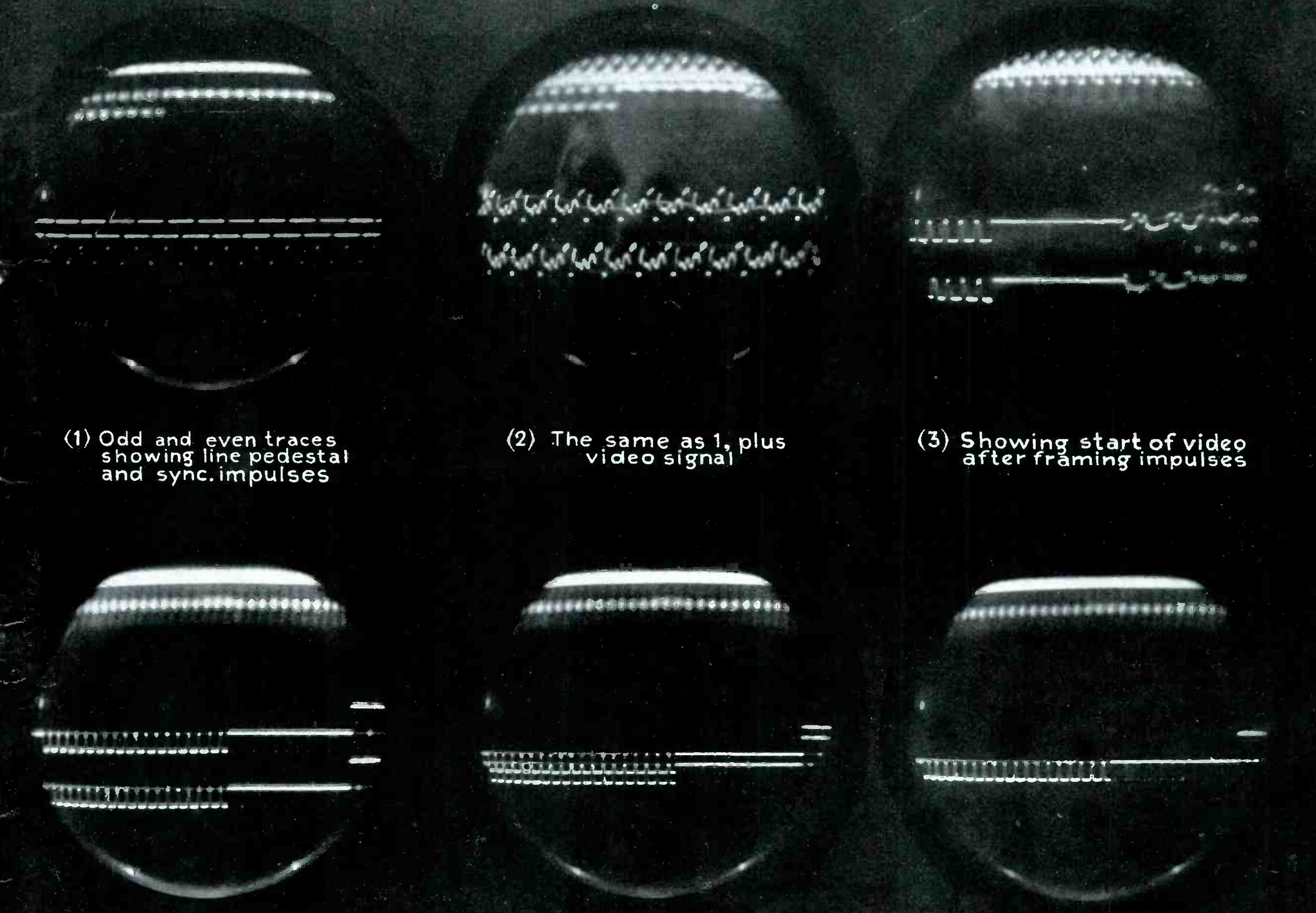
electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture

441-LINE TELEVISION WAVEFORMS



(1) Odd and even traces showing line pedestal and sync. impulses

(2) The same as 1, plus video signal

(3) Showing start of video after framing impulses

(4) Odd and even framing pedestals and sync. impulses

(5) Same as 4 with odd and even traces nearly merged

(6) Same as 4, but completely merged

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1937

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ELECTRONICS

radio, communication and industrial applications of electron tubes . . . design, engineering, manufacture

Contents • April 1937

COVER: *Photographs of single lines of 441 line television images. For a complete description see Crosstalk, this month.*

DEPARTMENTS

Volume 10 . . . Number 4

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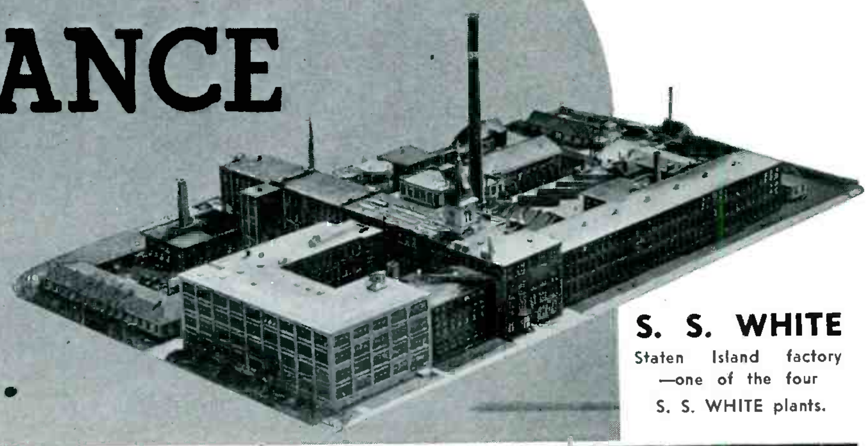
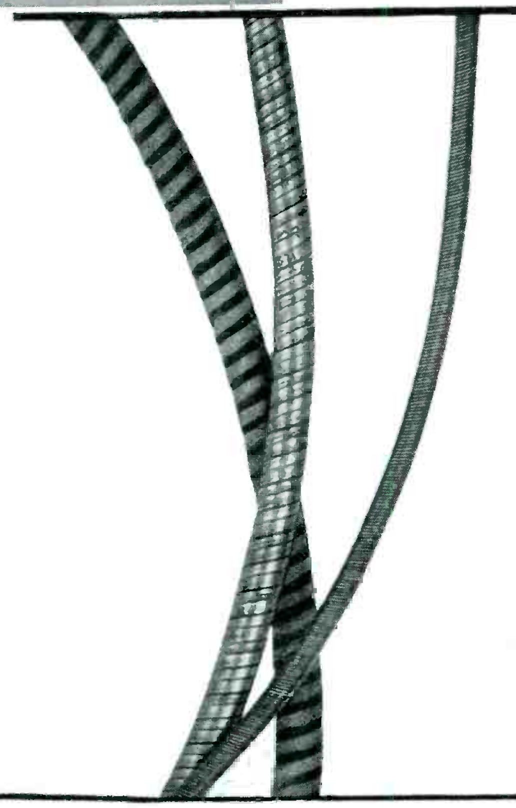
Universal ACCEPTANCE *by the Auto Radio Industry . . .*



S. S. WHITE
Staten Island factory —one of the four S. S. WHITE plants.



Available figures show that 1,412,000 auto radios were sold in 1936 • • • and an overwhelming percentage of them were equipped with

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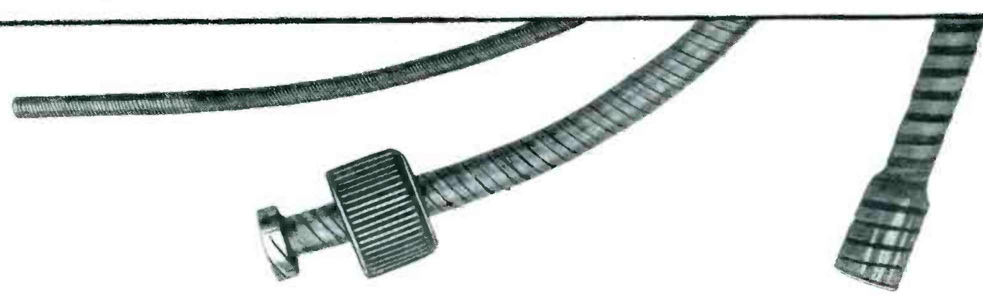

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the result of 30 years experience

GET SAMPLE BULB... TEST FOR YOURSELF

ARGUS MFG. CORP., 1890 E. 40th St., Cleveland, Ohio

Send us at once——Argus AR-60, 6 Ampere, 7½ to 100 Volt Rectifier Bulbs @ $6.00 each list price.

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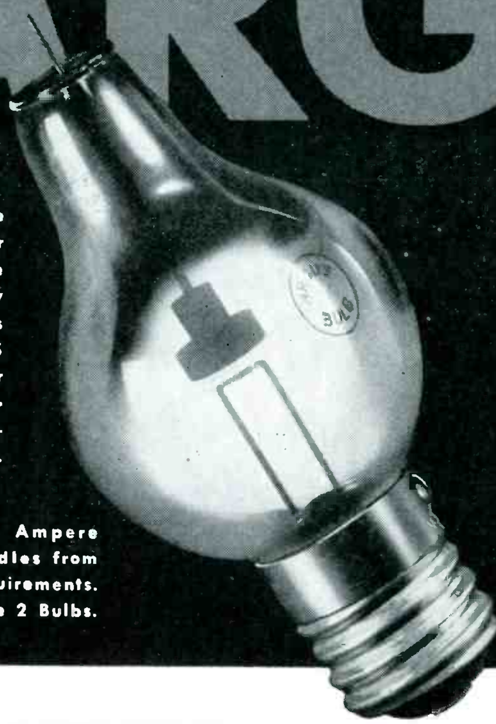

NEW Note the absence of Silver deposit inside the ARGUS Bulb and how clearly the filament is seen. This ARGUS feature allows for rapid heat dissipation, thus lengthening the Bulb life.

NEW This 6 Ampere ARGUS Bulb handles from 7½ to 100 Volt requirements. Other makes require 2 Bulbs.

precision built—half wave —gas filled—rectifier bulb

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7 OUTSTANDING ENGINEERING FEATURES

Engineers who have had wide experience in the vacuum tube industry for 30 years have built the NEW Argus Bulb, with its new features and its broader guarantee of service. Send at once for a sample Bulb for YOUR thorough testing. The Bulb's performance will show you why we can easily give the new 1500 hour Bulb guarantee. Use the coupon above today. Argus Mfg. Corp., Cleveland, Ohio

- decreased heat in the elements, and a longer life filament.
- a semi-transparent getter deposit and a new, tough quality of glass, all providing greater heat radiation, hence increasing the Bulb's life.
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- providing an improved carbon target, or anode, to withstand a far greater electronic force.
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Minimize Power Losses

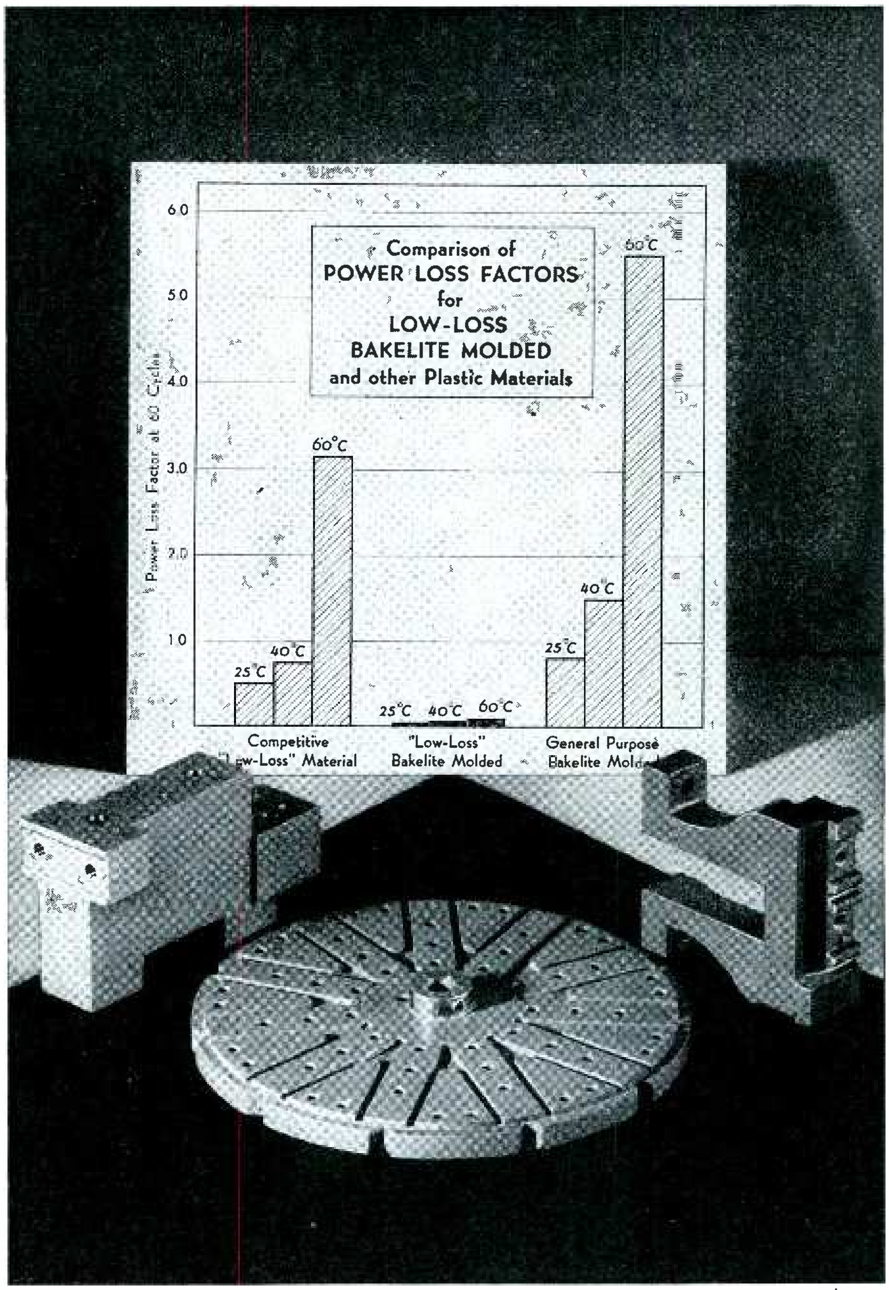
WITH BAKELITE MOLDED

For high-frequency parts of radio, television and other electronic devices, a special thermosetting plastic, *Low-Loss* Bakelite Molded, has introduced new possibilities for improvement in design.

The accompanying chart shows the values for power-loss factor of *Low-Loss* Bakelite Molded at 60 cycles and varying temperatures, in comparison with those of *General Purpose* Bakelite Molded and a competitive "low-loss" material. At 1,000,000 cycles, Low-Loss Bakelite Molded possesses a loss-factor of only 14% of the value obtained on the General Purpose type.

Also illustrated are three typical parts of modern radio capacitators and resistors that are now made for improved power efficiency from Low-Loss Bakelite Molded. Similar advantageous applications of this material throughout the field of electronics are practically unlimited.

Radio and electrical engineers are invited to consult us regarding any proposed application of Low-Loss Bakelite Molded, or of other types of the material. Also write for reference booklet 13M, "Bakelite Molded" which presents the characteristics of the various types.



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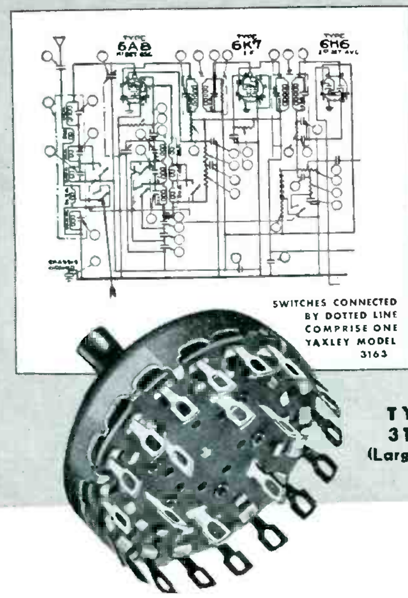
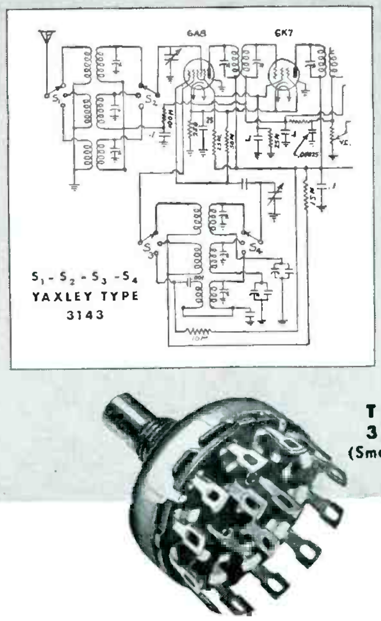
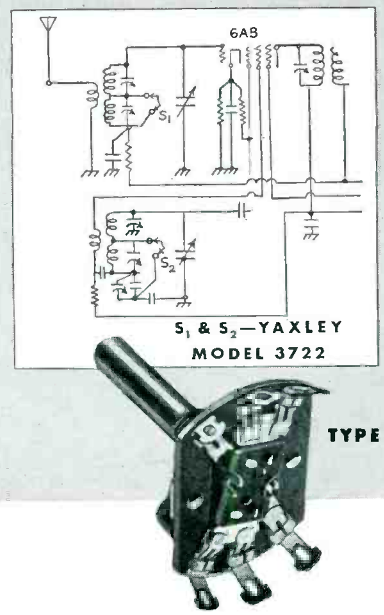


TYPE 3100 (Large Base)



TYPE 3100 (Small Base)



TYPE 3700

5 Reasons Why YAXLEY ALL-WAVE SWITCHES

Provide *Extreme Circuit Flexibility*

Each type of Yaxley Switch on this page performs more satisfactorily or economically in the typical circuit shown than any other available switch. These are not hypothetical examples, but are taken from actual receivers in which the respective switches are now successfully employed.

Type 3100 (Large Base)—A maximum of 18 positions on a 1$^{11}/_{16}$″ base. Provides more switching combinations in a single section than may be obtained by any other switch. Circuit shown is typical of its extreme adaptability.

Type 3100 (Small Base)—Accomplishes large switch performance in a miniature size. Provides a maximum of 12 positions on a 1¼″ base—a feat unduplicated by any other switch.

Type 3700—One of 22 standard constructions. Engineered especially for small chassis. Type 3700 has a maximum of 6 terminals. Accompanying circuit shows an actual wave-change application. Other switches of this series are adapted to tone control and tap switch requirements.

Type RM—Provides an almost limitless number of switching combinations through the use of back insulated contacts and interconnected rotor shoes. Diagram illustrates an entire 3-band receiver, the circuit switching of which is accomplished by a single RM section.

Type RL—Long production experience on this type has made it the standard of switch perfection. A stationary collector ring, not part of the rotor, makes more positions available—especially when all unused coils are to be shorted.

Large inventories of all parts for these switches assure you low cost and prompt deliveries. The Yaxley Manufacturing Division of P. R. Mallory welcomes your switch problems—send your circuit diagram and switch dimensions.

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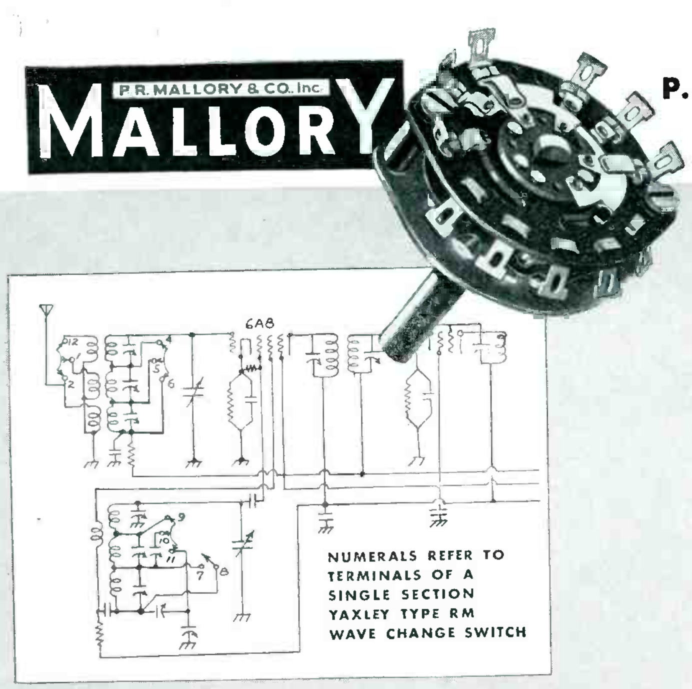
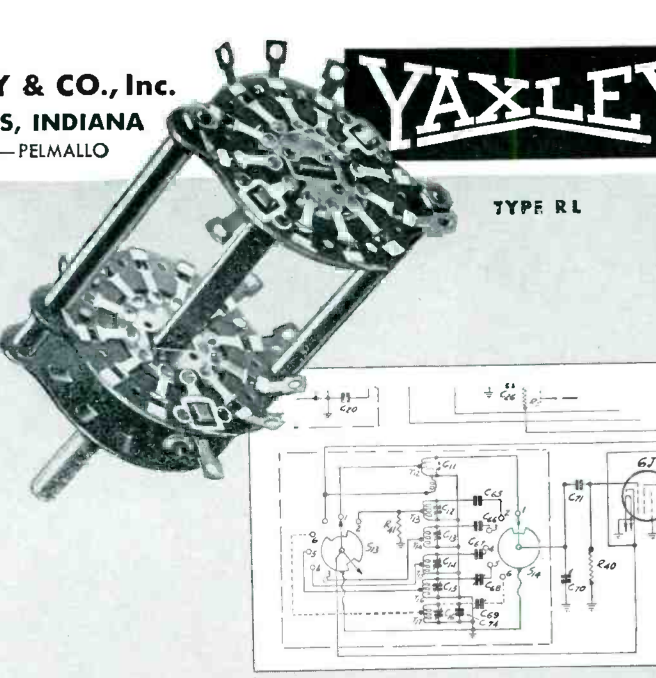


TYPE RM



TYPE RL

ELECTRONICS

APRIL 1937

KEITH HENNEY *Editor*

Crosstalk

▶ **MORE WE DON'T KNOW ABOUT RADIO** . . . In February *Electronics* were asked several questions, the answers to which would help the FCC and radio set designers. So far we have seen no answers. Either the industry cannot answer them or has not got around to the matter yet.

In the meantime other questions have come up, the answers to which would be of material value in the administration, assignment and allocation of radio facilities. Some of them follow. *Electronics* will be delighted to receive any discussion of these or the February questions.

Does ground conductivity in the immediate vicinity of a radio broadcast station antenna materially affect the long-distance propagation characteristic, and how may some quantitative data be obtained?

Why is it that certain broadcast antennas erected on top of buildings show remarkable efficiency, while others which appear equally as good are quite inefficient? And can the phase relationship between the current in the building and on the antenna be so adjusted that high efficiency can be obtained in all cases?

The standard between desired and undesired signal on the same frequency has been very well agreed to as 20 to 1. What variation in this standard should be allowed between areas where there is very good radio reception and where there is poor reception?

How may the average attenuation and the unattenuated field intensity at a given point be more accurately and readily determined than by the present method of projecting the ED curve?

To what extent may the so called wave tilt method be employed to compare and determine measuring points in making field intensity surveys?

What combined rates of attenuation (both including and excluding the acoustical characteristics of the studio and of the reproduction room) of the various audio frequencies (or resulting radio frequency sidebands) are permissible in high fidelity broadcast transmission and reception? In normal broadcast transmission and reception?

What individual rates of attenuation of the various components are permissible? To what extent are these values dependent upon the type of program?

▶ **WQXR** . . . Steady listening to early evening programs from the major and minor networks is a convincing demonstration of the fact that the broadcasters have got into a rut. This rut consists of a comedian, a jazz band, and stooges, male and female with assorted physical and mental difficulties. The pattern of each of these programs, preliminary to the real stuff of later hours (mostly dance music) is the same. And it is the most monotonous and highly paid drivel the broadcasters have as yet invented.

A British publication, years ago, stated that the ideal program from the control operator's standpoint was a single frequency of constant amplitude. Present 15-minute and half-hour programs approach this ideal asymptotically. The gags sound the same, the bands play the same tunes, the audience laughs when told, the announcer gets off his stuff at the exact predetermined moment. There doesn't seem to be a new idea in a hundred programs.

Thus it is a positive relief to be able to tune a receiver in New York City to 1550 kc. Here is WQXR (owned by J. V. L. Hogan, a radio engineer) and here is two hours (at least) of music with a minimum of talk. It is worth noting that sales of phonograph records make new peaks nearly every month. It must be that thousands of people have found that their own library of music is their only escape from complete radio monotony. WQXR is high fidelity, it plays the best of recorded music—and often studio music of much entertainment value—and there is no jumping up every 15 minutes to a hunt a new station, or to turn the thing off.

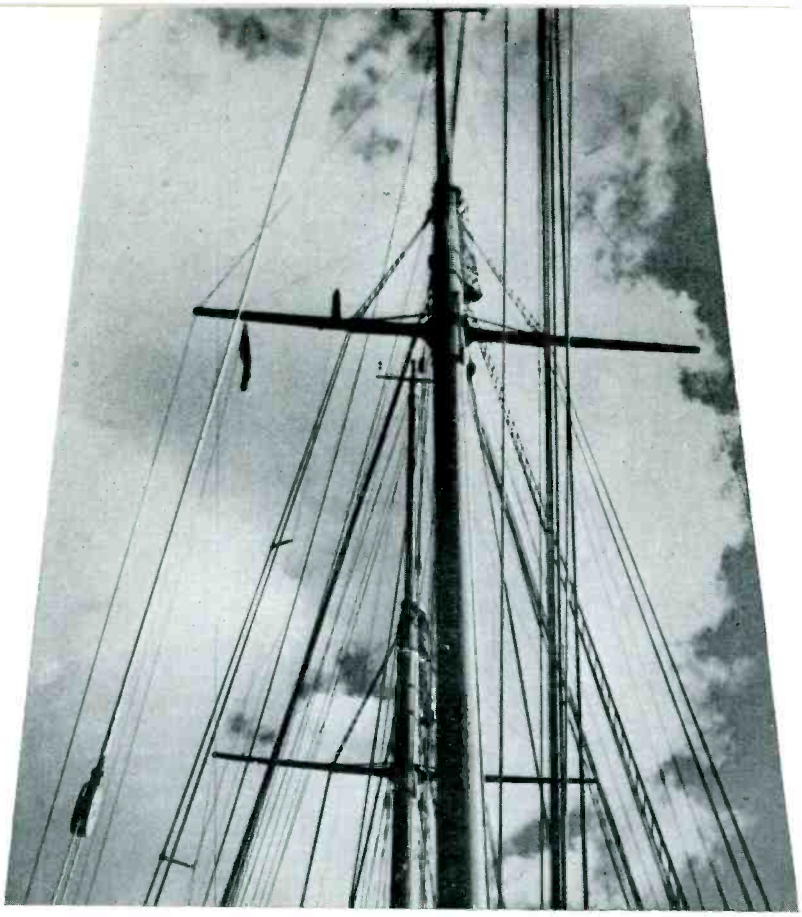
▶ **COVER** . . . The photographs on the cover are of the screen of a cathode-ray tube scanned horizontally at 420 traces per second. The vertical deflection consists of the signal under observation, together with a "pedestal" which occurs during every seventh trace, and is alternately of different amplitude. At the top of the screen is the super-imposed pattern of six traces and the two clear traces across the center are due to the occurrence of the pedestals. Each alternate trace through the center of the screen occurs each thirtieth of a second.

The signal, also present on the vertical deflection plates originates from television equipment which employs the new standard of 60 fields (30 frames) per second, and 441 interlaced lines per frame. Hence, the effective traces through the center of the oscillograph screen show sections of the "odd" and "even" scannings.

In Fig. 1, for example, a section of the signal voltage is shown, which consists of line pedestals with synchronizing impulses riding thereon. In Fig. 2 the video signal itself has been added and shows as a voltage variation during each line interval. In Fig. 3 a section near the framing pedestals is again shown plus the video signal which starts after the frame pedestal has ceased.

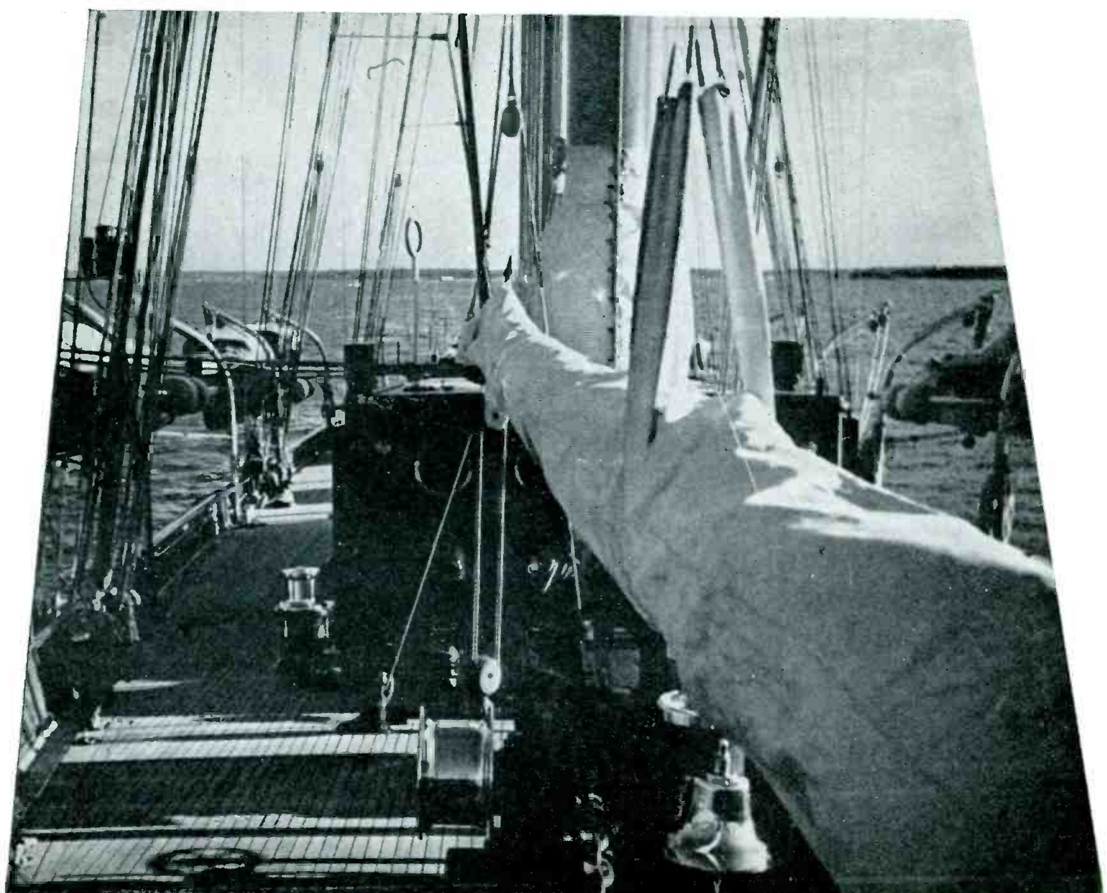
In Fig. 4, a section near the frame retrace is shown to illustrate the character of the 60 cycle synchronizing and pedestal components. The odd and even occurrences are nearly alike, except at the right hand edge. By altering the amplitude of the oscillograph pedestal voltage the two traces are slowly merged as in Figs. 5 and 6.

The photographs were made in the Hazeltine Service Laboratories.



STRANGE-SHIPMATES

An unusual combination of the old and the new, radio direction-finding on a wind-driven ship, has been achieved aboard the *Migrant*, three-masted steel yacht owned by Carll Tucker. The interfering effect of the metal masts and rigging surrounding the loop (on deck house, below) was overcome only after extensive work, including individual bonding of each stay to the steel hull, to eliminate noise.



Radio Compasses for Small Boats

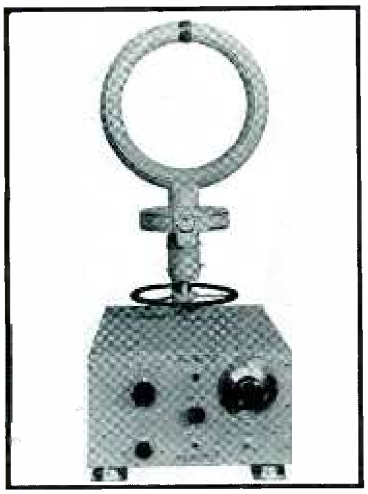
The marine radio direction finder, once restricted by price and size to large ocean-going vessels, has appeared in new, inexpensive, compact models suitable for small pleasure craft and fishing boats. Its uses and design are described herein

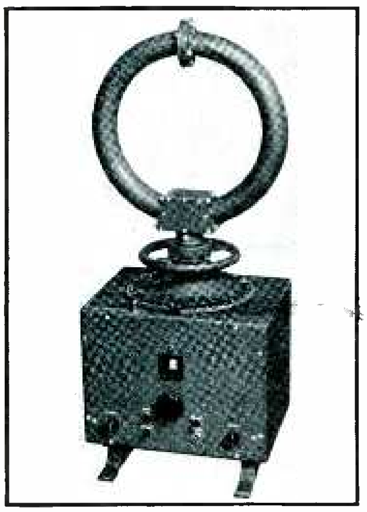
OF all the radio services maintained by the U. S. Government, one of the most extensive, and least appreciated by radio engineers generally, is the radio beacon system of the Lighthouse Service. On both seaboards and in the Great Lakes region, there are no fewer than 112 stations which transmit regular signals for use by ships equipped with radio direction finders. This large and expensive service has been maintained until recently almost entirely for the benefit of large ships, cargo vessels and passenger liners, which could afford to install the expensive direction finding equipment. Even the large ships, five years ago, were not making the fullest use of the system, because the accuracy of their equipment was limited.

During the past five years, however, the design of marine d-f equipment has undergone a thorough house-cleaning. The new sensitive circuits originally developed for broadcast and communication service have been incorporated in the receivers, and their stability increased. Even the loops have been redesigned. The net result is a considerable increase in the accuracy with which bearings can be taken, rivaling the sextant even at great distances from the beacon station. This accuracy has made the radio compass a reliable indicator not only of position but of the course pursued by the vessel. Equally important is the use of simpler design throughout in the newer radio compass equipment, which has reduced the size and expense of the equipment so that owners of small pleasure craft and fishing boats can afford to install it. Several manufacturers have produced models which sell for about 500 dollars, and there is one model which sells for less than 200 dollars, not including installation.

