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Features of the new WOR

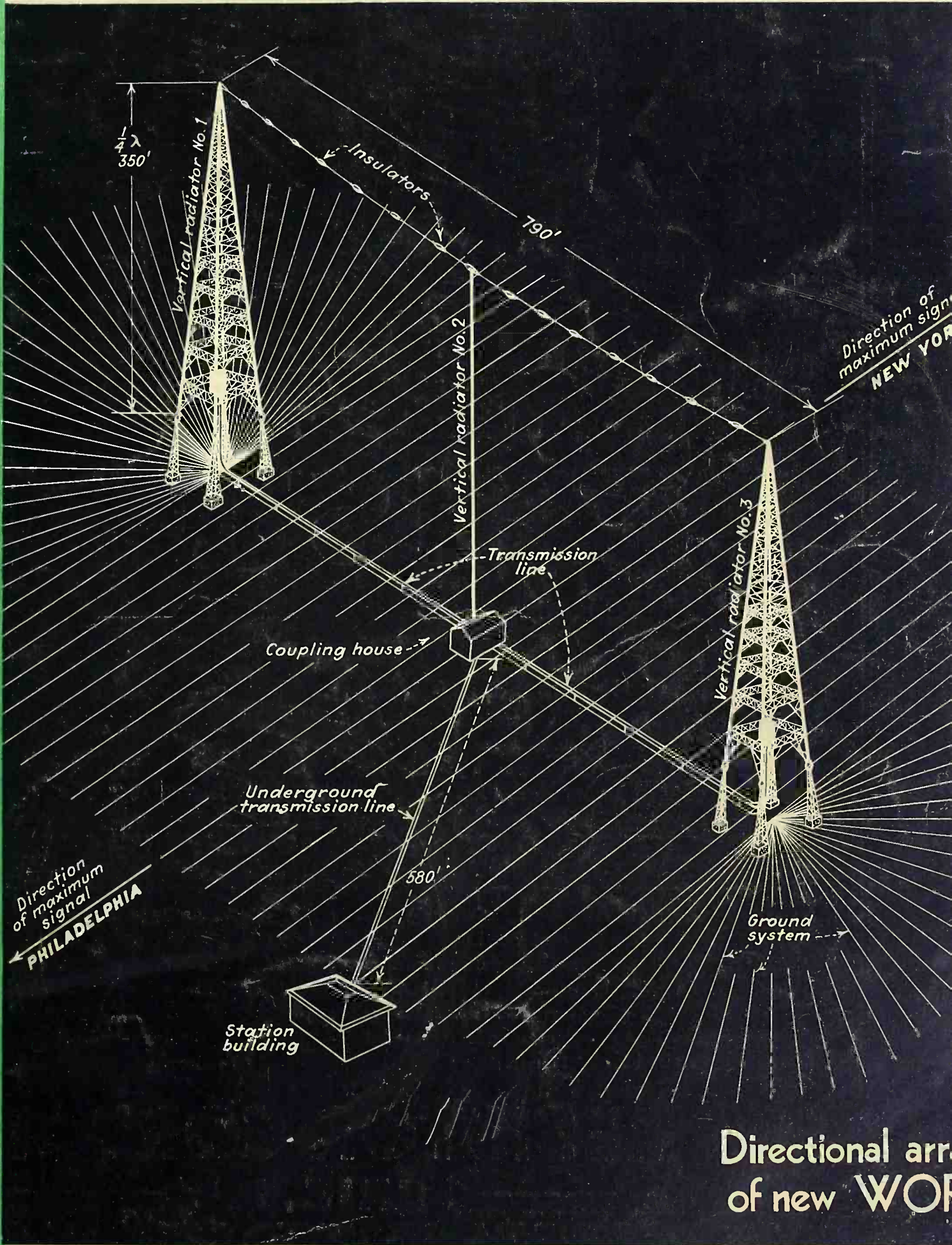
Vertical antenna calculations

D-c power transmission

Engraving on film -a new recording process

Problems of auto-radio antennas

Wired radio in Europe



Directional array of new WOR

McGRAW-HILL PUBLISHING COMPANY, INC.

Price 35 Cents

FEBRUARY, 1935

ELECTRONICS, February, 1935. Vol. 8, No. 2. Published monthly, price 35c. a copy. Subscription rates—United States, $3.00 a year. Canada, including duty, $3.50 a year. All other countries, $4.00 a year or 16 shillings. Entered as second class matter April 4, 1930, at Post Office at New York, N. Y., under the Act of March 3rd, 1879. Printed in U.S.A. Cable address "McGrawhill, New York." Member of A.B.P. Member of A.B.C. 330 West 42d Street, New York, N. Y.

Printed by The Schweinler Press, N. Y.

NEW YORK:
McGRAW-HILL
PUBLISHING
COMPANY, INC.

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February 1935

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Making history!

THREE epochal electronic developments were presented at the A. I. E. E. convention at New York last month, (1) the million-cycle co-axial conductor system; (2) direct-current power transmission with tube rectifiers and inverters; and (3) tube-commutated motors in large units.

THE whole problem of television may be changed by the revelations of what co-axial conductors and even open-wire circuits can do in the transmission of frequency bands several thousand kilocycles in width. The lower intensity levels required for television, make such wire transmission feasible with repeaters every 50 miles or so, it now appears. At a stroke, this means the "chaining" together of television stations, and possibly even "wired television" right to the customer's premises. The new co-axial construction also permits elaborate telephone carrier systems with 200 or more tuned telephone channels operating over a single conductor.

HIGH-TENSION direct-current power transmission, through rectifier and inverter tubes, means new simplicity and efficiency of operation. Circuits of various frequencies can be tied together, and energy can be delivered at any desired set of periodicities, as outlined in detail on following pages.

THE new Thyratron-commutated motor, already built in units up to 400 kw., operates on a.c., yet has smooth variable-speed torque, and has continuous power control from standstill to full speed. Tubes serve both as rectifiers and as commutating devices, providing a simple fool-proof speed-control system. In short this amazing motor exhibits delicacy, quickness and accuracy of power control, unapproached in any other large power motor unit. One of the large utility systems is now installing one of these new tube-commutated 4000-volt 400-hp. motors. Twenty or more other papers outlined current electronic methods for the benefit of the A. I. E. E. membership.

"After this week, I feel as if I were starting to school all over again," aptly commented one important electrical-engineering executive.

THE NEW WOR

Unique radiation system is outstanding feature of new 50 kw. transmitter at Cartaret, N. J.

SEVERAL important new developments in the broadcast field will be introduced when the new 50-kw. transmitter of WOR goes on the air next month. Following the recent trend toward directional antennas, the antenna of the new station is designed to concentrate the radiated power in the direction of the great population centers in New York and Philadelphia. The location of the transmitter, at Cartaret, N. J., about 17 miles southwest of New York, makes coverage of both cities feasible.

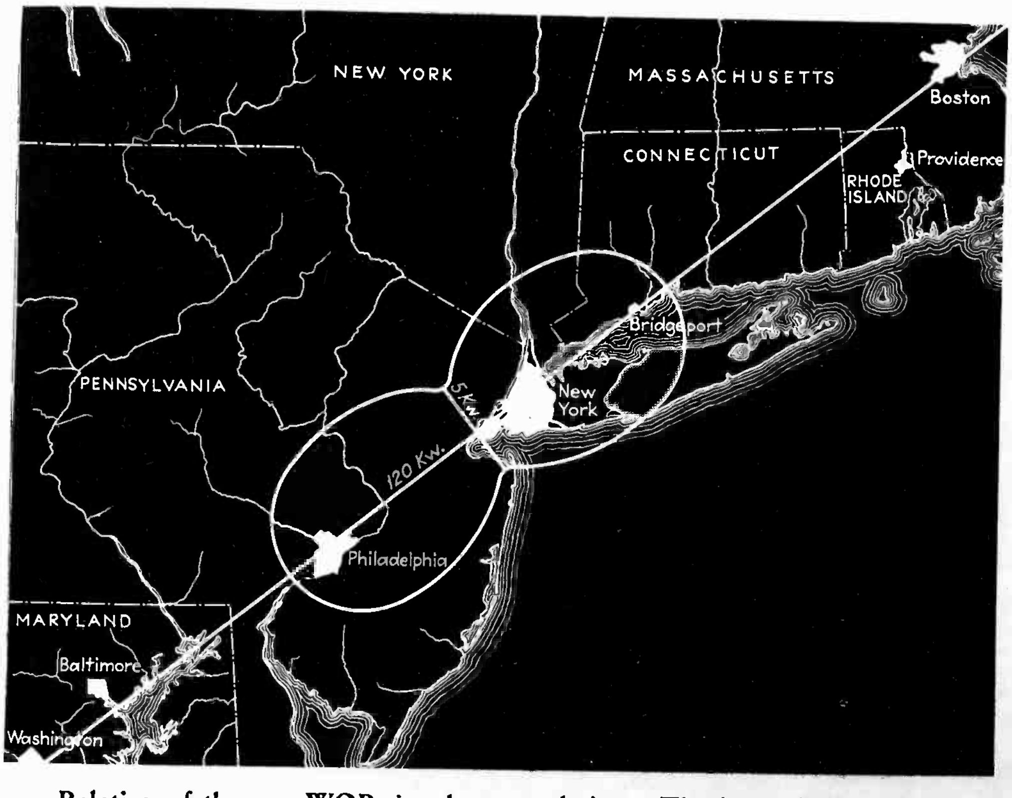
In the antenna design the engineers did not disregard the audience to the west and east of the transmitter, however, but made special provision for covering this area with a signal sufficient for its needs, while still conserving the bulk of the power for the north-south direction. The signal directed to New York is the equivalent of 120 kw., while the signal to the west and east is of the order of 5 kw., sufficient for the low-noise-level unpopulated areas westward to the mountains of New Jersey and eastward to the Atlantic. The antenna system is made up of three vertical radiators, two towers and a third wire suspended vertically midway between them. The towers give the strongly directional pattern, while the middle radiator modifies the pattern to give a useful signal at right angles to the main beam.

The relation of the radiated signal to the population served was the most important factor in designing the antenna system. In the accompanying figure, the result of this design can be pictured clearly. The transmitting antenna is located so that the axis of the maximum signal (corresponding to 120 kw. as radiated from a non-directional system) runs in a northeasterly direction, through the line connecting Cartaret, New York and Philadelphia. While these two latter cities are the most important, since they lie within the primary service area of the station, it is nevertheless true that Boston, Providence, Hartford, Bridgeport, Baltimore and Washington are also located on the axis of maximum signal, and will therefore be served with a useful signal, at least during daylight non-fading hours, and when noise conditions are not heavy.

In the illustration, the contour shown is actually the theoretical signal contour at one mile from the antenna, and does not represent, therefore, the actual radiation pattern over the area shown. The distortions of the contour due to ground attenuation, and the strong signal always noted over water will make the actual contour differ in shape to some extent. The contour shown corresponds roughly, however, to the five-millivolt signal produced by the antenna system. It will be seen that the cities of New York and Philadelphia are inside the five-millivolt contour; and since these cities also lie within the fading range of the station, the nine million population of these two cities will always have full service.

The towers, which are 385 feet high, and the middle wire are phased together and fed from a concentric transmission line, part of which is buried underground, a new departure in broadcast transmission line practice. The transmission line leaves the station building buried six feet underground and travels directly to the middle radiator, where it comes to the surface, feeds the middle radiator through a phase delay circuit, and then branches out to the towers on either side. The concentric line between the middle radiator and the towers is supported above ground on a specially constructed cat-walk.

The use of the buried transmission line was undertaken for several reasons. Trouble from expansion due to sudden heating or cooling will be largely done away with, since the temperature six feet down is fairly constant, or at worst damages slowly. Furthermore, the transmission line is thus removed from the field of the antenna and r-f feedback troubles are minimized. The transmission line is constructed from a $\frac{5}{8}$-inch tube housed in the center of a 3-inch copper tube. The center conductor is insulated with ceramic sections installed at regular intervals along the line. The entire line is airtight, and filled with a 10-pound pressure of nitrogen, which will keep air and moisture from entering the tube and changing the characteristics of the line. Expansion joints are provided



Relation of the new WOR signal to population. The hour-glass figure is the theoretical signal contour at one mile from the transmitting antenna, superimposed on the map of the service area. Note the amazingly large population centered on the axis of the 120 kw. signal

to permit the tube to change its length as the temperature changes, since these changes can become of serious proportions in the long length of the line, 1,400 feet total.

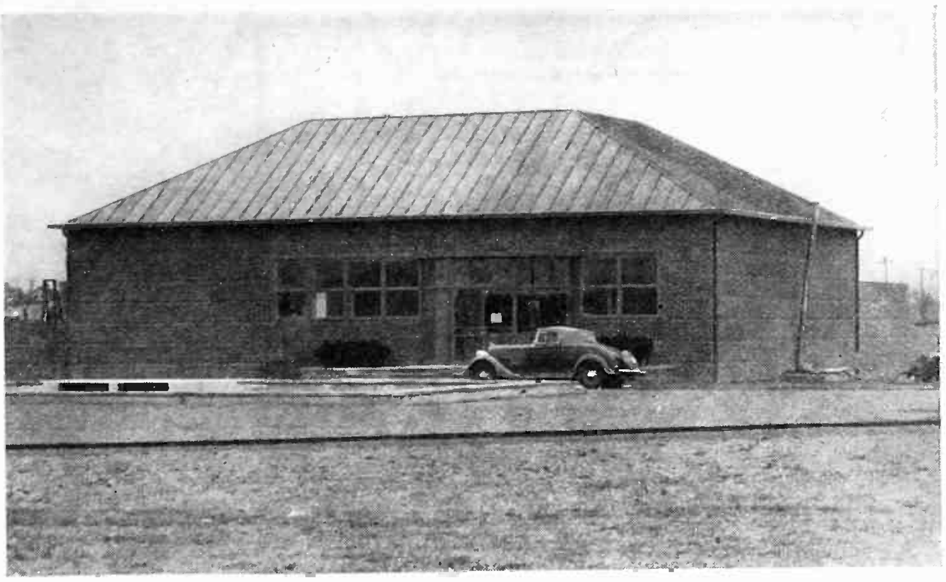
Beside the antenna, the transmitter building itself is of unusual interest. The building is entirely without windows, and is heated from the water used to cool the plates of the large power amplifier tubes, special heat interchange coils being used in the circulating system. The 110 kw. of energy which usually goes to waste in stations of this size is thus made use of in cold weather. During the summer, the water is cooled through the usual spray pond. The building contains 14,000 welded connections in its extensive grounding system and wherever else a good electrical connection is needed. There are no overhead conductors inside the building nor outside it. There is a mile of conduit laid in the floor, most of it in use, some reserved for future use. The entire transmittting installation, front panel and back is visible to the public through a glass-lined passageway which leads behind the transmitter proper. Even the supply of spare transmitting tubes is mounted in a display rack and fully visible to the visitor.

The building contains three separate transmitters and space for a fourth. Beside the main 50-kw. transmitter, the present 5-kw. transmitter of WOR will be installed as a stand-by auxiliary. It can be switched to the antenna, if the larger transmitter fails, directly from the control desk in two seconds if the filaments are hot, and within 30 seconds from a completely cold condition. The antenna switch which connects the transmission line to the main or auxiliary transmitters is mechanically interlocked so that it cannot be operated while r.f. is being generated by either transmitter.

A small beacon transmitter will also be operated for the benefit of airplane pilots who fly the nearby air lane between Newark and Philadelphia. Since the antenna towers are only a mile or two distant from this line a warning signal is sent on the frequency of the direction beacon so that the pilot is warned of the nearby antenna. Beacon lights on the towers and on the roof of the building are also provided as aids to airplane navigation. These lights are turned on and off automatically by a Weston Photronic cell. If the light in the main revolving beacon goes dead, a spare is automatically switched in place, and a signal light on the control operator's desk indicates that the burn-out has occurred. In addition to the beacon transmitter a 49-meter short-wave transmitter will be installed shortly.

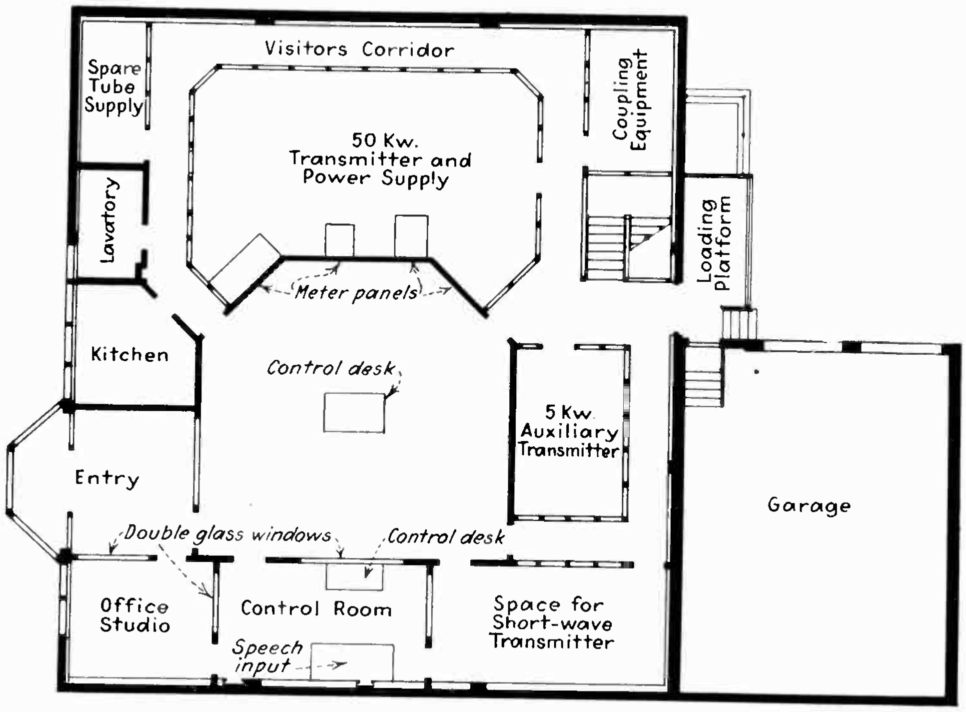
The power requirements of the station, 235 kw. when operated at 100 per cent. modulation, are supplied from one of two separate power lines entering the station underground from two different directions. The power cost is $30,000 per year. The control operator sees signal lights which show him if both power lines have power available, and which of them is actually being used at the time. Complete safety features are provided throughout the installation. The keys to open the doors of each transmitting section must be removed from a special key rack which automatically grounds the high tension buses when the key is removed. Doors to the behind-panel sections all have, in addition, power interlock switches.

The main transmitting room is laid out with the main control desk in the center, facing the control transmitter panels, which are grouped about it in a modified horseshoe pattern. Besides the signal lights and control relays available to the operator at the desk, he has complete view of all meters directly on the panels and of a special control panel which is one of the outstanding features of the station. This



The completed station building. Note the complete absence of any overhead conductors leaving or entering the station. Buried power lines, telephone cable, and an underground r-f transmission line to the antenna make this neat-looking installation possible

Plowing in the ground system. 35 miles of copper conductors were buried by this method, to provide the necessary ground plane



The floor plan of the transmitting building. The corridors surrounding the main transmitting equipment permits visitors to view it during operating hours

panel, mounted integral with the main panel of the transmitter, contains indicating devices which show the blower air temperature, the cooling water temperature, and which indicate the operation of all interlocking devices and tubes. If a shutdown occurs, the operator, by looking at the signal lights on this panel, can tell at just what point the trouble has occurred. If the panel windows are open, if the transmitter gate is open, if the coupling house gate is open, if the temperature of the cooling water has risen to the danger point, if the rectifier-blowers are not operating, any one of which could cause a shutdown, a light indicates just which one of these possible sources is at the root of the trouble. In addition tube overload indicators are mounted in this panel, one for every important tube in the station. If a rectifier goes bad, or if an amplifier burns out, a signal light corresponding to that particular tube flashes, and the operator is able to go directly to that tube and make a replacement with the least possible delay.

Meters are also provided on the transmitter panel which show the antenna current in the radiation system. No direct electric connection is made from the antenna to this meter; a magnetic coupling device mounted in the tuning house and used in conjunction with a thermocouple gives the indicating current.

The station is provided with high fidelity equipment throughout. Two duplicate cable lines lead to the studios in Newark and New York. These lines have a cut-off as high as 8500 cycles and as low as 30, and since the transmitter itself is flat within 2 db. between 30 and 10,000 cycles, the full range provided by the lines can be actually transmitted with ease. The station is thus following the trend to high fidelity transmission and can increase its range as better wire lines become available. Besides complete monitoring equipment, the duplicate of that in the studio, there is installed a complete small studio in the transmitter building, from which speakers may make broadcasts if it is more convenient for them to go to Cartaret than to New York. This room is used normally as the office of the chief operating engineer of the station, and is completely sound-treated.

Complete and thorough grounding of every metal object in the building (except the transmitting equipment itself) is necessary in all high power installations. In this case, this grounding program has been extended even so far as the padlock which locks the coupling house door; a copper braid is carefully riveted from the lock to the grounded casing of the house.

In keeping with the present day trend, the station has been carefully designed to present a pleasing appearance to the visitor. All of the apparatus contained in the main and auxiliary transmitters is clearly visible, through glass partitions, as shown in the floor plan.

THE NEW WOR

Antenna:

Type: Three-element directional array.
Radiators: Three, vertical, 385 feet high.
Signal ratio: 24 to 1. Maximum signal to New York and Philadelphia.

Radio frequency carrier:

Frequency: 710 kc.
Power: 50 kw.
Frequency stability: 3 cycles deviation.
Frequency monitoring: Heterodyne with auxiliary crystal.
Tubes used: 8—232-A's.

Modulation:

Capacity: 100 per cent.
Fidelity: 30 to 10,000 cycles, flat within 2 db.
Class: Low level, class A.
Tubes: 212-D.
Monitoring: Cathode-ray oscilloscope, portable.

Power supply:

A-c supply: 3 phase 4150 volts, 60 cycles.
Input power, 100% modulation: 235 kw.
Tube filaments: d-c fed from generators.
Rectifier tubes: 6—266-A's.
Rectifier output: 17,000 volts, 12 amperes.
Filter: 12 mfd. 8 henries, single section.

Special features:

Buried r-f concentric transmission line to antenna. Windowless transmitter building. No overhead conductors in station. All conductors leave transmitter house underground. Beacon transmitter for airplane warning. Building heated by water taken from plate-cooling of r-f amplifier tubes.

The problem of auto-radio antennas

THE radio industry is faced with a real problem in how and where to place antennas in all-steel top cars. Placed under the car, the electrical and mechanical requirements are completely contradictory. If the mechanical construction is good, the electrical qualities are bad; if the antenna is far enough from the car to insure good pick-up it is bad mechanically.

From the standpoint of functional design the antenna should be on top of the car and at a respectable distance from the steel top. It should be possible to make this antenna good looking as well as efficient.

