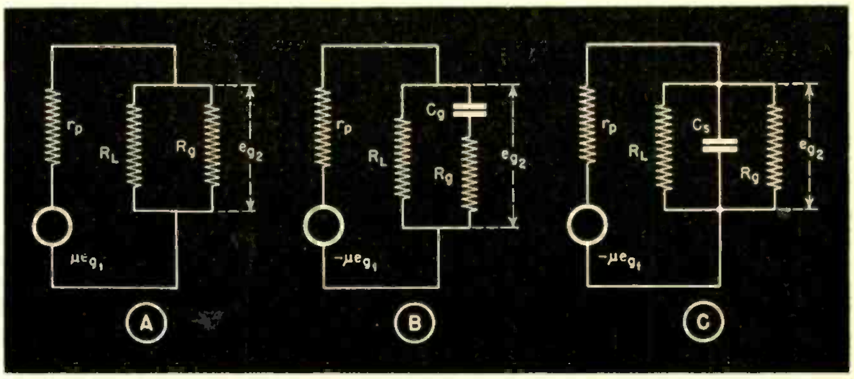


Fig. 2. Equivalent circuits at intermediate, low, and high frequencies.

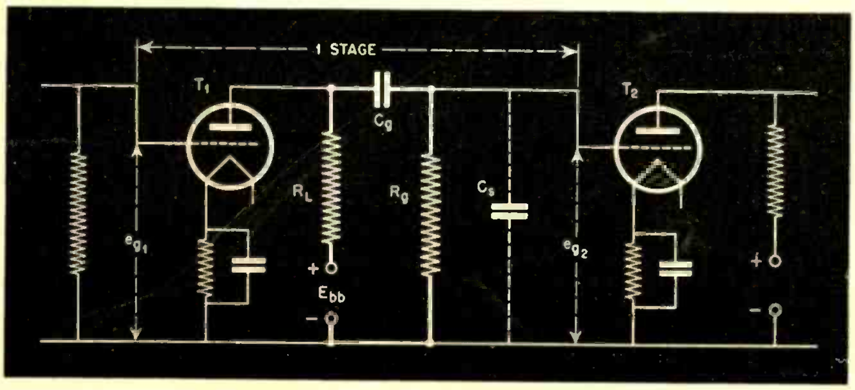


Fig. 1. Resistance-coupled triode stage.

that the amplification is directly proportional to the tube parameter μ.

In considering the effect of circuit parameters on the gain of a stage it is desirable to divide the response into intermediate, low, and high frequency ranges. See *Fig. 3*.

Intermediate-Frequency Amplification

At intermediate frequencies the reactance of the coupling condenser is negligible; the reactance of the shunt capacitance is very high. *Fig. 2-A* represents the equivalent circuit. The plate load in the a-c circuit is the parallel combination of R_L and R_g. Let this be represented by

$$R' = \frac{R_L R_g}{R_L + R_g}$$

Amplification at intermediate frequencies is then given by

$$A_M = \mu \frac{1}{1 + r_p/R'}$$

Expressed as a decibel gain

$$A_M = 20 \log \mu - 20 \log (1 + r_p/R')$$

The first term of this expression represents the upper limit of the gain; the second term represents the "loss" due to the finite resistance in the plate circuit. This "loss" decreases as R' increases.

Low-Frequency Amplification

At low frequencies the reactance of the coupling condenser may be large and may cause the output voltage e_{g2} to drop below the level at intermediate frequencies. *Fig. 2-B* represents the equivalent circuit. Let

$$R'' = R_g + \frac{r_p R_L}{r_p + R_L} \cong R_g$$

Amplification at low frequencies is then given by

$$A_L = A_M \frac{1}{\sqrt{1 + (1/2\pi f C_g R'')^2}}$$

Expressed as a decibel gain

$$A_L = 20 \log \mu - 20 \log (1 + r_p/R') - 10 \log [1 + (1/2\pi f C_g R'')^2]$$

The last term represents the drop due to the appreciable reactance of C_g at low frequencies. It is desirable to use as large a value of C_g and R'' as possible. C_g is to a certain extent

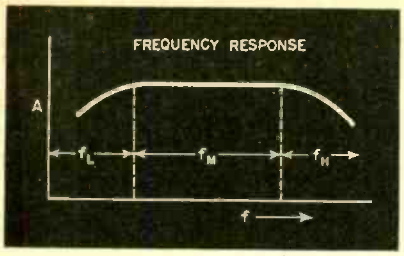


Fig. 3. Division of frequency response.

limited by its physical size which tends to increase C_s. Since R'' is primarily R_g, the gas content of the tube used in the second stage determines the limiting value of R''.

High-Frequency Amplification

At high frequencies the reactance of the shunt capacitance may be low and may cause the output voltage e_{g2} to drop below the level at intermediate frequencies. C_s is made up of the output capacitance of T_1, the input capacitance of T_2, and wire capacitance. *Fig. 2-C* represents the equivalent circuit. Let

$$R''' = \frac{r_p R_L R_g}{r_p R_L + r_p R_g + R_L R_g} \cong r_p$$

Amplification at high frequencies is then given by

$$A_H = A_M \frac{1}{\sqrt{1 + (2\pi f C_s R''')^2}}$$

Expressed as a decibel gain

$$A_H = 20 \log \mu - 20 \log (1 + r_p/R') - 10 \log [1 + (2\pi f C_s R''')^2]$$

The last term represents the drop due to the low reactance of C_s at high frequencies. The formula for R''' indicates that its value is approximately equal to r_p over which there is little control. Hence the only way of maintaining good high-frequency response is to keep the value of C_s down. Ordinarily, no difficulty is incurred in maintaining good high-frequency response in triode resistance-coupled audio amplifiers.

11. If the value of the capacitance of the coupling condenser in a resistance-coupled audio amplifier is increased what effect may be noted? (III-168)

12. What is the effect of leakage in the coupling condenser in an impedance- or resistance-coupled amplifier? (VI-132)

13. What would be the effect of a short-circuited coupling condenser in a conventional resistance-coupled audio amplifier? (II-280)

The coupling condenser in a resistance-coupled amplifier functions as a blocking condenser to prevent a high positive potential from being applied to the grid of T_2. See *Fig. 1.* An increase in the capacitance will reduce the reactance and result in an improved low-frequency response.

Any leakage in the coupling condenser will cause a direct current to flow through R_g with the result that the bias of T_2 will become less negative. The plate current of T_2 will rise and considerable distortion may result. For this reason it is not desirable to use an electrolytic condenser as a coupling condenser. A similar condition of much greater degree would result from a short-circuited coupling condenser. It would no longer act as a blocking condenser. T_2 would then have a positive grid bias which might severely damage the tube.

14. What is the direct-current plate voltage of a resistance-coupled amplifier stage which has a plate-supply voltage of 260 volts, a plate current of 1 milliampere, and a plate-load resistance of 100,000 ohms? (VI-133)

Plate potential = Supply potential — drop across plate load
= 260 volts — (0.001 amp.) × (100,000 ohms.)
= 160 volts

15. What is the stage amplification obtained with a single triode operating with the following constants; plate voltage 250, plate current 20 milliamperes, plate impedance 5000 ohms, load impedance 10,000 ohms, grid bias 4.5 volts, amplification factor 24. (IV-173)

Plate and grid voltages determine the plate impedance and the amplification but do not enter into the calculation.

$$\text{Amplification} = \mu \frac{R_L}{r_p + R_L} = 24 \times \frac{10{,}000}{15{,}000} = 16$$

Degeneration and Regeneration

16. What is the purpose of decoupling networks in the plate circuits of a multistage audio amplifier? (V-168)

Assume that the plate decoupling filters are not present in *Fig. 4.* The instantaneous a-c components of the plate currents (i_{p1} and i_{p2}) are 180° out of phase and i_{p2} (decreasing) is greater than i_{p1} (increasing). The net effect of these two currents is to produce an instantaneous voltage drop across the power supply impedance Z. Since the power supply output is usually shunted with a large capacitance, the voltage drop will appear only at very low frequencies where the reactance becomes appreciable. This voltage drop may alter the signal on T_2 in such a manner as to cause a further decrease in i_{p2}. This action is known as uncontrolled degeneration. If a third stage were added the plate currents in the first and third stages would be in phase and there would be a tendency toward regeneration or low-frequency oscillation. The latter is aptly called "motorboating." Both phenomena can be avoided by the use of decoupling filters C_F-R_F which provide a low impedance return to the cathode for the a-c components of the plate currents.