The uses to which these small-boat direction finders have been put are remarkable in their variety. An interesting example is the fishing fleet of New England. The fishermen patrol the banks until they find the fish. By means of the radio compass and three beacon stations they then take a "fix," that is, locate their position to within a few miles. When the hold is filled, they return to market, sell the fish, and then return to the same location, reaching the position by radio compass, and checking it by a three-station fix. If the fish have by that time moved, it is usually a short job (three or four hours) to relocate them, whereas without the direction finder it might take several days to locate the school. The compass is also very valuable in making a quick run to port when the hold is full. The direction finder is then used as a "homing" device, following the signal of a harbor station. A few hours gained in reaching the market may often mean a difference of a cent a pound in the market-price, enough to pay

Among the radio beacons maintained by the Lighthouse Service for radio-compass use are 30-odd lightships, which signal in groups of three on the same frequency so that cross-bearings can be taken





Two new direction-finders suitable for operation on small boats. Above, the Radiomarine Corporation's Model AR-8700, and below, the Kolster (Federal Telegraph) Model 103-A Both have 12-inch loops

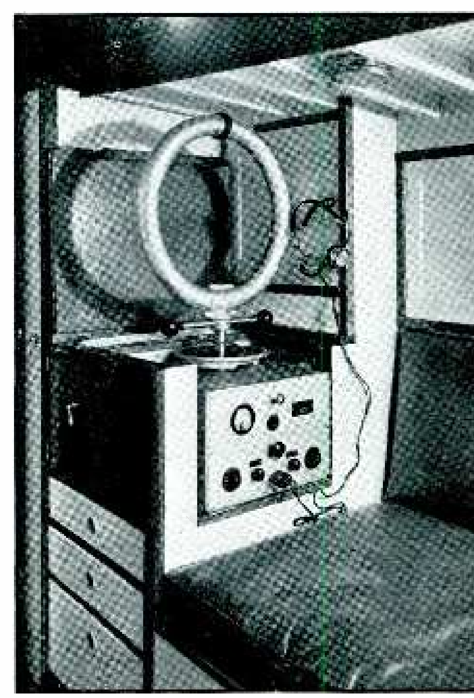
for the compass equipment in one trip. In fog, when astronomical sights are impossible, the compass is often the *only* means of returning to port. Nearly fifty fishing vessels have been equipped with small direction finders within the past three years, and the number is increasing as the good word is passed along.

Another interesting use of the small radio compass is aboard sailing yachts, where they are used not only for routine navigation but also in racing. In racing, the run of the tide may make the difference between first and last place, and this factor is very difficult to check. The time consumed in making astronomical sights and calculations is prohibitive, but with radio compass direct bearings can be taken in a few seconds and the tide flow checked continuously along the course. In long distance racing, such as the Bermuda races and the Miami-Nassau competition, exact navigation along the great-circle course (shortest distance) is imperative, but if the sun does not shine, exact navigation is virtually impossible unless a radio compass is aboard. The winner of the last Miami-Nassau race used a radio compass for navigation. The use of the compass as a homing instrument, in the presence of fog, may be sufficient justification for having the equipment, even if it is never used in routine navigation. Several power yacht owners have installed small radio compasses for just such contingencies.

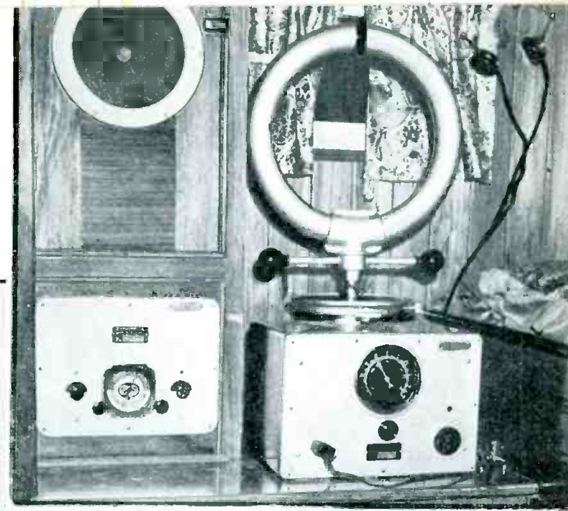
The Basic Elements of the Small Radio Compass

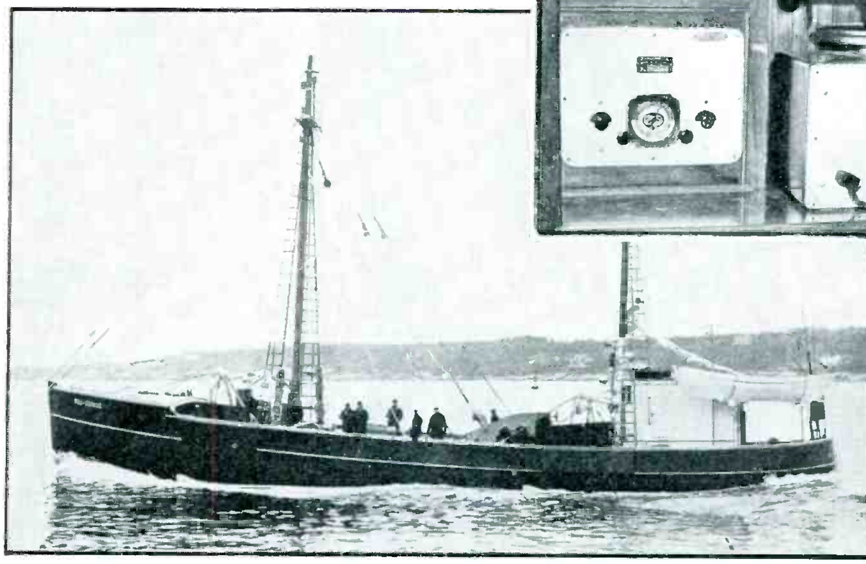
The basic elements of radio compass equipment are: a loop antenna, a balance antenna, a receiver, and a null indicator. The loop, which indicates the direction of the incoming signal, is mounted in an electrostatic shield and is balanced with respect to its center-tap, which is grounded. The two outer ends of the loop feed into the input stage of the receiver, which is commonly a push-pull r-f stage. The output of this stage is zero when the plane of the loop is at right angles to the incoming wave-front. The loop is rotated until the zero position is reached, as indicated by the null indicator, which is usually a pair of head phones. A pointer attached to the loop then indicates on a compass card the angle between the incoming signal and the keel-line of the boat.

The true direction of the incoming wave may be distorted by the presence of metal in the vicinity of the loop, such as the hull of the ship, stays and rigging, and the like. These metal objects produce two effects. One is the so-called quadrantial error, which is a permanent error in direction, readily corrected by calibrating the compass card. The other is a re-radiation effect which obscures the null position of the loop. This makes accurate bearings on distant stations difficult, since the headphones indicate merely a minimum signal, rather than a sharply defined null. Correction of this effect is secured by the use of an auxiliary antenna, which picks up voltage without regard to direction. This voltage is fed through a phase shifting coil or condenser to the first stage of the receiver where it balances out the re-radiated component so that the true null is obtained. In operation, the navigator shifts the loop to the minimum signal position, then tunes the phase-shift device until the minimum becomes more pronounced, and finally sets the loop on the exact null. An accuracy of one or two degrees is thereby attained up to 500 miles from the beacon station. The loop does not indicate the sense of the incoming signal, that is whether it comes from behind or in front. This 180° ambiguity is resolved by connecting the balance antenna through a resistance to one terminal of the loop, and turning the loop of the two positions of maximum signal. The antenna voltages add in one



Two d-f installations on pleasure craft, both Bludworth models. The below-decks model (above) can be used inside wooden cabins. The model shown mounted on the cruiser (left) is completely waterproof and will operate readily when submerged in hot salt water direction, and subtract in the other, so that the sense of the signal is given by the direction of the loudest maximum. The sense and direction of the signal is then completely determined with respect to the keel of the ship. If its direction with respect to true north is required, then an extra compass scale card (Ritchie ring) is rotated to show the angle between the keelline and true north, as indicated by magnetic or gyro compass. In elaborate installations, this adjustment of the Ritchie ring is accomplished automatically by a Selsyn motor connection to the master gyro-compass of the ship.





Radio aids the fishing fleet. The Rio Duoro, out of Gloucester, finds the fishing banks by following compass signals. The installation (inset) includes, at the left, a marine all-band radio receiver for news and entertainment

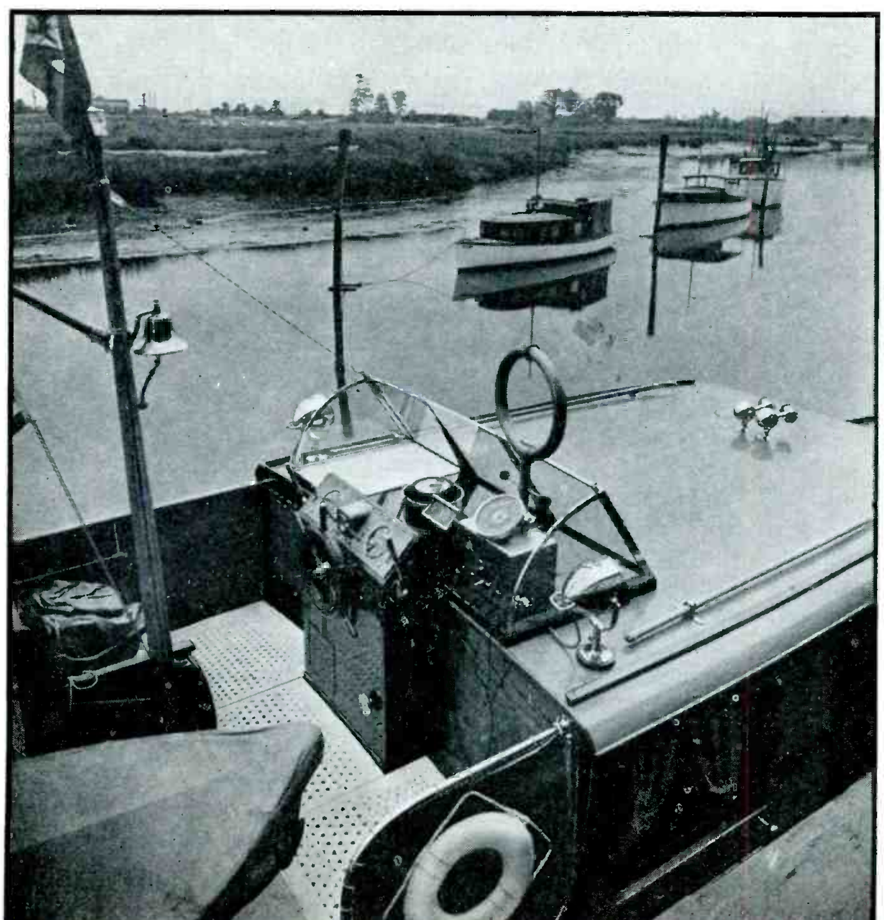
Receiver Characteristics R-f and A-f

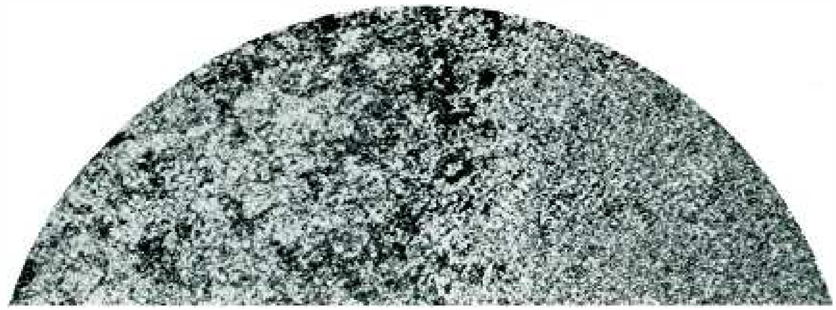
The frequency band on which the beacon stations operate extends from 286 to 314 kc, within which there are 14 2-kc channels. This restricted range makes for a large band spread on the dial of the receiver, but the limited channel width requires a high degree of selectivity and stability. The audio response is limited to about 1600 cycles by the use of sharp tuning in the r-f and i-f circuits, and in some cases by the use of an audio filter as well. Such a receiver is unsuited to broadcast use because of the limited audio response. For this reason, and because there is little demand for it, the receivers are not built to receive the broadcast station band. They do include frequencies as high as 540 kc, however, which includes the SOS frequency and the traffic frequencies, as well as the land-compass frequency on 375 kc. The receiver and loop circuits are tuned for highest efficiency in the region between 270 and 330 kc, within which the beacon stations lie.

The receiver sensitivity varies with the price range and intended use. The more elaborate receivers have a sensitivity of the order of 1 microvolt or less, giving a reliable range of nearly five hundred miles in daytime. At night, due to the shifting wave-front or "night" effect, the reliable range is usually less than this. Under favorable conditions, however, good bearings can be taken up to 1500 or 1600 miles.

The compensation or correction for the quadrantial error is accomplished in a variety of ways. In the simplest instruments, the correction is marked on the compass scale or on an auxiliary scale adjacent to it. A specially engraved compass card, engraved from calibration data obtained for each particular installation, may also be used. The more elaborate models include an automatic compensator (cam-drive), which introduces the desired correction directly to the pointer so that it indicates the true bearing.

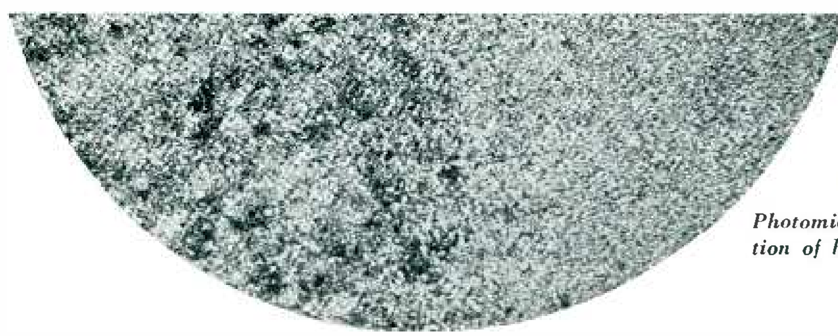
The power supply is commonly a six volt storage battery charged directly from the ship's power supply. B-supply voltage is obtained either from a genemotor or from a 90-volt dry battery. The more elaborate models include a meter for monitoring the plate voltage supply, to guard against failure while at sea.





Phototube Temperature Control

Although Mr. Powers's work has been most closely associated with automobile manufacturing, all heavy industry can learn from his photoelectric applications. For other uses of tubes in making automobiles, see *Electronics,* September 1935, June 1936



Photomicrograph (X200) of junction of hardened and soft parts of valve stem tip

By R. A. POWERS
Electronic Control Corp.
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ALL divisions of the metal processing industry have wanted a better system of temperature indication and control — a means that would be rapid and accurate. In the past the thermocouple and associated bridge, control, and indicating equipment have answered the problems; but with increased speed of production and changes in methods of heating, a new, faster method was necessary.

With the extremely large application of resistance heating by steel parts manufacturers, a further demand for a well designed, accurate, reliable temperature control unit was felt. In general, resistance heating consists of using the article or section of the article to be heated as the resistance across the secondary electrodes of a welding transformer. In cases such as the resistance heating of the tip of an automobile engine valve stem, the heating must be accomplished rapidly so that the heat will not travel down the stem before the quenching operation. The photomicrograph of the section of the tip of the valve stem clearly illustrates the sharp line between the heat treated section and the portion which was not heated. In the production of valves this hardened section must not be allowed to run up to the groove or slot for the pin or other device which holds the valve spring. Hardening at this section causes shearing of the pin.

About two years ago the phototube was introduced as a sensitive element which could be used for temperature control and indication. Since that time many improvements in the cell, cell housing, amplifier and associated control and indicating equipment have been introduced. Today, in some manufacturing plants, phototube temperature control is used as universally as the thermocouple might have been used in the past.

The illustration shows one of the first resistance heaters employed to rapidly heat treat the tips of the valve stems. The black enameled housing on the front of the resistance heater is an early model photoelectric temperature control unit. The tube projecting down from the under side of the unit is the admittance tube for the photo tube.

The operation of the valve stem heater is simple. The valve stem tip is inserted between the hydraulically driven dies which automatically close on the stem. At the completion of the closing cycle, the primary of the welding transformer is energized, and in less than two seconds the tip of the valve stem is brought from room temperature to 1800° F. At the desired temperature the photoelectric control unit turns off the primary of the welding transformer and opens the dies. The valve drops into a quenching tank. Production runs as high as 1800 valves per hour with the owner reporting a smaller number of rejections than was possible before photoelectric control was available.

This is a typical adaptation of phototube control of temperature in resistance heating. Among some of the other installations that have been made during the past year and half are numbered the following adaptations:

1. Controlling resistance heaters used for shrinking the metal shell on the ceramic insulator of spark plugs. The installation of phototube temperature controls on this battery of 16 heaters resulted in a tremendous saving in rejected spark plugs due to uneven heating formerly encountered.

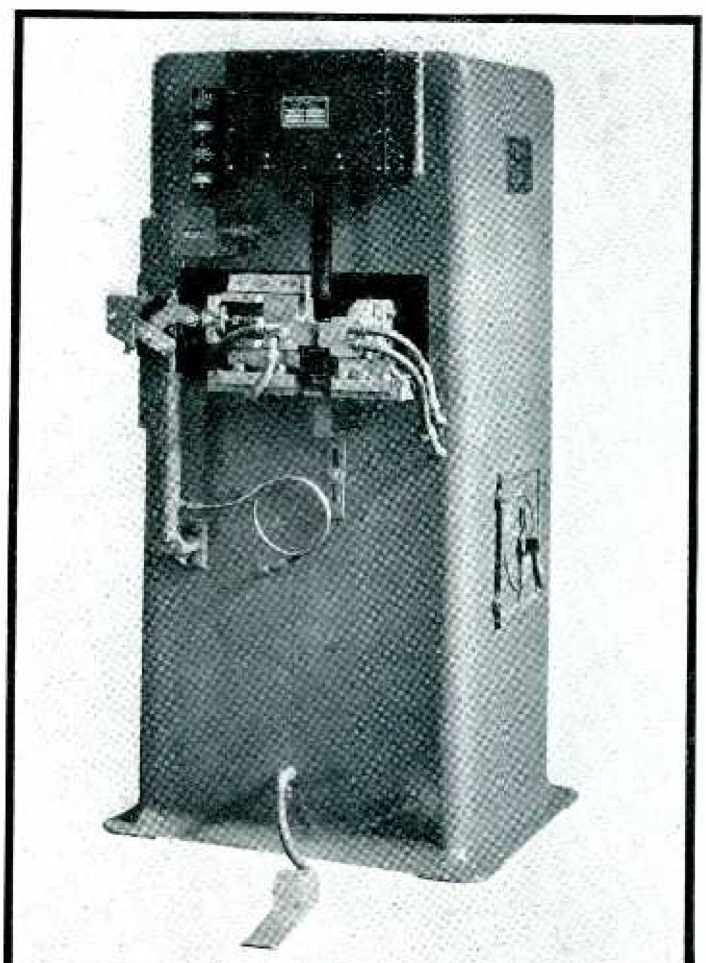
2. Controlling resistance heater used for annealing the central section of automobile front axle king pins. The temperature to be controlled in this installation was below 1000° F., where no red coloration of the steel was perceptible to the human eye.

3. Controlling an electric silver-soldering operation in the assembly of the stainless steel spokes to the metal rim in the 1937 type steering wheels. Three separate temperature control units individually control the heating and water quenching of three junctions simultaneously. Prior to the adaptation of the phototube units only one junction could be made at one time — and with a high per cent of rejections due tc the lack of constant temperature control.

4. Indicating the pouring temperature of an iron foundry cupola: A dual type phototube control unit individually turns on a red pilot lamp if the temperature is too high; a white lamp if correct; and a blue lamp if too cold.

5. Automatic indexing of copper billets from which soft copper tubing is extruded: The phototube looks at the billets in a controlled atmosphere furnace and when the billet reaches the correct temperature it is indexed to the extruding press, resulting in a saving of extruding dies and more uniform tubing.

6. Continuously indicating temperature of sheets in a steel mill: At a location remote from the phototube and amplifier, a recording meter is installed giving a continuous record of the temperature of the sheet strip.



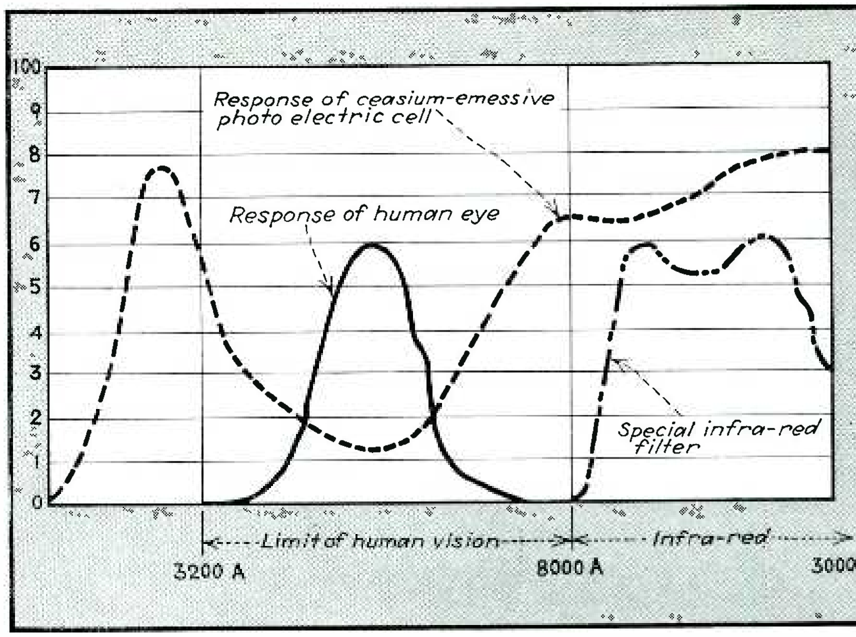
Early phototube temperature control unit for automatic heat treating valve stem tips; combines economy and speed

Stability is Necessary

Because stability of the entire photoelectric temperature control or indicating device starts with the stability of the phototube and its installation conditions, considerable thought has been given to this part of the equipment. With the remarkable strides made recently in the stability and life of the emissive type of cell, and with the color response of the caesium cell it was natural that the caesium phototube be more or less universally adopted for temperature control and indications. In actual installations these tubes operate for over 9000 hours without showing signs of fatigue or instability, providing that the ambient temperature is not allowed to exceed 150° F. This life, alone, is of unusual interest to the pyrometer or temperature control man, when compared with the life of the standard thermocouple.

The first phototube housing for temperature control and indications was little more than an admittance tube placed in such a position that the cathode of the phototube would be illuminated by the radiant energy from the heated object. Later the admittance tube was supplemented with an optical system in an attempt to have the cell illuminated by only the radiant energy from the object. This was done as the first thought of a way to eliminate the external light changes from reaching the cell — and thus eliminate the necessity of constant adjustment of the control or indicating device as the sun would come up in the morning

Comparative curves showing relative response of the human eye, caesium phototube, and the energy passed by the special infra red filter



and go down in the evening.

These were but feeble attempts to find an answer to the problem—and this problem was serious, because complete loss of accuracy in the control or indicator resulted from these diurnal or other external light changes.

Recently the admittance tube and the optical system were supplemented with a special filter placed between the heated object and the phototube.

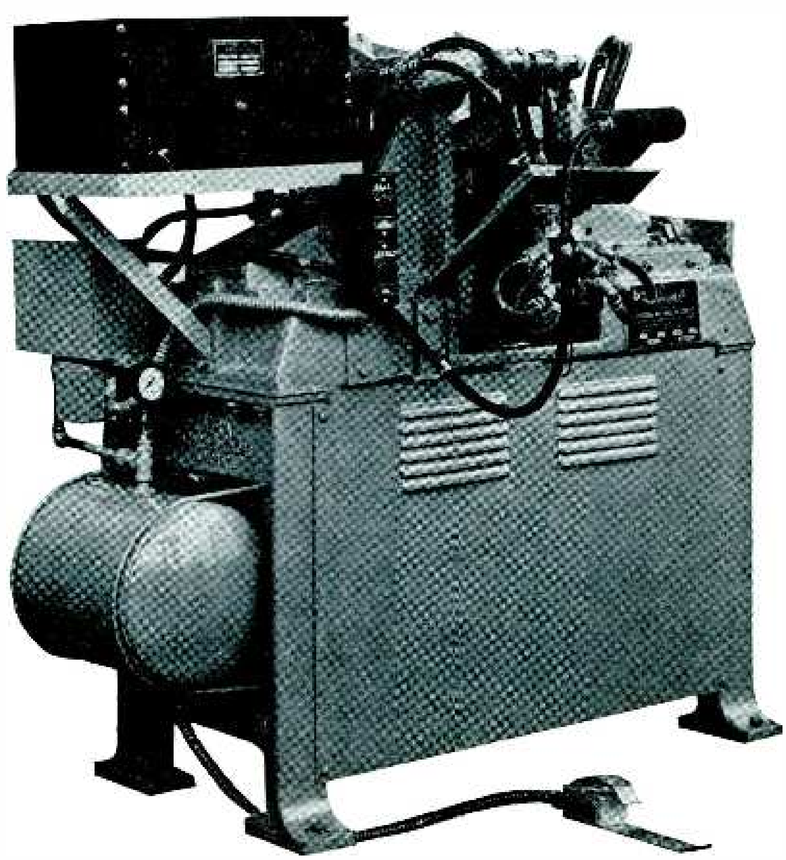
The filter prevents any, so called, visible radiation from impinging upon the cathode or sensitive area of the phototube.

A high percentage of the radiant energy reaching the earth's surface from the sun is infra-red; but infra-red is very poorly reflected by the average dark, black, or dull colored object found around the machine shop, foundry or heat treating shop. As a result in practical installations the need for adjustment due to external light value changes has been completely eliminated. The new phototube housing has as an added feature, a view finder, or focusing device. It is now possible to look into the view finder and adjust the optical system of the cell housing (with filter removed) so that the image of the heated object or portion of the heated object covers the cathode of the phototube.

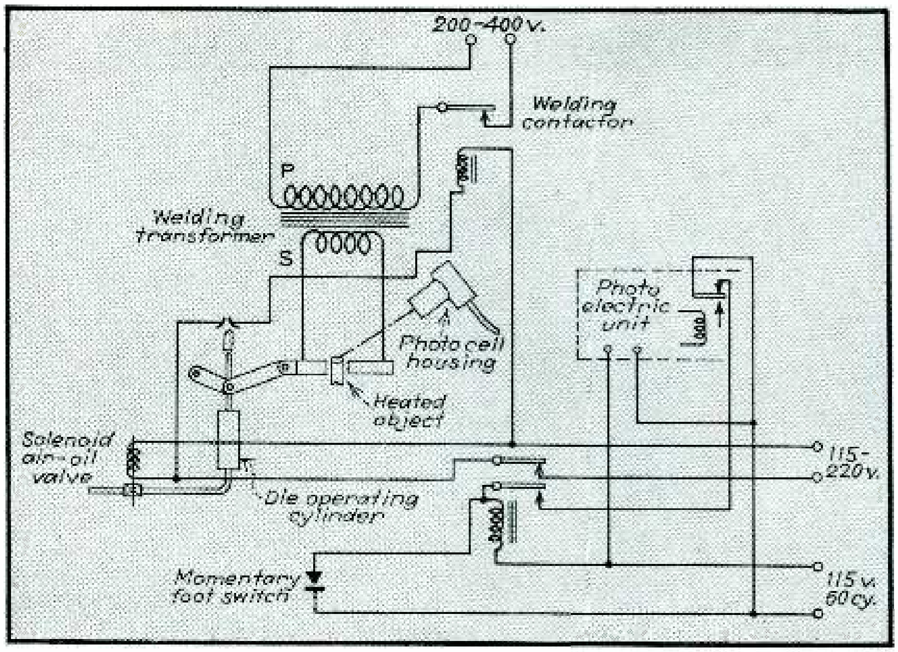
The light energy from the heated object reaching the cathode of the phototube falls off by the square of the distance; but as the distance from the heated object increases, the area of the object as projected to the phototube also increases by the square, when the finder is used.

With the tube and tube housing and stray light problems well solved, the problem of designing a suitable emissive cell amplifier was presented. The first phototube temperature control installations consisted of a standard light relay; one stage of amplification following the photoelectric cell. The output of this one-stage amplifier was connected to a sensitive relay of the telephone type and accurate control of temperature was expected. The results were not satisfying.

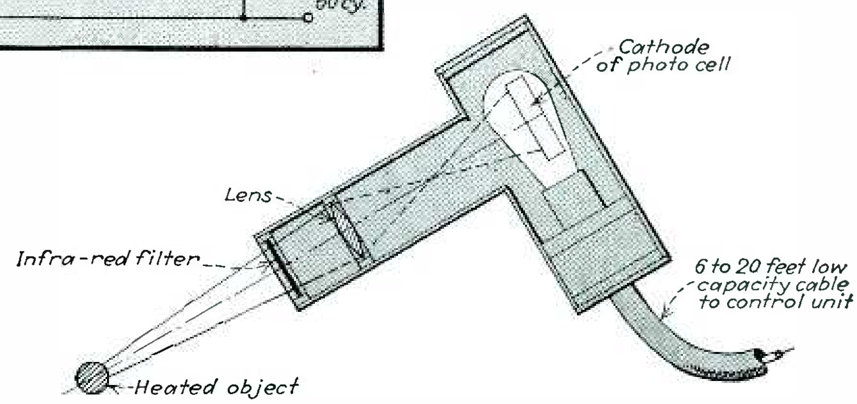
The phototube, its housing, and optical system required time, thought, and development. Today, the temperature control amplifier consists not of one stage of amplification, but three stages of high gain direct coupled amplification connected to a relay capable of becoming energized on one-half milliampere change in plate current of the last amplifier. Taking into consideration drift in the component



Heater for annealing central portion of the front axle king pin of automobiles; phototube control connected with amplifier by low capacity cable



Typical phototube temperature control. Hydraulically driven dies may be eliminated in favor of a solenoid locking the work in proper position



Sectional sketch of tube housing showing placement of filter, phototube etc. All visible light is excluded by means of the filter

parts of the amplifier, the instability of tubes, and means of correcting these instabilities, it has been possible to use as high as 50 megohms as a leak in the first stage of the phototube amplifier, and to use standard radio tubes throughout.

In what might be termed a deluxe model of the present phototube temperature control units, a series of 874 gaseous voltage regulators connected across the bleeder resistor of the direct coupled amplifier insures stability. As a result d-c voltage supplied to the amplifier from the self-contained power pack is constant — and the temperature control is accurate and reliable.

The first amplifier used a standard inexpensive light relay, using one stage of amplification with a special industrial type tube. Soon it was found that one stage was not sensitive enough for low temperature control; and that special industrial tubes were not immediately available in the remote communities of the United States.

Now, standard radio tubes are used in amplifying the feeble current changes coming from the emissive type phototube. To assure long life, stability, and low cost of operation these standard radio tubes are operated far below the rating set forth by the manufacturer.

Today, there are four general classifications of phototube temperature control and indication units available; which are as follows:

1. Single stage of amplification following a standard emissive type phototube. The cell is housed in a standard cell housing used for light relay purposes. The unit will control resistance type heaters etc. from 1300° F. to 1950° F. No filter or optical system is supplied with the phototube housing. Accuracy is completely lost.

2. Two stages of amplification following the emissive type phototube, voltage regulators feeding the phototube and cathode voltage of the first stage of amplification. This unit uses standard radio tubes in the amplifier and will control temperature from 1100° F. to 2000° F. Phototube housing equipped with special optical system and infra-red filter and connected to control unit with five feet of low capacity cable. Relay contacts in control unit capable of handling 500 watts non-inductive load. Accuracy plus or minus 10° F.

3. Three stages of amplification following a special emissive type phototube; gaseous type voltage regulators connected across the entire circuit. Uses standard radio tubes throughout control unit. Separate phototube housing with filters and optical system connected to the control unit with six feet of special low capacity cable. Complete device will control with an accuracy of plus or minus 5° F. throughout the entire spectrum from 985° F. to 3300° F. Relay contacts capable of controlling 500 watts non-inductive load.

4. The same control unit as 3 above with the addition of a special recording milliammeter in the plate circuit of the final stage of amplification so that an actual record of the temperature control may be obtained.

As a result, today one can find accurate temperature control and indication being accomplished with tubes. The phototube, its unusual response in the infra-red; adaptation of radio tubes to industrial circuits where long life and low cost of maintenance are essential; and advanced design and construction of the phototube housing have made this possible.

Practical Feedback Amplifiers

Complete design and performance data on three easy-to-construct degenerative power amplifiers, using ordinary components throughout and providing net gain up to 50 db with output up to 25 watts at one percent distortion, in single-sided and push-pull arrangements

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WHILE the theory of degenerative feed-back amplifiers has been discussed at some length in technical publications[1,2] the practical embodiment of this theory in operating circuits has not received widespread attention. Since the design of a practical circuit is not so simple as the theory might lead one to believe, it often happens that the engineer attempting to construct such an amplifier becomes involved with the instability problem or some other difficulty and concludes that the possible benefits are not worth the effort. But practical feed-back amplifiers can be built readily without involved design or expensive components if certain principles are followed. This article has two purposes: to present the design and performance data on three amplifiers which have been built and tested by the authors, and to show some of the fundamental ideas on which the designs are based.

The amplifier circuits

The circuit shown in Fig. 2 is a three-stage amplifier using a single 6L6 beam power tube in the output stage. The performance characteristics (Figs. 3 and 4) show the improvement as the feed-back is increased from 0 to 16 db. The circuit in Fig. 5 is a push-pull beam-tube amplifier with a push-pull driver stage but otherwise very similar to that shown in Fig. 2. The performance curves for this amplifier (Figs. 6 to 9) show considerable improvement in response, especially with the loudspeaker connected as a load (Fig. 9). In Fig. 10 is shown a four-tube all-triode unit, across three stages of which the feed-back is applied.

The engineer may construct any of the amplifiers shown with assurance that their performance will be as indicated in the frequency, distortion and overload curves. They may be substantially altered and in most cases improved upon without in any way injuring performance; the amplifiers shown represent only three of many experimental amplifiers constructed and definitely do not indicate maximum performance. In this respect it is of value to know the considerations on which the designs have been based. These are discussed in the following paragraphs.

