

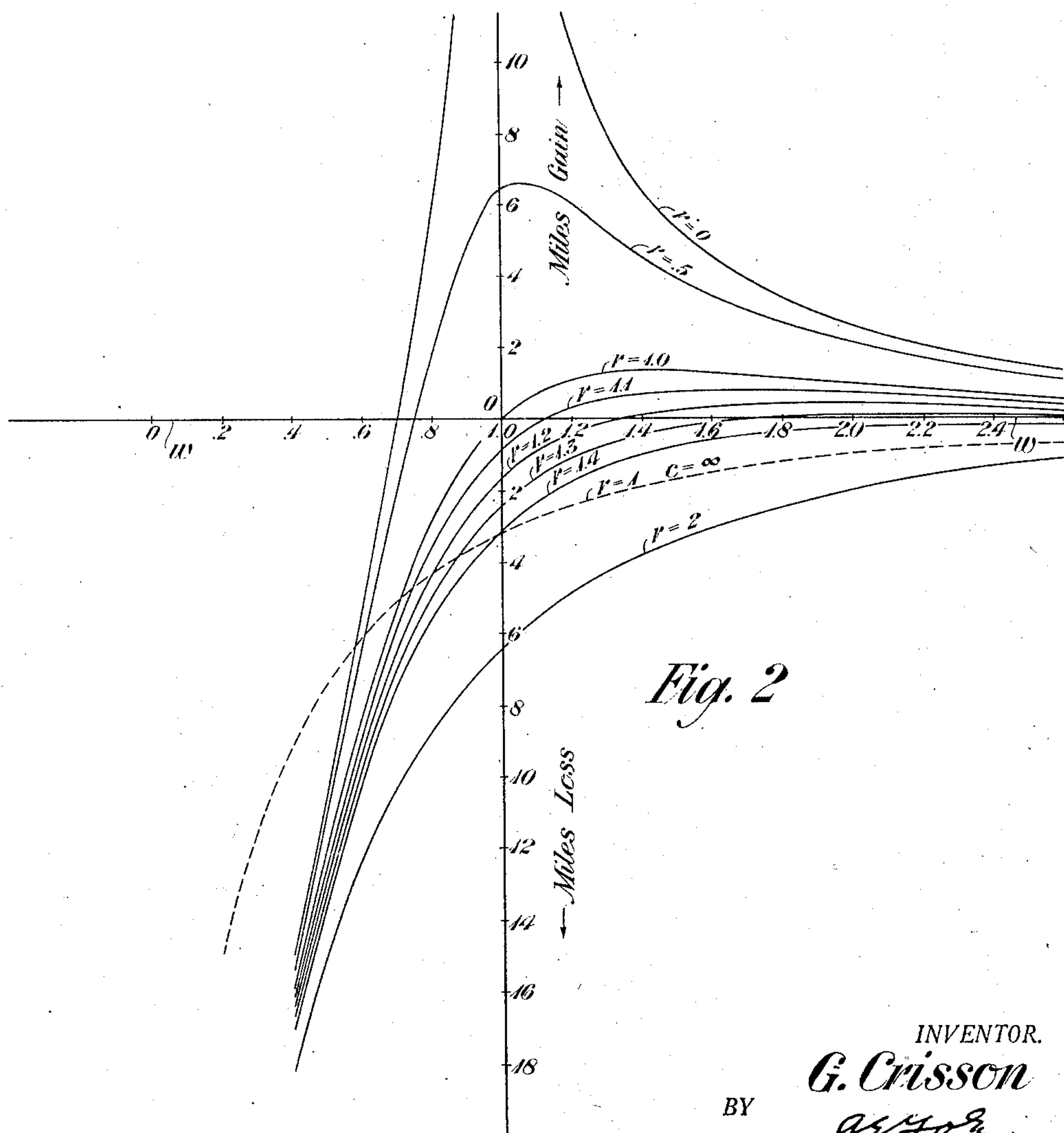
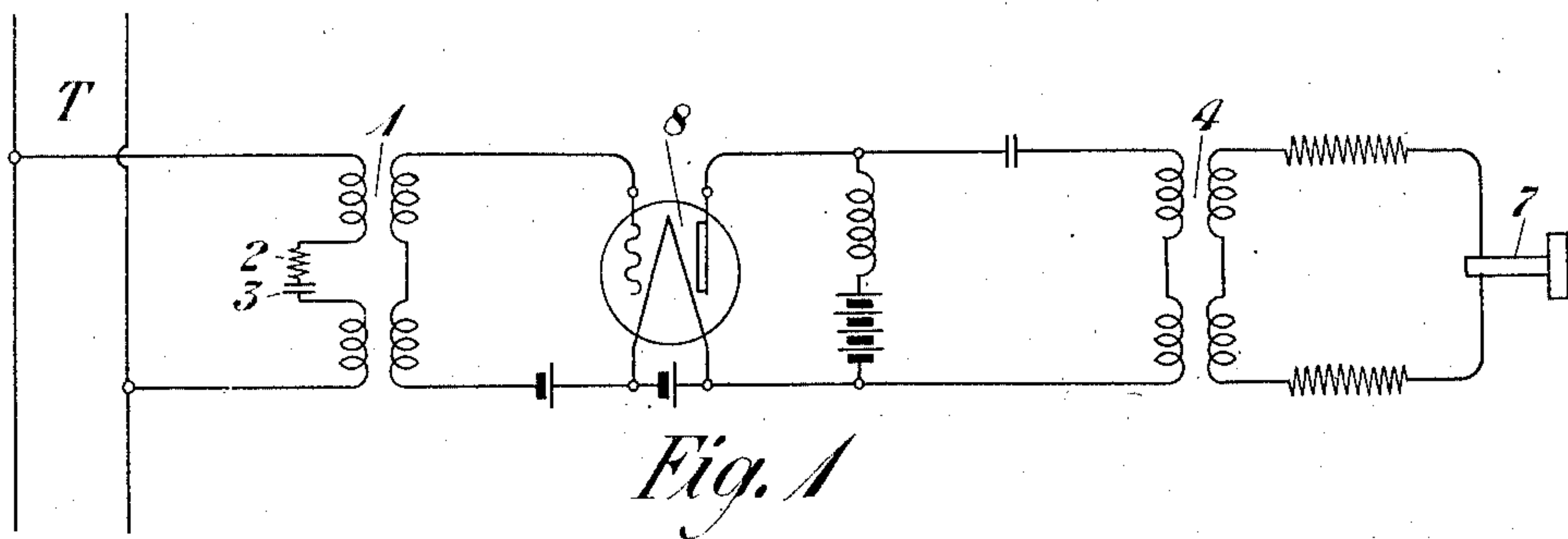
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G. CRISSON

