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H. NYQUIST ET AL

ECHO SUPPRESSOR

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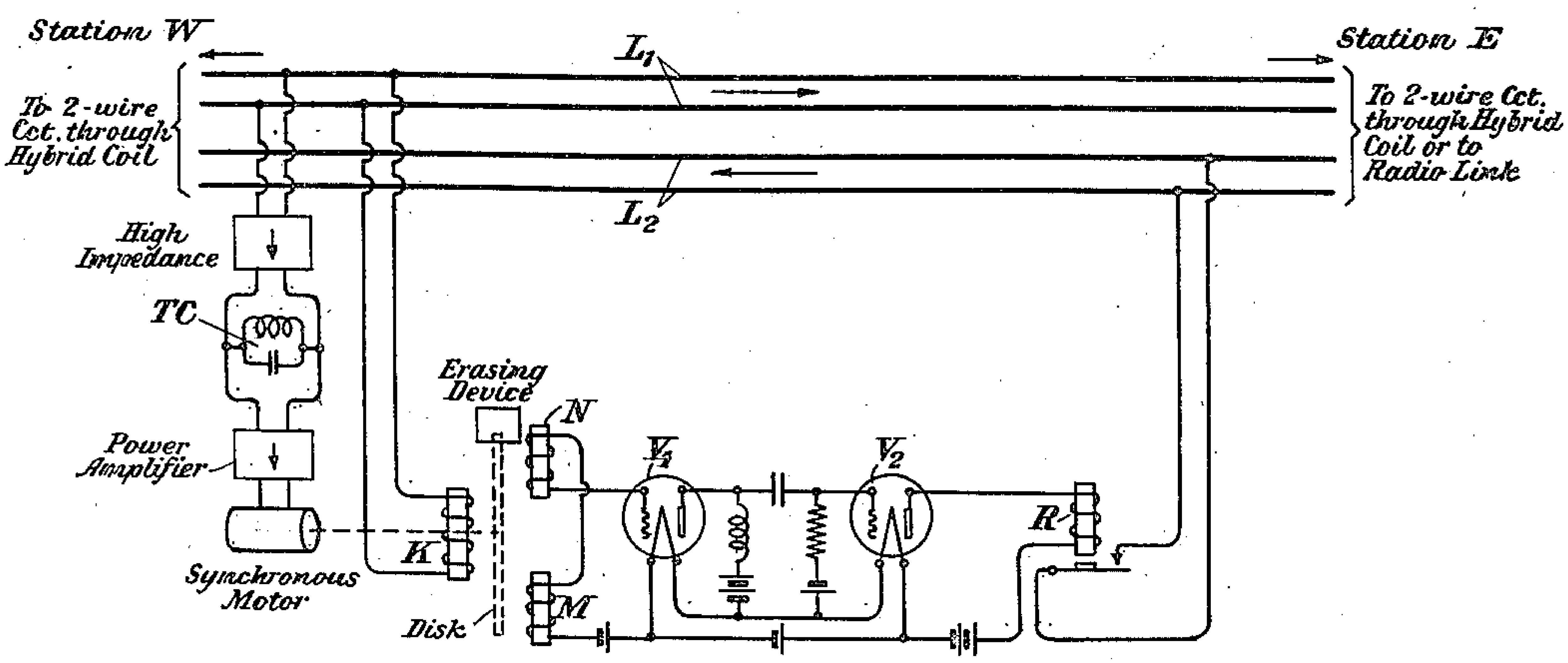