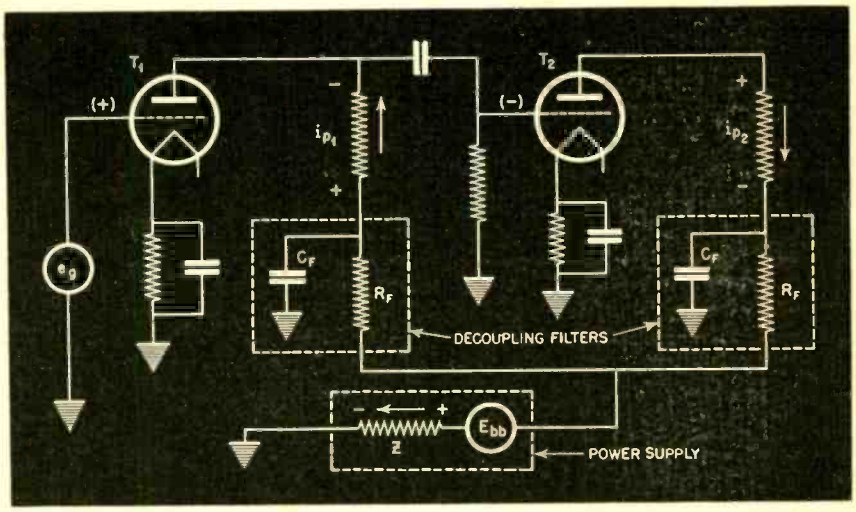


Fig. 4. Resistance-coupled stages with decoupling filters.

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[*To be continued*]

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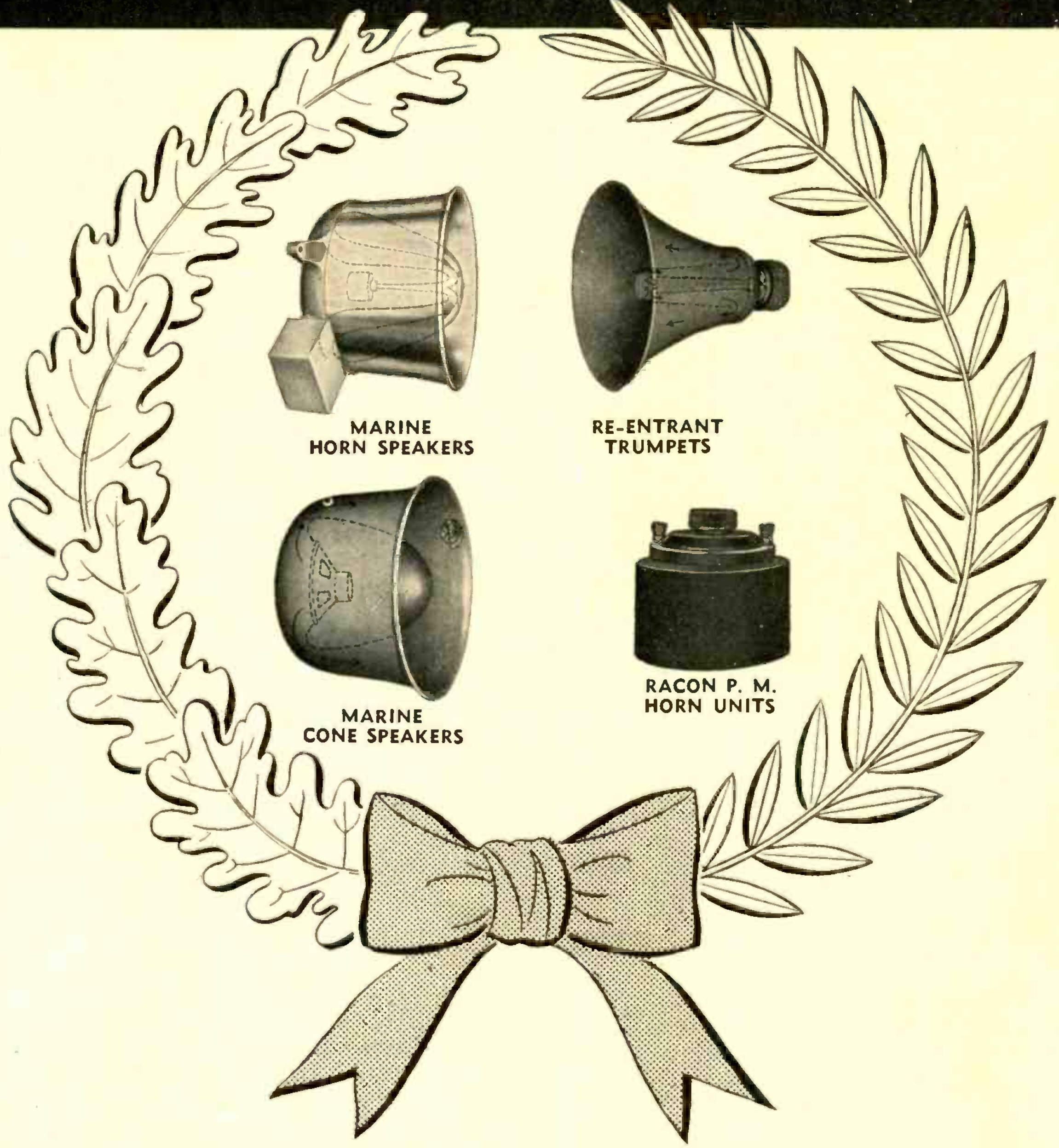

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FOUR RAYTHEON PLANTS AWARDED ARMY-NAVY "E"

For the first time in the radio or electronic industry, four Army-Navy "E" Burgees were awarded simultaneously to one organization. The power-tube, small tube, radar and equipment divisions of Raytheon Manufacturing Company of Newton and Waltham, Mass. were each awarded this high honor for excellence in the production of equipment for our fighting forces. The four "E" awards were presented to Raytheon before 20,000 employees and invited guests on the lawn of the spacious estate of Governor Gore at Waltham, Massachusetts in what was probably the most colorful outdoor "E" award ceremonies ever staged. The ceremonies were in charge of Mr. David T. Schultz, vice-president and treasurer.

The speech of acceptance was made by Mr. Laurence K. Marshall, president of Raytheon. Presentation of the Army-Navy "E" award was made by Commander Lewis L. Strauss of the U. S. Navy. Army-Navy "E" Insignia was presented by Colonel James H. Van Horn, U. S. Army. Formal acceptance for the employees was made by Miss Margaret Lavery, small tube division; Dominic Lanno, Equipment Division; Susan Costello, Radar Division and Arthur Short, Power Tube Division. Guests included Governor Leverett Saltonstall of Massachusetts who delivered "Greetings From the Commonwealth," Mayor John F. Devane of Waltham, Mass., Mayor Paul M. Goddard of Newton, Mass. and many high ranking Navy and Army officials.

L. K. Marshall, president of Raytheon, making speech of acceptance upon presentation of Army-Navy "E" Awards.

With this type of radio-telephone set, 84 seamen from the torpedoed SS Stag Hound flashed an SOS across the South Atlantic and were rescued. Here, two members of the Radiomarine Corporation of America, the manufacturer, are seen demonstrating it.

LIST OF AMERICAN STANDARDS

The American Standards Association has announced the publication of its new List of American Standards which will serve as a useful reference piece to the engineering and purchasing departments of manufacturing firms.

More than 600 standards are listed, 94 of which represent new and revised standards approved since the last (August 1942) issue. These are marked with an asterisk.

Standards are listed by subject and cover civil, mechanical, electrical, mining, chemical and other engineering fields as well as metals and materials, specifications of interest to the textile, wood, pulp and paper industry, methods of test for the finished product, dimensions, etc. They reach into every important engineering field and serve as a basis for many municipal, state and Federal regulations. By frequent review these standards are kept abreast of new developments in the fields to which they relate.

★

ACTIONS BY FCC

The Commission en banc on May 11 suspended until further order of the Commission Section 8.131 (a) of the Rules Governing Ship Service, which required the installation of automatic-alarm signal keying devices in connection with radio transmitting installations on certain vessels. This action was taken because it appears that present conditions have resulted in a shortage of critical materials and manpower necessary to manufacture and install such equipment, and the need for such equipment under wartime conditions has been greatly minimized due to the exigencies of wartime operation.

The Commission en banc on May 18 deleted Section 9.76 of its Rules and Regulations Governing Aviation Services regarding glide path and localizer service. The frequencies affected have been available for assignment to instrument landing stations under Section 9.76, and include the following: 93500 kc, 93900 kc, 94300 kc, 109500 kc, 109900 kc, 110300 kc.