FREQUENCY SELECTIVE DEVICE

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UNITED STATES PATENT OFFICE.

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FREQUENCY SELECTIVE DEVICE.

Application filed October 16, 1919. Serial No. 331,035.

To all whom it may concern:

Be it known that I, GEORGE CRISSON, residing at Hoboken, in the county of Hudson and State of New Jersey, have invented certain Improvements in Frequency Selective Devices, of which the following is a specification.

This invention relates to frequency selective devices, more particularly, it concerns arrangements of circuits whereby an electrical device is rendered selectively responsive to currents differing in frequencies.

Arrangements of this character are particularly useful in telephony and the form of the arrangement described herein is associated with telephone apparatus, it being readily understood, however, that the invention is applicable to many other branches of the arts. The device as described herein is used for preventing disturbances of low frequency, as frequently exist on telephone lines due to telegraphic and other signaling currents, from causing noise in a receiver, the device being so arranged as to have no effect on the voice currents, which are of higher frequency than the disturbances.

One form and arrangement of apparatus and circuits embodying the invention is shown in diagrammatic view in Figure 1 of the accompanying drawing, Fig. 2 being a graph showing the characteristics of the arrangement of Fig. 1 for various values of certain elements of the arrangement.

In the form shown in Figure 1, the invention is especially suitable for use as a high impedance monitoring circuit for service observing and other necessary purposes.

Reference letter T of Fig. 1 designates a telephone line and numeral 7 a telephone receiver, which is associated with the line in such manner that it responds with normal intensity to voice currents in the line but very weakly if at all to currents of low frequencies, such as disturbances caused by telegraphic or other signaling currents. The apparatus which associates the receiver with the line comprises a transformer 1, the primary of which is connected across the telephone line in series with a resistance 2 and a condenser 3. The secondary winding of the transformer is associated with the grid or input circuit of an electron tube amplifier 8, the output circuit of which is associated by means of the transformer 4 with the receiver 7. The transformer 1 be-

haves substantially like an inductance coil, its secondary circuit being effectively open because of the high impedance of the grid circuit of the electron tube. The primary circuit of the transformer has therefore substantially the same characteristic as a circuit comprised of serially connected inductance, resistance and capacity elements, and the amplifier causes a flow of current through the receiver proportional to the drop of voltage in the inductance element of the circuit.