Fig. 1

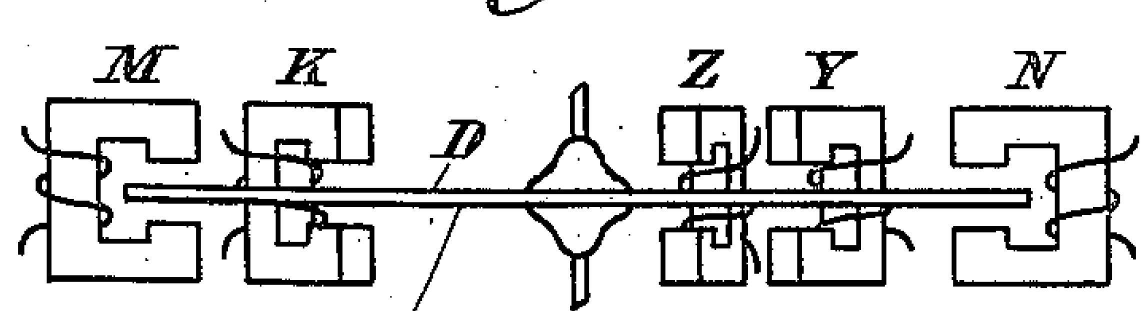

Fig. 2

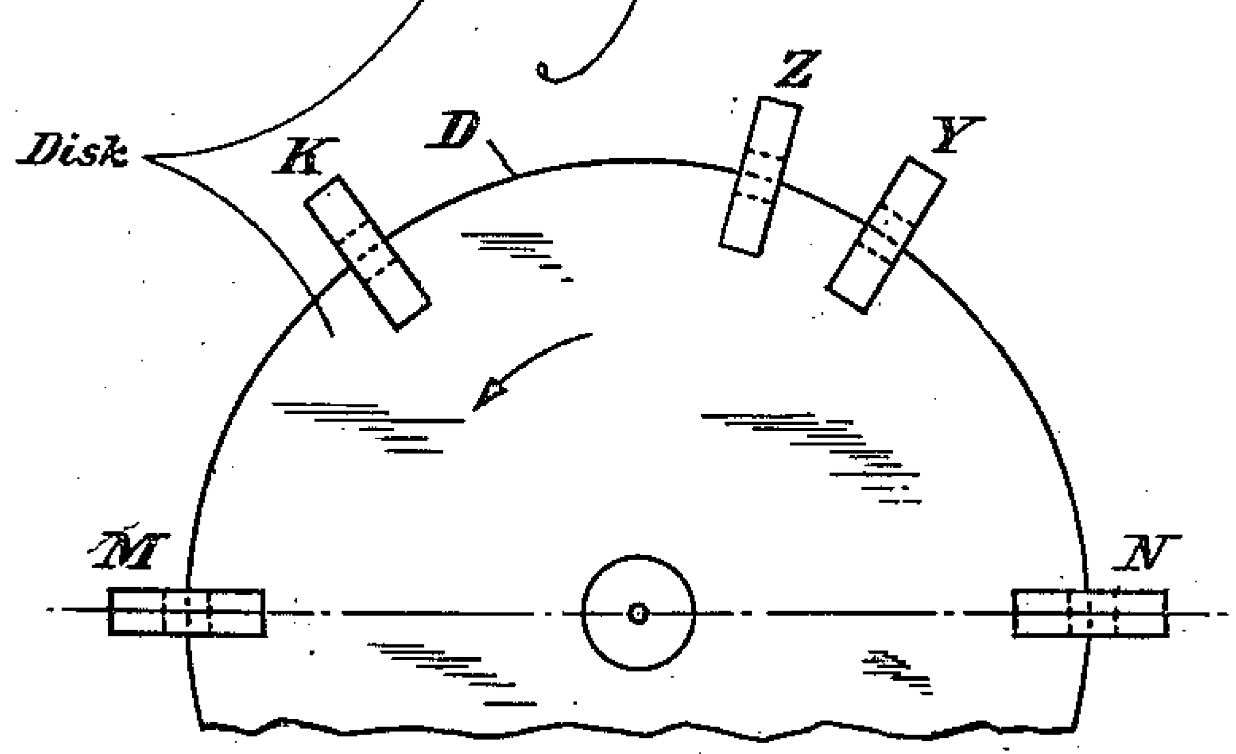

Fig. 3

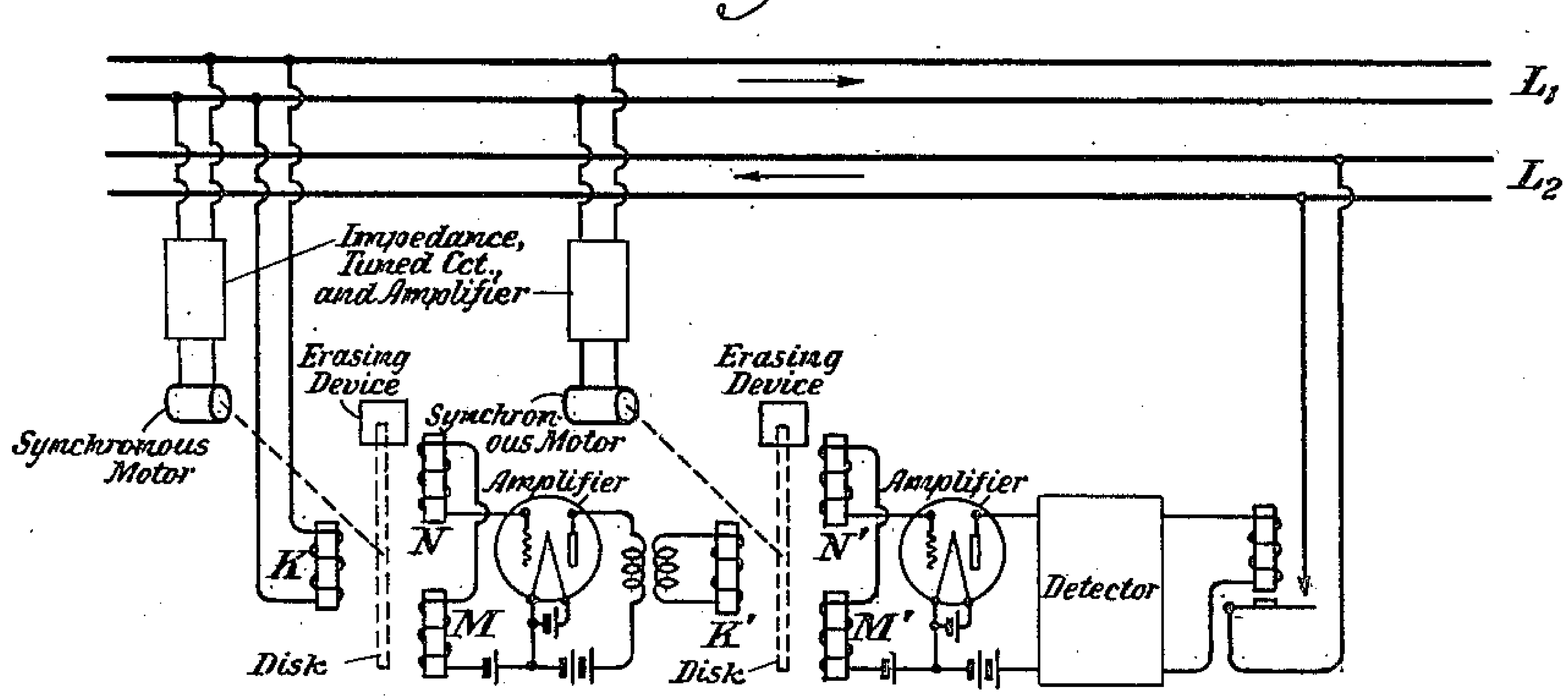

Fig. 4

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UNITED STATES PATENT OFFICE.

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ECHO SUPPRESSOR.

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This invention relates to the four-wire sections of two-way telephone systems, and more particularly to voice-operated devices associated with the circuits for preventing echoes therein.

