

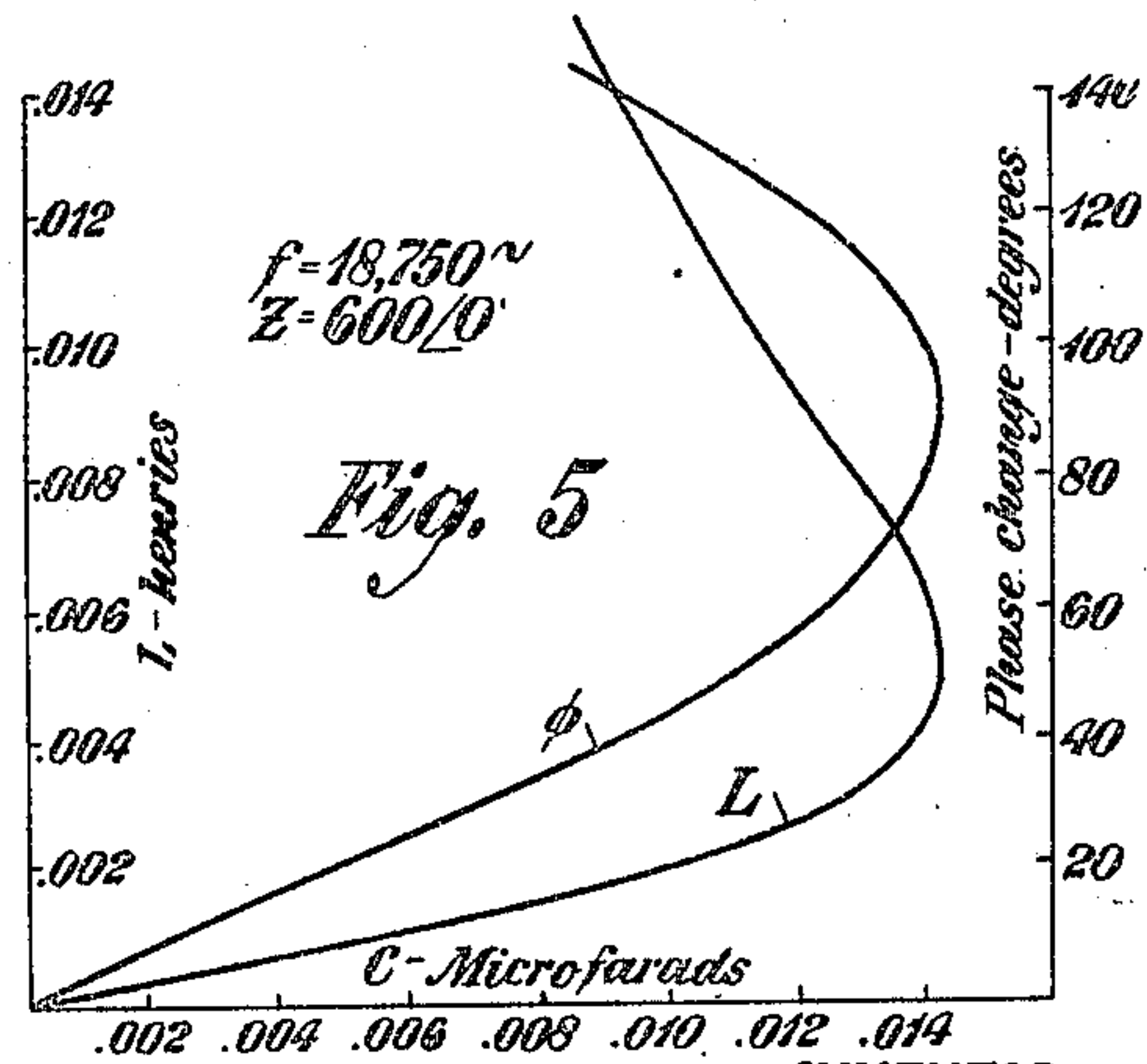
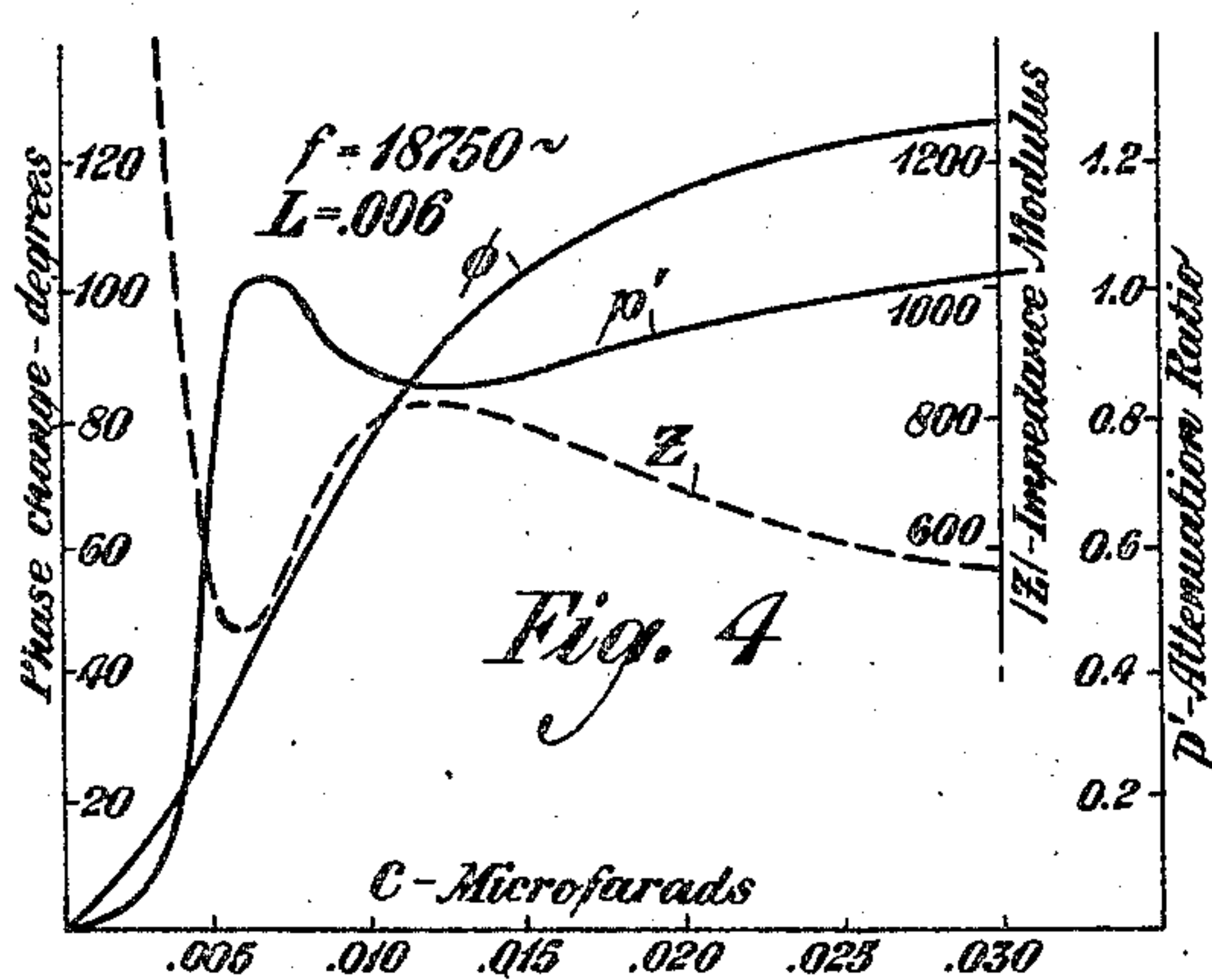