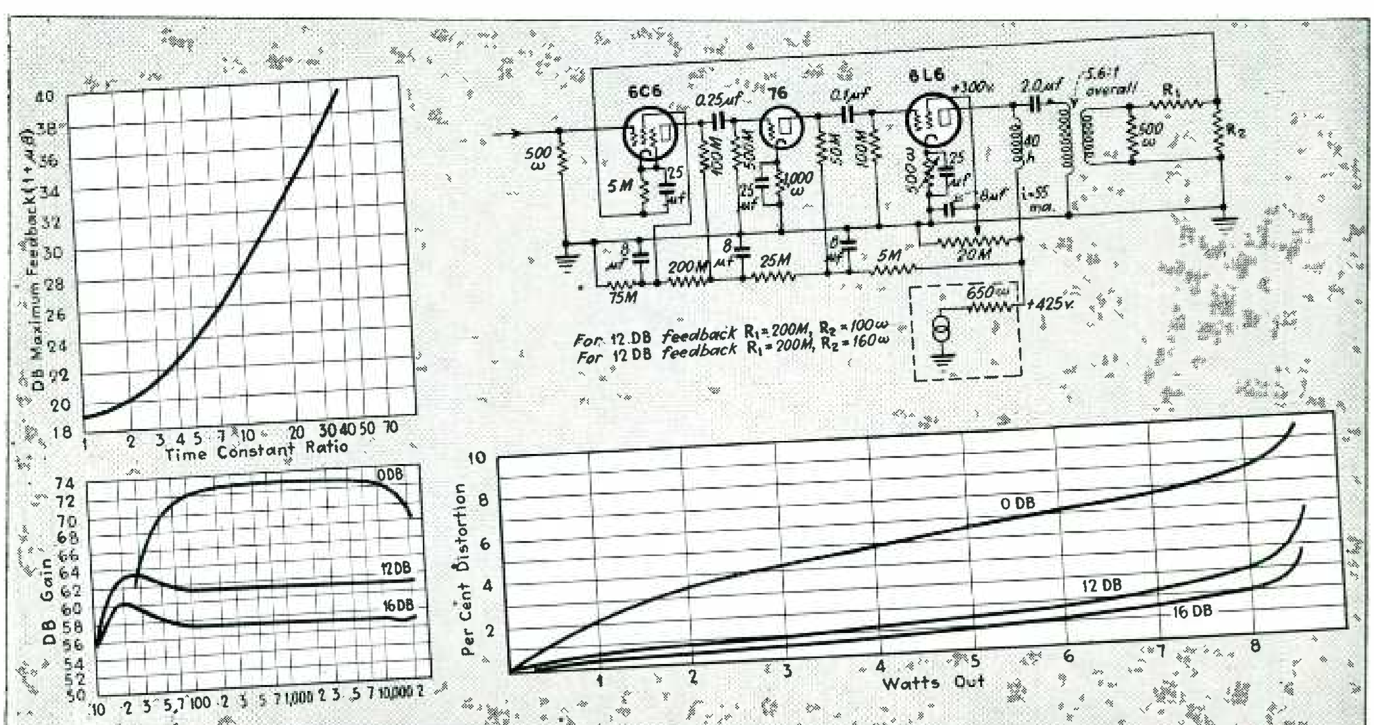
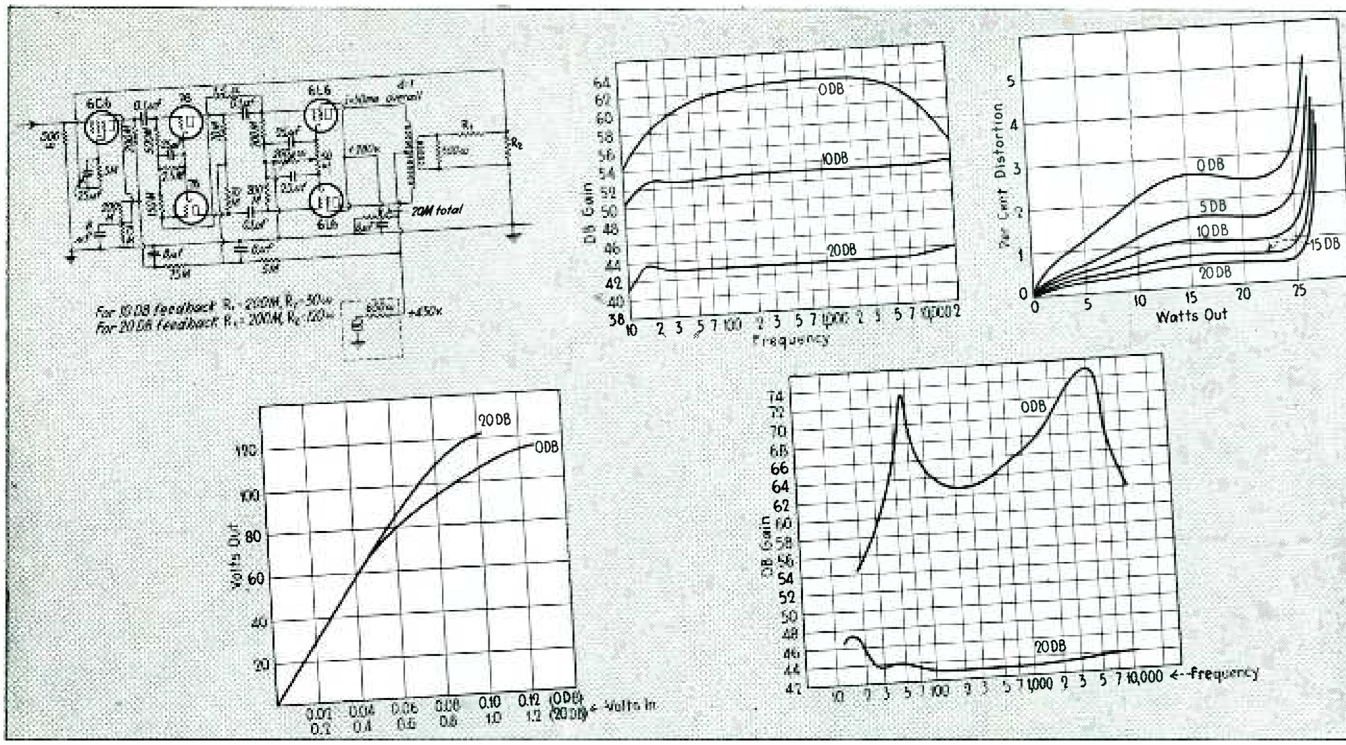


Fig. 1—(upper left) Maximum usable feedback in 3-stage amplifier with resistive feedback and usual coupling circuits. Figs. 2, 3, 4—Single-sided 6L6 unit, its measured frequency response, and single-frequency amplitude distortion vs. output power



Figs. 5 to 9—Push-pull 6L6 amplifier circuit, its measured frequency response, and distortion-output characteristic. Below, overload characteristic and (right) frequency response with loudspeaker load

Assuming an amplifier with a vector voltage gain of μ, a path with vector transmission of β is provided between the output and input, with the polarity so arranged that at some arbitrary frequency the feedback voltage is out of phase with the input voltage by 180°. If stable, the gain of the amplifier has been apparently reduced, and the new gain is given by the expression

$$\frac{\mu}{1 + \mu\beta} .$$

The all important matter in feedback is stability, or what is the same thing, freedom from oscillation. If at some frequency the combined phase shift of the amplifier and feedback circuit has reached 180°, the amplifier gain must have decreased such that the product of it and the magnitude of β is less than one, otherwise the reversal of phase will supply sufficient output voltage to the input to sustain oscillations once begun by some perturbation in the loop. But if the amplifier is stable it will show improvement, due to degenerative feedback, in frequency response, amplitude distortion, voltage regulation, and noise.

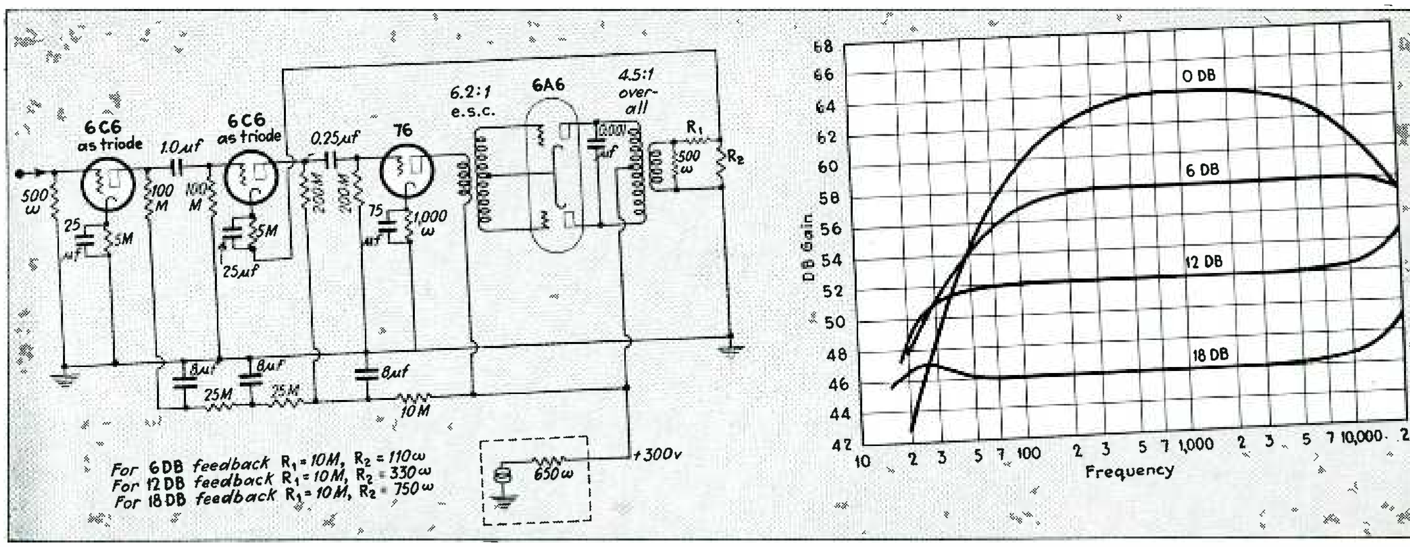
The question of how much feedback can be used in a given multi-stage amplifier can be predicted from straightforward analysis, some details of which are given below. Figure 1 gives the maximum permissible feedback in a three stage amplifier as a function of the distribution of the time constants (RC products) of the three coupling circuits and subject only to the restriction that at high frequencies transformers can be represented by a series inductance alone.

Frequently it will be desired to use feedback in amplifiers involving push-pull stages. Where there is more than one such stage, and they are resistance coupled, no unusual difficulties are encountered if feedback is used on both sides of the amplifier and if the feedback does not pass from one side of the amplifier to the other. If the outputs of the two sides are tied together by a transformer, feedback of any amount on both sides is undesirable because such feedback exaggerates the inequalities of the two sides of the amplifier. Also, feeding back from one side of a push-pull circuit to a previous stage which is "single-sided" will generally produce more undesirable output components than the push-pull connection was designed to minimize. However, these particular difficulties do not appear if feedback is achieved by a path between two points that are "single-sided" even if push-pull circuits intervene.

It will be noted that the circuits shown employ a single resistance voltage divider across the output transformer to get the feedback voltage, and that the feedback voltage is introduced between cathode and ground of the first tube. This method was found, as a practical matter, to be the most useful. It will be found practically that amplifier constants are variable enough to use a pure resistance feedback path and still achieve stability with the desired moderate amounts of feedback.

It is interesting also to note that simple modifications of the resistance feedback circuit can be made to give the amplifier an "equalizer" characteristic such as is often desired to improve the low or high frequency power output of a loudspeaker.

The feedback voltage may be inserted between grid and ground. This makes the feedback to some extent dependent on the impedance of the input device, which in general is not desirable. Inserting the voltage below the secondary of an input transformer usually causes trouble on account of the unavoidable winding capacities of the trans-



Figs. 10 and 11—A push-pull Class-B unit using a 6A6 double triode, with feedback applied over three stages. The measured frequency response (right) improves greatly as the feedback is increased

former. A bridge input circuit as indicated by Black[1] and using resistances and capacities to achieve balance may much lessen this trouble provided a well shielded transformer is used. These difficulties do not appear when the voltage is inserted in the cathode circuit, and the slight degeneration caused in the first tube by this resistance is not large enough to upset predictions.

Questions may be raised whether it is necessary to feed back around three stages. The answer of course is "No." However, it is perfectly feasible to involve three stages in the loop with the advantage that in doing so nothing is sacrified but gain. If feedback were used only in the output stage the driver voltage necessary to maintain full power output would be unreasonably increased, and might entail as much or more amplitude distortion as the feedback removes from the output stage.

Attention is called in particular to the "overload" curves shown for two of the amplifiers. Without feedback the curves show typical Class AB and B features, that is, effective change in amplifier gain due to current and voltage cut-off. While with a steady a-c signal there will be no more amplitude distortion than the distortion graphs show, a non-periodic or transient signal will suffer in reproduction. Sufficient feedback almost completely eliminates this effect within the extreme capabilities of the amplifier. This point, the writers feel, is generally given too little attention, especially because in a reasonably good amplifier whose steady-signal distortion is small, the transient distortion may be the preponderant effect and result in even poorer aural quality than if the converse were true.

The frequency response curves illustrate some interesting features. In two cases one notes that the gain is the same at some frequency with and without feedback. This is the frequency at which regeneration begins, and here the phase shift with feedback is one-half the value with no feedback. Worthy of note is that though regenerative at these frequencies the amplifier is stable. The old rule that where the frequency characteristic is "flat" the phase shift is small holds in the feedback case and shows therefore that amplifiers virtually free of frequency and phase distortion are readily made.

The phase shift and gain variation of a typical resistance coupled amplifier are given by the following expressions

$$\frac{\mu}{\mu_o} = \frac{1}{1 + \frac{1}{j\,\omega\,R_a\,C_a}} \qquad \omega < \frac{0.1}{R_b\,C_b}$$

or

$$\frac{\mu}{\mu_o} = \frac{1}{1 + j\,\omega\,R_b\,C_b} \qquad \omega > \frac{10}{R_a\,C_a}$$

where

μ = vector gain of amplifier at any frequency

μ_o = nominal gain at mid-frequencies

R_a = series combination of grid leak with the parallel combination of plate resistance and coupling resistance.

C_a = coupling capacity

R_b = parallel combination of plate plate resistance, coupling resistance and grid peak

C_b = effective shunt capacity

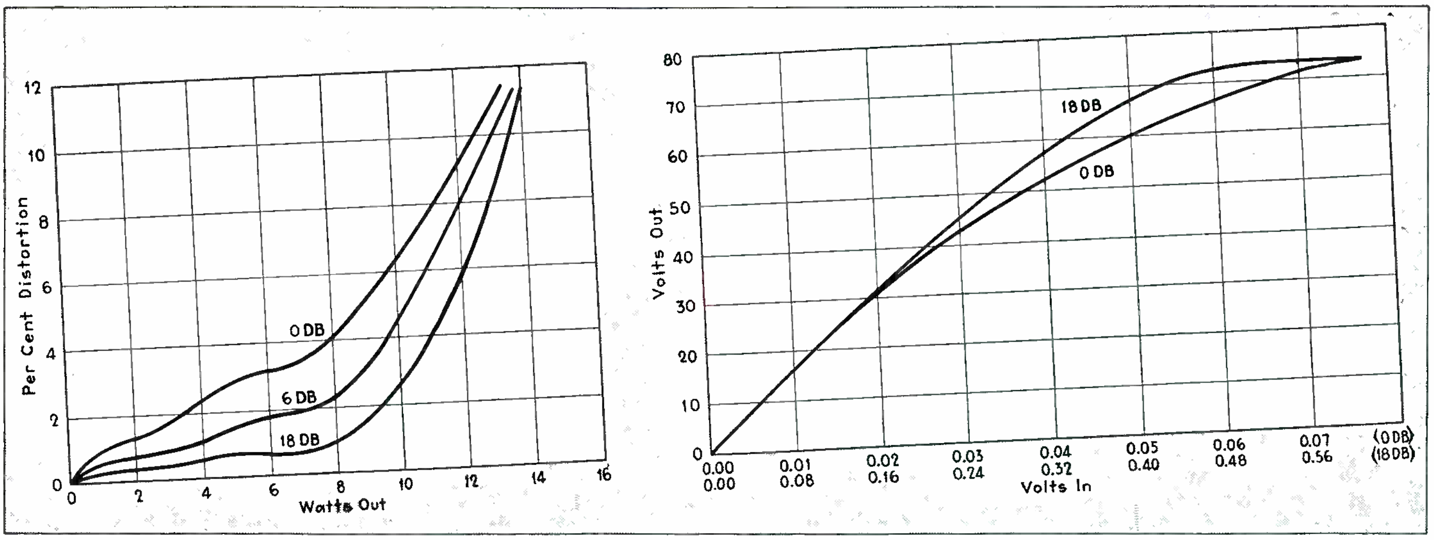
Both of these expressions are of the form $\frac{\mu}{\mu_0} = \frac{1}{1 + jX}$ where for the low frequencies $X_L = \frac{T_L}{\omega}$ and for the high frequencies $X_H = \frac{\omega}{T_H}$. T_L and T_H are the time constants of the low and high frequency coupling circuits and are given by $T_L = \frac{1}{R_a\,C_a}$ and $T_H = \frac{1}{R_b\,C_b}$. If the stage is inductance-coupled, such as is the case for the usual output stage, the low frequency time constant is determined by the primary inductance and the load resistances while the high frequency time constant is determined by the leakage inductance and the load resistances.

From this it will be seen that the gain of a single stage of resistance coupling varies in the following manner

$$\frac{\mu}{\mu_0} \angle\Theta = \frac{1}{\sqrt{1 + X^2}} \angle\,\Theta = \cos\Theta \angle\,\Theta$$

where $\Theta = \tan^{-1}X$

In order that the amplifier does not oscillate when feedback is used the quantity $\mu\beta$ must have an amplitude less than one when its phase is 180°. For the single stage amplifier an unlimited amount of feedback is possible since the maximum phase shift is 90°.



Figs. 12 and 13—Distortion and overload characteristics of the amplifier shown in Fig. 10. At 8 watts output, the distortion is halved by 6 db feedback, reduced below one per cent with 18 db feedback

In the case of two stages the gain and phase are given by

$$\frac{\mu}{\mu_0} = \cos\Theta_1 \cos\Theta_2 \angle \Theta \quad \text{where } \Theta_1 = \tan^{-1} X_1$$

$$\Theta = \Theta_1 + \Theta_2 \qquad \Theta_2 = \tan^{-1} X_2$$

The limiting amount of feedback is theoretically infinite in this case also since for the total phase shift to be 180° Θ_1 and Θ_2 must be 90° so that μ is zero. In practical two stage amplifiers unlimited feedback is not possible due to additional phase shifts caused principally by self bias circuits and transformer resonances.

In the same way that self-bias in a straight amplifier can be arranged to have an arbitrarily small effect, so may it be accomplished in a feedback amplifier, though this is not necessarily the best design procedure.

For three stage amplifiers the gain and phase are given by

$$\frac{\mu}{\mu_0} = \cos\Theta_1 \cos\Theta_2 \cos\Theta_3 \angle \Theta \quad \Theta_1 = \tan^{-1} X_1$$

$$\Theta_2 = \tan^{-1} X_2$$

$$\Theta = \Theta_1 + \Theta_2 + \Theta_3$$

$$\Theta_3 = \tan^{-1} X_3$$

The limiting amount of feedback is given by

$$1 = \mu\beta = \beta\mu_0 \cos\Theta_1 \cos\Theta_2 \cos\Theta_3$$

where

$$\Theta_1 + \Theta_2 + \Theta_3 = 180°$$

and

$$\mu_0\beta = \frac{1}{\cos\Theta_1 \cos\Theta_2 \cos\Theta_3}$$

The maximum value of $\mu_o B$ under these conditions occurs when two stages have the same time constants, that is, when $\Theta_2 = \Theta_3$. This means that more feedback is obtainable without oscillation if the time constant of one stage of a three stage amplifier is equal to either of the time constants of the other two than if it lies between them.

For this case of two like stages the maximum values of $\mu_o\beta$ have been computed for various ratios of the two time constants. The corresponding limiting amount of noise, distortion, and gain reduction is given by $\frac{1}{1 + \mu_0\beta}$ and is shown in Fig. 1 for the various time constant ratios. In power amplifiers the low frequency time constant of the output stage is fixed by the tubes and transformer used. The two previous stages, if resistance coupled, can be adjusted to give the optimum amount of feedback. Since it is impractical to have very large time constant ratios this optimum feedback in a three stage power amplifier is seldom greater than 25 db. The same reasoning holds for the high frequencies. Whichever time constant ratio is the least favorable will limit the maximum usable feedback.

One important result of feedback is the reduction in the output impedance of the amplifier. An amplifier having an output impedance of R_n without feedback and driving a load of R_L has an output impedance with feedback from the load point of

$$R = \frac{R_n}{1 + \mu\beta\left(1 + \frac{R_n}{R_L}\right)}$$

It is to be noted that the reduction of output impedance due to feedback is greater than the corresponding reduction in gain. The effect of low output impedance with feedback is illustrated in Fig. 7 where the impedance of the loudspeaker load used varied as much as seven to one over the frequency range.

In any given amplifier noise and distortion products for a given output are reduced by the use of degenerative feedback in the ratio of one to $(1 + \mu\beta)$. However, this is done at the expense of the input signal, that is, to maintain constant output with feedback the input signal must be increased $(1 + \mu\beta)$ times. In order to increase the signal additional amplification is necessary which may introduce additional noise and distortion components.

Increasing the gain of the amplifier and then reducing it to the same over-all value by degenerative feedback will decrease any noise or distortion components by the factor $\frac{1}{1 + \mu\beta}$ provided the additional amplification is inserted *ahead* of the point where the noise or distortion originates. In practice this means that amplitude distortion in the output and driver stages can easily be reduced by feedback around both stages since the additional amplification ahead of the driver introduces negligible distortion. If the additional gain is introduced *after* the point where the noise and distortion originate there is no reduction.

[1]H. S. Black: Stabilized Feedback Amplifiers, *Bell System Technical Journal*, Vol. XIII, No. 1, January 1934.

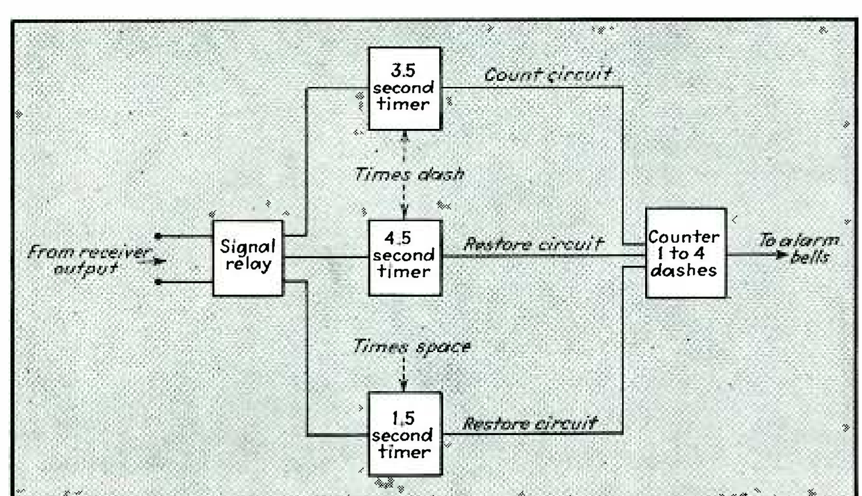
[2]F. E. Terman: Feedback Amplifier Design. *Electronics*, Vol. 10, No. 1, Page 12, January 1937.

Automatic SOS Alarms

Two new "auto alarms" of highly ingenious design will register automatically the reception of a distress signal, even through heavy interference, with an over-all efficiency of 80 percent. Details of commercial instruments recently approved by the FCC

IN 1929, in London, The International Convention for the Safety of Life at Sea promulgated a ruling that all cargo vessels of over 5500 tons gross tonnage keep a continuous watch for SOS signals, either by means of operators or by the installation of an automatic alarm device. In so doing, the London Convention started something. For years the desirability and technical feasibility of an automatic SOS alarm had been realized; in 1927 the Radio Telegraph Convention in Washington had gone so far as to set up a standard form of distress signal, consisting of a succession of long dashes, for this purpose. But the economic need for automatic alarms was not forthcoming until the London ruling. Then, with ship owners (particularly the smaller ones) facing the necessity of three operator shifts, a real demand for a practical auto alarm began to appear. Technical development work began in this country in 1928. The culmination of this development program came on February 19, 1937, when the Federal Communications Commission held a public hearing in Washington on the subject of "Auto Alarms". Among others, there were present at the hearing representatives of two manufacturers who had equipment ready for sale, Commission engineers who reported on the tests made on this equipment, and last but not least, delegates from the radio operators' union.

At the hearing it developed that two auto alarm devices, one developed by RCA for the Radiomarine Corporation, the other by the Federal Telegraph Co., for Mackay Radio and Telegraph, had been offered for test and found to have an efficiency of approximately 80 per cent, i.e. they would respond correctly to 80 per cent of all the distress signals sent to them, the signals meeting the prescribed strength and character designated by the Commission. This was deemed by the engineers to be a very high degree of achievement. In his report to the Commission, Assistant Chief Engineer E. K. Jett states "We (the engineering department of the FCC) firmly believe that the two alarms submitted for test represent the most effective and practicable automatic distress alarms which it is possible for American engineering skill to produce at this time, in accordance with the Madrid Regulations."



The auto-alarm receiver controls a relay which closes on each signal received. Three timers time the length of each signal and each space. If the signal is between 3.5 and 4.5 seconds long, and if the space is not longer than 1.5 seconds, a "count" is registered. Four counts actuate the alarm bells

The radio operators' union thought differently. A human operator, on the same basis, would have a 100 per cent efficiency, and would detect one alarm which the automatic device would miss, out of every five. Why, therefore, endanger shipping while throwing operators out of work? One answer to this objection is the fact that the time-average efficiency of an operator may be only 10 per cent, since he is required by law to listen during standby periods, only 6 minutes out of every hour. The automatic alarm, which is "on watch" continuously, is therefore several times more efficient than the operator. This fine point was left for the Commission to ponder, among other things, in deciding whether or not the two devices are to be approved.

On March 10, the Commission announced that the two auto alarms were approved, effective July 10, 1937, and subject to certain conditions to be met by the manufacturers. European nations have already approved similar alarms and they have been in use, with good effect, on British, French, Italian and German vessels for several years.

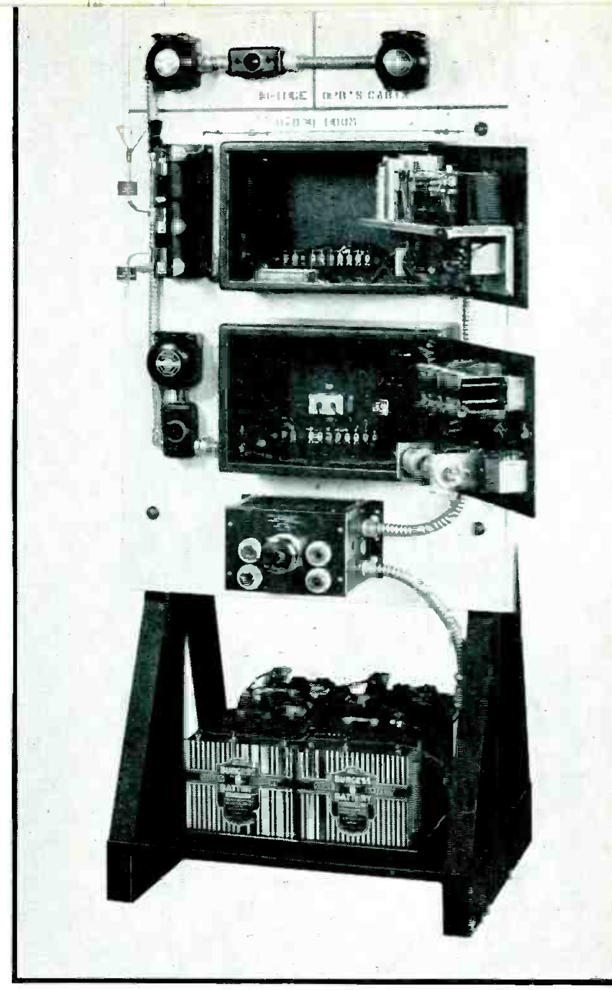
The Technical Problem of Radio Alarms

If it were not for static and man-made interference, the problem of designing an SOS auto alarm would be immeasurably simpler than it is when these factors must be contended with. The International Distress and Calling Frequency, 500 kc (600 meters) is one of the busiest channels in marine radio except during the 3-minute stand-by periods. Static, especially during summer months or in the tropics, is always present to some degree. Both types of interference can have two effects on the operation of an automatic alarm: they can, by chance, form a series of dashes similar to that of the distress signal, and so cause a false alarm; and, more important, they can interfere with the desired distress signal and so distort it (by prolonging dashes and filling spaces) that it does not actuate the alarm. A major consideration in the design of the alarm device is the balancing of these two probabilities, false alarms on the one hand, and inefficiency in detecting alarms on the other. If frequent false alarms are tolerated, the alarm-detecting efficiency can be raised; but the "wolf—wolf" aspect of false alarms is generally regarded as highly undesirable by shipowners and radio operators alike. The type of compromise adopted must be based on the judgment of the agency which is responsible for the conduct of marine radio in each country.

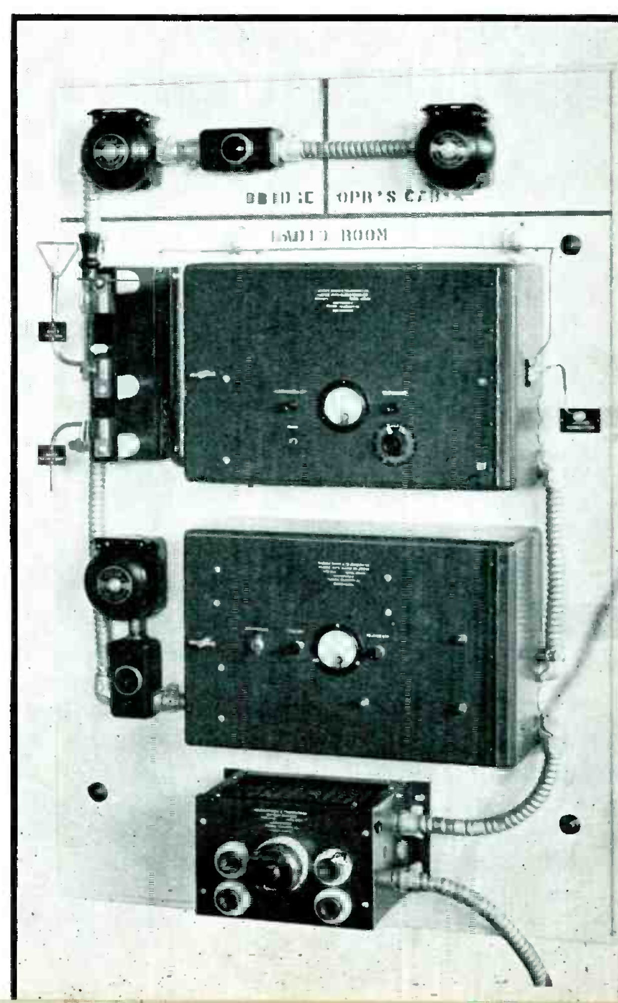
The standard distress signal, as set up by the Washington Conference in 1927 and later by the Madrid Convention in 1932, is a series of 12 dashes, each four seconds long, and spaced one second apart. The European alarms are designed to operate on any *three* consecutive dashes. The detecting efficiency is about 90 per cent, but false alarms, especially in the neighborhood of a crowded port, are numerous, averaging perhaps one every 200 hours in heavy interference. The American auto alarms, in accordance with the FCC specifications, respond to any *four* consecutive dashes in the twelve sent. The efficiency is thereby lowered to about 80 per cent (the reduction of efficiency is in the ratio of the difference between the total number of dashes sent and the number used to actuate the alarm, i.e. $(12 - 3)/(12 - 4) = 9/8$, or 90 per cent for three dashes against 80 per cent for four), but the probability of a false alarm is thereby decreased by some thirty times, so that one can be expected every year or two, on the average, in heavy static or interference, and much less often under normal operating conditions. No bona fide false alarms were produced in one month's continuous test by the government, and one of the manufacturers reports no false alarms in 18 months of development work.

The interference present on the band will be the more effective in producing false alarms or in destroying the character of actual distress signals, the lower the signal-to-noise ratio. The specifications call for proper operation of the auto alarm when the signal-to-noise ratio is 1-to-2 or higher. The noise must be of an intermittent character, since no alarm of this type can operate in the presence of continuous noise stronger than the signal. The FCC specifies a minimum signal of 500 microvolts at the terminals of the receiver. Since the average ship antenna has an effective height of 5 meters, the minimum signal strength required is 100 microvolts per meter, in intermittent noise of 200 microvolts per meter. In addition to this basic sensitivity requirement, the receiver must be adjustable in sensitivity and must operate on extremely *strong* distress signals as well. The upper limit of signal strength is set at 90,000 microvolts, which must be handled by the receiver without blocking. Selectivity is also a problem. A wide acceptance band is desirable to take care of improperly adjusted transmitters, but if the band is too wide, interference is increased from adjacent services (broadcasting and coastal telegraph). The limits set are 487.5 and 512.5 kc, giving a 12.5 kc tolerance either side of the 500 kc center, within which signals of from 500 to 90,000 microvolts must actuate the alarm.

Since the distress signal is, in general, sent manually, and precision cannot be expected, it was necessary to set up tolerances for the length of each dash and space. The "proper signal" so set up consists of 12 dashes, each not shorter than 3.5 seconds nor longer than 4.5 and eleven spaces between them, not longer than 1.5 seconds each. The alarm must be receptive to dashes and spaces of lengths within these limits but not receptive to those longer or shorter. No lower limit was set to the length of the space, but the alarm must be receptive to a space as short as 0.1 second, or shorter. The type of signal is des-



Two views of the Federal Telegraph (Mackay Radio) Auto Alarm, which times the distress signals mechanically. The upper unit is the receiver, the output of which controls the timer and counter in the lower unit. The alarm bells and warning bells are mounted in three locations



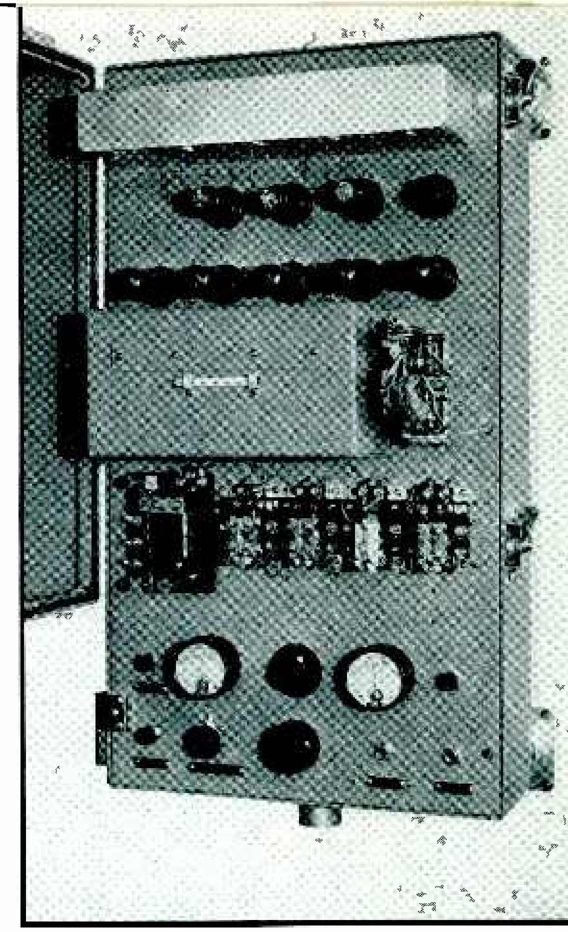
ignated as A2 (30 per cent modulated signal, with modulation frequency from 100 to 2500 cycles per second) or B (spark). It is not required that unmodulated cw signals actuate the alarm, but this point is left to the discretion of the designer. These specifications, together with others relating to effects of temperature changes, mechanical and electrical ruggedness, and the like were set up by the FCC in October, 1935. The two alarm devices built to these specifications were submitted about a year later and were subjected to laboratory tests at the Bureau of Standards and to a thirty-day field test at Fort Hancock, N. J., the Coast Guard Station at Sandy Hook. These field tests, which established that both auto alarms were about 80 per cent efficient, were carried out between November 24, and December 24, 1936. While the static level was below average, the conditions of signal interference were considerably above average, since the traffic in New York Harbor, within a few miles of the test point, is among the heaviest encountered anywhere in the world. Out of approximately 1200 test distress signals sent, ranging in strength from 442 to 15,000 microvolts and in frequency from 487.5 to 512.5 kc, both devices tested responded to nearly 1000, or approximately 80 per cent. A very large percentage of the successful indications was made through heavy interference, and the majority of failures were directly traceable to unusually heavy interference. Only in a few cases did the apparatus fail to function because of some internal cause.

Principle of Operation: Receivers and Selectors

The essential principle of operation in the two auto alarms tested is the same, although the circuits and selective mechanisms are different. Both devices consist of a receiver which responds to signals on 500 kc (plus or minus 12.5 kc) and converts them to d-c pulses which actuate a relay. This relay in turn controls a selector mechanism, which is nothing more or less than a timing device, which measures the duration of each incoming dash and space. The selector must respond only to dashes longer than 3.5 seconds and shorter than 4.5 seconds. If a dash longer or shorter than this is received, it must "erase" the record of any previous dashes and be ready to start again "from scratch". Likewise if a space longer than 1.5 seconds is encountered, the record must be erased and the device reset, automatically, for the next signal. It is only by restricting operation to these narrow limits that false alarms from interference can be reduced to a negligible amount. When four dashes of the correct length, spaced by the correct amount, are received, the final relay in the counting system closes and rings three alarm bells, one in the operating room, one in the radio operator's sleeping quarters, and one in the bridge of the vessel. The manner of reception and selection of the signals is significantly different in the two devices. The RCA auto alarm uses a superheterodyne receiver, acts on CW as well as ICW and spark signals, times the signals electronically in RC timing circuits, and counts dashes in a step-by-step notching relay, similar to those used in an automatic telephone switch. The Mackay alarm, on the other hand, uses a t-r-f receiver, operates only on ICW or spark signals, times the dashes by means of a motor-driven cam-clock arrangement, and counts them by means of eight interconnected relays, which "lock up" in succession unless an improper dash or space is received, whereupon they all open, ready to start again. With two such radically different means of accomplishing the result, it is remarkable that both alarms display, within 2 per cent, the same efficiency of detection and have the same freedom from false alarms.