The four-wire sections of two-way telephone systems have one path adapted for transmission in one direction and another path adapted for transmission in the opposite direction, and these two paths are connected at each end of the circuit in the case of all-wire systems through a hybrid coil to a two-wire line, which line is approximately balanced by a suitable network. In some systems the transmission is in part over a radio link, and in such cases the four-wire section may be connected at one end to a two-wire line through a hybrid coil and at the other end to radio apparatus for transmission over and reception from the radio link.

Since the balance of the two-wire line and the associated network is not perfect there is the likelihood that currents flowing in one of the transmission paths of the four-wire circuit will be reflected back from the two-wire line over the other transmission path, producing "echoes". In order to suppress these echoes voice-operated means have been devised which respond to voice currents in one path and function to short-circuit or otherwise disable the opposite path. For a full disclosure of echo suppressor arrangements as applied to all-wire circuits, reference may be had to an article by A. B. Clark and R. C. Mathes in the Journal of the American Institute of Electrical Engineers, June, 1925, pages 618 to 626.

If the transmission lines of the telephone system run parallel to power lines or are subject to other interference, the current responsive devices for disabling one path of the four-wire circuit may be falsely operated by the interfering currents in the voice channels.

The object of the applicants' invention is to provide a voice-operated echo suppressing arrangement which is free from operation by one or more frequencies and their harmonics, but will respond readily to all other frequencies within the range contemplated.

In general the applicants employ the well known amplifier-detector device for controlling a switch to short-circuit one transmission path, and balance out, or otherwise render ineffective, in the input to the amplifier, the frequencies which are to be barred.

The novel features and the advantages of the invention will be more clearly understood when the following description of one desirable embodiment and a modification thereof is read with reference to the accompanying drawing.

Figure 1 of the drawing shows diagrammatically, and in association with two lines adapted for transmission in opposite directions, an arrangement for protecting the voice-operated apparatus against one frequency and its harmonics, the arrangement involving the use of a disk telegraphone.

Fig. 2 is a view in elevation taken toward the edge of the disk, showing the disk and the associated electromagnetic devices.

Fig. 3 is a view taken toward one flat side of the disk and shows the circumferential spacing of the electromagnetic devices.

Fig. 4 shows diagrammatically a suitable modification of the arrangement shown in Fig. 1 for taking care, in certain cases, of two fundamental interfering frequencies and their harmonics.

Wherever like characters of reference are used in the several figures of the drawing, they designate corresponding parts.

With reference to the details of the drawing, and with particular reference first, to Fig. 1, the telephone lines L_1 and L_2 are understood to be the two paths of a four-wire circuit forming part of a two-way telephone system, as indicated and briefly discussed above. Line L_1 is adapted for transmission from station W at the left to station E at the right, and line L_2 is adapted for transmission in the opposite direction. It is understood of course that these voice paths are associated at one end directly and at the other end either directly or over a radio link to a two-wire line through the usual hybrid coil, as clearly disclosed in the above identified article.

The voice-operated device shown comprises a vacuum tube amplifier V_1, a vacuum tube detector V_2 associated therewith, and a relay

R controlled by the operation of the detector for short-circuiting the line L_2 in response to voice currents in the line L_1. It is to be understood of course that for the suppression of echoes in the opposite direction similar apparatus is provided to short-circuit the line L_1 in response to voice currents flowing in L_2. If now interfering currents, such as currents from power lines, having a certain frequency, flow in the line L_1, they may operate the amplifier-detector V_1—V_2 and the associated switching device to produce a false short-circuiting of the line L_2.