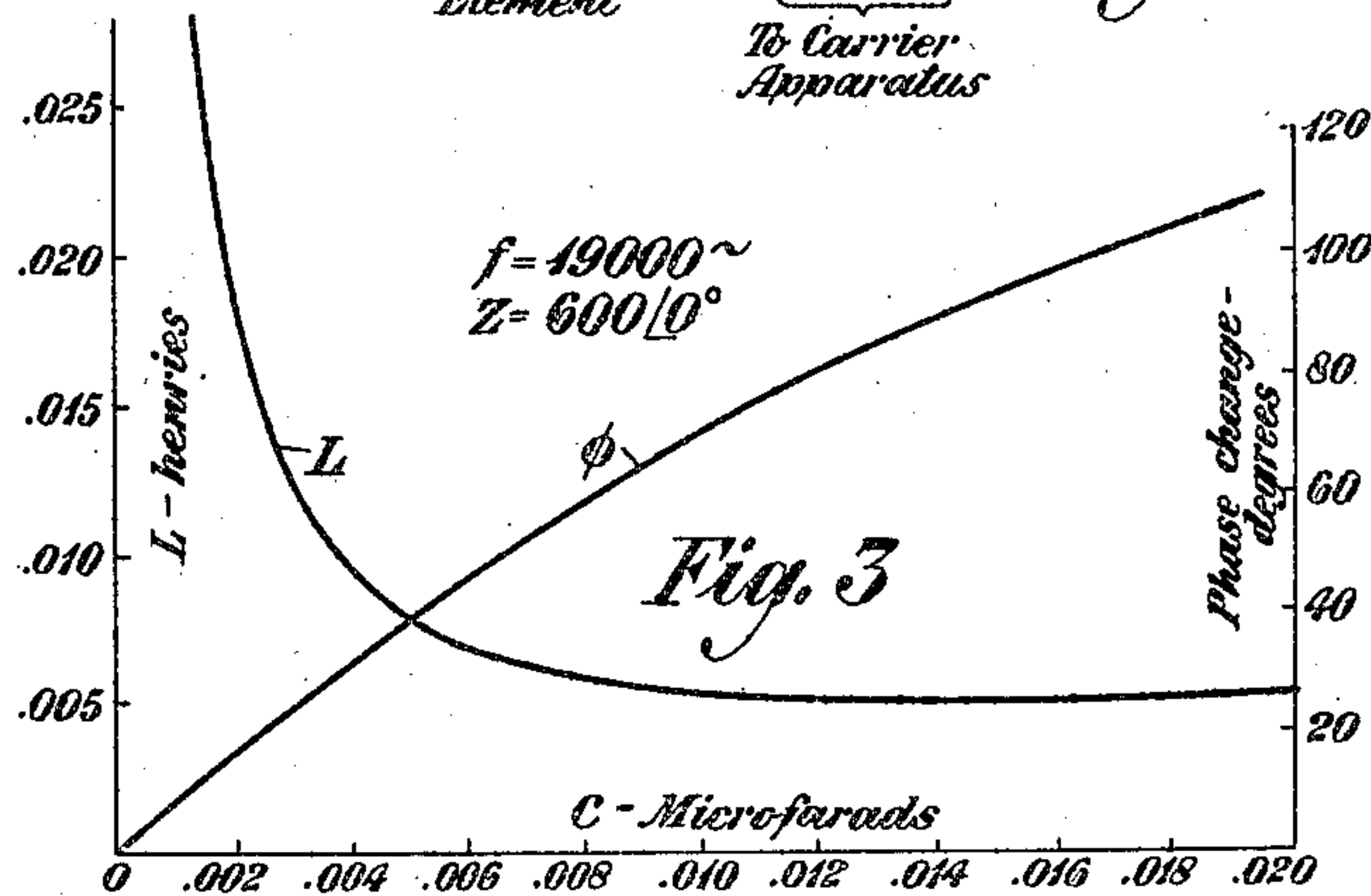
