

April 1, 1930.

H. A. AFFEL

1,752,360

REDUCTION OF STATIC INTERFERENCE IN CARRIER SYSTEMS

Filed Nov. 15, 1928

2 Sheets-Sheet 1

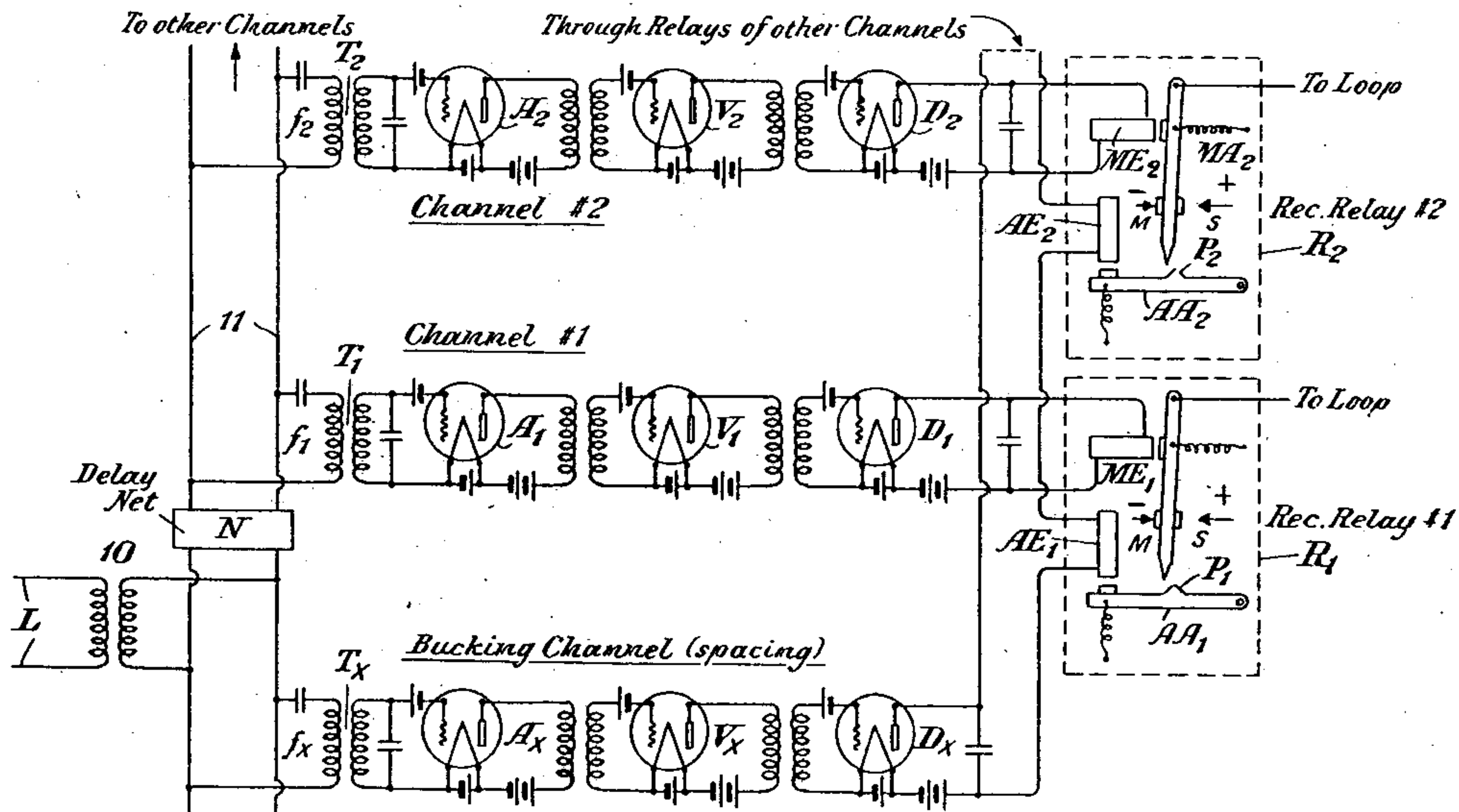


Fig. 1

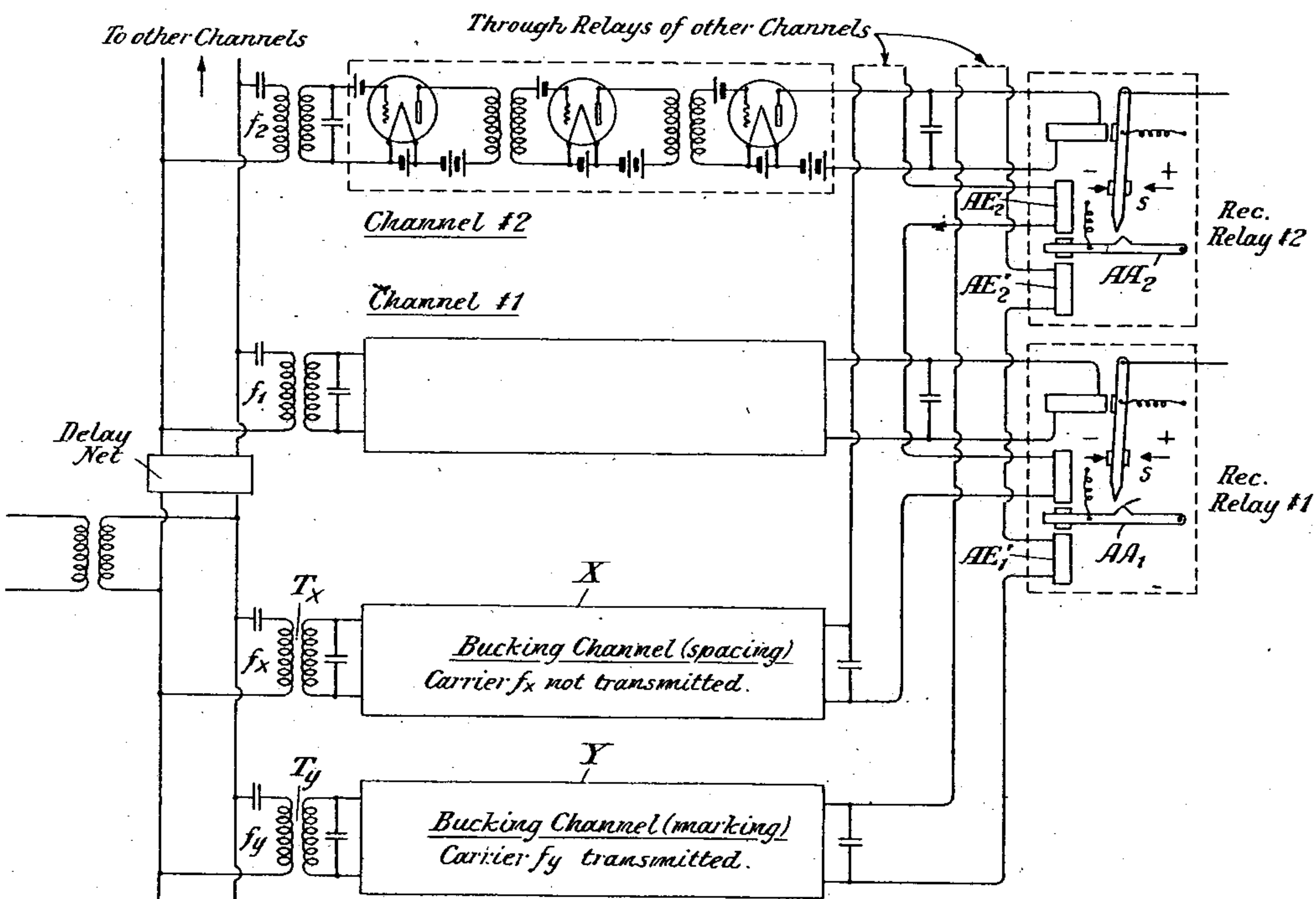


Fig. 2

INVENTOR

H. A. Affel

BY

g. H. H. H.

ATTORNEY

April 1, 1930.