Details of Mackay Auto Alarm Receiver and Selector

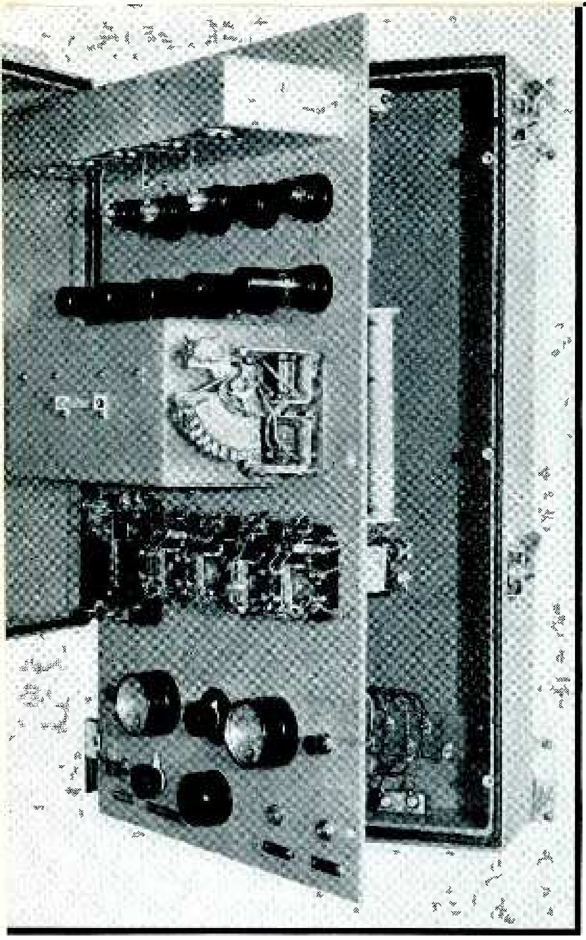
The Mackay Auto Alarm, model 101, includes a t-r-f receiver, a motor-driven timer, and a relay counter. The receiver consists of a 6D6 r-f amplifier, with two over-coupled tuned circuits in its grid, (fixed tuned to 500 kc, with 12.5 kc sidebands), coupled by two similar circuits to a 76 detector, which is followed by two 76's in transformer coupled audio stages, finally feeding an 89 connected as a high-mu plate circuit detector. The rectified audio current from this tube passes through



The RCA-Radiomarine Corporation Auto Alarm. At the top is the superhet receiver. Below, a row of five timing tubes, which control relays in the box-like oven. These relays actuate the main contactors for counting and alarm-ringing

the signal relay which actuates the selector. During operation this relay responds to any and all signals received within the 25 kc band of 500 microvolts strength or greater, and modulated 30 percent or higher.

The timing device consists of a standard governor-regulator motor, such as are used in teletypewriters, designed for continuous service. This motor, which runs at constant speed, drives a shaft through a reduction gear, the shaft rotating at 6 rpm. On this shaft are two magnetic clutches, one to measure the dashes, the other the spaces. The first clutch is energised from the main control relay referred to above. When a signal comes in, this clutch engages with a cam which starts to rotate with the shaft. If the signal ends before 3.5 seconds, the clutch is released and the cam returned to the starting position by spring action. But if the signal lasts 3.5 seconds or longer, the cam engages with a contactor whose contacts register a count by closing a counter relay. When the signal ends, the clutch opens and the cam returns to its starting position. If the signal lasts longer than 4.5 seconds, how-



A side view showing the rotary stepping switch (beside the oven) which registers a count when the timing tubes record the reception of a correct dash and space. An incorrect dash or space operates the "restore" coil, erasing the count

ever, a second segment of the cam engages a contactor which opens the counting relay circuit, thus "erasing" the count.

The second magnetic clutch times the spaces between dashes. When the first clutch has succeeded in recording one or more dashes, contacts are arranged whereby the second magnetic clutch becomes energised when the first clutch becomes deenergised, i.e., at the end of each dash. This second clutch engages a cam which thereupon begins to rotate with the shaft, continuing to rotate until the space is ended by the beginning of the next dash. If the rotation lasts for longer than 1.5 seconds, this second cam engages two contacts which open (erase) the counting circuit. This combination of cam and relay actions thereby combines to count all dashes longer than 3.5 seconds duration, but to erase the count if the dash lasts longer than 4.5 seconds, or the space following lasts longer than 1.5 seconds. When four such counts are registered, the end of the fourth dash operates the last counting relay on which auxiliary contacts actuate the alarm bells.

In addition to this selector system, of course, the entire receiver and selector is made self-policing, i.e., an alarm light will indicate too high or prolonged noise level, the failure of the motor, contactors, tube filaments, or receiver sensitivity, and so on, so that improper operation will indicate itself immediately. Provision is also made for testing the device by introducing a local r-f signal (from a buzzer), and for disconnecting the bridge and sleeping room alarms during routine test. The entire outfit operates from 24 volts at 1.8 amperes, and 90 volts, 12 to 25 milliamperes, both d-c.

The RCA-Radiomarine Auto Alarm Receiver and Selector

The receiver of the RCA-Radiomarine Auto Alarm (model AR-8600) is a superheterodyne, consisting of a 6A8 first detector, two 6K7 i-f amplifiers (i-f frequency 1100 kc), a 6H6 diode second detector, and an RCA-1611 d-c amplifier tube, the output of which is a direct current proportional to the carrier of the signal, and hence does not depend upon modulation of the signal. The output of the d-c amplifier tube controls a signal relay which actuates the selector mechanism, whenever a 500 microvolt signal is received.

The selector makes use of the electronic timing. A voltage regulator tube supplies a constant charging voltage which is applied by the signal relay to a series circuit of resistance and capacitance. The voltage across the capacitance (which is applied to the grid circuit of a tube) builds up gradually, until at the end of 3.5 seconds, it reaches a high enough value to actuate the grid of a relay in the plate circuit of the tube. This relay causes a rotary "notching" relay (stepping switch) to step up one notch. At this time the charging voltage is applied to another RC circuit, which at the end of 1 second actuates another tube and relay. This relay closes the "restore" coil of the stepping switch, so that if the signal lasts for longer than 4.5 seconds, the count of the stepping switch is erased. When the signal relay opens at the end of a dash, the charging voltage is applied to still another RC circuit, tube, and relay. This circuit is arranged so that if the space is longer than 1.5 seconds, the restore coil in the stepping switch is actuated, erasing the count. If four correct dashes and four correct spaces are received, however, the stepping switch moves four notches, and connects the alarm relay, which is energised when the signal relay opens at the end of the fourth dash. The alarm relay rings three bells, located on the bridge, in the operator's sleeping quarters, and in the radio room.

Both receiver and selector are housed in the same cabinet. Inside the selector relay compartment is a small thermostatically-controlled oven which protects the relays from excessive humidity. The entire alarm, which weighs 60 pounds, is operated from the 110-volt ship mains (d-c) and from a 6-volt storage battery. Policing alarms are provided for failure of either power supply, and for failure of tube filaments or relays, to indicate prolonged or excessive noise level, etc., as required by the FCC specifications. A more complete description of the RCA-Radiomarine alarm is given in the *RCA Review*, January 1937, page 49, by I. F. Byrnes and H. B. Martin. On April 7, S. D. Browning of the engineering department of the Federal Telegraph Co. presented a paper before the New York Section of the I.R.E., in which he described the operation and construction of the Mackay Auto Alarm.

In approving the two auto alarm devices, the FCC made the stipulation that each manufacturer furnish complete technical descriptions of their devices to the Commission and prepare approved written instructions for the use of the radio operator and ships officers. The Commission also required that provision be made for giving an alarm when the power supply fails altogether where the power leads enter the alarm unit, and to ring an alarm (or to substitute a new voltage supply) when the B-supply voltage falls below specified limits. The requirement that cargo ships of 5500 tons install a device or maintain a continuous watch was waived until August 6, 1937. In approving the devices the Commission did not offer an opinion regarding the relative virtues of the alarm device and an operator on watch, but simply determined that the devices met the requirements of the Safety Convention.

The Acoustical Labyrinth

Ingeniously, the labyrinth improves the low frequency response of loud speakers and cabinets. It eliminates "boom" by eliminating cabinet resonance. It does more than this, however, and provides better over-all response than an infinite baffle

By BENJAMIN J. OLNEY
Stromberg Carlson Telephone Manufacturing Co.

EVER since the first cone loudspeaker was used in a box baffle, engineers have wrestled with the problem of troublesome resonances in the cabinet enclosure behind the loudspeaker diaphragm. With the development of loudspeakers and associated equipment having an extended frequency range, it became evident that something must be done about this cavity resonance as it had now become a major cause of frequency distortion in the system.

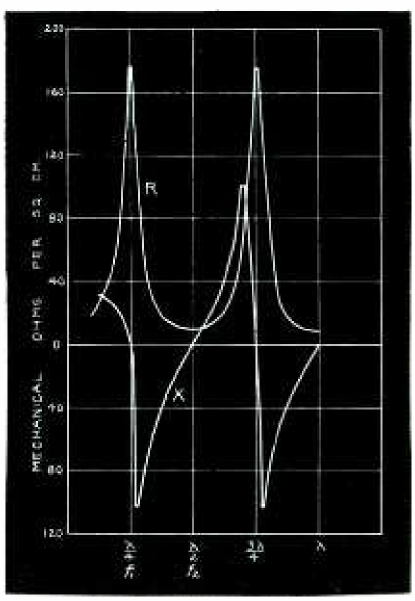


Fig. 1—Driving point impedance of a tube terminated in 10 ohms resistance

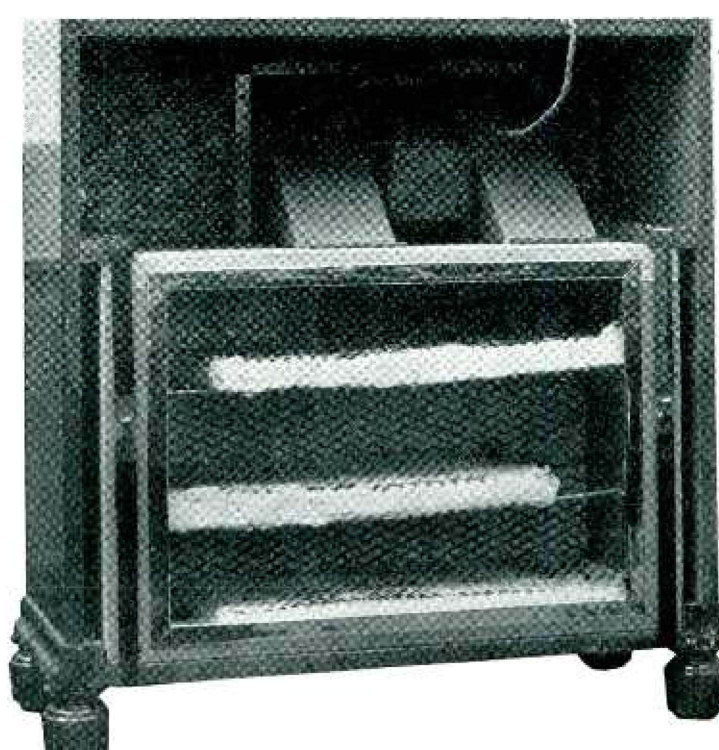
There also were other difficulties in reproduction in the low-frequency range with conventional cabinet type loudspeakers, among which were (a) poor response due to the inadequate baffle afforded by the cabinet and (b) insufficient resistance control of the diaphragm which resulted in overshooting of the moving system with consequent distortion. Another result of the inadequate damping just mentioned was a large variation in the electrical impedance of the loudspeaker at its primary resonance frequency which caused additional distortion in associated output tubes of certain types.

The acoustical labyrinth is a simple device which entirely eliminates cavity resonance by abolishing the cavity itself and which, in addition, overcomes to a substantial degree the other difficulties mentioned. It consists essentially of an absorbent walled conduit having one end coupled tightly to the back of the loudspeaker cone and the other end open. This conduit is in effect folded within the interior of the cabinet. In the photograph, the terminal opening is in the floor of the cabinet at the extreme left. The back of the cone is connected to the labyrinth through the felt lined housings shown, this construction leaving the field magnet in the open and permitting it to be operated at full efficiency without overheating.

The operation of the labyrinth may perhaps best be understood by considering first the impedance and transmission characteristics of a tube with non-absorbent walls and then passing to the practical case of the absorbent walled structure. We shall assume the tube to be driven by a rigid piston at one end and to be open at the other. The impedance per unit area on the piston is

$$Z_{00} = \rho c \frac{Z_l \cos kl + j\rho c \sin kl}{\rho c \cos kl + jZ_l \sin kl} \quad \ldots\ldots\ldots\ldots (1)$$

where Z_l is the impedance per unit area of the open end, ρ and c are, respectively, the density and the wave velocity pertaining to air, l



Acoustical labyrinth with back removed is the length of the tube and $k = 2\pi/\lambda$, where λ is the wave length in the same units as l.[1]

If the tube has a circular cross-section of radius r and is terminated in an infinite baffle, the impedance per unit area of the open end at low frequencies is[2]

$$Z_l = \rho c(k^2r^2/2 + j8kr/3\pi) \quad \text{.............. (2)}$$

It will be found that Z_l is, in general, small at low frequencies for tube areas comparable with usual loudspeaker cone areas.

In Fig. 1 is shown a plot of Eq. (1), assuming Z_l to be a pure resistance of 10 mechanical ohms per sq. cm. The abscissa is the length of the tube in terms of wave length of sound. When the frequency is such (f_1) that a given tube is one-quarter wave length long ($l = \lambda/4$), it will be noted that the impedance on the piston is a comparatively high pure resistance. When the frequency is increased to a value (f_2) corresponding to $l = \lambda/2$, the impedance becomes that of the open end, that is, the terminal impedance is transferred as if bodily to the driving point and the tube itself contributes no reactance. Furthermore, when the tube is an odd number of half wave lengths long, the phase of the air particle velocity at the open end becomes opposite to that at the driven end. At even numbers of half wave lengths no phase reversal occurs.[3] These critical impedance conditions occur repeatedly as the frequency is raised.

Now let us consider how some of the properties of the tube just discussed may be applied to a loudspeaker system. It has been mentioned, and later will be experimentally demonstrated, that the acoustic resistance load on a loudspeaker diaphragm of ordinary size is very small at low frequencies. This is true even though the diaphragm be mounted in an infinitely large baffle. However, by coupling our tube to the back of the diaphragm, we have available a very high resistance at the first quarter wave length frequency. By suitable proportioning the constants of the system, this region of high resistance and the primary mechanical resonance of the loudspeaker may both be made to occur at the same frequency f_1 located preferably below acoustic cut-off. In the practical case, this troublesome loudspeaker resonance is thus so highly damped as to be negligible in effect and the power handling capacity at low frequencies is determined by the heating of the driving coil and not, as is usual, by the striking of the moving system against its stops.

Probably everyone who has worked with open radiator loudspeakers has, at some time or other, ardently wished for a means for reversing the phase of the back radiation from the

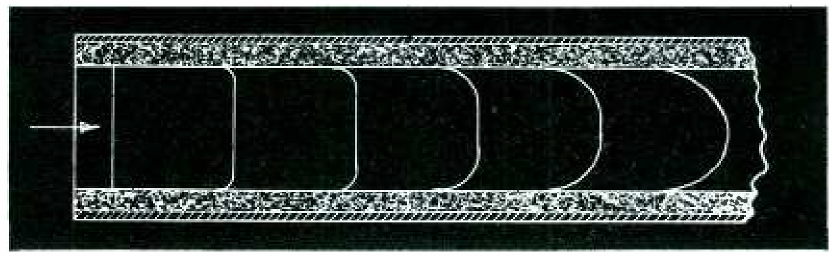


Fig. 2—Probable deformation of wave front in an absorbent conduit

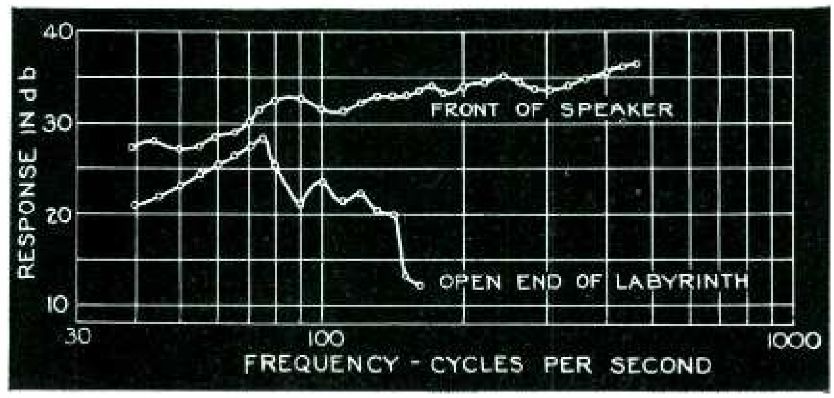


Fig. 3—Close-up response from front of speaker and from terminal opening of labyrinth

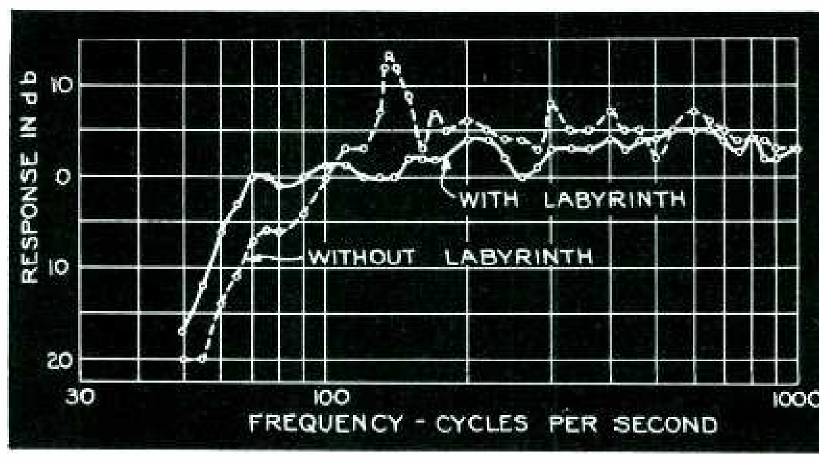


Fig. 4—Response of 8 in. cone loudspeaker in cabinet 2 ft. x 2 ft. x 1 ft. inside dimensions. Back of cabinet 2 in. from wall

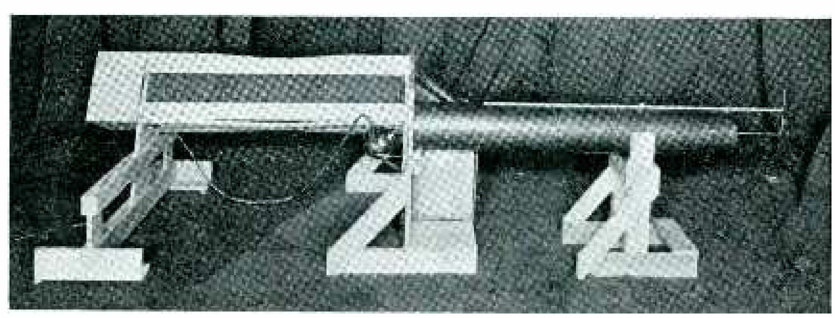


Fig. 5—Apparatus for the measurement of acoustic impedance

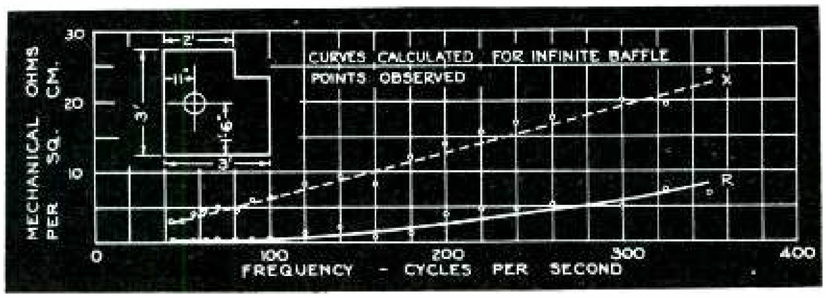


Fig. 6—Acoustic radiation impedance of 7-5/8 in. hole in plane baffle

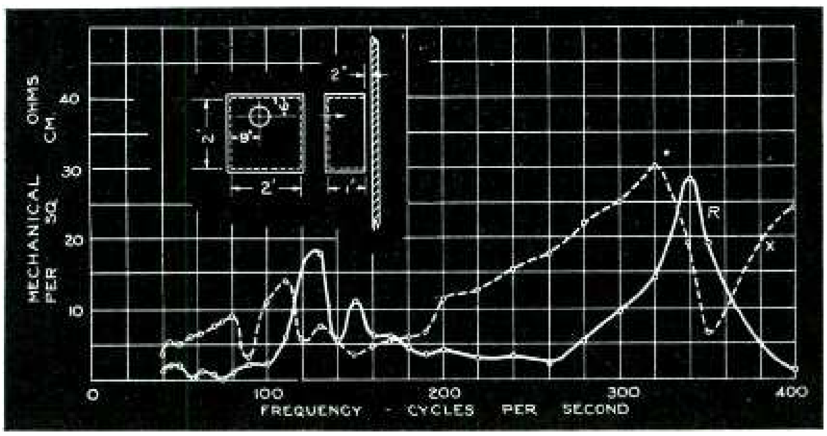


Fig. 7—Acoustic impedance of loudspeaker cabinet through 7-5/8 in. opening in front

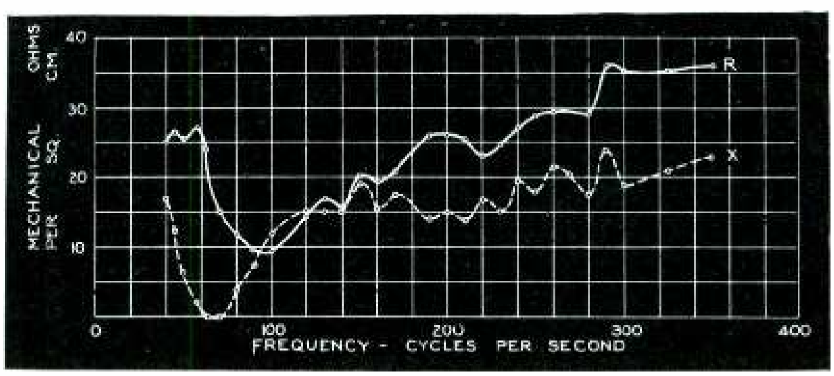


Fig. 8—Acoustic impedance of absorbent labyrinth measured at loudspeaker opening

diaphragm. We, therefore, enthusiastically take advantage of the condition occurring at the first half wavelength frequency f_2. By so proportioning the tube that this frequency lies near the lower end of the range to be transmitted, we have provided an auxiliary sound source (the open end of the tube) whose phase is the same as that at the front of the loudspeaker diaphragm and which cooperates with the latter to extend substantially the low frequency range. The fact that the tube impedance is low in this region also aids here by encouraging a greater amplitude of diaphragm motion.

Having employed to advantage the characteristics of the tube at its first two critical frequencies, we proceed upward in the frequency range and find to our embarrassment that the hitherto useful variations in its impedance and transmission now operate to produce undesirable dips and peaks in the response. However, by lining the tube with a material whose sound absorption rises suitably with frequency, we can suppress entirely these higher resonances besides accomplishing a desirable broadening out of the resistance peak at f_1. Also, the attenuation through the tube becomes very great above a moderately low frequency and the loudspeaker then behaves as a single sound source.

In the final development of the labyrinth, it was found necessary, in the absence of any adequate quantitative theory of the absorbent walled tube, to proceed experimentally and judge the results by means of measurements and listening tests. The analogous theory of the leaky electrical line would at first seem to be applicable to the case, as the absorbent lining of the tube may be shown by the following reasoning to constitute a shunt resistance element. Assume the tube (of length small compared with the wave length) to be rigidly closed at the distant end, this being equivalent to open-circuiting the receiving end of the analogous electrical line. Now, if the absorbent material acted as a series resistance there obviously could be no resistance component in the impedance measured at the driven end of the tube. We know, however, that the entire pressure generated by the driving piston must be exerted against the absorbent walls of the closed tube with consequent energy loss in the pores of the material. This loss, of course, must result in the appearance of a resistance component in the impedance on the piston. Hence, the absorbent material is equivalent to a shunt resistance.

When we attempt to apply the above theory to the practical labyrinth, however, we immediately run into the difficulty of assigning the correct value at a given frequency to the equivalent shunt resistance. In the first place, the published absorption coefficients of commercial materials are obtained under experimental conditions differing so widely from those existing in the present application that we do not feel justified in using them. They usually are obtained either for random or for normal incidence of sound upon the absorbing material, whereas grazing incidence prevails in the tube. Furthermore, no coefficients appear to be given at as low frequencies as we require.

Some speculations as to the mechanism of transmission through the tube result in further possible difficulty in the application of usual theory to this problem. Consider a plane wave generated by a piston at one end of an absorbent walled tube. It seems reasonable to assume that the abstraction of acoustic energy from the wave front will be more rapid near its absorbent boundary than at its center. Consequently the velocity is retarded at the periphery and the wave front becomes more and more convex as it progresses along the tube. It is probable too that the *rate* of absorption likewise changes progressively due to the shifting angle of incidence to the walls. Now, the classical theory of sound transmission in tubes is based upon the assumption of a plane progressive wave and, if the action outlined above takes place, must give way in that case to a much more complex one which the present author is in no position to invent.

The results of some measurements upon a typical labyrinth speaker system are given. Fig. 3 (page 23) shows the results of response measurements over the low frequency range of such a system mounted in a small cabinet, together with the effect of removing the labyrinth. The extension of the low frequency response below 100 cycles and the elimination of the cavity resonance peaks by application of the labyrinth are here definitely indicated. The two measurements were made by the rotating microphone method in a heavily damped room and under identical conditions.

In the set-up for comparing the response from the terminal opening of the labyrinth with that from the front of the loudspeaker, the microphone was placed inside the measuring room and close to a hole in the wall. The speaker system was located outside the room with its radiator to be measured sealed to the hole in the wall. The results show the response maximum at the open end occurring at the frequency f_2 and the rapidly increasing attenuation above this frequency due to absorption in the tube. At the higher indicated tube attenuations the measurements undoubtedly were vitiated by transmission through the walls of the measuring room and it is probable that the actual tube attenuation is even higher than that shown.

Measurements of acoustic impedance at various points in the loudspeaker system were felt to be essential to the progress of this development. A survey of published methods indicated that of Flanders[4] to have possible application. Flanders' apparatus, however, was intended for measurements over surfaces of the order of 0.7 inch in diameter whereas we were concerned with diaphragms and openings of about 8 inches in diameter. In changing the scale of the apparatus to this extent it was found desirable to employ a different mechanical arrangement, and the final set-up is in Fig. 5. Flanders' paper should be consulted for details of the method, which may only briefly be outlined here. In principle, the unknown impedance is measured in terms of that of a closed tube operated at one eighth wave length, at which the impedance of the reference tube is a pure acoustic capacitance having a value of 42 mechanical ohms per unit area. The sound source is a back-enclosed cone loudspeaker, seen at the left of the figure, which is coupled to a connecting tube together with which it is mounted on a carriage that may be swung into any of three positions. In one position (shown in the photograph) the end of the tube is joined to the impedance to be measured, which in this case is the labyrinth mounted on the baffle in the center. In the second position the end of the tube is closed tightly against the baffle providing an acoustic open circuit while, in the third position, the movable tube is connected to the reference tube shown at the right. This reference tube is of seamless steel construction having a $\frac{5}{16}$ inch wall and is provided with a tightly fitting piston by which the active length of the tube may be adjusted. The diameter of each tube is $7\frac{5}{8}$ inches. The unknown impedance is determined by measuring the relative phase and magnitude of the pressures at the output end of the movable tube for each of the three positions. This is done by means of the condenser microphone shown, which is connected to the center of the end cross-section of the tube by another tube of small bore. The microphone output is measured by an a-c potentiometer. In practice it was found essential to take precautions against the generation of spurious voltages due to other than air-borne sound in the tube, and to employ a heterodyne wave analyzer as a null indicator for the potentiometer at the low frequencies. All measurements were made in a heavily damped room.

The acoustic radiation impedance, measured by the above method, confronting one side of a typical loudspeaker diaphragm mounted in a plane baffle of moderate size is shown (Fig. 6). The peculiar shape of the baffle was made necessary by the arrangement of the measuring apparatus. The experimental values are indicated by the plotted points, while the curves were calculated from Eq. (2) which Rayleigh derived about 40 years ago. It appears from the present measurements that, although it was based on the assumption of an infinite baffle and radiation into free space, this equation may justifiably be applied to the usual practical conditions of operation.

Figure 7 shows the acoustic impedance on the back of a diaphragm

(*Continued on page* 36)

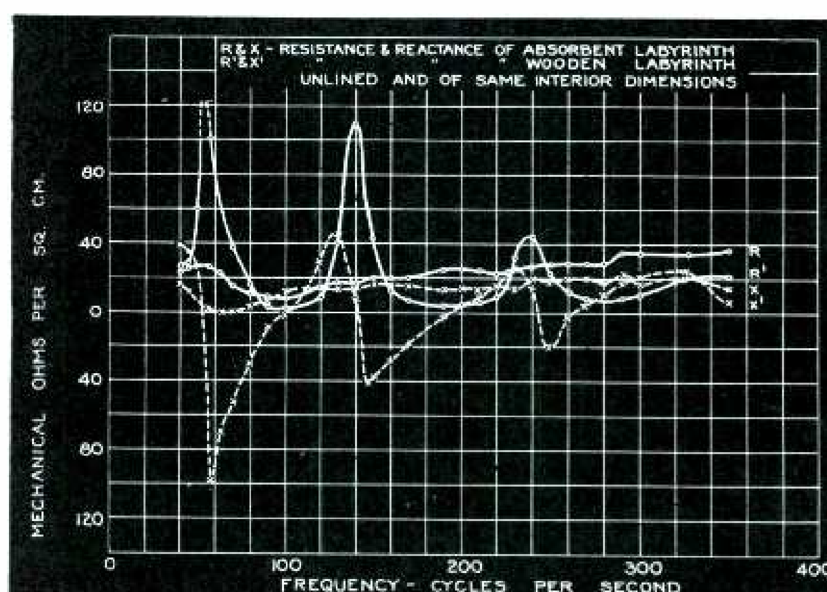
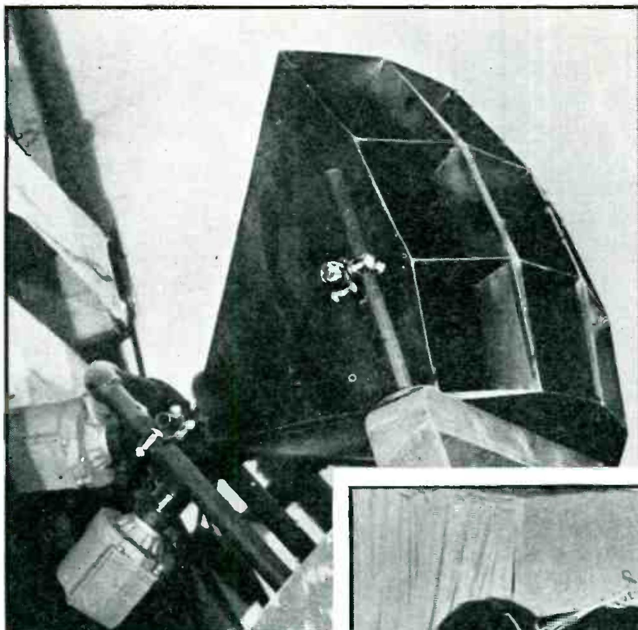
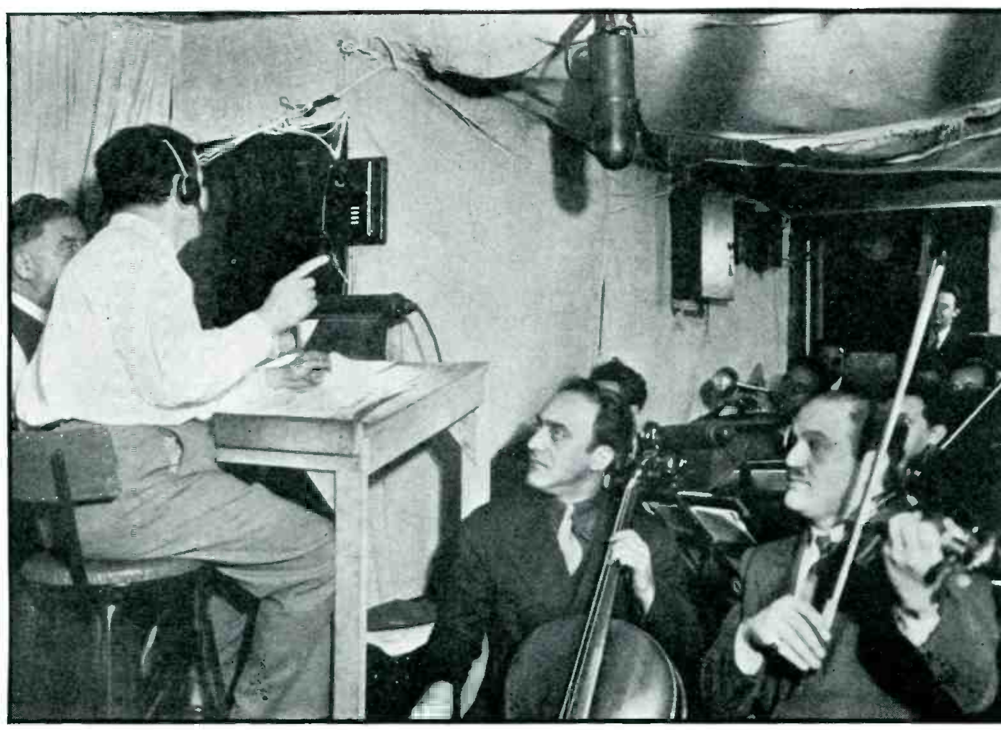


Fig. 9—Acoustic impedance of absorbent and nonabsorbent labyrinths, measured at loudspeaker opening



The ETERNAL ROAD



On either side of the stage are semi-circular coves extending upward 80 feet. At the base of each and facing is a group of 4 loud speakers. Sound strikes these deflecting coves, reaches the audience indirectly, providing reverberation. Below—sound effect man

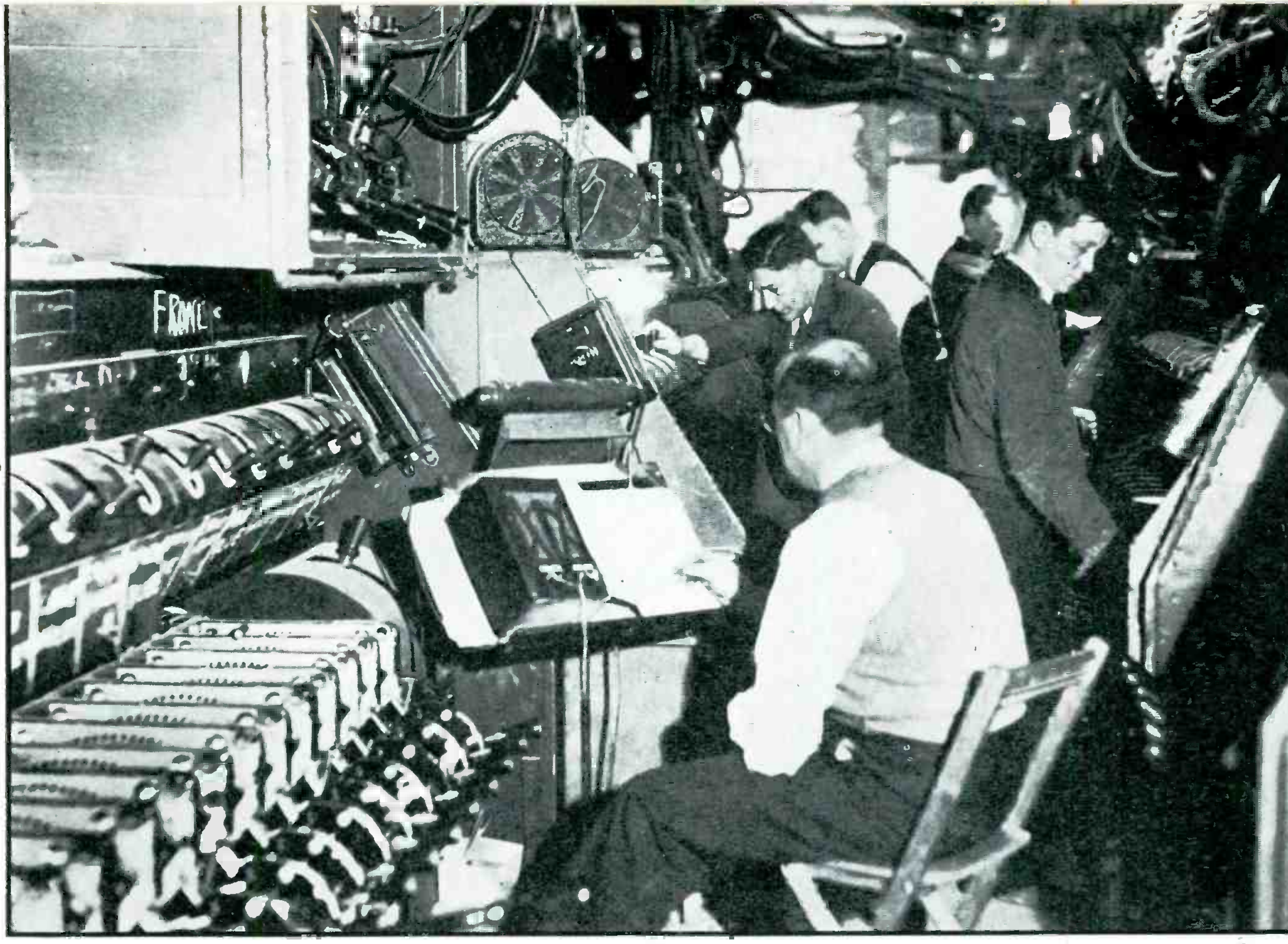
Right—The orchestra plays in a sound proof booth to a microphone. The conductor wears headphones. Twenty-eight giant loudspeakers spray the audience and performers with music, properly mixed

By **G. L. DIMMICK**

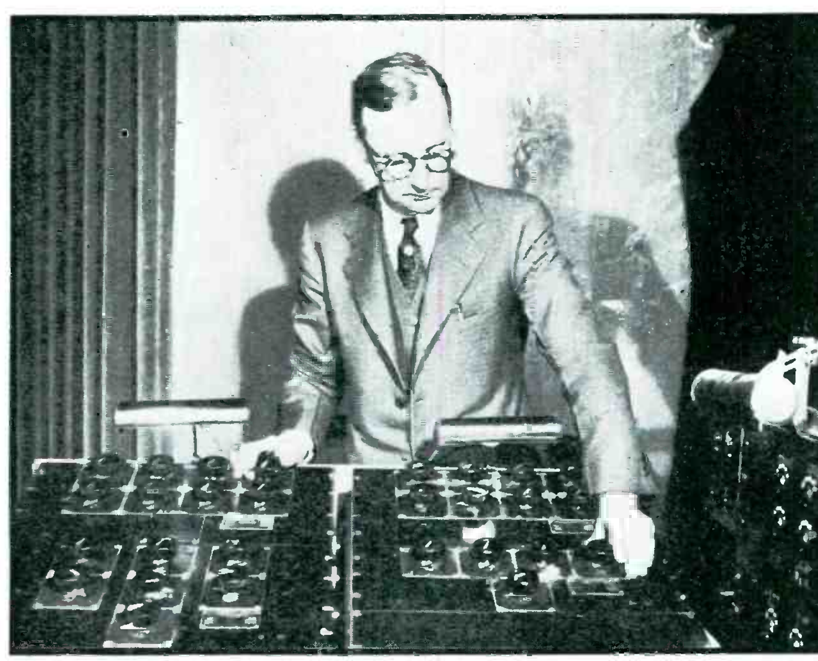
RCA Photophone
Camden, N. J.