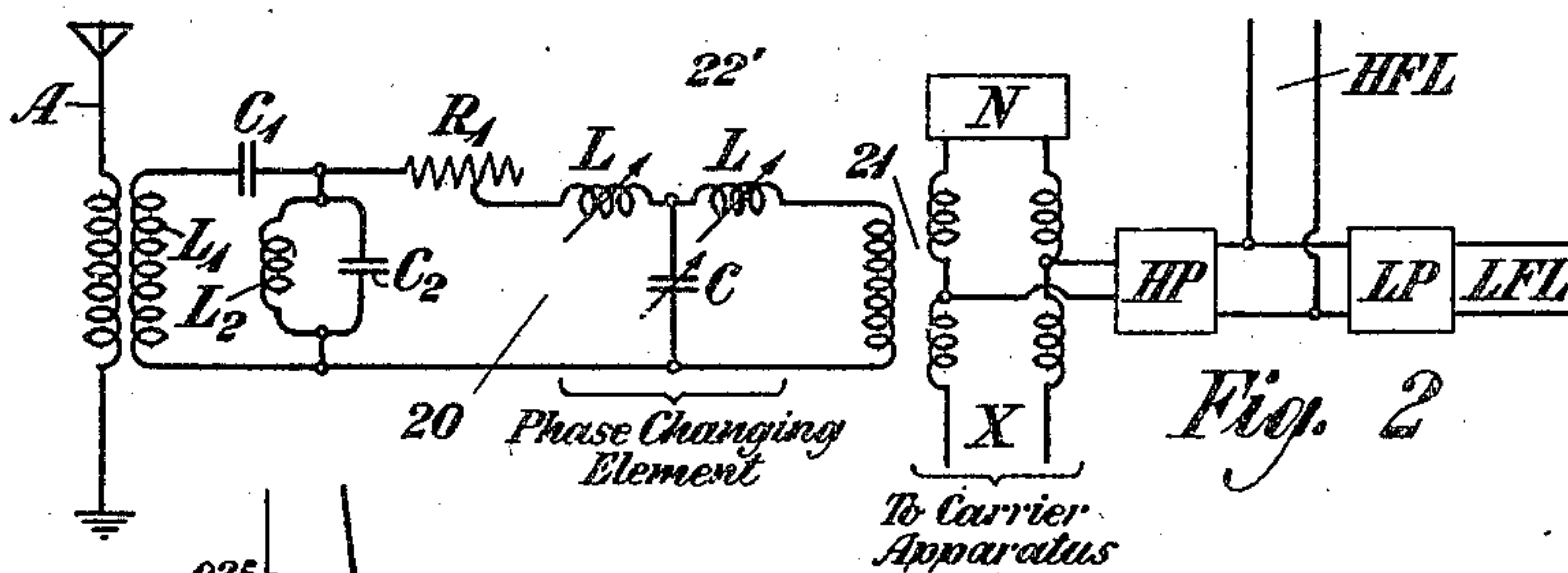
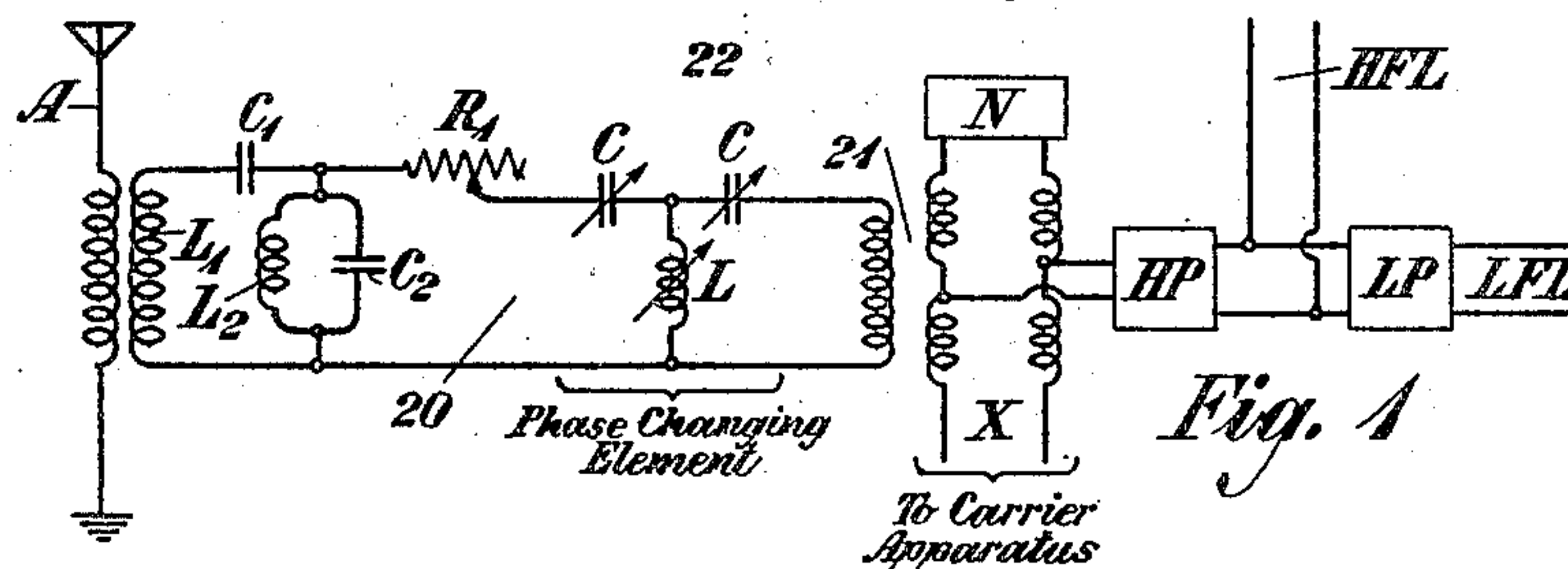
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1,543,772