★

CMP AMENDMENT

CMP Regulation No. 8, covering production requirements of controlled materials producers, has been amended

[*Continued on page 46*]

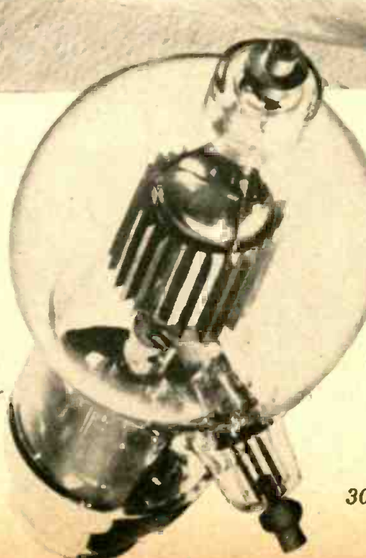
electronic briefs: FM

Radio is simply a method by which electrical energy is transmitted through space. By varying the intensity or frequency of this electrical energy, an intelligible signal can be created. The principle is the same whether dot dash code messages or voice and music are being transmitted. In the case of voice and music transmission the radio wave must be varied (modulated) at the same speed as the vibrations of the voice or music. The characteristics of electrical energy which can be varied or modulated are three: voltage, frequency and phase. Radio transmitters which vary the intensity (voltage) are called amplitude modulated and those which vary the frequency are called frequency modulated. The differences of these two systems can be understood easily by visualizing a beam of light. An audible signal can be transmitted by varying the light intensity (amplitude modulation) or by varying the color of the light beam (frequency modulation).

Static and other man-made electrical disturbances are identical in character to the amplitude modulated signal. Hence these disturbances are extremely bothersome to AM broadcasts. On the other hand these electrical disturbances do not essentially vary in frequency and consequently do not interfere with FM transmission. Another fortunate characteristic of FM is the fact that the stronger of two signals predominates, thus eliminating much inter-station interference and cross-talk. Further, and of great importance, the fidelity of tone can be made nearly perfect even when the heaviest of musical scores is being broadcast.

In frequency modulation as in all things in the field of electronics, vacuum tubes are the most important component. Eimac tubes have the distinction of being first choice of most of the leading electronic engineers throughout the world. They are consequently first in the most important new developments in electronics ... FM for example.

Army-Navy "E" flag awarded for high achievement in the production of war material.



Follow the leaders to

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

EITEL-McCULLOUGH, INC.
SAN BRUNO, CALIFORNIA

Export Agents: Frazar & Hansen
301 Clay Street, San Francisco, California

to indicate that in some instances, where a controlled material producer requires the same basic material as that which he produces to fabricate another form of controlled material, such material may be made available through the allotment procedure rather than by directive.

The regulation originally indicated that all such material would be made available to controlled material producers only through directives. However, in some instances the allotment procedure is more adaptable to certain circumstances. The action is taken by Amendment 1 to CMP Regulation No. 8 which deletes sub-paragraph (4) of paragraph (c) of the regulation.

★

"DOC" POWER PROMOTED

Dr. Ralph L. Power, who formerly operated his own radio advertising agency in Los Angeles to service Universal Microphone Co. and other manufacturing clients, has been promoted to the grade of Senior Inspector in the Army Signal Corps. He became an inspector last year and was assigned to a southern California field unit by the San Francisco zone headquarters.

★

LT. COMDR. RALPH BRENGLE APPOINTED TO NEW NAVAL POST

Lt. Comdr. Ralph T. Brengle, formerly Head of Radio Procurement Section, Bureau of Ships, has been appointed Assistant Head of Radio Division, Bureau of Ships.

Before entering the service Lt. Comdr. Brengle was head of the Ralph T. Brengle Sales Company of Chicago and is widely known in the radio industry.

MERKLE NOW CAPTAIN

Ralph Merkle, widely known commercial engineer in the radio field, has just earned a Captaincy in the United States Army. For the past several

months Captain Merkle has been in the office of the Chief Signal Officer, Washington, D. C. with a First Lieutenant's commission. He received leave of absence in June 1942 from Sylvania Electric Products Inc., where he held a responsible position in the Commercial Engineering Department. In addition to being Technical Editor of "Sylvania News," he has devoted much time and effort to the preparation of various types of Sylvania's technical publications and educational material.

Merkle has a wide background in the field of Radio Communications. Prior to his coming with Sylvania Electric Products Inc., in 1929, he was employed by the General Electric Company and Federal Radio Company.

★

HULTON CROLITE FIELD ENGINEER

The appointment of Ralph Hulton as Field Engineer in the Ohio and Michigan territories is now announced by Henry L. Crowley & Co., Inc., West Orange, N. J.

Hulton is a well known figure in the powder metallurgy and automotive fields, having been development engineer with Keystone Carbon and before that a sales engineer with the Moraine Products Division of General Motors in the Indiana and Ohio territories. He will make his headquarters in Detroit covering his territory from that point.

★

BURCHAM STANCOR REP.

Standard Transformer Corporation announces the appointment of Don H. Burcham, 917 S.W. Oak Street, Portland, Oregon, as their representative covering jobber and industrial sales in the states of Idaho, Montana, Oregon and Washington. This appointment became effective June 1, 1943.

★

DRESSEL ADVANCED BY STACKPOLE

An announcement from the Stackpole Carbon Company of St. Marys, Penna., brings word of the appointment of Henry Dressel as its Supervisor of Electronic Components Engineering.

Mr. Dressel has been a member of the Stackpole engineering staff for several years. Prior to that, he was associated with the Oak Manufacturing Company in Chicago.

★

NEW RATHEON DEPARTMENT

Dr. P. T. Weeks, Plant Manager of the Raytheon Production Corporation, 55 Chapel Street, Newton, Massachusetts, announces the organization of a Production Control Department.

Kenneth R. Johnson

Kenneth R. Johnson will direct this new department which will include a Scheduling section to be headed by Lyman W. Robbins; a Materials section to be headed by Leo Barsam; and a Fnished Stock Control section to be handled by Frank Fenwick. Mr. Johnson has been in charge of the Planning and Scheduling Department for the past year. Previous to joining the Raytheon organization, he was Production Manager and Assistant Publisher of the Boston Evening Transcript. He is a graduate of Iowa State College in Business Engineering, and also the Harvard Graduate School of Business.

[*Continued on page 63*]

THE SKILL *and* THE WILL
. . . today and tomorrow

Only one American in many thousands is privileged to wear the "E" pin, symbolic of high achievement on the production front. It symbolizes skill and determination above and beyond the high average standard set by American Industry. ❜ ❜ ❜ The men and women of Connecticut Telephone & Electric Division have been honored by the Army-Navy Production Award twice in a period of six months. This symbol of a job being well done in the cause of Victory is evidence, too, of what may be expected when the war is won. ❜ ❜ ❜ The manufacturer seeking cooperation in product engineering and improvement, the development of production control, or any problem involving the application of advanced electrical or electronic knowledge, is cordially invited to discuss the matter with our engineering staff.

ARMY E NAVY

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

MERIDEN — GREAT AMERICAN INDUSTRIES INC. — CONN.

DESIGN, ENGINEERING & PRODUCTION OF PRECISION ELECTRICAL EQUIPMENT

NEW PRODUCTS

"TUBE TYPE" CRYSTALS

Newly added to the wide range of piezoelectric quartz crystals produced by John Meck Industries, is this special purpose type, housed in a conventional metal tube case.

By means of this unusual mounting, complete freedom from moisture and atmospheric pressure changes are secured. Such crystals are widely used by the Armed services of this country and our Allies.

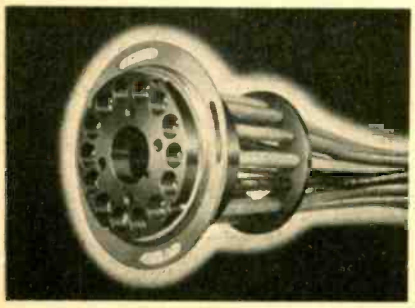
The new John Meck Industries plant at Plymouth, Indiana is fully equipped to fabricate all crystal oscillators and resonators, completely from the raw quartz.

★

ONE PIECE C-R TUBE SOCKET

The Franklin Manufacturing Co., 175 Varick St., New York, announces its new one-piece moulded construction Cathode Ray Tube Socket which was designed to completely enclose and seal the contacts against temperature and humidity conditions. This one piece socket provides high voltage flashover at high altitudes and high resistance between adjacent pins.

The Franklin Socket has an added feature in its strain relief ring which



protects the soldered joints against vibration pull or twist of the wires.

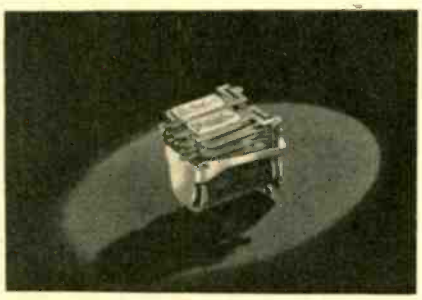
Franklin Cathode-Ray Tube Sockets are supplied in either assembled units complete with cable or ready for assembly.

★

AUTOMATIC ELECTRIC ANNOUNCES TINY NEW RELAYS

A line of tiny but sensitive and rugged new relays, providing twin contacts, "built-in" vibration resistance, and a wide range of operate and release speeds, has been announced by Automatic Electric Company, Chicago. Developed primarily for use in aircraft, these relays, knowns as Class "S", are being adopted also for electrical control applications in many other fields.

Typical assemblies, having a maximum of six contact springs, are only ¾"x1½"x1⅜" in size, and weigh 1⅔ oz. Assemblies with maximum capacity of 12 springs are slightly larger, and weigh about 2 oz. Relays can be supplied with any number of springs up to the maximum and with any combination of "make", "break" and "break-make" contact arrangements.