H. A. AFFEL

1,752,360

REDUCTION OF STATIC INTERFERENCE IN CARRIER SYSTEMS

Filed Nov. 15, 1928

2 Sheets-Sheet 2

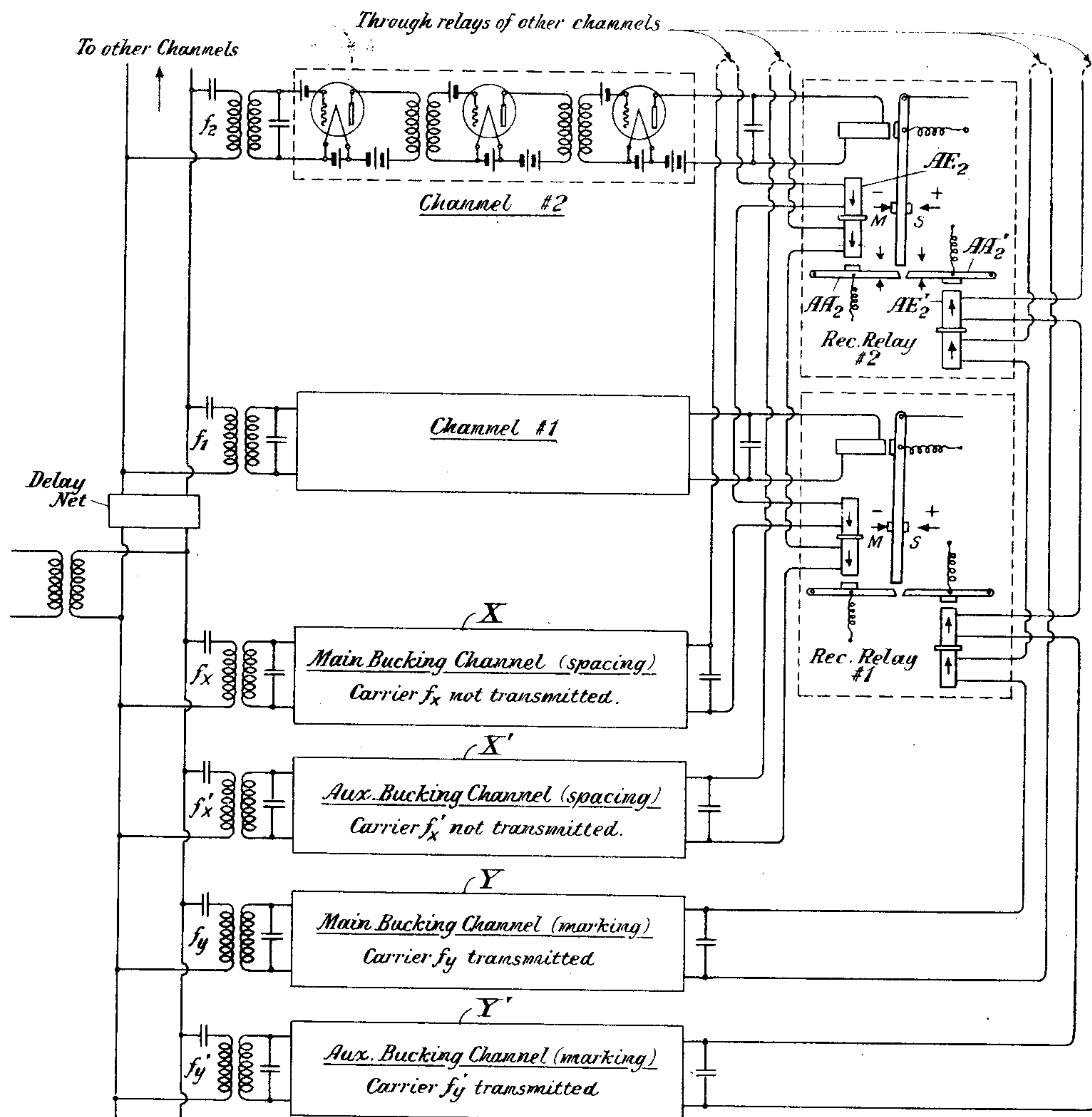


Fig. 3

INVENTOR
H.A. Affel
BY
[Signature]
ATTORNEY

UNITED STATES PATENT OFFICE

HERMAN A. AFFEL, OF RIDGEWOOD, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

REDUCTION OF STATIC INTERFERENCE IN CARRIER SYSTEMS

Application filed November 15, 1928. Serial No. 319,683.