R. N. HUNTER

APPARATUS FOR NEUTRALIZING RADIOINTERFERENCE ON WIRE LINES

Filed Nov. 20, 1922



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UNITED STATES PATENT OFFICE.

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APPARATUS FOR NEUTRALIZING RADIOINTERFERENCE ON WIRE LINES.

Application filed November 20, 1922. Serial No. 602,145.

To all whom it may concern:

Be it known that I, RUSSELL N. HUNTER, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Apparatus for Neutralizing Radiointerference on Wire Lines, of which the following is a specification.

This invention relates to transmission circuits, and more particularly to a new and improved system for overcoming interference on signaling conductors due to radio transmission.

In carrier transmission systems in which carrier channels are superposed on ordinary signaling conductors, interference is sometimes produced in one or more of the carrier channels due to radio signals transmitted at the carrier frequency assigned to the channel. In order to overcome this difficulty, it has heretofore been proposed to balance out the interfering frequency by impressing upon the channel a balancing frequency of equal amplitude and opposite phase, the balancing frequency being obtained from the disturbing source through the medium of an auxiliary circuit which is subject to the disturbing influence.

In applying this remedy, some difficulty has been experienced in obtaining the proper balance due to the fact that adjustments of the balancing potential must be made both with respect to phase and amplitude, and instrumentalities heretofore used for obtaining such adjustments have been of such a character that an adjustment of either the phase or the amplitude results in a change in the other, so that it has required considerable manipulation in order to obtain a balance. It is one of the objects of the present invention to provide a system in which the phase and amplitude of the balancing potential may be controlled each independently of the other, so that when the phase angle has once been adjusted, changes in amplitude may thereafter be made without changing the phase angle, or vice versa.

The arrangements whereby these results are accomplished may be understood from the following description of the invention when read in connection with the accompanying drawing, Fig. 1 of which illustrates a circuit arrangement for neutralizing radio interference in a carrier system involving

a high-pass filter for obtaining a phase adjustment independent of the amplitude adjustment.