For 1935 cars there is the possibility of a rod on top the car somewhat like the baggage rack rails of the old touring cars. Experiment shows that a distance of 3 or 4 inches from the roof provides an antenna better than previous aerials.

Now is the time, however, to consider the car of the future. This car will have more complete streamlining; possibly with a stabilizing fin, partly for need and partly for appearance. Here is the logical place for the antenna, concealed in the top of this fin-like structure. If a person spends \$50 or more for an auto-radio, he should be able to have as good pick-up antenna as possible, and the car manufacturers must perform their share in the necessity of seeing that cars and radios go together in the best fashion.

There is one difficulty visible now—this stabilizing fin in which is the antenna must be made of insulated non-metallic material. But it is a distinct possibility and should be considered seriously—*now.*

The following study of the characteristics of automobile antennas was undertaken by the RCA License Laboratory to aid designers of automobile receivers in improving the input circuits. Such a study is peculiarly desirable because of the opportunity of standardization of the automobile antenna, and, therefore, of making the input circuit have a high degree of discrimination against noise in favor of desired signal.

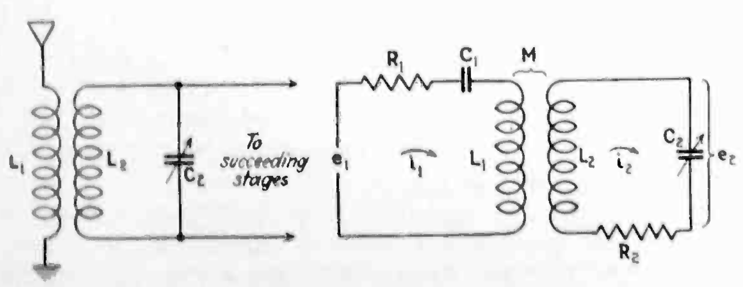


Fig. 1—Antenna and equivalent circuit

In Figure 1 is shown a simple antenna with its equivalent circuit. In such a circuit with secondary tuned to resonance, the voltage gain is equal to

$$\frac{e_2}{e_1} = A_v = \frac{-\omega^2 L_2 M}{R_2(R_1 + j X_1) + \omega^2 M^2} \quad \ldots\ldots\ldots\ldots (1)$$

and the maximum gain, secured when both primary and secondary are tuned to resonance and the coupling is optimum (when $M^2\omega^2 = R_1R_2$) is equal to

$$A_v = \frac{L_2}{2M} = \frac{\omega L_2}{2\sqrt{R_1 R_2}} \quad \ldots\ldots\ldots\ldots (2)$$

$$\text{or } A_v = \frac{\sqrt{Q_1 Q_2}}{2} \times \sqrt{\frac{L_2}{L_1}}$$

$$\text{where } Q_1 \text{ and } Q_2 = \frac{\omega L_1}{R_1} \text{ and } \frac{\omega L_2}{R_2}$$

Thus, in the idealized case of optimum coupling, the gain is directly proportional to the square root of the Q of the secondary and inversely proportional to the square root of the resistance of the primary. In other words, the antenna resistance is as important as the Q of the secondary in determining the gain.

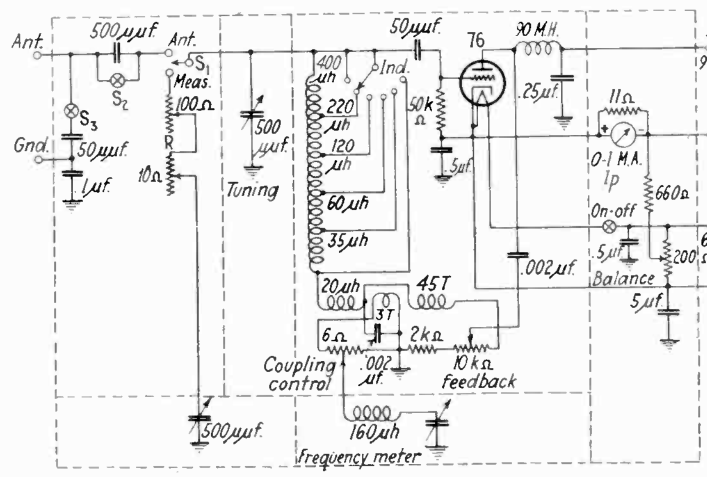


Fig. 2—Measuring set for antenna characteristics

Table I gives some typical values of gain with R varying between 10 and 100 ohms and Table II gives some typical values for Q of 25 to 200.

TABLE I

Q = 100
L = 200 microhenries

R	A, 600 kc.	A, 1,400 kc.
10	43.5	66.0
20	30.6	46.5
40	21.8	33.2
60	17.7	27.1
80	15.4	23.5
100	13.7	21.0

TABLE II

R = 20 ohms
L = 200 microhenries

Q	A, 600 kc.	A, 1,400 kc.
25	15.3	23.3
50	21.5	32.9
75	26.5	40.3
100	30.6	46.5
125	34.3	52.0
150	37.6	57.0
200	43.3	65.8

These will be maximum gains, as they are based on the condition of optimum coupling. The gains in any actual circuit will be correspondingly less. If the coupling is not optimum or if the primary is not resonant to the same frequency as the secondary, the gain may be calculated by use of equation (1) above.

If the coupling is greater than the optimum value the secondary tuning will be affected by the primary constants. If the primary is not tuned to resonance with the secondary the effect on secondary tuning may be simply determined as follows:

From coupled circuit theory

$$\frac{e_1}{i_2} = \frac{(R_1 + j X_1)(R_2 + j X_2)}{j \omega M} - j \omega M$$

$$= \frac{X_1 R_2 + R_1 X_2}{\omega M} + j\left(\frac{X_1 X_2 - R_1 R_2 - \omega^2 M^2}{\omega M}\right) \quad \ldots\ldots (4)$$

Now we wish to determine what setting of the tuning condenser will make the gain a maximum when the primary is reactive.

The gain will be a maximum when i_2 is maximum, or since e_1 is considered constant, when e_1/i_2 is a minimum. If e_1/i_2 is a minimum, e^2_1/i^2_2 is also a minimum. Using this expression to avoid imaginary terms, squaring (4), taking the terms which contain only X_c, a maximum value for the gain will be found when

$$X_c = X_L - \frac{\omega^2 M^2 X_1}{R^2_1 + X^2_1} \quad \ldots\ldots (5)$$

This gives us the value of reactance of the secondary tuning capacity which will give maximum gain. The value of X_1 may be either positive or negative, depending upon whether the inductive or capacity reactance term predominates.

Antenna impedance measurements

Now, to design an antenna input system for maximum gain it is necessary to know the impedance characteristics of the antenna. In Fig. 2 is shown the schematic diagram of an antenna impedance meter. The substitution method is employed. The device consists of an oscillator, a frequency meter and the equivalent antenna which is substituted for the actual antenna.

The antenna whose characteristics are to be measured is connected to the meter and the switch S_1 thrown to the Ant. position. The frequency meter is set to the desired frequency and the coupling of the frequency meter to the oscillatory circuit is adjusted by the coupling control. The plate current of the oscillator is read by the I_p meter. A balance adjustment is provided to buck out the steady d.c. to obtain greater sensitivity. This adjustment is best made by setting the feedback control to zero and then setting the balance control until the meter reads approximately full scale. The feedback is then set so the meter reads about half scale. The tuning condenser and inductance switch are then adjusted until the plate current meter indicates by a peak that the antenna is resonant to the desired frequency.

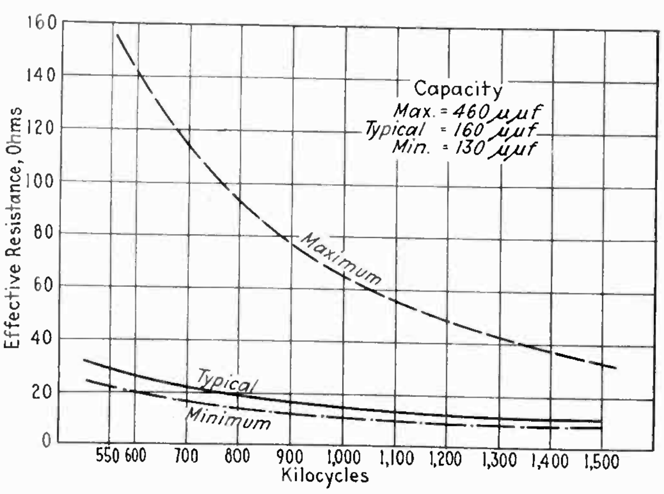


Fig. 3—Resistance characteritics of typical roof antennas

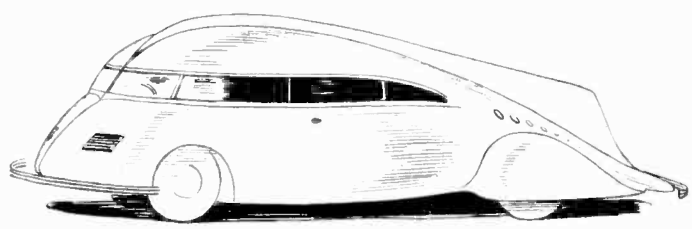
The switch S_1 is then thrown to the measure side and the capacity dial adjusted until resonance is again indicated by the peak on the meter. The reading of the capacity dial then gives the antenna capacity.

With the capacity dial so adjusted, set the decade resistor R until there is no change in meter deflection when the switch S_1 is thrown from the antenna to the measuring position. The decade resistor value is then equal to the equivalent antenna resistance.

In reading resistance it is desirable to reduce coupling of frequency meter to zero so that any inaccuracies in setting of capacity will not cause a difference in reflected resistance as switch S_1 is thrown.

In constructing the device there are a few precautions to observe. The capacity of resistor R to ground should be low; otherwise a false resistance reading will be obtained because of the shunting effect of such capacity. Each section should be shielded, as shown by the dotted lines. It is desirable to connect the ground terminal to the case, if only through a condenser, as the car battery polarity varies with the make of car. As a heater type tube is used it is necessary to adjust the balance control when the device is turned on or off to keep the meter on scale.

The range is from 1,700 kc. to 540 kc. with antenna capacities of 50 to 500 μμf. To increase the range a parallel capacity of 50 μμf. is provided for low capacity



Streamlined cars of the future offer an excellent place for the antenna—in the stabilizing fin

antennas and a series capacity of 500 μμf. for large capacity antennas. The resistance reading will be correct when the series capacity is used, but it is necessary to make a correction for the effect of the parallel capacity on the resistance reading. The parallel capacity will make the resistance reading lower than the actual value.

Antenna impedance values

It will be observed that the antenna impedance meter determines the effective series capacity and resistance of an antenna. Figure 3 gives typical values for the equivalent series capacity and resistance of automobile roof antennas. The equivalent capacity is practically constant over the broadcast band as the inductance of automobile antennas is small compared to the capacity. These curves were obtained by measurement of a number of cars of 8 different makes, all of 1934 or 1935 models.

It will be observed that the resistance and capacity of the typical antenna are close to the minimum observed. This is because the maximum values were due to some abnormal condition and were found in only a few instances. Leaving out of consideration these few abnormal cases the characteristics were found to be remarkably uniform.

A resistance which varies with frequency and a capacity which is constant with frequency can be represented, within limits, by the network of Fig. 4a. As we have seen, a resistance varying with frequency and a capacity constant with frequency are characteristic of the equivalent series values of actual automobile antennas. If we assume the network of Fig. 4a to be connected at one end to a generator of zero impedance and at the other end to the input terminals of a radio receiver it will simulate the impedance which the radio receiver "sees" looking into an actual antenna.

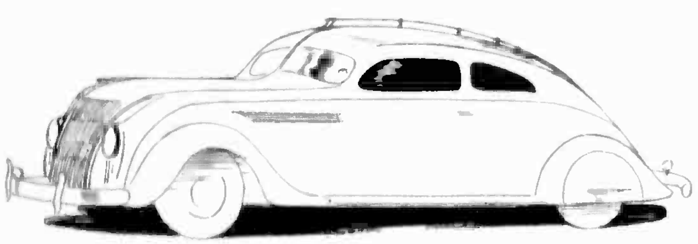
Assuming that R_2 is large, and using values for R_1 and C obtained from Fig. 3, we find that $R_1 = 7$ ohms, $R_2 = 80{,}000$ ohms and $C = 160$ μμf. approximately. These values, then, may be used for a dummy antenna for receiver measurements which will represent a typical automobile antenna.

Effective height

In addition to the impedance characteristics of an antenna we are interested in how much power it will abstract from a given field. In a field of E microvolts per meter an antenna of effective height h' will have induced in it a voltage of e microvolts. That is

$$E = \frac{e}{h'} \quad \text{or} \quad e = Eh'$$

Comparative effective heights are readily obtainable by means of a radio receiver using a diode second detector.



In advanced models of 1935 the antenna may be placed on top. These drawings were by Mr. Leon Sodersten

Since the d.c. in the diode resistor is proportional to the r-f carrier, by inserting a d-c microammeter in series with the diode resistor we can measure relative antenna voltages. Since the impedance of the antenna affects the voltage gain of the input circuit, it is necessary to employ, for measurement purposes, an input circuit whose gain is not appreciably affected by variations in antenna impedance.

Figure C shows such a circuit. This circuit is equivalent to a large inductance in series with a large resistance provided C_o is small. An example will illustrate why the resistance and capacity of the antenna may be neglected. Assume this following constants

$$C_o = 10 \text{ μμf.}$$
$$L_1 = 200 \text{ μh.}$$
$$R_1 = 10 \text{ ohms}$$

In an actual coil R_1 varies with frequency, but for illustrative purposes we can assume it to be constant.

$$L^1 = \frac{L_1}{m^2 - 1} \quad \text{and} \quad R' = \frac{R_1}{(m^2 - 1)^2}$$

Where L' is equivalent series inductance
R' is equivalent series resistance
m is ratio impressed frequency to resonant frequency. Let us determine R at 1,400 kc. and 600 kc. Maximum voltage is obtained on the first grid when

$$\omega L' = \frac{1}{\omega C'_o}$$

where C_o' is series combination of the capacity of the antenna and C_o. When C_o is 10 μμf. variation of antenna capacity from 100 to 200 μμf. produces in C_o' a variation from 9.1 to 9.5 μμf., so we can assume C_o' to be substantially 9.3 μμf. for all ordinary variations of antenna capacity.

Then at 1,400 kc.

$$\frac{1}{\omega C_o'} = 1.22 \times 10^4 \text{ ohms}$$
$$L^1 = 1.39 \times 10^{-3} \text{ henry} = 1390 \; \mu h$$
$$\text{but } L_1 = 200 \; \mu h$$
$$\text{so } m^2 - 1 = 1.44 \times 10^{-1}$$
$$\text{and } (m^2 - 1)^2 = 2.07 \times 10^{-2}$$

Then $R' = 500$ ohms and at 600 kc. $R' = 13{,}900$ ohms.

We see, then, that the equivalent circuit resistance is high compared with the antenna resistance, so that the voltage applied to the first grid will be very nearly proportional to the voltage induced in a given antenna; and we can compare antennas by use of such input circuit. This input circuit is not desirable to use in production, in spite of its substantial independence of antenna impedance, because of its relatively low and non-uniform gain. Calibration of the receiver for measurement purposes may then be effected by a signal generator, determining diode current as a function of input in microvolts for the frequencies at which it is desired to make the antenna measurements.

If, then, we measure the signal intensity in microvolts received by a given antenna when placed in a field of known strength, we can determine the effective height of the antenna. In making measurements of antennas on automobiles, with the field from a broadcasting station for instance, it is found that the directional effect of some types of antennas is very marked, due to shielding by the automobile body.

We have seen that both the effective height and the effective resistance of an antenna influence the power available for amplification in the receiver. In a coupled circuit the available power varies inversely as the square root of the antenna circuit resistance. However, if the antenna input system consists of a single circuit, the received current will vary inversely as the first power of the antenna circuit resistance. We can, therefore, express the figure of merit of a receiving antenna at any given frequency from the values for effective height and effective resistance at the frequency.

The figure of merit is then h'/R' for a single antenna input circuit, and is $h'/\sqrt{R'}$ for a coupled input circuit where h' is the effective height of the antenna and R' is the effective antenna resistance.

These expressions give us a basis of comparing antennas for their relative effectiveness for receiving purposes.

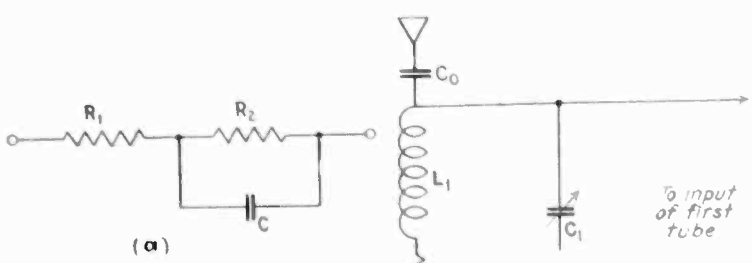


Fig. 4—Equivalent antenna circuit and (b) network to be used with antenna measurements

"Re-diffusion" broadcasting in Europe

How wire distribution circuits serve listeners in England and Holland

AMERICAN radio engineers returning from Europe have called attention to the wide use of audio distribution of broadcast programs now being made on the Continent and in Great Britain.

In Holland at least half of the listeners are served by such "rediffusion" or wire distribution of programs. In England some 200 different competing radio-diffusion companies are in operation, retransmitting over wires the regular Broadcasting Corporation programs. Such programs are picked up on sensitive receiving sets advantageously located outside of the field of local interference, so that the re-diffusion listeners get a superior freedom from interference than exists with the straight-radio installation. Similar systems have been installed in hotels and apartment buildings in America, but there has been very little house-to-house audio distribution on this side of the Atlantic, such as is becoming increasingly the vogue in Europe.

The typical audio frequency re-diffusion system abroad uses a network specially erected for the purpose. This network consists of open wire lines suspended from poles or house chimneys. The network contains twice as many wires as there are programs distributed. It is usual practice in Holland to distribute three programs, in Britain only two. Each consumer has a lead-covered branch feeder connected across the lines, which descends from the chimney fixing or pole to the living room. The consumer then has a switch to energize his loud-speaker and to select which of the available programs he shall listen to. He also has a volume control.

While this describes the most common system, there are also radio-frequency systems, notably in Holland, which use buried net works or existing telephone net works. In the latter case the volume level has to be that of ordinary telephone communication to prevent interference between the re-diffusion and the telephone services. In this case the consumer has an amplifier which raises the line level sufficiently to energize the loud speaker at full volume. When buried cable re-diffusion networks are used there is no amplifier in the consumer's house because there is no danger of interference with the telephone service. Telephone-wire systems are being widely used in Switzerland and there are a few systems of this kind being used in Holland, but none in England.

Rental prices for service

It is standard practice to charge the consumer a fixed rental. This averages about $14 per year in Holland and $19.50 in Great Britain. The rental is paid weekly. Although there is no installation fee, the consumer always buys his own loud speaker. This is usually done by easy payments. The minimum easy payments average 15 cents a week. The average cost of the speaker is $8. The re-diffusion company, however, offers a range of speakers,—frequently the same speaker in different cabinets but sometimes a better speaker in a more elaborate cabinet. The price of speakers ranges from $5 to $20. The company usually buys the speaker at half the price at which it sells it.

All of these re-diffusion companies are private enterprises. The 200 companies in England are combined in an association and have agreed not to lower rates or to compete in the territories which one individual company may secure.

The concession is usually given in the form of a permission from the town council to the company to cross streets with wires. In return the re-diffusion company agrees to pay the town council 7½% of the yearly turnover in lieu of taxes.

In Holland different re-diffusion companies operate in different sections of a given town or city. There are something like 100 different companies operating in Amsterdam alone. In Britain, except in the case of London, one re-diffusion company operates in one town. London is subdivided naturally into boroughs.

Each town is divided into rediffusion districts, at the center of which the amplifiers are installed. They are usually placed in shop windows to make an impressive display, and much is done to make the engineering equipment look impressive and the technical personnel smart, learned and important. The men who collect the money (called "collectors") tour the districts on bicycles, getting into close and friendly touch with the consumers.

Degree of saturation

Americans who have listened to re-diffusion do not recommend the tone quality it gives, because the reproduction is normally, (although not necessarily) very poor and sometimes inferior to that given by a typical radio set. Those who operate the re-diffusion service soon found that quality was not appreciated, that convenience and low fixed charges were the chief recommendations. It costs them less to give bad than good quality. The original British systems gave only one program reproduced on cheap speakers on grossly overloaded lines. In spite of this, many systems secured 25 per cent of the householders of a town as consumers. It is agreed among the re-diffusion companies that two programs are sufficient and no company in Britain attempts to give more. Convenience, in fact, sells the service.

The programs are picked up from any convenient station, British or foreign. The alternatives sent out are the pick of the British and the pick of the foreign. Meters can be installed in the amplifying stations, showing the load on any particular line for any program.

In Deventer, Holland, there are 7000 houses, 4000 of which are wired for re-diffusion. Development has been going on here during the past ten years. In Hull, England, where there is the largest re-diffusion system in the world, one house in every three is wired and development has been going on during the past five years. There are 20,000 houses wired in Hull of the 60,000 houses in the city. In Holland 50 per cent of those who listen to broadcasting get their service via wires. Wire broadcasting cannot, of course, be applied in rural districts and so it is estimated that 80 per cent of urban listeners take their service via re-diffusion and the remaining 20 per cent via wireless. In Britain there are six million licensed listeners and about nine million houses. One might expect, therefore, that in time there would be four million re-diffusion listeners, even if the rate of growth of listeners did not increase beyond its present figure.

Capital costs of installation

It is estimated that the capital cost per consumer in an audio frequency re-diffusion system as described above is of the order of $30. This cost reduces as the networks are more and more loaded. This figure applies to a system wherein one house in every four is wired. It reduces to perhaps $20 if one in three houses is wired. Where it is possible to wire new houses, as they are being built, with underground cable, the cost might come down to $10 per consumer.

There is of course a very big capital investment necessary before any considerable return is available. In the first year the cost per consumer may be anything from $100 to $200 and this figure may be higher in towns where new developments are looked upon with suspicion. In Holland the financiers expect to get their capital back in three years, but these expectations have not been realized in Great Britain. Nevertheless, the business of re-diffusion has been very successful, if assessed on any reasonable basis. There has been a great deal of difficulty in Britain to raise the necessary capital, and this has delayed expansion. The difficulty in raising capital comes about because the government has insisted upon its right to take over any existing system at a payment reckoned on assessed value of material at the time of purchase, and nothing will be paid for good will. The systems may be taken over on Jan. 1, 1936. These provisions have quite naturally brought about somewhat frenzied finance, but in spite of this banks have advanced money on no other security than the balance sheets of past years' workings.

