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# RECEIVING MEASUREMENTS AND ATMOSPHERIC DISTURBANCES AT THE NAVAL RADIO RESEARCH LABORATORY, BUREAU OF STANDARDS, WASHINGTON, JULY AND AUGUST, 1922*

By

L. W. Austin

(United States Naval Radio Research Laboratory, Washington, D. C.

*(Communication from the International Union for Scientific Radio Telegraphy)*

The following tables give the field intensities produced at this laboratory by the Lafayette and Nauen stations, and the corresponding strength of the atmospheric disturbances during July and August. The method of measurement has been already described.[1]

The calculated intensities for the signals assuming 480 amperes at Lafayette and 380 amperes at Nauen are

$$E \text{ (Lafayette)} = 31.5 \cdot 10^{-6} \text{ volts/meter}$$
$$E \text{ (Nauen)} = 15.3 \cdot 10^{-6} \text{ volts/meter}$$

It is seen that the observed morning values for the intensities are a little more than twice the calculated values, while the afternoon values, probably due largely to local fading, fall far below the calculated. The average ratios of afternoon values to morning values in July are for Lafayette 0.22 and Nauen 0.18, and, for August, Lafayette 0.32 and Nauen 0.24. The average ratios of signals to disturbances, in July, are for Lafayatte in the morning 0.42, in the afternoon 0.045; and for Nauen in the morning 0.73 and in the afternoon 0.032.

In August the signal disturbance ratio is for Lafayette 1.05 in the morning, and in the afternoon 0.075. For Nauen it is 0.58 in the morning, and 0.035 in the afternoon. In July, Lafayette faded five times so as to be unmeasurable, while Nauen becomes unmeasurable seven times and was not heard at all three

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*Received by the Editor, October 5, 1922.

[1] Proceedings of The Institute of Radio Engineers, 1922, part 3, pages 153 and 239.

times. Of course, it is impossible to say that Nauen was transmitting at these times, tho the signals were listened for during more than an hour. In August, Lafayette faded four times below the measurable value; while Nauen faded five times and was not heard seven times.

FIELD INTENSITY OF LAFAYETTE AND OF DISTURBANCES ($\lambda = 23{,}400$ m.) IN JULY, 1922, IN MICRO-VOLTS PER METER

| | 10 A. M. | | 3 P. M. | |
|---|---|---|---|---|
| Date | Signal | Disturbances | Signal | Disturbances |
| 1 | * | 300 | .... | |
| 3 | 100.0 | 100 | ** | 1,000 |
| 5 | 90.0 | 150 | 30.0 | 560 |
| 6 | 100.0 | 150 | 20.0 | 680 |
| 7 | 100.0 | 200 | 25.0 | 450 |
| 8 | 75.0 | 300 | 20.0 | 450 |
| 10 | | 80 | ** | 1,000 |
| 11 | 80.0 | 200 | 15.0 | 680 |
| 12 | 100.0 | 300 | 20.0 | 600 |
| 13 | | 80 | 20.0 | 400 |
| 14 | 90.0 | 100 | ** | 800 |
| 15 | 75.0 | 200 | | .... |
| 17 | 100.0 | 200 | | .... |
| 19 | 80.0 | 150 | 20.0 | 300 |
| 20 | 75.0 | 200 | ** | 500 |
| 21 | 50.0 | 300 | ** | 600 |
| 22 | 60.0 | 200 | | .... |
| 25 | 75.0 | 150 | 30.0 | 300 |
| 26 | 90.0 | 200 | 35.0 | 400 |
| 27 | 60.0 | 150 | 35.0 | 300 |
| 29 | 90.0 | 300 | | .... |
| 31 | 60.0 | 200 | 30.0 | 300 |
| Average | 81.6 | 191 | 17.6 | 548 |

**Too weak to measure.

*Not heard.

.Not taken.

## Field Intensity of Nauen and of Disturbances ($\lambda = 12{,}500$ m.) in July, 1922, in Micro-volts per Meter

| | 10 A. M. | | 3 P. M. | |
|---|---|---|---|---|
| Date | Signal | Dis-turbances | Signal | Dis-turbances |
| 1 | 34.0 | 50 | ** | .... |
| 3 | 56.0 | 60 | * | 800 |
| 5 | 30.0 | 50 | 13.0 | 200 |
| 6 | 51.0 | 40 | ** | 600 |
| 7 | 34.0 | 50 | 8.0 | 500 |
| 8 | 30.0 | 60 | .... | 400 |
| 10 | 34.0 | 40 | 8.0 | 600 |
| 11 | 30.0 | 30 | 10.5 | 800 |
| 12 | 30.0 | 50 | ** | 500 |
| 13 | 43.0 | 60 | ** | 200 |
| 14 | 30.0 | 50 | 8.0 | 300 |
| 15 | * | 60 | * | .... |
| 17 | 34.0 | 30 | .... | .... |
| 19 | 51.0 | 60 | 13.0 | 100 |
| 20 | 34.0 | 50 | ** | 200 |
| 21 | 30.0 | 40 | ** | 300 |
| 22 | 34.0 | 50 | .... | .... |
| 25 | 34.0 | 60 | 16.0 | 200 |
| 26 | 43.0 | 80 | 13.0 | 200 |
| 27 | * | 60 | * | 150 |
| 29 | 43.0 | 80 | .... | .... |
| 31 | 30.0 | 60 | 13.0 | 200 |
| Average | 37.2 | 50.8 | 6.4 | 36.8 |

**Too weak to measure.

*Not heard.

Not taken.

Field Intensity of Lafayette and of Disturbances ($\lambda = 23{,}400$ m.) in August, 1922, in Micro-volts per Meter

| | 10 A. M. | | 3 P. M. | |
|---|---|---|---|---|
| Date | Signal | Dis-turbances | Signal | Dis-turbances |
| 1 | 100.0 | 100 | 50.0 | 300 |
| 2 | 65.0 | 200 | 50.0 | 200 |
| 3 | 60.0 | 150 | 45.0 | 300 |
| 4 | 80.0 | 150 | ** | .... |
| 5 | 100.0 | 80 | ** | 1,000 |
| 7 | 65.0 | 100 | .... | .... |
| 8 | 40.0 | 200 | 25.0 | 500 |
| 9 | 50.0 | 300 | 40.0 | 200 |
| 10 | 60.0 | 200 | 15.0 | 300 |
| 11 | 75.0 | 200 | 20.0 | 400 |
| 12 | 70.0 | 150 | .... | .... |
| 14 | 60.0 | 200 | 15.0 | 200 |
| 15 | 50.0 | 80 | 10.0 | 1,000 |
| 16 | 75.0 | 100 | ** | 1,000 |
| 17 | 75.0 | 80 | 25.0 | 300 |
| 18 | 60.0 | 100 | .... | .... |
| 19 | 45.0 | 100 | ** | .... |
| 21 | 100.0 | 80 | 30.0 | 150 |
| 22 | 75.0 | 60 | 20.0 | 300 |
| 23 | 50.0 | 20 | ** | 1,000 |
| 24 | 100.0 | 30 | ** | 800 |
| 25 | 75.0 | 40 | .... | .... |
| 26 | 75.0 | 60 | .... | .... |
| 28 | 50.0 | 300 | 25.0 | 800 |
| 29 | 75.0 | 20 | 20.0 | 600 |
| Average | 69.2 | 124 | 20.5 | 519 |

**Too weak to measure.

*Not heard.

Not taken.

## Field Intensity of Nauen and of Disturbances ($\lambda = 12{,}500$ m.) in August, 1922, in Micro-volts per Meter

| Date | 10 A. M. | | 3 P. M. | |
|---|---|---|---|---|
| | Signal | Disturbances | Signal | Disturbances |
| 1 | 26.0 | 100 | ** | 500 |
| 2 | 30.0 | 80 | ** | 1,000 |
| 3 | 30.0 | 80 | 8.0 | 800 |
| 4 | 26.0 | 60 | ** | 600 |
| 5 | 34.0 | 40 | .... | .... |
| 7 | 43.0 | 30 | 16.0 | 300 |
| 8 | 34.0 | 60 | 8.0 | 600 |
| 9 | 30.0 | 20 | * | 100 |
| 10 | 30.0 | 60 | * | 100 |
| 11 | 26.0 | 40 | 10.5 | 300 |
| 12 | 34.0 | 40 | .... | .... |
| 14 | 38.0 | 80 | 16.0 | 200 |
| 15 | 34.0 | 60 | ** | 400 |
| 16 | 30.0 | 60 | ** | 200 |
| 17 | 34.0 | 40 | 16.0 | 150 |
| 18 | 26.0 | 50 | * | 200 |
| 19 | 30.0 | 80 | 13.0 | 300 |
| 21 | 30.0 | 60 | .... | .... |
| 22 | 26.0 | 80 | * | .... |
| 23 | 34.0 | 60 | * | 400 |
| 24 | 17.0 | 1,000 | * | 300 |
| 25 | * | 1,000 | * | 2,000 |
| 28 | 38.0 | 80 | 13.0 | 200 |
| 29 | 36.0 | 150 | 13.0 | 150 |
| Average | 31.1 | 131 | 12.6 | 440 |

**Too weak to measure.

*Not heard.

....Not taken.

SUMMARY: The intensities of the signals from the Lafayette and Nauen stations during July and August, 1922 are given, together with the simultaneous static intensities. A comparison of the calculated and actual strengths is also given.

# RADIO RECEIVING EQUIPMENT*

By

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(Assistant Chief Engineer, Westinghouse Electric and Manufacturing Company, Pittsburgh, Pennsylvania)

This paper is intended to discuss questions of design of those types of receiving apparatus which are adapted for reception over a limited range of wave length, and which depend for their operation on such manipulation as can be successfully carried out by persons entirely unfamiliar with the technique of radio apparatus. Their principal field of application is the reception of broadcast radio telephone signals.

Among the many requirements which an ideal receiver of this class should fulfil are that:

(1) It should tune in the wave length desired with only simple adjustments, which should not interact on each other. With a signal of normal audibility from a desired station, the signal strength from another equal or possibly more powerful station, separated by ten thousand cycles, should be below audibility.

(2) Its sensitivity should be such that its range will be limited by static interferences, fading, and so on, rather than by actual lack of response. Any local sources of power necessary for its operation should require infrequent attention.

The first-mentioned requirement, which may be termed selectivity, is more or less fulfilled by giving the receiver a characteristic in which its impedance to the desired band of wave length is very low in comparison with its impedance to the wave length above and below this band.

The curve in figure 1 shows the relation of admittance to wave length in a simple oscillating circuit which has the constants of the antenna ordinarily used and which is tuned to a definite wave length by the addition of a variable inductance.

An examination of this curve shows that, altho the maximum signal is obtained for the wave length to which the circuit is tuned, appreciable response is given to wave lengths differing considerably from those for which it is in resonance.

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In order to obtain the desired selectivity, it is necessary considerably to increase the time constant of this circuit. This result can be accomplished in one or both of two ways: namely, by increasing the inductance element with a corresponding reduction, of capacity or by decreasing the effective resistance by regeneration.

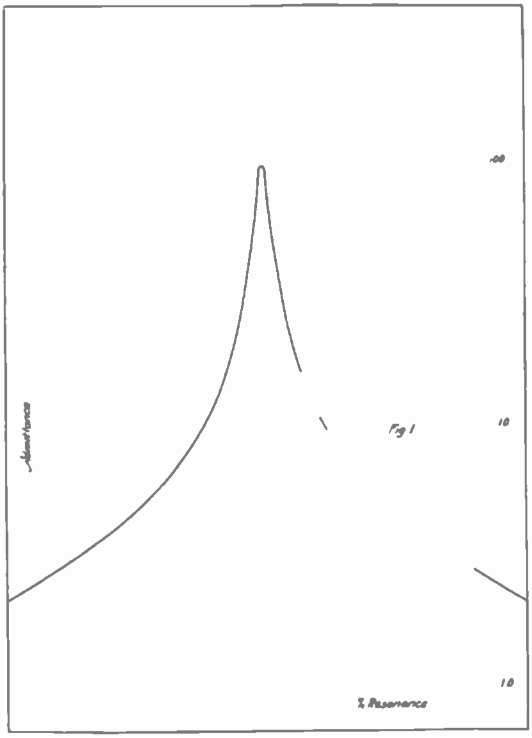

FIGURE 1

The curve in Figure 2 shows the effect of placing an additional capacity of 25 micro-microfarads in series with the circuit with a corresponding increase in inductance to bring the circuit in resonance with the same wave length as under the first condition. It will be noted that the selectivity is very considerably improved.

In the case of a vacuum tube detector, which is nominally a voltage-operated device, the large inductance implies a correspondingly large voltage available for operation of the detector, with the resultant increase in signal strength. In the case of the crystal detector, the maximum signal strength is obtained when the effective resistance due to the detector is equal to that of the balance of the antenna circuit. It therefore should be connected across such part of the inductance as will give the best compromise between selectivity and sensitivity.

The use of the regenerative vacuum tube offers the further possibility of increase of selectivity with the additional advantage of a very marked increase in sensitivity.

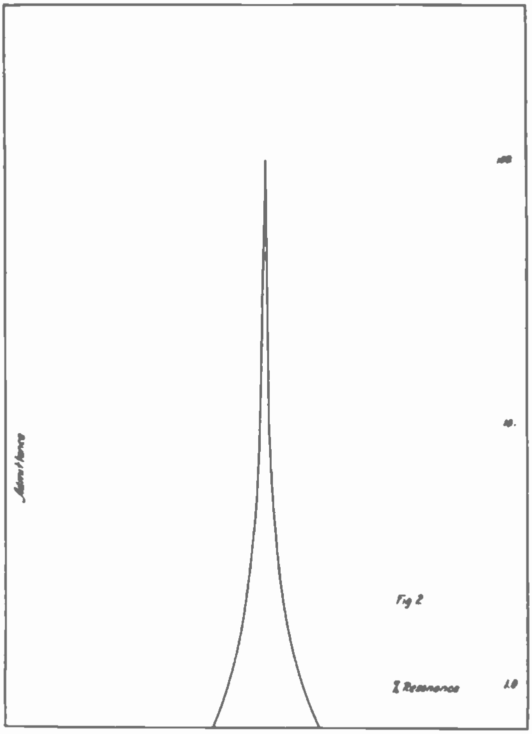

FIGURE 2

The curve, Figure 3, shows the relation of admittance to wave length of the same circuit as that for Curve 2, with the exception that the resistance element is assumed to be one percent of that in Figure 2. This is an amount of regeneration which can readily be obtained. The ordinates of this curve are drawn to a scale one hundred times that of Figure 1 and 2, and it might be assumed that the signal strength would be one hundred times that which would be obtained from the circuit of Figure 2. This condition does not necessarily follow, owing to the fact that there is a definite limit to the component of antenna current which is proportional to the incoming signal.

This condition may be illustrated by the diagram, Figure 4. In this diagram, *O E* represents the incoming signal field affecting the receiving antenna. Should the impedance of the receiving antenna circuit be infinite, the voltage induced in this circuit will be in the phase $O\,C$. For finite values of resistance impedance in this circuit, the current will be bounded by the circle $O\,B\,A$. Thus, for a given value of resistance impedance, the current will be represented by the line $O\,B$. The field surrounding the antenna due to this current will have the same phase and relative length, and the total effective field will be the sum of $O\,E$ and $O\,B$, or $O\,D$. For zero resistance the current will have the phase and relative length $O\,A$, with a zero resultant field. Further consideration will show that this ultimate received antenna current is independent of the height of the antenna, provided all sections of its length are affected by the same field intensity, it being dependent only upon the field per unit length.

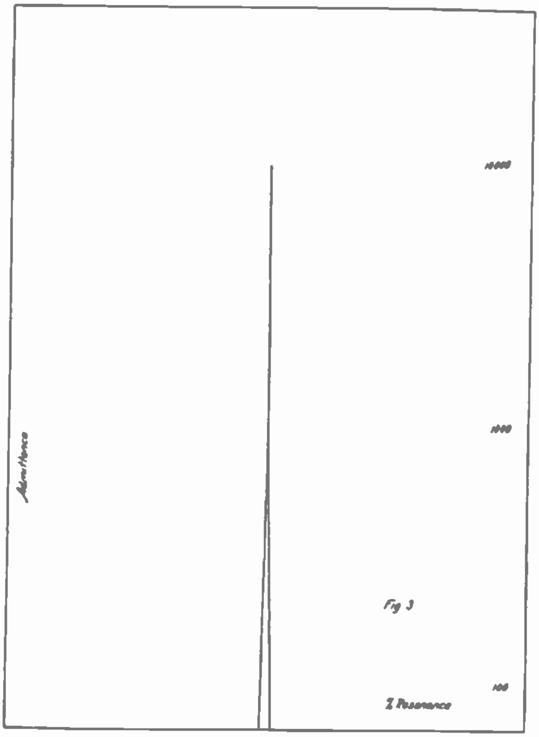

FIGURE 3

The antenna therefore may be considered as a constant voltage generator, having a definite internal impedance, which is proportional to antenna height. This generator supplies a load circuit having the constants of the oscillating circuit.

In the case of a regenerative system in which the regeneration is carried out to such an extent as to produce oscillations, the current due to the incoming signal will be super-imposed on the local current, and have a value dependent entirely upon the effective resistance but independent of any local oscillating current.

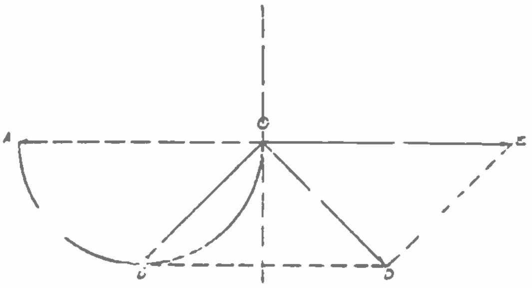

Figure 4

Figure 5 shows the conditions determining the resistance of the antenna circuit under the oscillating condition. In this curve the line *G* shows the relation of voltage impressed on grid terminals to the oscillating component of plate circuit. Curve *P* shows the oscillating component of plate circuit set up by this impressed grid voltage. From this curve it will be seen that, once the oscillations are started, they will increase to a point where the curve *P* intersects the line *G*. The effective resistance of the antenna circuit is determined by the relation of the angle of this intersection to the angle of *G* with the base. In actual practice, it is possible to reduce the angle of intersection at this point to such a value that the antenna current due to incoming signal will closely approach the ultimate value. Any possible increase of the sensitivity is therefore limited to an increase of the inductance across which the detecting circuit is connected. The extent to which this increase can be carried out is largely a matter of design.

The limitation of sensitivity due to ultimate antenna current also imposes an apparent reduction in selectivity and is a feature which usually is not considered in the discussion of the oscillating circuit.

Referring to the curves, Figures 2 and 3, these show the characteristic of simple circuits made up of capacity, inductance and resistance. In the case of an actual antenna circuit, it has been shown that there is, in addition, a limiting impedance which is proportional to the height. In the consideration of the sharpness of tuning of the antenna circuit, it is necessary to consider this limiting impedance in addition to the actual impedance of the oscillating circuit. Therefore, the actual increase of sharpness of tuning which can be obtained by regeneration is largely determined by this limiting impedance, or, in other words, by the antenna height.

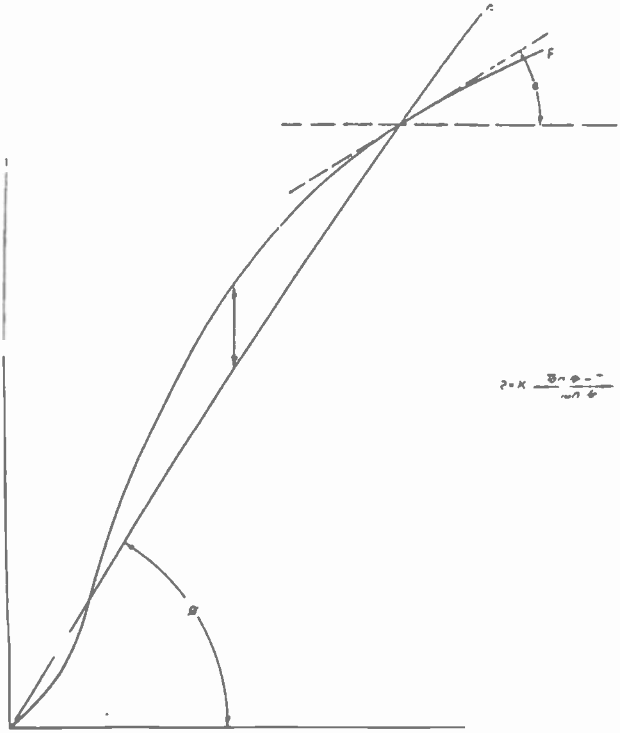

FIGURE 5

In Figure 6 are shown two curves taken with similar receiving sets, but on antennas of different heights. The left-hand curve is from a single-wire, inverted-L antenna, having a height of 35 feet (10.6 m.) above ground, and a length of horizontal portion of 75 feet (23 m.). The right-hand curve was taken from an antenna having a height above ground of 15 feet (4.6 m.), the length of horizontal portion being the same. The same receiver was used in each case.

These two curves show the very great increase of selectivity to be obtained by the use of the low antenna. In fact, the increase is considerably greater than would be expected from consideration of the comparative heights of the two antennas. It is probably accounted for by the condition that the effective height of the lower antenna is a considerably smaller percentage of its actual height than in the case of the higher antenna, owing to the indefinite height of the ground connection which was made to the hot water heating system, thus giving an effect equivalent to raising the height of the actual ground.

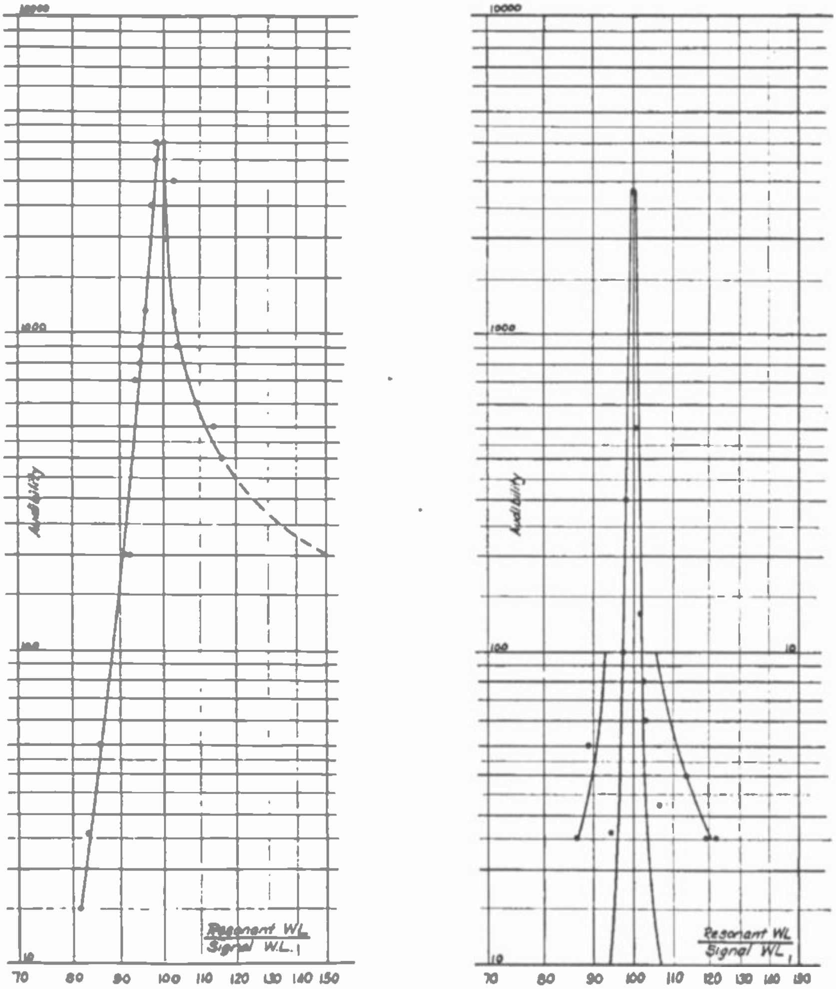

FIGURE 6

Due to the absorption by objects on or near the ground, it is usually impossible to realize completely the condition of equal signal strength with low as with high antenna, and of course the possibilities in this direction depend on the surroundings of the antenna in question.