In order to prevent the operation of the echo suppressor by currents of a given frequency or its harmonics, the applicants employ a device for balancing out in the input circuit of the amplifier V_1 the given frequency and its harmonics. This device may take the form of a soft iron disk telegraphone, as will now be more specifically described. The electromagnetic device K has its winding connected across the line L_1. This device and the electromagnetic devices M and N, which are connected series-opposing in the input circuit of the tube V_1, are associated with a disk, as indicated in Fig. 1 and more clearly shown in Figs. 2 and 3. The device K serves to record the currents in line L_1 on the disk D by magnetizing it with varying intensity as it rotates at a speed to be discussed hereinafter. When the magnetized portion on the disk rotates past the inductive devices M and N, voltages are induced in the windings of M and N similar in form to the line currents. The device N is located just far enough beyond the device M in the path of the rotating disk so that the voltages of the fundamental interfering frequency against which protection is desired are a whole number of cycles out of phase in the windings of these devices, and voltages of all other frequencies, except, of course, the harmonics of this fundamental interfering frequency, are not entirely out of phase. All harmonics of the fundamental frequency of course will, like the fundamental frequency, be a whole number of cycles out of phase. If the voltages induced in M and N are equal, and the windings of these two devices are connected series-opposing, the resultant voltage in the input of the amplifier V_1, due to the interfering frequencies, is zero, as will readily be understood by those skilled in the art. Any other frequencies within the range contemplated, however, are transmitted to the amplifier, their voltages in M and N not being a whole number of periods apart. Thus it is seen that the arrangement for preventing operation of the amplifier-detector by a given frequency or its harmonics does not interfere with the operation by currents of any other frequency.

The electromagnetic devices indicated in Fig. 1 as comprising an erasing device, and more clearly shown in Figs. 2 and 3 as Y and Z, serve to demagnetize the disk after it has passed N and before it again passes K. The device Y may be a powerful magnet which increases the magnetism to a very high value in one direction, and the device Z a magnet of opposite polarity so adjusted as to bring the magnetism back to zero.

As clearly shown in Fig. 3, the electromagnets M and N are placed at opposite points in the path of the disk D. It will be understood that such positioning of M and N is not necessary. The fundamental requirement is that the time which elapses while a point on the disk passes from M to N be evenly divisible by the periods of the fundamental frequency to be eliminated. The spacing of M and N then must, obviously, have the proper relation to the speed of rotation of the disk. If a frequency of 60 cycles per second and all harmonics of that frequency are to be eliminated, then M and N may be positioned as shown in Fig. 3, and the time of one-half of a revolution of the disk must be n times $\frac{1}{60}$ seconds where n represents any whole number. In other words, with M and N in the positions shown in the drawing, a speed of rotation of the disk of $\frac{30}{n}$ revolutions per second is required to balance out the 60-cycle frequency and its harmonics.

It may be required that more than one fundamental frequency with the harmonics be eliminated and prevented from operating the echo suppressor. For instance, the line L_1 may run beside two power lines, one carrying 60 cycles and another 25 cycles. In this case, with M and N positioned as shown, the time of one-half of a revolution of the disk must be equal to $\frac{n}{60}$ which equals $\frac{m}{25}$, where n is one whole number and m is another whole number. Obviously the shortest time which satisfies both equations is $\frac{1}{5}$ second, n being equal to 12 and m being equal to 5. Thus we have a required speed of 2.5 revolutions per second.

The ordinary driving motor cannot run on both 60 cycles and 25 cycles. Accordingly, it becomes more difficult in this case of the two fundamental frequencies to provide for the automatic adjustment of the device to frequency changes. In such a case it becomes necessary to use two telegraphones operating in tandem, one disk being driven by a 60-cycle synchronous motor, for instance, and the other by a 25-cycle synchronous motor. This of course necessitates a duplication of the devices K, M, N, Y, and Z, and we have the arrangement diagrammatically shown in Fig. 4 of the drawing.

As indicated above, it is important that the disk or disks of the telegraphone arrangement be rotated at the proper speed. If the interfering frequency can be utilized to drive a synchronous motor, as the actuating device for the disk, the arrangement shown diagrammatically and in part schematically in Fig. 1 will take care of the case in which only one frequency with its harmonics is to be eliminated from the amplifier. A synchronous motor arranged to drive the disk is connected across the line L_1, and a high impedance device, a tuned circuit TC and a power amplifier are interposed. The arrangement of Fig. 4 provides for two synchronous motors each connected across the line L_1, as more fully disclosed in Fig. 1, and arranged to drive one of the two telegraphone disks.