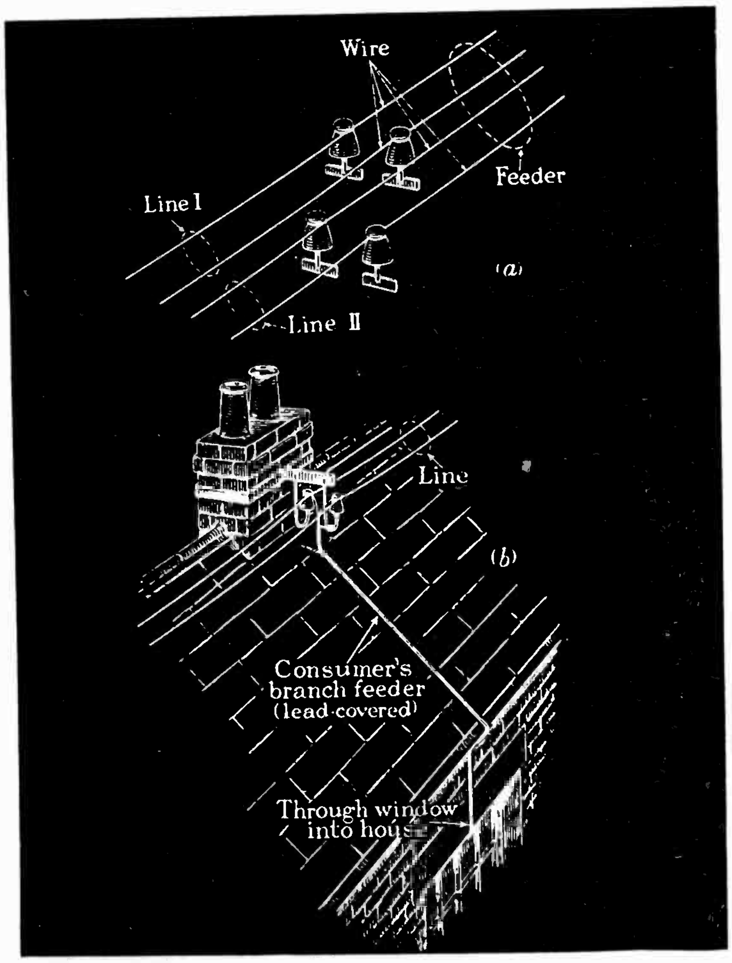
Most European broadcasting systems are run by bodies appointed by the government and free from direct commercial interest. Typically, the B.B.C. is constituted under royal charter "to send out programs to the satisfaction of the Postmaster General." This official appears to be satisfied and never interferes with B.B.C. policy.

Every listener is supposed to pay $2.50 a year in return for a license to listen and over six million people in Britain pay this tax. Therefore, there is no copyright problem since the B.B.C. is the agent between the listener and the copyright owner. The listener is free from all responsibility once he had paid the necessary tax. Re-diffusion systems are looked upon merely as a means to give listeners a service in a way different from radio. Thus every re-diffusion consumer has to pay the tax.

The Postmaster General forbids the initiation of programs by the re-diffusion company because this would introduce a new factor not envisaged under the scheme of monopolistic broadcasting. The P.M.G. even goes so far as to forbid the re-diffusion people to relay to their consumers any programs picked up from abroad to which he may object. The object of this regulation is to prevent the re-diffusion companies from paying for sponsored programs to be radiated by stations abroad, picked up in Great Britain and re-diffused to subscribers to a wire system.

It is necessary, for the benefit of American readers to emphasize the conditions that exist in Europe. The average cheap British receiving set sells for $50 and an enormous number of sets retail at $80. Most sets have three tubes, but the number of superheterodynes using five tubes, is on the increase and undoubtedly will become more and more popular. It sells today at $80. "Easy-payment" systems are widely applied, but the rate of payment for a radio set is at least twice as high as the rate of subscription to a re-diffusion system.

Also, a great many houses are without electric-mains supply and anybody living in these houses who wants to listen is forced to use a battery-operated set. He finds it both a nuisance and an expense. Many subscribers have come to re-diffusion service because this dispenses with the necessity of having batteries. It is, however, necessary to qualify this last point, because in Holland electric distribution is more advanced than in England and yet as has been pointed out before, the large majority of Dutch householders use re-diffusion.



Manner of conducting program into listener's home

Calculation of VERTICAL ANTENNA radiation patterns

By Edmund A. Laport
Upper Montclair, N. J.

Editor's Note: *Mr. Laport has reduced to simple geometry one of the difficult problems of antenna design, that is, predicting the space distribution of the radiated energy. For those who may have no need actually to apply the methods outlined, the discussion of them will afford a simple and direct explanation of the reasons for high and low angle radiation and the appearance of radiation lobes.*

The solution of the space characteristics of any antenna or array of antennas takes one far into the field of electromagnetic theory where those who tread are relatively few. Growing popular interest in this subject, however, brings a need for some method for solving problems involving antenna space characteristics which is within the grasp of the average man. In present day communication and broadcast practice, one must know something about the manner in which an antenna distributes its energy in space. In the past, such knowledge was the private domain of the antenna specialists.

In entering upon this work we must concentrate upon the most elementary examples. The physical principles which produce the characteristic distribution of the radiant energy must be understood first. The actual work of solving a specific case is relatively easy after that. By confining ourselves to vertical antennas, by considering only a perfectly conducting ground, by using only effective relative values of antenna current and field intensity, by assuming sinusoidal current distribution in the antenna and by neglecting the possible influence of conducting structures which are frequently found near the antenna, the process of obtaining space characteristics can be reduced to a simple form. The method to be outlined can be readily extended to cover most of the applications of interest to men in the field.

The method is a geometrical one.[1] With a moderate amount of practice, enough so that the various operations are carried out in proper order without confusion, the solution of any single-antenna problem is a matter of but a few minutes' work. The restrictions outlined above are those customarily assumed for antenna problems in general. It must be remembered, however, that actual field conditions often depart widely from these restrictions. In broadcasting, there are very few strictly vertical antennas, there are usually steel towers or other conductors in the field of the antenna, and what we call "good" ground is in reality a rather poor conductor of radio frequency currents. The idealized solution is of great value and interest in all antenna problems, however, and forms the basis of reference in all cases.

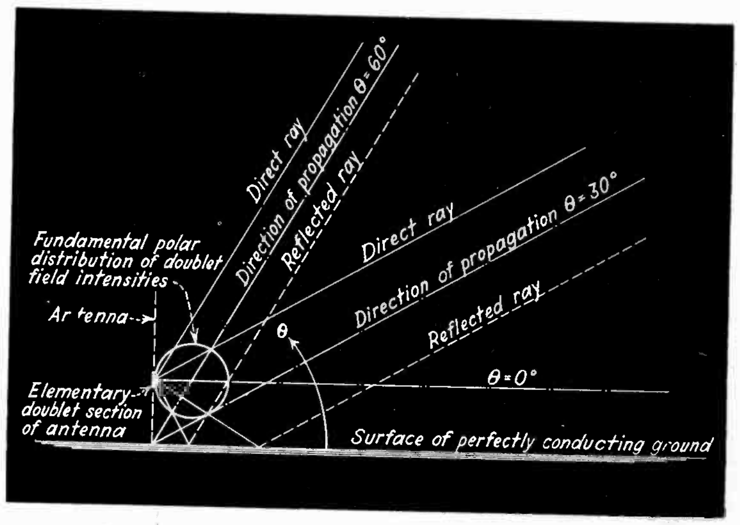


Fig. 2. A doublet located above a perfectly conducting ground. The reflections from the ground combine with the direct radiation, causing wave interference

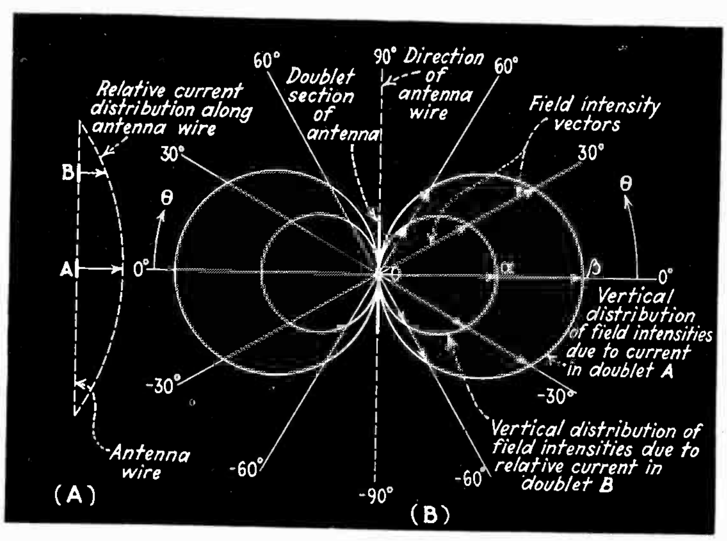


Fig. 1. (A) Typical vertical antenna, showing the current distribution and two doublets. (B) Field intensities radiated from doublets A and B at various angles above and below the horizon

Double field strength distribution in free space

A doublet is considered to be a very short electrical section of a straight conductor carrying an oscillating current, the current in the doublet itself being essentially uniform. Let us say that a one-foot section marked off in any part of a broadcast antenna is an example of a doublet, the one-foot length being arbitrary. An antenna may be considered as being made up of a large number of doublets in series, though the currents in the various doublets may vary in amplitude and direction. A doublet as an elementary section of a half-wave an-

[1]This method was first described by the writer in a lecture before the Connecticut Valley Section, I.R.E., on Jan. 28, 1932.

tenna is illustrated in Fig. 1-A. In 1-B is shown the manner in which the electromagnetic field intensity would be distributed in space about an oscillating doublet *if it existed by itself in free space.* This figure is of fundamental importance in antenna work. It says that vectors drawn outward from O at any angle θ fall on a circle drawn tangent to the wire through O. It says that the field intensity is a maximum at right angles to the wire, and also that the field intensity is proportional to the current in the wire. If we call the normal to the wire 0°, then $E = E_0 \cos \theta$. There is no radiation in the direction of the wire.

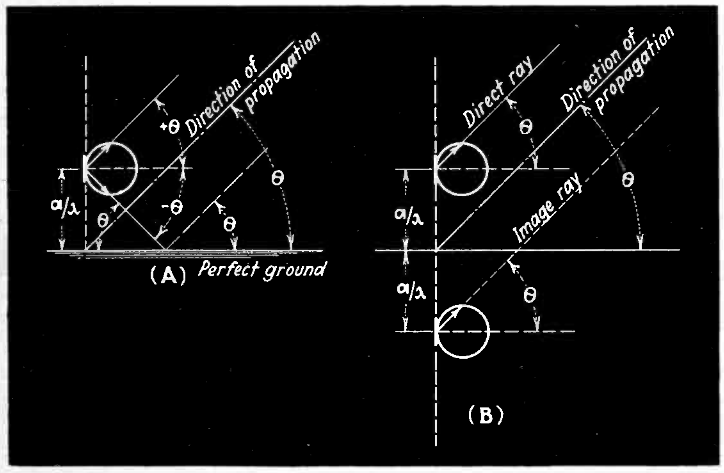


Fig. 3. In the diagram at the right, the effect of the ground reflections has been replaced by an "image doublet" located below the ground plane. The propogated waves in both cases are the same

Considering further a single vertical doublet, let us place it above a plane perfect conductor of infinite extent. A number of new matters now press for attention. As a perfect conductor the surface acts as a reflector. "Rays" of radiant energy which impinge upon it are reflected like light from a mirror. In Fig. 2 it can be seen how all radiation emitted by the doublet at angles below the horizontal will eventually hit the "ground" and be reflected back into space by it. The angle of reflection equals the angle of incidence, and both incident and reflected rays are in the same vertical plane. In this way all energy directed downward upon the ground is returned to free space above the ground, which is the region of direct radiation from the doublet. At any point in space, then, two distinct rays of energy are received—one transmitted directly from the doublet, and another which has been reflected from the ground. All emissions from the doublet at any instant are in phase, but at any point in space above the ground plane, the reflected wave reaches it after travelling a longer path, so there is some phase difference between the direct and reflected waves. The resultant field observed will be the vector sum of the two component intensities. If they arrive in phase, they add arithmetically, and if they arrive 180° out of phase, they substract arithmetically. For phase angles between 0° and 180° the resultant may be anything between their sum and their difference. The phase difference between direct and reflected rays depends upon the frequency of the current in the doublet and its height above ground, as well as the angle above the horizon of the point of observation. As indicated by Fig. 2, the assumed points of observation are far enough away so that the paths of the direct and reflected rays are parallel. They are also assumed to lie on the surface of a hemisphere, enclosing the antenna which is at its center so that field intensities at various angles above the horizon are mutually comparable.

At this point it is convenient to think of these facts in geometrical form, as in Fig. 3. We now designate the physical dimensions in terms of the wavelength of operation. The dimensions can then be converted into electrical space degrees, on the basis that one wavelength contains 360°, from which relative phase angles can be obtained. (This has been carried out in Fig. 4 for the specific case of a doublet which is one-quarter wavelength (90°) above the ground.) Fig. 3-B introduces another fundamental conception—the theoretical presence of the image of the doublet. The conditions of reflection are the same as if the ground were physically removed, and a second oscillating doublet located the same distance below the ground plane, carrying the same amplitude and phase of current. There are many reasons why the actual work is simplified by treating reflected waves as radiation from a subterranean image, and neglecting all radiation emanating at angles below the horizontal.

With an imperfect ground having both inductivity (dielectric constant) and low conductivity at radio frequencies, the image radiation is greatly modified from that of the idealized conditions. The amplitude of the image wave is no longer equal to that of the direct wave, and the angle of reflection no longer is equal to the angle of incidence. The mechanics of the action is such that the relative amplitudes and phase-twist of the reflected ray are different for different values of θ. When the conductivity and inductivity of the soil are known for a particular location the amplitude and phase of the reflected ray can be calculated[2] and used in this method of solution to yield a more realistic space characteristic.

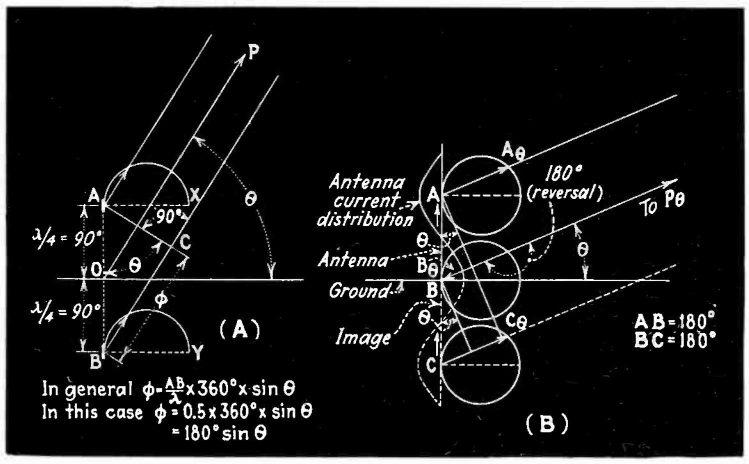


Fig. 4. (A) Doublet and image, expressed for the case of a doublet located one quarter wave above ground (cf. Fig. 5). (B) An antenna operated at its third harmonic, with current anti-nodes located at the ground and one half-wave length above it. (cf. Figs. 7 and 8.)

In Fig. 4-A, O is the point in the ground plane directly under the doublet A. A and its image B are on the same line, and OA equals OB. Due to the parallelism of direct and image rays at any angle θ a perpendicular drawn from A on to BC makes the angle $BAC = \theta$. The distance BC, in degrees, is the angle by which B ray lags A ray at the point P. This angle has been designated ϕ, and $\phi = AB \sin \theta$, by geometry. If the construction work is carefully drawn to scale, BC can be measured directly with a scale in terms of the scale of AB.

[2]See, for example, Proc. I.R.E., March, 1933, pp. 405-410.

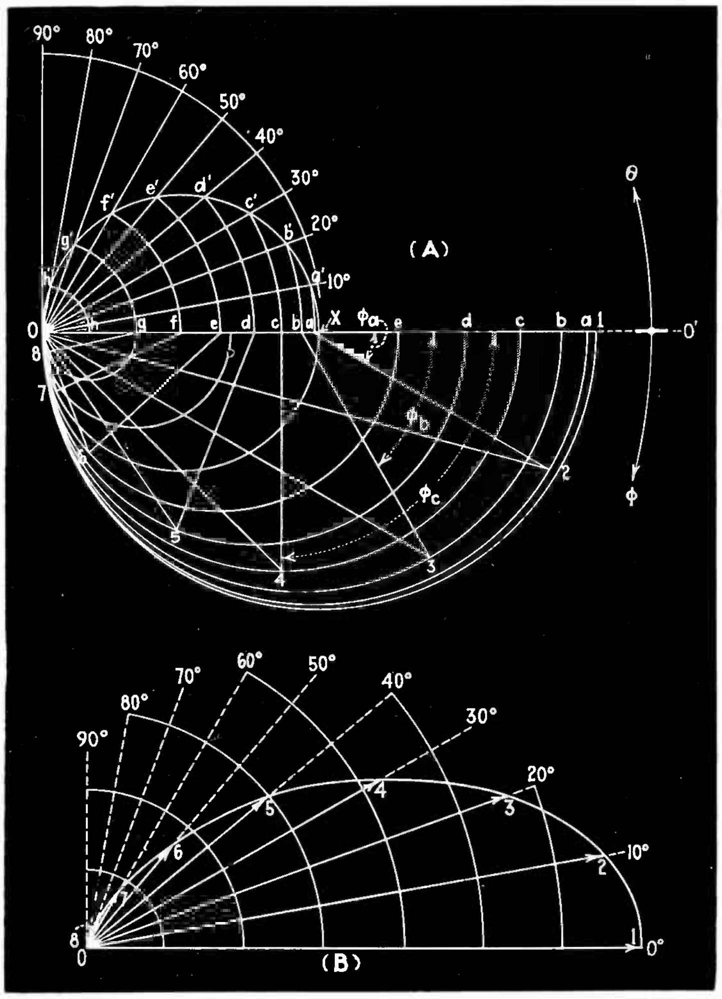


Fig. 5. Complete solution of the case shown in Fig. 4 (A), i. e. a doublet located one quarter wave above ground. (A) is the working diagram, whose construction is completely outlined in the text, while (B) is the polar plot of field intensities, the answer to the problem

The relative field intensity distribution in a vertical plane for the case of a doublet one-quarter wavelength above perfect ground is completely developed in Fig. 5-A. The relative intensity is calculated every 10°, an interval depending entirely upon the nature of the problem.

The construction details of Fig. 5-A are as follows: Draw a horizontal straight line *O-O'*. Mark off on this line a length *OX*, of any convenient length. Draw a semi-circle above the line *OX*, using *OX* as the diameter. Through *O* draw lines *O-a'*, *O-b'*, *O-c'*, etc. every ten degrees as shown. The ten degree interval is chosen for convenience. The points *a'*, *b'*, *c'*, etc. mark the intersections of these lines with the semi-circle. The lines *O-a'*, *O-b'*, etc. are the relative field intensities of the direct radiation from the doublet at *O*, as shown in Fig. 1.

With *O* as a center draw arcs *a-a'*, *b-b'*, *c-c'*, etc. The lengths *O-a*, *O-b*, *O-c*, etc. are the relative direct field intensities, brought down to line *OX* for convenience.

Having found the relative field intensities of the direct radiation it is then necessary to find the relative field intensities of the reflected radiation. This is done as follows. With *X* as a center, and with *OX* as radius draw the semi-circle *"1"* below the line; then with *a* as a center and *O-a* as the radius draw semi-circle *"a"* below the line, and so on until the nine semi-circles have been drawn.

The radii *X*-1, *a*-2, *b*-3, *c*-4, which represent the relative reflected field intensities, are drawn in as follows. The angles ϕ_a, ϕ_b, ϕ_c, etc. are calculated from the following relation:

$$\phi = AB^\circ \sin \theta.$$

This relation has already been given, with reference to Fig. 4-A. In the case we are considering, that is, when the doublet is $\frac{1}{4}$ wave above ground, the distance AB° is a half wave ($\frac{1}{2}$ of 360°), that is, 180°. The values of θ have been taken in this case to be 10°, 20°, 30°, and so on. In other words:

$$\phi_a = 180^\circ \sin 10^\circ = 180^\circ\ (0.174) = 31^\circ$$

and

$$\phi_b = 180^\circ \sin 20^\circ = 180^\circ\ (0.342) = 61.5^\circ$$

and so on.

When all the values of ϕ have been calculated the lines *a*-2, *b*-3, *c*-4, and so on are drawn using the proper value of ϕ for each line. These lines are the relative *reflected* field intensities of the radiation.

The direct and reflected parts of the field intensities are then added, vector fashion, by drawing the third side of each triangle, that is, the lines *O*-2, *O*-3, *O*-4, and so on. These lines are the resultant field intensities for the 10° angles, that is *O*-2 is the intensity at 10° above the horizon, *O*-3 the intensity at 30°, and so on.

A polar plot of these values, shown in Fig. 5-B, is made by laying off the length of *O*-1, *O*-2, *O*-3, and so on at the proper angle and connecting the ends of the lines with the smooth curve as shown. The result is the familiar polar plot of the radiation from a doublet situated $\frac{1}{4}$ wave above ground. The successive resultants *O*-2, *O*-3, *O*-4, etc. are plotted in polar coordinates in 5-B.

In Fig. 5 all the values of ϕ were less than 180°.