Under conditions in which the reduction of signal strength with height is due, as is often the case in thickly built-up districts, to the appreciable absorption near the ground, it is possible to improve the selectivity of the antenna by the use of a coupled secondary circuit in the receiving set. If another resonance circuit of the same constants were connected to the output circuit of a vacuum tube amplifier connected to a resonance circuit having the constants corresponding to that of Figure 2, the characteristic of this double circuit would be proportional to the product of the characteristic curves, which, it is evident, would give a very greatly increased selectivity.

This arrangement constitutes the ideal method of improving the selectivity of a receiver. If, in place of the relay coupling between the oscillating circuits, a direct coupling were used, the relation of the secondary to primary would, in a sense, be a duplicate of that existing between primary and the transmitter, with the equivalent antenna height of secondary corresponding to the looseness of coupling, thus permitting the possibility of a receiver connected to a high antenna and with the selectivity of a low one. However, the extent to which this can be carried out is limited by the fact that, as the apparent secondary antenna height is reduced by reduction of coupling, the reduction of primary resistance by regeneration is also reduced, with a corresponding limitation of ultimate secondary signal current and its attendant reduction of selectivity.

Owing to the difficulty of carrying out the necessary interacting adjustments, the use of a coupled circuit receiver is justified only under those particular conditions in which it is not possible to take advantage of the selectivity of the low antenna.

A further possibility towards the solution of the receiver problem for congested districts is the use of a closed coil or loop in place of an open antenna. The loop receiver will have the advantage that, similar to the short antenna, it embraces a limited field area, and at the same time can usually be placed sufficiently above ground level to be in a somewhat denser field than would be the case with a corresponding short, open antenna. The limiting impedance of the loop is comparatively low, but as the induced signal voltages are also low, it is necessary that a regenerative system be used in order to obtain the benefit of selectivity. It, of course, has certain possibilities of eliminating interference, due to its directional properties. In general, the loop receiver under its best conditions, will give results which are practically identical with those obtained from a receiver connected to a properly proportioned, open antenna, barring, of course, the possibility that the relative position of the interfering station may be such as to permit of advantage being taken of the directional effect. It has the advantage of convenience of installation and of not being restricted to location as regards height where the field density may be low. However, the first cost and maintenance expense of such a receiver are far greater than those of the equivalent regenerative set on an open antenna, and for these reasons, cannot, at the present time, be considered as a real competitor of the open antenna receiver.

The foregoing conclusions in regard to the conditions effecting selectivity are based on the premises that the receiver is used for the reception of modulated continuous wave signals and that the interferences to be dealt with are those set up by similar transmitters.

In the case of interference resulting from atmospherics, or static, the particular precautions which would minimize interference from other transmitters would have insignificant effect, and at the present time there is no practical scheme which gives any appreciable reduction of interference from static.

In the case of interference from damped wave transmitters, the effects will lie between the conditions of a modulated continuous wave signal and static, the similarity to one or the other being determined by the decrement of the interfering signal.

In the case of the usual amateur spark transmitter, which is the one most likely to set up the interference, the conditions will be not far removed from those governing the effects of static, owing to the usual high decrement of these transmitters.

The solution of the problem of interference from this source should be in the direction of elimination of the spark transmitter by the substitution of continuous wave sets, rather than by any receiver development, owing to the actual great width of wave band covered by even the best type of spark transmitter.

The one serious defect of the regenerative receiver is the interference it can produce on other receivers due to radiation when regeneration is carried to the oscillating point. The intensity of this radiation can be controlled to a certain extent by the antenna circuit constants and the constancy of regeneration of the receiving set with various wave length adjustments.

With increase of the inductance element in the antenna circuit, the antenna current for a given voltage applied to a receiving tube is correspondingly reduced, with attendant reduction of interference; and, with constancy of regeneration with varying wave length adjustment, the possibility of the set producing strong oscillations during the tuning operation will be reduced. This latter feature has considerable bearing on the system of regeneration which it is advisable to employ.

The mechanism of regeneration implies a coupling between anode circuit of tube and oscillating circuit, such that any fluctuations in anode current sets up corresponding oscillations in the oscillating circuit, and of such phase relation as to reinforce the original oscillations which had acted on the grid of the tube. This coupling may be electro-magnatic or electro-static.

In the electro-magnetic coupling a coil which is in series with the anode circuit is so disposed that its field embraces more or less of the inductance in the oscillating circuit.

With the electro-static coupling, advantage is usually taken of the capacity between grid and anode elements of the tube and its connections. When the impedance of the anode circuit ia altered by a varying grid potential, corresponding potentials are induced on the grid element thru the capacity of tube and connections. When the grid is connected to a resonant circuit and the impedance in the anode circuit is principally a resistance, the phase relation of induced potential on grid thru anode is 90 degrees displaced from the original controlling potential of the grid. An inductive reactance in the anode circuit so shifts the induced potentials that it assists or adds to the grid controlling potential. A capacitive reactance so shifts the phase relation that the induced charge on the grid subtracts from the original controlling potential. Therefore, by incorporating a variable inductance in the anode circuit, the amount of regeneration can be controlled at will.

The inductive coupling method of regeneration possesses the advantage that when the anode coil is coupled to the variable inductance which controls the wave length of the oscillating circuit, the amount of regeneration remains practically constant over an extended wave length band. In the case of the capacitive coupling, both the effect of capacity between anode and grid circuits and the effect of inductance in the plate circuit vary with change of wave length. The regeneration, therefore, requires readjustment with each readjustment of wave length of the set. For this reason the operation of tuning-in a signal is more complicated. The inductive coupling method, however, requires proper proportioning of the relation between coupling coil and tuning inductance, while the capacitive coupling merely requires the insertion of a variable inductance in the anode circuit and the necessary by-pass condensers to shunt the radio frequency fluctuations in this circuit around inter-tube transformers or telephone receivers. For this reason, this arrangement has been a great favorite with radio experimenters as well as manufacturers of receiving apparatus, who have merely assembled conventional parts in a containing case.

From the standpoint of interference produced by the receiver, therefore, the inductive coupling method is considerably superior to the capacitive coupling, owing to the fact that the coupling can be set at some value below the oscillating condition, which it will maintain thruout the whole range of wave length adjustment. The degree of regeneration which can be obtained over the whole range without oscillations occurring at any point is, of course, dependent upon the excellence of design of the set. In case of the capacitive coupling, as the degree of regeneration increases at a very rapid rate with decrease of wave length setting, it is necessary, in order to obtain any appreciable regenerative effect, that simultaneous adjustment of anode inductance be made with adjustment of wave length.

The design of the oscillating circuit tuning elements of a receiver is largely determined by the range of wave length desired and in the regenerative scheme employed, if any. The inductance or capacity elements alone may be variable, or, to obtain a greater range of wave length adjustment, they may both be variable.

When the inductive coupling for regeneration is employed, it is usually desirable that at least the inductance element in the oscillating circuit be varied for adjustment of resonant wave length, as by this means the proper coupling between the resonant circuit inductance and the feed-back coupling coil for constant regeneration at various wave lengths can be obtained.

In Figure 7 is shown the interior of a typical regenerative receiver, using inductive coupling for regeneration, and simultaneous variation of both inductance and capacity for wave length adjustment. This receiver covers a comparatively long range of wave length with one continuous adjustment, and in order to compensate for the comparatively small angle of adjusting of the knob which will carry a heterodyne note thru the audibility range, it is fitted with a so-called "vernier" condenser, consisting of a small single plate variable condenser in parallel with the main tuning condenser. The total range of this condenser is made equivalent in wave length change to a few divisions of the main tuning dial. This receiver is normally intended to be used as a single circuit set. However, for conditions surrounding the antenna under which it is not possible to realize the necessary selectivity, it can be used as a tuned coupled circuit set by using a separate primary tuner, as shown in Figure 8 the secondary tuner being merely short circuited on itself.

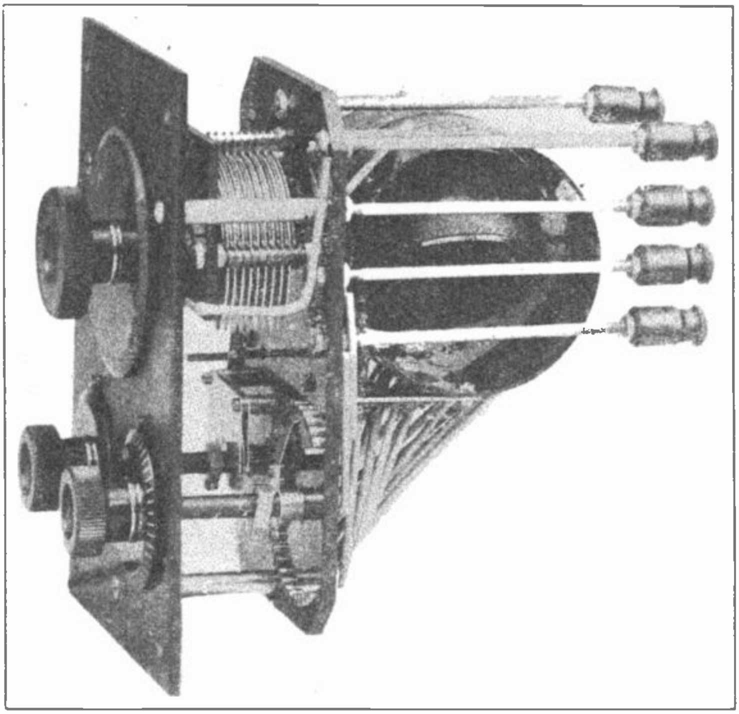

FIGURE 7

When the boxes containing the two elements are placed side by side, they give about the proper coupling for usual operating conditions. As the coupling is between the variable inductances, these can be proportioned so that they maintain the proper coupling value over the whole range.

In Figure 9 is shown a single-circuit regenerative receiver in which the inductance element alone is varied for the purposes of tuning, a fixed capacity being used in series with the antenna circuit for the purpose of increasing the selectivity. However, this fixed capacity is made in two steps, thus permitting two separate wave length ranges. The regenerative coupling coil and the main tuning inductance are so inter-related as to give practically constant regeneration over the whole range of possible wave length adjustment, when the set is connected to the average antenna.

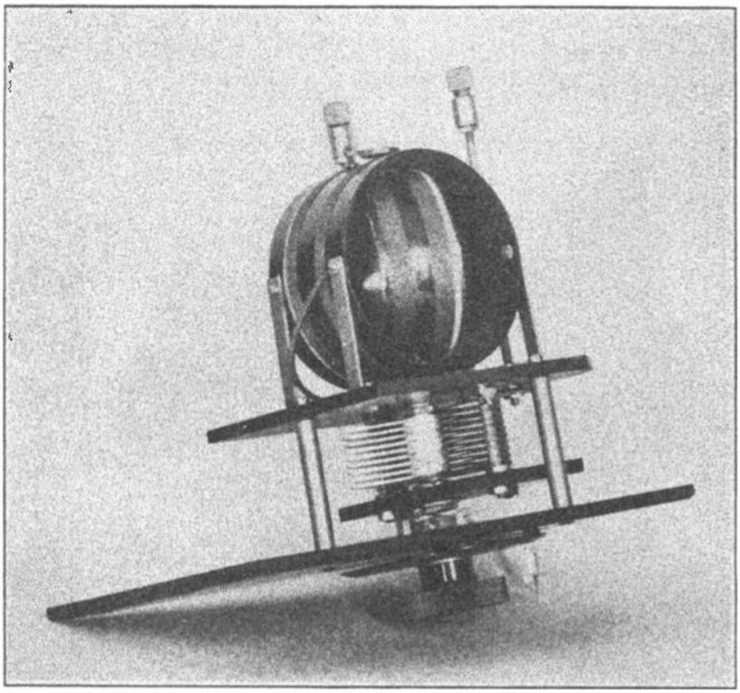

FIGURE 8

The foregoing remarks mainly cover questions of design affecting the tuning elements of the receiver, and on the general assumption that a three-element vacuum tube receiving system of the requisite sensitivity is employed.

The problems which may be presented for future development will be influenced largely by the condition imposed on the operation of the transmitting stations. With the transmitters grouped in one band of wave length, the possibilities of improvement are very remote. With the separation of transmitting waves, the ease of solution of the interference problem increases with the extent of this separation. The logical solution would appear to be a separation which would correspond to the possibilities of available receiving apparatus, and it is probable that, as the number of transmitters continues to increase, with a corresponding reduction of wave separation, the development of receiving apparatus will keep pace with the increasing exactitude of requirements.

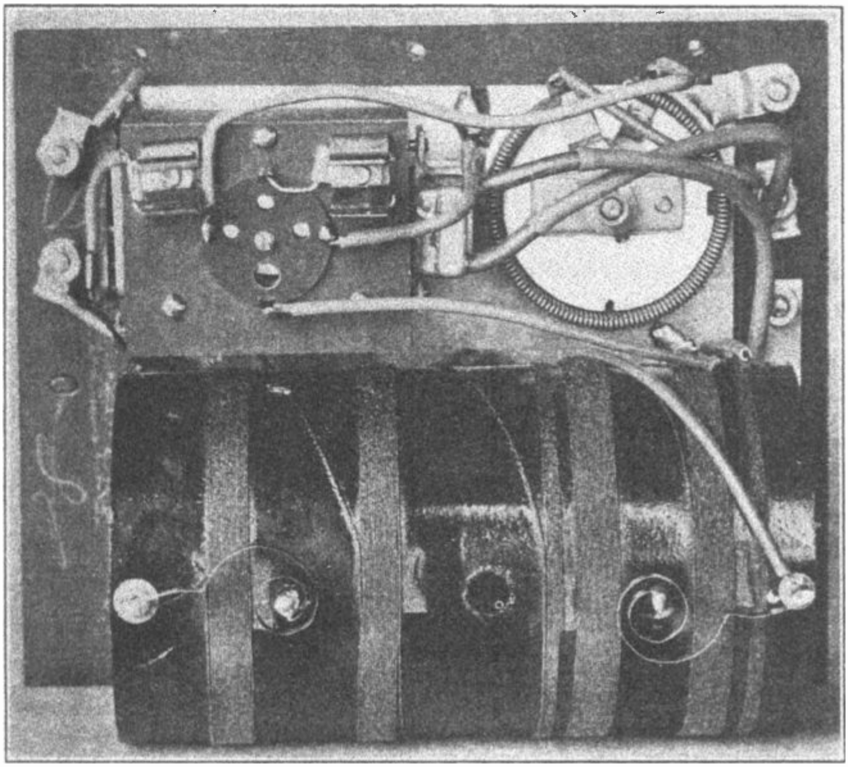

FIGURE 9

SUMMARY: The requirements and possibilities of a receiver for radio-telephone broadcast signals and the importance of considering the antenna in the design of this receiver are discussed. It is brought out that the increase of signal strength which is obtainable by regeneration is limited to a definite value, which is determined by the strength of the incoming field, and it is shown by curves that this maximum signal strength is independent of antenna height. Some of the possibilities in the direction of eliminating interference by various circuit arrangements are discussed.

# OSCILLOGRAPHIC STUDY OF ELECTRON TUBE CHARACTERISTICS*

By

E. Leon Chaffee

(Harvard University, Cambridge, Massachusetts)

The following paper describes an oscillographic method of studying vacuum tubes which was developed for use in an investigation on electron tube detectors containing gas. The method is, however, applicable to the study of any three-electrode tube and there are appended to the description of the apparatus curves taken on several types of vacuum tubes.

The point-by-point method of obtaining the static characteristics of a vacuum tube is both laborious and inaccurate. So much time is required to make the large number of readings necessary to obtain even one curve that conditions are likely to change during the process. This is particularly true in the study of gas-filled tubes. Furthermore, small kinks or points of irregularity in the characteristic curves, sometimes of great importance in explaining the action of gas-filled detectors, can only be investigated by some oscillographic method such as is here described.

The apparatus may be used, in addition to giving the static characteristics, to show the operation of a tube as a detector or amplifier by oscillographing the changes in plate and grid currents as small potential variations are impressed on the grid. The results obtained in this way are of pedagogical value in showing the action of amplifiers and detectors.

A brief description of the apparatus and method follows. The deflections of two vibrators of a special oscillograph are recorded photographically on bromide paper wound on a revolving drum. Except in a special use, one vibrator records the plate current and the other the grid current. A motor rotates the drum and at the same time slides a contact over a circular potentiometer so that distances around the drum, which is a direction lengthwise of the bromide paper, are proportional to volts.

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* Received by the Editor, March 8, 1922.

Figure 1 shows the connections used in obtaining the curves of plate-current against grid-volts for any constant value of the plate volts, $E_b$. The potentiometer referred to above is shown at $P$, and in this case is connected across the filament battery $E_a$ and the extra battery $E'$ so that the potential of the grid is made to vary from $-E'$ to $+E_a$ with respect to the negative end of the filament. The plate vibrator is shown at $O_b$ and the grid vibrator at $O_c$. In the grid circuit is a condenser $C$ which can be shorted by switch $S_c$. A switch $S$ is also included in the grid circuit. When $S$ is thrown to the right, a 1-ohm resistance thru which flows a small measured alternating current of about 6 cycles, is connected in the grid circuit. By this means a small slow variation of potential is superposed on the gradually increasing potential caused by the movement of the contact over the potentiometer $P$. The plate current shows a corresponding small alternate increase and decrease due to the small superposed alternating potential in the grid, the amplitude of the plate current variation being a maximum on that part of the characteristic curve where the amplification is a maximum.

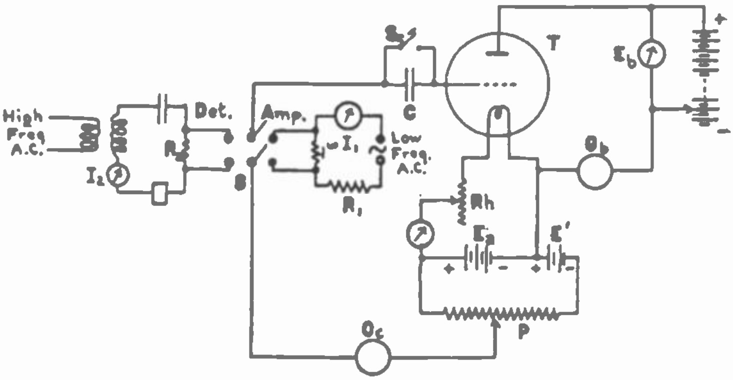

FIGURE 1

When switch $S$ is thrown to the left, the tube is operated as a detector. A small resistance $R_2$ thru which a small measured radio frequency current flows is included in the grid circuit. An interrupter $B$ periodically interrupts this radio frequency current at the rate of about 6 times per second. Each time the radio frequency potential variations are impressed on the grid, the plate current shows a change if rectification takes place and the change in plate current is a measure of the amount of rectification, or sensitiveness of the tube as a detector.

Curves giving the variation of plate current with plate voltage for various constant values of grid voltage are of well known interest in studying the characteristics of electron tubes. Figure 2 shows the connections for taking curves of this type. *P* is the motor-driven potentiometer which now varies the plate potential from zero upward as the drum carrying the bromide paper rotates. *P′* is a second potentiometer substituted for *P* in Figure 1 and used to set the grid voltage to any constant value. Otherwise the connections are the same in the two arrangements of Figures 1 and 2.

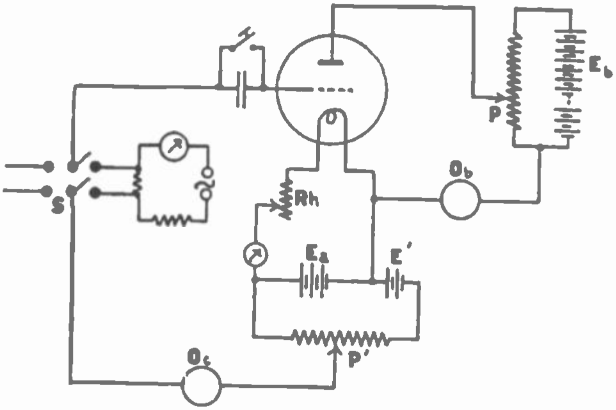

FIGURE 2

When a tube is used as a detector only, a strong signal impressed on the grid will give an appreciable fractional change in plate current. The effect of a weak signal may be studied by a special method of magnification explained by the connections shown in Figure 3.

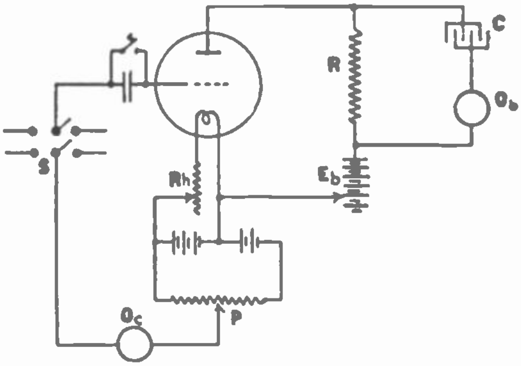

FIGURE 3

About the high resistance *R* is shunted a large condenser *C* in series with the plate vibrator $O_b$. Placed in this position the vibrator carries no direct current, and deflects only when there is a variation in plate current. This arrangement permits the vibrator to be used at its maximum sensitivity, that is unshunted. When the plate current suddenly drops, the voltage across the resistance *R* drops and the large condenser *C* partially discharges thru the vibrator, giving a quick throw—the amplitude of which is roughly proportional to the magnitude of change of the plate current. The condenser *C* had, in the arrangement used, a capacity of 10 $\mu$f. and the resistance *R* was from 1,000 to 10,000 ohms, according to conditions. It is desirable to make *R* as small as possible consistent with sensitivity because a very high resistance in the plate circuit flattens the characteristics of the tube.

In addition to the connections shown in Figures 1, 2, and 3, means were provided for rapidly calibrating the two vibrators by sending 0.1, 1.0, or 10 milliamperes thru the vibrator, according to the amount the vibrators were shunted to reduce sensitiveness. These deflections caused by the calibrating current are recorded photographically after each curve. The abscissa voltage scale was also recorded photographically, as will appear on the curves.

The oscillograph is a reconstructed Duddell oscillograph. In place of the strip vibrators, which had insufficient sensitivity, two small d'Arsonval coils were substituted. Each coil was wound with 100 turns of one and one-half mil (0.0015 inch or 0.0038 cm.) wire on an ivory bobbin about ¾ inch (1.9 cm.) long and ⅛ inch (0.32 cm.) wide. These coils were held by taut suspension between the poles of the electromagnet. Over the active winding were wound a few short circuited turns to provide damping. The coils so constructed had a period of about 1/30 second,

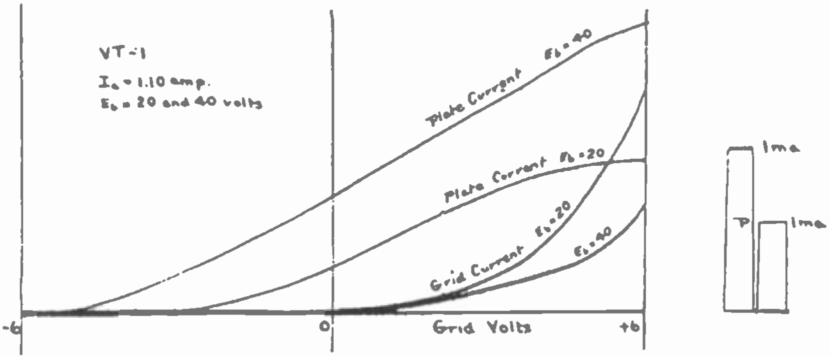

FIGURE 4

and a sensitivity of about 1 millimeter deflection at a distance of 1 meter (39.4 inches) for a current of 2 microamperes.