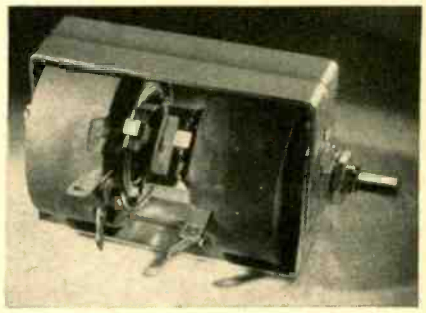
Vibration resistance, provided by torsion instead of power-wasting friction, insures against false operation or release of contacts at up to 10.5 g's (1/16" excursion at 60 cps.), as determined by a cathode-ray oscillograph and stroboscopic examination. Twin contacts, on springs of special design, assure positive contact operation, and will make or break 1 amp. non-inductive, or ½ amp. inductive load, and carry 2 amps.

Operate speeds range from 2 to 16 ms., release speeds from 5 to 85 ms.; coils are available from 150 to 3500 ohms, for operation at up to 48 volts d.c. Other features include extreme resistance to humidity, to temperatures from minus 40 to plus 130 degrees F., and to insulation test voltages up to 500 volts (a.c. test current). Mounting and operating data will be sent on request.

★

TANDEM POWER RHEOSTATS

Compact, sturdy tandem power rheostat assemblies of two or more sections are announced by Clarostat Mfg. Co., Inc., 285-7 N. 6th St., Brooklyn,



N. Y. These assemblies are made up of two 25-watt or two 50-watt rheostats rigidly coupled together and held in a metal cradle. The usual one-hole mounting and locking-projection features are retained. The individual rheostats can be of any standard resistance value, taper, tap and hop-off, and all units go through the same degree of rotation as the single shaft is turned. The units are fully insulated from each other and from ground. Because of the wide choice of resistance values and other factors, such assemblies are necessarily made only on a special order.

★

COMPACTED-METAL FABRICATION

Having pioneered the fabrication of steatite insulation and of high-frequency iron cores from highly-compressed powdered materials, Henry L. Crowley & Co., Inc., West Orange, N. J., now announces the extension of its activities to compacted-metal fabrication of intricate shapes and sizes. The process begins with fine metallic powders, compressed in dies under tremendous pressures into given shapes and sizes, followed by sintering to convert such pieces into solid metal masses. Gears, cams, bearings, either simple or intricate, are thus obtainable without

[Continued on page 50]

Shoemakers' lasts
...AND THE BATTLE OF PRODUCTION

"SHOEMAKER stick to thy last" may have been good advice once . . . but it doesn't apply in the Battle of Production, where the ability of American industry to enter new fields and make new things has amazed the world.

Take Rola, for example. Recognized for years as a leading maker of Sound Reproducing Equipment, Rola's principal war assignment became the manufacture of various types of transformers for the intricate communications systems of our Army and Navy Air Forces.

The specifications were unusually "tough" but Rola was equipped to do the unusual. Calling upon the skill and ingenuity of its people and upon an experience that dates from the very beginning of Radio Communications, Rola "tooled up". New machines were designed, new methods and processes devised, new tests and inspections employed, so that today the name "Rola" on a transformer is as much a hall-mark of quality as it is on the 25,000,000 radio loud-speakers that Rola has produced.

If transformers are a part of any product you are making, Rola solicits an opportunity to discuss your requirements with you. Many of the country's foremost prime producers of communications equipment have found our product and our performance eminently satisfactory. We are sure you would, too. The Rola Company, Inc., 2530 Superior Ave., Cleveland, Ohio.

RECEIVER OUTPUT • MODULATION • MICROPHONE
FILAMENT • AUDIO INPUT • RADIO STAGE • POWER • CHOKE COILS
HEAD SETS • RELATED ELECTRONIC ITEMS

★ ROLA ★

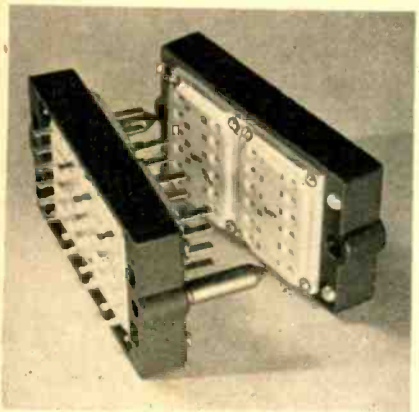
MAKERS OF THE FINEST IN SOUND REPRODUCING AND ELECTRONIC EQUIPMENT the usual time-consuming and costly machining operations. Precious manpower and machine tools are thereby released for other vital war production, while scoring a marked speedup.

★

NEW LAPP PLUG-RECEPTACLE

A plug-receptacle assembly of new design is announced by Lapp Insulator Co., Inc., LeRoy, N. Y. For use with panel-rack type of radio equipment, this connector features mechanical precision, rugged construction to withstand considerable mistreatment in the field, full-floating contacts, and, because of the fact that steatite is used as the insulation, a particularly high order of resistance to flashover and surface tracking.

In construction, each plug and receptacle consists of a zinc die-casting on which are mounted four ceramic plates, which hold the metal contacts in full floating position. At the ends of the male plug are accurately ma-



chined steel pins, which engage corresponding holes in the female receptacle, to provide positive and accurate alignment.

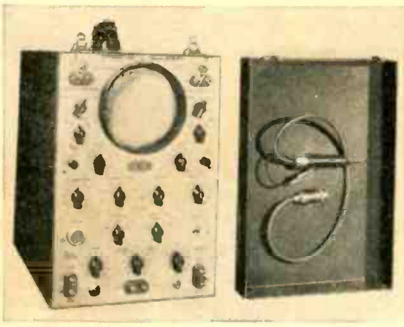
As now produced, the design provides 24 contacts. Considerable freedom in circuit design is permitted, as contacts can be chosen so that high-voltage conductors are relatively isolated one from another. Units carrying contacts in any multiple of 12 can quickly be produced.

★

NEW 5-INCH OSCILLOGRAPH

Larger screen size together with the inclusion of a Z-axis amplifier to modulate the beam with any signal applied to its input terminals or with a return trace blanking impulse produced by the linear-time-base generator, distinguishes this new Type 241 Du Mont 5-inch cathode-ray oscillograph from the previously announced 3-inch Type 224.

A development and product of Allen B. Du Mont Laboratories, Inc., Passaic, N. J., this oscillograph has a uniform Y-axis or vertical deflection re-



sponse from 20 c.p.s. to 2 megacycles. It offers a comparably faithful square and sinusoidal wave response. The X-axis or horizontal deflection amplifier has a uniform characteristic from 10 c.p.s. to 100 kilocycles. Both amplifiers have distortionless input attenuators and gain controls. Provision is made to connect signals directly with the deflection plates when frequencies to be observed are beyond the useful limits of the amplifiers.

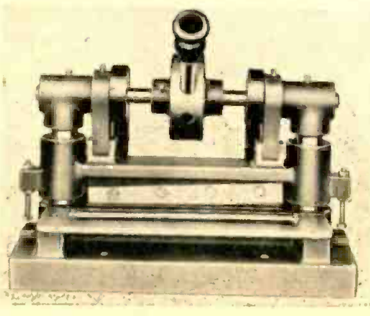
The instrument is housed in a black wrinkle-finished case with removable front cover that protects the front panel when not in use. The removable test probe, held inside the cover by clips, consists of a compensated 10:1 attenuator mounted in an insulated probe and supplied with a 3-foot length of coaxial cable and connector. This feature permits connections to relatively high impedance circuits without serious loading, while minimizing stray pickup.

Self-contained, operating directly off 60-cycle 115-volt a.c. line, this instrument weighs 65 lbs. and measures 17½" high, 10¾" wide, 21" deep.

★

DI-ACRO SHEAR NO. 2

The O'Neil-Irwin Mfg. Co., Minneapolis, Minn., have introduced their Di-Acro Shear No. 2 suitable for precision work on light and medium weight metals and materials that cannot other-



wise be rapidly worked to accurate tolerances, with a hand-operated "scissors" shear, or with a heavy foot-operated floor-type shear.

It can be quickly arranged for shearing, slitting, squaring, stripping or notching to extremely close tolerances. All ductile and pliable metals and materials can be accurately worked, including spring tempered metals, fabrics, plastics, leathers, rubber, and the very lightest of tissues, frequently eliminating the preparation expense and time delay of preparing blanking and forming dies.