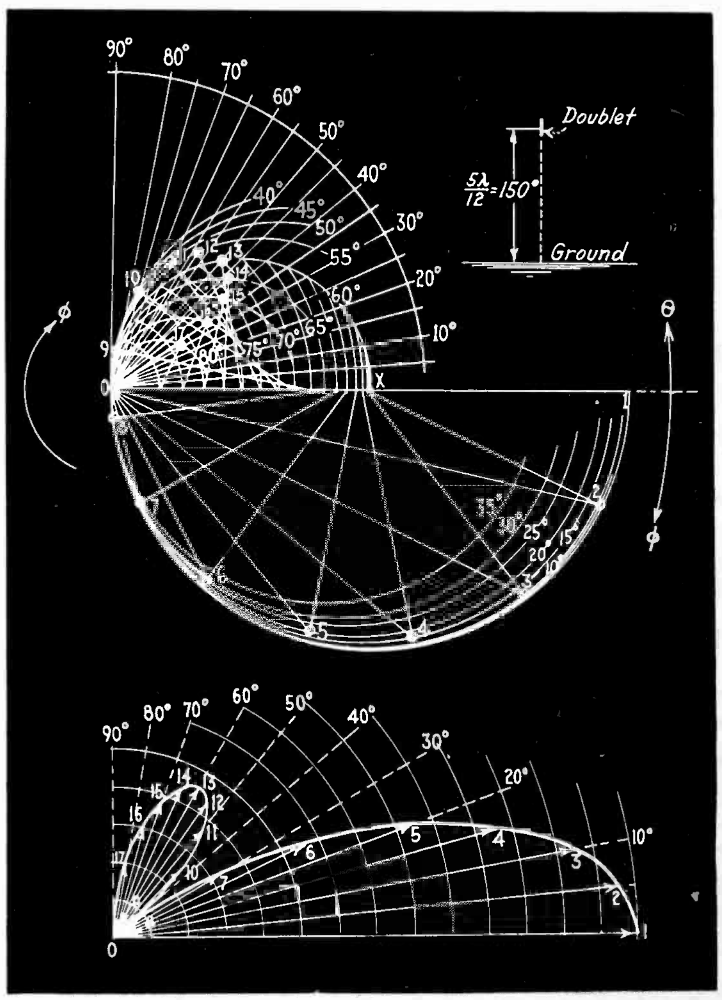


Fig. 6. Solution of a doublet located 5/12 wave-length above ground, in which a lobe of high angle radiation appears. The construction is the same as that of Fig. 5, except that Φ has values larger than 180°

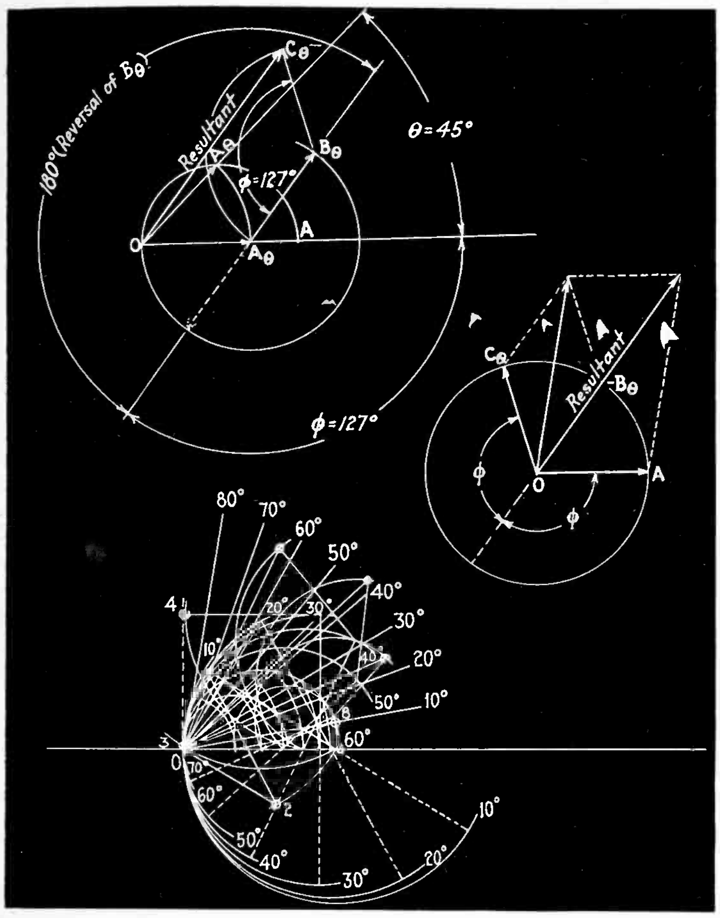


Fig. 7. Sample construction for the case of a vertical antenna operated at its third harmonic, described in text

When they exceed 180°, the second vector swings above the line as in Fig. 6-A. Fig. 6 is the case of a vertical doublet 150 space degrees above perfect ground. The construction principles are the same as for Fig. 5. Between 30° and 40° the sum of the direct and reflected vectors passes through zero and develops a second maximum at nearly 60°. For different heights of the doublet between 90° and 180° the size of the two lobes changes, and the angles of maximum and zero change. In 6-B is shown the plot of the radius-vectors obtained from the construction of 6-A.

Space characteristics of a doublet vs. half-wave dipole antenna

The space characteristic for the half-wave dipole (or the quarter-wave antenna with perfect ground) is found to be almost the same as that of the elementary doublet which we have been studying. The doublet problem is therefore of particular practical significance since it can be used to replace a dipole when calculating space characteristics.

In making the substitution, the doublet is located in space where the center of current of the dipole would occur, which is the point of maximum current. In cases common in broadcasting, where the radiator is only a portion of a complete dipole, the center of current is not usually the point of maximum current.

The calculation of the space-characteristics of electrically long antennas (such as when the antenna is oscillating at its 3rd, 4th or higher harmonics) is more work, but the same method can be used. The case of a grounded antenna operating at its third harmonic is developed in Figs. 4-B and 7, and the final result plotted in Fig. 8.

In a freely oscillating wire, the currents in adjacent half-wave sections are in opposite directions, while currents in alternate sections are co-phased. In Fig. 4-B the vector B_θ has a direction which is reversed with respect to vectors A_θ and C_θ. The field from the reversed element is also reversed, and this must be taken into account in making the vector additions. Assuming that the velocity of propagation in the wire is the same as in space (which is not always true) the distance from A to B is 180°, and is the same as from B to C. Angles A to B is 180°, and is the same as from B to C.

In Fig. 7-A and 7-B the resolution of three vectors A_θ, B_θ, and C_θ is demonstrated for $\theta = 45°$. O-A is the diameter of the doublet semi-circle, and A_θ is found to be the length from O to this semi-circle at an angle of 45° through O. This length is brought down to the O-A line. The value of ϕ is found as in previous examples and measured clockwise. Since B^θ is reversed with respect to A_θ, an additional 180° of rotation is given to this vector, the reversal of the dotted vector. A_θ, B_θ, and C_θ are all equal in magnitude, from the conditions in the antenna. The third vector is now drawn from the tip of B_θ at a reversed angle ϕ. The resultant is O-C_θ.

In Fig. 7-B is shown another method of adding these same vectors. The choice of methods is a personal one.

In Fig. 7-C we have a complete construction for the vertical third-harmonic antenna, with calculations every 10°. This is merely the accumulated result of performing the entire problem with one diagram. It is shown as an example of the need for careful marking and identification of lines and of the need for careful delineation. In working problems of this sort the work should be done on a large sheet so that the lines are more easily followed. The use of different colors of ink is a great aid in the more involved constructions. There is much to recommend the solution of each step on a separate sheet. Indeed, there is a great range of choice in how one may draw the figures, and those used in this paper are intended only to demonstrate the mechanics of wave-interference by vector addition.

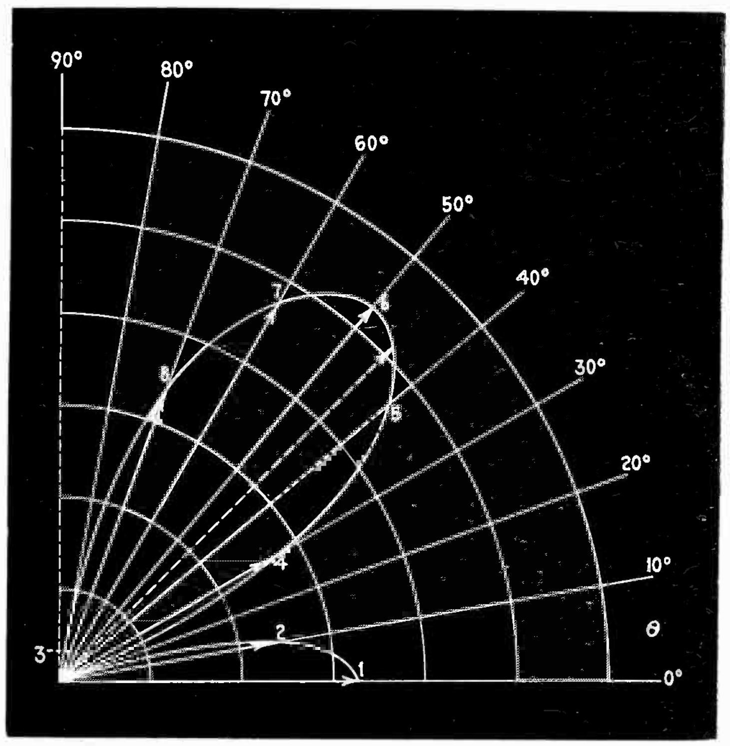


Fig. 8—The polar plot of field intensities for the case illustrated in Fig. 7, i. e., an antenna operated at its third harmonic. The large amount of high angle radiation in this case is clearly indicated

Electron-tube telemetering

for gas and water works

By E. G. WATTS

Pittsburgh Equitable Meter Company
Pittsburgh, Pennsylvania

IN THIS day of scientific measurement, it is surprising to find that many small municipal waterworks are operated with inexact knowledge of remote storage conditions, notably where elevated tanks are used. In the absence of better means, pumping station staffs have for many years relied on pressure indications or reports of overflowing from the vicinity of the tank or reservoir. Such uncertainty as to supply is a hazard, as well as a cause of undue expense for useless pumping.

A similar condition is almost universal on city gas distribution systems. Usually no practical method of ascertaining remote pressure and flow conditions is available. Proper pressure control is indeterminate; users may be inconvenienced by low pressure, or excessive loss through leaks may occur as the result of needlessly high pressure. For pressure regulation on long distance pipe-lines, periodic reports by telephone are required. Control by this indirect method is at best only partly effective.

The need for remote-indicating devices has long been felt in these industries. To produce a telemetering system acceptable in all cases, it is necessary to fulfill several conditions peculiar to gas, water and oil applications, in addition to providing the special mechanical devices required. Most systems have been designed for use by electric utilities, who have their own wires. In gas, water and oil industries, it is usually necessary to lease telephone lines. Rental, determined by the type and characteristics of the channel required, must be kept at a minimum.

The ability of a system to operate over the simplest types of line, over any type of superposed circuit[1], and at long distances, is an important factor. The calibration should be uninfluenced by line characteristics so that installation is simple. Installation costs may amount to 50 per cent or more of the selling price if it is necessary to send an engineer to calibrate each system.

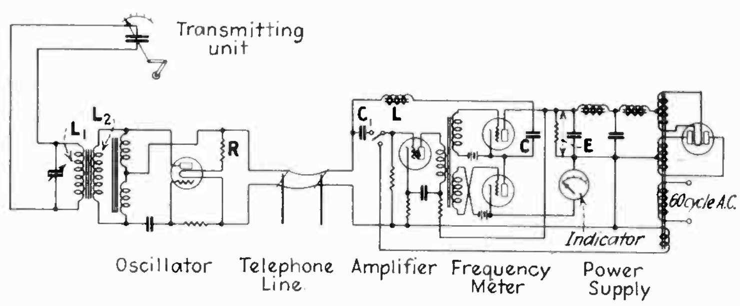
▲

RECOGNITION of electron tubes as industrial tools proceeds continuously and convincingly. Numerous methods of reading physical or electrical quantities at a distance have been developed and are in service; several of them depend upon some function performed by an electron tube.

In this application the frequency of an oscillator varies with the quantity to be measured. These frequency variations are transmitted to the receiver whose indication is, therefore, independent of voltage variation along this line.

Vacuum tubes enter the manhole

In the oil and natural gas fields, on tank farms, and on pipe-lines, an electric spark is a fire hazard. Power line wiring to the transmission point (often a manhole), relays, sliding contacts, or rotating apparatus subject to possible overheating if stalled, are all taboo in such cases. These limitations give rise to formidable problems in the design of an economically practicable telemetering system, and only by electronic methods have they been solved. Of the thirty-odd systems available in this country and abroad, none fulfill the conditions imposed, having in most cases been designed primarily for electric utilities[1]. Although electronic methods have not as yet come into wide use, amplifiers and photocells have been used in a few systems, but usually only to replace mechanical contactors[2].



Circuit of transmitter and receiver

With the all-electronic telemetering system for operation by either wire or radio with the mechanical devices required for its actuation by gas or liquid pressure and fluid levels described below it has been possible to fulfill all the conditions imposed by using as the translation medium a voltage of variable frequency, acting upon a voltage-independent receiver requiring practically no signal input power. An oscillator is used as the frequency source[3,4], and the receiver consists of a self-indicating vacuum-tube frequency-meter fed by an amplifier. The method has the advantages of being adapted for the operation of several receivers from one transmitter, the possibility of switching one receiver onto any one of a number of transmitters, and inherently unlimited distance capability.

In selecting the frequency range to be used, the voice band was avoided, to facilitate simultaneous telephony and reduce cross-talk. The effect of line characteristics is less, and oscillator stability better below the voice band than above; it was desired also to use the 60 cycle supply frequency as a receiver check point, so the upper end of the range was fixed at 60 cycles. The lower end is 35.75 cycles.

Power for the oscillator is supplied from the receiving end, over the telephone line. The line potential thus consists of the signal a.c. superimposed on the power supply d.c. A filter composed of inductor L and capacitor C_1 segregates the two components. The line is operated reactively, (not terminated in a matched impedance) and inductor L also serves the purpose of anti-resonating the line and filter circuit in the frequency band used. This reduces the effect of the line on the oscillator frequency.

A Hartley circuit was found to be the simplest and most stable. Tuning with an air condenser of practical size is made possible by the transformer L_1L_2, which gives a step-up of the capacitance. The equivalent increased capacitance appearing in shunt with L_2 forms the anti-resonant circuit. The d-c drop across resistor R, produced by the filament current, provides the plate potential. The output of the oscillator is impressed on the line by the a-c drop caused by the alternating components of the tube electrode currents. The grid current predominates, so the output is taken from the grid circuit, instead of the plate as is usually the case. A disadvantage of this output method is the loss of the filtering effect of the tuned circuit on harmonics, which are reduced by adjustment of the grid bias and by the design of the tuned circuit.

The oscillator tube has a ten-volt, 60-milliampere filamentary cathode. With 60 volts on the plate, 6 to 8 volts r-m-s output is obtained at the line terminals. Plate input power is 0.25 watt. The total oscillator voltage between plate and grid is about 55, r-m-s.

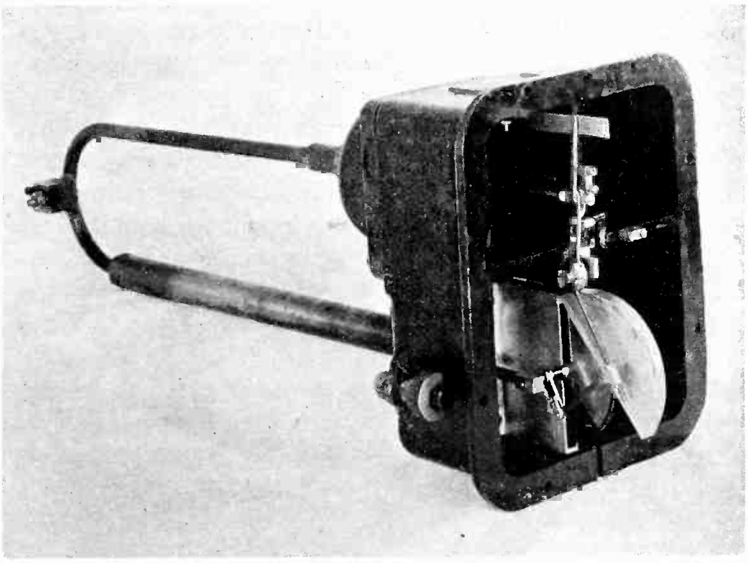
One of the problems encountered in development of the oscillator was the elimination of the effect of oscillation amplitude on the inductance of the iron core inductors, and hence on the frequency. This effect greatly exceeded that of the direct current thru the windings, and had a positive coefficient throughout the range investigated. The variations in the frequency were reduced by the use of an alloy core, combined with adjustment of the d.c. in the coil and the L/C ratio of the tuned circuit.

The receiver

The self-indicating frequency meter is of a well-known type[4,5]. Two triodes serve as grid-controlled valves, alternating charging and discharging a condenser at the frequency of the received signal. The average value of the current in either direction, as read on a d-c ammeter, is directly proportional to the frequency[6]. This type of frequency meter is completely independent of input voltage above a limit set by the frequency and the time constants of the charge and discharge circuits. The indication is affected by voltage if the condenser can not charge up to the full voltage applied, in the time of one half cycle, as a change in the voltage on the grids alters the tube resistances and hence the time constants. The resulting change in the charge alters the current value. But as soon as the charge becomes substantially complete, as the result of increased voltage on the grids, or lowered frequency (and hence a longer time to charge), no further increase in current is possible. Consequently, changes in voltage above this level have no effect on the indication.

The average value of the charging current (in amperes) for a sinusoidal grid voltage is given by fCE, where f is in cycles, C is in farads, and E is the d-c charging voltage. C is determined by the maximum value of d-c current desired for operation of the indicator. As the time constants are also a function of C, the minimum input level for independence, at a given charging voltage, is approximately a direct function of this current, and also of the frequency. Hence, theoretically the input required may be reduced to a very low value by using a small condenser and sensitive meter. Practically, however, with the switchboard type meters and the recorders necessary for commercial service, ten milliamperes full scale is the limit. For this current at 60 cycles, with a 0.5 μf condenser, about 15 volts r-m-s, minimum is required on the grids under optimum tube conditions. The amplifier and coupling transformer reduce the required minimum to 3.5 volts r-m-s. The value received from the telephone line is kept above 4.5 volts for safety. The input may be increased to 25 volts or more before the frequency meter begins to show the effects of waveform distortion, even though the amplifier grid is run far positive. This is because power is available from the oscillator to supply grid losses.

The grid bias of the frequency meter has an optimum value at which the least a-c voltage is required to reach the independent level. This bias is such that with the a.c. removed the current flowing through the two plate circuits in series is not quite cut off. With a d-c charging voltage of 360, the optimum grid bias is 15.5. Two copper-oxide rectifiers supply the bias, as a self-biasing method cannot be used. The grids swing positive with the a.c. applied, so the conditions affecting the coupling transformer design and amplifier plate circuit are the same as in Class B amplifier and its associated driving stage.



Manometer-transmitter assembly

The higher the amplification factor of the frequency-meter tubes, the less a-c input is required, provided the plate resistance is not also increased. Inasmuch as this calls for transconductance increasing at the same rate as the amplification factor, a practical limit is reached at about 15 for triodes with economically sized cathodes. This is the value in the special industrial triodes used, which are similar to the radio receiver type 56.

As the frequency meter requires zero frequency for zero condenser current, a suppressed zero milliameter with a range of 6-10 ma. is used, to set the lower end of the range at a frequency within reach of the oscillator. The movement is heavily damped to eliminate fluttering due to the pulsating current. The frequency scale is

[*Continued on page 62*]

Engraved sound tracks for film recording

—a new variable-width process

MECHANICAL engraving, the first method of sound recording ever devised, and still universally used for disc records, has now been applied to sound-on-film recording. Sound tracks of the variable width type, very similar in appearance to those photographically recorded, can be engraved directly on film by this new method, and the record, once made, is ready for reproduction without further processing. Compared with the complicated chemical processes required for film development, the mechanical system is simplicity itself, and the quality of the mechanically made records is fully the equal if not superior to the photographic variety.

The new process has been invented by J. A. Miller, Fellow of the Society of Motion Picture Engineers, Officer d'Academie Française, and a pioneer radio and sound picture engineer; and developed to commercial utility by the Philips-Miller Company of Holland in co-operation with the laboratories of the H. V. Philips Gloeilampenfabrieken, of Eindhoven. The process makes use of a magnetically controlled sapphire stylus, which is carefully ground to a wedge-shaped point, as shown in the illustration. Under the stylus is a specially prepared film composed of three separate layers. The layer next to the stylus is a very thin opaque black coating, not more than 2 or 3 microns thick. Under this coating is a transparent layer of a special material into which the stylus can cut without dragging. The bottom layer is the celluloid film itself. The entire strip is punched with sprocket holes, so that it can be moved underneath the stylus at constant speed.

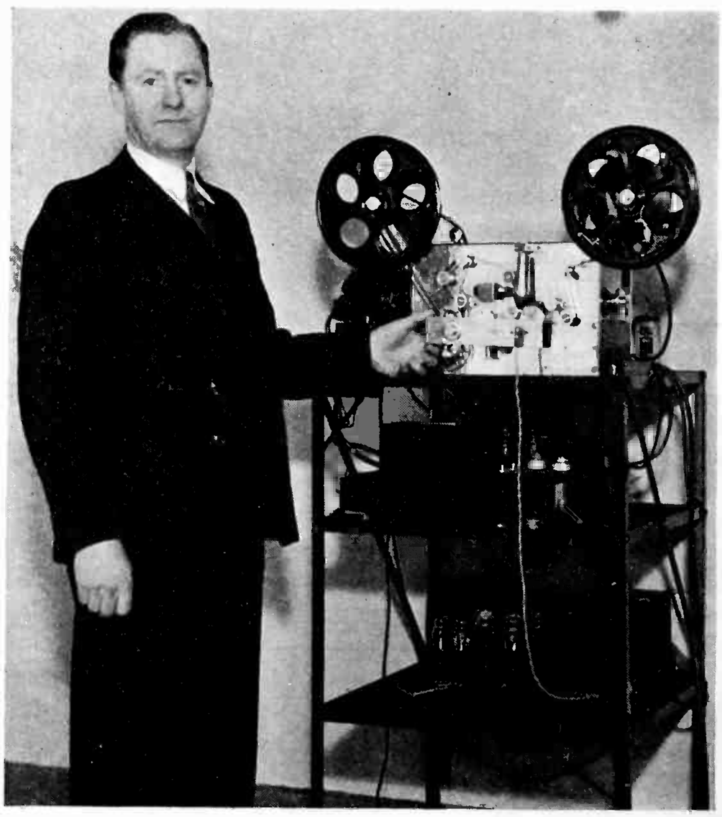
The stylus is controlled by a simple magnetic drive, similar in many ways to a magnetic loudspeaker motor. The stylus, under the influence of the current in the magnet coils, digs into the film, removing a part of the black coating on it, and exposing the transparent layers underneath. The width of the track is determined by the depth to which the stylus cuts into the film. Because of the double-wedge point of the stylus, the cut made is very narrow when the stylus is just resting on the film. But as the depth of cutting increases under the influence of the current, the width of the exposed portion increases proportionately. Thus if a high intensity thousand cycle note is impressed on the coil of the magnetic control, the stylus will cut into the film and the width of the sound track will go from minimum to maximum one thousand times per second. The track produced is similar in general appearance to the type of track recorded optically by means of a light valve. There are several important differences between the mechanical and optical methods, however, which make the engraving process highly desirable.

No processing required

The first and perhaps most important advantage of the mechanical method is its simplicity. The record is immediately ready for use when it leaves the recorder. No development and fixing are necessary as is the case in photographic recording. When used for motion picture work, the record can be "played back" to the director immediately after it is made, whereas a considerable wait is necessary when photographic recording is used. This saving of time reduces the cost of production all along the line. In fact Mr. Miller has estimated that motion-picture producers can save 15 per cent of their production cost by the use of mechanical recording.

The film used is not expensive, although somewhat more costly than ordinary film, and it is declared to be permanent and impervious to climatic conditions.