Figure 4 shows the usual static characteristic of plate and grid currents plotted against grid voltage for a Western Electric "VT-1" tube. The filament current and plate voltages are given on the curves. The calibration of the vibrators are given at the extreme right of the figure.

Figure 5 shows the plate and grid current plotted against plate voltage for the same tube. The grid current for grid voltage equal to zero is everywhere zero.

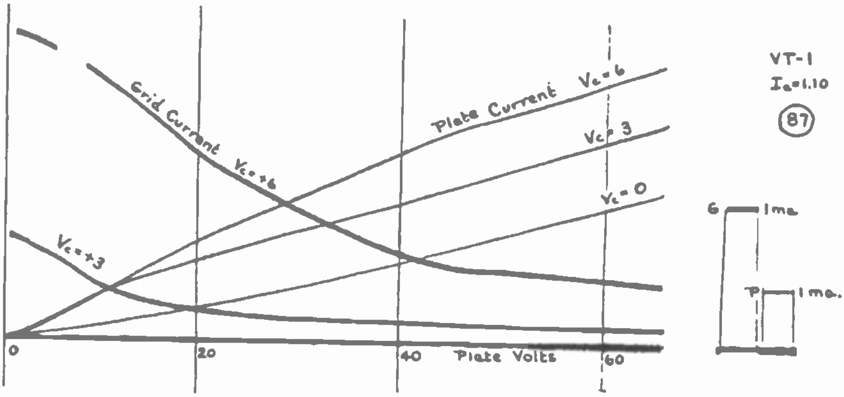

FIGURE 5

Figure 6 gives the plate and grid current plotted against grid voltage for a tube containing a trace of gas, probably air. The plate voltage was so high that the gas was ionized altho showing no perceptible blue glow. The positive ion grid current is evident

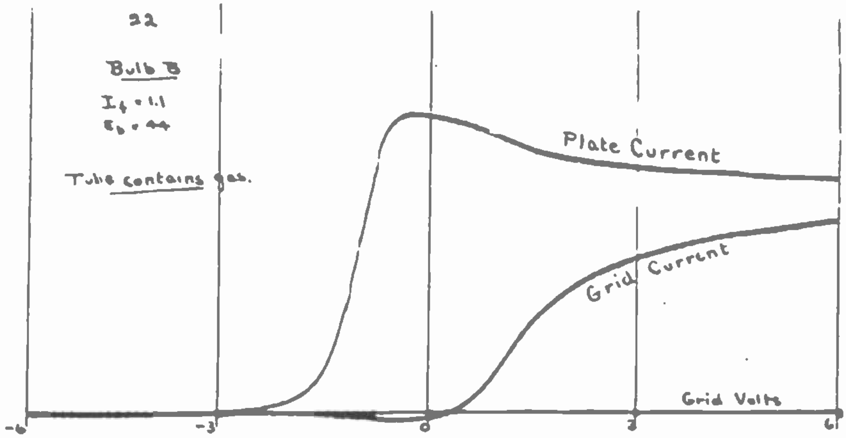

FIGURE 6

between grid voltages of −1.5 and +0.5. Also the excessively steep rise of plate current should be noted giving a large mutual conductance which is characteristic of gas tubes.

Figure 7 shows characteristic curves of a gas tube taken similar to those of Figure 6, except that an alternating poten-

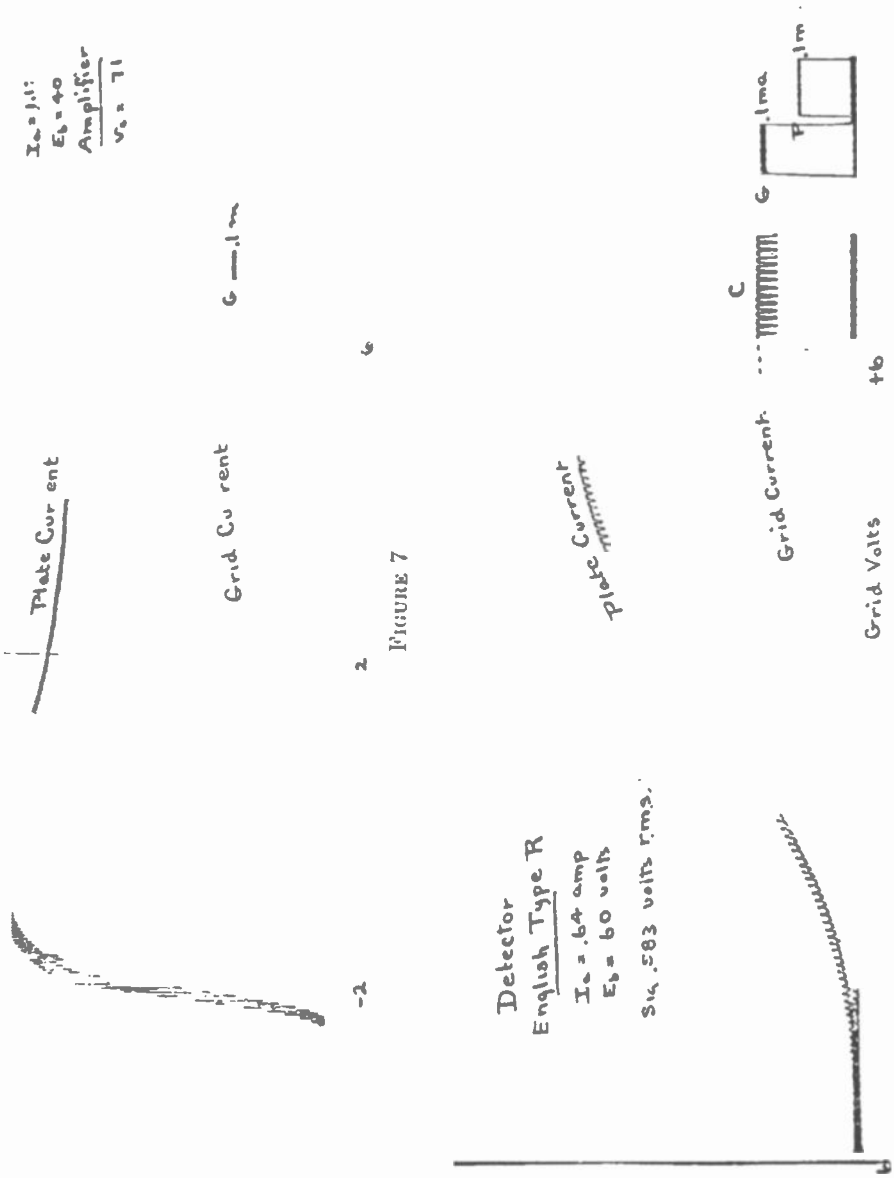

FIGURE 7

tial of 0.071 r.m.s. (root-mean-square) is impressed on the grid in addition to the slowly varying grid voltage for giving the abscissas of the curves. The amplifying effect of the tube is here shown.

Figure 8 shows an English Type "R" tube used as a detector. An interrupted radio frequency potential of 0.583 volts r.m.s. was impressed on the grid, and the resulting change in plate current gives an indication of the intensity of the signal and hence the sensitivity of the detector. The two regions on the plate current curve where rectification takes place is well shown. At the lower bend where $\frac{d^2 I_p}{d E_g^2}$ is positive, an increase in current results, but at the upper bend when the second derivative is negative, a decrease in plate current is obtained. The sensitivity with a grid condenser is shown at $C$ at the right hand end of the curves. In this case, a decrease of plate current results, as would be expected, and the sensitivity in this case is greater than without a grid condenser.

Figures 9 and 10 show the detector action of gas tubes operating at high plate potential and low filament current. The trace of gas is perpetually ionized giving steep curves with sharp bends at the upper end where the detector sensitivity is great.

It is well known that a gas tube operated under certain critically adjusted plate and grid voltages and filament current often give phenomenal sensitivity as detectors. These sensitive spots on the characteristics are due to small kinks in the curves resulting from ionization of small traces of gas, too small in amount to make the tube break over into the familiar blue glow.

These kinks are exceedingly difficult to find when the characteristics are plotted point by point. It was to find these kinks that the apparatus described above was set up.

Figure 11 shows the detector action of a gas tube operating at a plate potential of 18 volts and rather high filament current. Under these conditions the kinks are enhanced. Two kinks are evident at *a* and *b* of the plate current curve but only the kink at *b* shows in the grid current.

The action at *b* is easily explained. Ionization of a small amount of some gas takes place, producing positive ions. These positive ions are attracted toward the grid but pass thru the grid toward the more negative filament. The space charge between filament and grid is partially neutralized, resulting in an increase in grid and plate current. The gas soon becomes totally ionized and no further increase in number of positive ions results. The curves then return to their former course.

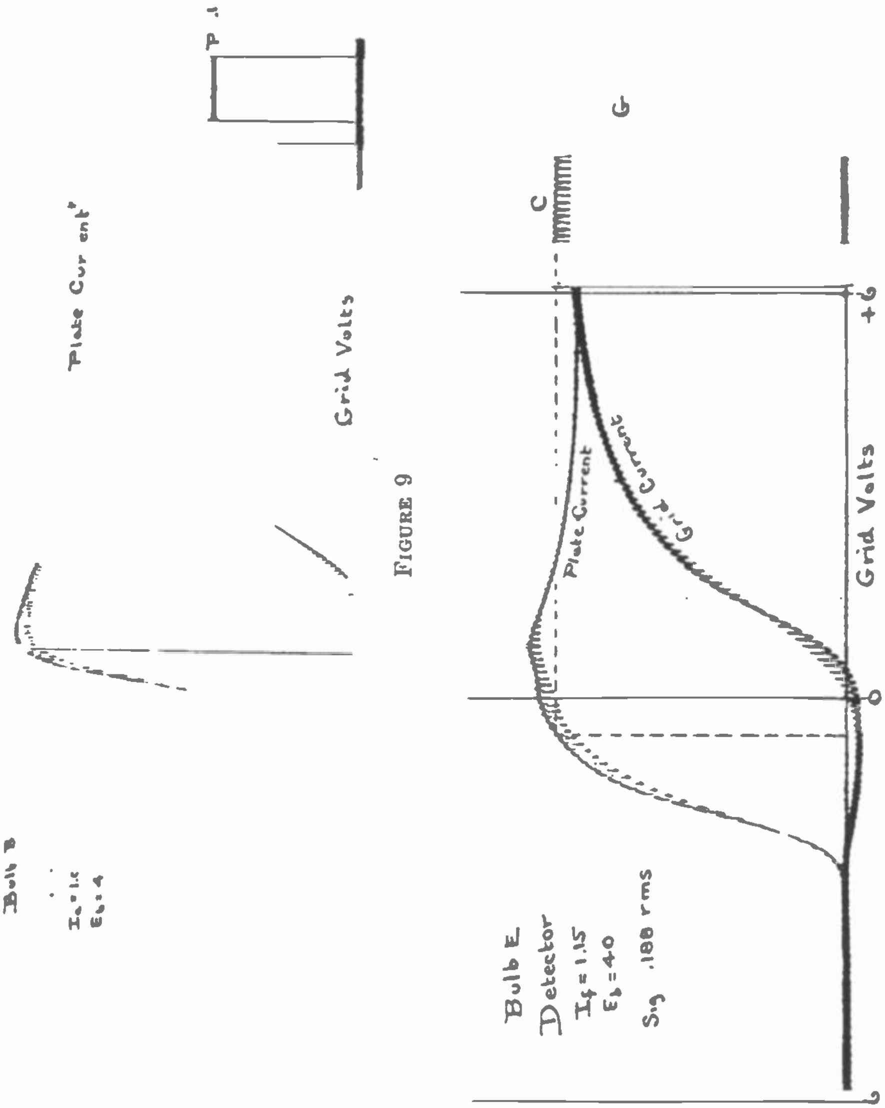

FIGURE 9

The effect at *a* is different, since any ionization would show in the grid current as at *b*. The electrons have an insufficient velocity to ionize the atoms of gas, but sufficient to excite them to radiate ultra violet light. At this so-called "resonance" velocity, some of the energy of the electrons is absorbed. The effective potential from plate to filament is thereby decreased, and a retardation or actual decrease in plate current results as the grid voltage is increased. The grid current is unaffected since the absorption of energy takes place between grid and plate.

The position of these kinks depends upon the kind of gas and the structural constants of the tube. Too much gas produces large changes of current which show hysteresis and do not give usable detectors.

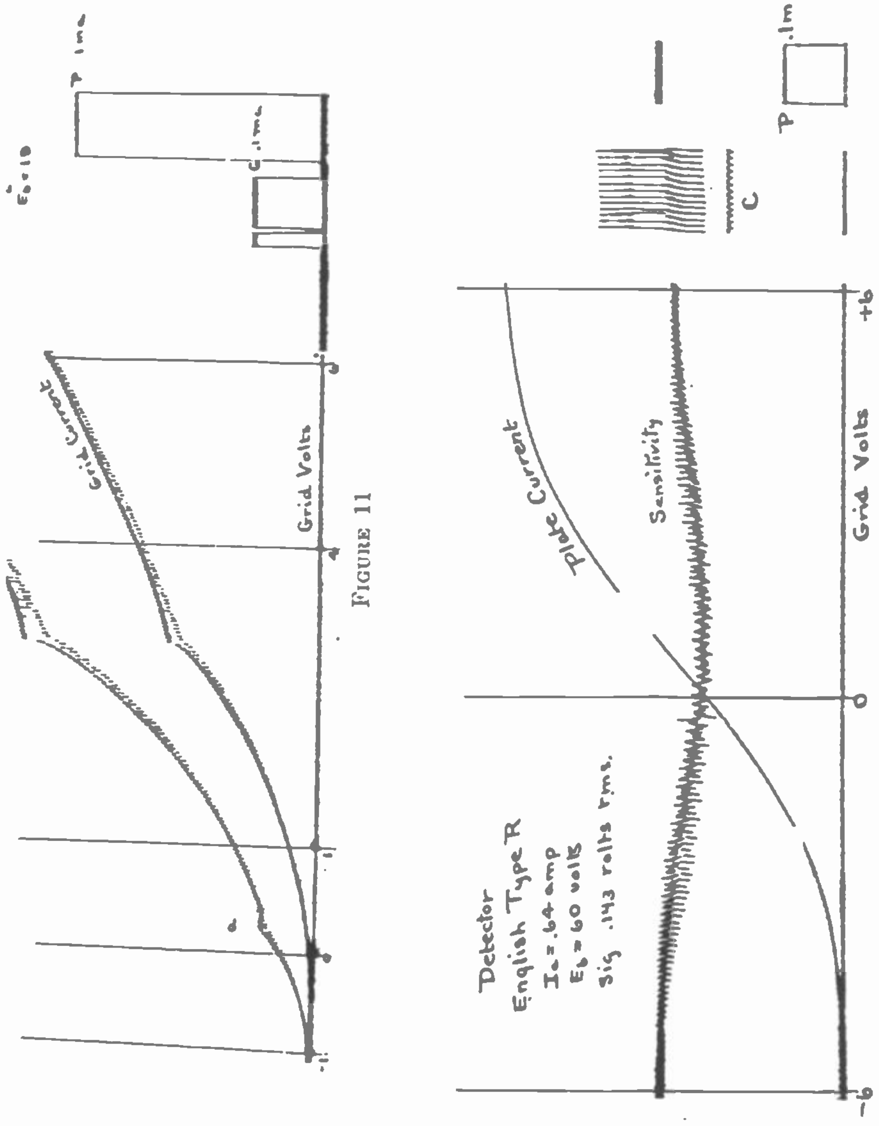

FIGURE 11

The signal voltages impressed on the grids of the detector tubes shown are of course excessive, and show sensitivity for a on either side of a kind equal to the extreme variation of grid voltage. In order to show more definitely the detector action at the kink, the signal voltage was much reduced and the variation in plate current magnified by the condenser connection shown in Figure 3 and described above. The grid vibrator was used to trace the magnified sensitivity.

Figure 12 shows the magnified sensitivity of a hard tube used as a detector. The extent of vibration indicates sensitivity. The changes in plate current are hardly perceptible on the plate current curve except when using a grid condenser as shown at *C*. Above the plate current line at *C* is the magnified sensitivity with a grid condenser.

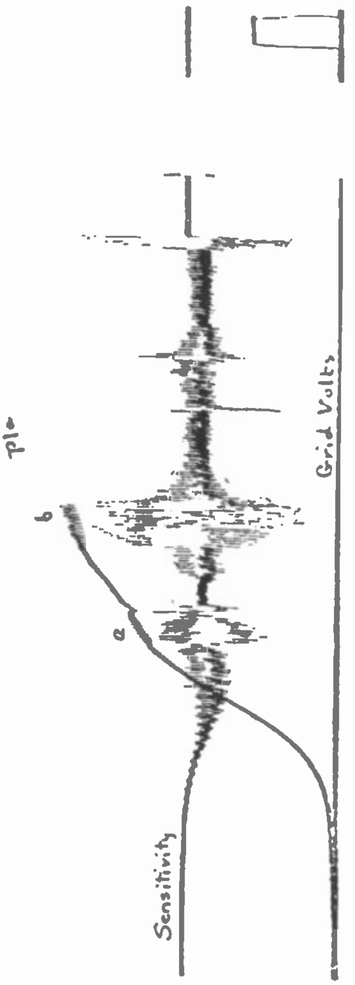

FIGURE 13

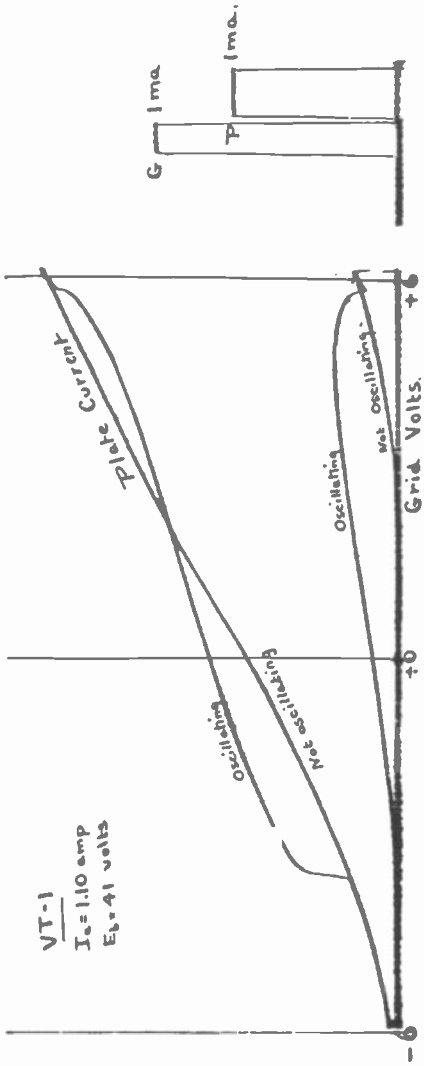

Figure 13 shows the same method used for a gas tube. The plate current shows four regions of kinks. At *a* and *b* there are two close together, at *c* and *d* there is only one. The sensitivity is shown by the jagged curve marked "sensitivity."

Figure 14 shows the oscillating characteristics of a "VT-1" tube as the grid volts are varied. The curve is self-explanatory.

Cruft Laboratory,
Cambridge, Massachusetts.

**SUMMARY:** A special oscillograph is used to record simultaneously the plate current and the grid current of an electron tube. By superposing a slow audio frequency variation of voltage on the regularly increasing grid voltage during the photographing of the oscillogram, corresponding audio frequency variations are produced in the plate current, the amplitudes of which are proportional to the amplification of the tube at that setting.

Detector action can similarly be studied by applying a rising radio frequency voltage to the grid, and periodically interrupting it at a low audio frequency.

The study of tubes containing gas, and the recording of kinks in their characteristics is particularly facilitated by the use of the apparatus described.

# PHOTOELECTRIC ELECTRON TUBES*

By

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In recent years there has been put on the market, and used quite extensively, a class of vacuum tubes known as "gas content detectors." The advantage of this detector tube lies in the fact that it does not require a high plate voltage for operation, in fact the plate voltage is often as low as 18 volts; but must be adjusted carefully to the best value for loudest signal response. For such tubes the adjustment of filament current is also critical, and these two characteristics constitute a rather serious disadvantage. In the case of higher vacuum tubes used as detectors, adjustments are not so critical, the disadvantage being that higher plate voltages are necessary for good audibility of signal response.

During the year 1920-21 considerable work was done by the authors of this paper on the effect of the variation of pressure, and of the nature of gas content upon the efficiency, constants, and characteristics of detector tubes, and the results were abstracted in the March, 1922, issue of "The Physical Review." It was found that for a tube containing a certain gas the plate voltage for best signal response, which will be called the "operating voltage," decreased along a curve as the pressure increased, as shown in Figure 1. The curve shown was drawn from data obtained from three tubes, the gas content being air. For other gases the curves are similar in shape. Moreover it was found that for increasing pressures the operating voltage approaches the ionizing potential of the gas in the tube. Accordingly it should be possible to introduce into the tube a gas having a low ionizing potential, and thus obtain a detector having a corre-

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spondingly low operating plate voltage. The introduction of mercury vapor showed this to be a fact, altho in all cases the operating voltages were a few volts higher than the ionizing potential of the gas or metallic vapor content.

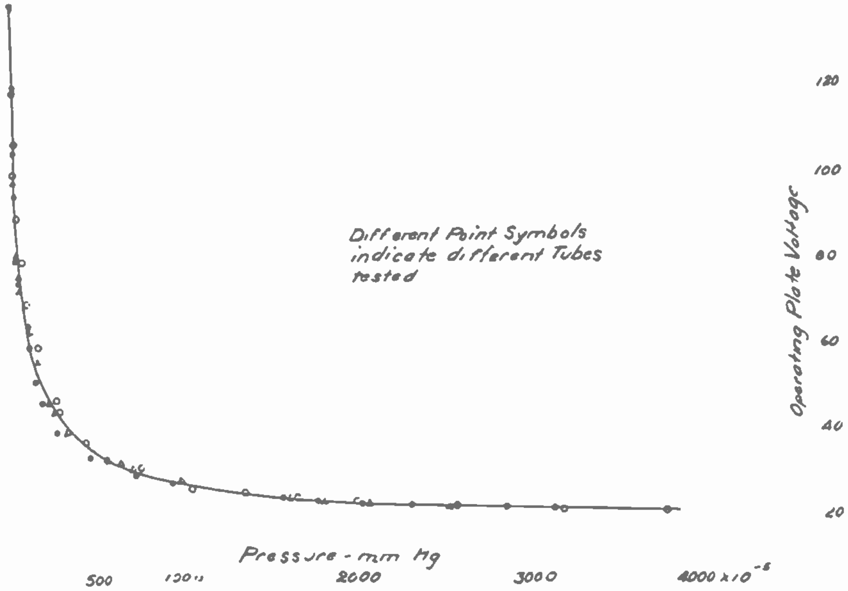


FIGURE 1

Recently this latter phase of the problem was again taken up, and three of the so-called alkali metals were introduced into detector tubes. The vapors of potassium-sodium alloy, rubidium, and caesium have ionizing potentials of less than four volts, and are the sensitive materials used to coat the walls of photo-electric cells. Small quantities of potassium-sodium alloy in a liquid state similar to mercury were put into several three-electrode tubes and the tubes were then tested and found to yield very remarkable results.