With a high inductance in the transformer 1, the loss to transmission over the line T and the effect on the balance of nearby repeaters can be made as small as we please. Such an inductance alone might tend to permit low frequency impulses to reach the receiver 7. Placing the resistance 2 in series with the transformer 1 reduces the efficiency of the system for low frequencies, but at the same time this keeps the impedance high across the line T. This avoids harmful transmission losses and impedance effects in the line T that would be caused if the discrimination against low frequencies were obtained by reducing the inductance of the transformer 1. The capacity of the condenser 3, coacting with the inductance of the transformer 1, further modifies the behavior of the system, causing the discrimination against low frequencies to take place at a more sharply defined frequency than would otherwise be the case.

The drop of voltage in the transformer 1 is small for low frequencies and large for high frequencies, and by proper proportionment of the elements of the circuit, as explained below, this drop may be made substantially equal (in absolute value) to the voltage across the line for currents of voice frequencies, and considerably less than the voltage across the line for currents of low frequencies so that the receiver responds with normal intensity to the voice currents and but weakly, if at all, to low frequency disturbances. The arrangement of this invention, therefore, introduces a loss in transmission between the line and the receiver for currents of low frequencies the value of this loss being determined at any frequency by the ratio of the voltage across the line T to the voltage across the inductance element of the circuit. In telephony it has been found convenient to express transmission loss in terms of the number of miles of standard cable

which has an equal loss in transmission at 800 cycles, the length M in miles of a standard cable which will cause a ratio $|V|$ of output to input voltage being given by the well known equation:

$$M = 21.2 \log_{10} |V|.$$

The ratio $|V|$ of the voltage across the inductance element to the voltage across the line at any frequency may be determined mathematically as follows:

Let R =resistance of the circuit,

L =inductance of the circuit,

C =capacity of the circuit,

f =any frequency in cycles,

f_c =frequency at which L and C resonate,

$$\omega = 2\pi f$$

$$\omega_c = 2\pi f_c = \frac{1}{\sqrt{LC}}$$

$$w = \frac{f}{f_c} = \frac{\omega}{\omega_c}; \text{ when } w=1 \text{ the circuit is resonant.}$$

E =E. M. F. acting in the circuit

e =drop of voltage in the inductance element.

$$j = \sqrt{-1}$$

$$\text{Then } V = \frac{e}{E} = \frac{j\omega L}{R + j\left(\omega L - \frac{1}{\omega C}\right)} \quad (1)$$

to simplify this expression,

Let $r = \frac{R}{\omega_c L}$ = ratio of resistance to

inductive reactance at resonant frequency.

then $R = r\omega_c L$ (2)

$$C = \frac{1}{\omega_c^2 L} \quad (3)$$

$$\text{also } \omega = w\omega_c \quad (4)$$

Substituting (2) (3) and (4) in (1) and simplifying

$$V = \frac{(w^2 - 1) + jwr}{r^2 + \left(w - \frac{1}{w}\right)^2} \quad (5)$$

and the absolute value of V is

$$|V| = \frac{\sqrt{(w^2 - 1)^2 + w^2 r^2}}{r^2 + \left(w - \frac{1}{w}\right)^2} \quad (6)$$

Hence

$$M = 21.1 \log_{10} |V|$$

this equation having a negative value when there is a loss in transmission and a positive value when there is a gain, i. e. if the voltage across the inductance element is larger than the voltage across the line.