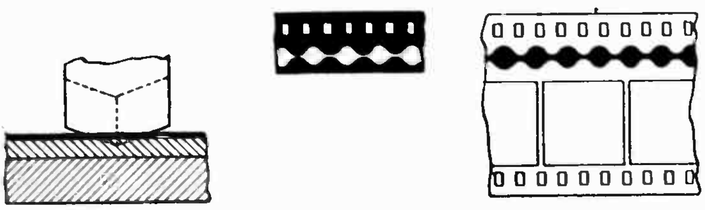
There are several serious limitations to the use of optically recorded sound tracks. Because of the finite grain size of the emulsion used in photographic film, the degree of detail is limited. This means that very high frequencies cannot be reproduced accurately. Furthermore the effects of halation and the finite width of slit which must be used, both detract from the ability of the optical method to record high frequencies. In the mechanical method, however, the line of the record between light and dark is absolutely clear-cut, since the grain both of the opaque coating and of the cutting material can be made extremely fine. The edge to which the sapphire



J. A. Miller with his sound-track engraving apparatus. The magnetically controlled cutting stylus is mounted beneath the film in the topmost section. Recording and play-back amplifiers are shown below

stylus can be ground depends on the skill of the cutter and hardness of the jewel, but in general it is many times narrower than the corresponding width of the slit used in optical recording.

The mechanical method offers one disadvantage that has only recently been overcome. The transparent part of the film, in the track, is marked with tiny ridges which have been cut by the stylus. These ridges at first proved to be the source of light refractions, when light was passed through the track for reproduction purposes. This trouble has been overcome, however, so that the quality of the reproduction is not affected by it.



At left: The stylus cuts into a film having three layers. The bottom layer is the film itself, the middle layer a special material into which the stylus cuts, and the top layer a very thin opaque coating. Because of its wedge-shaped cutting edge the deeper the stylus cuts, the greater the width of the cut. Variable-width sound tracks of the kind shown to the right are produced when the stylus is controlled by a voice amplifier

One serious objection to mechanical recording heretofore has been the extremely high power required to record high frequencies. In the variable-velocity type of recorder, the power required to operate the stylus varies as the square of the frequency. At frequencies of 10,000 cycles per second or higher, the power which would be required would burn out any control coil which might be used. In this present system, two methods have been used to overcome this difficulty. One is the high amplification made possible by the use of the wedge-shaped cutting edge. A vertical motion of a few thousandths of an inch is sufficient to increase the width of the track from a hairline to full width of $\frac{1}{8}$ of an inch. Such a high degree of amplification is made possible by the use of a very small angle between the cutting edge and the film itself.

In addition to this amplification principle, mechanical resonance is used to accentuate the response of the cutter at high frequencies. The magnet armature and stylus system are mechanically tuned so that comparatively little power is required to operate the stylus throughout the audible range. The success of the system at high frequencies is attested by the fact that sounds above the upper audible limit have been recorded successfully with it, while frequencies as high as 10,000 cycles can be recorded with ease.

Used in motion picture recording

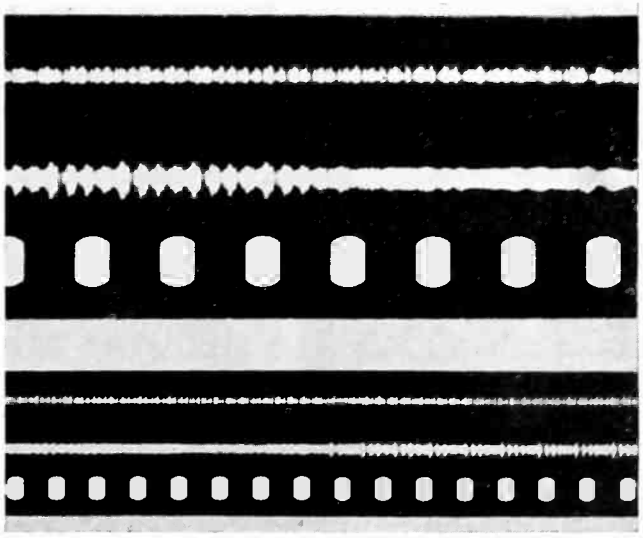
Sound recording and picture recording are performed separately in all modern motion-picture work. This is necessary because the emulsion used on picture film is not suitable for sound film, and vice-versa. When the two negatives, picture and sound, have been taken the sound is then re-recorded onto the master negative in its proper location with respect to the pictures. This master negative is then used for printing the release prints which are distributed to the theatres.

The mechanical system of engraving sound tracks is suited to use in the original recording. As has been pointed out, immediate play-back is very important in such work. In fact where wax-disc recording is used, a featherweight magnetic pick-up is occasionally used to play back the recording. But the danger of injury to the record is very great. In the engraving system, the record is complete as soon as it is made, and it cannot be injured by play-back regardless of the number of times it is used. Re-recording can be accomplished by direct printing from the original record and prints will be very sharp and clear cut. The simplicity of the system also adapts it for use in testing the acoustics of stage set-ups, entirely apart from the taking of the picture itself.

The introduction of 16-mm. sound-on-film into the home has been delayed for many reasons, but one of the most serious is the extreme difficulty of producing high quality sound tracks on small size film. The limitations of grain size, halation, and slit-width become exaggerated when the track must be confined to a small space, and as a result most 16-mm. sound film is very poor. Compensation for the high frequencies in such equipment must begin in many cases as low as 2000 cycles. The mechanically engraved track is not subject to this trouble for the same reasons that the grain size and halation are not factors, and the cutting edge can be made extremely fine.

With a simple recorder, requiring no more elaborate equipment than a simple amplifier such as is contained in any radio receiver, recordings can be made at home and replayed as many times as desired.

The editors of *Electronics* witnessed the operation of the recorder shown in the illustration. The recorder consisted of a microphone and regulation voice circuit coupled to a power amplifier. This amplifier was connected directly to the recording instrument. As the machine operated, the cutter followed the voice frequency with an audible sound, and continuous strip of the coating was removed from the moving film. The film was then removed from the cutting sprockets and placed in front of a photocell reproduction unit on the same panel. A reproduction amplifier takes the output of the photocell and feeds it to an ordinary dynamic loudspeaker. The faithfulness of reproduction was excellent. An entire two-reel film, the master negative of which was printed from mechanically recorded tracks, was shown. The music and speech compared favorably with optical recording and certain carefully made passages were definitely superior to optical recording.



Enlarged samples of sound-tracks engraved by the mechanical recorder. The track at the bottom is actual size. Prints are made from these records in the usual manner

HIGH LIGHTS ON ELECTRONIC

Photo-cell sets type from teletype copy

The Semagraph transmitter, a device which makes possible automatic typesetting direct from teletype copy such as that used by the press associations, is being demonstrated to newspapermen by Curtis B. Johnson, publisher of the Charlotte (N. C.) *Observer*.

Mr. Curtis is sponsoring the Semagraph, automatic typesetting machine invented by Buford L. Green, who also invented the transmitter. An important point stressed in connection with the transmitter is its adaptability to the present equipment used by the Associated Press, United Press and International News Service, thus eliminating the need for additional equipment for its operation.

The Semagraph employs a photoelectric cell that has a capacity of 2,400 light changes a minute. It is designed for setting straight news matter and its speed is limited only by the capacity of the composing machines.

The Semagraph typewriter was also demonstrated. It is a machine that turns out printed lines with each character in the line simultaneously coded, the symbols being directly under the letters on the type bars. It is from these code signals that the Semagraph, through the photo-electric cell application, operates the composing machines.

No perforated tape is used in connection with the Semagraph or Semagraph typewriter. The printed lines as produced on the typewriter are for the benefit of the editors.

The type bars on the receiving machine were coded just as the type bars on the Semagraph typewriter. Copy can be taken from the receiving machine and placed directly on the Semagraph without rewriting.

✦

Novel characteristics of tube-commutated 400-hp motor

A revolutionary new type of electric motor, which utilizes a "stationary commutator" and has the characteristics of a series-type d.-c. machine but which operates through Thyratrons from an a.-c. power source, has been developed by E. F. W. Alexanderson, consulting engineer of the General Electric Company, Schenectady, N. Y.

One motor of this type, intended for driving an induced-draft fan, has already been built and is now on test in the Schenectady Works. It is rated 400 hp. at 625 r.p.m. and 75 hp. at 350 r.p.m. These are the specified ranges of horsepower and speed for the particular application, although the motor may be successfully controlled down to standstill, if required. The equipment operates from a 2,300-volt, three-phase, 60-cycle power supply.

The motor has a stationary armature and a revolving field of the type used in synchronous motors. The armature, however, is provided with a special winding. Unidirectional current is supplied by means of a group of full-wave rectifiers which operate from the three-phase 60-cycle current source. The operation of the Thyratron rectifiers is controlled by means of grids in these tubes so that power is supplied to the motor windings in the proper sequence and amount necessary to give the required torque for operation. This control is obtained by means of a small distributor mounted on one end of the motor shaft. Speed control is obtained by varying the voltage supplied to the motor armature, by means of a phase-shifting device acting upon the same grids in the Thyratron tubes. Through this method, it is possible to obtain smooth speed control over the entire range for which the motor is designed.

Among the noteworthy features of this motor are the following:

(1) While running from alternating current, the motor has the characteristics of a series-type direct-current machine.

(2) The speed of the motor is independent of the frequency of the power supply.

(3) Smooth control of the speed can be obtained over the full range.

(4) In event of a momentary interruption of the supply circuit, the motor will, upon the restoration of power, start and return to the speed at which it was previously operating, without drawing excessive current from the line.

(5) The efficiency is high and the efficiency curve relatively flat—a distinct advantage, particularly in the lower portion of the speed range.

Because of these characteristics, motors of this type are applicable to such auxiliaries as fans, centrifugal pumps, compressors, and similar equipment having load characteristics such

"BOMBARDING" IN THE BEAUTY-SHOP

With the aid of electrically-conducting curlers, and in the presence of a high-frequency field, this "permanent-wave" machine in a London beauty-shop avoids heavy wires to operate the heaters

that the series type of motor can be used to advantage.

The revolving field of the motor is connected in series with the neutrals of the armature windings and, as a result, the motor has the characteristics of the well-known series-type direct-current motor.

The Thyratron tubes, according to Dr. Alexanderson, perform two distinct functions, one being commutation and the other being grid-controlled rectification. Each of these functions has significance in the performance of the new motor. Through the commutator function, the smooth variable speed-torque characteristics of a d.-c. motor are obtainable, without any reference to synchronism with the power source used. The grid-controlled rectifier function provides the motor with continuous power control from standstill to maximum speed, without wasting power in resistance.

✦

Electron microscope hunts chemical affinities

By Dr. E. E. Free

Uses of the new electron microscopes to peer into the inexpressibly tiny interiors of atoms and molecules, were described before the recent meeting of the British Association for the Advancement of Science, at Aberdeen, Scotland, by Dr. H. de Laszlo.

The limit of magnification of ordinary microscopes is reached long before even the largest molecule is visible. Even the somewhat more powerful instruments called ultra-microscopes fall far short of disclosing individual molecules or atoms, let alone of seeing inside them. Beams of X-rays have been used to show the mutual arrangements of atoms inside crystals but individual atoms or small groups of atoms are invisible to these also. Yet it is precisely these single atoms or atomic pairs, triplets and similar small groups which chemists most want to know about, since this might clear up the whole mystery of chemical affinity; the force which makes atoms stick together tightly in certain chemical compounds while avoiding other compounds. It is these forces, for example, which make steel harder than lead or coal easier to burn than asbestos. This is what Dr. de Laszlo reports that the new electron microscopes are doing.

A tiny beam of these minute, invisible electrons is shot through a crowd of the atoms or molecules to be studied, like a searchlight beam through a swarm of insects. The electrons are diverted and reflected in various ways, depending on the structures and natures of the atoms or molecules which they hit.

✦

Electronic clock keeps nation's time

Two Crystal oscillators purchased by the Navy Department from the General Radio Company, are now installed respectively at the U. S. Naval Observatory, Washington, and at the Mare Island Navy Yard.

The outfit at the Naval Observatory is used in checking the nation's standard time in an interesting way, which simplifies operation and eliminates all possible error. The General Radio crystal oscillator operates a synchronous motor, and the output of this motor operates the time-comparer and broadcaster.

"Where previously it required sixteen minutes for an astronomer to compare the sidereal and mean-time transmitting clocks, the new time-comparer now does this in about five seconds," reports Captain J. F. Hellweg, superintendent of the Naval Observatory. "In the case of the original scheme, the officer in charge of the watch operated the mechanism each time the mean-time clock broadcast. With the new time-comparer and broadcaster, the instrument is automatic. It throws its own switch, controls Arlington and Annapolis, and broadcasts its own time."

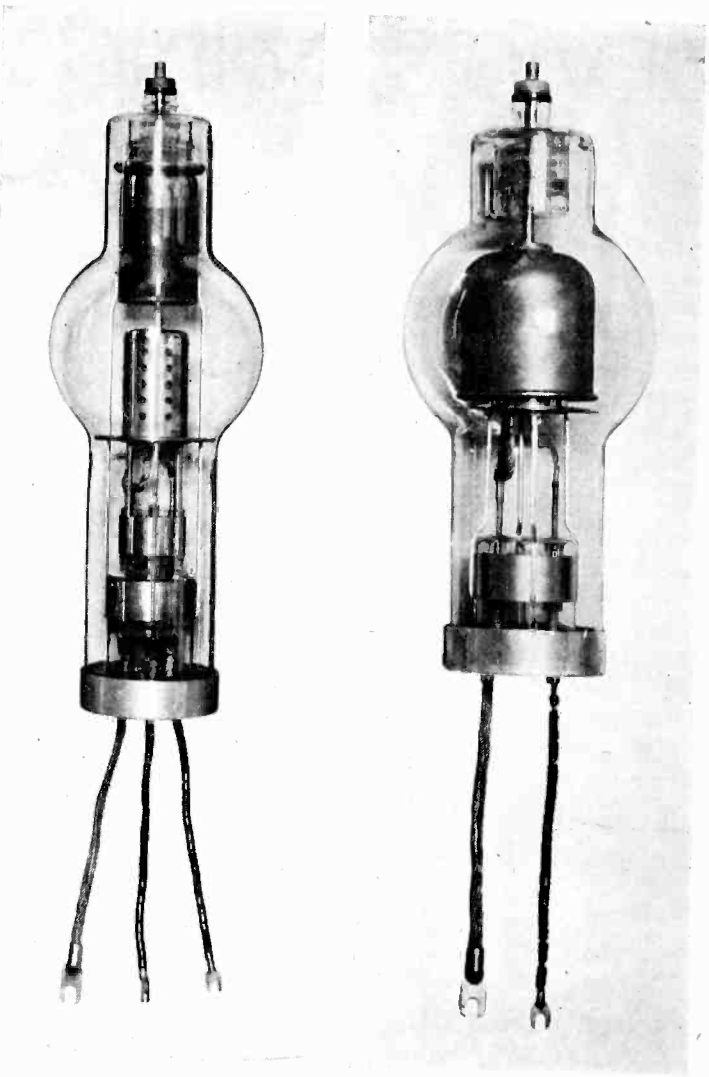
The crystal-oscillator electronic clock at the U. S. Naval Observatory now compares and sends its own broadcasts

PHOTOTUBE USED FOR RACE-HORSE TIMING

Racetrack officials inspect a new electronic timer, proposed for use in timing horse racing with extreme accuracy

High-tension d-c transmission

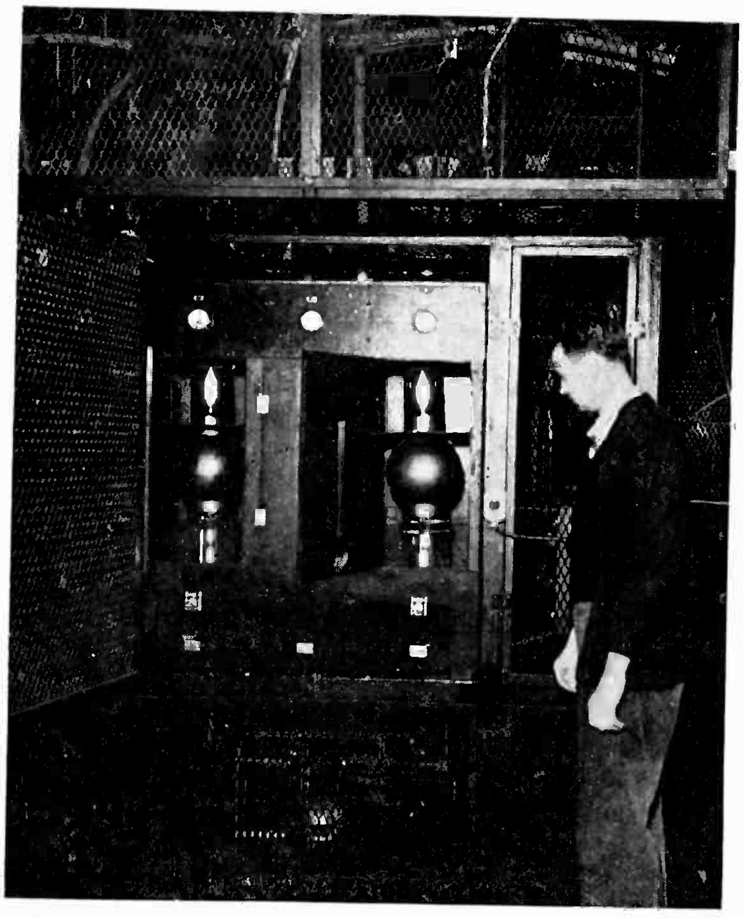
Electronic rectifiers and inverters open new power possibilities



Types of Thyratron and Phanotron tubes used

ALREADY transmitting and converting power in amounts up to 3000 kw., a complete new system of direct-current high-tension transmission and distribution has been developed at Schenectady, N. Y., making it possible to interconnect non-synchronous systems through static apparatus. This has been done by the utilization of electronic devices, including Thyratron and Phanotron tubes. With the new system a higher order of stability has been obtained as contrasted with previous practice, and faults similar to short-circuits result in a reduced instead of an increased power flow on the circuit involved.

The new system of constant-current direct-current transmission, was described in a paper presented at the winter convention of the American Institute of Electrical Engineers, in New York City in January, by Dr. C. H. Willis, B. D. Bedford, and Dr. F. R. Elder. Dr. Willis is a member of the faculty of Princeton University, and the other two men are with the General Electrical Company.



Part of the direct-current transmission line at Schenectady

In brief, the essential features of the new system of electric power transmission are:

It is a constant-current direct-current system.

It is a system where the power flow is in one direction only at the will of the operator; but the power can be transmitted in either direction if desired.

Control of the amount of power flow is under the control of the operator at all times.

No wattless power is transmitted.

The full insulation voltage of the line can be utilized, increasing the voltage available and reducing current and losses.

A short circuit on any circuit of this type results in a reduction of power flow on the circuit involved.

Power can be transmitted by either overhead or underground lines any distance desired.

A circuit of this type can be tapped at any point to furnish power or to take power.

The nature of the circuit is such that systems of like or unlike frequencies can be operated together to feed any other system of like or unlike frequencies.

Overhead systems of this type should be more reliable, and less disturbance will be caused by lightning.

The system cannot become out of phase or out of synchronism with the system feeding it or with the system receiving power.

Alternating current is at present almost universally used for power transmission. The difficulties of connecting systems, or even generating plants, together are many, as systems of unlike frequencies cannot be connected together readily except by means of motor generator sets, and the power flow through these motor generator sets is uncontrollable except by elaborate and expensive apparatus. Systems of like frequency are difficult to keep together in synchronism because of the phase angle resulting from the reactances of transformers and circuits. Control of power flow is largely determined by the demands of the system, and the operators have little control except by means of circuit breakers, which may be opened or closed, automatically or manually, usually resulting in interruption of service. This means that in case of faults anywhere on the system, a large concentration of power results, which may be sufficient to shake the system apart and cause considerable damage.

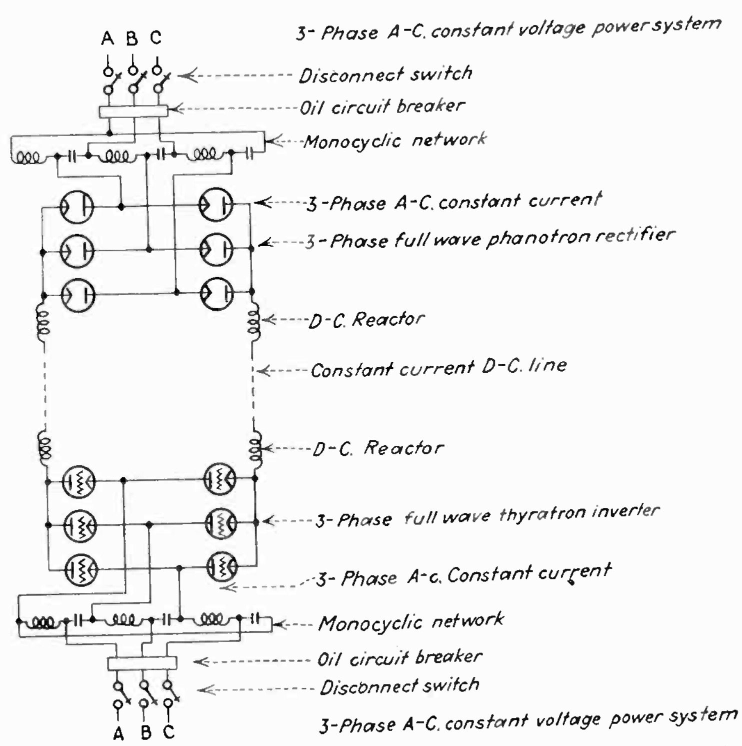
The newly developed direct-current system, on the other hand, places in the hands of the operator full control of his system. He can at all times control not only the amount of power flow but its direction. The system cannot get out of phase or out of synchronism; and faults, such as short circuits, cause a drop in power flow rather than an increase such as exists on all present systems.

Stations of like frequency or unlike frequency can be connected together with the new system to feed the same distributing system without any trouble.

The 150-kw. and 3,000-kw. lines

As most loads of power systems are of lagging power factor, the transmission of the resulting wattless current adversely affects the capacity of the circuits, the transformers, and the generators feeding the system. With the new system, all the load on the generating stations will be slightly leading, rather than lagging; and no wattless power is transmitted. The wattless current required by the loads is supplied by the inverter equipment. This results in lower generator and transformer heating, and improved regulation.

In the paper presented by Dr. Willis, Mr. Bedford and Dr. Elder there was described a circuit installed in the Research Laboratory at Schenectady arranged for



Block diagram of direct-current transmission system

the transmission of 150 kilowatts of power, the circuit operating at a maximum peak of 15,000 volts and 10 amperes. In one of the factory buildings in the Schenectady works there has been made a larger installation, referred to in the discussion at the Institute meeting, in which connection is made to a 13,800-volt, 60-cycle, three-phase, alternating-current bus of the New York Power and Light Corporation with a circuit for transmitting a constant direct current of 200 amperes at 15,000 volts. This circuit includes about 15,000 feet of underground conductor, and is connected back to the 13,800-volt bus, after being inverted from direct- to alternating-current of the proper characteristics.