## CHARACTERISTIC CURVES

Figure 2 shows plate current-grid voltage curves for various plate voltages. A peculiarity to be noted is the flattening out of the bend at saturation as the plate voltage increases. It should also be noticed that for negative grid voltages the curves are smooth, which is not the case for tubes containing gas, these latter having "humps" in their curves. Mercury vapor filled tubes also have the smooth curves mentioned. Figures 3, 4, and 5 show similar curves for different tubes. For all of the curves of this paper, the type UV-201 Radiotron was used. The tube of Figure 5 contained traces of gas so that the curve at 40 volts turned over much as it does in a gas-filled tube. This will be also noticed for higher plate voltages in the preceding three sets

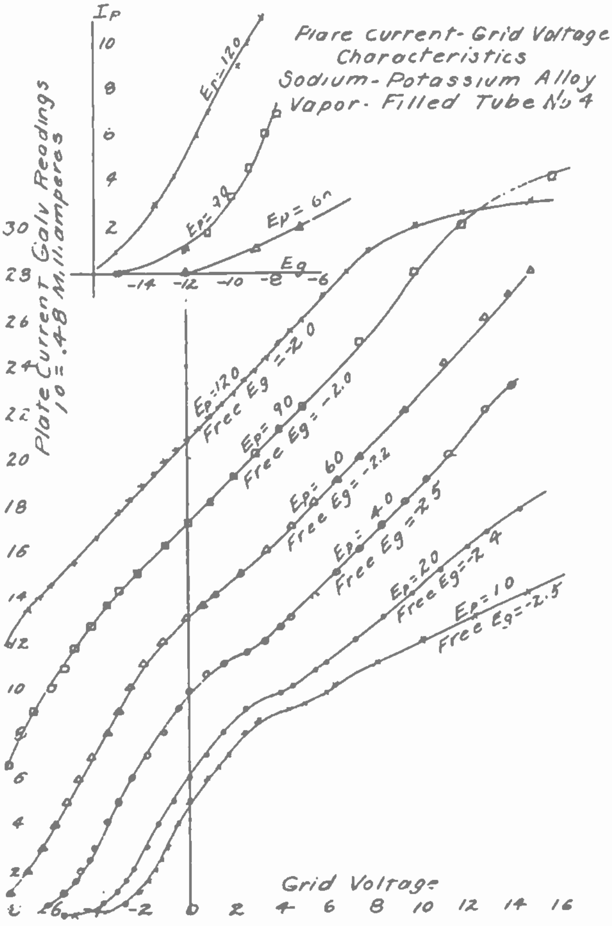


FIGURE 2

of curves. Below these "critical" plate voltages the curves again increase after passing the saturation point. In Figures 3, 4, and 5 it should be noted that the tube has quite a pronounced characteristic curve at zero plate voltage, when the plate was connected thru the galvanometer shunt to the negative end of the filament. In Figure 4 is also shown the zero plate voltage curve when the plate circuit connection is made to the positive end of the filament. The plate current is increased as would be expected. All curves were obtained for plate circuit connection to negative filament unless otherwise specified. With the connection to the negative filament lead, the plate current is at least fifty times as great as for a tube which does not contain the alkali metal vapor. This flow of current without any external

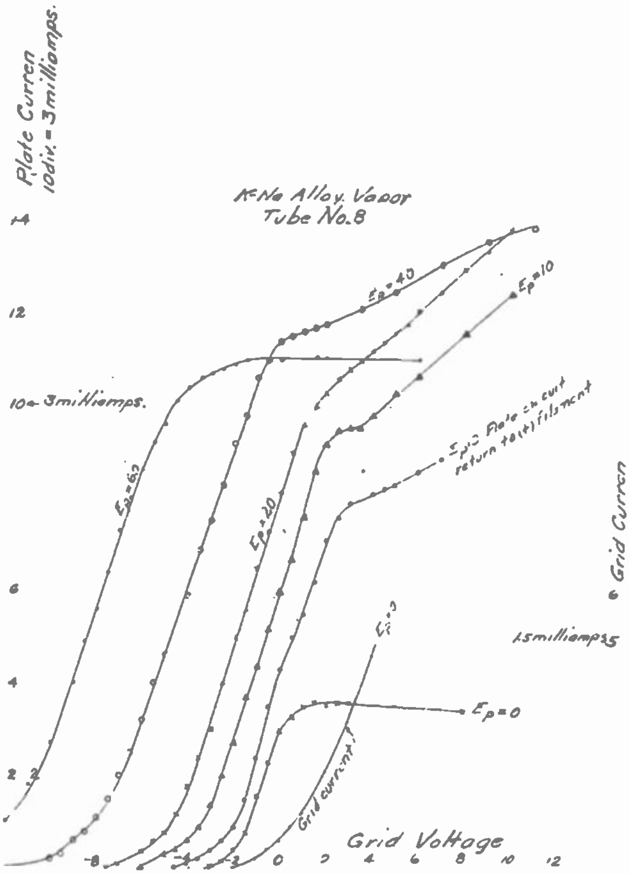


FIGURE 3

source of potential is also present in the photoelectric cell, hence the action of the tube as a detector of damped or undamped waves is wholly a photoelectric phenomenon controlled by grid potential at zero plate voltage, and partially so at other plate voltages. The negative free grid potential, as indicated on the curves by the plate current when the grid was disconnected, varied from $-2$ to $-2.5$ volts. Figure 6 shows characteristic curves for two alloy vapor tubes which were more completely exhausted before sealing off. Later curves will show detector and amplifier characteristics of these particular tubes. Figure 7 shows grid current curves for a typical tube, and Figure 8 shows a plate current-filament current curve. In Figure 7 the assymetry of the curve at $-2$ volts grid indicates that the tube is a sensitive detector.

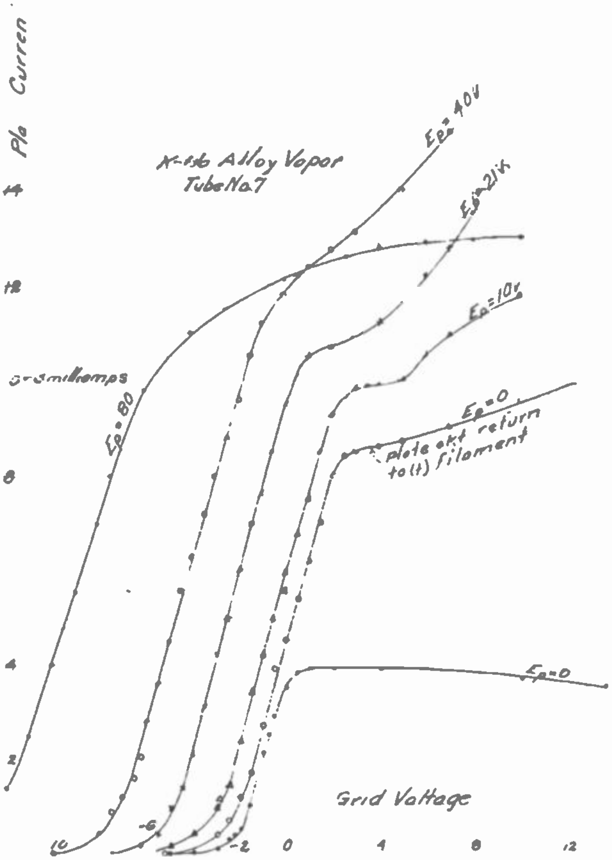


FIGURE 4

The shape of the plate current-grid voltage curves seemed to indicate that the tubes would function well as amplifiers since the curves are smooth and straight for negative grid voltages and it seems from their good performance as amplifiers, that the dynamic characteristics are also straight lines. Figure 9 shows plate voltage-grid voltage curves with constant plate current for two tubes. These curves are straight lines for high vacuum tubes, and, as the curves illustrated, show the alkali vapor filled tubes have this desirable characteristic. Curve A, Figure 9, is typical for a gas content tube, which is a very unsatisfactory amplifier as the slope of the curves, being the no load amplification constant of the tube, is not constant. The tubes

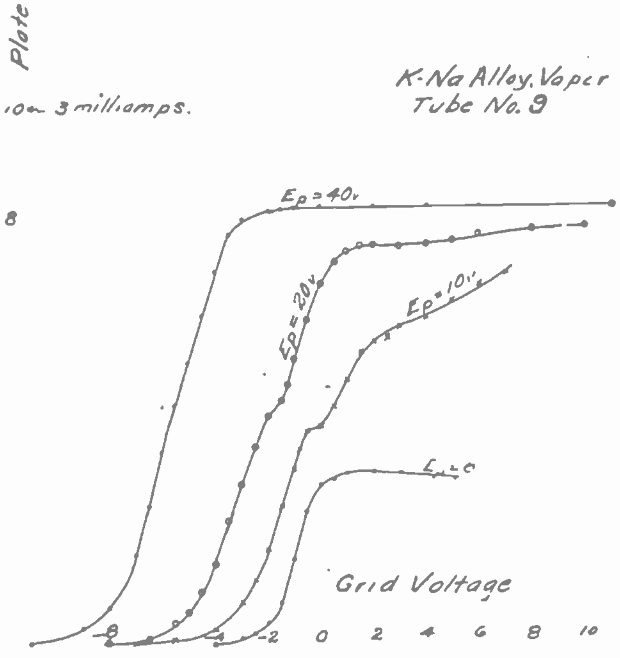


FIGURE 5

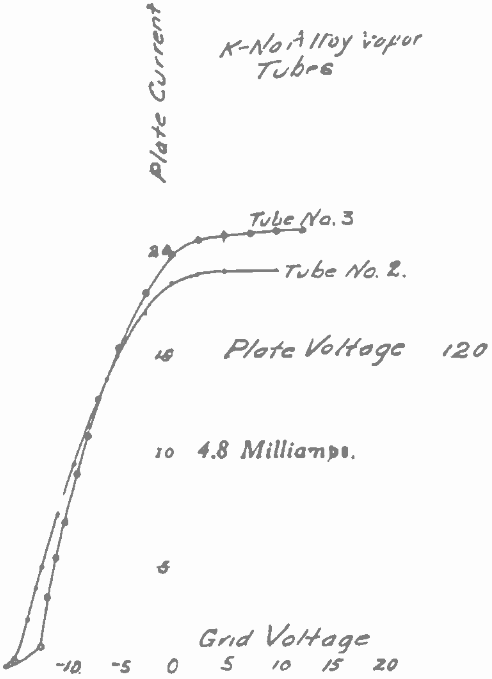


FIGURE 6

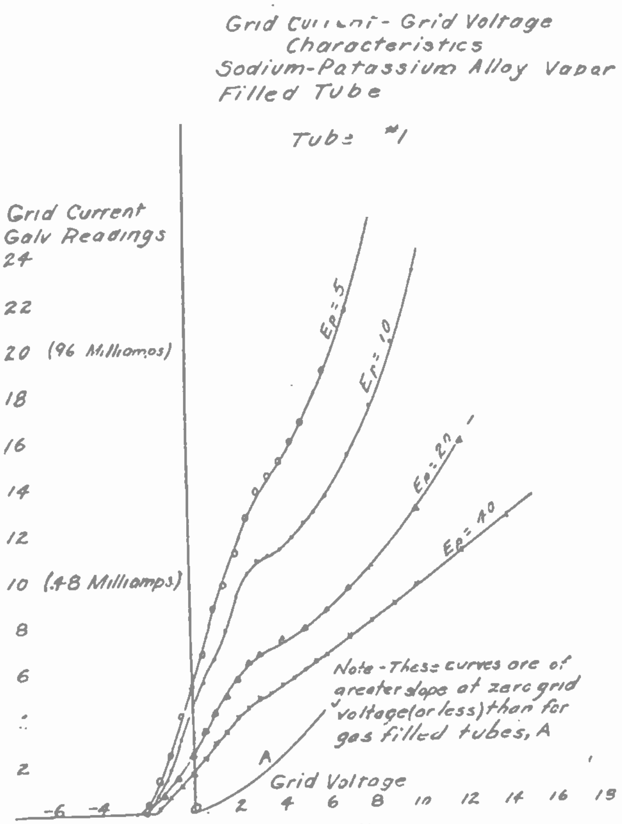
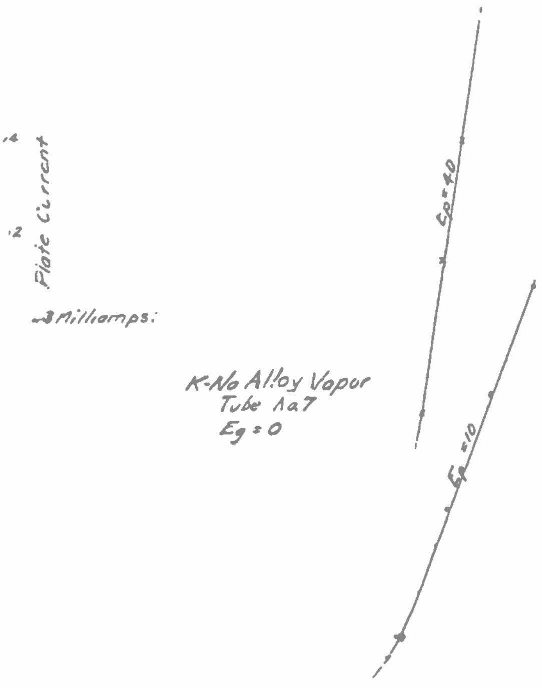

Grid Current - Grid Voltage
Characteristics
Sodium-Patassium Alloy Vapor
Filled Tube
Tube #1
Grid Current
Galv Readings
24
22
20 (96 Milliamps)
18
16
14
12
10 (.48 Milliamps)
8
6
4
2
-6
-4
Ep=5
Ep=10
Ep=20
Ep=40
A
Note - These curves are of greater slope at zero grid voltage (or less) than for gas filled tubes, A
Grid Voltage
2
4
6
8
10
12
14
16
18

FIGURE 7


.4
.2
Plate Current
.3 Milliamps.
K-Na Alloy Vapor
Tube Aa7
Eg = 0
Ep=40
Ep=10

of Figure 9 contained a small amount of the alloy so that the vapor pressure would be as high as possible. Figure 10 shows these same curves for a tube containing a small amount of the alloy evaporated into the tube and deposited on the tube walls by condensation. The slope of the curves of Figures 9 and 10 indicate high amplification constants.

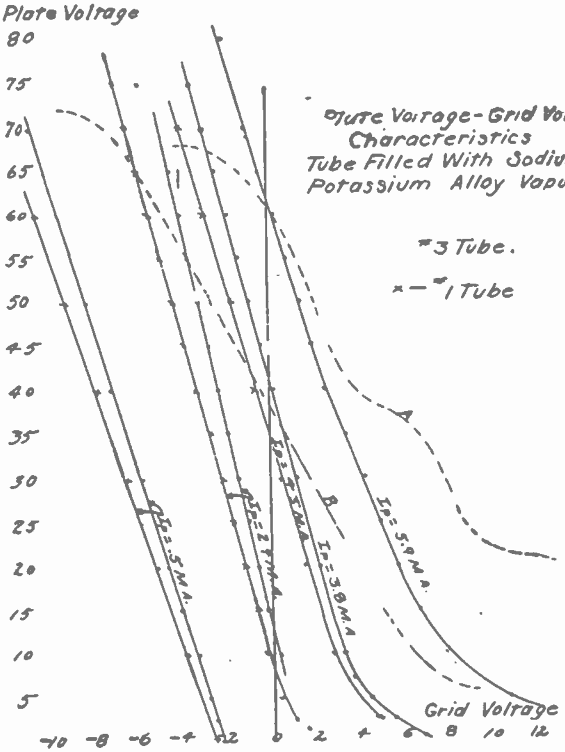


FIGURE 9

The amplification constants of three tubes were measured for different plate voltages and the curves of Figure 11 show the results. The method used for measuring the amplification constant, $\mu_o$ was that described in Van der Bijl's "The Thermionic Tube," page 203. The apparent increase of the value of $\mu_o$ at low plate voltages seems to indicate some source of error in the method, but precautions were taken to weaken the applied 1,000 cycle voltage, and to vary the grid potential with a grid battery. It is to be expected that the value of $\mu_o$ would remain constant for varying plate voltages for a high vacuum tube, but such a tube was tested and curve B obtained. In case of gas content tubes the value of $\mu_o$ does not remain constant but varies along a curve such as A in the figure. It is probable that the *effective* geometry of the tube is altered by the ionization of gas contained therein. The variation of mutual conductance, measured by a method described in the same reference, with plate voltage is

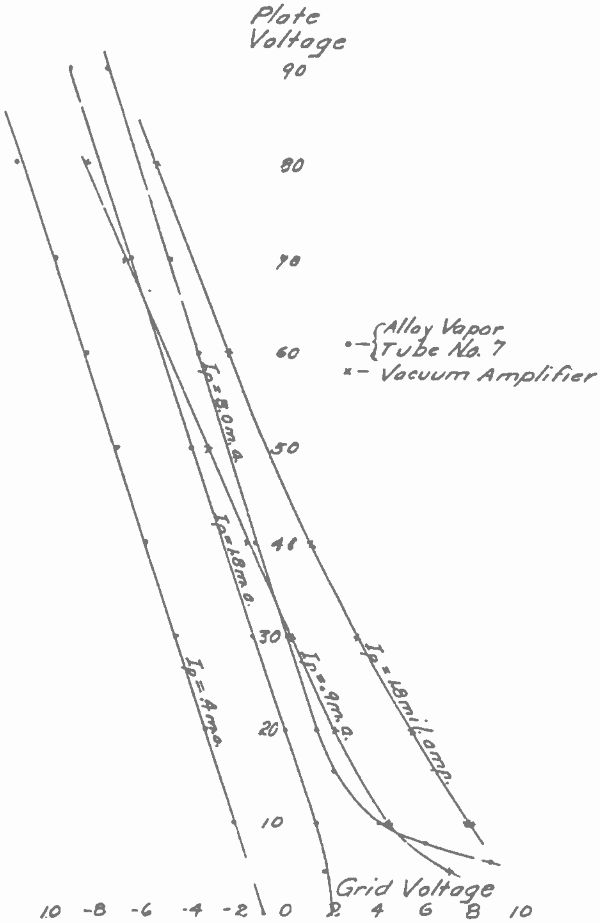


FIGURE 10

shown in Figure 12. These curves are interesting and indicate that the alkali vapor tubes would be excellent detectors in that the mutual conductance is high at low plate voltages, and is not extremely critical as regards adjustment of plate voltage. Curves A and B are typical of gas content tubes and fairly high vacuum tubes, respectively. For the alkali vapor tubes the mutual conductance increases gradually with filament temperature just as it does in the case of a high vacuum tube.

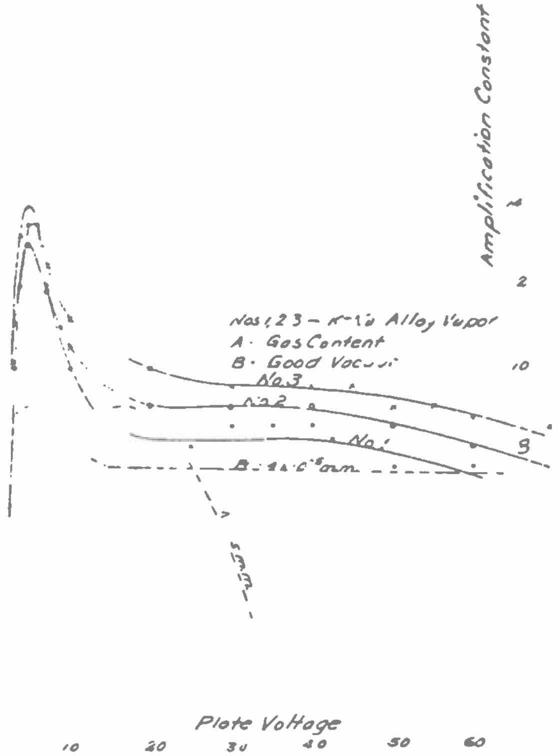


FIGURE 11

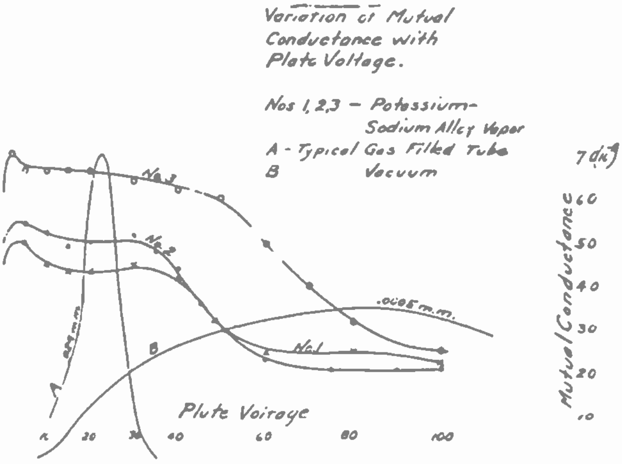


FIGURE 12

## PRACTICAL OPERATION AS DETECTORS

To show how the tube functions as a detector of damped waves a comparison test circuit was connected as shown in Figure 13. A buzzer excited oscillating circuit is used together with a loop receiver, the inductances being 40 inch (1.02 m.) loops placed in adjacent rooms so that the buzzer could not be heard in the room. The intensity of response in the receiver was measured by matching it with a standard tone signal furnished by a 1,000 cycle audio oscillator and attenuated thru an audibility meter *M*. The proportion in which this signal is re-

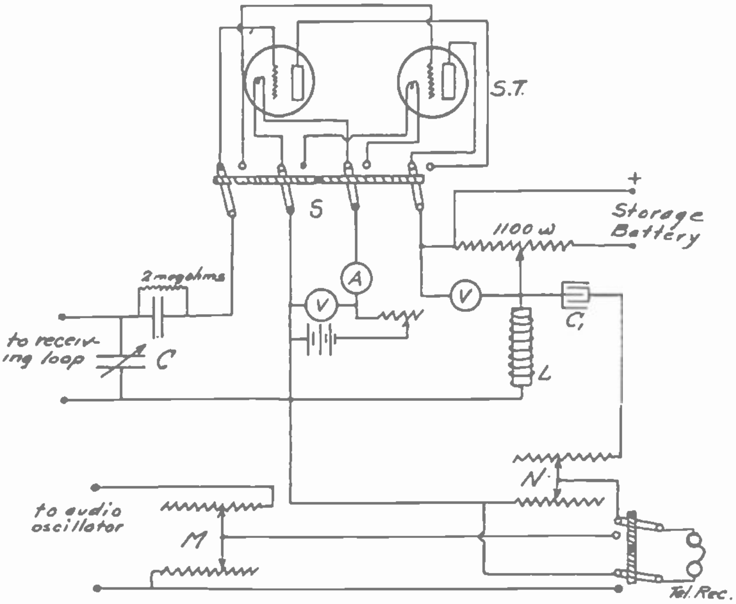


FIGURE 13

duced was calculated from the readings on the audibility meter setting. It was convenient to set the intensity of the received signal to a certain value by shifting switch *S* to the standard tube and measuring the audibility of the signal directly with audibility meter *N*. By means of the condenser *C* the received signal could be adjusted by detuning. A signal having a directly measured audibility of 5.5 times was used for all the measurements, as this represents a pretty weak signal. The purpose of the inductance *L* and condenser $C_1$ was to maintain constant plate potential on the tube when audibility meter *N* was varied. This method of measuring the efficiency of a detector is described in Van der Bijl's "The Thermionic Tube," pages 337 and 347, and is recommended by that author. Figure 14 shows how the per cent. intensity varies with plate voltage. It will be notde that while the maximum detecting efficiency occurs at about 10 volts the adjustment of plate voltage is not at all critical as is the case for a gas content tube. Moreover the intensity is quite

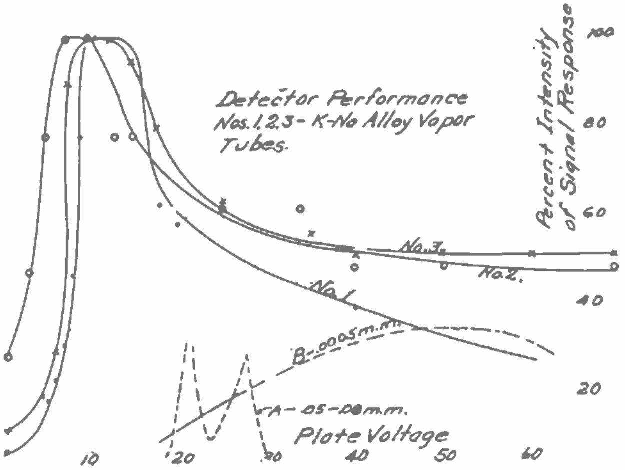


FIGURE 14

considerable at zero plate voltage and up to 50 or 60 volts. Curve A shows a typical curve for a tube containing a gas such as neon, nitrogen or argon at 0.05 mm. pressure. This shows the extremely critical nature of such a tube, and also the fact that the alkali metal vapor tubes are at least 3½ times as sensitive as the gas content tubes. A dozen tubes were filled and tested by comparing with several gas content tubes and it was found that the sensitiveness of the alkali vapor tubes was from 3 to 5 times that of the gas content tubes. Curve B is typical for the amplifier type tube, having a fairly good vacuum. By actual trial it was found that better results were obtained with a grid condenser of approximately 0.0003 microfarads and a grid leak of 2 megohms than with a carefully adjusted applied negative grid potential. It should be mentioned that it is important to use a rather weak signal when comparing detector tubes. If the received signal is extremely strong the intensity curve will be that of A, Figure 15, but if the intensity is weak the curve will be that of B, for a tube of fairly good vacuum. However, qualitative comparisons showed that the alkali vapor tubes were also most sensitive at 10 volts for strong signals of audibilities of 100-400 upon the standard tube; and that they also were much more sensitive than gas content tubes while receiving these strong signals. The variation of signal intensity with filament current was like that for high vacuum tubes, the intensity gradually increasing with filament current to a maximum and then gradually falling off with further increase.