WHEN Mr. Kurt Weill decided to record the music which he had composed for Max Reinhardt's production "The Eternal Road" and to eliminate the orchestra from the theatre, he set a precedent for the legitimate stage. His decision was prompted by the many real advantages resulting from the use of reproduced music.

More space is made available for elaborate stage settings. The orchestra may be recorded under the most favorable acoustic conditions, and the music to be recorded may be rehearsed until the most exacting requirements of the composer are satisfied. In reproducing the music in the theatre, the volume may be controlled with ease and directional effects ob-



Electricians at work, getting orders by loud speaker. Right—master control system for all sound apparatus, located in a box on the 4th tier. Below—dual prompters' box facing stage controlling sound and lights. Loud speakers become microphones at throw of switch



tained by placing several loudspeakers at different positions on the stage.

Film recording was chosen because of its longer playing time and because of the ease of cutting. The RCA ultra-violet push-pull method was chosen because of its large volume range and freedom from distortion. (See March and June 1936, *Electronics*, July 1934 and August 1936 *Journal of the Society of Motion Picture Engineers*.)

The recording of the music for "The Eternal Road" was done at Liederkranz Hall, New York City. The Hall is approximately 75 feet long, 50 feet wide and 30 feet high. The internal construction is largely of wood, providing sufficient acoustic damping to prevent excessive reverberation, but having enough reverberation to give the live quality necessary for most effective reproduction of a large orchestra or chorus. A platform about 4 feet high and large enough to accommodate the orchestra was constructed at one end of the Hall. To secure adequate coverage with the smallest number of microphones, the orchestra was bunched rather closely together. The string instruments were to the front and right, the wood winds to the front and left and the horns to the back. Two ribbon microphones were sus-

[*Continued on page* 75]

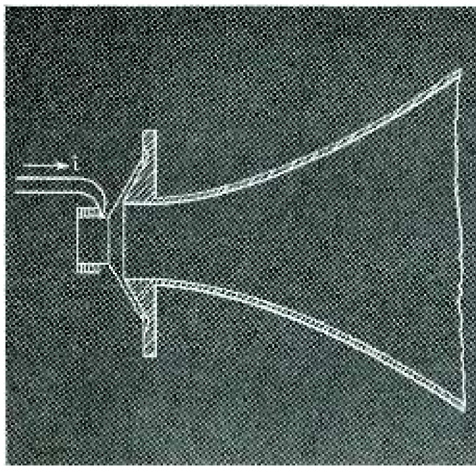


Fig. 1. Schematic diagram of horn loud speaker

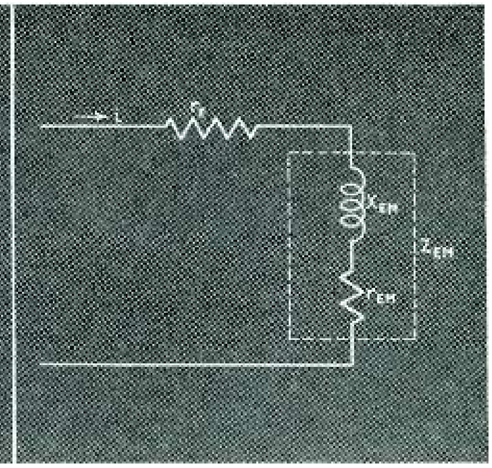


Fig. 2. Impedance presented to an electric current by horn loud speaker

Efficiency of Horn Loud Speakers

By FRANK MASSA
RCA Mfg. Co
Camden, N. J.

IN a recent article[1] the author published a family of theoretical curves which were computed to show the maximum possible efficiencies that could be realized in a horn loud speaker at different frequencies for various conditions of design. Since the appearance of this article, there have been several inquiries regarding the equation used for computing these curves as well as a desired explanation of the derivation of this equation.

The purpose of this article is to derive the equation for the maximum efficiency of a horn loud speaker and to show some interesting conclusions (some of which are contrary to popular belief) which have been reached as a result of this analysis.

The following assumptions will be made in carrying out the mathematical analysis:

1. The horn shall be of exponentially increasing cross section, with a cut-off frequency lower than the frequency being radiated by the speaker.

2. The horn mouth shall be large enough so that no reflections occur as the sound wave emerges from it.

3. The vibrating system driving the horn shall be a pure mass (i.e. the stiffness of the diaphragm mounting shall be low enough to make its resonant frequency lie below the frequency being generated in the horn and the stiffness in the throat chamber[2] shall be high enough so that its impedance is higher than the horn throat resistance at the frequency being radiated.)

4. Each portion of the cone shall be assumed to move in phase.

5. The voice coil shall be assumed to be a pure electric resistance.

The schematic diagram of the horn loud speaker being discussed is shown in Fig. 1. For this diagram the following constants will be assumed:

i is the r.m.s. current in amperes flowing through the voice coil,

r_E is the electrical resistance of the voice coil in ohms,

l is the length of the conductor in the voice coil in cms.,

B is the air gap flux density in gausses,

m_1 is the mass of the voice coil in grams, excluding mass of insulation,

m_2 is the mass of the cone plus air load, voice coil form, and insulation, in grams,

A_c is the area of the cone in sq. cms. and

A_h is the area of the horn throat in sq. cms.

It is obvious that the electric energy which flows into the voice coil of Fig. 1 is used up in part as heat dissipation in the voice coil and part is converted into sound energy at the throat of the horn. The efficiency of the loud speaker will be defined as the ratio of the acoustic power output to the electric power input. Expressed mathematically this becomes,

$$\% \text{ Efficiency} = 100 P_A/P_E \qquad (1)$$

where P_A is the acoustical output from the horn, and P_E is the electrical input to the horn, both measured in watts.

In order to see more clearly the conditions which exist during the transfer of electric energy to acoustic energy in the loud speaker, the equivalent electric impedance presented to the circuit by the system of Fig. 1 is shown in Fig. 2, in which z_{EM} is the electric impedance appearing in series with the ohmic resistance of the voice coil due to the mechanical impedance of the vibrating system. This impedance was first pointed out by Kennelly[3] and is called the motional impedance. The motional impedance is made up of a resistive and a reactive component and in the absence of mechanical losses, the real component represents the acoustic radiation resistance presented by the horn.

It can be shown[4] that the magnitude of the motional impedance is

$$z_{EM} = (B^2l^2/z_M) \times 10^{-9} \qquad (2)$$

vector electric ohms where z_M is the mechanical impedance of the vibrating system in mechanical ohms. For the case assumed, in which the mechanical losses have been neglected and both the compliance and the diaphragm suspension and horn throat chamber are not assumed to be of consequence in the frequency range concerned, it follows that the mechanical impedance in mechanical ohms is given by,

$$z_M = r_M + j\omega(m_1 + m_2) \quad (3)$$

where r_M is the mechanical resistance presented to the diaphragm by the horn, and $\omega = 2\pi f$ is the angular velocity in which f is the frequency. The resistance in mechanical ohms is given by

$$r_M = \rho c A_c^2/A_h \quad (4)$$

where ρ is the density of the medium into which sound is being radiated and measured in grams per c.c., and c is the velocity of sound in the medium in cm. per sec. For air under average conditions,

$$r_M = 42 A_c^2/A_h \quad (5)$$

mechanical ohms.

We are now in a position to determine the motional impedance in a more useful form. By substituting Eq. (5) into Eq. (3) and the result into Eq. (2), the equation for the motional impedance becomes,

$$z_{EM} = \frac{B^2l^2\times10^{-9}}{(42 A_c^2/A_h) + j\omega(m_1+m_2)} \quad (6)$$

from which the real component of the impedance of Fig. 2 becomes

$$r_{EM} = \frac{42(B^2l^2A_c^2\times10^{-9})/A_h}{(42 A_c^2/A_h)^2 + \omega^2(m_1+m_2)^2} \quad (7)$$

electric ohms.

Referring again to Fig. 2, it is obvious that the total electric power input to the circuit for the current i is

$$P_E = i^2(r_E + r_{EM}) \quad 8))$$

watts, and the acoustic power radiated is

$$P_A = i^2 r_{EM} \quad (9)$$

watts, so that the percentage efficiency becomes

$$\%\eta = 100\, r_{EM}/(r_E+r_{EM}) \quad (10)$$

or, letting $K = B^2l^2 \times 10^{-9}$ we may express the efficiency as

$$\%\eta = \frac{100\, Kr_M}{r_E[r_M^2+\omega^2(m_1+m_2)^2]+Kr_M} \quad (11)$$

It can be seen from Eq. (11) that, for a given speaker, the efficiency decreases as the frequency increases. To obtain the maximum possible efficiency at any particular frequency, Eq. (11) may be differentiated with respect to r_M, keeping the remaining terms constant. This gives,

$$\frac{d\eta}{dr_M} = Kr_E[r_M^2 + \omega^2(m_1+m_2)^2] + K^2r_M - 2\,Kr_Er_M^2 - K^2r_M = 0 \quad (12)$$

from which the mechanical resistance presented to the diaphragm by the horn for maximum efficiency at a given frequency becomes,

$$r_M = \omega(m_1 + m_2) \quad (13)$$

Substituting Eq. (13) in Eq. (11) gives the expression for maximum efficiency, which can be realized for the assumed horn loudspeaker at any given frequency as,

$$\%\eta_{max} = \frac{100K}{2r_E\omega(m_1+m_2)+K} \quad (14)$$

This equation assumes, of course, that Eq. (13) is satisfied.

In order to place Eq. (14) in a form which involves only the fundamental constants of the voice coil material, the following relations will be introduced. Let $m_2 = km_1$, where k is a numeric representing the ratio of mass of the cone, voice coil form, insulation, and air load, to the mass of the voice coil. Then,

$$m_1+m_2 = m_1(1+k). \quad (15)$$

However, if we let D represent the density of the voice coil conductor in grams per c.c. and A the area of the cross section of the conductor in sq. cms. whose length is l, we have that,

$$m_1 = DlA \quad (16)$$

and

$$r_E = Rl/A \quad (17)$$

where R is the resistivity of the conductor in ohms per c.c. The maximum possible efficiency at any frequency then becomes,

$$\%\eta_{max} = \frac{100\,B^2}{4\pi f(1+k)DR\times10^{-9}+B^2} \quad (18)$$

in terms of the symbolic notation already explained.

It must be emphasized that the maximum efficiency in Eq. (18) can be realized only at a given frequency provided that Eq. (13) is also satisfied at that frequency. This means that to secure maximum efficiency at all frequencies for a given vibrating system, the throat area of the horn should vary inversely as the frequency, since, as indicated in Eq. (5) a reciprocal relationship exists between the throat area and the mechanical resistance. For a fixed throat, however, the efficiency will be less than that given by Eq. (18) at every frequency except for the one frequency for which Eq. (13) is satisfied. The actual values of efficiency for a fixed throat at other frequencies may be found from Eq. (11).

The purpose of deriving Eq. (18) is to show how the various components of a horn loudspeaker are effective in determining the maximum

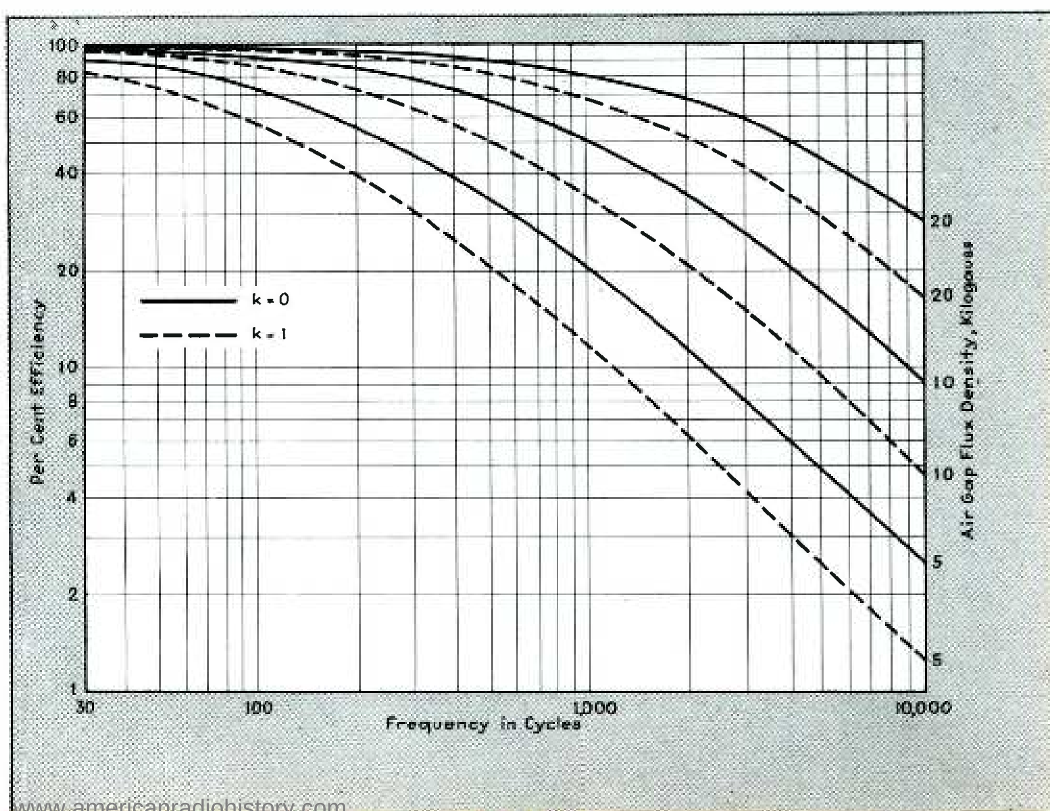


Fig. 3. Maximum efficiencies obtainable in a horn loud speaker employing an aluminum voice coil

efficiency which can be realized at various frequencies. In Figs. 3 and 4 are shown two families of curves in which the maximum efficiency at each frequency has been computed for both aluminum and copper voice coils. For the solid curves, $k = 0$, which assumes the hypothetically ideal case in which the total mass in the vibrating system is in the voice coil conductor. For the dotted curves, $k = 1$ which assumes that the voice coil mass is one half of the total mass of the vibrating system. This latter assumption is more nearly representative of what is encountered in actual practice, but even for the hypothetical case it is evident that to secure high efficiency at very high frequencies it will be necessary to use new materials which can either cause an increase in the air gap flux density to a value considerably above 20,000 gausses or can provide a conductor for the voice coil which has a much lower density-resistivity product than aluminum.

Eq. (18) brings out the further fact that at the higher frequencies where the efficiency is inherently low (left hand member of the denominator predominating) it is of vital importance to make k as small as possible, which means that the voice coil mass should be as large as possible. At the lower frequencies where the efficiency is inherently high, it is obvious that it is not necessary to make k very small. This means that the voice coil mass can be smaller than the cone mass, at low frequencies, without appreciable sacrifice in efficiency. On the other hand, the voice coil mass should be higher than the cone mass at the higher frequencies to secure best performance.

Conclusions

A careful analysis of Eq. (18) reveals interesting facts, all of which are not generally recognized. A summarized list of the deductions made from this equation are given below.

1. The efficiency of a horn loud speaker increases as the mass of the voice coil is increased, since k decreases as m_1 increases.

2. If the voice coil mass is not the greater part of the mass of the vibrating system at the higher frequencies, a condition prevalent in some high frequency speakers, greater gains in efficiency may be realized by increasing the mass of the voice coil than can be realized by using special magnetic materials to increase the air gap flux densities beyond 20,000 gausses.

3. The efficiency of a horn loud speaker is independent of the size of wire used in the construction of its voice coil.

4. The efficiency is dependent on the product of the resistivity and the density of the voice coil conductor[5]. When properly designed, the loud speaker efficiency will increase as this product is decreased. However, as actually constructed, some speakers will show an increase in efficiency if this product is increased. (See item 8 below).

5. Efficiency at the lower frequencies is inherently high for a horn loud speaker, even with reliably low air gap densities and with voice coils whose mass is less than the remaining mass of the vibrating system. When the frequency is low, the efficiency will be high.

6. At high frequencies, the efficiency will be very low unless the air gap flux density is very high and unless the mass of the voice coil is the larger part of the entire mass of the vibrating system.

7. At high frequencies, the efficiency is critically dependent on the ratio of the voice coil mass to the mass of the remainder of the vibrating system, since the factor k plays an important role in determining the value of the efficiency when the frequency is high.

8. In specific instances it is possible to improve the high frequency efficiency of a loud speaker by changing from an aluminum to a copper wire voice coil in spite of the fact that copper has twice the resistivity-density product of aluminum. This improvement will occur in a speaker if the aluminum coil is less than 1/3 the mass of the remainder of the vibrating system. By changing to copper under these conditions, the voice coil mass will approximately triple since copper has approximately three times the density of aluminum, so that k will be reduced to one third of the value it has for an aluminum coil. The factor $(1 + k)$, with the copper coil, will then become less than one half the value it had with the aluminum coil, and although the product, DR, is doubled by changing to copper, the numerical value of the whole denominator will be reduced, with a resultant increase in efficiency.

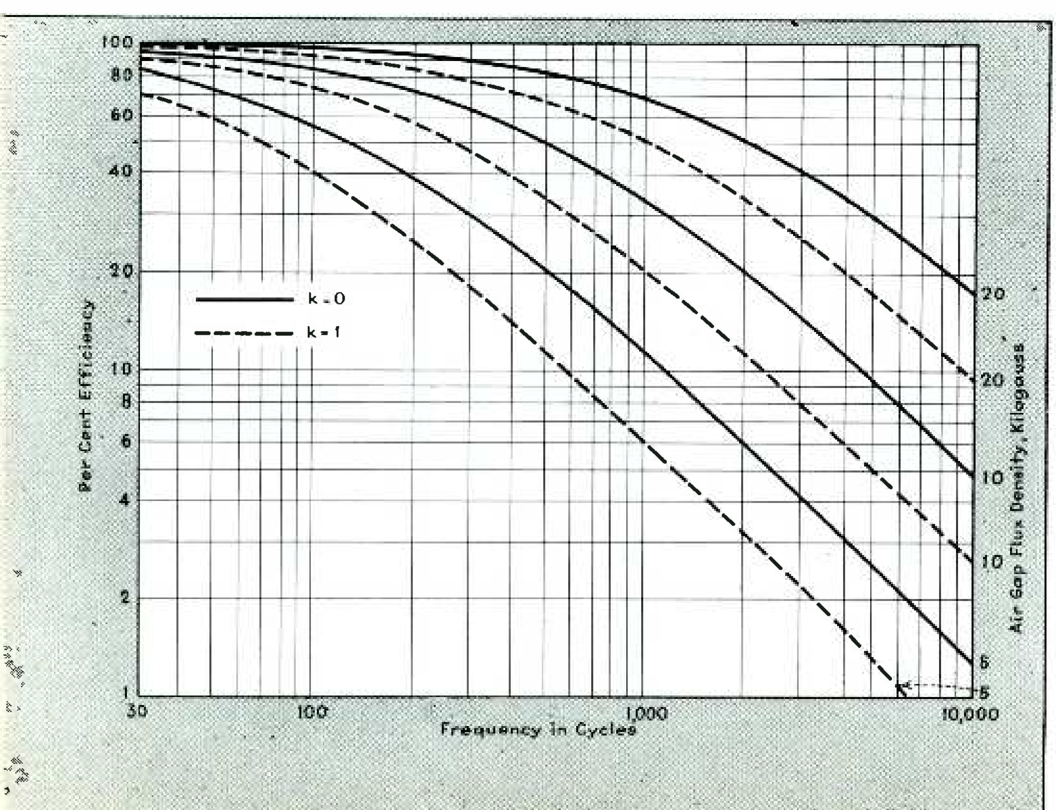


Fig. 4. Maximum efficiencies obtainable in a horn loud speaker employing a copper voice coil

[1] Loudspeakers for High Fidelity Wide Range Reproduction of Sound, by Frank Massa, *Jour. Accos. Soc. of Am.*, Oct., 1936, p. 126.

[2] Loudspeaker Design, by Frank Massa, *Electronics*, p. 20, Feb. 1936.

[3] "Electrical Vibration Instruments," by A. E. Kennelly, p. 76. (Macmillan).

[4] "Applied Acoustics," by Olson and Massa, p. 173. (Blakiston).

[5] It is interesting to note that, this same conclusion was reached by C. R. Hanna in his analysis of loudspeaker efficiency under somewhat different conditions of operation. See article by C. R. Hanna, p. 253, *J. A. I. E. E.*, April 1928.

Photo-Emf Cell Characteristics

Measurement methods used in determining the current and voltage output of selenium-on-iron self-generating cells, in terms of the intensity and wavelength of the incident light

By R. M. HOLMES
University of Vermont

DURING the past few years several types of photo-emf cells have been developed and manufactured for technical uses. These cells convert radiant energy directly into electrical energy. Essentially they consist of a disk of metal with a layer of poorly conducting material on the outer surface of which a translucent metallic film is deposited. The particular photo-emf cell which is the subject of this article is manufactured in Germany under the trade name "Electrocell." In this cell the metallic disk is iron and the material adhering to the iron is selenium. Light penetrating the translucent metallic film deposited on the outer surface of the selenium causes electrons to flow from the selenium to the translucent film thence around the outside circuit and returning to the inner surface of the selenium layer via the iron disk. If the cell is on open circuit electrons flow to the translucent film, the latter thereby becoming negatively charged relative to the iron disk. Consequently, the cell acts like a generator since energy of a certain type is supplied to the device and electrical energy is delivered by the apparatus. The cell characteristics which are of particular interest are: the relation between luminous flux and the current produced, the relation between luminous flux and the potential difference across the terminals of the cell when the latter is on open circuit, and finally the relation between current and wave length of light when the energy in the illumination by various colors is kept constant.

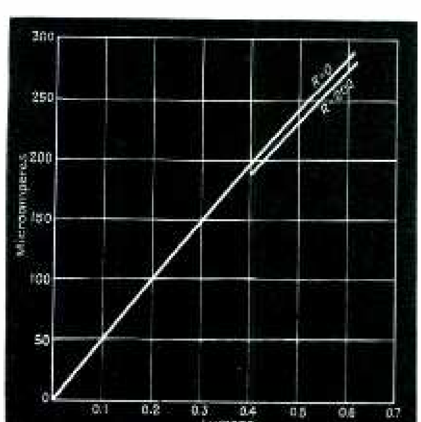


Fig. 1—Current output vs. illumination for low light levels

Figure 1 shows the relation between current and illumination for the case where the resistance in the outside circuit is nearly zero and also for the case where this resistance is 200 ohms. The latter value of resistance was selected since it is of the order of magnitude of the resistance of a sensitive relay or of a microammeter which might be used in connection with the photo-emf cell. The currents were measured with a D'Arsonval galvanometer provided with a suitable shunting arrangement. The illumination was from a 300-watt projection lamp operated at constant voltage by a storage battery. The candle power of this lamp was determined by comparison with a lamp standardized at the National Bureau of Standards, a Lummer-Brodhun photometer being used for making the comparison. The 300-watt lamp was operated at a color temperature of 3230 degrees Kelvin, this value of color temperature being taken from information furnished by the Incandescent Lamp Dept. of the General Electric Co. The radiation emitted was consequently identical with the radiation from a "black body" at the above temperature. The visible radiation falling on the photo-emf cell is plotted in lumens. The number of lumens emitted by a lamp equals $4\pi C$, where C is the

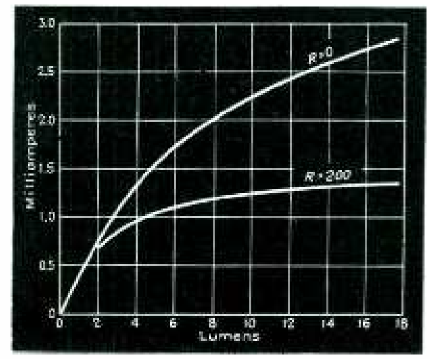


Fig. 2—Extension of Fig. 1 to higher light levels

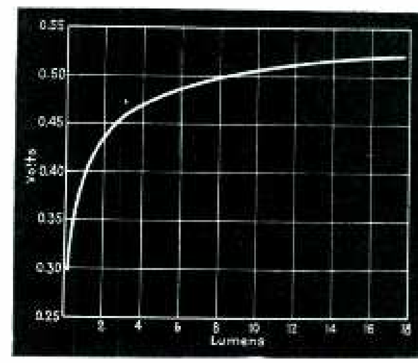


Fig. 3—Voltage output vs. illumination, high levels

candle power. The number of lumens, L, falling on a surface of area A and at a distance d from a source of radiation is given by $L = 4\pi CA/4\pi d^2$ or $L = CA/d^2$. In the measurements reported here, $A =$ 9.15 sq.cm., this being the exposed area of the sensitive surface of the cell. Since the current from a photo-emf cell depends upon this exposed area it is considered best to plot current against the total luminous flux incident on the exposed area rather than against lumens per sq.cm. or against foot candles, these last two being similar units. For the purpose of comparison between the metric and the English unit one may take the specific case of 0.5 lumen on the cell. This is equivalent to 0.5/9.15 or 0.0547 lumens per sq.cm. and it is equivalent to 51 ft. candles. The curve shows the current to be nearly a linear function of luminous flux for the values recorded in Fig. 1. When the resist-

[*Continued on page* 56]

Tubes at Work

Five phototubes view a "wall of light" for timing horses accurately, a phototube and a shutter sorts letters by "spotting" the stamps. Circuits for capacity-relays and for using the neglected selenium cell. New forms of barrier-layer cells

Elaborate Horse-Race Timer Uses Five Photo Tubes

HORSE RACE TIMING by means of phototubes used in conjunction with camera equipment is not a new development in electronics, but the methods used have been continually improved since the idea was first presented. One of the latest devices, the multiple eye camera, has been developed by Ralph Powers of Detroit, and has been in use for some time at the River Down race track. As shown in the picture, five separate phototubes mounted one above the other, and five separate light sources are used. This arrangement provides a "wall" of light which is intercepted regardless of the position of the horse's head as he crosses the line. All five phototubes are fed to the common input of the photo amplifier, which is compensated so that the speed of operation of the relays is independent of the light level, hence indications are as reliable on dark as well as on bright days.

As the first horse crosses the finish line the phototube relay actuates a camera located in a booth above the grandstand, which immediately takes a "still" picture of the finish. An automatic indexing device delivers an impulse to the second camera which takes a picture of the second horse, and so on until four individual pictures have been taken. These still pictures are taken on 4 x 5 glass plates, which are developed in 28 sec., fixed in 25 sec., enlarged, developed and fixed in the following minute, so that the judges have an 8 x 10 enlargement of the finish two minutes after the horses cross the line.

Running simultaneously with the still picture equipment is a high speed 35 mm. motion picture camera operating at 180 pictures per second. In the event that the still picture equipment fails, the motion picture film is used to describe the finish. The illustration shows an exceptionally close finish photographed by the multiple eye camera. The white line in the photograph is a cable stretched above the track, over the heads of the horses, but directly in line with the camera lens and the finish line.

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Photocell Sorts Letters For British Post Office

A MECHANISM HAS BEEN developed by the British Post Office for indicating whether stamps are correctly placed on letters for cancellation. It can also be adapted to distinguish between stamps of different colors. The letters are carried along a narrow channel on edge, by a moving band and at a chosen point a bright light is caused to fall on them. Light from two parts of the paper, that is, the stamp and the plain envelope, is allowed to fall alternately on a photocell by means of a revolving shutter. If the stamp is in position, the amount of light will differ and an alternating current will be generated in the cell circuit. This current is amplified by a special arrangement of tubes tuned to the shutter frequency and is used to operate a relay which kicks the letter into an appropriate compartment. The amplifiers are biassed so as not to operate below a certain input and thus the device ignores such things as ink writing and variation of paper color.

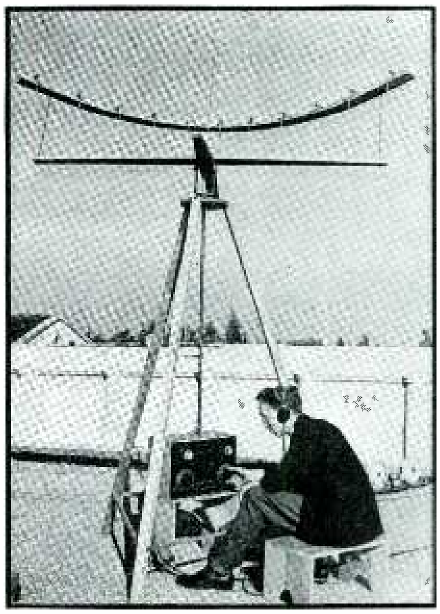
Letters with advertising matter printed on them can still be passed through the machine as most of them do not have the printing in the place normally occupied by the stamp. The present machine, which is purely of an experimental nature, can deal with 1000 letters per minute.

The U. S. Postoffice also makes use of phototubes, but for quite a different purpose. In the Government Printing office, the perforation of large sheets of stamps is kept in register by a phototube relay, so that the 3/64-inch perforations are accurately centered in the 7-64-inch space between each row of stamps.

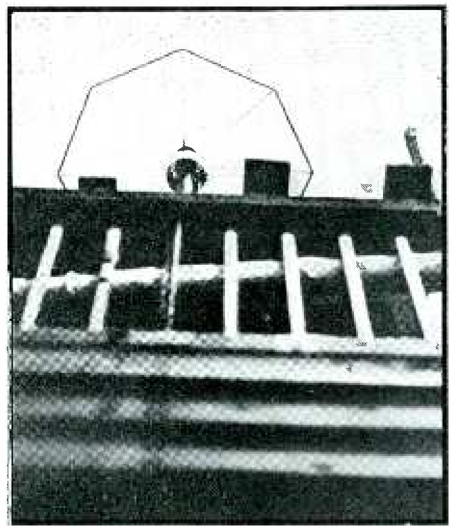
A neck-and-neck finish recorded by the Powers Camera

Index of Recent Electron Tube Applications

UNUSUAL ANTENNA STRUCTURES—FOR STRATOSPHERE, TELEVISION, AIRPORTS



Parabolic reflector antenna used for receiving 1.5 meter signals from a stratosphere explorer balloon. At receiver is Prof. Easton of Caltech



Berlin's "pancake" television radiator, 453 feet high, which sends video images on 6.7 meters. The "edges" of the pancake are horizontal dipole elements which concentrate the energy in the horizontal plane

Directional "loop" antenna at the Glendale, California, airport used for sending instructions to American Airlines pilots on regular runs

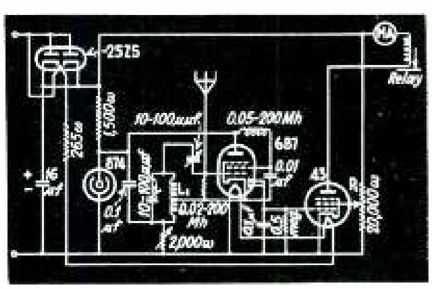


Fig. 1—Voltage-regulated relay circuit

Two Practical Capacity-Operated Relays

Capacity operated relays are among the most generally useful tube-operated control devices, and among the simplest to construct from standard parts and tubes. They may be used for burglar protection, counting and sorting of metallic objects, and for general "space-control" such as indicating when the foul-line in a bowling alley has been overstepped. Two simple but highly practical capacity-operated circuits developed by Frank Shepard, Jr., of RCA Radiotron are shown in the accompanying diagrams.