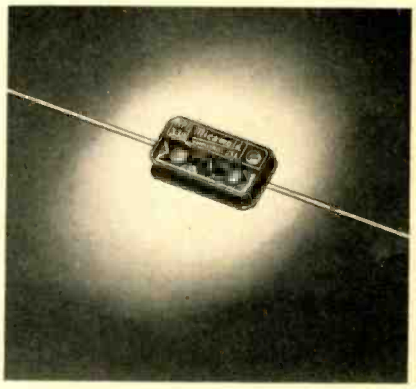
The Di-Acro Shear is highly adaptable for rapidly developing accurate shapes in bi-metals, sensitized materials, mica, varnished cambrics, fiber slot insulation and other dielectrics, and materials required for the manufacture of precision instruments and recording devices.

Accurate squaring, slitting, stripping and notching to die accuracy is readily provided by adjustment of material guides, blade pitch and stops.

★

MICAMOLD TYPE 338 CAPACITOR

Micamold Radio Corporation announces the perfection of a small-size capacitor for application in compact radio, sound and electronic equipment.



This newly developed, small capacitor, known as the Type 338, has body dimensions 3/4" long by 7/16" wide and 7/32" thick, and is available in capacities up to .01 mfd., with a rating of 120 volts d.c. working. Because it is hermetically sealed, the 338 will operate satisfactorily under highly humid conditions. It has been approved in a series of tests, including immersion tests, meeting rigid government specifications. For further information, write to the Micamold Radio Corporation, 1087 Flushing Ave., Brooklyn, N. Y.

HELPING AMERICA MEASURE UP

★ We can feel sure that the men who fight our battles are fully equal to the mighty task that faces them. ★ But the planes, tanks, ships, and guns they fight with must measure up, too. That's our job—those of us at home. How much? . . . How good? . . . are questions that only our hard work can answer. ★ Electrical instruments are a small but extremely vital part of America's war machine. Here at Simpson we are making *all* we can, the *best* we can, as *fast* as we can.

SIMPSON ELECTRIC COMPANY
5200-5218 W. Kinzie Street, Chicago, Illinois

Simpson

INSTRUMENTS THAT STAY ACCURATE

Buy War Bonds and Stamps for Victory

TECHNICANA

[*Continued from page 18*]

ture at constant speed by a synchronous motor. Since the light beams swing at right angles to the direction of paper travel, twelve curves are produced revealing the function of six areas on each foot. These curves reveal the duration, amount, and sequence of simultaneous pressure changes with 95 per cent accuracy. The oscillograph was designed and built in the Myodynamics Laboratory by Arthur L. Heath, Research Associate, with assistance from General Electric engineers.

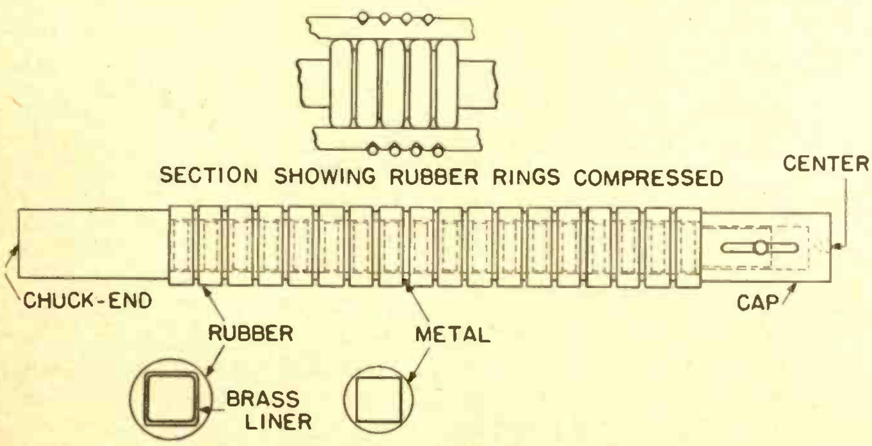
More recently, the scope of usefulness of the oscillograph has been widened by its application to the recording of Muscle Action current curves. For this purpose four high gain amplifiers were constructed by Dr. H. D. Bouman and matched to the General Electric galvanometer elements. Records of this type are of major importance to the study of infantile paralysis and other forms of neuromuscular pathology. Such records make it possible to demonstrate the presence of spasm in muscles formerly considered to be unaffected by the disease, infantile paralysis.

★

ANTI-BREAKAGE ARBOR

An arbor which minimizes breakage of ceramic coil forms during the winding operation has been devised by A. C. Schlansker, a foreman in the General Electric Electronics Department. The breakage problem was inherent in the operation due to varying mechanical tolerances of the forms and the fact that the coils are wound under high tension.

The arbor consists of a square shaft which can be held in the chuck of the winding machine. Assembled on the shaft are alternate metal and soft-rubber brass-lined washers with a diameter slightly smaller than the minimum inside diameter of the ceramic form. When the coil form is slid over the winding arbor, a sliding cap which fits over one end of the square shaft is pushed against the stack of rubber and metal washers by a tailstock center device. The resulting compression of the rubber washers bulges their diameters, and they obtain a firm, evenly distributed grip on the surface of the ceramic coil.

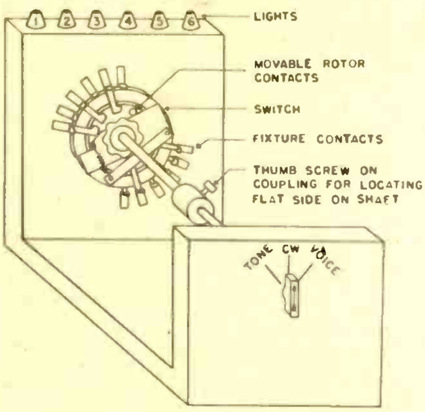


MINIMIZES BREAKAGE IN WINDING CERAMIC COILS

★

SWITCH TEST

By suggesting a fixture for electrically and mechanically testing a signal selector switch used in radio transmitters in production at one of General Electric's Works, Mrs. Catherine Marchewka has eliminated the possibility of a defective switch going into the final assembly before being detected.



FIXTURE FOR TESTING SIGNAL SELECTOR SWITCH

The test fixture is simple and foolproof. As shown in the sketch, the switch is mounted on a vertical backboard and is coupled to an extended shaft from a model switchboard. By turning the switchboard selector to each of its three positions, the switch is checked electrically by observing proper combinations of six lights mounted on top of the backboard.

The switch controls a series of contact points in each position, and this arrangement permits all of them to be checked quickly and accurately. In the "Tone" position of the selector, lamps 2, 3, 4 and 6 light; in the "CW" position, 3 and 5 light; and in the "Voice" position, 1, 4, and 6 light. If one or more of the lights in a sequence fail to go on as they should, the switch is rejected. Mechanical action of the switch is also checked while it is in the fixture. Previously, this switch received no preliminary electrical test. Defective units that got by a visual test had to be removed later from the final assembly.

★

PRODUCTION-CHECKUP

The cathode-ray checkup of every Clarostat control coming off the production line is now disclosed for the first time. This precision test has been practiced as standard Clarostat production routine for several years past and, in conjunction with the development of the stabilized coated element for composition-element controls, is responsible for a remarkable uniformity of product.

In the cathode-ray or electronic checkup each control is placed in turn in a fixture wired to the cathode-ray tube. As the operator swings a lever on the fixture, the vivid dot trace meanders diagonally across the screen in response to resistance vs. rotation. At a glance the inspectors and engineers alike have "all the answers," as Chief Engineer George J. Mucher puts it. Resistance curve, taper, hop-off, transition points or ink blends, flaws or cracks, potential noise sources, comparative resistance values, useful rotation, grounds, etc. are checked visually, positively, quickly, and far better than with the usual earphone test. Such factors as resistance curve, taper, hop-off and transition points can be held to within narrow tolerances by respective markings on the cathode-ray tube screen. The trace provides far more data than would be furnished by a large variety of meters, earphones, neon bulbs and other indicators usually employed in such production checkups.