The above tests and measurements, being quantitative were fairly conclusive proof that the potassium-sodium alloy vapor

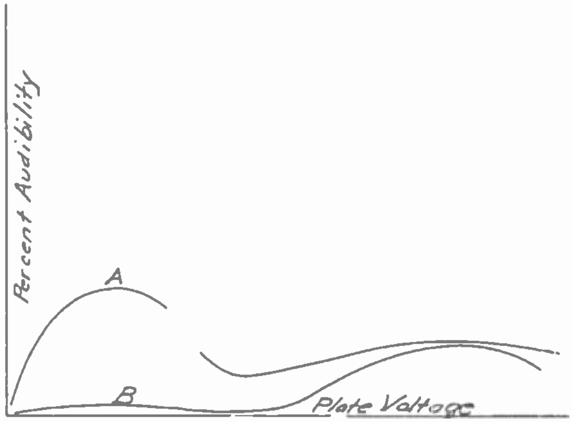


FIGURE 15

content detector tubes are far superior in every way to the common or inert gas content tubes. However, to be sure as to their practical utility the tubes were placed in standard receivers to receive the 2,500 meter spark station at Arlington, the 17,000 meter station at Annapolis, and the 360 meter broadcasting stations at Pittsburgh, Schenectady, Detroit, and Chicago. The results obtained were consistent with the measurements. The tubes were used as oscillating detectors for receiving the broad casting stations by the regenerative and "zero beat" methods, and also by the heterodyne method to receive the 17,000 meter Annapolis Station; and the authors were astonished at the results. Speech and signal reception were remarkably clear and distinct, and with practically no need of frequent readjustments, as are often needed when using gas content detector tubes. The tubes even function fairly well as oscillating detectors at zero plate voltage, receiving all of the above mentioned stations, using an antenna 50 feet (15 m.) high and no amplifier.

They were also used as amplifiers in these same circuits, and gave louder and clearer speech with 10 volts on the plates than did vacuum amplifier tubes at 30 or 40 volts. In regard to the matter of the life of the filament this has not yet been determined, but some of these tubes have been used about 20 hours and no increase in filament resistance has been observed. It is known to chemists that potassium or sodium is capable of forming an alloy with tungsten, but no doubt the temperature of the filament keeps the vapor sufficiently free from its surface to prevent appreciable action. No deposit of the alkali metal remains upon the electrodes or the stem supporting them after the filament is once heated. In the process of preparing the tubes the filament is maintained incandescent while distilling over the potassium-sodium alloy, and any deposit of the alloy upon the electrodes or supporting stem is prevented. Three of the tubes have been used intermittently for three months and no increase of filament resistance has been observed. The authors are of the opinion that the filament life of these tubes will be considerably better than that of the gas content tubes, especially since the sensitiveness is greater at a reduced filament temperature. In all of the foregoing tests the filament voltage was maintained constant at about 4.7 volts.

It is hoped that further investigation will show some other alkali metal vapor, or other vapor to be still more effective in three-element electron tubes. Also some particular proportions and dimensions will show maximum results. The potassium-sodium alloy was kindly furnished by Dr. Jakob Kunz.

Laboratory of Physics,
University of Illinois,
July 1, 1922.

**SUMMARY:** Three electrode tubes containing alkali vapor metals or vapcr of alloys of alkali metals possessing low ionizing potentials and the characteristics of a photoelectric cell give remarkable results as detectors both in the plain and the oscillating condition with 10 volts on the plate, these detectors are extremely sensitive, at least three times that of the gas content tube. The photoelectric properties cause the tube to function fairly well with zero plate voltage. It is probable that the source of energy in this case is the luminous and non-luminous radiation from the incandescent filament. These tubes also make sensitive amplifiers.

# APPENDIX I*

PREPARATION OF TUBES—The potassium sodium alloy was contained in an evacuated glass tube A, in Figure 1. Two electron tubes, as shown in the figure, were connected to the *T* connection and rested in a horizontal position. Tube *B* led to the

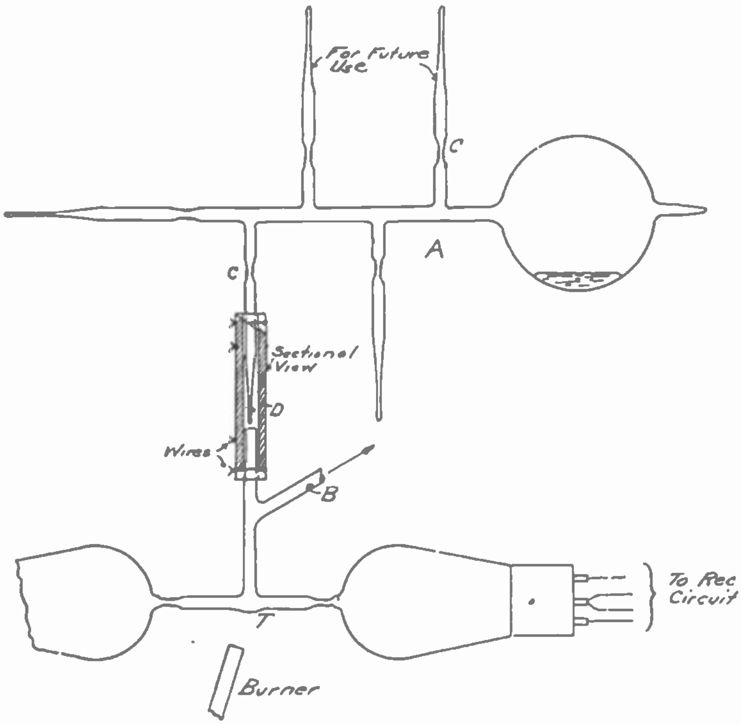


FIGURE 1

evacuating system consisting of charcoal tube immersed in liquid air, phosporous pentoxide tube, mercury trap immersed in liquid air, McLeod vacuum gauge, mercury condensation pump, and rotary supporting pump. The tube *A* had a number of branch outlets, as shown, these being drawn out so that the tips are easily broken off. Constructions were formed in these branches at *C* so that they may be sealed off. A piece of heavy gauge rubber tubing is slipped over one of the outlets and tightly wired as shown in the figure. With a good lubricant on the glass tubing where the rubber tubing is slipped on, a high vacuum was easily obtained. When the pressure was about $10^{-4}$ mm. of mercury the tip *D* (which has had a nick filed about 6 mm.

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(0.25 inch) from the end) was broken off by bending the tubing. The evacuation was then continued while the filaments were kept incandescent, 150 volts applied to the plates, and the electron tube walls and especially the constriction where the electron tubes were to be sealed off were heated. This was continued until the electron tubes, being connected to receiving circuits functioned as detectors best at about 60 to 80 volts on the plate. It should be mentioned here that this is an excellent method of determining when the tube is well outgassed.

The first step in introducing the alloy after the above process has been carried out was to tip the tube *A* until a large drop of the alloy ran down thru the vertical tube into the *T* connection. Tube *A* was then sealed off at *C*. The alloy was then carefully heated until distillation took place and a thin film of the alloy condensed on the glass walls of the electron tubes. During the distilling process the filaments were kept at a dull red heat to prevent condensation of the alloy on the electrodes or stem which supports them. The electron tube is then sealed off when the vacuum gauge reads about $4 \times 10^{-5}$ mm. of mercury. If a very thin film is deposited it will be of various colors, but as the film gets thicker it will attain a silvered appearance. Four tubes have been treated at one time by using a cross instead of a *T* connection.

Some tubes have been prepared by condensing only an extremely thin film of a purple color on a small portion of the walls. After use a short time the film disappears, but the tube still maintains the low plate voltage characteristics. However, the tubes containing sufficient alloy to make a permanent silvery coating on the glass walls have proven to be the most sensitive. A small amount of alloy has also been poured at high vacuum into a few electron tubes, which gave excellent results; but this is a difficult and wasteful process.

Another method which was used with fair success was to pour small amounts of alloy from the bulb of a tube similar to that of *A* into the tips of the branches. The branches were then broken off exposing the alloy to the air. This broken end was then fused onto a side outlet in the stem of the electron tube, and when the evacuation was complete the tip was heated so that the expanding alloy broke the white crust formed on its surface by exposure to air, and distilled over into the electron tube. This process is not recommended on account of the liability of the alloy taking fire when exposed to moist air.

It is extremely important to clean all glass tubing with "aqua regia" and distilled water so that the alloy will not stick to it. The construction at the stem or tip of the electron tube should not be less than 1.5 mm. (0.06 inch) inside diameter or the vapor will not distill thru it easily. It will usually be found necessary to distill the vapor progressively by heating gradually toward the opening of the electron tube. The constriction should be heated slowly until it is free from all condensed alloy before sealing off or the glass will crack after cooling. Too much heat will burn the alloy, giving it a dark brown color.

The potassium sodium alloy should be prepared by putting sodium and potassium into a glass tube in the proportion of 23 gms. sodium and 39 gms. potassium; then the tube should be quickly exhausted and sealed. Heat should be then applied to the sodium and potassium until it fuses and mixes. The containing tube should be provided with a connecting tube with a very small hole in the connecting neck. The fused mixture can can be poured thru this hole into the connecting tube which process filters it. This second tube should be provided with a drawn down stem and constriction so that the alloy can be transferred into the containing tube *A* of Figure 1 by a process similar to the transfer of alloy into the *T* connection as described.

# THERMIONIC TUBES*

By

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Quite a number of years ago, Mr. Edison brought before us an experimental lamp novelty consisting of a glass bulb containing a filament and a plate with the air exhausted. Later it was applied in a new art—now known as radio. Quite recently a third element was added, which was called a grid. Since that time there have been great strides made in this country and abroad by scientists and engineers in developing this device from a toy to a powerful instrument for uses in high power circuits.

The earlier tubes were first used as detectors and later as amplifiers, until it was found that they could be used as oscillation generators and power amplifiers. The life of these old tubes was very short, owing to the presence of gas which in time destroyed the cathode. Since that time some difficult problems have been solved in the development of these tubes.

The first one which will be taken up is the production of high vacuum within these tubes and the effect it has on their operation. Methods for production of low pressures have been devised by several people and excellent results have been obtained. I do not intend to dwell on any definite method of producing an extremely low pressure, but what I am trying to bring forward is that even if we have exhaust means for producing pressures as low as $10^{-7}$ bars or lower, we are still confronted with the space pressure surrounding the elements within the tube while under operation. Very little information is available concerning this point. If we exhaust a tube by baking the vessel at a temperature close to the collapsing point of glass, and then measure the pressure, we find that we have produced a vacuum as low as it is possible to obtain. We next heat up the metals within the vessel. These give off gas, thus changing the pressure. We repeat this continually by raising the plate temperature, either by radio frequency,

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induction, or bombardment. The induction method I will take up later on, but the bombardment method I will describe here.

We first heat the filament—apply a positive potential on the plate and alternating potential on the grid. We will notice that there is considerable ionization present. If the vessel is of glass it is best to keep it extremely hot. I wish to emphasize that this is a method for producing tubes without the use of a "getter." By "getters" we mean the substances such as phosphorus, arsenic, sulphur, and so on. These substances, when applied to the metals and volatilized by heating them, trap the gases. They are then deposited on the walls of the tube as a film. Whether the presence of this gas containing film is reliable when working high temperature tubes is questionable. We are building tubes of extremely high capacities and it is quite obvious that we have to get rid of all the gas possible and not have the vessel contain any film holding gases.

Many interesting phenomena are observed with slight residual gasses always present even in the hardest of tubes. After running for some time with an electron current to the plate at a fixed voltage, a steady value for the pressure may be reached. If the voltage is increased, but not sufficiently to overheat the plate, the tube will harden. If the filament alone is simply heated and no potential applied to the plate, we find that the residual gas has increased. When a filament is heated and no potential applied to the plate, the tube pressure would be equally distributed thruout the vessel, except for a minute space surrounding the filament. If we apply a potential to the plate we produce a field surrounding the filament created by the electron emission. This field has a much lower gas pressure than the remaining portion of the vessel. This leads to the conclusion that these effects are due to ionized gas. At these voltages the ions are positive and their observed disappearance must be due to the fact that they are driven into the walls of the vessel. Some suggestions have been made that they are driven into the filament, but how can they be if they must be retained with the filament at 2,000°C.? So it seems advisable to give up the theory that they return to the filament.

Much data have been supplied by different investigators of the clean-up of gases, and from conclusions drawn it seems that high temperature devices clean up much more readily. For instance, take the clean-up of the tube containing a coated cathode. An experiment with this type has been made wherein the whole tube was immersed in liquid air. The electron current was maintained constant. Clean-up was slow, probably owing to the slow saturation of the walls of the tube with the gas. To facilitate a more rapid clean-up, I have placed a tungsten filament within a tube of this character, shielding the coated filament by the grid support so as to prevent the high temperature from affecting the coating on the filament. In this case liquid air was not used, letting the walls of the vessel heat up so that the gases would penetrate at this temperature. When the tube was sealed off from the exhausting means, the glass contained the gas trapped at this high temperature. I found the rate of clean-up was about the same as for a tungsten filament tube. Further, a coated filament tube which would previously work at 2,000 volts, would function properly at several thousand volts higher.

A conclusion can be drawn that coated filament using the bombardment means and other low temperature means of clean-up places them in a low voltage condition. I have not indicated any particular gas or pressure in these experiments, but merely have expressed a method which may be used, because of confusion which may arise and elaborate descriptive matter which would be required thoroly to identify any particular gas.

To produce tubes of the highest possible quality, we first have to consider what type of a tube we wish to construct. If it is a tube for receiving purposes it naturally will be of small dimensions. In case of building a tube of small dimensions we would choose for its container ordinary soft glass. The metals have to be of such a nature that under normal working conditions they will not heat themselves or the glass to such a temperature as to spoil the operation. The operating voltage must also be considered. If we take an ordinary receiving tube and apply a certain plate potential and no grid bias, we would normally consider a tube good which showed less than a micro-ampere negative grid current. Let us consider a tube of this type with its filament grid and plate, such as the Westinghouse coated filament W.D.-11 described below. We find that there is still a slight presence of gas in this tube which cannot be measured on a microammeter. This being the case, we use in this tube a filament with the least possible watts, so as not to heat the space surrounding this filament, and also use a plate potential that will not disturb the extremely small amount of gas present. To make a comparison, I will illustrate a tube such as the Westinghouse W.T-22 (see description below), which has a greater spacing between its elements. It also has a higher filament watt consumption and a higher plate potential. A tube with such space relations can be used as a power amplifier while having as much as half a micro-ampere negative grid current and yet has a straight characteristic curve. Consider the development of still larger tubes, such as power tubes,—for instance, the Westinghouse W.T-24. Its normal rating is 250 watts. That is, it will consume 500 watts on the plate working at 50 percent efficiency. It will supply 250 watts oscillating energy or 250 watts modulated energy with a certain grid bias. Consider tubes of this character under working conditions,—two used as oscillators and three as modulators, using the constant current system of modulation. We find that under best conditions the modulator tube power consumption should be the same as the oscillators, and the dynamic characteristic of these modulators should be such that the grids will not go positive when 80 percent or 90 percent modulation is desired. Great care must be taken in the design of such a tube. It must be a power-wasting device and still have good control.

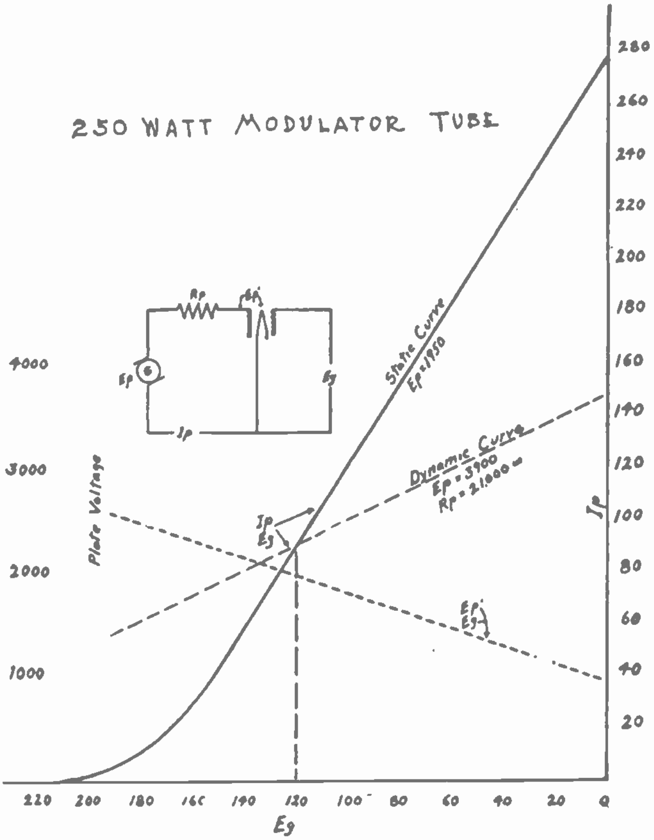


FIGURE 1

There is one feature which must be especially cared for. That is the presence of gas. It must permit a current value in the neighborhood of not over 10 micro-amperes in the grid circuit. This may seem extremely low in comparison to some tubes which are being produced, but, nevertheless, the grid current is one of the greatest factors in giving good modulation. If you do not have an extremely low grid current, the modulator will oscillate at a radio frequency and will not parallel. Take three tubes all having the same characteristics. We place the tubes in a circuit at 2,000 volt plate potential, 125 volts grid bias, and find that we get 150 milliamperes plate current thru each. When we start to modulate at a certain frequency, the tubes will "shoot over" or start oscillating at an extremely high frequency, due to some disturbance. This action is further increased by adding more modulator tubes. To overcome this difficulty, when other tubes are not available, high frequency choke coils may be added in the plate circuit of each tube.

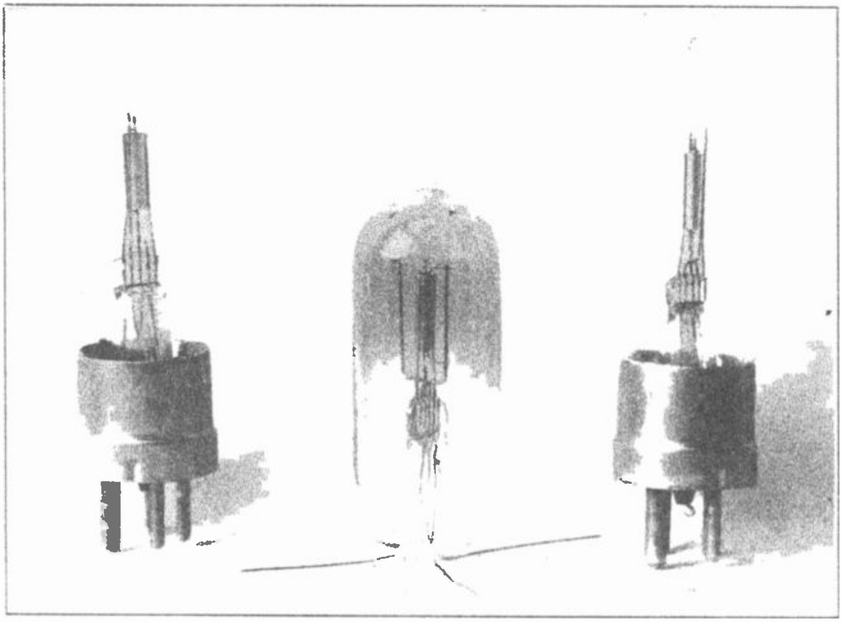


FIGURE 2

We have mentioned several tubes manufactured by the Westinghouse Company. It seems appropriate to give a description of their constructions and characteristics. The W.D-11 is a high vacuum tube which is used as a detector or amplifier, either audio or radio frequency. It has a particular application in the Radiola Senior and another in the Radiola Grand, both manufactured by the Westinghouse Company. In this latter application one tube is used as a detector, three others as amplifiers at audio frequency. The detector is used at 22.5 volt plate. The amplifiers are operated at 45 to 65 volts. The filament consumption on these tubes is about 0.25 ampere at one volt, and suitable for operation on a single dry cell or on two Edison Leland primary cells (as in the Radiola Grand). The tube requires no grid bias. This tube is made as follows: The container is a soft glass bulb, sealed in a special four prong base, which makes it non-interchangeable with other types of tubes. A nickel plate 0.005 inch (0.013 cm.) thick is made into a cylinder ⅛ inch (0.32 cm.) diameter and ⅝ inch (1.6 cm.) long. The grid is a cylindrical helix 1/16 inch (0.16) cm.) diameter made of 0.014 inch (0.036 cm.) nickel wire. The filament is a platinum iridium strip 0.00025 inch (0.00064 cm.) by 0.005 inch (0.013 cm.) and ⅝ inch (1.6 cm.) long, coated by a special process with a barium and strontium oxide. This fila-