In Fig. 1 is shown a stabilized circuit which makes use of an 874 voltage regulator tube to supply constant voltage to the oscillator, which uses the pentode section of the 6B7 tube. The amplitude of oscillation of this section depends on the ratio of the antenna-to-ground capacity to C_1 in Fig. 2.

As the antenna-to-ground capacity is increased, the amplitude of oscillation can be made to increase. The oscillating voltage is rectified in the double-diode section of the 6B7, and applied to the grid circuit of the 43 relay tube. The screen grid of the 43 is given an adjustable bias, by which the maximum relay current can be controlled. As the antenna-to-ground capacity increases, the amplitude of the rectified voltage increases, and the plate current in the 43 relay tube changes accordingly.

Ralph Powers (left) with his "Multiple Eye" horse-race timer which uses five phototubes

A somewhat similar circuit using metal tubes is shown in Fig. 2 The

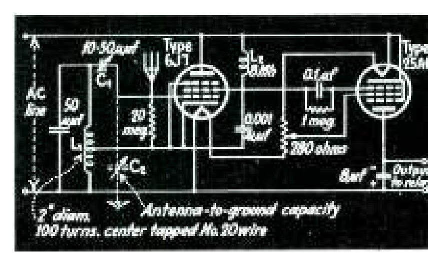


Fig. 2—Relay circuit using metal tubes

6J7 tube is used as an oscillator. The rectifying action of the grid of the 25A6 relay tube causes a rectified a-c voltage, equal to the peak value of oscillating voltage on the cathode 6J7, to be built up in the grid-leak and condenser. The oscillator oscillates on each positive cycle of plate voltage, but during this time the 25A6 tube, whose plate connects to the other side of the line, is non-conducting. The negative charge built up on the grid of 25A6 does not leak off during the non-conduction period, however, and hence is effective in controlling the relay current during the alternate conduction periods.

By increasing the resistance of the choke coil feeding the screen of the 6J7, the sensitivity of the circuit may be increased until it becomes unstable, i.e. until the relay will not open and release at the same value of capacity.

When a long antenna is used, it is desirable to construct the tuned circuit of the oscillator so that it operates at a low frequency, since radiation losses

(*Continued on page* 40)

LABYRINTH

(*Continued from page 27*)

mounted in a cabinet intended to represent the conditions of loudspeaker enclosure in a typical radio console placed with its back close to a wall. The impedance minimum at 140 cycles corresponds with the response peak at the same frequency in Fig. 3. It will be noted that the resistance below 100 cycles is very small. The total resistance on the diaphragm of a typical cabinet type loudspeaker is the sum of the resistances shown in Figs. 6 and 7 and is still small. As the sound power is directly proportional to the radiation resistance for a given diaphragm velocity it follows that effective sound radiation under the above conditions may be attained only with high velocities which, at the low frequencies under consideration, result in excessive displacement amplitudes.

The impedance on the back of the diaphragm of a loudspeaker mounted in a labyrinth of the type illustrated in the photograph is shown in Fig. 8. In contrast with Figs. 6 and 7, it will be observed that the resistance component predominates over most of the range and becomes very large at low frequencies. As an indication of the amount of damping afforded the loudspeaker, whose natural resonance frequency is located near 40 cycles, it may be stated that the resistance in this region is approximately 200 times that afforded by an infinite plane baffle. This resistance peak corresponds to the one occurring at $\lambda/4$ in Fig. 1. The effect of the absorbent lining of the labyrinth in modifying this peak and in reducing the reactance variations at such a low frequency is noteworthy. At higher frequencies the rise in absorption accounts for the virtual elimination of the higher order resonances of the tube.

A further experiment was performed to compare the impedance characteristics of an absorbent labyrinth with one having the same internal dimensions but made of solid wood. The results are shown in Fig. 9, where for comparison the curves of Fig. 8 have been replotted on the same scale as those for the wooden labyrinth. This gives further and striking evidence of the effectiveness of the absorbent lining. The measured curves for the wooden labyrinth are seen to have the same general characteristics as the theoretical ones for an unlined tube shown in Fig. 1. The marked falling off with ascending frequency of the amplitude of the peaks in the curve for the wooden labyrinth was caused by the inadvertent use of felt lined housings to connect the loudspeaker

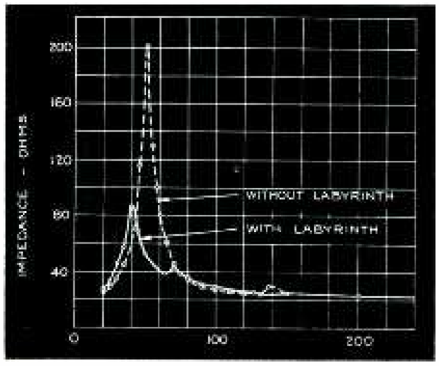


Fig. 10—Electrical impedance of loudspeaker in cabinet illustrating damping action of labyrinth

to the labyrinth. Even without the lined housings there would, of course, have been some falling off in the amplitude of the impedance variations due principally to the increase with frequency of the radiation resistance of the open end.

In Fig. 10 we have the results of electrical impedance measurements made on the same loudspeaker with and without a labyrinth. This again strikingly illustrates the effect of the labyrinth in damping the fundamental mechanical resonance of the loudspeaker moving system, as evidenced by the reduction to about one-third its former amplitude of the impedance peak resulting from the reflected velocity rise of the driving coil. The natural frequency is shifted from 50 down to 40 cycles by the additional air mass reactance of the labyrinth. The reduction in impedance variation is, as before mentioned, advantageous when working from certain types of vacuum tubes.

Listening tests on labyrinth loudspeaker systems compared with those of the conventional cabinet type indicate a much greater naturalness of reproduction for the former, particularly when the original sound sources are quickly available for direct listening. The absence of the usual cavity resonance "boom" is at once noticeable on speech. In the rendition of impulsive sounds of low pitch there may be recognized a striking improvement due to the elimination by the labyrinth of the usual spurious transients and "hang-overs". In what may be called "loudness efficiency" the labyrinth speaker system will be found somewhat lower than one of the conventional cabinet type employing a similar driving unit. This is the expected result of the elimination of resonance peaks and non-linear distortion. The difference is difficult to evaluate because it varies with the type of program, but is not considered to be of great consequence in view of the important improvement in fidelity obtainable in the labyrinth system.

Some incidental advantages of the labyrinth system also are worth mentioning. First, unlike the usual open-backed cabinet, its internal characteristics are not adversely affected when it is placed with its back close to a wall. In fact, such a position is most favorable because the loudspeaker then operates with enhanced efficiency as a consequence of the smaller solid angle of radiation. Second, the shape of the cabinet is immaterial so long as it will contain the labyrinth. This assumes considerable importance in the case of automatic phonograph combinations where the shape of the record changing mechanism frequently calls for a cabinet so deep that cavity resonances are more than usually troublesome. Finally, as the loudspeaker, labyrinth and sub-baffle comprise in themselves the complete acoustic system independently of the cabinet, the panel resonance characteristics of the latter have an insignificant effect on the performance.

This article is based on data which originally appeared in a paper by the same author published in the October 1936 issue of the *Journal of the Acoustical Society of America.*

[1] Crandall, "Theory of Vibrating Systems and Sound," p. 100 Eq. (288)

[2] Rayleigh, "Theory of Sound," Vol. II, p. 165.

[3] Reference 1, p. 101

[4] Flanders, A Method of Measuring Acoustic Impedance, *Jour. Acous. Soc. Am.* 4,402, 1932

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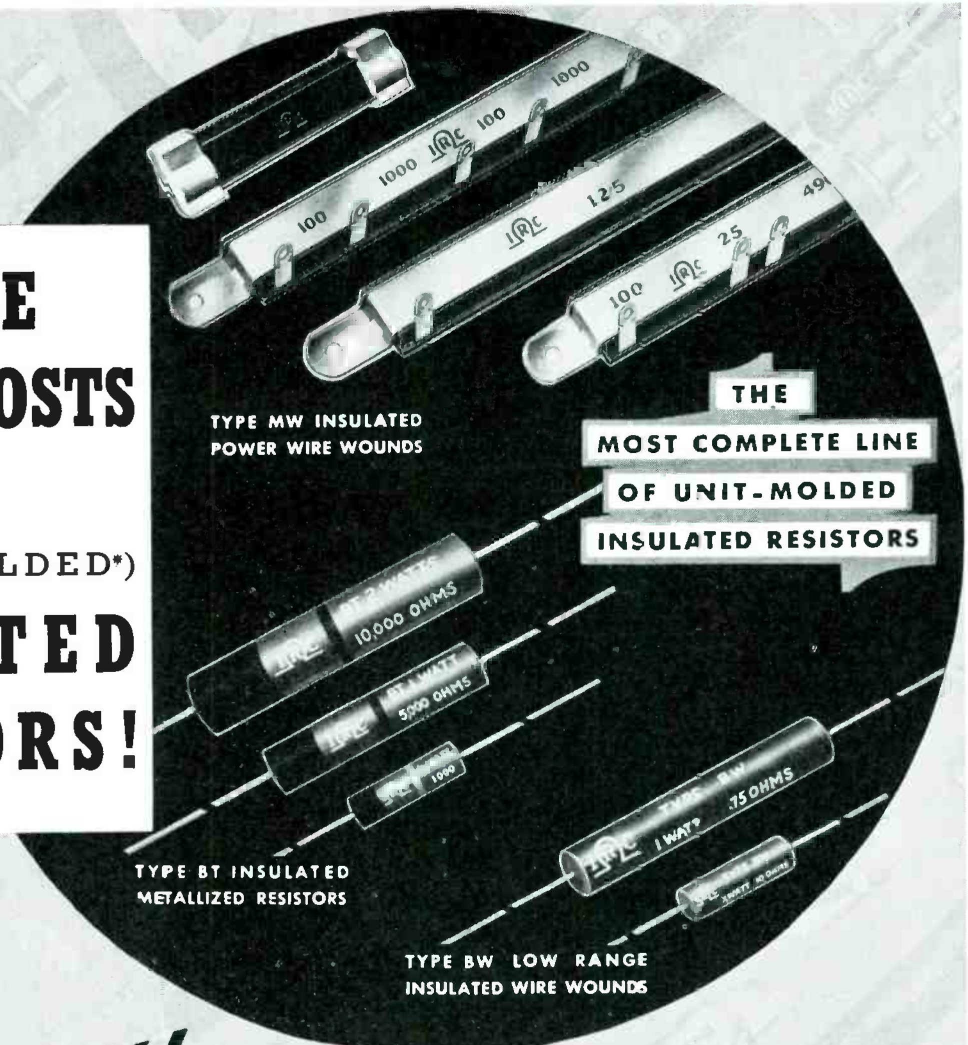

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TUBES AT WORK

[*Continued from page* 35]

from the antenna will thereby be reduced. The value of the sensitivity control condenser C_1 also varies according to the antenna-to-ground capacity involved. For high sensitivity all losses in the oscillating circuits should be kept as low as possible, i.e. the resonant impedance of the tuned circuit should be as high as possible, indicating good insulation and high Q-values for the coils.

• • •

UNIQUE STRATOSPHERE TRANSMITTER

Prof. Anthony Easton of Caltech with the one-pound radio transmitter carried aloft by a stratosphere balloon. The acorn tube delivers 1.5 meter signals, indicating wind velocity, humidity, temperature, and barometric pressure

• • •

Calibrating Radio Frequency Ammeters With Photocells

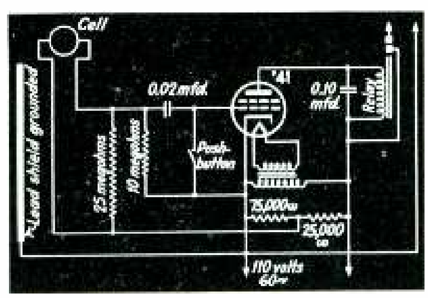
THE CALIBRATION OF ordinary radio frequency ammeters, when the frequency is of the order of millions of cycles per second, presents great difficulties. In order to overcome this an entirely new type of transfer instrument has been devised. It consists of a fine wire heated to incandescence in a vacuum, with a photocell placed so that it receives light from it. Then, if a certain number of amperes, direct current, produce a certain photoelectric

current the same number of amperes at radio frequency, however great, will produce exactly the same photoelectric current. Furthermore, since the amount of light emitted by an incandescent filament is proportional to the fifth power of the current a very sensitive ammeter is produced.

• • •

A Dependable Selenium Cell Circuit

ALTHOUGH THE SELENIUM cell was undoubtedly the first light-sensitive device to be applied in relay and audio frequency circuits, during the past ten years engineers have turned to the electronic (photo-emissive) tubes because of their greater stability. The compactness of the selenium cell and its sensitivity to low light levels have always been in its favor, and have influenced several workers to improve its construction and manufacture. Some of the newer selenium cells are of considerable merit.



Selenium Cell Circuit

The circuit shown in the accompanying diagram, due to Dr. Edward Praetorious of the Acousto-Lite Laboratories in Los Angeles, has been brought to the attention of the editors by Mr. Samuel Wein of New York. The cell current, obtained from the 110 volt a-c supply through the voltage divider, passes through a high resistance which is applied to the grid of the relay tube through a time-delay circuit. When the light is completely removed from the cell, the plate current falls to a low value, causing the relay to "drop out". Until the time delay circuit has dissipated the condenser charge, the plate current remains at a low value. If the relay is to be "pulled-in" before the end of the time-delay is reached, the push button can be connected, which will instantly re-energize the relay. When the light beam is re-established, the action of the circuit is in no way changed by the action of the push-button.

• • •

Unusual Barrier Cells Appear in Germany

TWO INTERESTING TYPES of barrier type photo cells, each containing two photo-sensitive units, have recently been pro-

SUPERIOR TUBES

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If we can take the late Mr. Webster's word for it, superior means—"Surpassing in quality, more excellent, preferable, of higher grade, etc." Those are virtues easy to boast of but difficult to possess.

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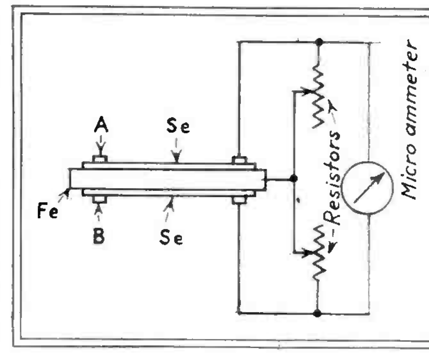
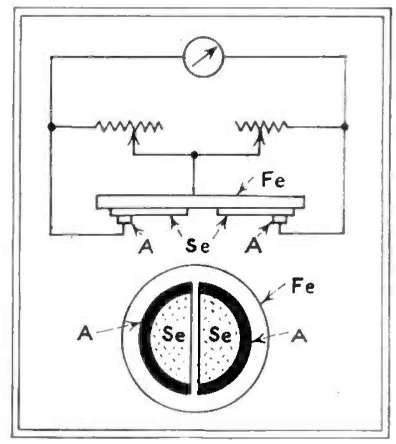
duced by the Sudeutsches Apparat Fabrik of Nurnberg, Germany. One type is the so-called "double cell," for use

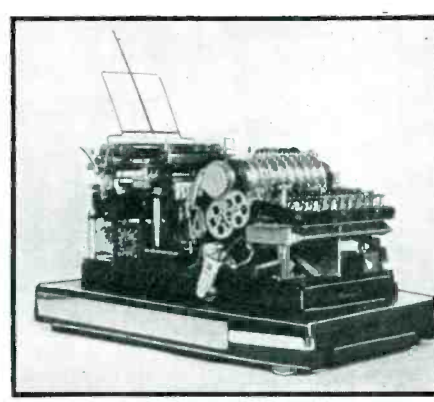




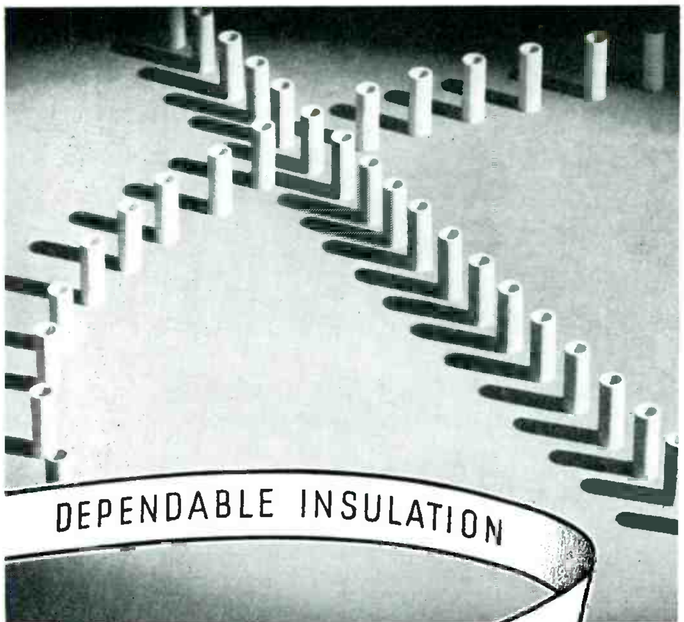
New double barrier cells

where two sources of illumination are to be measured. The cell shown in the figure consists of an iron disc and two selenium films on each side of the disc. The second type, also shown, is a differential cell, both surfaces being exposed to the same light source. The relative amount of area exposed on each side of the cell determines the net current produced.

AUTOMATIC CODER



A new self-coding typewriter, electrically operated, is operated like an ordinary typewriter but turns out coded copy. Over 10 million code combinations are available in the device



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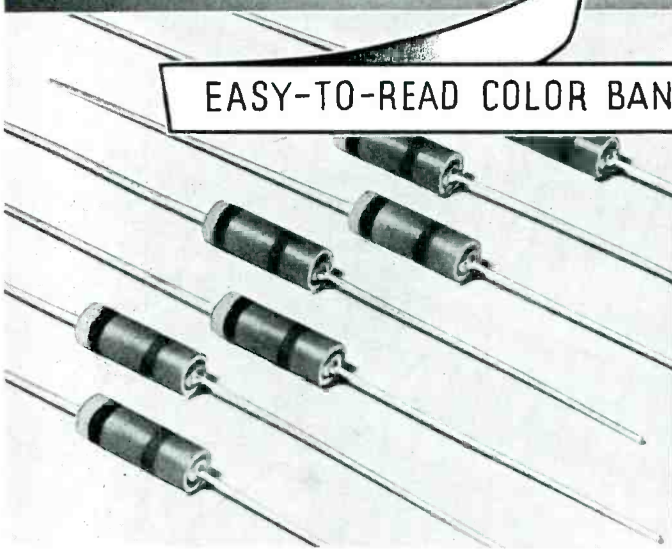

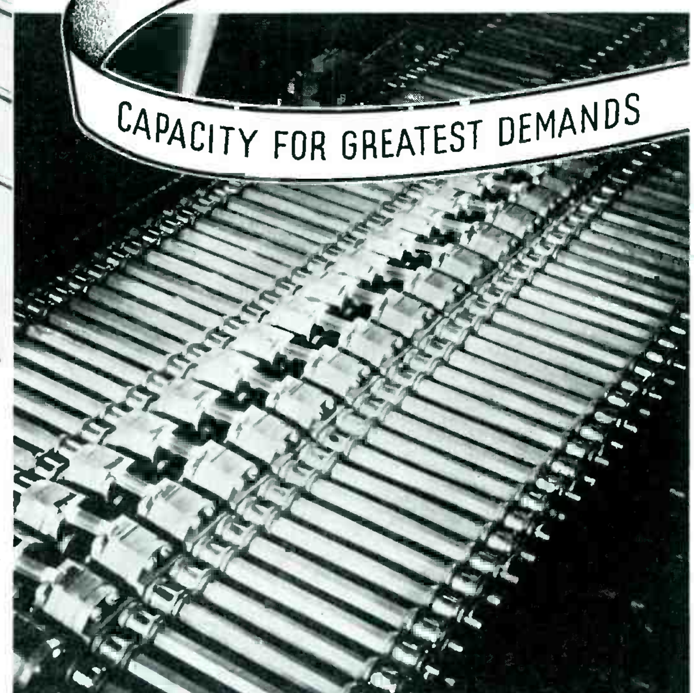

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NEW BOOKS

The Physics of Electron Tubes

BY L. R. KOLLER. *McGraw-Hill Book Co., Inc., New York, N. Y., 1937 (234 pages, illustrated, $3.00). Second edition, revised and enlarged.*

THE SECOND EDITION of this well-known member of the "International Series in Physics" has been enlarged some thirty pages and contains considerable new material. As in the first edition, the author has restricted himself to descriptions of the fundamental physical phenomena which underlie the operation of electron tubes, and has not concerned himself with electron tube circuits or the effects of circuit conditions on tube operation. Within this stated sphere, he has succeeded very well in presenting the essential facts of emission, space-charge, ionization, and photo-sensitivity.

The second edition contains new material on electron optics, secondary-emission multipliers, positive ion emission, and some of the newer gaseous tubes, including the ignitron. The extensive bibliographies at the end of each chapter have been brought up to date and expanded.

The one fault which this reviewer finds with the book is its sketchy treatment of grid-action in vacuum tubes, on which there is hardly more than a few paragraphs. This subject, which is surely a basic element in electron tube physics, was inadequately handled in the first edition, and very little improvement in this respect can be found in the second. With this one exception, the book is a complete and authoritative treatment of the inner action of electron tubes.—D.G.F.

• • •

Electron Tubes In Industry

By KEITH HENNEY. *Second Edition 1937, McGraw-Hill Book Co., New York, N. Y. (539 pages. Price $5.00.)*

SECOND EDITION of "Electron Tubes in Industry" covers briefly a great many phases of the wide field of non-radio electronic applications. It contains much new material in addition to all the important parts of the first edition. The descriptions are clear, complete, and remarkably concise. Mathematical expressions necessary to the complete and proper understanding of an application principle are given; otherwise, they are omitted. It is refreshing to read a book where simple electronic principles are not lost in a maze of unnecessary and perhaps irrelevant mathematics.

The first chapter gives enough of the theory of electrical engineering to enable the novice to understand fundamental electronic principles, and to follow the illustrations in the following chapters. It also is an excellent review for those who have not thought about such matters for a number of years.

The book describes first a fundamental type of tube with its theory of application, and then follows with specific practical illustrations of its use. This procedure is repeated for various classifications of tubes used in industrial electronics. In this way the author has done an excellent job of including and correlating typical examples of vacuum tube, gas tube, photoelectric, and cathode-ray principles and applications under a single cover.

Mechanical, electrical, chemical, and other engineers, and non-engineering executives should find in this book suggestions invaluable for their own particular problems. The book is an inspiration to the electronic engineer and should give him many new ideas. The complete list of references included as foot-notes are of value to the research man, to the student, and to all desirous of further investigating any particular subject.

The circuit drawings have several minor mistakes, most of which would have been avoided if circuits had been drawn with dots and jumpers instead of dots alone. These errors, however, detract little from the intrinsic worth of the book.—F. H. S., JR.

SOUND-TRACKS ON PAPER

Sound recorded photoelectrically in parallel lines on photographic film is transferred to metal and printed on ordinary paper, from which it can be reproduced by a phototube pick-up, shown above

• • •

Vacuum Tube Laboratory Guide

(Anleitung zum Arbeiten im Rohrenlaboratorium)

BY M. KNOLL. *Julius Springer, Berlin 1937. 67 pages, 57 figures.*

THANKS to the interest and perseverence of two teachers, a vacuum tube laboratory was established in 1931 at the Berlin Institute of Technology. It has the purpose of preparing engineers for the problems arising in the manufacture and development of vacuum tubes. Four hours a week during the university year are devoted to laboratory work. This time permits handling 14 problems: Pumps, McLeod gauge, resistance and ionization manometers, temperature measurements by optical methods and electron velocities, getters, Richardson's constant, pumping and testing a vacuum tube, and a tube with indirectly heated barium paste cathode, preparation of a discharge tube filled with a noble gas, preparation of a sodium photocell by electrolysis, study of fields in tubes with the aid of an electrolytic trough, electronic microscope.

The instructions to each exercise in this manual are given under a series of convenient headings: equipment, construction, principles, measuring methods, accuracy or sensitivity range, experiments, discussion of results. At the end of each exercise is a list of references intended for ready use, almost exclusively in German. The author's name is known to readers of *Electronics* from an article describing the electronic microscope in the number for September 1933 (see also December 1936, p. 52).

Some of the sections seem to be rather short. In the chapter on high vacuum pumps it is not clear whether the speed of the pump is referred to a certain pressure (1/1000 mm. mercury). Gas discharge tubes with several electrodes might have furnished useful material for study. Apart from this the selection of the material and its presentation is to be highly commended, since it impresses upon the engineer's mind the need for regarding the tube as a product liable to changes, and not a device made to conform with a rigid pattern. It covers material that is often unduly neglected in books on vacuum tubes.

THE ELECTRON ART

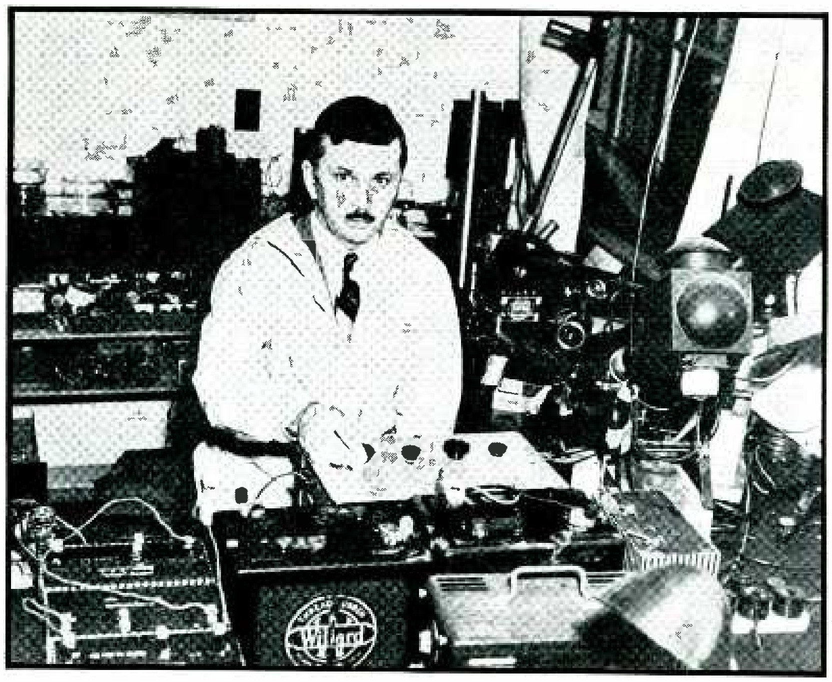
EACH month the world's technical literature is scanned to see what physicists and engineers are doing with tubes, for presentation in tabloid form to Electronics' readers.

Frequency Stability of Self-Excited Oscillators

IN A SURVEY of the factors affecting the stability of self-excited oscillators, Antseliovich has given some idea of the relative importance of the different factors. It is shown that the relative variation of the frequency, $\Delta f/f$, caused by changes in the grid current is of the order of 0.01% to 0.00001%, and that when the load on the oscillator is varied, $\Delta f/f$ is of the order of 0.1% or more. For changes in the internal resistance of the tube, which is one of the most important changes in tube constants $\Delta f/f$ will be of the order of 0.005% to 0.0001%. As a result of changes in the temperature of the tube, the dimensions of the electrodes and their spacing can be altered, as well as the capacity between the supply leads through the socket. In this case the frequency deviation will be of the order of 0.1%; for changes in plate dissipation it will be about 0.005% to 0.075%. Changes in the slope of the oscillation curve can be responsible for $\Delta f/f$ as high as 0.01%.

Several factors can also cause the frequency to vary until a stable thermal condition is reached. Changes in the temperature of components of the oscillating circuit may cause a relative frequency variation of 0.1% while displacement of the components of the oscillating circuit, due to temperature variations and consequent changes in capacity to ground, may amount to 0.5%. It is obvious that, in the first place, proper attention must be paid to the thermal compensation and structural features of the oscillating circuit. What is more, the frequency stability of a continuously variable oscillator does not remain constant over the entire wavelength range. This has been investigated both theoretically and experimentally for self-excited oscillators for frequencies between 50 kc. and 60 Mc. and it was found that the stability decreased with the frequency. While the frequency band for optimum stability depends to a very considerable extent upon the construction of the oscillator, it appears that greatest stability for properly designed, compact oscillators lies between 1,000 and 6,000 kc.—*International Broadcast and Sound Engineer*, 1937 *Yearbook*.

NEW MICROVOLTMETER USED IN CANCER RESEARCH



Professor Harold S. Burr, of Yale, with the vacuum tube microvoltmeter used for measuring the voltages produced in dying cell tissue. The high sensitivity, 5 microvolts, makes possible advance diagnosis of cancer

I.R.E.-U.R.S.I. Meeting

THE ANNUAL joint meeting of the Institute of Radio Engineers and the American Section of the International Scientific Radio Union will be held on April 30, 1937, in the building of the National Academy of Sciences, 2101 Constitution Ave., Washington, D. C. Of the thirteen papers listed on the tentative program, the following four will be of particular interest to readers of *Electronics:*

"A Method of Measuring the Static Characteristics of a Power Tube and Calculations of Its Operating Characteristics," by E. L. Chaffee, Harvard University.

"Measurement of Vacuum Tube Admittances at Ultra-High Frequencies," by B. Salzberg, J. M. Miller, and D. G. Burnside, RCA Manufacturing Co.

"The Frequency Stability of Ultra-High Frequency Oscillators," by Arnold Peterson, Massachusetts Institute of Technology (in cooperation with the General Radio Co.).

"An Analysis of the Operation of Voltage Controlled Electron Multipliers at Ultra-High Frequencies," by W. R. Ferris.

Most of the remaining papers are concerned with the ionosphere, and studies of the propagation of radio signals.

Tube Exports

ACCORDING TO the Bureau of Foreign and Domestic Commerce, exports of radio receiving tubes during January 1937 amounted to 253,520 tubes valued at $280,597. Argentina is reported as the biggest customer at $40,623 with the U. S.S. R. following with sales of $32,115.

New Fact in Electricity

PROF. BELLI, of Milan, has published some experiments conducted by himself which demonstrated that the negative electric fluid is dissipated in about half the time required by that which is positive. This fact had escaped the observation of Coulomb, and also of M. Biot. M. Peltier, greatly surprised at the difference thus found by the Italian professor, is now engaged in an attempt to discover the cause.—From *Mag. Pop. Sci.* as reported in the *Journal of the Franklin Institute*, p. 71, January, 1837.

A New Achievement for a Famous Name

A great drama of life and death was enacted when the raging waters of the Ohio and Mississippi spread terror and disaster during the recent flood. Out of this great drama emerged the nation's cast of heroes whose efforts saved thousands of lives from watery graves and controlled the inevitable aftermath of disease. ☆ Bendix is proud to have been able to play a part in the timely rescue efforts of the many governmental and independent agencies. The Coast Guard rushed men, boats, planes and communication trucks, some equipped with Bendix transmitters, receivers and other equipment to the flooded area. In cooperation with the Naval Reserve, Army and Amateurs, they established a joint emergency radio net-

PHOTOS COURTESY U. S. COAST GUARD

work to facilitate rescue work and relieve human suffering. ☆ Such occasions as this bear testimony to the reliability and efficiency of Bendix Radio products under all conditions. Bendix Radio Corporation provides complete research, engineering and manufacturing facilities for every type of radio equipment.

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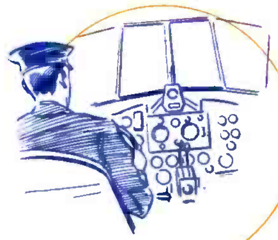

Out of the storm-swept skies that erased all visibility, a dozen sea-planes alighted on the land-locked waters of Pearl Harbor . . and Man once again defeated the elements. These twelve Navy planes had spanned the 2553 miles of open sea from San Diego to Honolulu, thus completing the longest over-water mass flight in aviation history. ☆ With the weather as thick as pea soup and visibility nil, these fliers flew with confidence toward a mile-square spot in a vast ocean. They knew their goal MUST be ahead! Adverse weather conditions were forgotten, for these PBY-1 Consolidated long-range patrol boats were kept on a sure course with the unfailing precision and dependability of Bendix Radio Direction Finders. ☆ When efficient performance is needed, over land or sea, Bendix equipment will not fail. Bendix Radio Corporation offers the finest engineering facilities for the development and manufacture of aircraft radio products of every type for use in commercial, naval and military aviation.

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- Intercommunicating Telephones
- Ground Station Equipment
  - Traffic Control
  - Transmitters
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Improvements in Resistance Coupled Amplifiers

TWO IMPROVEMENTS in the design of resistance-capacitance coupled amplifiers are discussed by O. H. Schmitt in the March 1937 issue of the *Review of Scientific Instruments.* The first of these relates to a method of decreasing the time interval during which a tube may be blocked because of large voltage suddenly applied to the grids of one of the tubes. The second indicates a simple method of obtaining good insulation between plate and grid of succeeding tubes with commercial condensers.

Blocking of the resistance coupled amplifier can usually be traced to the first stage in which a positive potential on the grid causes a large current to flow into the blocking condenser thereby building up a negative voltage on the grid of the succeeding tube. If the usual coupling arrangement is replaced by that shown in Fig. 1 in which an

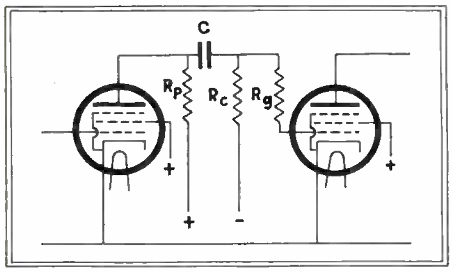


Fig. 1—Resistance coupled amplifier circuit for reducing the time of blocking when a large voltage impulse is applied

additional resistance, R_g, is inserted in series with the blocking condenser, C, the voltage on the blocking condenser will build up more slowly and blocking is less likely to occur.

The time during which the second stage can be blocked with the usual coupling circuit is given by,

$$t = CR_p/(E_b - E_p)$$

whereas with the improved circuit the blocking time is

$$t = \frac{C\{R_p(R_g+R_c)+R_cR_g\}}{\{(E_b-E_p)(R_g+R_c)\}}$$

where $(E_b - E_p)$ is the difference between the plate battery supply voltage and the voltage actually on the plate of the tube, or the drop in voltage across R_p, and the remaining symbols have the significance indicated in the schematic wiring diagram. It is shown that for two 6J7 tubes operating from a 500 volt plate supply and coupled through a 0.1 μfd. condenser, and in which $R_p =$ 100,000 ohms and $R_c = R_g = 2$ megohms, there is a tenfold decrease in the tendency to block.

Stable operation in resistance-capacitance coupled amplifiers depends to a large extent on the maintenance of proper electrode voltages. Unless the blocking condensers have unusually high insulation resistance, there is likelihood that the grid bias will be influence by leakage through the blocking condenser. By introducing an extra blocking condenser and resistor in each stage as shown in Fig. 2, inexpensive

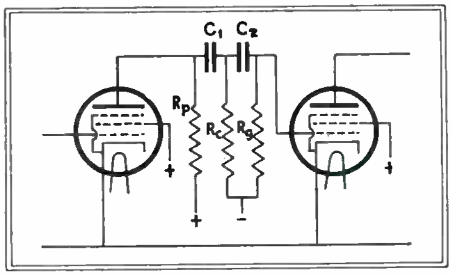


Fig. 2—By adding an additional blocking condenser and grid resistor, ordinary commercial condensers may be used in a stable resistance coupled amplifier

commercial condensers may be used in place of specially selected or laboratory standard condensers while still maintaining the stability obtainable with the highest quality mica condensers.