This equation is plotted for several values of r in Fig. 2, the ordinates of this graph

being in terms of miles gain or loss and the abscissæ in terms of w . The curves for which r is equal to or greater than unity show a rapidly increasing loss of transmission for low values of w , i. e. at low frequencies, and a substantially constant transmission, with but slight gain or loss, at high frequencies. By proper choice of the elements of the circuit, therefore, the arrangement may be designed to cause a decided loss in transmission for low frequency disturbances without having any appreciable effect in the transmission of the voice currents. For example if the inductance of transformer 1 is 5 henrys and if the requirements are that the transmission of 100 cycle currents must be reduced by 14 miles and the transmission of the voice currents must not be increased at any frequency more than 1 mile, it will be found that the curve for which $r=1.1$ gives the sharpest cut-off consistent with the requirements. This curve indicates a loss of 14 miles at $w=.45$, which then corresponds to 100 cycles. The resonant frequency is therefore:

$$f_c = \frac{100}{.45} = 222 \text{ cycles,}$$

from which

$$\omega_c = 2\pi f_c = 1395,$$

$$C = \frac{1}{\omega_c^2 L} \text{ farads} = .103 \text{ mf.}$$

$$\text{and } R = r\omega_c L = 7673 \text{ ohms.}$$

From this value of R must be subtracted the effective resistance of the transformer and the resistance of the source if accurate results are desired.

If, then, the above determined values of L , R and C are used in the arrangement of this invention, it will be found to have the characteristics determined by the curve for which $r=1.1$. Its transmission at low frequencies is exceedingly poor and it does not reach the point of zero loss until w is equal to 1.13 or 244 cycles. For currents above this frequency the curve shows a slight gain, which, however, gradually declines as the frequency rises, (the curve being tangent to the axis of abscissæ when w is infinite).

A smaller value of r gives a sharper cutting off action but a corresponding rise of the maximum gain. A larger value of r , on the other hand, gives a more gradual cut-off with a smaller rise of the maximum gain. The best value of r depends, of course, on the actual condition to be met.

The dotted curve is drawn to show the characteristic of the arrangement in the special case when the value of C is infinite, in other words, when the condenser is omitted. In this case there is no resonant frequency and ω_c becomes the frequency at

which the resistance and reactance are equal, r being chosen as unity. In this case

$$V = \frac{j\omega L}{R + j\omega L}$$

$$\text{and } |V| = \frac{w}{\sqrt{1+w^2}}$$

As shown by the curve, the characteristic of the arrangement without a condenser has only a gradual cut-off which may be desirable under certain conditions.

What is claimed is:

1. A device for monitoring on a telephone transmission line, comprising a telephone receiver, a three electrode vacuum tube with its output circuit associated with said receiver, a shunt across the line having high impedance compared to the characteristic impedance of the line, comprising inductance resistance and capacity elements, and means connecting the grid of said tube in shunt relation to said inductance element.

2. A device for monitoring on a transmission line, comprising a three electrode vacuum tube, a bridge across the line having high impedance compared to the characteristic impedance of the line, and a connection between said bridge and the grid of said tube, the impedance elements of the bridge and the connection of the grid being so related as to give a high loss on the grid for frequencies below a certain limit and a low uniform gain or loss for frequencies above that limit.

3. In combination, a transmission line, a telephone receiver to be connected therewith at an intermediate point; a shunt across the line comprising inductance, resistance and capacity elements in series, a three-electrode vacuum tube with its grid circuit connected to impress upon the grid the voltage drop through the said inductance,

said telephone receiver being connected with the plate circuit of said tube.

4. In combination, a transmission line, a telephone receiver to be connected therewith at an intermediate point, a shunt across the line comprising a divided transformer primary winding and resistance and capacity in series between the parts of said winding, a three-electrode vacuum tube comprising the corresponding transformer secondary winding in its grid circuit, said telephone receiver being connected to the plate circuit of said tube.

5. In combination, a transmission line having a certain characteristic impedance, a telephone receiver to be connected therewith at an intermediate point, a shunt across the line having an impedance high compared to the said characteristic impedance of the line and comprising inductance, resistance and capacity elements in series, a three-electrode vacuum tube with its grid circuit connected to impress upon the grid the voltage drop through the said inductance, said telephone receiver being connected with the plate circuit of said tube.

6. In combination, a transmission line, a telephone receiver to be connected therewith at an intermediate point, a shunt across the line comprising inductance, resistance and capacity elements in series, said inductance and capacity elements being tuned to a low frequency compared to the essential voice frequency range, a three-electrode vacuum tube with its grid circuit connected to impress upon the grid the voltage drop through the said inductance, said telephone receiver being connected with the plate circuit of said tube.

In testimony whereof, I, have signed my name to this specification this 15th day of October 1919.

GEORGE CRISSON.