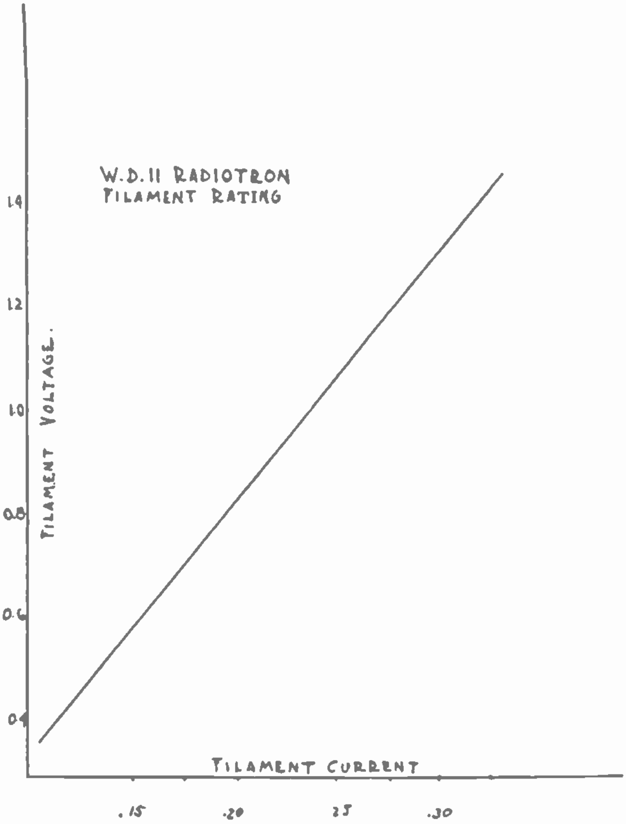


FIGURE 3

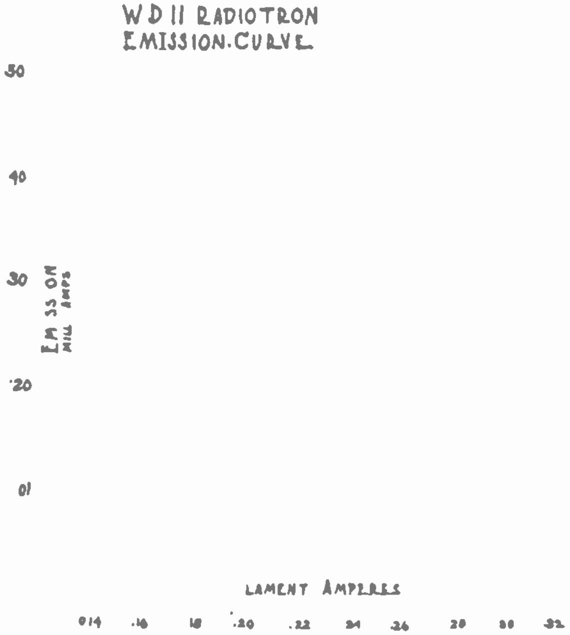


FIGURE 4

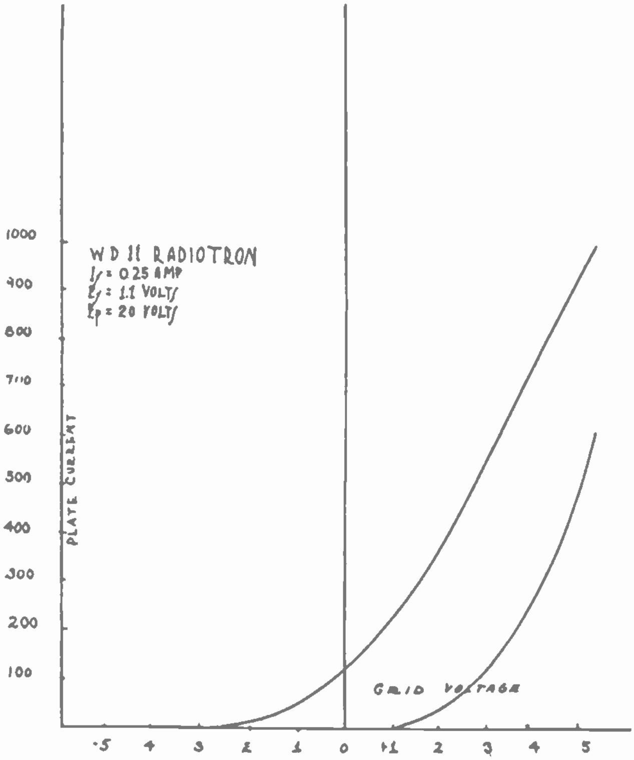


FIGURE 5

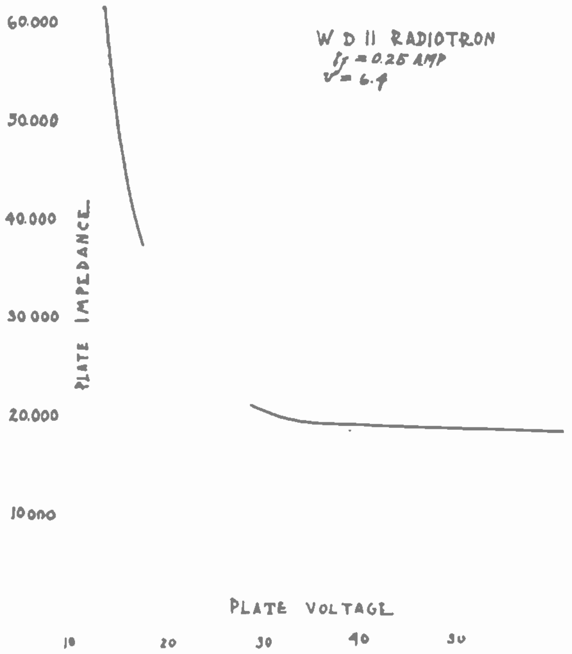


FIGURE 6

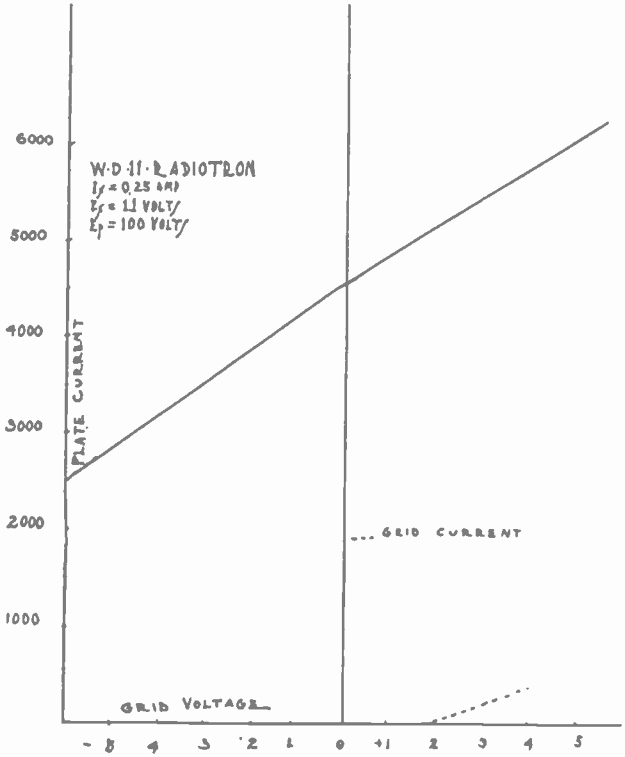


FIGURE 7

ment is held under tension by a spring. All parts are supported from a single press on nickel wire. The tubes are evacuated by a specially timed process. Induction beating is used to secure the complete removal of gasses without injury to the delicate coated filament.

The tubes are tested for grid current and filament potential. In addition, an amplification test determines by actual measurement the amount of audio frequency energy obtainable for certain grid excitation.

The tube called W.T.-22 is a 5-watt power tube used as an amplifier or an oscillator in small sets. It can be operated at 7 volts on the filament drawing about 1.25 amperes. The plate will operate on voltages from 100 to 500. The plate current is from 10 to 50 milliamperes.

This tube is placed in a soft glass container slightly larger than W.D-11 and mounted in a standard Navy type base.

The plate is 0.005 inch (0.013 cm.) molybdenum built into a rectangular box like shape, ⅞ inch (2.23 cm.) long and ¾ inch (1.9 cm.) by ¼ inch (0.64 cm.) wide. It is held on nickel supports.

A helical grid is made of molybdenum wire welded to molybdenum supports, and conforms to the shape of the plate. The filament is M-shaped and held on tungsten supports. It is made of a platinum iridium alloy coated similarly to W.D-11.

W.D-24 is a power tube used as an oscillator on a 2,000 volt direct current circuit. The filament is rated at 15 amperes at 10 volts. The plate current can go as high as 250 milliamperes.

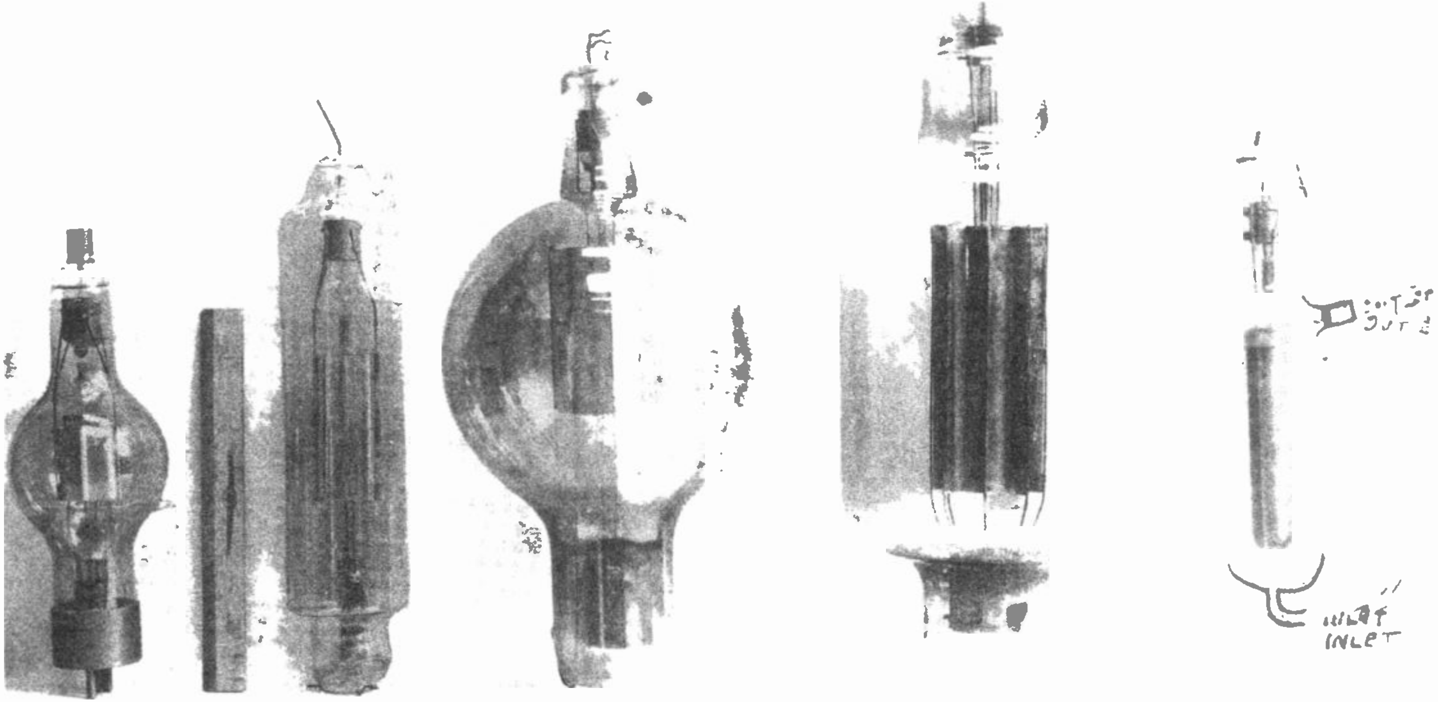
This tube is built in a hard glass container 14 inches(35.6cm.) long and 5 inches (12.8 cm.) in diameter. The grid and the filament are supported from the lower press, the plate from the upper press.

The plate is oval shaped, made of two halves joined together as two ribs. The grid conforms to this shape. The filament is V shaped and held under tension by a spring from the upper press.

Plate and grid are made of molybdenum. The filament is of tungsten. All the supports are of molybdenum. The leads are of tungsten.

W.T-25 is a modulator tube very similar to W.T-24, but with a lower plate impedance and a straight line characteristic.

The writer is also exhibiting samples of a 5 kilowatt, a 10 kilowatt, and a 25 kilowatt tube. The 5 and 10 kilowatt tubes are built in hard glass containers of suitably large size. They conform in general character to the W.T-24 except for their plate voltage, which is 10,000 to 20,000 direct current.



250 Watt Oscillator

1 Kilowatt Rectifier

5 Kilowatt Oscillator

0 Kilowatt Oscillator

25 Kilowatt Metal Tube Water Cooled

FIGURE 8

The 25 kilowatt tube has a plate sealed in the glass and forming part of the container. The glass serves only to insulate the filament and the grid leads. The plate is water cooled on the outside and is capable in this way of dissipating up to 10 kilowatt. This tube can be operated at 20,000 volts direct current with more than 2 amperes plate current.

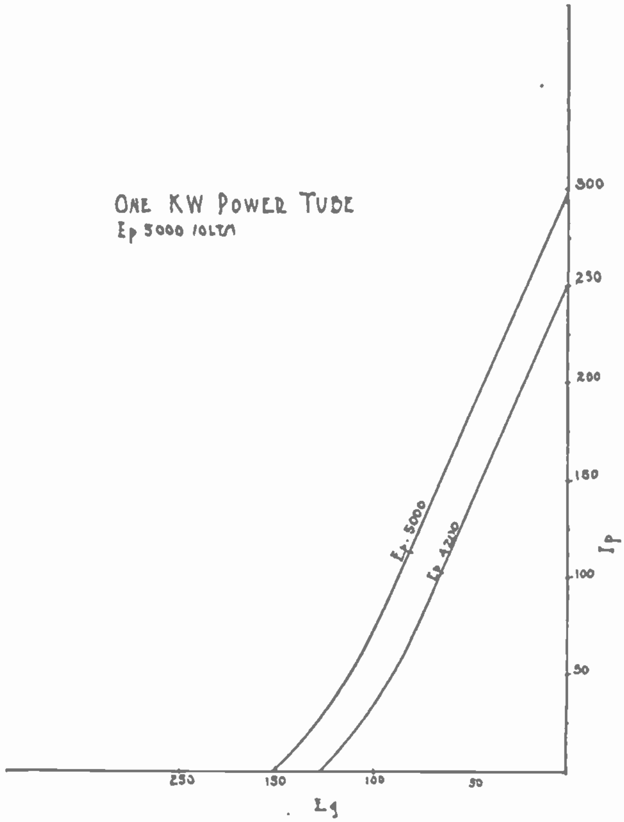


FIGURE 9

To produce tubes which have no negative grid current present is quite an interesting problem, which I believe has been quite satisfactorily solved by a method known as pre-treating of elements. The best method we have found is to heat the metals approximately up to their melting point within a vacuum furnace. In 1914 or 1915 the Western Electric Company made for their Arlington transmitter some special tubes. These tubes had a ribbon bent back upon itself, forming an oblong plate. Each end of the ribbon had a lead wire brought out. A current was passed thru this ribbon to heat and drive out the gas.

About this time the writer invented heating by high frequency.* Since then new applications have arisen. The writer will now endeavor to explain the use of this method in several applications.

Power tubes have had a number of limitations. The capacities of these tubes were limited by the size of the cathode. The energy consumed in the cathode was extremely high relative to the space energy, that is—the energy dissipated in the plate and filament circuit. This formed the limit of the capacity of the tube. These limitations made it necessary to reduce the plate current and raise the plate voltage. High voltages in power tubes are accompanied by electrostatic stresses. High frequency oscillations are liable to puncture the glass under these conditions. The limit of plate direct current voltage is about 10,000 to 20,000. It is evident that the problem of raising the capacity hinges essentially on high filament emission for certain energy input.

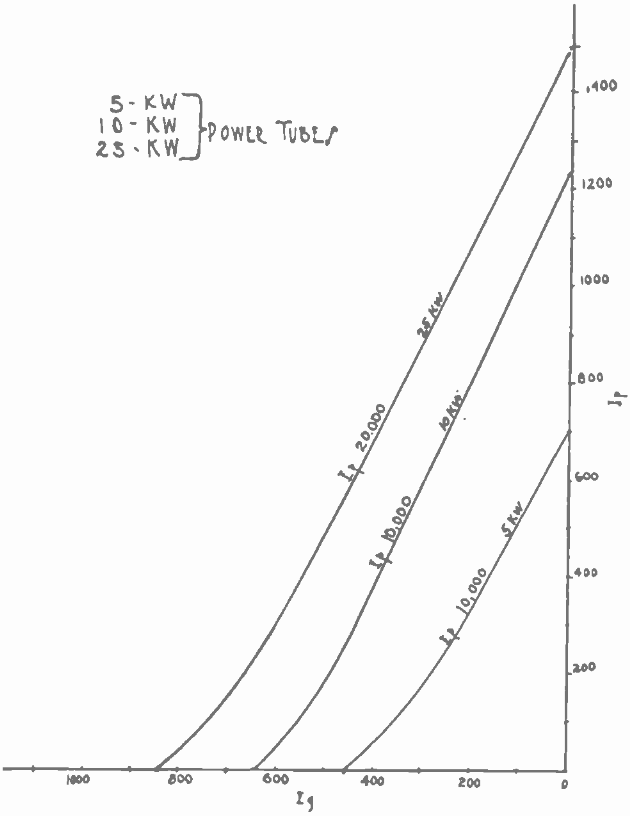


FIGURE 10

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* Patent application, serial number 128,375 of October 30, 1916.

To facilitate the electron emission the cathode may be coated with oxides. By this method it is possible to reduce considerably the watts input to cathode and get the same emission. A cathode of this nature has smaller dimensions and therefore the means of support are simpler and the lead-in wires are made smaller. Since the voltage drop thru the cathode is limited, the leads to supply the energy to tungsten cathodes are large and unwieldy. Coated cathodes require either a much smaller lead-in wire or else the same lead-in wire will permit much larger electron emission. The writer will show below how the leads can be omitted altogether. This is accomplished by heating at radio frequency. A compact cylindrical cathode possesses all the advantages and none of the disadvantages of the usual type of cathode.

It is well known that at higher temperatures the escape of occluded gases destroys the vacuum. A coated filament will keep all parts of the tube below a safe temperature, that is, a temperature which will not liberate occluded gases.

A peculiar phenomenon has been observed where the filament supports were not specially treated. It appeared that as soon as heat was applied to the filament a certain amount of gas showed in the tube. This undoubtedly came from the supports. The gas was in only very minute quantities, yet it had a secondary effect on the filament. Hot spots appeared on the plate, presumably due to corresponding high temperature points on the filament. It is conceivable that the filament would undergo a bombardment by positive ions with a consequent volatilization of metal and creation of hot spots.

The presence of volatilization in a device which has a large coated cathode area many times larger than an ordinary tungsten filament would be quite minute. As previously mentioned, the presence of gases or positive ions is indicated by a grid current. To prevent the presence of positive ions and volatilization, it is quite necessary to have the metals free from gases before enclosing them within the vessel. This is accomplished by heating them up to approximately their melting point in a vacuum furnace.

The usual methods of heating the filament have been direct or alternating current. The use of radio frequency permits a number of changes in design, simplifying the structures and increasing the rigidity of filament. In order to obtain a strong filament construction able to withstand the ionizing forces and subsequent handling, a thick rugged filament is always used in high power tubes. This means a large heating current and thick lead-in wires to carry this current. The glass surrounding thick lead-in wires is subject to severe strains, with liability to fracture. The employment of radio frequency cathode heating makes it unnecessary to carry heavy current thru the glass.

Figures 11 and 12 show two types of construction developed by the author, using radio frequency heating. In Figure 11 the coiled plate carries radio frequency current and induces by transformer action a large current in the centrally located cylindrical cathode. Figure 12 shows a separate inductor located on the outside of the tube and a cylindrical plate split in an axial direction. No lead-in wire is required in Figure 12. In Figure 11 only thin leads are necessary,—sufficient to carry current to induce heating in the cathode. By supplying a sufficient number of convolutions in the inductor the current thru the lead-in wires can be made very small.

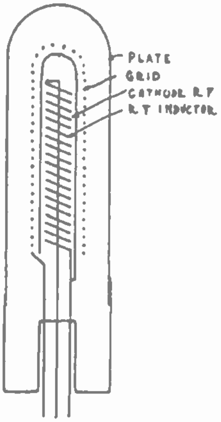


**FIGURE 11**
Interior of Inductor
Heated Cathode Tube

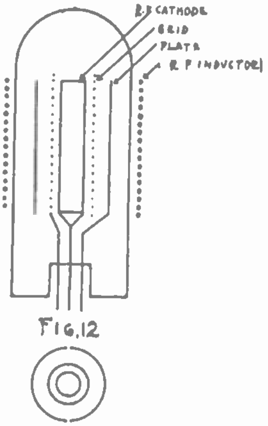


**FIGURE 12**
Plan of Exterior
Inductor Heater Tube

Figure 12 is an example of an equi-potential electrode tube. Such a tube would possess marked advantages when used as an oscillator, power amplifier, or rectifier.

In Figure 13 is shown a rectifier having a plate and a tungsten filament. In this circuit it will be seen that the electron flow is densest towards the negative side of the filament. When the contact *R* is at the point *V* on the resistance *VZ*, the galvanometer *G* will register a slight thermionic current, but the latter will be very small. As *R* moved along *VZ*, this current is rapidly increasing, partly because a greater portion of the filament is coming under the influence of the plate and partly because the attractive force, represented by the plate potential, has also been increased.

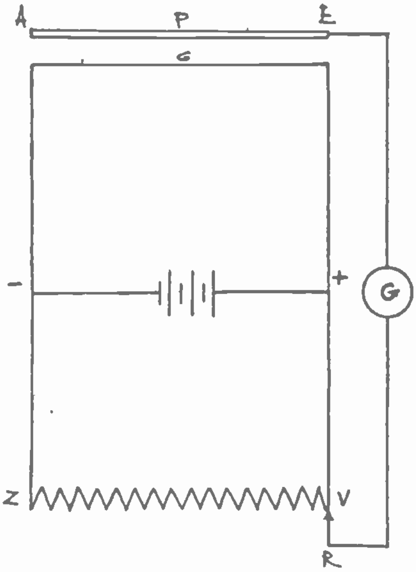


FIGURE 13

From the above consideration we see that:

(1) If an electrode within a vacuum is connected directly to the negative end of the filament, there will be no tendency for an electron flow to be established.

(2) If the electrode is connected directly to the positive end of the filament, electrons will flow from every part of the filament to it, since it is at a higher potential than the filament. Most of the electron current will come from the negative end of the filament since it is there that the potential difference between electrode and filament is greatest. The potential of the electrode will be positive and equal to the emf. across the filament.

(3) If the battery supplying the filament is shunted by a resistance which has a variable contact sliding along it, and the electrode is connected to the sliding contact, the potential of the former may be varied between zero and a positive value equal to the emf. of the battery. The electron flow to the electrode will gradually increase as the sliding contact is moved towards the positive end of the resistance.

The potential gradient along a filament is always a complication, altho practical advantage is often taken of it. It becomes a serious factor when the voltage across the filament is say 30 volts—as may be the case in a large tube. Another important effect is the variation of temperature along filaments.

Normally the temperature along a filament is uniform, except at the ends where cooling takes place. However, when there is a plate current, this current adds itself to the filament current and causes one half of the filament to be hotter than the other. This may be shown by arranging a circuit similar to the one shown in Figure 14. The plate circuit may be completed by closing a switch. Between the negative end *B* of the filament and the battery *A* is connected an ammeter $G_1$. Between *C* and *A* is another ammeter $G_2$.

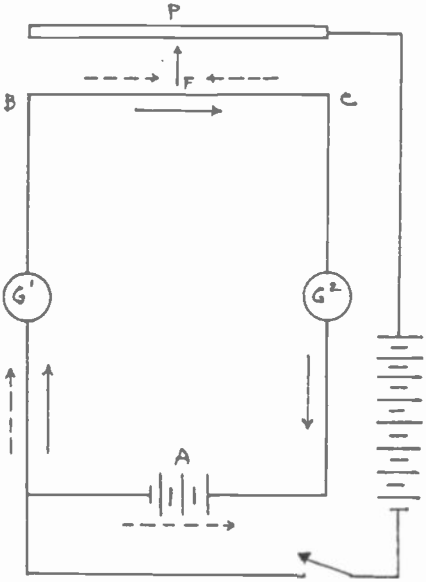


Figure 14

If we leave the switch open we will see that the filament current readings $G_1$ and $G_2$ are the same. Suppose the filament current flowing in the direction of the arrow-heads is 1 ampere as registered by both ammeters, on closing the switch it will be noticed that the reading in $G_1$ will increase above 1 ampere, while that of $G_2$ will decrease below that value.