Fig. 2 shows a similar circuit arrangement employing a low-pass type of filter for obtaining the phase adjustment.

Figs. 3 and 4 graphically represent the operation of the highpass filter of Fig. 1 as a phase adjusting device.

Fig. 5 graphically illustrates the operation of a low-pass filter as a phase adjusting device.

Referring to Fig. 1, HFL designates a transmission line over which carrier frequencies may be transmitted. The line HFL terminates at a carrier station in two branches, a low frequency branch LFL connected to the carrier line through the low-pass filter LP, and a carrier branch X associated with the high frequency line HFL through a high-pass filter HP. Associated with the carrier branch X will be transmitting and receiving apparatus for a plurality of channels having different frequencies, but as this apparatus is not concerned with the present invention the details thereof need not be disclosed.

A high frequency carrier line, such as HFL, is subject to interference from radio transmitting stations, and the interfering currents, if they happen to fall within the range of one of the receiving channels, will, of course, produce disturbing signals in the receiving apparatus of such a channel. In order to overcome this difficulty, it is proposed by the present invention to superpose on the carrier branch X electromotive forces equal in amplitude but opposite in phase to the disturbing electromotive forces. For this purpose an antenna system A is provided for receiving electromotive forces from the distant radio station producing the interference. A circuit 20 associates the antenna A with the carrier branch X through a balanced transformer 21 so arranged that potentials from the antenna A will be impressed upon the carrier branch X, but will not be transmitted back through the high-pass filter HP to the high frequency line HFL. The circuit 20 is tuned by means of an inductance L_1 and a capacity C_1 to the radio frequency producing the interference, and a shunt and a resonant combination comprising an inductance L_2 and capacity C_2 is bridged across the circuit 20 for shunt-

ing out other frequencies than the particular frequency which it is desired to use for neutralizing purposes.

A single section of a high-pass filter 22 is included in the circuit 20 for producing phase changes in the balancing electromotive force, and an adjustable resistance device R_1 is also included in the circuit 20 for adjusting the amplitude independently of the phase changing device 22. The high-pass filter section 22 comprises series capacities C with a shunt inductance L bridged across the circuit at the junction point of the two capacities C . By adjusting the values of the capacities alone or making suitable adjustments of both the capacities and the inductance, phase adjustments may be made without producing any change in amplitude. While this result may appear to be somewhat unusual, when it is remembered that a high-pass filter is substantially non-attenuating with respect to frequencies lying within its range, the reason for the result becomes more apparent.

In making phase adjustments by means of the high-pass filter 22, the inductance and capacity elements will be varied in steps, but the two condensers should be kept equal to each other. The relation between the inductance and capacity is given by the formula:

$$L = \frac{1 + R^2 C^2 \omega^2}{2 C \omega^2} \quad (1)$$

in which ω represents 2π times the frequency. The relation of this formula is derived on the assumption that, when one side of the network is terminated in a resistance of R ohms, the impedance, looking into the other side of the network, will also be R ohms non-inductive. The phase change due to the network is given by the formula:

$$\phi = \tan^{-1} \left[\frac{R}{L\omega - \frac{1}{C\omega}} \right] \quad (2)$$

Curves computed in accordance with formulae 1 and 2 are illustrated in Fig. 3, for the case in which the frequency whose phase angle is to be changed is 19,000 cycles, and the impedance of the circuit looking into the transformer 21 from the filter is 600 ohms. In Fig. 3, the curve designated L is a plot showing the value of the inductance corresponding to each capacity setting of the capacity C of the filter 22. The curve marked ϕ shows the phase change for each adjustment of the capacity C , the inductance L , of course, being correspondingly adjusted. It will be seen that by varying the capacity from .002 microfarads to .02 microfarads the inductance L will be adjusted from about .018 henrys to about .005 henrys, and a phase change of about 90° will be obtained. The amount of this phase change may be

increased as indicated by the curves by further increasing and further reducing the capacity. This may not be practical, however, as further increase in the capacity does not tend to produce a corresponding change in phase, while the smaller values of the capacity involve very sudden increases in the amount of inductance. Consequently, where phase changes materially greater than 90° are desired, it may be necessary to use two filter sections in series to obtain the desired phase change.