In the case of the conventional, single blocked amplifier the variation in grid bias due to the leakage in the condenser is given by

$$\Delta E_c = E_pR_g/(R_c+R_g) \cong E_pR_g/R_c,$$

whereas for the improved circuit of Fig. 2 the corresponding expression is,

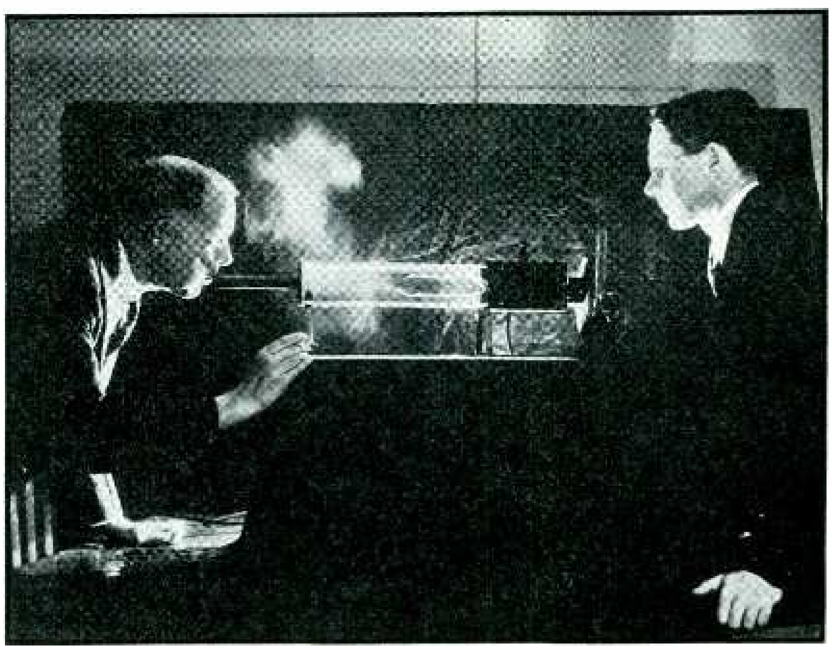
$$\Delta E_c = E_bR_cR_g/\{(R_{c1}+R_c)(R_{c2}+R_g)\}$$
$$\cong E_pR_cR_g/R_{c1}R_{c2},$$

where R_{c1} and R_{c2} are the leakage resistances of C_1 and C_2 respectively. The author shows that in a practical circuit the insulation resistance requirements of the condenser are reduced from 10^{10} ohms for the usual circuit to 1.4×10^8 ohms for the improved circuit.

Progress in Electronics During 1936

THE FEBRUARY 1937 issue of the *Proc. I. R. E.* gave considerable space to a series of reports prepared by its various technical committees in which "Radio Progress During 1936" was outlined. While the entire report will be of interest to a large number of readers of *Electronics*, especially those who were unable to attend the New York I. R. E. meeting at which papers on this subject were read, the report of the technical committee on electronics will be of particular interest. The report is divided into sections on television tubes, ultra-high frequency vacuum tubes, receiving tubes, transmitting tubes, gas tubes, photoelectric devices, and miscellaneous devices. Because of the numerous advances reported during 1936, only a brief mention could be made of the highlights in the field. However, there is included a bibliography of 61 references.

SHOW DUST PURIFIER TO AIEE



G. W. Penney (left) and L. W. Chubb of the Westinghouse Laboratories examining a high-voltage dust remover. The dust becomes ionized in the presence of a high electric field, and is attracted to the charged plates. The device is expected to be of value in the treatment of hay fever

He can almost take her in *BLINDFOLDED!*

. . . HE SPECIALIZES

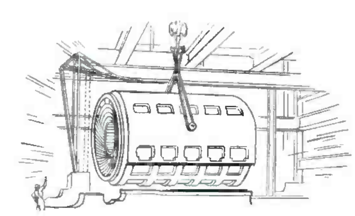
MICA Insulator Company

DRIVING RAIN . . . a tossing sea, treacherous shoals ahead . . . yet a great ship must be safely harbored. To the New York Harbor Pilot this is just part of the day's work.

It takes years to gain the knowledge . . . to develop the uncanny sixth sense of these men. Boyhood apprenticeship . . . years of specialized training . . . literally a lifetime devoted to one job.

Making electrical insulation has been literally a lifetime job at Mica Insulator Co. Through over 40 years of specialization we have gained a most unusual experience . . . we, too, have developed "a sixth sense" in the solution of electrical insulation problems. We welcome the opportunity to put this knowledge and our research facilities to work for you.

200 Varick St., New York; 542 S. Dearborn St., Chicago; 1276 W. 3d St., Cleveland. Birmingham, Boston, Cincinnati, Los Angeles, San Francisco, Seattle. Montreal, Toronto



FLOOD—BREAKDOWN—EMERGENCY!

A large generator has broken down.

New insulation is needed—and needed in a hurry: Micanite Parts, Micanite Sheets: Varnished Cloth: Lamicoid.

A telephone call to Mica Insulator Co. gets quick action. They know what is wanted and they have a flexible organization that can get it out in emergency time.

Dependable insulation shipped in 24 hours but fit to stay in service for a decade.

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MICANITE . . . EMPIRE VARNISHED INSULATIONS . . . LAMICOID LAMINATED PLASTIC MATERIALS

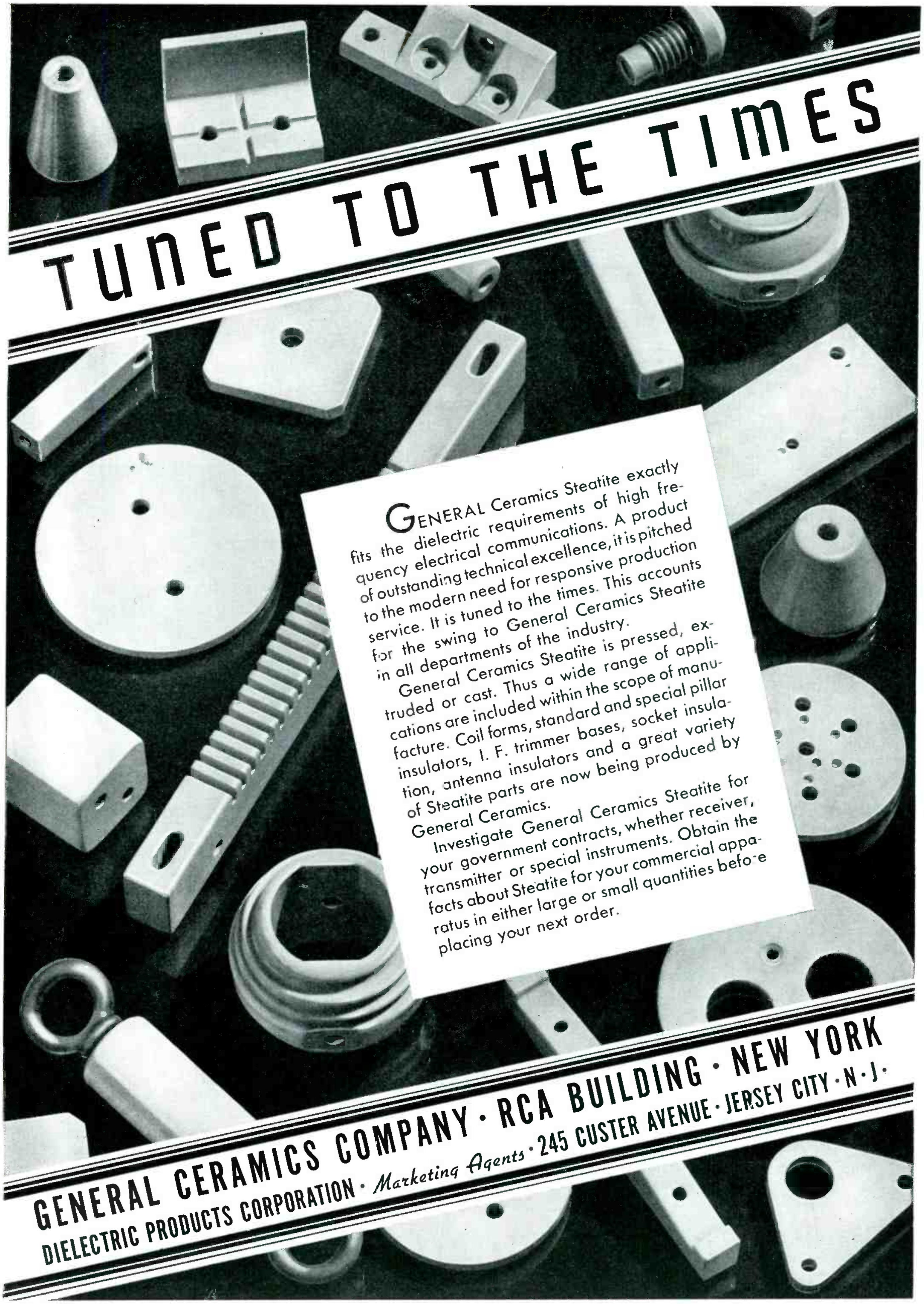
TUNED TO THE TIMES
GENERAL Ceramics Steatite exactly fits the dielectric requirements of high frequency electrical communications. A product of outstanding technical excellence, it is pitched to the modern need for responsive production service. It is tuned to the times. This accounts for the swing to General Ceramics Steatite in all departments of the industry.
General Ceramics Steatite is pressed, extruded or cast. Thus a wide range of applications are included within the scope of manufacture. Coil forms, standard and special pillar insulators, I. F. trimmer bases, socket insulation, antenna insulators and a great variety of Steatite parts are now being produced by General Ceramics.
Investigate General Ceramics Steatite for your government contracts, whether receiver, transmitter or special instruments. Obtain the facts about Steatite for your commercial apparatus in either large or small quantities before placing your next order.
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PHOTO-EMF

[*Continued from page* 33]

ance external to the cell is practically zero the current is 242 microamperes and when the external resistance is 200 ohms the current is 233 microamperes for the luminous flux considered. Thus with negligible external resistance the output is 484 microamperes per lumen and with 200 ohms external resistance the output is 466 microamperes per lumen, both in the straight line part of the curve. These outputs are remarkably high. The curve for the 200 ohm resistance is not shown for values below 0.4 lumen because at the lower values the curves nearly coincide. Figure 2 shows the current curves for stronger illuminations. It is evident that the nearly linear relation between current and luminous flux existing at the lower illuminations does not hold when the illumination is strong.

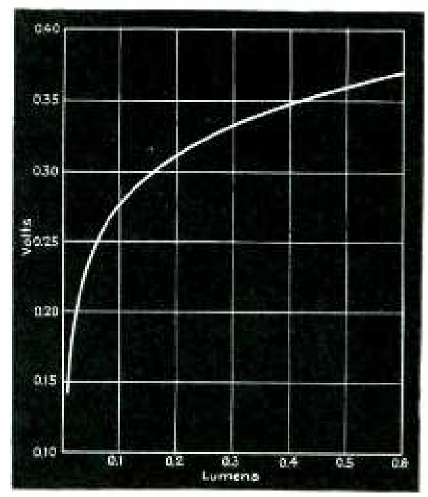

Fig. 4—Voltage output at low light levels

Figures 3 and 4 show the potential difference at the terminals of the cell on open circuit. These potential differences were measured with a potentiometer. The potential difference increases with illumination much more rapidly than is the case with current. Although potential difference should not depend upon the exposed area of the sensitive surface, it is for the sake of uniformity plotted against total lumens received. For the smallest illumination used from the 300 watt lamp (0.0081 lumens on the cell or 0.00089 lumens per sq.cm.) the

THE EVERLASTING VIGIL

To the everlasting watch along the coast, SYNTHANE laminated bakelite makes one vital contribution—dependability of the insulation in lighting and signalling circuits. Put that reliance into your product by using SYNTHANE.

SYNTHANE is a material possessing a combination of many desirable properties—electrical, mechanical, chemical and physical—for many purposes. Write for information and data sheets. SYNTHANE CORPORATION, Oaks, Penna.

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potential difference had the remarkably high value of 0.142 volts. An automobile lamp rated 21 candle power and at a distance of 740 cm. produced a potential difference of 20 millivolts. Using the rated output of this lamp the illumination on the cell was 0.000038 lumens per sq.cm. or 0.035 ft. candles. Figs. 3 and 4 show the rate of increase of potential difference to be less at the stronger illuminations.

Figure 5 shows the current in the outside circuit when external resistance is almost zero as a function of wave length of light using an equal energy spectrum. The equal energy spectrum with the exception of the wave length 675 mμ was obtained from a General Electric mercury vapor lamp rated at 400 watts and operated at an automatically regulated a-c voltage. The mercury vapor lamp emits several definite wave lengths of light in the infra-red, in the visible and in the ultra-violet regions of the spectrum. By means of a selection of Wratten light filters always used in combination with a 2 cm. water cell and with a 1 cm. cell containing a 10 per cent aqueous solution of copper sulphate it is possible to absorb practically all of the radiation except the one color which is to be transmitted to the cell. Water absorbs nearly all of the infra-red of wave length greater than about 1350 mμ but it does not absorb the near infra-red. Copper sulfate solution of the concentration specified absorbs everything above about 700 mμ. It is advisable to include the water, however, to prevent heating the copper sulphate solution. The amounts of

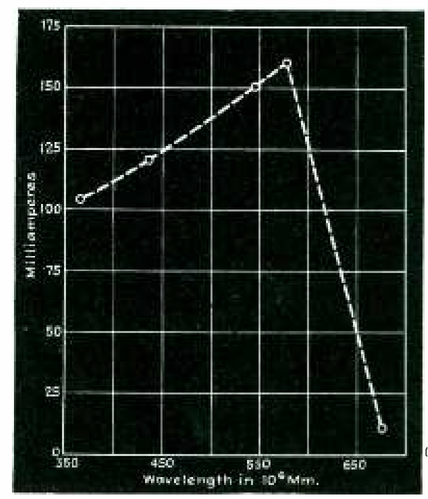


Fig. 5. Spectral response curve

energy in the various colors emitted by the mercury vapor lamp will naturally be quite different. To secure an equal energy spectrum it is necessary to allow the light of each wave length selected by the filter system to fall on the blackened surface of a sensitive thermopile connected to a galvanometer and it is necessary to determine the various distances between the mercury vapor lamp and the thermopile needed to produce a constant deflection of the galvalometer. Then the photo-emf cell is substituted for the thermopile and using distances as above determined the cell may be exposed separately to radiations of different wave lengths but having equal energies and the currents produced may be measured. The current values shown in Fig. 5 were obtained in this manner excepting the value for a wave length of 675 mμ. It was not feasible to use one of the red lines from the mercury vapor lamp because the filter combination excluding the infra-red would not transmit enough of the mercury vapor red line to obtain a satisfactory galvanometer deflection when using the thermopile. The radiation used for this wave length was therefore obtained from a tungsten filament lamp with filters suitable for the transmission of a narrow band of light having an average wave length of 675 mμ.

The points obtained are connected by a dash line. The individual points are accurate but one cannot be certain of the currents at wave lengths between those for which readings were taken. The measurements no doubt give a fairly close indication of the effect of wave length on the current from this photo-emf cell. Points of interest are: (*a*) The cell is quite sensitive in the near ultra-violet. (*b*) The maximum sensitivity occurs in the yellow, the largest current in these measurements being for a wave length of 578 mμ which is just slightly greater than the wave length (557 mμ) at which the normal eye is most sensitive. (*c*) The sensitivity decreases rapidly in the red end of the spectrum.

The author wishes to acknowledge assistance rendered by Mr. A. L. Howard who did a large amount of the work involved in securing these measurements.

5 NEW Mercury Vapor Rectifiers

FEATURING—

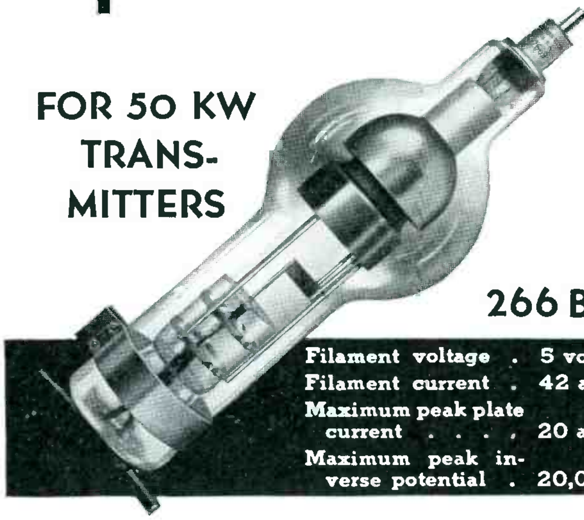
1. *Enclosed field structure.* The anode surrounds the cathode shield and limits ionization to a small volume.

2. *Rugged filament design.*

3. *Reliable glass construction.* Careful control of manufacturing processes minimizes glass strains.

Station operators throughout the country are proving daily that these tubes are remarkable for their reliability, long life and freedom from arcback.

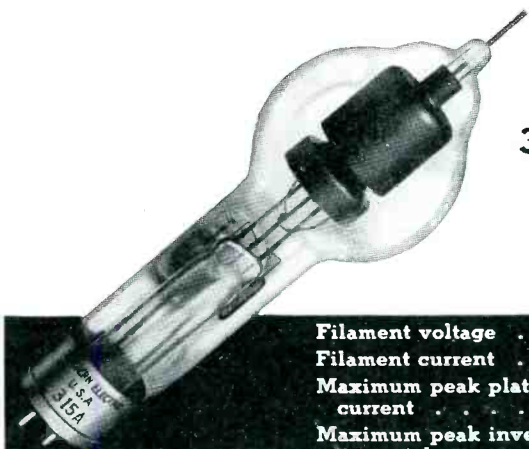
FOR 50 KW TRANSMITTERS

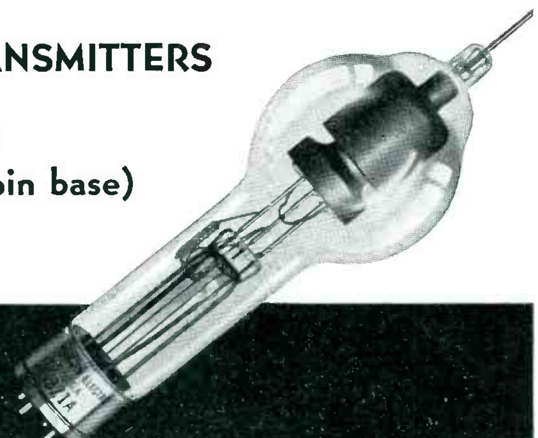


266 B

Filament voltage	5 volts
Filament current	42 amperes
Maximum peak plate current	20 amperes
Maximum peak inverse potential	20,000 volts

FOR 5 KW TRANSMITTERS



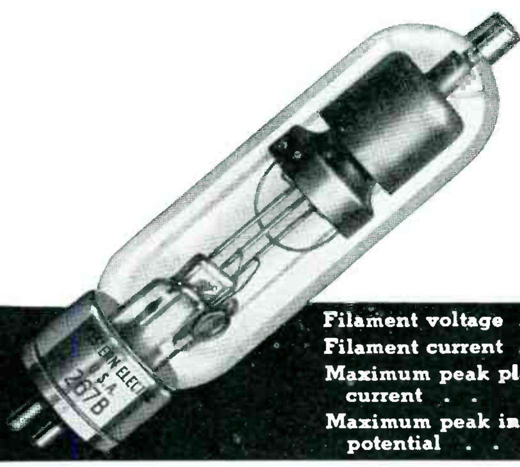


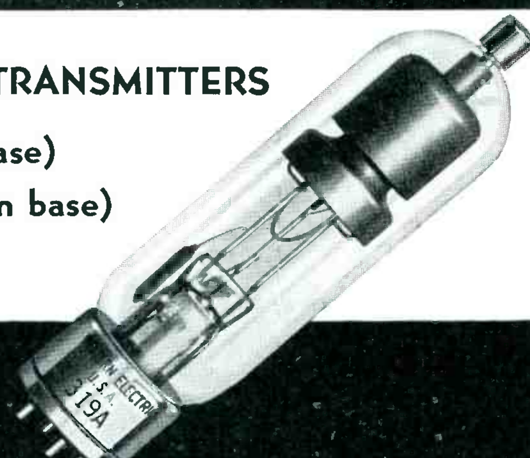
315 A (2 pin base)

321 A (4 pin base)

Filament voltage	5 volts
Filament current	10 amperes
Maximum peak plate current	2.5 amperes
Maximum peak inverse potential	12,500 volts

FOR 1 KW TRANSMITTERS





267 B (2 pin base)

319 A (4 pin base)

Filament voltage	5 volts
Filament current	6.75 amperes
Maximum peak plate current	2.5 amperes
Maximum peak inverse potential	7500 volts

Western Electric

Distributed by GRAYBAR Electric Co. *In Canada: Northern Electric Co., Ltd.*

RADIO TELEPHONE BROADCASTING EQUIPMENT

MANUFACTURING REVIEW

News

✦ Mr. Emil R. Capita, designer of high frequency bombarders has announced the formation of his own company, the Ecco High Frequency Corporation, 120 West 20th St., New York City. This organization, of which Mr. Capita is president, will manufacture high frequency bombarding and associated equipment.

✦ A twenty-five per cent increase in its production space has been recently announced by the Clarostat Manufacturing Co., Inc., in the company's own building at 285 North Sixth St., Brooklyn, N. Y.

✦ According to an announcement from the RCA Communications, Inc., a direct radio telegraph circuit has been recently opened between New York City and Monrovia, Liberia.

✦ An increase of approximately twenty-five per cent in manufacturing space has been made by the International Resistance Company, 401 N. Broad St., Philadelphia, Pa., according to a statement made by Ernest Searing, president of the International Resistance Corporation.

✦ Appointment of Herman Scheibler as director of Sonotone Corp., has been announced by Dean Babbitt, president. Dr. Scheibler has been active for a number of years in electrical and industrial engineering. He is a graduate of the University of Budapest and also studied under Professor Irving Fisher at Yale University.

✦ David Sarnoff, president of the Radio Corporation of America, recently announced that a dividend on the outstanding shares of the Corporation's $3.50 cumulative convertible first preferred stock has been declared by the Board of Directors. The dividend of 87½ cents a share is to be paid April 1, 1937.

✦ The ninth annual report of the Hygrade Sylvania Corp. for the year ending Dec. 31, 1936 shows a net increase in sales of 29% over 1935, and that dividends of $1.625 a share on the preferred stock and $0.50 on the common stock were paid out of 1936 earnings. In addition an extra dividend of $1.00 per share on the common stock was paid December 1936 to stockholders. Average number of employees on the payroll during 1936 was 3207, an increase of 231 or 7.2% over the 1935 figure.

New Products

Car Antennas

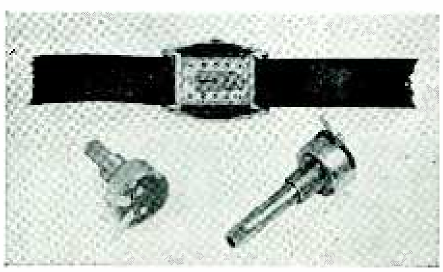
Two NEW CAR ANTENNAS, designed to meet all automotive-radio requirements are announced by the Insuline Corp. of America, 25 Park Place, New York City. One of these, the "Poletenna", is of the telescopic type opening to a maximum length of 8 feet. It is intended for clamping to the rear bumper of any make of car, but may also be used for amateur operation on the higher frequency bands. The second antenna, known as the "Airflow", consists of a length of rust-proof metal supported on the top of the car by means of rubber vacuum cups, and consequently may be easily and quickly installed without drilling the top of the car. List prices are $2.50 and $3.00 respectively.

Wave Trap

A WAVE TRAP using an iron core inductance and having two ranges (one from 1720 to 700 kc. and the other from 400 to 700 kc.) has been recently marketed by the Meissner Manufacturing Co., Mount Carmel, Ill.

Midget Control

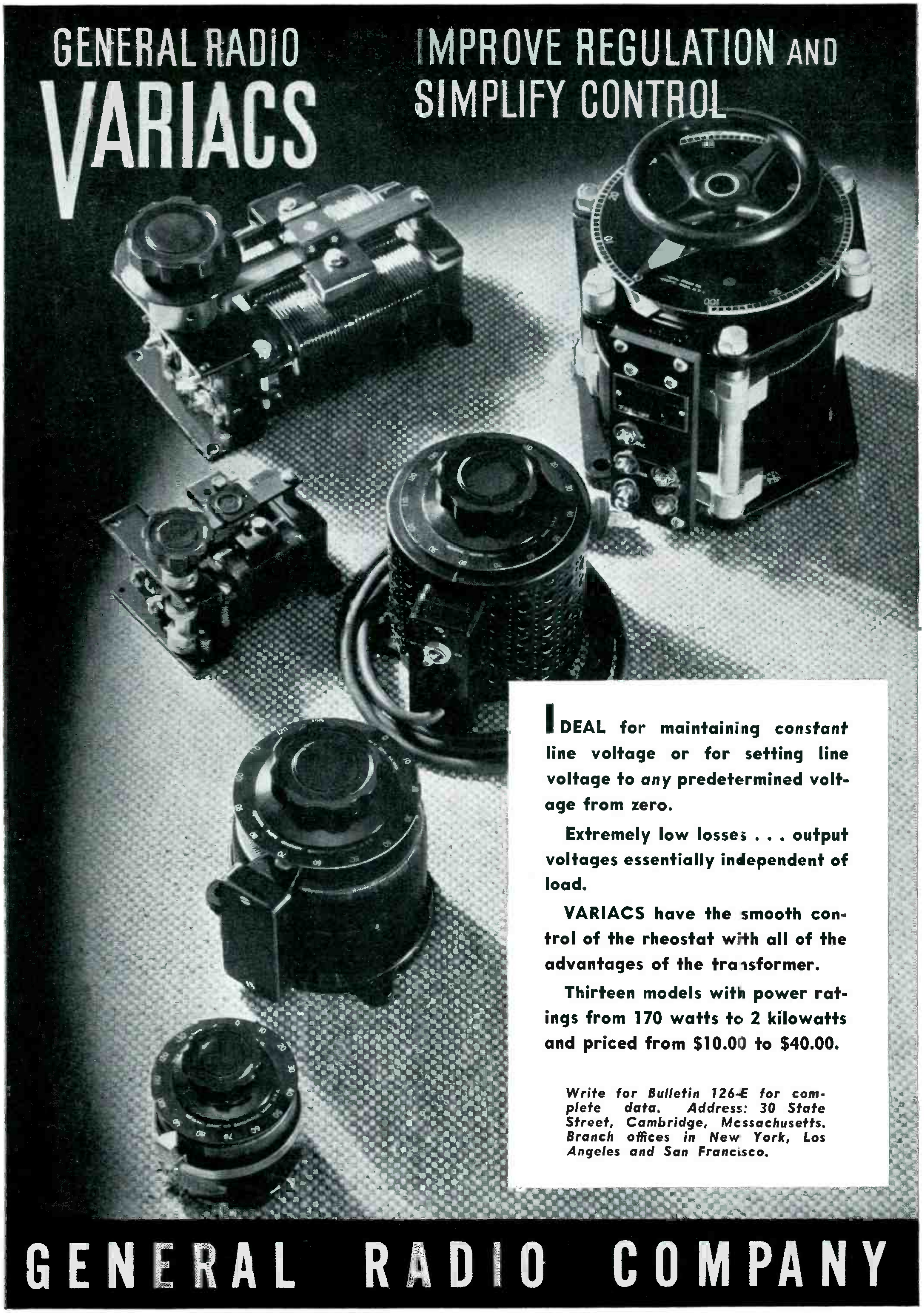
ONE OF THE LATEST control units produced by Centralab, 900 E. Keefe Ave., Milwaukee, Wis., known as the "Sub-Midget," is an ultra small control for installation in limited spaces. The controls are available in rheostat or potentiometer types with insulated or grounded shafts. The sub-midget is of particular interest to automobile



radio manufacturers who require a tone control with hollow shaft for installation in remote control. The volume control shaft passes through the unit and concentric knobs are used for volume and tone control. The sub-midget is used where resistance curve is not critical; tone and sensitivity controls are its chief application.

Convertible Microphone

A CONVERTIBLE MICROPHONE which can be conveniently and quickly changed from a non-directive to a semi-directive unit, is one of the recent developments of the Bell Telephone Laboratories. A small detachable disk supplied at one end of the microphone makes it possible to use this unit for a wide variety of applications, including directional and non-directional service. The microphone case is cylindrical in shape, with one end rounded off in the form of a hemisphere. Sound waves arriving at the unit from all angles reach the diaphragm within, when the directional baffle is not employed. However, if it is desired to operate the unit as a directional microphone, a snug fitting disc ring is slipped over the hemispherical end with a resultant reduction in the pick-up of sound wave in all directions except that in which the microphone is pointed. When adjusted for non-directional operation, the output response is approximately — 90 db ± 3 db. With the directional adjustment, the low frequency response is substantially the same with a gradual rise in level from — 90 db. at 2,000 cycles to — 80 db. at 9000 cycles. Manufactured by the Western Electric Company.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VARIACS
IMPROVE REGULATION AND
SIMPLIFY CONTROL
IDEAL for maintaining *constant* line voltage or for setting line voltage to *any* predetermined voltage from zero.
Extremely low losses . . . output voltages essentially independent of load.
VARIACS have the smooth control of the rheostat with all of the advantages of the transformer.
Thirteen models with power ratings from 170 watts to 2 kilowatts and priced from $10.00 to $40.00.
Write for Bulletin 126-E for complete data. Address: 30 State Street, Cambridge, Massachusetts. Branch offices in New York, Los Angeles and San Francisco.
GENERAL RADIO COMPANY

Analyzer

"SUPERSENSITIVE" all-purpose analyzer offered by Weston Electrical Instrument Corp., Newark, N. J. Model 772, ideal for servicing present-day receivers and transmitters, television receivers, all-cathode ray tube equipment, telephone and telegraph circuits and photo-electric circuits. It has five d.c. voltage ranges from 0 to 1,000 at 20,000 ohms per volt; five a.c. voltage ranges from 0 to 1,000 at 1,000 ohms per volt; six current ranges from 250 ma. down to ½ ma.; four resistance ranges from 0 to 30,000,000 ohms. Complete with necessary test leads, instruction book and carrying case; net price less Model 666 socket selectors, $46.50.

Direct Reading Analyzer

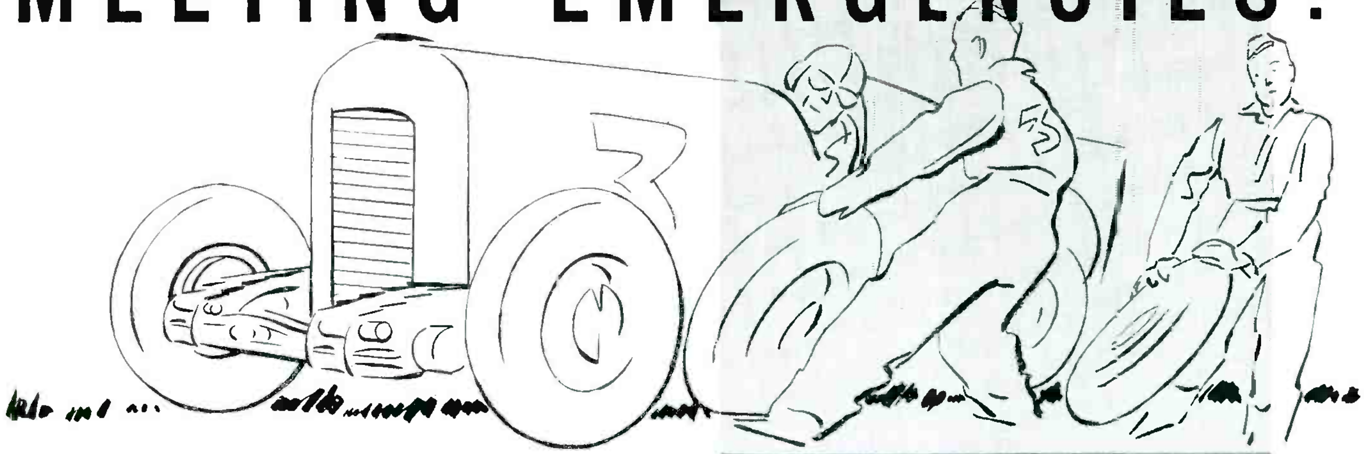
IN ADDITION to offering an unusually complete array of a.c. and d.c. voltage ranges, the Model 95 analyzer recently announced by the Clough-Brengle Co., 2815 W. 19th St., Chicago, has direct reading capacity scales to cover all

values from 250 micromicrofarads to 16 microfarads. The resistance ranges are from ½ ohm to 20 megohms. Operation of this unit is entirely from a built-in power supply. The unit, known as the Model 95 Super Unimeter, is offered in both portable and 19-in. relay rack mounting types.

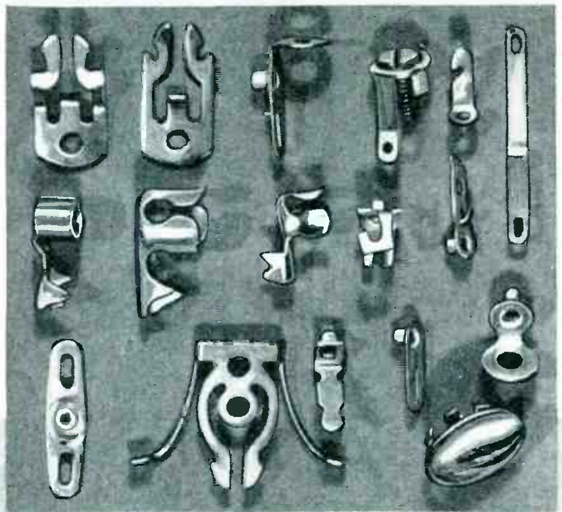
Coaxial Cable

A NEW HEAVY DUTY coaxial cable has been announced by Victor J. Andrew, 7221 South Francisco Ave., Chicago, Ill. This cable, known as Type 22 cable is more than ⅝ in. in diameter and is supplied in lengths up to 500 ft. on cable reels. The cable is recommended for broadcast stations of ratings as much as one kw. although it is claimed that the cable will carry a peak hour of 20 kilowatts.

MEETING EMERGENCIES!



Mechanical knowledge, efficiently applied—and with speed, has made Cinch the creator of innumerable parts to meet emergency conditions in the manufacture of radio sets. Each part shown here was created, designed or adapted to fit a definite need. And so well was this done that these parts have become permanent parts of many sets—and from a dozen to hundreds of variations of each are now in production.



You also meet "emergencies"— Let us help you with the next one. "CINCH" *performance* proves we both benefit.

"Cinch" and Oak Radio Sockets are licensed under H. H. Eby socket patents

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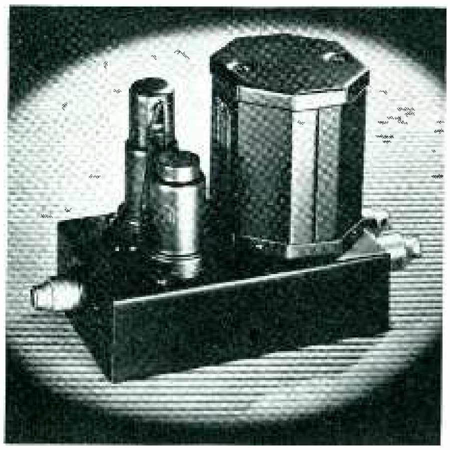
Portable Recording Device

A PORTABLE RECORDING machine intended especially for use in schools and colleges has just been announced by the Universal Microphone Company, Inglewood, Calif. The complete equipment, weighing about 50 lb., is contained in a black leatherette case measuring 16 in. x 22 in. x 9 in. The machine contains a velocity microphone, with folding microphone stand, together with complete recording and playback equipment for instantaneous work. The unit is operated from the 110 volt a.c. line.