The phenomenon is explained by the existence of an electron current in the plate circuit which flows round by *H* and the switch and divides at the connection to the filament. Part of the electron current flows via $G_1$ to the filament and thence to the plate, as shown by the dotted line arrow-heads. It therefore reinforces the filament current from the battery which is flowing in the same direction. Another portion of the thermionic current flows via *A*, $G_2$, *C*, the filament, and thence to the plate. This current opposes the existing filament current and causes a reduction in the

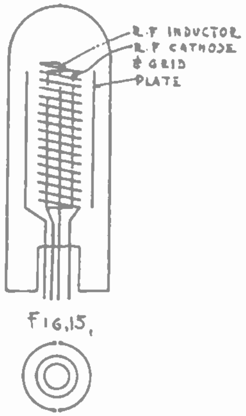


FIGURE 15
Plan of Grid Inductor Heater Tube

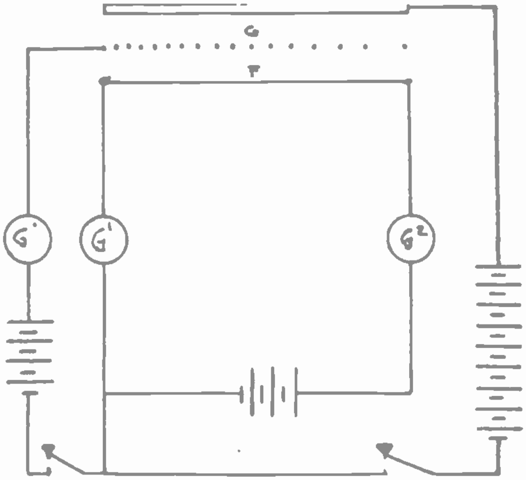
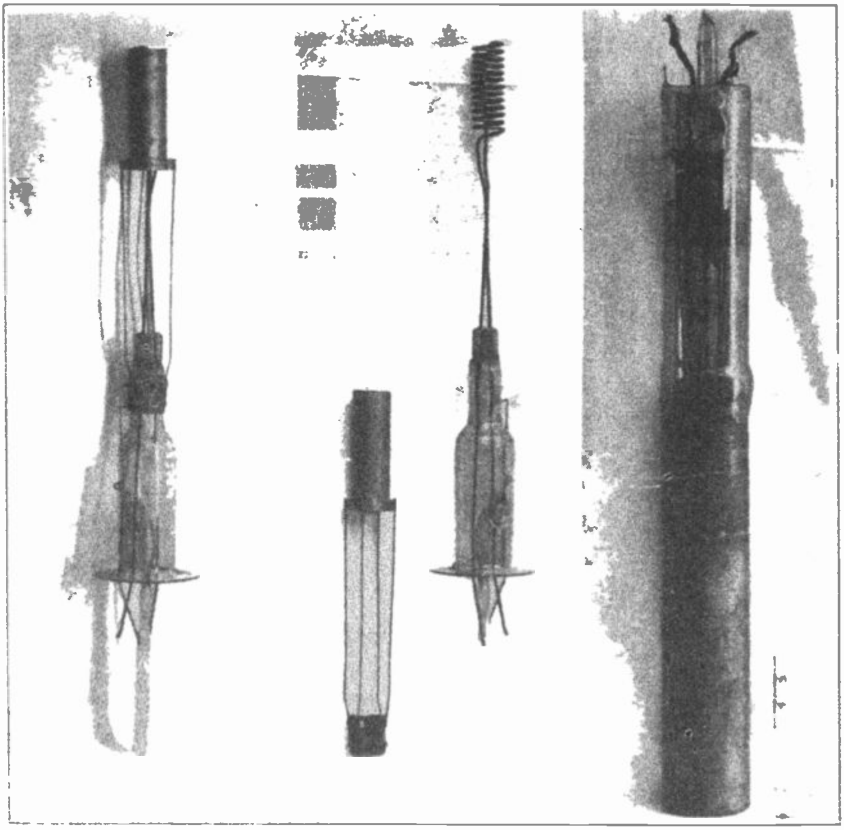


FIGURE 16
A Grid in a Tube which Has Filament Drop Should Be Spaced Accordingly



Radio Frequency Heated Cathode, Assembled

Radio Frequency Cathode

Radio Frequency Inductor

100 Kilowatt Radio Frequency Heated Cathode Tube

FIGURE 17

current passing thru $G_2$. The result is that the negative half of a filament is always hotter than the positive half, no matter to which side of the battery the negative of the plate battery may be connected. In practice this peculiar effect is of no importance except when the temperature of the filament is already near melting point and the plate current great. Under such conditions the filament is likely to burn out when the plate circuit is completed.

From the above considerations the advantages of an equipotential emitting surface are evident.

The writer has constructed and operated tubes of this description. They show the possibilities of large electron emission and one line of future progress in high power tubes.

**SUMMARY:** The general scope of the paper covers the present day commercial tube; states the methods of design; and gives the general dimensions. It later brings forth an entirely new method for obtaining electron emission and control. This new method of heating provides means for heating sheets or discs of tungsten or other high temperature metals to incandescence, which sheets or discs are enclosed in evacuated vessels or ones containing gas.

The tubes in which the grids are made the inductor to heat the cathode provide a radio frequency method for shutting off the current twice per cycle, and gives a double frequency in the output circuit. By these new methods set forth in the paper, it is evident that the tube engineering art will be greatly benefited.

# DIGEST OF UNITED STATES PATENTS RELATING TO RADIO TELEGRAPHY AND TELEPHONY*

ISSUED AUGUST 29, 1922-OCTOBER 24, 1922

By

JOHN B. BRADY

(PATENT LAWYER, OURAY BUILDING, WASHINGTON, D. C.)

1,427,350—J. Bethenod, filed September 2, 1919, issued August 29, 1922.

RADIO TELEGRAPHIC COUPLING for use with a radio frequency alternator wherein the armature winding is divided in the several sections, each of the sections being connected directly to a primary winding of separate transformers, and the secondary windings of each of the transformers connected with an antenna ground system. The central point of each section of the alternator and the central point of each primary winding is grounded.

1,427,832—F. S. McCullough, filed July 7. 1919, issued September 5, 1922. Assigned to Glenn L. Martin.

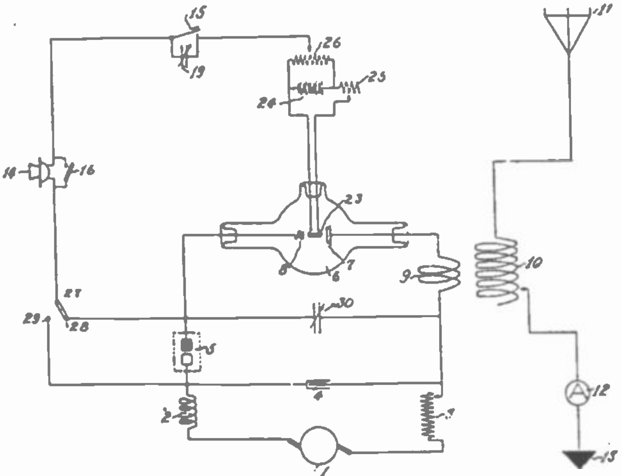


FIG. 3.

NUMBER 1,427,832—Radio Telephony

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*Received by the Editor, November 3, 1922.

Radio Telephony. This patent shows an adaptation of an arc generator as a source of oscillations for a radio telephone transmitter. The invention includes a high frequency spark gap placed in series with the arc to serve as a stabilizer, filter, buffer, or equalizer for the irregular oscillations inherent with the arc generator. The high frequency spark gap comprises a tube containing an inert gas, an anode and a cathode between which the stabilizing arc is formed, and a control member in the form of a third electrode between the spark gap electrodes which is connected in circuit with a microphone or other form of modulator. The oscillation circuit is inductively coupled with an antenna ground system.

1,427,833—F. S. McCullough, filed August 2, 1919, issued September 5, 1922. Assigned to Glenn L. Martin.

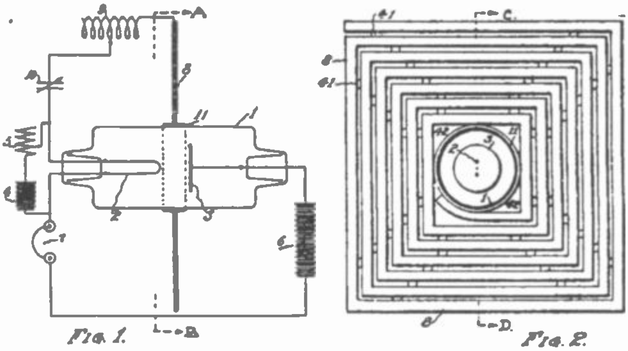


Fig. 1. Fig. 2.

Number 1,427,833—Radio Telegraphy

Radio Telegraphy. This invention relates to a construction of directional radio receiving apparatus. The receiver includes a vacuum tube containing a filament and a plate with a flat spiral coil surrounding the tube exteriorly and having its plane perpendicular to the axis of the tube. The flat coil serves as a collector of the transmitted energy and has the characteristies of a loop in the sense that it is aligned with the distant transmitting station with the axis of the tube perpendicular to the line joining the transmitting and receiving stations. The collector is mounted upon a ring or band fitting on the vacuum tube positioned intermediately of the electrodes within the tube. A tuned circuit is connected with the coil collector and the telephone receivers placed in the circuits including the electrodes within the tube.

1,428,156—L. Espenschied, filed September 26, 1919, issued

September 5, 1922. Assigned to American Telephone and Telegraph Company.

LOW-FREQUENCY AMPLIFIER illustrated in connection with a line wire system comprising a plurality of tubes successively arranged in balanced relation with a modulating device connected to the incoming circuit and the amplifier connected in the output circuit of the modulating device. A de-modulating device has its input circuit connected to the output circuit of the amplifier and the output circuit of the de-modulator connected to the line. A source of alternating current of a frequency suitable for amplification by the amplifier circuit is connected to the input circuit of the modulating device and the output circuit of the demodulating device.

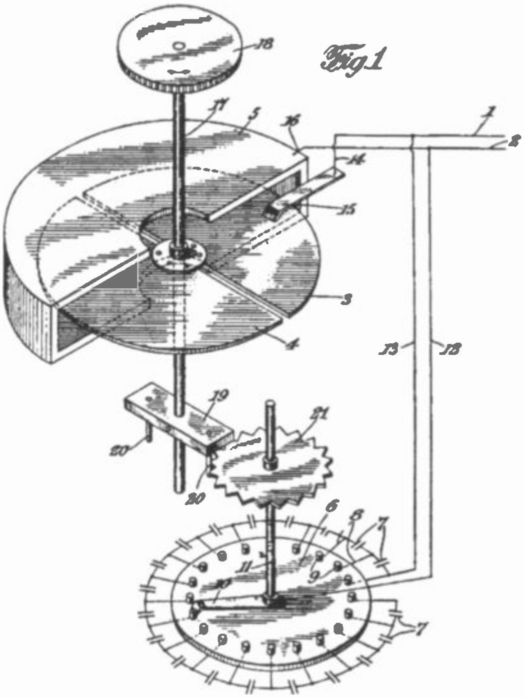
1,428,507—E. A. Sperry, filed March 12, 1920, issued September 5, 1922.

RADIO REPEATER SYSTEM. This invention relates to a system for automatically transmitting the readings of an indicator, such as a compass, a fire control instrument on board a ship, or other form of dial indicator, and reproducing the readings at a distant receiver. The transmitter circuit and receiver circuit are arranged so that a step by step mechanism at the transmitter controls the movement of a step by step mechanism at the receiver. The transmission of impulses at one frequency may move the step by step indicator in one direction at the receiver while the transmission of impulses of a different frequency may move the indicator step by step in the opposite direction, thereby controlling a dial at the receiver in accordance with the movement of the dial at the transmitter.

1,428,856—L. O. Parker, filed May 13, 1918, issued September 12, 1922. Assigned to Westinghouse Electric and Manufacturing Company.

SPARK GAP APPARATUS. This invention is directed to the construction of a rotary spark gap wherein the rotor comprises a toothed disk co-operating with a stationary electrode, the stationary electrode being mounted circumferentially adjustable and radially adjustable with relation to the rotary electrodes.

1,429,227—W. Dubilier, filed September 28, 1921, issued Septem ber 19, 1922. Assigned to Dubilier Condenser and Radio Corporation.

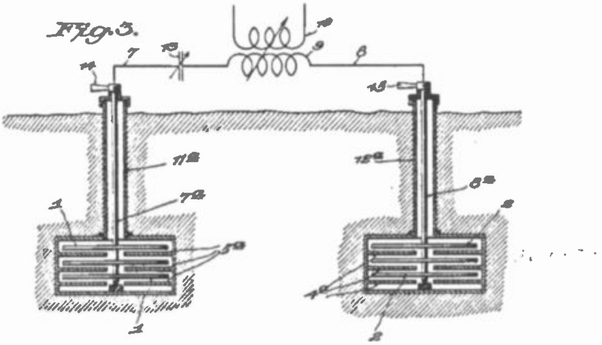


Number 1,429,227—Variable Condenser

Variable Condenser, comprising a plurality of fixed condensers arranged with intermediate connections to a set of contacts, and a variable condenser having a control for changing the position of the variable plates simultaneously with the cutting in of a predetermined number of the fixed capacities. The variable condenser is made in two parts having semi-circular plates arranged to be shifted in such manner that just prior to the time when the fixed condenser is shifted from one value to the adjacent value one of the parts of the variable condenser may be shifted to approach maximum capacity value and the other of its parts shifted to main capacity value, and at the instant the fixed condenser is adjusted, the part of the variable condenser which is at maximum is cut out of the circuit and the part which is of minimum capacity value is substituted in circuit therefor.

1,429,240—E. C. Hanson and E. T. Jones, filed February 24, 1920, issued September 19, 1922.

Radio Signaling System, utilizing an underground antenna system having concentrated capacity areas buried in the earth and connected to the radio signaling apparatus. The capacity areas are constructed so that their mutual capacity areas resemble in principle the usual variable condenser in that the stationary metallic plates are formed in a casing buried in the earth and rotary plates arranged to be intermeshed with the stationary plates. The rotary plates are secured upon a shaft which may be revolved from the surafce of the earth under control of an operator. The object of the invention is to secure a concentrated capacity area giving the same effective capacity as a long buried underground wire and at the same time provide a means for securing an equivalent optimum wire length by adjusting the position of the rotary plates.



Number 1,429,240—Radio Signaling System

1,429,497—R. A. Fessenden, filed June 6, 1917, issued September 19, 1922. Assigned to Submarine Signal Company.

Method and Apparatus for Detecting, Measuring and Utilizing Low Frequency Impulses existing in a circuit with high frequency impulses which consists in passing the low frequency impulses together with the undesired high frequency impulses thru an amplifier, the amplification constant of which is the function of the ratio of the frequency in the amplified circuit to the frequency of the current to be amplified, and employing as the frequency of the amplified circuit a frequency of the order of one thousand per second, whereby said low frequency comparatively inaudible impulses are highly magnified and rendered audible, while said undesired high frequency impulses are substantially weeded out.

1,429,634—C. Robinson and R. M. Chamney, filed November 18, 1919, issued September 19, 1922.

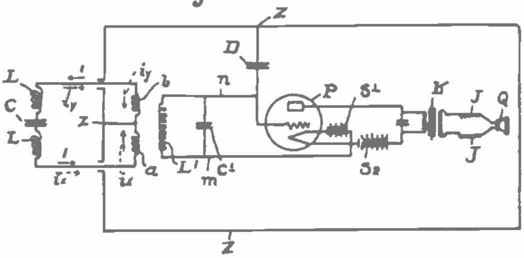
Telephonic Repeater, including a three-parallel core magnetic structure with line windings on two of the cores and a booster winding in two equal halves in series to assist one another on the same cores connected with the output circuit of an electron tube. A winding on the other core is connected in the grid circuit, the complete assembly serving as a current amplifier.

1,429,858—E. C. Fasoldt, filed April 7, 1922, issued September 19, 1922. Assigned two-thirds to Louis R. Krug.

Rheostat for securing fine adjustment in values of resistance for such purposes as heating filaments. The resistance is spirally wound and the contact element may be turned axially to reach any point on the turns of the coil.

1,429,572—Henri Jean Joseph Marie de Regnauld de Bellescize, filed August 14, 1918, issued September 19, 1922.

Fig. 3.



Number 1,429,572—Circuit Receiver

Circuit Receiver. This invention has relation to the balancing of the dissymmetries existing in the usual coupling in a radio receiver. The patent points out the disadvantages of dissymmetries at a receiver, that is, the impossibility of sharp tuning for one predetermined transmission and the impossible elimination of very powerful waves of a different length from that of the waves which are to be received. The disadvantage of the undesired oscillations at the receiver is also discussed. The responsiveness to strays and atmospherics is another drawback largely accountable to dissymmetry in the circuits. In this invention the connections between the condenser $C'$ and the ground are rendered symmetrical, and the two parasitic actions existing between primary $L\ C$ and secondary $L'\ C'$ are nullified by circuit connections shown, thereby securing the desired symmetry of circuits.

1,430,256—E. S. Pridham and P. L. Jensen, filed August 21, 1917, issued September 26, 1922. Assigned to Commercial Wireless and Development Company.

METHOD OF AND APPARATUS FOR TELEPHONICALLY TRANSMITTING SPEECH, in an environment of extraneous noises such as air craft radio telephone transmission. The method claimed consists in balancing the noise in the transmitter to maintain a static condition of the telephone circuit normally and to direct speech into the transmitter in such manner that it is unopposed.

1,430,257—E. S. Pridham, filed May 7, 1918, issued September 26, 1922. Assigned to The Magnavox Company.

TELEPHONE TRANSMITTER, constructed with a perforated casing surrounding the variable resistance transmitter element whereby free access of sound vibrations is permitted to both sides of the diafram.

1,430,258—E. S. Pridham, filed December 26, 1918, issued September 26, 1922. Assigned to The Magnavox Company.

TELEPHONE TRANSMITTER, arranged for balancing out extraneous sounds. A transmitter button is connected by an arm with a diafram so that sounds have access to both sides of the diafram and sounds that have access to but one side of the diafram produce their full effect on the transmitter button.

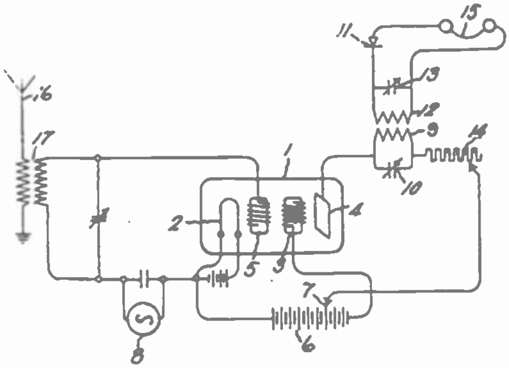
1,430,607—W. C. White, filed October 31, 1917, issued October 3, 1922. Assigned to General Electric Company.

CONSTANT RESISTANCE ELECTRON DISCHARGE DEVICE. This patent is directed to a circuit of an electron tube whereby the tube has a constant resistance characteristic. Normally, the current which will flow thru an electron discharge device comprising an incandescent cathode and an anode enclosed in a highly evacuated envelope will, between certain limits, vary approximately as the 3/2 power of the applied voltage. In other words, the apparent resistance of such a device varies with the voltage applied to it. In some cases this characteristic is objectionable, as, for example, when such a device is included in a measuring circuit which comprises other resistance. In such a case the relation between current and voltage in the circuit will be a complex one and a calibration will be necessary to determine this relation. The present invention overcomes this disadvantage by constructing and arranging an electron discharge device in such a way that the current therethru will vary directly as the applied voltage between certain well defined limits. A definite positive potential is impressed upon the grid of the tube which may be in the form of a separate battery or by connection of the grid with the positive end of the cathode. With this connection the apparent resistance between the filament and plate is constant over a definite working range of potential existing from a positive potential to a potential near the saturation potential.

1,430,808—Ray S. Hoyt, filed November 29, 1918, issued October 3, 1922. Assigned to American Telephone and Telegraph Company.

TWO-WAY IMPEDANCE EQUALIZER FOR TRANSFORMERS, the equalizing impedance elements being so proportioned with reference to the external impedances and the self-inductances of the windings of the transformer, that if either external impedance be disconnected, the impedance of the remainder of the system will be substantially equal, over a considerable range of frequencies, to that of the disconnected external impedance.

1,430,883—B. Bradbury, filed March 23, 1921, issued October 3, 1922. Assigned to General Electric Company.



NUMBER 1,430,883—Signal Receiving System

SIGNAL RECEIVING SYSTEM. This patent shows a new form of continuous wave receiver having an electron tube connected in a tuned receiving circuit functioning as a radio frequency amplifier, and a detector circuit inductively associated with the output circuit of the amplifier and tuned to the frequency of the incoming signals. The novelty of the receiver resides in the supplying of a continuous audio frequency current in the tuned circuit associated with the radio frequency amplifier. Normally, there is no appreciable flow of audio frequency in the detector circuit, but upon the receipt of a radio frequency signaling current, the source of audio frequency energy at the receiver modulates the incoming energy and the modulated radio frequency signaling current is transmitted to the detector circuit where it is rectified, and the rectified current used to produce the desired audible response.

1,430,902—John Hays Hammond, Jr., filed May 10, 1918, renewed February 20, 1922, issued October 3, 1922.

LIGHT-SIGNAL SYSTEM, wherein lights may be carried by a mobile body such as a ship and a local circuit controlled to light the lamps upon receipt of sound waves.

1,431,219—George Crisson, filed May 20, 1919, issued October 10, 1922. Assigned to American Telephone and Telegraph Company.

ELECTRON TUBE REPEATER, with circuit connections for preventing interference between the individual tubes. The filaments of all of the tubes are connected in series in the heating circuit and connections are provided to prevent the flow of the variable component of the plate current of each tube in parts of the filament heating circuit other than the filament of each tube.

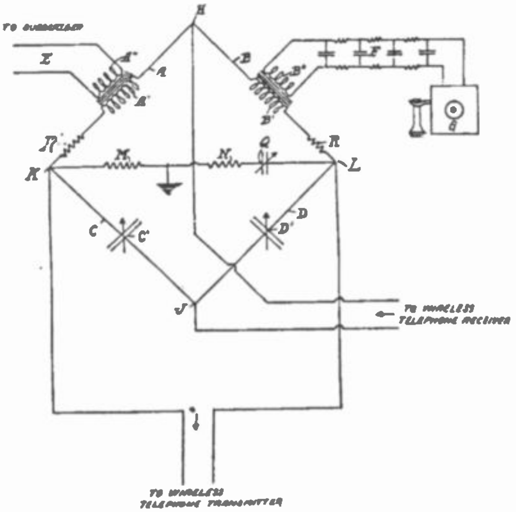
1,431,393—A. L. Golden, filed May 16, 1917, renewed August 9, 1922, issued October 10, 1922. Assigned to National Radio Company.

OSCILLATOR, comprising a spark gap construction for an oscillation circuit adapted for use with either radio telegraphy or telephony where smooth uniform radio frequency oscillations are required. The spark passes between the surfaces of two electrodes secured in a vertical position and submerged in distilled water. One of the electrodes is screw-threaded to permit micrometer adjustment of the distance between the electrodes which seldom exceeds three-thousandths of an inch (0.008 cm.) in this particular construction. The distilled water in which the electrodes are submerged is cooled by the circulation of cold water thru a coil submerged in the chamber surrounding the spark gap. The oscillation circuit is associated with the spark gap and a supply circuit connected therewith and an antenna radiating system linked with the oscillating circuit, the modulator being suitably associated with the antenna system.

1,432,022—R. A. Heising, filed October 11, 1916, issued October 17, 1922. Assigned to Western Electric Company, Incorporated.