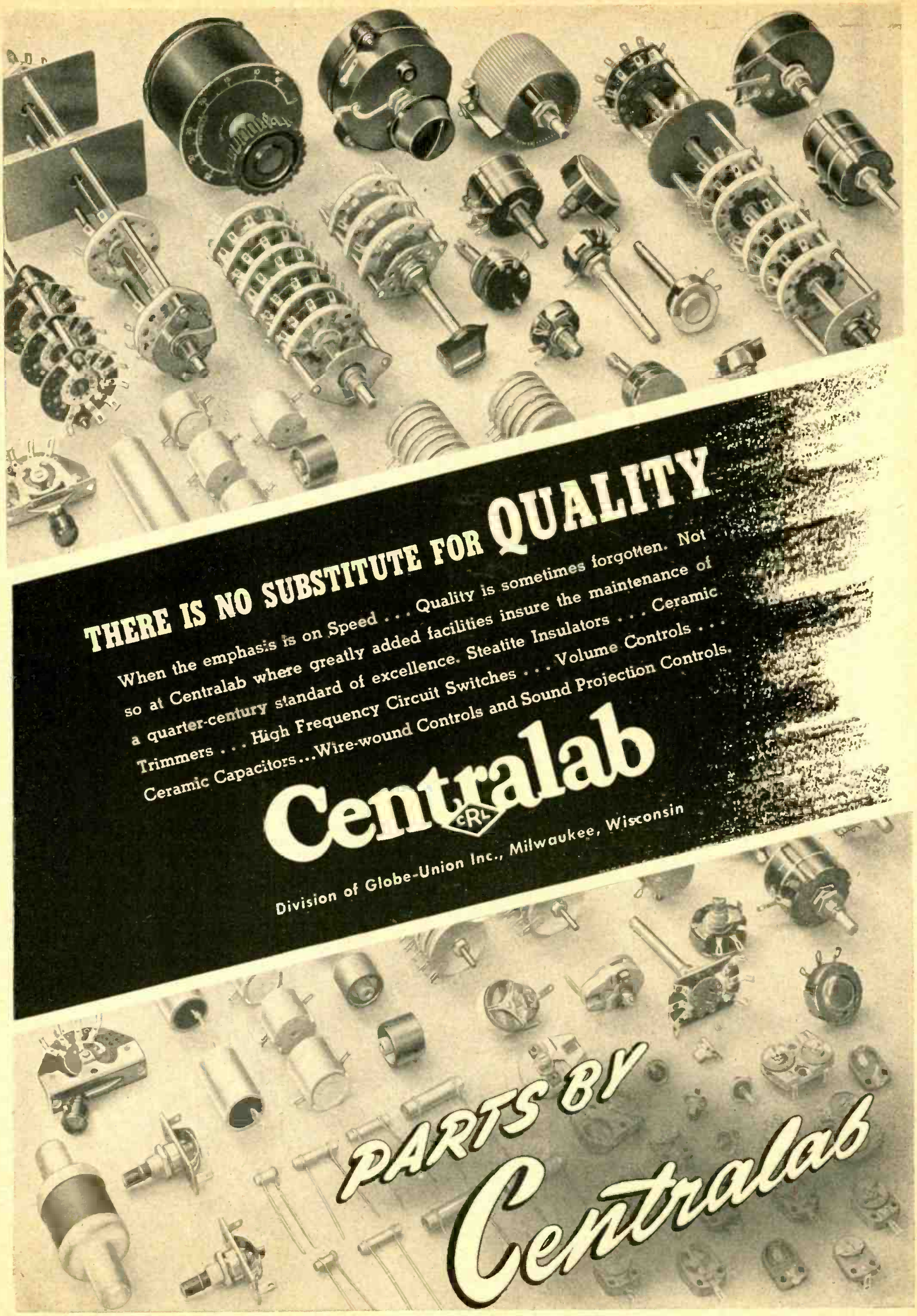
★

SHIELDED SCREWDRIVER BIT

All small assembly operations in which fillister or round head screws are used can be facilitated by the use of a shielded screwdriver bit developed by F. Capello, a methods man at General Electric's Schenectady Works.

A standard straight screwdriver bit

[*Continued on page 58*]


THERE IS NO SUBSTITUTE FOR QUALITY
When the emphasis is on Speed . . . Quality is sometimes forgotten. Not so at Centralab where greatly added facilities insure the maintenance of a quarter-century standard of excellence. Steatite Insulators . . . Ceramic Trimmers . . . High Frequency Circuit Switches . . . Volume Controls . . . Ceramic Capacitors...Wire-wound Controls and Sound Projection Controls.
Centralab
CRL
Division of Globe-Union Inc., Milwaukee, Wisconsin
PARTS BY
Centralab

TO HIT 'EM H-A-R-D-E-R

THE year 1943 promises to be the grimmest, hardest year this country has ever faced. Every effort, and every dollar of national income not absolutely needed for existence, should go into war work and War Bonds.

In the Pay Roll Savings Plan, America finds a potent weapon for the winning of the war—and one of the soundest guarantees of the preservation of the American way of life!

Today about 30,000,000 wage earners, in 175,000 plants, are buying War Bonds at the rate of nearly half a billion dollars a month. *Great as this sum is, it is not enough!* For the more dollars made available now, the fewer the lives laid down on the bloody roads to Berlin and Tokio!

You've undoubtedly got a Pay Roll Savings Plan in your own plant. But how long is it since you last checked up on its progress? *If it now shows only about 10% of the gross payroll going into War Bonds, it needs jacking up!*

This is a *continuing* effort—and it needs *continual* attention and *continual* stimulation to get fullest results.

You can well afford to give this matter your close personal attention! The actual case histories of thousands of plants prove that the successful working out of a Pay Roll Savings Plan gives labor and management a common interest that almost inevitably results in better mutual understanding and better labor relations.

Minor misunderstandings and wage disputes become fewer. Production usually increases, and company spirit soars. And it goes without saying that workers with substantial savings are usually far more satisfied and more dependable.

And one thing more, these War Bonds are not only going to help win the war, they are also going to do much to close the dangerous inflationary gap, and help prevent post-war depression. The time and effort *you* now put in in selling War Bonds and teaching your workers to save, rather than to spend, will be richly repaid many times over—now and when the war is won.

You've done your bit Now do your best!

This space is a contribution to victory today and sound business tomorrow by RADIO

COAXIAL LINES

[*Continued from page 30*]

measure of power dissipated at the same instant if r is the resistance of the line. The job then is clearly that of minimizing i^2r/i^2Z_o or more simply r/Z_o. The resistance r may be calculated in the usual way, taking into account, however, that only the skin depth, δ, is to be considered.

$$\text{Resistance} = \text{specific resistance} \times \frac{\text{length}}{\text{area}}$$

$$r = \rho \times \frac{l}{2\pi a \delta} + \rho \times \frac{l}{2\pi b \delta}$$

where ρ is the specific resistance as before, l is the length of the line, and the denominator represents areas as explained in *Fig. 5*.

The evaluation of Z_o is a somewhat more lengthy task not directly concerned with energy dissipation and will not be gone into here. For a coaxial line operating in its fundamental mode, which is the only mode of much practical value, the form of the expression is the same as for any continuous line. It turns out that with air dielectric it depends only on the ratio of the sizes of the inner and outer conductors.

$$Z_o = 138 \log \frac{b}{a}$$

We are now ready to examine the expression for the fraction of energy dissipated. It reduces to

$$\frac{r}{Z_o} = \frac{2\pi (a+b)\, l \sqrt{\rho f}}{138\, ab \log b/a}$$

In *Fig. 6* this expression is plotted against the ratio of the radius of the outer conductor to that of the inner wire. It is seen that b/a has a minimum at 3.6. This means that best lines will in general be obtained if the outside conductor is 3.6 times as large as the inner wire. Since the minimum is rather flat, slight variations from this value will be unimportant, but a larger variation from the optimum value will result in an important increase in the dissipative loss.

The final problem of energy dissipation because of resistance is to try to see how losses in terms of db per unit length may be calculated. The db loss per mile, for example, is as we have defined it; equal to 10 times the logarithm of the ratio of the energy passing through a line at a certain point to that passing through the same line at a point one mile closer to the source. In *Fig. 7* such a line is indicated. We wish to calculate a constant L where

$$L = 10 \log \frac{P_1}{P_0} \text{ db per mile}$$

The power at P_1 is just that at P_0 minus the loss. If we first calculate L_1 for a very short distance Δl, so that we can make the approximation that it is constant over that length we can simply write

$$L_1 = 10 \log \frac{P_0 - i^2r}{P_0}$$

$$= 10 \log \frac{l - i^2r/i^2Z_0}{l}$$

$$= \log (l - r/Z_0) \text{ db loss per length } l.$$

We can then divide L_1 by Δl expressed in miles and obtain L as has been pointed out before.

U.H.F. TRANSMITTERS

[*Continued from page 27*]

of the true sidebands, with one four-hundredth the energy content. Some u.h.f. crystal-controlled transmitters are no better than this, so the figures may be considered as passable.

One of the handicaps in line design of this type has been the extremely limited choice of tubes. This situation is improving, of course, and after the war many excellent tubes will be available for this purpose.

WAVE GENERATORS

[*Continued from page 23*]

to or beyond cutoff so that *C1* is normally charging through *R1*. When a pulse or square wave of positive polarity is applied to the grid, the capacitor *C1* discharges through the tube very quickly. As soon as the positive excursion of the input voltage is completed *C1* again begins to charge, increasing the voltage drop across it. If *R1* is made sufficiently high so that *C1* charges to only a small fraction of the supply voltage before it is discharged, a highly linear sawtooth may be produced.

Fig. 11 shows the resulting output waves when a pulse and square wave are used to control the discharge. This circuit may be combined with the blocking oscillator as shown in *Fig. 12*, making a sawtooth generator suitable for oscilloscope use. The grid of the sawtooth generator, *V2*, is normally biased beyond cutoff by the blocking oscillator bias until oscillations begin when the grid is driven positive, discharging the charging capacitor, *C2*. Synchronization amplitude is controlled by *R1*.

RADIO-ELECTRONIC COMPONENTS

[*Continued from page 32*]

lower than 250°C, thereby necessitating use with a dissipation rate lower than that at which the resistor may be operated without injury to itself.