In this 3000-kilowatt constant-current direct-current circuit, a group of condensers and reactors are so connected to the 13,800-volt bus that constant-current alternating current is obtained; the circuit being tuned so that this current is 200 amperes, the voltage varies with the load. The alternating current is then rectified

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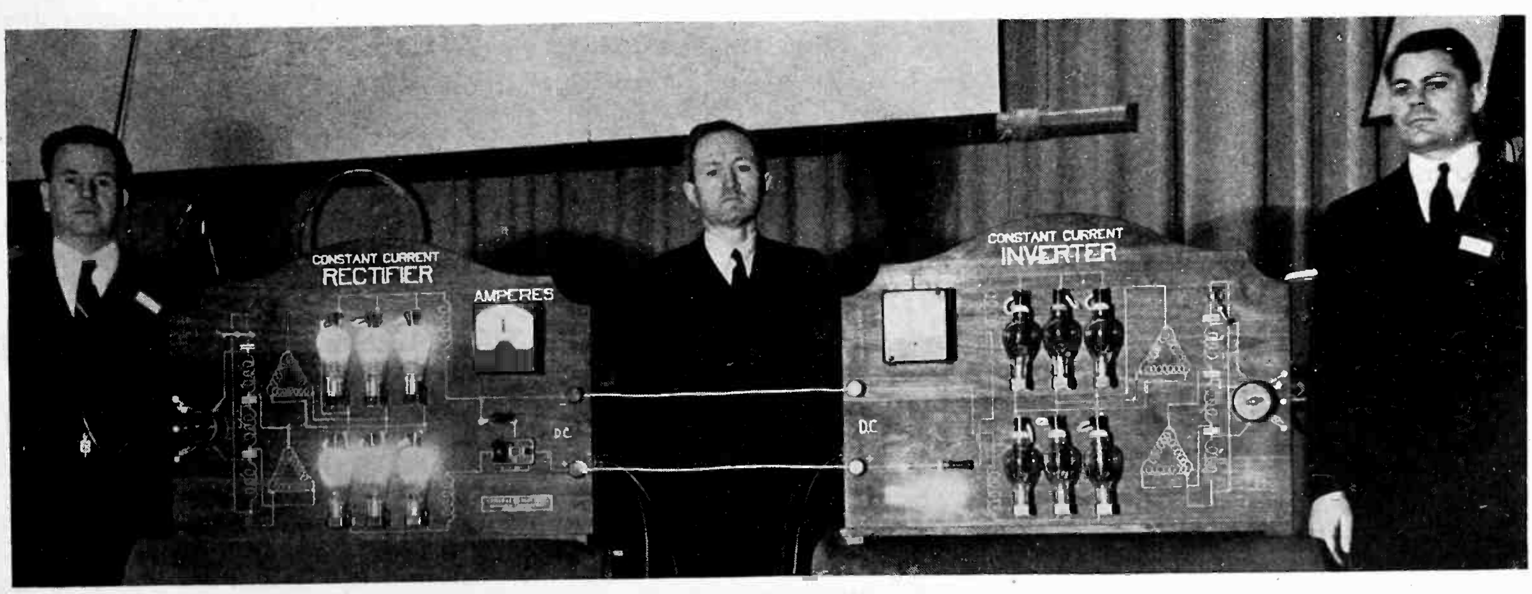


Operating model of direct-current system, exhibited by the three authors at New York Convention, A. I. E. E.

An electronic fader

By Verne V. Gunsolley

In line with the trend toward the substitution of electronic devices for those of mechanical operation, comes the adaptation to one of the most fundamental units in broadcast and sound engineering: the fader.

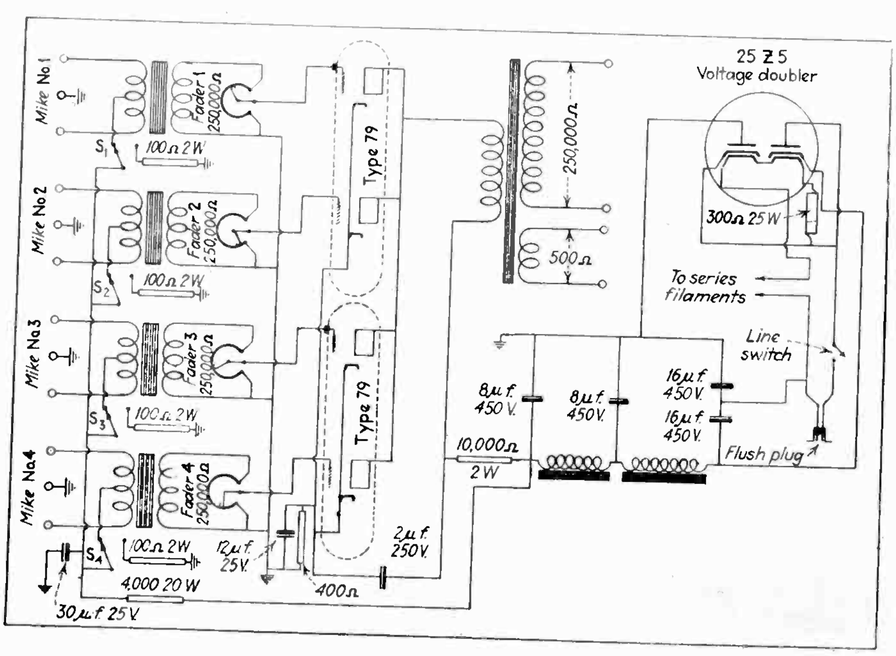
This fader developed by H. L. Mills* is shown in the diagram where the customary constant impedance network is eliminated by the use of type 79 tubes (or the prototype 53), the plates of which are tied together. The arm of each potentiometer is connected to the grid of its corresponding triode. Since the grid is biased negative for Class A operation there is no grid current and no current carrying contacts, hence no noise. Also, because the potentiometer operates without load, it lasts indefinitely and can be a most ordinary type costing much less than a dollar.

The usual fader has a limited number of steps, each one of which presents a "constant" impedance depending upon the accuracy of the calculations and the measurements of resistance, and the permanancy in use. In the electronic fader the number of steps is infinite and the impedance absolutely constant throughout the range. It has the further advantage that it is independent of the type and condition of the microphone. If any disorder develops in the microphone input circuit it has no effect on the other circuits provided it is not a disorder of audio frequency. Troubles are limited practically to the failure of the tubes which may be easily replaced at little expense and inconvenience.

One very interesting question was brought to the attention of the writer. It was claimed that since all the plates are tied together, if only one plate is used at a time, the plate resistances of the other three plates are in parallel, acting like a load resistor of one third the plate resistance of the active triode. Since the optimum load resistance for a triode is two or more times the plate resistance, the conclusion drawn was that this type of fader presented excessive harmonic distortion as a disadvantage outweighing the advantages. There was no doubt about the high quality of reproduction, however, and the objector was at some loss to account for the paradox. The answer is to be found in the simple principle of "Newton's microscope." Suppose the plate characteristic of the 79 (or 53) to be drawn to such a scale that the radius of curvature (introduced by loading the plate with one third its resistance) is three inches. Since the input due to the microphone is very low, the excursion up and down the plate curve is exceedingly small. When this small excursion is amplified 6,000 times or so, as in the average amplifier, the radius of curvature is likewise amplified the same amount; to 18,000 inches or 1,500 feet, on the same scale. Any curve of such a radius is quite as straight as would be the case were the 79 used as a power output tube, matched with its optimum impedance.

A portable remote amplifier has been made in which advantage has been taken of the light weight and compactness of this new fader system. Four positions are provided. To accommodate this number with old style faders of equal performance would have required a separate panel for the faders alone. Since, with the new fader, no compromise with weight and quality is necessary, the same performance is available on the remote amplifier as from the most expensive and highly engineered studio equipment. The fader equipment in the amplifier weighs less than 7 ounces.

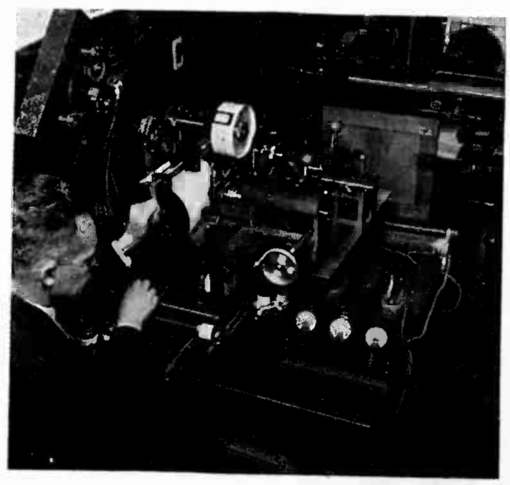
*Chief Engineer, United Sound Engineering Co., St. Paul, Minn.



Electron-tube fader circuit

Photocell used for spectroscopy measurements

Spectroscopy, the study of the composition of matter through analysis of the light emitted by atoms and molecules, has become one of the most important fields of modern science. The method used to analyze the spectrum of any given light involves the use of a delicate machine known as a comparator, which is capable of making measurements on a photographic plate to within 1/25,000 of an inch. By this means the spectrum lines of the spectrum photographs are recorded to an accuracy of six or seven decimal places. A device for performing this operation was described in *Electronics* in the November 1934, issue on page 358. When this type of comparator is used, the services of a highly trained operator are necessary in order to obtain the highest degree of accuracy.



The photocell is used to measure spectrum photographs in this new comparator, invented by Prof. George R. Harrison

Recently, however, a new type of spectroscopic comparator has been developed by Prof. George R. Harrison, Director of the Spectroscopy Laboratory, Massachusetts Institute of Technology. A photocell which takes the place of the eye of the operator, can make measurements ten times as fast as the conventional method and the

TUBES AND CIRCUITS + +

results are twice as accurate. In the new machine a beam of light is made to pass through the photographic plate, and this beam actuates a photocell amplifier system. When the instrument is set on the peak of a spectrum line, the photocell operates a thyratron and flashes a mercury arc. The light from the arc photographs the reading of the wave length on a moving film.

With the use of these readings the spectroscopist can identify the spectrum lines in the picture. From these lines the energy levels of the substance being analyzed are calculated by a very laborious process which hitherto has been carried out with pencil and paper. A companion machine to the photocell analyzer is the interval sorter which makes the mathematical computation automatically. The interval sorter or mathematical machine has the amazing capacity of 50,000 subtractions per minute, at the same time recording the results photographically. Using these two machines it has been possible to speed up greatly the application of spectroscopic analysis, a science which is proving of great value in physics, chemistry, metallurgy, astronomy and even in medicine.

✦

Phototubes used for catching speeders

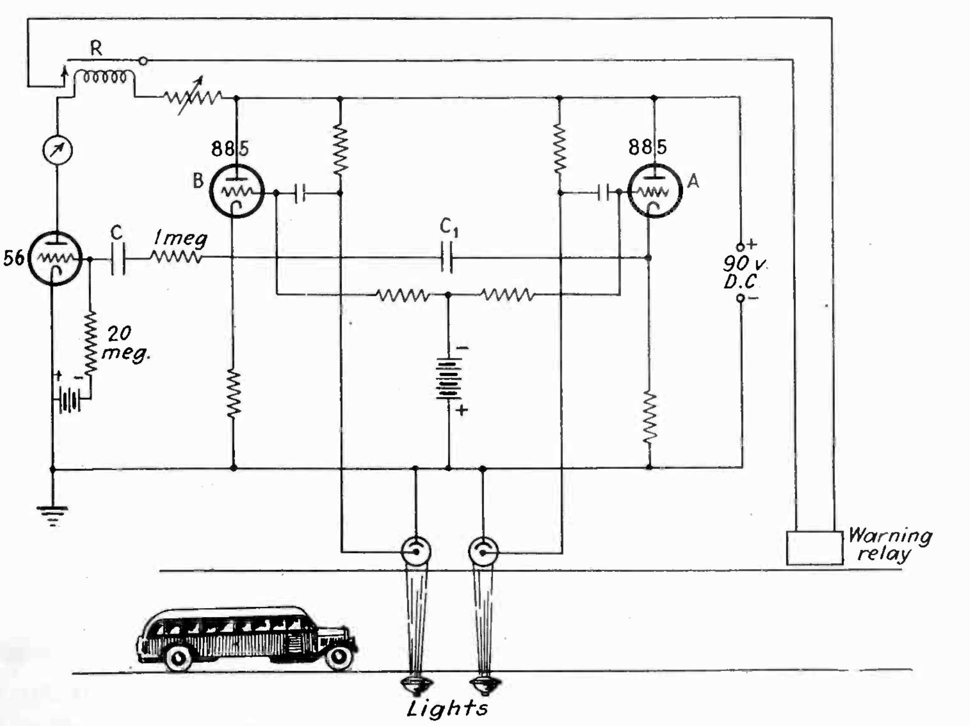
The policeman whose duty it is to apprehend speeding motorists has recently been given an electrical partner to aid him in his work. A device for automatically measuring the speed of a car as it passes a given point has been developed, using two photocells and a vacuum tube relay circuit. This device, designed by Mr. F. H. Shepard of RCA Radiotron Co., Inc., automatically gives warning when an automobile passes a pair of phototubes too rapidly.

As shown in the figure, initially, gas-triode A is conducting, gas-triode B is not, and relay R is open. When the front of a car interrupts light to the first photocell, the cell current decreases sharply, and the grid of tube B is charged positive. This starts tube B conducting. The cathode of tube B was initially at ground potential but is now positive; so C_1 applies a positive potential to the cathode of tube A and stops conduction in tube A. When light on the second cell is intercepted, current through the second cell decreases sharply and a reverse procedure takes place: the grid of tube A is charged positive, tube A starts conducting, the cathode of tube B is pulled positive, and tube B stops. It will be seen that tube B conducts only during the time that it takes the car to go the distance between the two phototubes.

When tube B starts conducting and its cathode jumps to a positive potential, C pulls the grid of the 56 as far positive as electron current from the filament will permit—to about zero potential. This increases the 56 plate current to close relay R. While tube B continues to conduct, condenser C charges up through the 1-megohm resistor because there is a potential difference between the positive cathode of tube B and the zero-potential grid of the 56. When tube B stops conducting and its cathode returns to ground potential, condenser C applies a negative voltage due to this accumulated charge to the grid of the 56. The magnitude of this voltage depends on how long tube B was conducting which in turn depends on how slowly the car passed the phototubes. If a large enough negative voltage is placed on the grid by the condenser, plate current through the 56 will be decreased below the release value of relay R. Therefore, when a slow car reaches the first phototube, it will close relay R; when it reaches the second phototube, it will open relay R before the warning relay, which is relatively slow-acting, can close. A fast car, however, will actuate the warning relay because relay R will close and stay closed.

By the time the car has passed both phototubes and light is shining on them again, the charge on C has leaked off, plate current of the 56 has returned to normal, and everything is set for the next car. The circuit is so adjusted that normal plate current through the 56 is less than the pull-over value of the relay R but greater than the release value; so when a fast car fails to open relay R after closing it, the relay will remain closed even after the current through it returns to normal. Therefore, once the warning signal is turned on by a fast car it will stay on for any number of fast cars following and will only be turned off by a slow car. After that, it will stay off for any number of slow cars and will be turned on again by a speeder.

By changing the details of installation, this circuit can be used in many different applications. The installation diagrammed is for a single line of traffic. For two lines of traffic going in the same direction, such as is found on four-lane highways, bridges, and vehicular tunnels, a vertical beam of light can be used for each lane. By mounting the light source and phototube in a hood overhead, in conjunction with a mirror buried at the lower end of a vertical pipe sunk in the road, trouble due to sunlight and other stray light is avoided. By placing the warning signal in a prominent position along the road, the speeder can be cautioned; by placing it in a police booth, he can be caught. By adding a recording mechanism to the circuit, twenty-four hour surveys can be made automatically for insurance companies or traffic engineers of speeding conditions at such points as the entrance to a small town on an express highway, or the approach to a railroad crossing. By replacing the relays with a d-c milliammeter calibrated in miles per hour, an accurate measurement can be made of the instantaneous speed of racing vehicles.



Circuit used in the photoelectric speed trap

electronics

McGraw-Hill Publishing Company, Inc.
330 West 42d Street
New York City

ORESTES H. CALDWELL, *Editor*

KEITH HENNEY, *Managing Editor*
DONALD FINK

Vol. VIII —FEBRUARY, 1935— Number 2

New models from noise elimination

ANYTHING that has to do with noise abatement involves the interest of the electronic engineer. But this noise abatement movement has a larger result in creating new industries and new payrolls to pull us out of the depression.

New noiseless models of machines, equipment and other products, tend to *make obsolete* former *noisy* types. In this way earlier equipment still in the customer's hands becomes automatically outmoded. Typewriters, office machines, automobiles, railroad cars, electrical appliances, plumbing equipment, building materials, floor surfaces, furniture, all afford examples of the new trend toward noiseless operation.

Manufacturers in all lines are critically examining their wares today, to see what can be done to make these products noiseproof and efficient. Competition in certain fields has already shifted over to the basis of *silence in operation*, and purchasers are discriminating in favor of equipment that recognizes the public's demand for noise abatement.

"Engineers" must have a license

MANY radio engineers will be surprised to learn that in twenty-six states of the Union it is now illegal for anyone to engage in responsible engineering practice, either as a consultant or an employed "engineer," without first registering and obtaining an "engineer's license."

This movement to put engineers on a professional basis, like doctors and lawyers who must meet the requirements of boards of examiners, has now spread widely, and the new state statutes are being increasingly enforced. Caught unawares in this new political vortex, engineers of the older classifications are watching closely the new development, and in belated self-defense, have approved model engineers' licensing laws. In most states the requirements for licenses are nominal at first, but after a few years of the statute, strict examinations are imposed. Initial license fees for engineers usually run about $25, with renewals at a dollar per year.

These laws invariably are very definite in limiting the application of the word "engineer" to persons who have qualified and registered. Each state is, of course, a law unto itself, so that every radio man will want to find out for himself what his own state requires of him in order that he may continue to refer to himself as an "engineer."

Legal safeguards through recording

THE Federal Court verdict in the Station KMBC case, in which the station was held jointly liable for a libelous statement coming over the chain network from a distant studio, will direct attention to the desirability of recording speeches where an element of risk exists. As things stand with the present system of direct broadcast from the microphone, a libel can be uttered and broadcast before the station supervisor himself realizes it, and so the station is helpless to guard against becoming an unwitting accomplice.

But if such speeches were first recorded and scrutinized for objectionable phrases, the recording could then be played back into the broadcast system with full confidence. Only a few seconds' or minutes' delay need occur between studio utterance and consignment to the kilocycles, but legal safety would be assured. Already the networks have recording meters continuously in circuit drawing graphs of everything that goes onto the system, but this is only for the purpose of insuring adequate levels. The next step may be to record all utterances, and retransmit them after purging them of any legal dynamite.

Facsimile for police radio

AS an adjunct to the rapidly growing police radio system the application of facsimile would have tremendous value. One of the weak links in the present networks is the need by headquarters and cruisers of a permanent record of transmissions. Facsimile would overcome this lack, and at the same time perform other highly important functions.

For example, it is now impossible to hold suspected criminals for any length of time. But if through a facsimile system, perhaps a nation-wide Federal network, finger prints could be sent to the huge Washington library to be checked against the marks of known criminals, almost immediate identification could be obtained.

Of course such a system could handle not only finger prints, but typed or written messages, photographs, samples of handwriting and other visual means of identifying persons suspected of crime.

Facsimile is now available of speed and detail and of such low cost that a national set-up would not be difficult or unduly expensive. It would serve a distinct public service.

A "radio-interference" clause for apartment leases

RADIO interference in apartment houses has proven one almost insurmountable difficulty to the wider use of radio sets in metropolitan centers. Little provision is usually made for adequate antennas, and the aerial put up by the tenant is often so poorly located that it picks up more electrical interference than signal.

One suggestion to control interference from tenants' premises would be a clause in the lease under which the tenant "promises to commit no radio nuisance," and to "permit no source of radio interference to continue" on his premises. Modern lease forms which anticipate so many other contingencies should include a clause of this kind for the protection of radio.

The other remedy is to get the landlord to install an adequate group-antenna for the building, with the pick-up high on the roof, thus giving better program clarity and also freedom from contamination with electrical noises that arise within the building itself.

Headphone due for renaissance

FOR that pocket-size radio set, often suggested for the busy layman and the beat-walking policeman, headphones will be a necessity. One of the stumbling blocks to the development of this type of personal radio is the difficulty of making the incoming signals audible. What is needed is a new type of headphone, light, compact, efficient.

Headphones could be used to great advantage in the radio-ridden home so that those who listen can do so without disturbing the remainder of the family for hours without end.

But it is possible that a still higher duty lies in wait for a newer type of headphone. In high fidelity reception, standing waves within the listener's room may destroy the higher frequencies, or set up an annoying pattern of sound waves. Headphones would eliminate this problem. Furthermore, with the close coupling obtainable to the ears, high fidelity and clarity can easily be obtained.

A new type of aural device which would be easy to wear, inconspicuous perhaps, of wide and flat tone range might awaken the headphone industry, long dormant but once of vast dimensions.

CITY NOISES IN CORNER-STONE

Recorded on a copper disk, chromium-plated, and sealed in a bronze casket cemented into the corner-stone of the new building for the American Foundation for the Blind, noises of street traffic and New York life of 1935, have been preserved for posterity. A cadmium-plated pick-up was included.

D-c power transmission

[*Continued from page 57*]

by means of six Phanotron tubes. (If two-way transmission is desired, Thyratron tubes are used.)

High-voltage constant-current direct current is thus produced. After passing through some direct-current smoothing reactors the current goes through the 15,000-foot length of underground conductor—representing transmission of the energy—after which it is received and passed through another direct-current smoothing reactor. Six Thyratron tubes then invert the direct-current into 60-cycle three phase alternating current of constant value. Another group of reactors and condensers then changes this constant current into constant-potential alternating current, the current output at this point varying with the load. Connection is then made back to the alternating-current bus in the factory. Such an arrangement of condensers and reactors constitutes what is known as a monocyclic network.

One feature of such a network is that, if it is tuned for a certain definite current and if it receives this current, constant potential results at the output terminals. On the other hand, if it is supplied from a constant potential bus, constant current will be obtained at the terminals. Neglecting the losses in the reactors and condensers, the power factor on both sides of the network is equal, but of opposite value.

The rectifier end of this network connected to a constant-potential system will furnish a sufficient voltage to cause the full-load current of the direct-current system to flow. Thus, if a short circuit of low resistance exists close to the rectifier, the voltage furnished by the rectifier will be very low—only sufficient to overcome the low resistance of the short circuit. The power flow, then, will be reduced; and, if the resistance is of very low value, the voltage will collapse to practically zero.

At the receiving end of the line, or the inverter, the tubes, being arranged to pass current in one direction only, will operate as an inverter as long as constant current is received from the rectifier. Failing to receive this constant current, the inverter becomes a rectifier and draws full-load current at low voltage from the alternating-current system to which it is connected.