It should be noted that if the echo suppressor is to operate with the minimum delay the recording device K should be placed on the path of the disk as close to the electromagnetic device M as is possible. If sudden changes occur in the load on the interfering power wires, a short period of time elapses during which M and N have induced voltages of the interfering frequencies which are unequal in magnitude and therefore will not give a zero resultant even though properly phased. In order that this time may be brought to the minimum, the time intervals n and m, discussed above, should be as small as possible.

It will be understood that other types of telegraphone may be employed. Furthermore, the electric phonograph may be used as a recording and reproducing device. Many other embodiments of the invention, widely different from that shown in the drawing and specifically described hereinabove for the purpose of clear illustration, may be used within the scope of the appended claims.

What is claimed is:

1. In association with two telephone lines adapted for transmission in opposite directions, controlling means responsive to currents in one of said lines, switching means controlled thereby for disabling the opposite line, and means for preventing the operation of said controlling means by currents of a given frequency or its harmonics flowing in the first line, said last named means permitting the operation of said controlling means by currents of any frequency other than the given frequency or its harmonics.

2. In association with two telephone lines adapted for transmission in opposite directions, controlling means responsive to currents in one of said lines, switching means controlled thereby for disabling the opposite line, and means for preventing the operation of said controlling means by currents of any one of a plurality of given frequencies or their harmonics flowing in the first line, said last named means permitting the operation of said controlling means by currents of any frequency other than the given frequencies or their harmonics.

3. In association with two telephone lines adapted for transmission in opposite directions, controlling means responsive to currents in one of said lines, switching means controlled thereby for disabling the opposite line, and means for balancing out in the input of said controlling means waves of a given frequency or its harmonics.

4. In association with two telephone lines adapted for transmission in opposite directions, controlling means responsive to currents in one of said lines, switching means controlled thereby for disabling the opposite line, and means for balancing out in the input of said controlling means waves of any one of a plurality of given frequencies or their harmonics.

5. In association with two telephone lines adapted for transmission in opposite directions, controlling means responsive to currents in one of said lines, switching means controlled thereby for disabling the opposite line, two electromagnetic devices having their windings connected series-opposing in the input of said controlling means, and means for inducing in said electromagnetic devices, successively, alternating voltages corresponding to the currents in the first line, the successive actions of said means on the two electromagnetic devices being separated by a time interval which is evenly divisible by the period of time corresponding to one cycle of a given frequency.

6. In association with two telephone lines adapted for transmission in opposite directions, controlling means responsive to currents in one of said lines, switching means controlled thereby for disabling the opposite line, a moving member, means for recording by magnetization on said moving member the varying intensity of the currents in the first line, two electromagnetic devices in the path of said moving member having their windings connected series-opposing in the input of said controlling means, and means for actuating said moving member, the speed at which said member moves bearing a relation to the distance on the path thereof between said two electromagnetic devices such that the time which elapses while a point on said moving member travels between said devices is evenly divisible by the period of time corresponding to one cycle of a given frequency.

7. In association with two telephone lines adapted for transmission in opposite directions, controlling means responsive to currents in one of said lines, switching means controlled thereby for disabling the opposite line, a moving member, means for recording by magnetization on said moving member the varying intensity of the currents in the first line, two electromagnetic devices in the path of said moving member having their windings connected series-opposing in the input of said controlling means, means for ac-

tuating said moving member, the speed at which said member moves bearing a relation to the distance on the path thereof between said two electromagnetic devices such that the time which elapses while a point on said moving member travels between said devices is evenly divisible by the period of time corresponding to one cycle of a given frequency, and means for demagnetizing said moving member.

In testimony whereof, we have signed our names to this specification this 8th day of October, 1927.

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KENNETH W. PFLEGER.