In general the resistance wire is wound on ceramic forms, although fiber or bakelite strips are employed where the rating is not extreme. Proper annealing of the wire after winding to remove mechanical strains insures against molecular variations or aging in service. Several types of protective coating are employed such as vitreous enamel, molded bakelite, fiber, asbestos, fiber-board etc.

Leakage between the resistance wire and any metal protective covering or mounting should be low (high resistance) under conditions of high humidity. One hundred megohms is a typical lower limit for leakage resistance after 7 days in an atmosphere with a humidity of 98% at a temperature of 100°F.

Flexible type wire-wound resistors are similar to the fixed wire-wound type just described as far as characteristics are concerned. In this type of resistor the conducting element is spiral wound on a flexible core. Spun glass is often used for both the core and a protective braid covering. Under severe overloads this material will fuse, permanently embedding the wire in the glass; however, this usually does no harm.

Composition Type Resistors

Fixed composition-type resistors are employed where the power to be dissipated is low. Designs vary from one half to one watt per square inch of radiating surface. These values are determined mainly by the maximum voltage which can be applied without exceeding a prescribed resistance change.

The conducting material most widely used is carbon or graphite mixed with a binder of clay or bakelite. The mixture is then extruded, pressed or molded into its final physical shape. Another type employs a coating of conducting material baked onto a glass filament and enclosed in an insulating tube. Both the carbon and filament types have relatively low inductance and capacitance. Typical characteristics are shown in *Fig. 2*.

The cold voltage characteristic shows the instantaneous effect of voltage applied to a resistor. Measurements are made the instant voltage is applied so that any temperature rise will not affect the results. From the curve it is quite apparent that voltage alone has little effect on the resistance value. The hot load curves are made after ten minutes of heating or after the resistance change due to temperature rise has stabilized. The decrease in resistance is due to the negative temperature coefficient of carbon. On cooling, however, the resistance returns to its original value even after severe temporary overload.

The life test curves are a history of resistance change over a 5000-hour period under full load conditions. Almost any resistor having a conservative rating will withstand this test, so that it is of no value in determining the relative merits of a resistor. In place of the normal life test which requires 5000 hours, an accelerated life-humidity test is often required. This consists of subjecting the resistor to 130°F at 90% relative humidity and automatically applying a 100% load in a cycle, on for 1½ hours and off for ½ hour. Loading in cycles of this nature more nearly simulates severe operating conditions, as alternate heating and cooling of the resistor promotes moisture absorption through "breathing" to a much greater extent than either no load or continuous load. With this test the relative merits of a resistor can be obtained within 500 hours.

A typical frequency vs. resistance curve is also shown. The decrease in resistance is due to capacity between conducting particles, the actual value being determined by the number of capacitance paths as compared to the number of direct conduction paths. Thus a resistor of a given value with a large cross section will have relatively more capacitance paths and therefore less resistance at a given high frequency, than one with a smaller cross section.

This is the first of three articles. The remaining articles will deal with capacitors and inductors, and will appear in the July and August issues, respectively.—Editor.

TECHNICANA

[*Continued from page 52*]

is used and the shield consists of a thin bushing which is pressed over the bit to completely shield the working surface of the screwdriver. This arrangement keeps the screwdriver centered on the screw and thus largely eliminates the possibility of burring the slot or slipping off the screw and thus marring the finished surfaces. This type of bit can be used in either manual or power-driven screwdrivers.

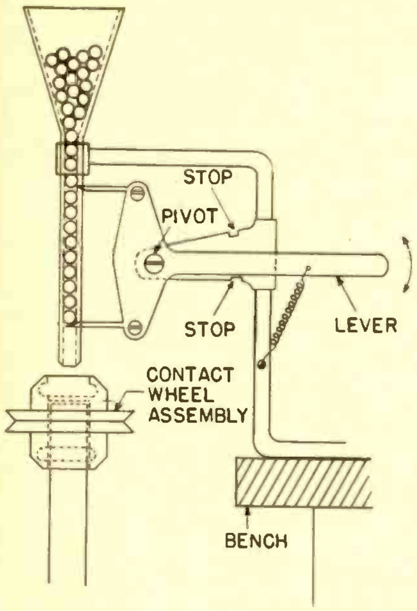
★

LOADS BALL BEARINGS EASILY

Loading of ball bearings into contact wheel assemblies for radio transmitters in mass production has been simplified by a fixture devised by W. D. Simpson, an assistant general foreman in the General Electric Electronics Department.

It consists of a funnel-shaped hopper with a tubular section attached to its lower end. The inside diameter of the tubular section is just slightly larger than the diameter of the ball bearings so that they will pass through it in line and without congestion.

A lever arrangement pivots from the frame holding the hopper in a manner that pushes two pins through the walls of the tube alternately at two locations. In this particular application, the pinholes have been located so that between them there is room for 9 ball bearings in the tube. An upward movement of the lever withdraws the lower pin from the inside of the tube allowing the 9 bearings to drop into the contact wheel assembly. The same movement injects the upper pin into the tube preventing more than 9 bearings from entering the assembly. Spring return of the



LOADS BALL BEARINGS EASILY

lever to its lower, normal position simultaneously reverses the position of the pins, automatically permitting another 9 bearings to fall into the space in the tube between them.

A vertical slot in the side of the tube permits a visual check of the bearings during the operation of the device.

★

BOOK REVIEW

ELECTROMAGNETIC WAVES, by S. A. Shelkunoff, published by D. Van Nostrand Company, Inc., 250 Fourth Ave., New York, N. Y. 530 pages, price $7.50.

This masterful treatment of the subject of Electromagnetic Waves is based on Dr. Shelkunoff's notes on several courses for advanced students. It is intended both as a textbook for advanced students and as a reference work for the practicing radio engineer.

The first part of the book is devoted largely to a presentation of the author's point of view and his terminology. The opening chapter discusses vector and coordinate systems, the second chapter is devoted to the mathematics of oscillations and waves, and the third chapter to Bessel and Legendre Functions. These chapters require a mathematical background of hyperbolic functions and the theory of functions of a complex variable. Cylindrical and spherical harmonics, Bessel's Functions, and the Fourier Integral are discussed as an introduction to later material.

The fourth chapter deals with the fundamental Electromagnetic Equations employing the meter - kilogram-second-coulomb (MKS) or Giorgi system of units. This chapter, while somewhat involved, is a thorough and logical treatment of the subject. It requires careful reading to follow the author's concepts. Following this are three chapters on transducers, networks, wave theory and transmission theory. The treatment of transmission and wave theory is especially impressive and complete. In these chapters the author has gone far toward the unification of the space concepts of waves and the network concept of circuits. Transmission lines are treated as transducers with gratifying results. The section on wave filters is brief but thorough.

The remainder of the book treats antennas, wave guides and resonators and radiation generally. This reviewer was particularly impressed with the author's three-dimensional treatment of radiation and electromagnetic fields. As he points out, in many cases a three-dimensional problem is often rigorously reducible to a set of one-dimensional problems. Once the one-dimensional problem is solved in sufficiently general terms, the results can be used in the solution of more general problems. The author is inclined toward the three-dimensional concept, dropping such dimensions as may prove unimportant to the treatment of the problem only when they have proven to be unimportant. This point of view obviously leads to a better understanding of wave phenomena and it benefits the reader by suggesting more direct methods of attacking new problems. The treatment of wave guides is particularly complete and thorough.

The last chapter is a brief treatment of the impedance concept and its significance at discontinuities in wave guides. It is of especial importance as an introduction to the wide use of wave guides, which is certain to follow in the future.

The book is well and interestingly written. It follows a logical sequence, and while much of the material is general, it is rigorous and thorough. It is highly recommended to radio engineers as a reference book and to advanced communications students interested in microwave transmission.—*C. F. N.*

ALLIED'S RADIO DATA HANDBOOK. Edited by Lieut. Nelson M. Cooke, United States Navy, U. S. Naval Research Laboratory, Washington, D. C. Published by Allied Radio Corporation, 833 W. Jackson Blvd., Chicago, Ill. Forty-eight pages, six by nine inches. Price, 25c postpaid.

A comprehensive, condensed handbook of formulas, charts, and data most commonly used in the field of radio and electronics. All subjects are clearly presented and conveniently arranged and cross-indexed for ready reference.

Divided into four parts: Mathematical Data, Radio and Electronic Formulas, Engineering and Servicing Information, and a complete set of four-place Log and Trig Tables.

Formulas are given for Decibels, Resistance, Capacitance, Inductance, Reactance, Resonance, Frequency, "Q" Factor, Impedance, Conductance, Susceptance, Admittance, Transients, Peak Average and R.M.S. Voltage and Current Values, Meter Shunts and Multipliers, Vacuum-Tube Constants, etc.

Data section contains such subjects as Radio Color Codes, Interchangeable Tubes, Pilot Lamps, Plug-in Ballast Resistors, Coil Winding, and others.