If a short circuit occurs on the direct-current line, and if the constant current of the system is 200 amperes and the regulation of the line is 10 per cent, then the current flow into the short circuit will be about 20 amperes. The voltage on the direct-current line drops to that point necessary to cause 20 amperes to flow in the short circuit.

As soon as the short circuit is removed, normal current flows in the normal direction, the rectifier furnishes its share of the current, the inverter receives the current, and the current is inverted and furnished to the receiver system as constant-potential alternating current.

If, when the line is operating under normal conditions, the cable is short-circuited by means of a single-pole knife-blade switch, the voltmeter reading drops practically to zero but the current remains constant. If the switch is then opened, the voltage returns very promptly and at all times the current remains constant.

A further interesting demonstration is made by short-circuiting the line through a six-ampere 250-volt cartridge fuse. The fuse blows, thus opening the short circuit; little disturbance is caused by the blowing of such a small fuse.

In still another demonstration an insulator normally used on an 11,000-volt alternating-current line is employed. Two such insulators are usually used on such a line, but in the demonstration there is only one. If an attempt is made to arc over the insulator by short-circuiting it with a small wire, the arc-over of the insulator cannot continue. It is indicated that overhead lines can be built with fewer insulators than are now required for alternating-current power since, while they may arc over because of a lightning flash, the dynamic current of the system is limited and the arc will extinguish itself. Each insulator thus becomes a lightning arrester to clear the line of any high-voltage transients.

Electron-tube telemetering

[*Continued from page 51*]

not absolutely linear, owing to the slight change in charging voltage throughout the range because of regulation in the rectifier-filter system. The frequency required for 6 ma. is consequently nearer 35.75, instead of 36 as required under theoretical conditions. A great non-linearity and widening of the range would have been unimportant insofar as calibration is concerned, but since the oscillator capacitance range is a squared function of the frequency range, restriction of the latter simplifies the variable condenser construction.

The calibration is completely independent of tube characteristics. The only variable for which stabilization is necessary is the d-c charging voltage, which is maintained within a negligible range by a resonance type line voltage compensator on the power input to the whole system. The transmission line resistance is only a fraction of the total resistance in the d-c transmitter circuit, so thermal changes are negligible in effect.

In the majority of gas and water installations the connecting link between the quantity under measurement and the electrical circuits is a mercury manometer actuating a float. This device can be designed for operation on widely differing ranges of pressure, and may be used on either liquids or gases. The float, riding in a pool of mercury, is coupled to the transmitter variable condenser through an adjustable lever and pivot system.

The maximum distance over which the circuit shown will operate is between 20 and 50 miles, depending on the type of line. Adaptation for greater distances is simply a matter of utilizing a larger part of the oscillator output, by means of a different output method. The majority of installations, on city gas and water lines, work over distances of 5 miles and less. Other systems indicate gas pressure on overland pipe-lines at their entrance to steel plants over 100 miles distant. Systems to indicate remote river stages by radio are being installed for the War Department.

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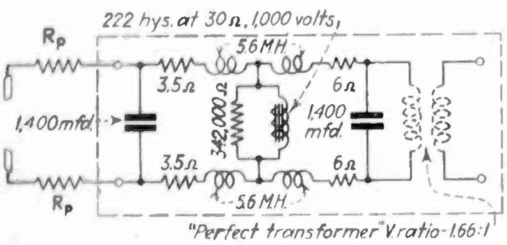
1. Report on Telemetering, Supervisory Control and Associated Communication Circuits: Committee on Automatic Stations, Instruments and Measurements, A.I.E.E. 1932.
2. "Instruments." Vol. 5, p. 66, Mar. 1932. p 91, Apr. 1932.
3. U. S. Patent No. 1,718,497 (G.E. Co.)
4. U. S. Patent No. 1,809,683 (G.E. Co.)
5. Proc. I.R.E. 19, 659, Apr. 1931.

A REVIEW OF THE ELECTRONIC ART HERE AND ABROAD

High power modulation transformers

THE USE of Class B modulation in high power transmitters requires an accurately designed modulation transformer, capable of matching the impedances of the circuit and at the same time introducing a loss which is small, and uniform throughout the entire audio range. According to a discussion in the transformer bulletin issued by the American Transformer Company of Newark, N. J., such transformers may be made to accommodate almost any amount of power from 100 watts to



Equivalent network of modulation transformer

500,000 watts. The larger size transformers, capable of modulating a 500 kw. transmitter, are of extremely large dimensions, ten feet high. The insertion loss of such transformers is remarkably low. The variation in loss throughout the range from 30 to 10,000 cycles is less than ¼ of a db.

✦

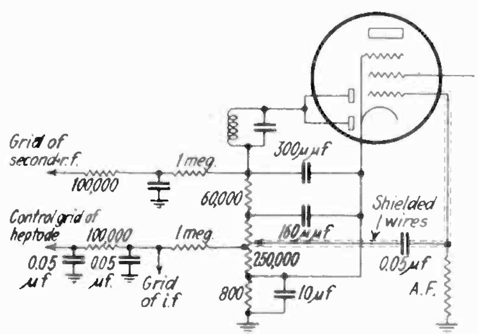
Navy installs air-conditioned room for testing radio equipment

THE NAVAL RESEARCH LABORATORY is installing a specially designed air-tight room in which to imitate, by air conditioning and proper insulation, the conditions of cold and rarified atmosphere encountered in high-altitude flight and in stratosphere exploration. The test room will consist of an air-tight, completely insulated vault 15′ by 20′ by 10′, equipped with air-conditioning machinery capable of maintaining any desired temperature between 50° below zero and 150° above zero, Fahrenheit. Control of humidity and air pressure will also be provided.

The room will be used to test, under actual operating conditions, the various radio instruments and measuring equipment used in high altitude flying, and for reproducing any sort of weather to which the equipment may be subjected.

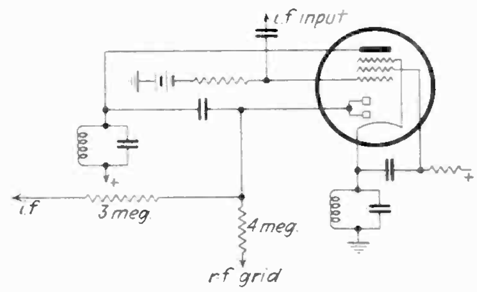
French opinions on an American all-wave receiver

[P. BESSON, M. COUPPEZ.] Several engineers availed themselves of the occasion furnished them by a recent description of a new American receiver sold in France to express their opinions about advantages and disadvantages of the circuit arrangements. The receiver consists of two stages of r-f amplification with pentodes, only one of which is used for the ordinary broadcast band, frequency changer (heptode) intermediate frequency amplifier (pentode) and detector (diode a-f pentode), one a-f triode, push-pull output. The use of two r-f stages for the short wave band is pointed out as unusual, requiring great care in the choice of the condenser, but justified in view of the lower background noise in the short wave region. Another important advantage is the complete suppression of image-frequencies as is readily seen when connecting the aerial to the second pentode in the



Anti-fading circuit employed in set criticized by French engineers

range of 8 to 18 Mc. One engineer, however, criticizes the choice of r-f pentodes which he thinks have too high a resistance when used with ordinary r-f transformers. He prefers tuned plate loads, resistance-capacity coupled to the next grid. He also believes the anti-fading system to be inadequate. This control is two-fold and acts upon the circuits one upon the grid of the second r-f stage, the other upon the i-f amplifier as well as upon the frequency changer. The connection to the second r-f grid taps the grid leak resistor after the first 60,000 ohms counted from the diode plate the connection to the other tubes at 185,000 ohms, in the center of a 250,000 ohm resistor. The r-f amplifier is therefore more closely controlled than the i.f., so that frequency changing can take place at the highest possible signal level. When the carrier fades, the r-f amplification is the first to increase, the intermediate frequency only in the second place, if at all, thus ensuring quiet operation. It is pointed out that the tube can give only a moderate control bias, three to four volts, and that the use of this tube for volume control



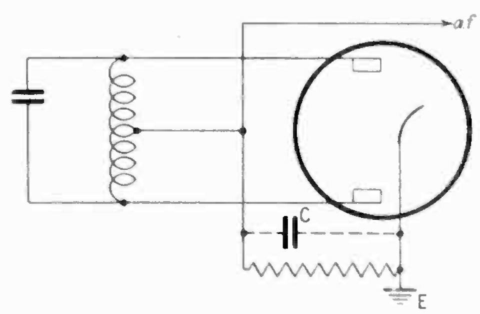
Circuit suggested by French engineers for a.v.c.

alone in the i-f stage would have been preferable. In this case the i-f signal is first amplified in the tube and then detected giving about —40 volts for control purposes. A separate detector for producing the a.f. would of course be required—*Onde électrique* 130 No. 154: 415-428. No. 156: 542-544. 1934.

✦

Remarks on diode detection

[MARC CHAUVIERRE, Director Etabl. Integra.] The view that diodes give better detection is an illusion since in actual diodes the characteristic has a distinct curvature near the origin. Moreover if the audio amplifying tube following upon the detector is a pentode or similar tube, it has a curved rather than a straight operating line and hence recti-



Distortion occurs in C of the bi-phase detector

fies besides amplifying. This second detection is opposed to the first detection and introduces the same inconveniences as grid leak detection at large signal strength which it is intended to replace.

Much of the curvature of the characteristic of diodes or tubes used as diodes can be straightened out by inserting a space charge grid close to the cathode, and this arrangement seems to be indispensable for good quality. The grid leak condenser C, another source of distortion, many be dispensed with when using biphase detection provided the midpoint M is carefully chosen.—*Onde électrique* 13 No. 156: 524-532. 1934.

✦

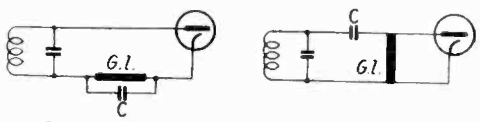
Automatic volume control

[E. KLOTS *a.o.*] Modern receivers bring in stations whose field strength varies between about 10μV. and a few volts, that is, a ratio of about 1:200,000 or 106 db. Automatic volume control devices are intended to keep the input to the detector constant to within say 5 db. regardless of fading and signal strength. The methods most commonly adopted to this end use the d-c component of the rectified detector output for controlling the grid bias of the r-f or i-f amplifier stages and in this way the input to the detector.

Whatever the system chosen, the first step is to examine how the d-c output of the detector varies with the r-f input, and how the gain of the amplifier varies with the grid bias applied to the tubes.

To compute the gain per stage, the mutual conductance is plotted as a function of grid bias. With a variable-mu tube, a long drawn out exponential curve is obtained which starts near zero at about —40 volts and later rises rapidly to a few mA per volt in the neighborhood of the normal grid bias (minus one or two volts). Since amplification is proportional to mutual conductance, on taking logarithms in order to get decibels, a somewhat flatter curve is obtained between —40 and normal grid bias; it represents gain per stage (in arbitrary units, but proportional to decibels) against grid bias. Since the attenuation obtained at various grid biases, with reference to normal operation, is the main interest, the gain at normal grid bias can be given the value zero in this curve; maximum bias may produce a value of —30 or —40 db. The curve obtained with variable-mu tubes consists of two fairly straight portions, namely a rather flat one for high bias and a steep one, between, for instance, —10 and normal bias. For two or three stages the reduction is twofold or threefold.

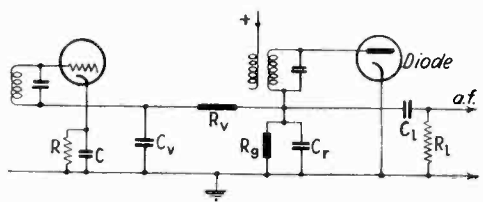
Used as a detector the d-c voltage produced by the diode is roughly the same as the r.m.s. radio frequency voltage applied at its electrodes, or about 5 volts at 5 volts r.m.s. input. Added to the normal bias, this amount would lead to a grid bias of about minus seven volts. If 5 volts at the detector gives the desired loud speaker volume, and



Shunt and series circuits for separating d.c., r.f. and a.f.

the gain curve is straight from this point down for about 30 or 40 db., then evidently three such control stages will give satisfactory volume control. It will, however, be observed that under these conditions the set is practically always throttled to below the gain of which it is capable, and in general, a variation of 30 db. leads into and over the bend of the curve. Matters are much improved by deciding on a lower detector input, one volt, for instance, as this brings the set closer to normal operation and the actual bias higher up on the gain curve. It appears that for best results the detector must be operated at a moderate input only on the weakest worthwhile signal, but this restriction means high audio amplification. As an anti-fading device, however, the system works satisfactorily.

Instead of satisfying the condition of low input to the detector, extremely high r-f amplification may be resorted to and the gain control made inoperative over a certain range by applying to it a retarding potential from a separate and constant source. Suppose again that a.v.c. is to cover a range of 106 db. distributed over three stages of amplification. An attenuation of 35 or 36 db. per stage may, depending upon the r.f. tube, correspond to a bias of —10 to —12 volts. Let this latter bias be chosen as the threshold value of a.v.c.; that is this value is supposed to be produced at the detector when the field strength is just above the noise level (10 to 25 μV. depending on local conditions). The amplification necessary to produce 12 or 13 volts in three stages is about 500,000 or 80 per stage. The gain control goes into action for all values above 12 volts, usually in a region of the gain curve where it is flat and straight. Now when the field strength has risen by 106 db., the detector input has risen by about 8.5 db. or 2.66 times its former value in volts, that is to 34 volts r.m.s. or 48 volts peak unmodulated carrier, and higher if losses and modulation are in-



Conventional a.v.c. through R_v and C_v

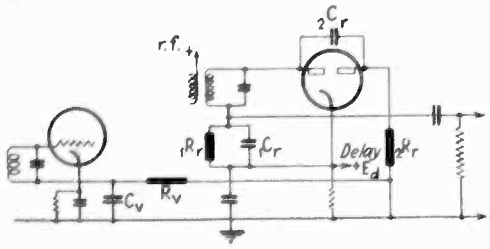
cluded. The tube preceding the detector would have to be capable of giving this output without introducing distortion. Thus while this system of delayed a.v.c. leads to a more constant level than ordinary a.v.c. it is apt to produce overloading and distortion. The usual course adopted is to fix the retarding or delay voltage at a few volts instead of at a dozen volts, sacrificing a portion of the gain of which the set would be capable.

Other methods of reducing the high voltage required at the detector for making delayed a.v.c. possible are to use a larger number of controlled stages, or to develop new tubes, or to employ d-c amplification of the rectified detector output, or to apply a.v.c. to the intermediate stages with one stage of amplification added for a.v.c. The changes of tubes with age and the differences between tubes speak against d-c amplification. In delayed a.v.c. applied to the intermediate frequency stage the primary of the last i-f transformer is connected to the a.v.c. tube, a diode-triode for instance, or diode-pentode, the voltage is first amplified, the cathode being self-biased by means of two resistances and the grid returned to the junction of the two resistances. The amplified voltage in the plate circuit (a choke coil tuned to somewhat below the intermediate frequency) is applied over a con-

ROVING MICROPHONE AIDS DEAF

In Leningrad headphones and a microphone are used to develop vocal organs of partially deaf children

denser to the diode which is connected to ground over a resistance R and is normally negative with respect to the cathode. The voltage drop in the cathode resistances forms the delay voltage. The input required is the same as for the delayed a.v.c., but divided by the amplification of the amplifier. Many modifications of this circuit are possible.



Delayed a.v.c. One plate of double diode is less negative than the other by the voltage across E_d

As an example of special tubes lending themselves to a.v.c., the anti-fading hexode can be mentioned in which the first grid is the control grid, the second and fourth grids are screen grids, while small changes in the potential of the third grid cause the entire plate current grid voltage characteristics to be uplifted and tilted. The third grid requires for this change about one-fifth of the voltage required by an ordinary amplifying tube.

The actual a.v.c. circuits based on these principles are rather simple. It is known that the detector tube absorbs r-f energy and generates d-c current pulsating at r.f. and modulated at a.f. The sign of the voltage produced is opposite to that of the r.f. applied. That is the plate of the diode is negative. Outside of the detector tube the incoming high frequency and the rectified current circulate without influencing one another; it is, however, necessary to provide a path of low resistance for the r.f. so that it is not weakened before arriving at the detector. On the other hand as the purpose of the detector is to generate as high an a-f voltage as possible, the a.f. must be restricted to a path of high resistance which at the same time smoothes out the pulsations. This path is inserted either in series with the secondary of the r-f transformer, excluding or by-passing the r.f. or it is placed directly across the detector (parallel arrangement); a condenser between the secondary and the plate or cathode preventing it from being short-circuited by the radio frequency coil. The danger is to have too much a-f resistance in the series arrangement and too little in the parallel arrangement unless choke coils and by-pass condensers are added.

A.v.c. must not interfere with these arrangements. In the case of ordinary a.v.c. it seems at first sight sufficient to run a wire from the negative or plate end of the grid to the grid of the controlled tubes by-passing the r.f. which might enter this line by means of a condenser Cv. But a straight connection of this kind would impress a-f voltages on the amplifiers. A high resistance Rv, about one meg, must be inserted and the by-pass condenser made equal to about 0.1 μf. to provide for a suitable time lag in the working of a.v.c.

For delayed a.v.c. two diodes or a double diode must be used, one for detection, the other for gain control. The series arrangement is used for detection, the parallel circuit for gain control. Metallic rectifiers can be used in place of diodes.—*Ver d. Ing.* 78. No. 47: 1381-1384. 1934. See also *Wireless Eng.* 11:406-414. 542-547. 1934.

✦

German electronics

The recent issue of *Telefunken Zeitung* Volume 15, No. 68, contains the following articles (in German):

- F. Henriger "Barkhausen-Kurz oscillations"
- R. Bechmann "Quartz-controlled high power Telefunken transmitters"
- W. Runge "Elements of decimeter-wave practice"
- R. Hofer "Theory of anode modulation"
- L. Leng "Telefunken precision frequency meter"

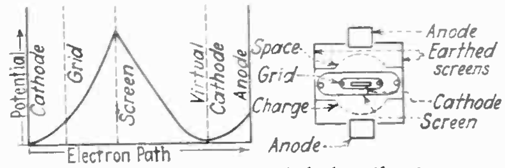
✦

A new output tetrode

At the Physical and Optical Societies' Exhibition at the Royal College of Science, London, the Marconiphone Company exhibited for the first time a new output tetrode, based on principles not hitherto used.

Consider diagram (right) which is a picture of the potential gradient in an ideal tetrode, when the applied anode voltage is lower than that of the screen. It is clear that the secondary emission from the anode produces a space charge which depresses the potential, at some point between screen and anode, almost to cathode potential.

We can regard this low potential region as the virtual cathode of a diode. As the anode voltage is raised the anode current increases rapidly and the potential of the virtual cathode also rises, until the space charge due to secondary emission disappears and the tetrode reaches apparent saturation for the given screen potential.



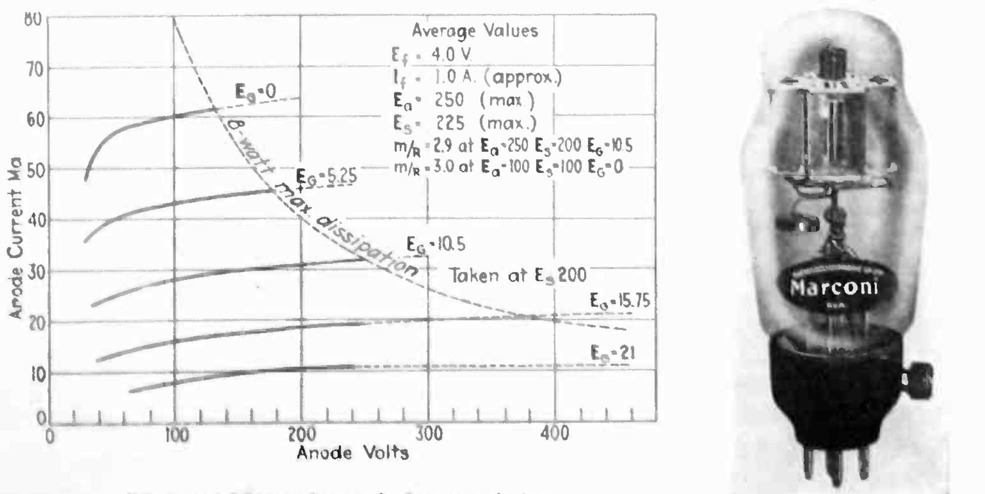
Tetrode and potential distribution

In practice, the necessary electrode supports distort the field in such a manner as to restrict the formation of the virtual cathode to two relatively narrow quadrants, and over the remaining arcs of the electron stream the anode secondary emission is unrestricted, so that the familiar "dip" in anode current appears as the anode voltage is lowered.

The new tetrode overcomes this failing first by employing two relatively narrow anode plates on the vertical axis at right angles to the plane of the electrode supports. The anode is thus restricted to that part of the electron stream in which the virtual cathode will form. In the actual tube, the anodes are made in the form of closed boxes to ensure efficient eddy current heating during the pumping schedule.

Secondly, to prevent stray secondary emission from circumscribing the space charge and so reaching the ends of the screen adjacent to its supports, two earthed plates are introduced, which in effect complete the space charge circle. By extending the earthed plates nearly to the anodes it is possible to modify the space charge and so adjust the tube characteristics.

The Marconi N40, as this tube is known, is being marketed immediately with characteristics suited to a majority of European circuits. It has been demonstrated that the new tetrode can be made with a better "knee" than a pentode, and the anode current curves are straighter. A noticeable increase in output is then available, with less third harmonic.



Marconi N40 tube and characteristics

+ NEW PRODUCTS

THE MANUFACTURERS OFFER

Insulated resistor

A NEW LINE of ¼ watt insulated carbon resistors has been placed on the market recently by The Erie Resistor Corporation, 630 W. 12th Street, Erie, Pa. This new product consists of a moulded carbon resistance unit enclosed in a ceramic case. Leads are brought out at the ends to facilitate wiring and insulation with spaghetti, if necessary.

Many features hitherto unavailable in carbon resistors are incorporated in this new product. The ceramic insulation eliminates the danger of "shorts" even in the smallest spaces. Including the ceramic shell, over-all dimensions are smaller than for the corresponding non-insulated Erie Resistor. Outside

ACTUAL SIZE

dimensions are 11/64 in. x 7/16 in. The use of these resistors simplifies many difficult installation problems and in many caes makes relocation possible with greater resultant efficiency. For example, they can be placed inside I. F. transformer cans without the addition of further insulation.

These resistors present a distinct improvement in respect to color coding, consisting of color bands completely encircling the ceramic shell. The ceramic covering is so designed that it cannot be removed from the resistance pin, although it is made slightly loose to compensate for contraction and expansion of the resistor inside it.—*Electronics.*

✦

Coil forms

COMBINING to an exceptional degree the qualities necessary for perfect coil forms, Spauldite tubing represents a real improvement over ordinary tubes for this purpose, according to its makers, the Spaulding Fibre Company, Tonawanda, N. Y.