Circuit Connection on Electron Discharge Apparatus. This invention makes use of alternating current for heating the filaments of the electron tube used in a radio transmitter wherein the variations of potential differences between the grid and filament or the plate and filament are corrected to secure results approximating those obtained with direct current filament supply. In the circuits of this invention the alternating current is supplied from the secondary of a transformer and the connections from the anode and grid to the cathode are made to some point in the filament circuit which has a potential equal to the average potential of the filament, which in general is that of the middle point of the filament. When the connections are made in this way, the average voltage or difference of potential at any instance between different portions of the cathode and the grid and the anode due to the heating current will be zero.

1,432,354—W. H. Nottage, filed March 30, 1921, issued October 17, 1922. Assigned to Radio Corporation of America.



Number 1,432,354—Radio Signaling Apparatus

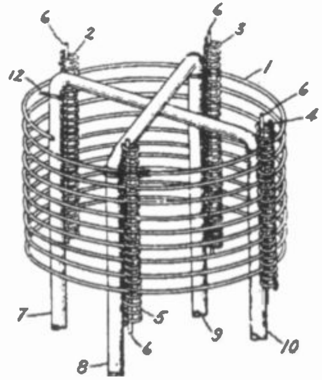
Radio Signaling Apparatus. The invention covered by this patent relates to a Wheatstone bridge circuit arranged for transferring connections from a line wire system to a radio system for transmission of signals coming in over a land line by radio and for transfer of signals received by radio to a telephone land line. In the Wheatstone bridge circuit a transformer winding is arranged in each of two adjacent arms. The secondary of these transformers may lead to land telephone lines which branch out to subscribers. The radio receiver is connected to two opposite junctions of the bridge and the radio transmitter is connected to the two other junctions of the bridge. With this arrangement signals coming in on the radio receiver will not affect the radio transmitter but will affect the land line so that they can be heard over that land line. Signals transmitted over the land line will not affect the radio receiver but will affect the radio transmitter by which they will be transmitted, because the latter is responsive to audible frequencies and the former is only affected by radio frequencies from the antenna.

1,432,384—W. W. Conners, filed June 12, 1919, issued October 17, 1922.

METHOD AND APPARATUS FOR INDICATING THE GEOGRAPHICAL LOCATION OR MOVEMENT OF BODIES. This patent shows an apparatus by which the movement of a tracing arm at a radio transmitting station produces a corresponding movement of an indicating arm upon a chart at a receiving station. For transmitting the geographical location of any point, the following principle is employed: A tracing arm is provided and arranged to move a switch arm over a set of contacts in such manner that a directive wave is propagated and rotatingly directed over a predetermined arc, starting a uniformly radiating wave at the beginning of the movement over the first wave over the arc, stopping the second wave at the conclusion of the movement of the first wave over the arc, receiving the second wave at the receiving station during its period of transmission, and noting the interval elapsing between the starting and stopping of the second wave in graduated units, receiving the first wave at the receiving station at the instance of its passage across the receiving station and noting the interval elapsing between the starting of the second wave and the passage of the first in the aforementioned units, reducing the ratio between the predetermined arc and the arc covered by the first wave to the instant of its reception at the receiving station from said intervals and thereby determining the angle between the beginning of the predetermined arc and the straight line passing thru the two stations.

1,432,411—J. H. Payne, Jr., filed April 21, 1921, issued October 17, 1922. Assigned to General Electric Company.

Fig. 2.



Number 1,432,411—Electrode

Electrode. This patent is directed to a rigid construction for a helical grid electrode for an electron tube. The electrode comprises a helix of relatively large diameter, the terms of which are supported at four points about the periphery of the helix by helices of comparatively small diameter mounted in a vertical position. The turns of the helix grid are interposed between every adjacent pair of turns of the small helices and a rod extends longitudinally thru each of the small helices locking the turns of the helix grid into position.

1,432,438—J. Bethenod, filed February 16, 1922, issued October 17, 1922.

Radio Telegraphic Coupling. This invention is directed to a coupling for transferring the radio frequency energy generated by an alternator to an antenna-ground system. The alternator of this invention has an armature winding divided into several sections not comprising any direct electric connection between them. A plurality of transformers each magnetically independent of the other have their primary windings inserted in series in a circuit alternately with the sections of the armature windings and the secondary windings of the transformers connected to the transmitting antenna and ground system.

1,432,455—Alfred N. Goldsmith, filed July 28, 1919, issued October 17, 1922. Assigned to Radio Corporation of America.

Method and Apparatus for Receiving Sustained Wave Signals, without producing the beats at the receiver. The incoming sustained wave energy is modulated periodically or intermittently at a rate capable of producing an audio frequency cycle and an audible tone in the receiver. This modulation is effective by intermittently shielding the secondary from the primary coils acting as a transformer in the receiving circuits at a rate capable of modulating the incoming energy at an audible frequency, thereby varying the coupling and producing an audio frequency in the receiver. The apparatus may comprise a rotatable disk having a plurality of conducting projections movable thru the mutual field of the coils at a frequency corresponding to that of an audible tone.

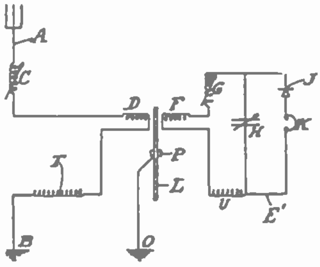
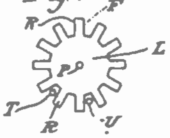
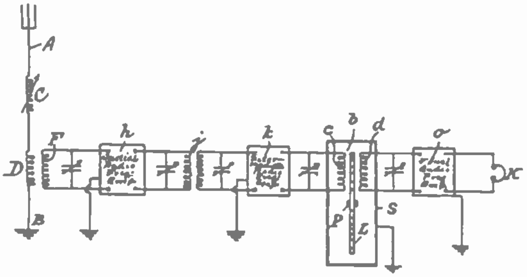


Fig. 6.

Fig. 7

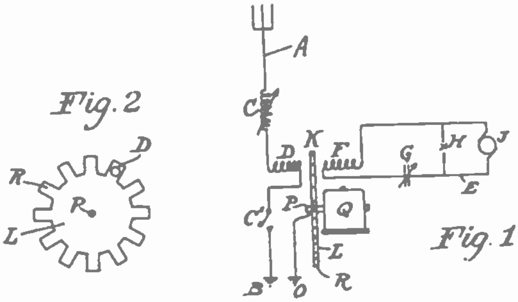




Number 1,432,455—Method and Apparatus for Receiving Sustained Wave Signals

1,432,456—Alfred N. Goldsmith, filed July 29, 1919, issued October 17, 1922. Assigned to Radio Corporation of America.

Method and Apparatus for Transmitting Sustained Wave Signals, or tone transmission from a sustained wave generator. Sustained wave transmitters produce signals of constant amplitude radio frequency current, which signals are inaudible, or practically so, in a receiving system having the usual rectifying detector. This invention finds its application where it is desired to radiate a signal wave of such character that it is possible of reception and detection in the usual detector of a receiving set; for example, in a sustained wave transmitter on ship board, it may be desirable to transmit distress signals on a signal wave of a character to be received by the usual rectifying detector and not only by those receivers equipped for heterodyne or beat reception. The sustained wave radiation of an arc, alternator, oscillating electron tube, or other sustained wave transmitter, is periodically modulated by intermittently shielding the secondary from the primary coils forming the radio frequency transformer at a rate capable of producing radiation of tone character. This intermittent shielding is brought about by a rotating member having a plurality of conducting projections movable thru the mutual field of the inductively related coils at a frequency corresponding to that of an audible note.



Number 1,432,456—Method and Apparatus for Transmitting Sustained Wave Signals

1,432,800—Louis Steinberger and Guy Hill, filed May 18, 1918, issued October 24, 1922.

Insulsted Support for Electrical Conductors, such as flat metallic strip. The metal strip is molded at its center in insulating material.

1,432,863—Kenneth S. Johnson, filed July 1, 1918, issued October 24, 1922. Assigned to Western Electric Company, Incorporated.

Transmission System. The patent shows a circuit connection of an electron tube amplifier with a line wherein the transformer coupling the line and the input circuit of the amplifier has an impedance connected to the primary side of the transformer closely approximating the effective impedance of the line.

1,432, 867—M. J. Kelly, filed November 15, 1919, issued October 24, 1922. Assigned to Western Electric Company, Incorporated.

Electron Discharge Device and Method of Making the Same. The grid and plate of the electron tube of this invention are provided with a black coating such as nickel oxide produced by oxidation in an electric furnace at a temperature of about 900° C. The object of the invention is to eliminate the "blocking" sometimes produced in electron tubes due partially to undesirable secondary emission from the grid and thermionic particles collected on the grid from filament emission, and also to increase the radiation characteristics of the electrodes to permit an increase in the power amplified and still maintain the temperature within safe limits. The nickel oxide coating on the grid practically eliminates secondary emission and thermionic emission due to the presence of particles of coating emitted from the filament. The coating having the characteristics of a black body radiator provides a means whereby the electrodes more efficiently radiate heat so that greater amounts of power may be supplied to them at a given temperature operation. Where the tube is to be used as a detector or an amplifier of minute currents, the coating is removed from the surface of the plate which lies in the path of the electron stream. The coating may be removed by action of a jet of hydrogen or other reducing agent while the face of the electrode is heated.

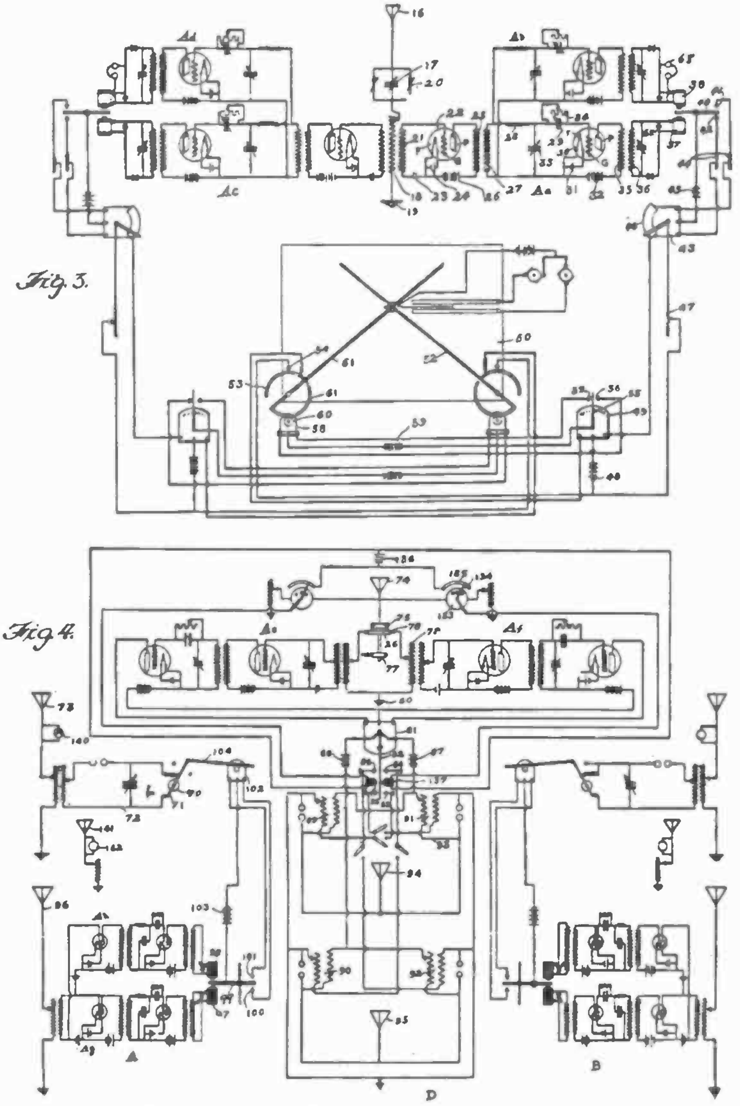
1,432,965—William L. Casper, filed September 3, 1919, issued October 24, 1922. Assigned to Western Electric Company, Incorporated.

Electric Circuits. This patent shows a filter circuit for use with electron tubes comprising a plurality of sections, each section having a branch in series with the line and a branch in shunt with the line. Each branch comprises an impedance element of such value that the phase angle of the series branch of each section equals the phase angle of the shunt branch of each section.

1,432, 992—J. O. Gargan, filed September 5, 1918, issued October 24, 1922. Assigned to Western Electric Company, Incorporated.

Vacuum Tube Socket. This patent shows a construction of support for carrying spare vacuum tubes in a radio set. The socket is not intended for connecting the terminals of the tube with external radio circuits, but is adapted to be secured in the corner of the cabinet containing the radio apparatus to carry a spare tube and prevent vibration or breakage thereof. The construction includes a resilient mounting on rubber strips and a spring-pressed member which engages the terminal pins of the tube and locks the tube by engagement with a bayonet slot co-operating with a pin in the side of the base of the tube.

1,433,070—W. W. Connors, filed June 6, 1919, issued October 24, 1922.



Number 1,433,070—Method and Apparatus for Determining the Actual Location and Actual Movement of Bodies

Method and Apparatus for Determining the Actual Location and Actual Movement of Bodies. This patent shows an arrangement of radio transmitting stations Figure 4, and a receiving station, Figure 3, with apparatus at the receiving station whereby a plurality of transmitting stations may operate to control the apparatus at the receiving station for performing such functions as reproducing graphically geographical representations and an altitude representation of an object such as a map or topographic survey existing at the transmitting stations. The receiving apparatus includes a similitude board arranged to represent the field of movement of a motile bodv. An indicator is arranged to be moved over the board in accordance with signals received from transmitting stations.

1,433,224. J. Parkin, Jr., filed March 29, 1920, issued October 24, 1922.

VARIABLE CONDENSER construction comprising a container for a quantity of mercury which may be rotated, the body of mercury remaining stationary by reason of its own specific gravity while a plate carried in the wall of the container and separated from the mercury by dielectric is moved relatively to the body of mercury. The container has the shape of a pair of disks separated from each other with the mercury between the disks in the lower half of the container; the opposite plate of the condenser is carried by the container separated from the mercury body by a dielectric.

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The following digests should be considered as included with digests appearing in previous issues of the PROCEEDINGS.

1,422,447—Le Roy Wilson Kalsay, filed February 8, 1921, issued July 11, 1922. Assigned to Western Electric, Company, Incorporated.

SWITCHING KEY, comprising an oscillatory member pivotally mounted within a rectangular frame. The member is arranged to be rocked in single plane to connect contacts carried by the member with stationary contacts mounted on the frame.

1,422,837—Irving B. Crandall, filed October 13, 1917, issued July 18, 1922. Assigned to Western Electric Company, Incorporated.

CONNECTING TRANSMITTERS TO VACUUM TUBE AMPLIFIERS. This patent shows a circuit connection between a telephone transmitter and an electron tube amplifier in which the "B" battery is employed to supply both the plate potential and the transmitter circuit.

1,426,516—Louis Steinberger, filed April 29, 1918, issued August 22, 1922.

INSULATOR of the molded interlocked strain member type. The invention resides in the construction of the imbedded portions of the strain members. Each strain member is provided with imbedded arm and ring portions increasing the tensile strength of the insulator.

1,426,754—Robert C. Mathes, filed October 23, 1916, issued August 22, 1922. Assigned to Western Electric Company, Incorporated.

CIRCUITS FOR ELECTRON DISCHARGE DEVICES, in which a resistance is connected in the input circuit of a tube and a battery related therewith for bringing the grid to a different potential than the filament and arranged so that gradual fluctuations in the strength of the plate battery will be compensated by fluctuations in the grid battery

1,426,755—Robert C. Mathes, filed May 9, 1919, issued August 22, 1922. Assigned to Western Electric Company, Incorporated.

VACUUM TUBE CIRCUITS AND METHODS OF OPERATING THEM. A plurality of electron tubes are connected in tandem in such manner that the input circuit of one of the tubes includes the filament electrode of the succeeding tube.

1,426,788—Louis Steinberger, filed November 26, 1918, issued August 22, 1922.

INSULATOR STRAIN MEMBER for a molded insulator. The strain members are interlocked and imbedded in the insulator The invention resides in the ring shape bridge construction formed in the leg portions of the strain members for increasing the tensile strength of the insulator.

1,426,789—Louis Steinberger, filed January 28, 1922, issued August 22, 1922.

INSULATOR of molded material having interlocked strain members imbedded therein. The imbedded portions of each of the strain members are in the form of rings circular in cross section.

1,426,807—Harold D. Arnold and John P. Minton, filed November 12, 1917, issued August 22, 1922. Assigned to Western Electric Company, Incorporated.

METHOD AND SYSTEM FOR TESTING TRANSMITTERS OR RECEIVERS for telephone systems. A generator such as a vacuum tube oscillator is arranged to supply a current continuously variable in frequency in a regular manner. The current is amplified and operates the receiver acoustically coupled with the transmitter under test. The operation of the transmitter can be observed from meters connected in the transmitter circuit.

## LIST OF RADIO TRADE MARKS PUBLISHED BY PATENT OFFICE PRIOR TO REGISTRATION

The numbers given are serial numbers of pending applications:

161,016—"TELERADIO" for radio and electrical equipment. Teleradio Engineering Corporation, New York, N. Y. Claims use since March 11, 1922. Published August 29, 1922.

161,679—"THE RADIO BOYS' SERIES"—series of books published periodically. Grosset & Dunlap, Incorporated, New York, N. Y. Claims use since March 1, 1922. Published August 29, 1922.

164,214—"RADION"—insulation material and horns for radio loud speakers. American Hard Rubber Company, Hempstead and New York, N. Y. Claims use since April 14, 1922. Published August 29, 1922.

163,112—"AMPERITE"—filament control adjuster. Radiall Company, New York, N. Y. Claims use since March 15, 1922. Published August 29, 1922.

163,304—"AUDIOLA" for radio apparatus. Audiola Radio Company, Chicago, Illinois. Claims use since March 31, 1922. Published August 29, 1922.

164,454—"RA-FONE" for radio receiving sets. Ra-Tone Electric Company, Detroit, Michigan. Claims use since early part of March, 1922. Published August 29, 1922.

162,601—"ATLANTIC WAVES IN EVERY HOME" for radio apparatus. Atlantic Instrument Company, Incorporated, New York, N. Y. Claims use since on or about January 2, 1922. Published September 26, 1922.

163,091—"LALLEY RADIO" forming two hemispheres, one in black and one in red. Radio receiving sets. Lalley Radio Corporation, Detroit, Michigan. Claims use since April 17, 1922. Published September 26, 1922.

163,421—"AERIOLA GRAND" for radio apparatus. Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania. Claims use since December 23, 1921. Published September 26, 1922.

163,508—"ALADDIN MULTITONE COMPLETE CRYSTAL RECEIVER" in ornamental design. Philip E. Edelman, New York, N. Y. Claims use since December 22, 1921. Published September 26, 1922.

163,555—"MAXOLOUD" for radio apparatus. Paul F. Weiss, doing business as Radio Improvement Company, not incorporated, Chicago, Illinois. Claims use since March 29, 1922. Published September 26, 1922.

164,321—Symbol of antenna and ground with letters "H R C" for radio receiving apparatus. Heslar Radio Corporation, Indianapolis, Indiana. Claims use since April 25, 1922. Published September 26, 1922.

164,439—"JRH RADIO" arranged in triangle, for radio receiving apparatus. J. Roy Hunt, Incorporated, Long Island City, N. Y. Claims use since April 15, 1922. Published September 26, 1922.

164,444—"MORADIO" for radio apparatus. Moreland Sales Corporation, Newark, New Jersey. Claims use since March 15, 1922. Published September 26, 1922.

164,598—"OIDAR—THE VOICE HEARD ROUND THE WORLD" arranged in the form of a globe. For radio apparatus. Ludwig Hommel and Company, Pittsburgh, Pennsylvania. Claims use since April 24, 1922. Published September 26, 1922.

164,604—"AEROVOX" for radio apparatus. The Radiola Wireless Corporation, New York, N. Y. Claims use since April 1, 1922. Published September 26, 1922.

164,728—"AMPLITONE" antenna wire. W. C. Shinn Manufacturing Company, Niles, Michigan and Chicago, Illinois. Claims use since April 25, 1922. Published September 26 1922.

161,941—"Radio Digest"—weekly publication. Earl C. Rayner, Chicago, Illinois. Claims use since April 4, 1922. Published October 3, 1922.

163,412—"Pink-a-Tone—Detector of the Air" arranged ornamentally. Radio receiving sets. Pinkerton Electric Equipment Company, New York, N. Y. Claims use since on or about April 10, 1922. Published October 10, 1922.

163,528—"The Standard Radio Guide"—radio manual issued at intervals. Modern Publishing Company, New York, N. Y. Claims use since April 20, 1922. Published October 10, 1922.

162,615—"Edelman's Multitone" for radio receiving sets. Philip E. Edelman, New York, N. Y. Claims use since August 1, 1921. Published October 17, 1922.

162,805—"Zenith" in wavelike design, for radio apparatus. Chicago Radio Laboratory, Chicago, Illinois. Claims use since about October, 1918. Published October 17, 1922.

163,425—"Great Radio Voice—Thorophone—(Thunderphone)" arranged in ornamental design; for radio receiving apparatus. Winkler-Reichmann Company, Chicago, Illinois. Claims use since April 20, 1922. Published October 17, 1922.

163,864—"Radio Review"—monthly publications. Experimenter Publishing Company, Incorporated, New York, N. Y. Claims use since January 20, 1922. Published October 17, 1922.

164,080—"Radio Remco Products" arranged in ornamental design; for radio apparatus. Alfred J. Steinberger, doing business as Radio Equipment and Manufacturing Company, Brooklyn, New York. Claims use since on or about February 1, 1922. Published October 17, 1922.

164,864—"The Radio Boys"—printed books published in series. A. L. Burt Company, New York, N. Y. Claims use since April 21, 1922. Published October 17, 1922.

165,250—"The World's Voice" arranged in ornamental design. For radio receiving apparatus. Victor Radio Corporation, New York, N. Y. Claims use since May 15, 1922. Published October 17, 1922.

165,374—"Radionelle" for radio receiving apparatus. A. H.

Grebe and Company, Incorporated, Richmond Hill, N. Y. Claims use since on or about March 1, 1922. Published October 17, 1922.

165,604—" 'STATI-TUBE'—ROCHESTER, N. Y." for Radio detector, amplifier, and transmitter tubes. Radio Stati-Tube Manufacturing Company, Incorporated, Rochester, N. Y. Claims use since May, 1921. Published October 17, 1922.

165,819—"ROYALFONE—KING OF ALL" for head telephone receivers. Royal Electrical Laboratories, Newark, New Jersey. Claims use since March 1, 1922. Published October 17, 1922.

165,887—"RAD-WIN-CO" in ornamental design; for radio apparatus. Radio Winding Corporation, New York, N. Y. Claims use since May 15, 1922. Published October 17, 1922.

166,040—"RADAK" for radio equipment. Clapp-Eastham Company, Cambridge, Massachusetts. Claims use since June 3, 1922. Published October 17, 1922.

166,490—"X-RAD" for radio apparatus. X-Rad Corporation, New York, N. Y. Claims use since on or about May 20, 1922. Published October 17, 1922.

167,784—"RICO" for radio telephones. Radio Industries Corporation, New York, N. Y. Claims use since June 10, 1922. Published October 17, 1922.

167,882—"CONQUEROR" arranged in ornamental design; for radio receiving apparatus. Lewis and De Roy Radio Corporation, New York, N. Y. Claims use since April 1, 1922. Published October 17, 1922.

167,962—"AERIOTRON" for electron tubes. Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania. Claims use since December 10, 1921. Published October 17, 1922.

168,496—"ERECTO-RADIO" for radio receiving equipment. Stephenson Radio Company, Indianapolis, Indiana. Claims use since June 30, 1922. Published October 17, 1922.