Should serve as a distinct aid to the student who is learning useful fundamentals, the serviceman who wants technical and maintenance data, the experimenter who wants nomographs and practical information, and the engineer seeking a time-saving reference.

★

NEW LITERATURE

SPRING DESIGN MANUAL

With the rapid multiplication of mechanical and industrial spring-activated equipment and products, the need for an up-to-the-minute manual on springs is acute.

Mid-West Spring Manufacturing Company, 4262 S. Western Ave., Chicago, Ill., has met this need with a convenient manual 4"x9", astonishingly complete in formulas of spring design and engineering for compression, extension, torsion, flat spiral or motor, flat springs, wire forms, etc., with illustrations, diagrams, and tables.

The manual provides the executive, engineer, production man or purchasing agent with all required information, compact and readily accessible.

New convenience for simplifying and saving time in making out specifications, is afforded in detachable extension sheets following "blue-print" diagrams, with spaces for details, and inquirer's sketches if desired.

"Spring Design and Engineering" is the title of the manual just off the press. Copies may be had without charge by addressing Mid-West Spring Manufacturing Co.

★

NEW RADIO TRAINING KITS BROCHURE

Lafayette Radio Corporation's Special Department for handling the needs of instructors and school management has just prepared this new brochure to aid schools in their government training courses.

Lafayette's engineers have expressly designed the kits mentioned in this folder to fit present training programs. Starting with fundamentals and progressing to basic receiver and transmitter operation, a progressive training program may be built up around these kits. Lafayette Radio Corporation, 901 W. Jackson Blvd., Chicago, Illinois.

★

"MUSIC AND MANPOWER"

What is probably the most exhaustive and authentic study of the subject to date, a 24-page book on "Music and Manpower," has just been released by Operadio Manufacturing Company, of St. Charles, Ill.

Treating the subject of industrial music as a production factor both historically and currently, the book represents important reading to any ex-

ecutive concerned with the problem of maintaining or increasing war production in the face of a dwindling manpower supply.

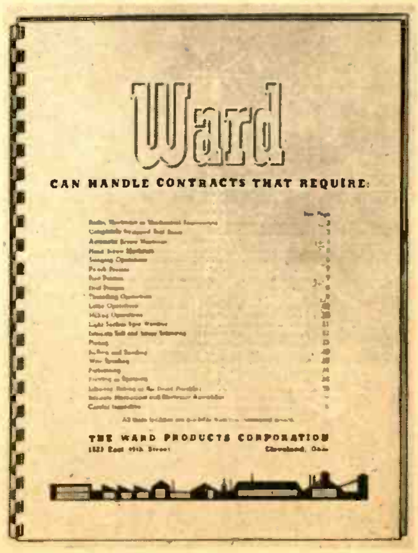
Although only a limited edition has been printed, a copy of "Music and Manpower" will be sent gladly to any executive addressing Operadio Manufacturing Company, St. Charles, Ill.

★

WARD PRODUCTS BROCHURE

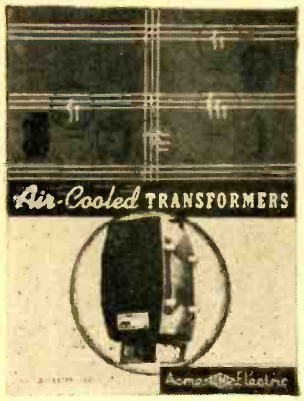
The Ward Products Corporation has issued a 24 page illustrated brochure outlining in detail the production facilities and equipment available in its two plants for handling contract work from other manufacturers.

Primarily engaged in making radio antenna equipment, the company is interested in any current or post war contracts in related fields which involve a reasonable number of the facilities described — regardless of the product classification. Manufacturers with production problems can obtain a copy of the book by writing to The Ward Products Corporation, 1523 East 45th Street, Cleveland, Ohio.



ACME AIR-COOLED TRANSFORMER CATALOG

"Power Where You Need It," a new bulletin issued by Acme Electric & Mfg. Co. of Cuba, New York, outlines and gives examples of air cooled transformer applications in war production industry.



The bulletin also describes in detail the various types of air-cooled transformers manufactured by this company, and lists the complete range of 55 degree ratings in auto type, two winding type, three winding type and four winding type transformers up to 50 KVA.

CORRECTION

In the article "Using the Slide Rule in Vector Algebra," appearing in the May issue of RADIO, typographical errors occur in *Example 1,* appearing on page 65.

In the second paragraph of this example the figure 19.8, mentioned twice, should obviously be 9.8 in each case.

The third paragraph should read in substance, "The phase angle is the angle whose tangent is X/R or 15/47. The tangent as found on the rule is then .319. The angle is readily found by placing the right-hand index of C over .319 on D and reading the angle on the tangent scale on the reverse side of the rule. This angle is found to be 17.7 degrees."

★

THIS MONTH

[*Continued from page 46*]

NEW "UNIVERSAL" EXPEDITER

Neville Robinson, formerly materiel expediter with the Plomb Tool Co., Los Angeles, has joined the staff of the Universal Microphone Co., Inglewood, Cal., in the same capacity.

★

LAFAYETTE OPENS WAR ORDER DIVISION

To expedite orders for vital materials necessary to the war effort, Lafayette Radio Corporation of Chicago have opened a special division to facilitate prompt deliveries and procurement of war materials.

S. Berk and D. Muir

The new division will be in charge of Mr. David Muir according to an announcement made by Mr. S. W. Berk, vice president. Mr. Muir has long been associated with Lafayette and was formerly in charge of purchases.

★

SALES MANAGERS CLUB, WESTERN GROUP, CHANGES TITLE

The Sales Managers Club, Western Group, a trade association of radio parts manufacturers which has been in existence for over ten years, has changed its name to the Association of Electronic Parts and Equipment Manufacturers, to be known in the trade as "E. P. & E. M." The Association, which now has over fifty members, has made this change so as to be readily identified with the industry which it represents. There will be no change in the functions of the organization. The group meets on the second Thursday of each month in Chicago, and has been a potent factor in radio industry matters. It is currently rendering a service to its members on priorities problems, price controls, government contracts and regulations, and manpower problems. It is also giving earnest consideration now to postwar planning. The present chairman of E. P. & E. M. is Mr. Jerome J. Kahn. The Sales Managers Club, Eastern Group, has not changed its name but will continue its identity and affiliation with the Western Group as heretofore.

★

NEW "UNIVERSAL" OFFICIALS

James R. Fouch, who founded the Universal Microphone Co., Inglewood, Cal., in 1928 and who has been its President since that time, late in March became Chairman of the Board.

The Presidency will be filled by James L. Fouch, former vice-president, who has been with the organization practically since its inception.

The new Vice-President and Treasurer will be Cecil L. Sly, former Secretary-Treasurer, who joined the company two years ago as controller.

The new Secretary will be Durwood (Jack) Allen, with the firm the last three years in accounting control capacities.

★

WHAT'S WRONG WITH THIS PICTURE?

Missing from Mr. Thomas' lapel is the "E" pin which he wears with pride. Having won the Army-Navy Award last September and more recently the added Star for maintenance of its production record, IRC in acknowledging Mr. Thomas' outstanding performance as Works Manager has announced his election as Vice President in charge of Production.

Mr. Thomas is one of the pioneer production men in radio manufacturing having been associated with the industry since the early 1920's. He is a member of the Radio Club of America and both through his former connections and his IRC activities is well and favorably known throughout the field.

★

ELECTRONIC RESEARCH SUPPLY AGENCY

The Electronic Research Supply Agency, which will provide radio laboratories serving the Army or Navy with critical components not quickly available elsewhere, will not be required to accept orders on the basis of their ratings, according to a directive to the Agency just issued by C. E. Wilson, Executive Vice Chairman of the War Production Board.

The Agency has not been fully set up administratively and is not yet engaged in actual operations. Announcement of the organizational details, with the names of those with whom the laboratories can deal and the location of the Agency's office, will be made later.

Based upon directions to be given by the Army, the Navy, the Office of Scientific Research and Development and WPB, the Agency itself will work out the sequence in which orders on it will be filled. In dealing with its own suppliers, the Agency will be assigned ratings by WPB or will extend the ratings of its customers. It is authorized to apply for priorities assistance or allotments on approved forms.

The Agency was organized for use of electronic laboratories whose needs could not be supplied on time in commercial channels. Laboratories are expected to continue to draw upon their usual suppliers to the fullest extent, using the Agency only for last resort.

★

STAR FOR RCA "E" FLAG

The Army-Navy Production Award for meritorious services on the production front has been won for the second time by the Radio Corporation of America's plant at Harrison, N. J., according to notification received from Robert P. Patterson, Under Secretary of War. To mark the maintenance of high production standard a white star has been added to the Army-Navy "E" Flag, presented to the workers at the Harrison plant on September 8, 1942, for "high achievement in the production of war equipment."

ADVERTISING INDEX

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