The ideal coil form has no electrical absorption, high resistance to moisture, and perfect threading and punching qualities. Tests show that Spauldite coil forms nearly approach this ideal. Spauldite coil form tubes and two kinds of ordinary tubes were tested for moisture resistance under identical conditions. The Spauldite tubes showed the greatest resistance to moisture. After 24 hours' immersion in water, the Spauldite tubes showed under one per cent increase in weight.—*Electronics.*

✦

High fidelity speaker

A NEW HIGH fidelity speaker with large power handling capacity and wide frequency range has been announced by the Rola Company, 2530 Superior Avenue, Cleveland, Ohio. The speaker is 12 in. in diameter and is suitable for both alternating and direct current field excitation. The response is flat within 10 db. from 50 to 7,500 cycles. The new design is made possible by the use of a new cone, a new method of cone suspension, a new spider, and a large high efficiency voice coil. For best results, a 6 ft. x 6 ft. effective baffle is recommended. The field coil consumes 18 watts, although a minimum as low as 8 watts will give satisfactory reproduction with some loss in efficiency. The voice coil will handle 15 watts under continuous operation, or 20 watts for intermittent reproduction.—*Electronics.*

✦

Beat frequency oscillator

A BEAT frequency oscillator having a range from 20 to 17,000 cycles has been announced by the RCA Victor Co., Inc., Camden, N. J. The new oscillator type TMV-52-E uses electron-coupled oscillators and provides a laboratory calibration throughout its entire range. Output varies less than 10 per cent (plus or minus .5 DB) over the entire range. A reed indicator is used for quick and accurate adjustment of the calibration. A balanced output transformer for use in coupling to 250, 500, and 5,000 ohm impedances is provided. Type RCA-840 Radiotrons are employed as the radio frequency oscillators. The oscillator is particularly recommended for use in the test equipment of a modern broadcast station. It is available in two cases, one for rack type mounting and the other for portable use fitted with a carrying handle.—*Electronics.*

Velocity microphone

THE NEW Velocity Microphone De Luxe Model "M," manufactured by Bruno Laboratories, 22 West 22nd Street, New York City, has been designed to meet the requirements of broadcasting studios, recording studios, sound equipment companies and public address users.

Two powerful cobalt magnets are used to produce a strong magnetic field in which is suspended a specially treated aluminum alloy ribbon. Cavity resonances have been entirely eliminated by the correct placement of the magnetic assembly.

The microphone is ruggedly constructed and has a flat frequency response curve from 30 to 14,000 cps. The coupling transformer used in these units is wound on a "permalloy" core with an impedance output of either 200 or 500 ohms; other ohmages can be supplied. A universal ball swivel joint is furnished with this microphone, enabling the user to focus it in the most suitable direction. Ten feet of shielded rubber covered cable is supplied with each unit.—*Electronics.*

✦

Crystal contact microphone

EMPLOYING the Brush type of sensitive crystal, the Astatic Microphone Laboratory, Inc., Youngstown, Ohio, has developed its new Model C-104 contact microphone in response to a widespread demand for a supersensitive direct-contact microphone not dependent upon air as its transmitting medium and capable of detecting sounds in solids. Small, compact and rugged, this microphone will discover concealed activity and its positive location with surprising precision, thereby opening new and extensive fields. List $21.—*Electronics.*

Dynamic microphones

A SERIES of three dynamic microphones suitable for use wherever a self-generating microphone is needed, in broadcasting, sound recording and public address work, has been announced by the Radio Receptor Co., Inc., 106 Seventh Avenue, New York City. Model 6A has a response within plus or minus 1 db of 30 to 12,000 cycles per second, while models 6B and 6C are flat within 2db from 40 to 7,500 cycles per second. The list price of model 6A is $100, of 6B, $50, and of 6C, $33. Features claimed for these microphones by the manufacturers are extreme ruggedness, blast- and weather-proof construction, a wide angle pickup, complete absence of background noise, small size, no current supply requirements, and convenience in mounting and connecting. The output resistance of these microphones is 30 ohms while the sensitivity for normal speech ranges from 49 to 59 db below reference level.—*Electronics.*

✦

Electrostatic voltmeters

THE FERRANTI electrostatic voltmeter, introduced in this country originally up to 3,000 volts maximum full scale, is now supplied with full scales up to 18,000 volts maximum. These high range meters can be furnished in single, dual or triple range types and have numerous applications in present day testing.

Ferranti Electrostatic Voltmeters consume zero current and have incorporated in the instrument an over-voltage safety device which effectively protects the movement.

In addition to this high range of instruments this company now offers Electrostatic Voltmeters in $3\frac{1}{4}$ in. and 4 in. dial patterns in full scales up to 3,500 volts. These meters are entirely independent of frequency, wave form and temperature and may be used directly on either A.C. or D.C. circuits. They are made by Ferranti Electric, Inc., 130 W. 42nd St., N. Y. C.—*Electronics.*

✦

Centralized sound system

A NEW centralized sound system, developed by the Gates Radio & Supply Company of Quincy, Illinois, is now on the market.

The top panel of the unit contains a three stage, high gain amplifier for delivering sound to a number of magnetic speakers or dynamic speakers, and is a complete unit, including power supply, line voltmeter and plate milliammeter. Volume and tone controls are also provided.

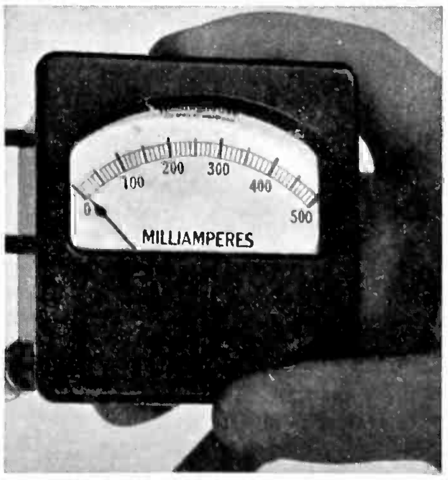
The mixing panel below the amplifier has four positions for carbon, condenser or crystal microphones with pre-amplifiers attached. The fader panel below the mixer is for use with phonograph records, making it possible to fade gradually from music to voice announcements without abrupt changes.

The bottom panel is the power supply, which will deliver 6 volts D.C. and 180 volts D.C. to as many as four condenser microphones. Full information is available by writing for Bulletin 1008.—*Electronics.*

✦

Miniature rectangular meters

A LINE OF moderately priced miniature meters is announced by the Westinghouse Electric & Manufacturing Company, E. Pittsburgh, Pa. The movements are of the direct-current d'Arsonval type, with copper oxide full-wave rectifier type for use on alternating current. For reading direct current ranges from 20 microamps. to 800 amps., and from 1 to 5,000 volts are available. For radio frequency measurements ranges from 100 milliamperes to 800 amp. can be provided. The so-called Rectox instruments are available for 20 microamperes to 10 milliamps. and from $\frac{1}{2}$ to 150 volts.



Refinements in the design of the movement of these meters are: soft iron pole tips welded to the permanent magnet in accurately aligned fixtures; improved springs; and an entirely new method of supporting the iron core in a die-cast bracket which uses jewel bearings. In the sensitive microammeters, strong cobalt steel magnets are used.—*Electronics.*

✦

Solder pots

RANGING IN capacity from $5\frac{1}{2}$ pounds to 125 pounds, a new line of solder-melting pots for electric operation has been announced by Struthers Dunn, Inc., 139 N. Juniper St., Philadelphia. Designed for melting solder, lead and babbitt metal, each unit is provided with a three-heat switch which permits rapid melting, maintenance of even temperature, or half-heat. The list prices range from $17.60 for the $5\frac{1}{2}$ pound size to $88.00 for the 125 pound size.—*Electronics.*

✦

Power switchgear

VARIOUS forms of power switchgear for use in broadcast stations and in other high-power electrical supply requirements is offered by the Roller-Smith Company, 233 Broadway, New York. The switches are made in both the hand-operated type. and the automatic reclosing circuit-breaker type. Meter mountings and fuse plug receptacles are provided according to specifications. For installation of 600 volts and higher open type control panels are provided. For 600 volts or less enclosed, dead front control panels are recommended. The variety of switches available for this service includes both standard and specially designed units for all power requirements. — *Electronics.*

✦

Portable cathode ray oscillograph

A NEW portable cathode ray oscillograph, type 145, which uses either a 3 in. or 5 in. tube, is announced by the Allen B. DuMont Laboratories of 542 Valley Road, Upper Montclair, New Jersey.

The type 145 has been designed to fill the need for an easily portable unit which may be used for industrial checks, radio service work, transmitter modulation determinations, class room demonstrations, and general laboratory measurements.

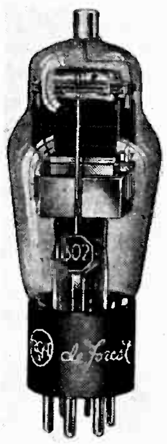
This unit comprises a sweep circuit which enables waves between 20 and 20,000 cycles per second to be studied, two single stage amplifiers which are linear from 20 to 100,000 cycles per second, and a power supply which furnishes the necessary voltages to the sweep circuit, the amplifiers and the cathode ray tube.

The main operating controls are all mounted on the front panel, while the gain controls, input binding posts, and switching arrangement are mounted at the rear. A switching arrangement makes it possible to apply voltages directly to the deflection plates or through an amplifier to the horizontal and vertical deflection plates. Another switching arrangement enables synchronization to be obtained with the wave under investigation or with any separate synchronizing pulse. The synchronizing pulse may be fed through one or both amplifiers to enable the sweep to be synchronized to small input voltages.—*Electronics.*

An intermediate power pentode, RCA-802

A NEW r-f power pentode, the RCA 802, has been announced by the RCA Radiotron Co., Inc., Harrison, N. J. This tube is designed as a low power transmitting tube. suitable for use as an r-f amplifier in class B or C, both for radiotelephone and telegraph. The tube can be operated at 56 mc. (the five meter band), with almost the maximum rated input, and at 7.5 meters full ratings may be used without fear of overload.

The standard synthetic resin base is used in this tube, rather than a special material which would add to its cost.



The plate lead is taken out at the top. The losses in the base are thus reduced to about 250 milliwatts at 5 meters. Following are typical operating characteristics:

Maximum plate voltage, 500 volts.
Maximum screen voltage, 250 volts.
Suppressor voltage (max) 40 volts.
Plate current d-c, 30 milliamps.
Carrier power (class B telephony) 3.5 watts (max.)
Carrier power (suppressor modulation) 3.5 watts.
Class C amplifier telegraph, carrier power, 16 watts.
Driving power: from .18 to 1.0 watt depending on operation.

The tube is a heater-type, 6.3 volts, with standard six prong base, and has an internal shield connected to its cathode. —*Electronics.*

✦

Oil cell for measuring power factor of insulating oils

INTENDED FOR accurate measurement of the power factor and dielectric constant of the oil used in transformers and cable, a new oil cell has been announced by the General Radio Company of Cambridge, Mass. Known as Type 683-A Oil Cell, the device has three terminals, one for each of the two condenser plates and a third for the guard electrodes. The oil to be tested is poured into the cell and fills the space between the electrodes. By measurements on a power factor bridge, the dielectric and power factor properties of the sample may be determined to a high degree of accuracy. The list price of the cell is $150.—*Electronics.*

✦

Dial airplane transmitter

A NEW RADIO transmitter makes it possible for a radioman at an airport or on shipboard to select any one of ten frequencies by merely giving a telephone dial one twirl and waiting an instant for it to snap back. The frequency-shifting device resembles a miniature telephone board serving ten dial telephones.

The transmitter represents the latest developments made by Bell Telephone Laboratories in Western Electric aviation and ship-to-shore radio equipment. Automatic control is so complete that the user's voice may be made to put the transmitter on or off the air instantly or to shut it down completely after an interval of from one to 15 minutes.

Any ten frequencies in the high frequency range of from 2 to 18 megacycles are available. A quick shift of frequencies is important in aviation ground stations and ship-to-shore service where transmission conditions require the use of different frequencies for satisfactory communication depending on time of day and the distance to be covered.—*Electronics.*

✦

Standard signal generator

THE FERRIS INSTRUMENT CORP., of Boonton, N. J. has developed a standard signal generator for use primarily in the development laboratories of radio receiver manufacturers. The complete unit, Model 14 A, for 60 cycle operation, lists at $1,220.00. The battery operated model, Model 14B, lists at $1,205.00. Coils regularly furnished for the unit provide a radio frequency range from 150 to 20,000 kilocycles. A self-contained audio frequency modulator provides a 400 cycle modulation frequency, for use in sensitivity, selectivity and overload measurements, and means for adjusting the modulation percentage from 5 to 40 per cent in five steps, without reference to curves, and without calculations. The attenuator provides outputs of from 5 microvolts to 500 millivolts, and additional taps at one and two volts. Many refinements in tuning controls and filtering make this instrument one of great precision and dependability.—*Electronics.*

Precision audio transformers

A NEW LINE of custom-built precision audio transformers with frequency charactersitics uniform within plus or minus one half db from 30 to 16,000 cycles is announced by American Transformer Company, Newark, N. J. According to the manufacturer, these units establish an entirely new standard of performance for a standard product and meet the most exacting requirements in broadcasting stations and recording studios.

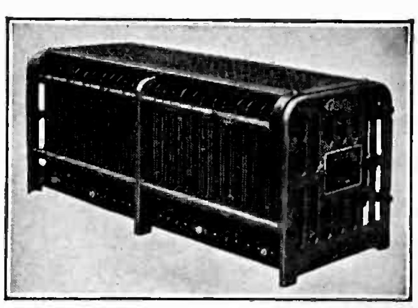
In addition to the unusually extended straight-line frequency characteristics AmerTran's new line is so designed that the slight rising or falling characteristic of one unit is compensated by the opposite characteristic in other units with which it ordinarily is used in an amplifier. New construction provides highly efficient electromagnetic and electrostatic shielding without the necessity of heavy cast-alloy cases. The line includes 38 designs which meet all requirements in broadcast and recording speech input amplifiers.—*Electronics.*

✦

Resistor for energy dissipation

THE TYPE wg resistor, built by the States Company, Hartford, Conn., can be used as a phantom antenna, in the tank circuit, and elsewhere in high-frequency circuits where non-inductive units with low distributed capacity characteristics are essential, and where a large amount of energy must be dissipated. The frame is designed for convenient mounting for various switchboard frames.

These resistors are rugged in construction, yet very light in weight, as the metal in the frame is chiefly aluminum. A 30-unit frame capable of dissipating 8¼ kilowatts weighs only 12 lbs. The insulation between units and frame will withstand an operating voltage of 2,000



volts, and additional insulation may be readily added to insulate frame from ground.

The units are easily removed for replacing, or to change the resistance and wattage rating, should this change become necessary on account of transmitter alterations.—*Electronics.*

U. S. PATENTS

IN THE FIELD OF ELECTRONICS

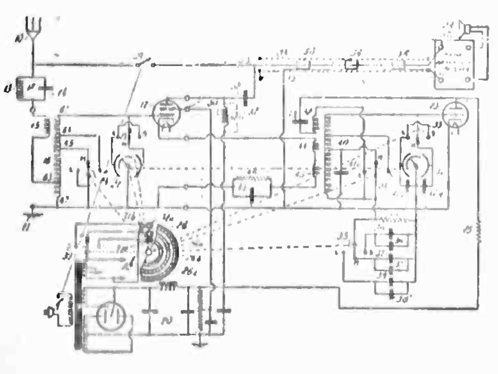
Radio circuits

Ultra short-wave receiver. A combination superheterodyne-super-regenerator receiver for ultra-short-waves. Austin Bailey, A. T. & T. Co. No. 1,984,451.

Radio cabinet. Method of supporting the loud speaker, the chassis, and the control panel at an angle downward from the vertical within the cabinet. A. T. Murray, United American Bosch Corp. No. 1,988,132.

Automatic volume control. Deriving a unidirectional voltage from the plate circuit of a push-pull audio amplifier tube, causing this derived voltage to affect one or more of the carrier frequency amplifier tubes. Also in a system having several tubes, one of which has a higher amplification factor than another, the method of controlling the output level by deriving a uni-directional current, passing the current through a divided resistor to produce several voltages and applying one of the voltages to the grid of the lower amplification tube and the lesser of the voltages to the grid of the higher amplification tube, so that their efficiencies are modified to the same extent. R. D. Brown, Jr., Philco. No. 1,988,370.

Tuning scale. Tuning scale for use in a multi-band receiver comprising tuning elements, one of which is continu-



ously variable and another which is variable in steps. H. M. Lewis, Hazeltine Corp. No. 1,987,857.

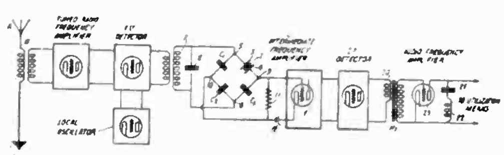
Direction-finding system. An antenna comprising two perpendicularly crossed loops and a non-directional radiating element at the center of the antenna, means for supplying double side-band currents with negligible carrier to the crossed loops to produce a rotating beam. J. W. Greig, B.T.L. No. 1,988,006.

Antenna system. Directional antenna of sinuous form consisting of mutually perpendicular coplanar segments, each of a length h, and applying to each antenna electrical waves of length λ greater than $2h$ and less than $4h$, whereby maximum radiation occurs at an angle inclined to said antenna plane. Marius Latour, San Sebastian, Spain. No. 1,987,780.

Antenna circuit. Use of a loading coil in series with the coupling coil in the antenna circuits of a receiver so that the antenna is tuned to a frequency lower than the lowest frequency of the tuning range of the receiver, the said coil having a low distributed capacity whereby its natural resonance is at least as high as the highest frequency of the tuning range of the receiver. J. M. Miller, Atwater Kent Mfg. Co. No. 1,986,641.

Automatic volume control. Method using two tubes in push-pull across a signal circuit and controlling the plate resistance of these tubes as a volume control. Arthur Pfister, R.C.A. No. 1,986,644.

Superheterodyne circuit. Means of increasing adjacent channel selectivity by a discriminator having a frequency response characteristic which decreases rapidly for frequencies off resonance.



The amplifier is provided with a sharp cutoff prior to the point in the frequency range where undesired side band interference is positioned. The system involved shows a quartz crystal. W. S. Barden, R.C.A. No. 1,987,984.

Antenna circuit. A coupling circuit involving a series of shunt and series tuned circuits. Paul Müller, Siemens & Halske. No. 1,987,124.

Remote control receiver. Motor operated tuning appartaus. L. M. Clement, Federal Tel. Co. No. 1,985,403.

Short wave receiver. A receiver for ultra high frequencies modulated at a lower frequency, comprising a tube and network for coupling the grid and plate circuits together. J. G. Streiffert and W. F. Bartoe, Columbus, Ohio. No. 1,986,081.

Superheterodyne. A bridge circuit comprising a signal and image frequency source in one arm, means connected to the conjugate of this arm for producing beats with the signal frequency, a constant effective capacity in each of another pair of conjugate arms and means for providing in the third pair of arms effective capacities that vary inversely with frequency changes within the band defined by the signal and image frequencies. S. W. Seeley and G. Mountjoy, R.C.A. No. 1,985,696.

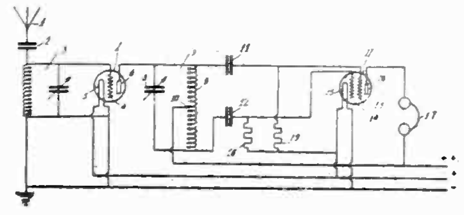
Amplification, detection, etc.

Regulating system. Obtaining substantially constant output voltage across a constant or varying load from a source of fluctuating input voltage. No. 1,985,-634 and 1,985,635, to W. K. Fleming, Raytheon.

Tone control. Patent No. 1,984,357 and 1,984,450 to J. G. Aceves, assigned to L. G. Pacent on compensated amplifier and tone control circuit.

Facsimile transmitter. Scanning apparatus comprising a pair of cylinders, one of said cylinders nesting within the other, a slotted opening in the outer cylinder to permit the introduction of sheet material into contact with the inner cylinder, etc. L. V. R. Philpott, WE&M Co. No. 1,985,057.

Symmetrical detector. A double grid detector tube has the input connected in



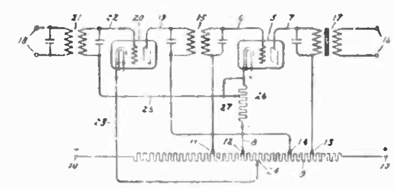
push-pull. Klaas Posthumus, R.C.A. No. 1,986,851.

Detector. A screen grid tube arranged for grid circuit detection. The screen is coupled to the plate through a transformer to offer in the plate circuit a high impedance to flow of r-f current and to increase the a-f output. W. A. Harris, R.C.A. No. 1,986,812.

Audio frequency compensation. In a receiver of the type with a tunable r-f selector circuit in which the selectivity is variable to the extent that higher audio frequencies are attenuated, a resonant circuit is made part of the audio system, whose capability of building up higher audio frequency voltages is varied directly as the selectivity of the r-f system is increased. K. H. Krambeer, Siemens & Halske, Berlin. No. 1,985,999.

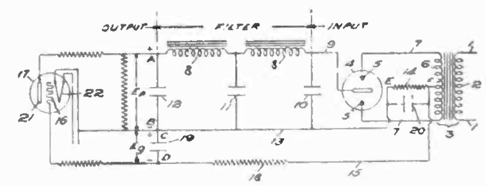
Neutralizing system. Circuit for neutralizing the admittance of the input circuit in a tube amplifier. P. T. Farnsworth, March 11, 1929, 29 claims. No. 1,986,331.

Automatic volume control. W. L.



Carlson, G.E. Co. No. 1,985,914.

Power supply system. Rectifier-filter system for supplying power to an amplifier tube with circuit for eliminating a-c

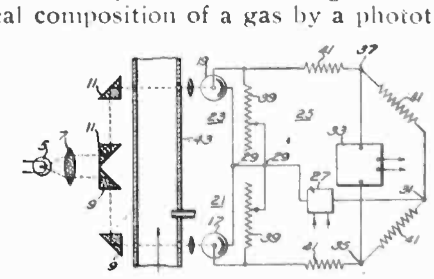


ripple flowing through a grid bias resistance. James Millen. No. 1,988,209.

Electron tube applications

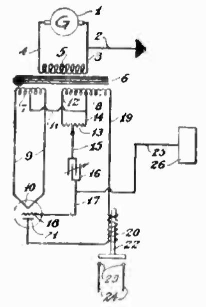
Frequency multiplication. System using tube operated from a source of polyphase energy. Georg von Arco, Telefunken. No. 1,988,097.

Gas analysis. Determining the chemical composition of a gas by a phototube



system. C. A. Styer, WE&M Co. No. 1,977,359.

Capacity control. An electronic relay in which the impulse comes from a plate connected to the grid of a tube. Rex D.



McDill, East Cleveland, Ohio. No. 1,980,816.

Patent suits

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