It will also be noticed in the curve L of Fig. 3 the value of the inductance does not change materially over a very considerable variation in the values of the capacity of the filter, the curve L being almost flat through a large part of its range. This at once suggests that the network may be simplified by maintaining the inductance constant and only adjusting the two capacities. The curves of Fig. 4 illustrate the characteristics of the filter section as a phase adjusting device for a frequency of 18,750 cycles with a terminal impedance of 600 ohms and a non-adjustable shunt inductance of .006 henrys. The curve marked ϕ indicates the phase change corresponding to different values of capacity. The curve marked ρ' represents the variation in ratio of the current flowing into the 600 ohm impedance with the filter in circuit to the current which would flow into the impedance with the filter removed. Obviously, if the filter introduced no attenuation at the frequency under consideration, this ratio would be unity. An examination of the curve ρ' shows that for a capacity range from about .0055 microfarads to somewhere over .03 microfarads this ratio does not depart excessively from unity, and consequently the phase adjustment over this range may be obtained without material change in amplitude of the current. The phase change corresponding to this change in capacity runs from approximately 35° to approximately 125° , a total phase change of about 90° . It is not practical to make adjustments outside of the range indicated, for an increase in the capacity does not produce any substantial phase change, while a decrease in the capacity below the value .0055 produces a very marked increase in attenuation and also results in a very sharp increase in the impedance of the filter, as indicated by the dotted line curve Z . Where phase changes greater than 90° are desired, it is best that two filter sections in series should be used, so that the first section will shift the phase 90° , and the second section, by a corresponding adjustment, will shift it 90° further.

Fig. 2 illustrates a modified circuit in which a low pass filter section 22' is used as a phase changing element. The other fea-

tures of the circuit for balancing out interference are the same as those of Fig. 1 and need not be described. The filter section comprises a shunt capacity C connected to the midpoints of two half section inductances L . The inductances should be kept equal to each other, and the relation between inductance and capacity for different adjustments of the filter is given by the formula:

$$C = \frac{2L}{R^2 + w^2 L^2} \quad (3)$$

The phase change due to the network is given by the formula:

$$\phi = \tan^{-1} \left[\frac{2R w L}{R^2 - w^2 L^2} \right] \quad (4)$$

The characteristics of this type of filter as a phase changing device are shown by the curves of Fig. 5 for the case of a frequency of 18,750 cycles and a terminal impedance of 600 ohms. In Fig. 5 the curve L gives the values of inductance corresponding to different values of the capacity, while the curve marked ϕ indicates the phase change corresponding to each capacity value. The type of filter employed in Fig. 2 involves only one variable condenser, instead of the two necessary for the high-pass type of Fig. 1, but in this case a fixed inductance cannot be used as the inductance varies materially for each material change in capacity, as indicated by the curve L . There is no part of the curve in which the inductance stays reasonably constant over a range of capacity changes. This type of filter, however, has the advantage that a greater phase change is obtained with a single section of the filter, so that in most cases it would not be necessary to use two sections. For example, if the inductance be varied from zero to .014 henrys, a phase change from zero to 140° will be obtained. The capacity will be varied from zero to a maximum of slightly over .014 microfarads, and from this maximum point the capacity values fall off with further increase in inductance to a value of about .009 microfarads.

If desired the inductances L in the filter section 22' of Fig. 2 may be so wound as to have a certain amount of mutual inductance. This however, as a greater phase change per section is possible when the mutual inductance is zero.