Pre-Amplifier

THE UNITED TRANSFORMER CORPORATION, 72 Spring St., New York City, has brought out a pre-amplifier which obtains its power directly from the main amplifier. The pre-amplifier incorporates a resistance coupled amplifier feeding a 6C5 tube. The overall



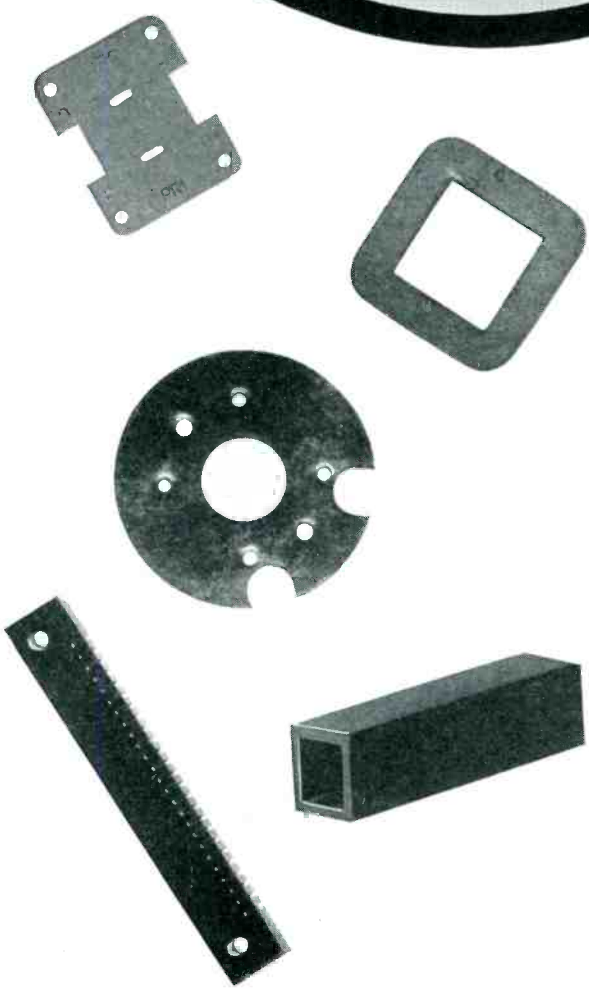
gain is 60 db. A high input impedance is obtained and the output impedance is suitable for feeding into a line. To assure low hum level, additional filtering is provided in the pre-amplifier. If desired, a separate power supply can also be obtained for this unit.

Condenser Mounting Flanges

SLOTTED FLANGES which permit easy mounting of Aerovox PBS cardboard base electrolytic condensers are now available from the Aerovox Corporation, 70 Washington St., Brooklyn, N. Y.

Filament Alloy

UNDER THE NAME of "Tensite", the Wilbur B. Driver Co., Newark, N. J., has introduced a new aluminum-nickel filament alloy adapted to two volt tubes. Tensite has a high tensile strength when heated and provides greater mechanical strength than pure nickel. It may be drawn down to 0.001 of an inch for the filaments of radio tubes.



Condenser Microphone

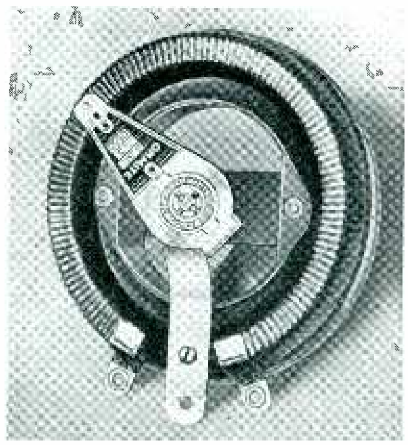
MODEL 490-A bomb condenser microphone is a recent development of the Carrier Microphone Co., 525 S. Commercial St., Inglewood, Cal. Intended for high fidelity use, it has a frequency response which is sensibly flat from 30 to 10,000 cycles per second, and it is claimed that there is no high frequency distortion due to reflection since only a small flat surface is exposed. The amplifier is a single stage affair using a 955 acorn tube with an output of —25 db. The output impedance is either 50 ohms or 200 ohms. The amplifier housing is 3 9/16 inches in diameter and the entire unit, including microphone, amplifier and cable connection weighs but two pounds.

Noise Filter

A NOISE FILTER which is to be inserted between the power line and the radio receiver has been announced by the Technical Appliance Corporation, 17 East 16th St., New York City, and is known as the Type 104 line filter. It is claimed that this device is effective in reducing noise not only in the broadcast stand, but in the high frequency bands of all-wave receivers.

Power Rheostat

A POWER RHEOSTAT, 12 in. in diameter, and rated at 1,000 watts, is announced as a new product of the Ohmite Manufacturing Co., 4833 West Flournoy St., Chicago, Ill. This new one killowatt rheostat is known as Model U and will undoubtedly find wide use in the control of the speed of small motors,



for control of arc welding machines, etc. It is constructed of metal and ceramic materials throughout. The shaft and bushing assembly of this rheostat is electrically dead, being insulated from the live circuit by porcelain insulation capable of withstanding high voltages. Because rheostats of this size are often used in applications where the initial windings are subjected to fairly heavy current, tapered sections are commonly supplied with this rheostat.

Electrolytic Condenser

PLUG-IN electrolytic condenser which fits the standard vacuum tube 810 octal base has been recently placed on the market by the Tobe Deutschmann Corp., Canton, Mass.

Exponential Speakers

THE CINAUDAGRAPH CORP., Stamford, Conn., announces a new series of air-column speakers and horns which differ in construction from the conventional exponential horn unit. Spun aluminum exponential horns are available for use with the speaker unit. The horns are removable from the speaker units and are demountable for ease in transportation. Ring bolts are provided so that the assembled units may be swung from overhead wires or ropes. The smallest of the speakers is the FYA model which weighs 9 lb. without the horn and has a voice coil 1½ in. in diameter with an impedance of 6 ohms. This unit is capable of handling a steady power input of 15 watts or peak power up to 20 watts. It is claimed that the frequency response is substantially flat from 100 to 6000 cycles. The exponential horn for this model has an air-column length of 28 in. and a bell diameter of 24 in. The largest and most powerful unit is the Model FUA having a voice coil 3½ in. in diameter and of 6 ohms impedance. It is capable of handling 30 watts of audio power continuously with a peak of 40 watts.

Factory Call System

A FACTORY call system constructed on the unit principle rather than on the custom built basis, and having the flexibility required for adaptation to any size factory, is announced by the Webster Company, 3825 W. Lake St., Chicago. A feature of this factory call system is said to be the ease with which it can be installed.

Oscillograph

A COMPLETE OSCILLOGRAPH using the 913 cathode ray tube and thyratron linear sweep, with horizontal and vertical amplifiers, combined with an adjustable electronic wobbulator is the description of the Model 77 oscillograph announced by the Triumph Mfg. Co., 4017 W. Lake St., Chicago, Ill. A single full wave power pack employing a type 80 rectifier supplies all the operating voltages. A type 885 gas tube performs the dual function of supplying the linear sweep circuit and the single trace wobbulator. The linear horizontal sweep circuit may be continuously varied from 15 to 35,000 cycles and the electronic wobbulator may be varied to sweep any band width from 0 to 55 kc. The unit is supplied in a portable steel case approximately 14" x 10" x 8" and weighs only 13 lb. Price complete with tubes $49.95.

Neon Test Lamps

Two NEW TYPES of neon test lamps have been developed for use in the radio and automotive fields by the Sundt Engineering Co., 4238 Lincoln Ave., Chicago, Ill. These tubes are classified as the electrodeless type and the current measuring type. The former type produces a discharge between two metal end caps deposited on the outside tips of the tube. The current passing through these tubes is in the neighborhood of 3 microamperes and the current-light ratio is said to be very high. Because of their high impedance, these tubes may be used in high voltage, low current circuits. The current measuring type is of the internal electrode glow tube type in which the length of glow along the 6-inch electrode is a measure of the current passing through the tube. This type may be used for d-c measurements or for indicating the relative current in r-f circuits provided the current through the tube is limited to 10 ma.

Correction

Through a typographical error the name of the Wilbur B. Driver Co., wire manufacturers, was given as William B. Driver in an advertisement in the March issue of *Electronics.*

Literature

✦ **Tube Developments.** Long ago we lost all track of what particular tube type numbers had what characteristics and were suitable for what purpose. Nevertheless, the host of new tube announcements continues. The technical bulletins listed below and received during the past month represent the manufacturer's effort to help out in a complex situation.

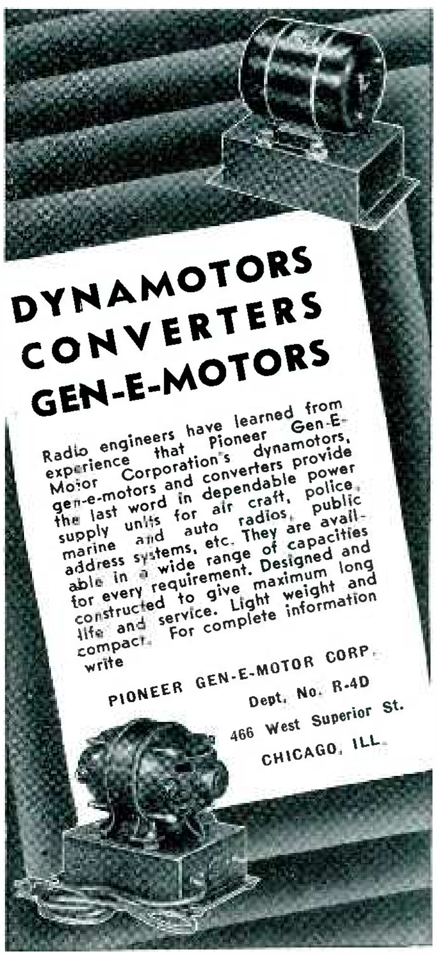
Raytheon has released tentative data sheets on the characteristics of the 5T4 filament type high vacuum rectifier, the 6A5G triode power amplifier, the 6B8G duo-diode pentode in glass envelope, the 6B8 duo-diode pentode in metal envelope, the 6C8G twin triode amplifier and phase inverter, the 25L6G pentode output tube in glass envelope, the 25L6 pentode output tube, the 25A7G rectifier and pentode output tube, the 6Y7G twin triode power amplifier, and the 1G5G pentode power amplifier.

A tentative data sheet on the 5T4 is also issued by the Radiotron Division of the RCA Manufacturing Co., Harrison, N. J. The tube has a d-c output current of 250 ma., a peak inverse voltage of 1250, and an operating voltage of 450 volts r.m.s.

Technical data sheets have been issued by the Hygrade Sylvania Corp., Emporium, Pa., and New York City, covering the characteristics of the 1G5G two volt output pentode, the 6C8G double triode amplifier, the 6U7G r-f pentode, the 6V7G duo-diode triode, and the 25L6G beam power amplifier.

Approval of the ratings of eleven different types of power tubes manufactured by Taylor Tubes, Inc., 2341 Wabansia Ave., Chicago, has been given by the Federal Communications Commission. For high level modulation in the last r-f stage, two of the Taylor tubes are rated at 50 watts, three at 75 watts, two at 125 watts, and four at ¼ kw. For low level modulation or for the last r-f stage operating as a linear power amplifier, four tubes have been rated at 25 watts, one at 50 watts, and four at 75 watts.

✦ **Condenser Catalog.** Catalog 8-F entitled "Radio Capacitors" and published by the Solar Manufacturing Corporation, 599 Broadway, New York City describes a complete line of wet electrolytic capacitors, dry electrolytics, paper, and mica insulated condensers of various capacities and types of construction. In addition to the condensers described there is a description of a commercial unit of the bridge type for measuring capacity, power factor, resistance, and which may also be used to detect defects in commercial condensers.



✦ **Recording Equipment.** A price list of accessories for recording, such as needles, aluminum and cellulose discs, etc., is available from the Mirror Record Corporation, 58 West 125th Street, New York City.

✦ **Interference Data.** A condensed summary on methods of eliminating man-made interference in home and auto radio installations is contained in a handy booklet released by the Continental Carbon, Inc., Cleveland, Ohio. This 24-page vestpocket booklet is obtainable for ten cents from the Continental Carbon Distributors or direct from the factory, 13900 Loraine Avenue, Cleveland, Ohio.

✦ **Beam Power Amplifiers.** The operation of the 6L6 beam power tube and distortion stabilized feedback circuit are discussed in a technical bulletin and catalog entitled "Beam Power Amplifiers," published by the United Transformer Corporation, 72 Spring Street, New York City. Amplifier components, as well as kits suitable for building amplifiers are listed.

✦ **Magnet Steel.** The technical characteristics, applications, and uses of a magnet steel commercially known as Nipermag is described in a four-page bulletin issued by the Cinaudagraph Corporation, Stamford, Conn.

✦ **Low Loss Parts.** A bulletin describing the Boonton high-Q radio components for laboratory and receiving purposes is available from Boonton Radio Corporation, Boonton, N. J.

✦ **Lacquer Finishes.** A series of technical bulletins describing various lacquers and chemical resistant finishes which are finding use in the radio field, are available from the Roxalin Flexible Lacquer Company, Elizabeth, N. J.

✦ **Antenna Systems.** A 12-page technical bulletin describing the installation of master antenna systems for hotels and apartments has been issued recently by The Technical Appliance Corporation, 17 East 16th Street, New York City.

✦ **Platinum Products.** A 44-page illustrated booklet illustrating the use of platinum laboratory ware, and alloys of platinum and other precious metals is the catalog No. 16 of the American Platinum Works, Newark, N. J. Of special interest to tube manufacturers is a section dealing with the use of platinum wires for tube filaments.

✦ **Nickel Silver.** The Riverside Metal Company, announce that a new edition of their reference work on nickel silver is about to come from the press. This is a 48 page booklet giving complete data on sheet, strip, wire and rod alloy of nickel material. It is available for free distribution. Address 1 Pavillion Ave., Burlington County, Riverside, N. J.

✦ **Radio Parts.** A 42-page catalog of Yaxley switches, condensers, rectifiers, jacks, and other component parts has just been released by the P. R. Mallory & Company, Inc., Indianapolis, Ind. In addition to the regular catalog section, several pages are devoted to specifying suitable replacement units which may be used in assisting the service man to make a quick and suitable selection of material for his needs.

✦ **Optical Equipment.** A loose-leaf booklet of particular interest to college, industrial and research laboratories describes the universal optical bench and other optical equipment manufactured by R. Fuess, Inc., 245 West 55th Street, New York City. The optical bench is provided with a complete set of accessories, lens holder, iris diaphragms, microscope screen or filter lamp houses, riders, and other specialized units. The flexibility of the equipment described enables the research worker to carry on investigations in spectroscopic examination, microscopy, or photomicrography with the minimum investment of capital.

✦ **P-A Equipment.** A series of amplifiers and portable sound systems is described in an 8-page folder giving technical information on the products of the Amplifier Company of America, 37 West 20th Street, New York City.

✦ **Transformers.** A transformer intended for the operation of neon signs and having an unusually attractive appearance is described in a technical bulletins issued by the Acme Electric & Manufacturing Company, Cleveland, Ohio. These transformers are available in stock sizes from 60 to 210 watts.

✦ **Sound Equipment.** Bulletin S-36 recently issued by the Atlas Sound Corporation, 1451 39th Street, Brooklyn, N. Y., describes a series of horns, speaker units, stands, deflector baffles, microphones, and amplifiers for general public address and sound distributing work.

✦ **Recording Equipment.** A folder entitled "How Radio Stations Use Instantaneous Recording," published by the Presto Recording Corporation, 139 West 19th Street, New York City, enumerates some two dozen different uses for Presto recording turntables and related equipment.

✦ **Resistance Manual.** A handy, pocket size manual, in durable cover, containing complete resistor information for engineers and designers of electric and electronic equipment has just been issued by the International Resistance Company, 401 North Broad Street, Philadelphia, Pa.

✦ **Electric Equipment.** The Bull Dog Electric Products Company, of Detroit, Mich., issued a new edition of their catalog January, 1937. The products described are controlling and distributing switches, cabinets and other apparatus for electric light and power distributing systems.

✦ **Test Equipment.** Technical bulletins and price lists have been received describing the type 100AQ meter and the type 110AQX checker, both manufactured by the Boonton Radio Corp., Boonton, N. J. The Q meter is a high speed laboratory and factory instrument for the measurement of the electrical characteristics of coils, condensers, resistors, and other circuit components in the frequency range from 50 kc. to 50 mc. The QX checker is a precision instrument for the production testing, grouping, and adjusting of coils and condensers at radio frequencies. Over the ordinary bridge method of measurement it provides a more simple, dependable, and stable method of comparing Q and L or C in one operation.

✦ **Relays.** Technical data sheets describing sensitive relays manufactured by Sigma Instrument, Inc., 388 Capello Road, Belmont, Mass., are available. The type 1-A relays have a field resistance of from 2½ to 6,750 ohms and are rated to operate on 4 milliwatts d.c. The type 2-A relays are available with field resistance values up from 100 to 8,000 ohms and are rated at 12 milliwatts, d.c. The latter are provided with contacts which will handle 150 watts non-inductive loads whereas the type 1-A will handle 50 watts at 110 volts a.c.

✦ **Transmitter.** A technical bulletin describing a 1,000-watt transmitter manufactured by the Transmitter Manufacturing Co., 130 Cedar Street, New York City features a completely band switching exciter unit, automatic plug-in chassis, channel protected cabling, grid excitation control, no neutralizing adjustment, power control grid for half or full power output, complete remote control facilities, and a high fidelity speed amplifier combined with a two-channel mixer.

✦ **Wires and Cables.** Bulletin BW3 issued by the General Cable Corporation, 420 Lexington Avenue, New York City, describes a complete line of electrical conductors for power and lighting circuits. In addition to providing a catalog on General Cable products, the 48-page booklet contains a number of pages of useful general information on electrical characteristics of conductors, conversion tables, etc.

✦ **Resistors.** Catalog No. 15 describes rheostats and resistance units for the industrial, radio, and electronic fields which are manufactured by and available from the Ohmite Manufacturing Company, 4835 Flournoy Street, Chicago, Ill. In addition to the usual line of variable and fixed resistors information is also presented on T- and L-pad attenuators having power dissipation of 25 and 50 watts.

Fig. 1

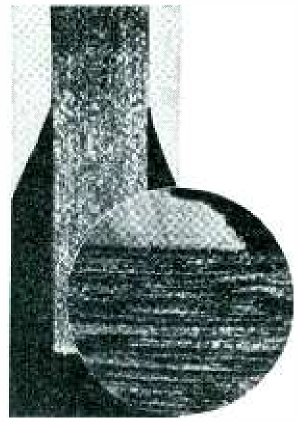


Fig. 2

Radio Engineers Will Hold 25th Anniversary Meeting in New York

NEW YORK — Celebrating the 25th anniversary of its organization, the Institute of Radio Engineers will hold its annual meeting at the Hotel Pennsylvania May 10, 11 and 12.

Over 1,500 of the geniuses and technicians responsible for the development and growth of the amazing industry of radio broad casting and communication change views in prepara greatest year in hi

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IN THIS ISSUE EDITORIALLY

Will be a review of the radio art during the 25 years of the Institute's growth in this amazing industry. It will feature articles on set production, broadcasting, aircraft communication and other branches of the radio industry. It will contain the full story of the convention and its background — a useful and valuable record for those who attend the convention and those who cannot.

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ETERNAL ROAD

[*Continued from page* 29]

pended from booms about 10 feet from the floor, 10 feet apart and 8 feet from the nearest instruments. They were pointed toward the back row of instruments, compensating to a large extent for the different distances to the various instruments. The ribbon microphone is most sensitive in the direction at right angles to the axis of the ribbon and falls off to zero sensitivity in the direction parallel to the ribbon. The fact that these microphones have equal sensitivity on the two sides made it possible to obtain an intimate pickup from one side and a reverberant pickup from the other side. The best balance between direct and reflected sound was obtained by the simple process of varying the distance between the microphones and the orchestra.

The necessary recording equipment, a high fidelity monitoring system and a push-pull film phonograph were assembled in an adjoining room. The output from each of the microphones was fed through cables to a pair of microphone amplifiers. These in turn were fed into a mixing panel with the necessary facilities for mixing the output from the two microphones, for adjusting the level of either microphone and for adjusting the level of the combined signal. From the mixing panel, the signal was fed into the recording amplifier connected to the recording galvanometer. A Neon type volume indicator and a monitoring amplifier were bridged across the recording amplifier. The volume indicator consisted of 13 small neon lamps connected in such a way that as the signal was raised, each lamp in turn would light at a predetermined level. The indicator covered a range of 48 deg. It was placed just over the mixing panel so as to be easily visible by the mixer. A monitoring speaker at one end of the room was used to judge the quality and balance of the orchestra. The push-pull film phonograph and the recorder were equipped with three-phase synchronous motors, thus insuring perfect synchronism.

During the recording of the orchestra selections, it was necessary to compress the volume range somewhat. The original volume range of the orchestra was about 55 db. It was found advisable to compress this to about 45 db. by allowing the very loud passages to overshoot the sound track as much as 3 db. and by raising the level as much at 7 db. during the very weak passages. So that the time for the loud and weak passages could be known in advance, the mixer followed the musical score and made the necessary volume changes smoothly and slowly.

After the orchestra recordings had been completed, preliminary prints were made for the purpose of synchronizing the subsequent chorus recordings. A chorus of seventy-five voices was assembled in the large hall. Each member was given a Sonatone bone conduction receiver which fastened behind his ear. The director, who was also supplied with a Sonatone receiver, occupied a partially sound proof booth with a window facing the chorus. All of the receivers were connected in parallel and were fed from the film phonograph amplifier. In this way recordings were made of the chorus singing in perfect synchronism with the accompaniment of the orchestra.

The final prints of all the recordings were made on an ultra-violet non-slip printer. Even though the negatives were perfect, the full quality could not be transferred to the print if intermittent slippage occurred between the films during the printing operation. With the sprocket type printer in common use at the present time, it is nearly impossible to prevent intermittent slippage. The non-slip printer automatically compensates for film shrinkage and insures perfect contact and no relative motion between films. The use of ultra-violet light for printing further improves the quality by restricting the exposure to the surface of the print.

The negatives were recorded on regular positive sound recording film. They were processed to a gamma of about 2.0 and a density of 1.9. The prints were made on regular motion picture positive film and were processed to a gamma of about 2 and a density of 1.4.

Four push-pull soundheads are employed as film phonographs to reproduce "The Eternal Road" music in the Manhattan Theatre. A Selsyn generator supplies the power for the soundhead motors so that they can be interlocked. The orchestra and chorus are reproduced from two of the film phonographs while the other two are used for sound effects. A mixing console has facilities for mixing any or all of the outputs from the four films and for varying the levels. A number of loudspeakers on the stage permit the sound to be directed to the audience from various points. The orchestra may be allowed to come from one direction, the chorus from another and sound effects from still another. In addition to the recorded sound, provision is made for the direct pickup of a small chorus, individual voices, and local sound effects.

• • •

PATENT SUITS

1,403,475 (*a*), H. D. Arnold,; 1,403,-932, R. H. Wilson; 1,507,016, L. de Forest; 1,507,017, same; 1,811,095, H. J. Round; 1,936,162, R. A. Heising; Re. 18,579, Ballantine & Hull, D. C., N. D. Ill., E. Div., Doc. 14976, *R.C.A. et al.* v. *Hetro Electrical Industries, Inc., et al.* Consent decree, holding patents valid and infringed; injunction April 13, 1936.

1,403,475 (*b*), H. D. Arnold; 1,403,-932, R. H. Wilson; 1,507,016, L. de Forest; 1,507,017, same; 1,618,017, F. Lowenstein; 1,702,833, W. S. Lemmon; 1,811,095, H. J. Round, filed Dec. 17, 1936, D.C., S.D.Calif. (Los Angeles), Doc. 1078-M, *R.C.A. et al* v. *J. Forbes.*

1,403,475 (*c*), H. D. Arnold; 1,403,-932, R. H. Wilson; 1,507,016, L. de Forest; 1,507,017, same; 1,618,017, F. Lowenstein; 1,702,833, W. S. Lemmon; 1,811,095, H. J. Round; Re. 18,579, Ballantine & Hull, filed Dec. 4, 1936, D. C., S. D. Calif. (Los Angeles), Doc. 1064 C, *R.C.A. et al.* v. *B. S. Rothenstein (Pathe Radio & Television Co.)*. Same, filed Dec. 17, 1936, D.C., S.D. Calif. (Los Angeles), Doc. E 1082-J, *R.C.A. et al.* v. *F. Sage.*

1,815,768, A. Georgiev, Electrolyte, D. C., S. D. N. Y., Doc. E 76/188, *Aerovox Corp.* v. *Bruno-N. Y., Inc.* Dismissed without prejudice Jan. 11, 1937.

1,354,939, H. D. Arnold; 1,459,412, A. M. Nicolson; 1,479,778, H. J. Van der Bijl; 1,893,466, R. F. Gowen, filed Dec. 16, 1936, D. C., S. D. Calif. (Los Angeles), Doc. E 1077-J, *R.C.A. et al.* v. *Pacific Trading Co.*

U. S. PATENTS

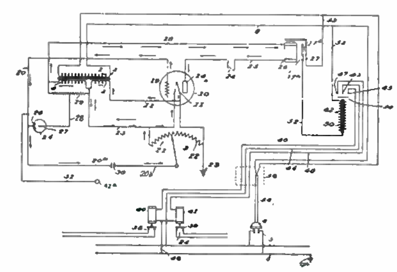
Electron Tube Applications

Ignition testing. A device comprising a vacuum tube with connections to the contacts of an interrupter of an internal combustion ignition system, an illuminating element and a rotating apertured element for viewing the illumination. W. P. Brush, San Francisco, Calif. No. 2,067,256.

Pressure measurements. In connection with an engine including a chamber in which a fluid undergoes rapid variations of pressure, the chamber is provided with an aperture to which is fitted a diaphragm, one side of which has a reflecting surface. Light is projected onto this reflecting surface and its variations are the measure of the pressure variations within the cylinder. Marcel Demontvignier and André Labarthe, France. No. 2,067,262.

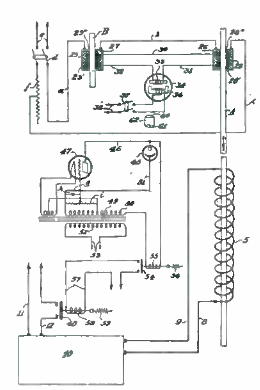
Elevator control. Use of a gaseous discharge tube, a condenser and resistance for effecting delay periods, etc. A. A. Chubb, G. E. Co., Ltd. No. 2,067,378.

Touch sensitive apparatus. A photocell, an amplifier, a relay, etc., in a bridge circuit, the bridge constituting a balanced circuit when the photocell



is darkened and the touch control element is undisturbed by proximity of a body thereto. E. V. Bereche, Industrial Electronic Control Co., Inc., New York, N. Y. No. 2,052,916.

Heat-treating. Apparatus for heat-treating a ferrous metal strip comprising an electric furnace, a heated



strip and a standard strip with means whereby the differences in permeability between the portion of the strip passing through the furnace compared to the permeability of the standard piece will cause operation of the furnace control means. A. R. Stargardter, Gillette Safety Razor Co., Boston. No. 2,059,976.

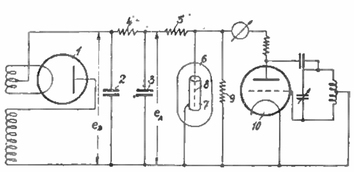
Potentiometer indicator. Electrical bridge comprising photo elements, an amplifier, etc. R. W. Gilbert, Gilbert Corp., East Orange, N. J. No. 2,059,786.

Metal detector. Apparatus for detecting the presence and locating metallic bodies hidden beneath the surface of the ground, comprising an exploring coil, an oscillator, etc. H. L. Berry, Tucumcari, N. M. No. 2,048,591.

Welding. In an electric spot welding machine, use of a rectifier tube for control. David Sciaky, Paris, France. No. 2,054,343.

Pressure measuring. Use of piezo-electric crystal to record the magnitude of and the variations in the pressure exerted between two elements. R. J. Beavers and H. R. Laird, Western Electric Co. No. 2,054,787.

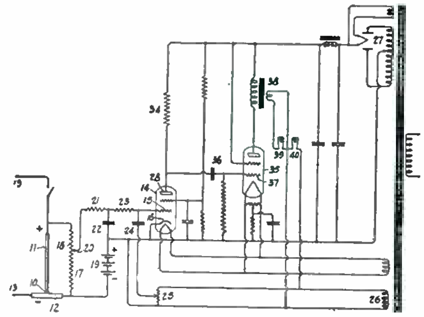
Voltage control. A system for obtaining constant voltage from an electric current source having a variable



voltage by means of glow discharge tubes. Kurt Schlesinger, Berlin, Germany. No. 2,054,883.

Alarm. Device for indicating illumination values, a time survey and means to prevent momentary fluctuations in illumination causing a change in the signal. A. H. Lamb, Weston Electrical Instrument Corp. No. 2,054,380.

Voltage indicator. Indicating to an arc welding operator the voltage of his welding arc. W. Richter, A. O.



Smith Corp. No. 2,045,801. See also No. 2,045,800, arc length indicator, and No. 2,045,803, welding apparatus.

BRITISH PATENTS

Modulation system. Modulation is effected according to the floating-carrier method, by using Class B amplifiers for the modulating-voltage, and by utilizing the variation in their direct current resistance to alter the grid or plate-voltage of the carrier-wave amplifier, and to raise and lower the carrier level according to signal volume. British Thomson-Houston Co., Ltd. No. 453,732.

Automobile antenna. An aerial for use on an automobile consists of a U-shaped dipole, broadly tuned to the frequency at which the most serious ignition interference occurs. R. M. Smith, Marconi Co. No. 453,736.

Oscillator. A feed-back oscillator giving considerable power output comprises a multi-grid tube with one grid employed for feed-back and with the frequency controlled by oscillations from a separate control oscillator applied to another grid. Marconi Co. No. 453,852.

Automatic tuning. The muting of a noise suppressor system is removed by a voltage produced by the error detector which is inoperative as regards action on the tuning system during manual tuning. Murphy Radio, Ltd. No. 453,858.

Mosaic. A photo-electrically sensitized mosaic screen for use in a cathode-ray-tube forms a finely apertured wire base such as gauze, which is rolled flat and then insulated by an enamel which enters the apertures; the apertures are then filled with metal either by pressing the material in paste or powder form, or by depositing the metal electrolytically. This may be effected on to a backing plate subsequently removed by grinding. The mesh may have 22,500 or 40,000 openings per square inch. One side of all the metal insets is then coated with photo-sensitive material. In a modification the screen may be formed from a thin metal sheet by a photo-engraving process by which a pattern of the apertures is photographed on a thin plate and an acid is applied to eat away the material unprotected by the photographic layer; the layer is then cleaned, enamelled and filled with metal which is sensitized on one side. L. E. Flory, Marconi Co. No. 454,422.

Wide band amplifier. Uniform amplification over a band of frequencies is obtained by coupling tuned grid and anode circuits of a high frequency amplifier through an ohmic resistance. Philips. No. 454,435.

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Sound Pictures and Public Address
Personnel in sound pictures and electrical transcription recording studios; in studios recording sound for home, public address or theatre entertainment; manufacturers and users of public address equipment; and manufacturers of components entering into this type of equipment.

Industrial Electron-Tube Equipment
Personnel in the plants of manufacturers and users of electron tubes and associated apparatus for industrial purposes such as control, power conversion and transmission, packaging, sorting, counting, traffic control, etc., medical equipment and components entering into such equipment.

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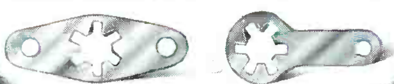
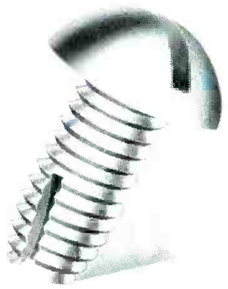
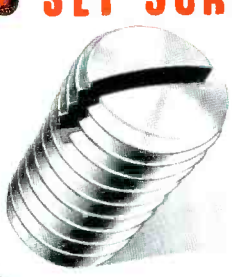


2 TAPPING SCREWS
WITH STANDARD MACHINE SCREW THREADS

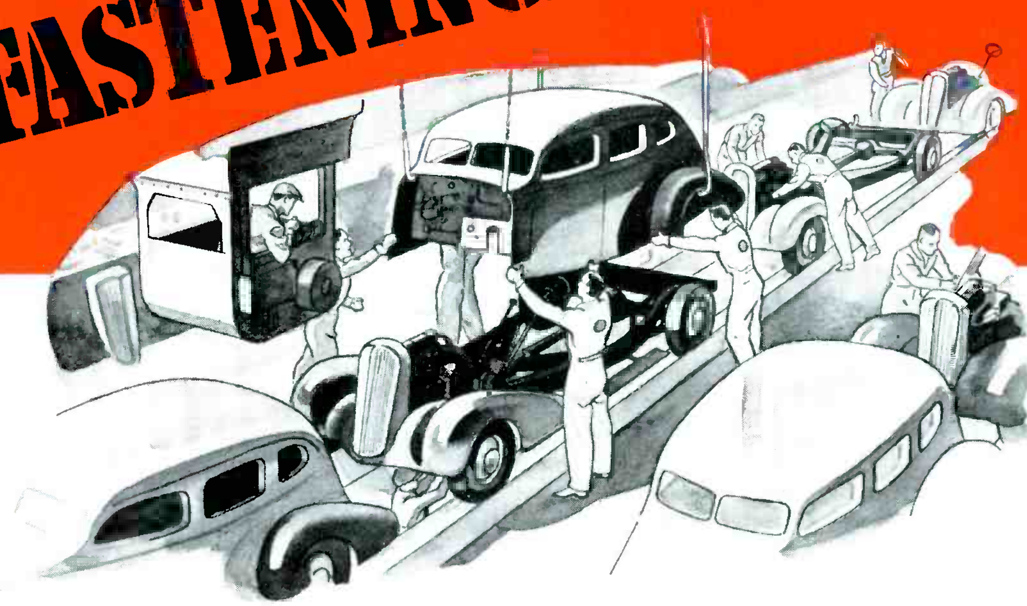


3 SELF-LOCKING SET SCREWS



4 SPRING WASHERS . . PLAIN PARTS

OFFERS A FOUR-FOLD FASTENING SERVICE



● To the metal products industries of America, the name Shakeproof represents far more than a source of supply. Rather, it has been an inspiration for better assembly methods—reduced unit costs, quickened production and improved performance of finished goods. With a background of precision manufacturing and metallurgical research, Shakeproof's engineering department is continually striving to improve Shakeproof products and develop still better metal fastening methods and materials . . . . . . If you have not taken advantage of Shakeproof's Four-Fold Fastening Service, do so now! Inquiries on specific problems are given immediate attention. Descriptive literature and test samples of any Shakeproof product will be furnished on request. Write us today!

U. S. Patent Nos.
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Patents Pending
Foreign Patents
Copr. 1937
Illinois Tool Works

SHAKEPROOF LOCK WASHER COMPANY

Distributor of Shakeproof Products Manufactured by Illinois Tool Works

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