In the arrangements of both of Figs. 1 and 2 the filter sections may be adjusted to produce the desired phase angle for the balancing component without producing any material change in the amplitude of the current, as the filter section is approximately non-attenuating. Adjustments in amplitude may be made by a simple series adjustable resistance R_1 included

in the circuit 20. Variations in the resistance R_1 will produce little or no effect upon the action of the filter section as a phase changer. Consequently, the phase and amplitude of the current may be independently adjusted.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a wire signaling system subject to interference due to radio signaling, an auxiliary circuit upon which a similar disturbing electromotive force may be impressed for balancing purposes, a device associated with said auxiliary circuit for adjusting the phase of the current resulting from said balancing electromotive force and a device associated with said auxiliary circuit for adjusting the amplitude of said current, said phase adjusting device and amplitude adjusting device controlling their respective functions independently of each other, said phase adjusting device having substantially no attenuation at the interfering frequency.

2. In a wire signaling system subject to interference due to radio signaling, an auxiliary circuit upon which a similar disturbing electromotive force may be impressed for balancing purposes, a device associated with said auxiliary circuit for adjusting the phase of the current resulting from said balancing electromotive force and a device associated with said auxiliary circuit for adjusting the amplitude of said current, said phase adjusting device and amplitude adjusting device controlling their respective functions independently of each other, said phase adjusting device having substantially no attenuation at the interfering frequency, and said phase adjusting device comprising a filter section having series and shunt impedances so proportioned that the attenuation of the section is substantially zero at the interfering frequency.

3. In a wire signaling system subject to interference due to radio signaling, an auxiliary circuit upon which a similar disturbing electromotive force may be impressed for balancing purposes, a device associated with said auxiliary circuit for adjusting the phase of the current resulting from said balancing electromotive force and a device associated with said auxiliary circuit for adjusting the amplitude of said current, said phase adjusting device and amplitude adjusting device controlling their respective functions independently of each other, and said phase adjusting device having substantially no attenuation at the interfering frequency, and said phase adjusting device comprising a filter section having series and

shunt impedances, one of said impedances being inductive and the other capacitative, and said impedance elements being so proportioned that the attenuation of the section is substantially zero at the interfering frequency.

4. The method of changing the phase shift of a filter section having series and shunt impedance elements, which consists in so varying the absolute values of said elements as to produce a desired phase shift at a given frequency and so varying the relative values of the series and shunt elements as to produce substantially no change in impedance at the given frequency.

5. The method of changing the phase shift of a filter section having series and shunt impedance elements, which consists in so varying the absolute values of said elements as to produce a desired phase shift at a given frequency and so varying the relative values of the series and shunt elements as to maintain the attenuation at a substantially negligible value for the desired frequency.

6. The method of changing the phase shift of a filter section having series and shunt impedance elements, which consists in so varying the absolute values of said elements as to produce a desired phase shift at a given frequency and so varying the relative values of the series and shunt elements as to produce substantially no change in impedance and maintain the attenuation at a substantially negligible value for the desired frequency.

7. The method of changing the phase shift of a filter section having series and

shunt impedance elements, one of which is inductive and the other capacitative, which consists in so varying the absolute values of the inductance and capacity of said elements as to produce a desired phase shift at a given frequency and so varying the relative values of the inductance and capacity as to produce substantially no change in impedance at the given frequency.

8. The method of changing the phase shift of a filter section having series and shunt impedance elements, one of which is inductive and the other capacitative, which consists in so varying the absolute values of the inductance and capacity of said elements as to produce a desired phase shift at a given frequency and so varying the relative values of the inductance and capacity as to maintain the attenuation at a substantially negligible value for the given frequency.

9. The method of changing the phase shift of a filter section having series and shunt impedance elements, one of which is inductive and the other capacitative, which consists in so varying the absolute values of the inductance and capacity of said elements as to produce a desired phase shift at a given frequency and so varying the relative values of the inductance and capacity as to produce substantially no change in the impedance while maintaining the attenuation at substantially negligible value for the given frequency.

In testimony whereof, I have signed my name to this specification this 18th day of November, 1922.

RUSSELL N. HUNTER.