This invention relates to wire and wireless carrier telegraph systems, and more particularly to arrangements for reducing the effect of lightning and other atmospheric interference upon such systems.

In carrier telegraph systems, lightning interference may produce interference either (1) as an undesired pulse during the spacing or no current interval, in which case the interference appears as a false marking signal, or (2) an instantaneous overloading of repeaters or receiving vacuum tube apparatus by the relatively large energy of the interfering pulse, in which case the "crowding" of the vacuum tubes by the superposition of the interfering pulse upon the normal carrier current of the channel reduces the current which operates the receiving relay, so that a false spacing signal may appear during a marking impulse.

In order to overcome this difficulty it has been proposed to provide, in addition to the regular receiving channels of the carrier system an auxiliary "bucking" channel in which no signals are ordinarily received, due to the fact that no carrier is transmitted corresponding to this channel. When a lightning discharge occurs, the auxiliary channel picks up one of the component frequencies of the lightning discharge, which is rectified to produce a pulse corresponding to the disturbing pulse occurring in the signal channels of the system. This pulse is transmitted through auxiliary windings of each of the receiving relays in such a direction as to tend to hold the armature of each receiving relay upon either its marking or spacing contact, depending upon which contact it rested against at the time the disturbing impulse occurred.

In order to send the correcting impulse through the auxiliary winding in the proper direction, it was the practice to associate with each receiving relay a reversing device controlled by the received signals so that the connections to the auxiliary winding were shifted each time the armature moved from one contact to the other. Due in part to the relatively small current appearing in the output of the rectifier, it was impracticable to operate the auxiliary windings of the various receiving

relays in parallel and they could not be operated from a rectifier in series because of the interrupting action of the various reversing relays. Consequently, it seemed best to provide a separate rectifier corresponding to each channel to provide the particular correcting impulses for the auxiliary winding of the given channel.

In order to do away with the necessity for the reversing relays and in order to be able to employ a single rectifier associated with the bucking circuit and common to the several receiving channels, it is proposed in accordance with the present invention to control and correct the action of the receiving relays mechanically instead of electrically. Accordingly, each receiving relay is provided with an auxiliary electromagnet built within its casing, which electromagnet controls an auxiliary armature so arranged as to lock or frictionally hold the main armature of the relay upon the contact against which it happens to rest whenever a disturbing impulse is rectified by the rectifier of the auxiliary or bucking channel. As the circuits of the auxiliary electromagnets of the receiving relays are not interrupted, the electromagnets of all of the channels may be operated in series from a common rectifier.

The invention will now be more fully understood from the following description, when read in connection with the accompanying drawing in which Figures 1, 2 and 3 illustrate circuit diagrams embodying the principles of the invention in accordance with several different modes of application.

Referring to Fig. 1, which illustrates the invention in its simplest form, the various currents of a multiplex carrier system are received in a circuit L which may be connected to either a wire line or a radio antenna. The circuit L is connected through a transformer 10 to the bus-bars 11 to which the various receiving channels are connected. There may be any desired number of receiving channels connected to the bus-bars 11, but in the ordinary wire carrier telegraph practice there are usually ten channels. The apparatus for each channel is similar to that of all the other channels except that the se-

lecting apparatus of the channel is adjusted to select the particular frequency assigned to the particular channel.

Of the two channels illustrated, a description of the apparatus of one, for example, channel No. 2, will suffice. This comprises a tuned selecting circuit T_2 associated with the bus-bars 11 for selecting the carrier frequency f_2 assigned to the channel. Vacuum tube amplifiers A_2 and V_2 are provided for amplifying the carrier frequencies. A rectifying vacuum tube D_2 is also provided for translating the carrier frequencies into direct current signal impulses. The grid of the vacuum tube D_2 is so biased by means of a C battery that with no carrier current present, no current will flow in the plate circuit. When carrier current is applied to the grid, however, a rectified one-way current flows in the plate circuit of the rectifier Tube D_2 . The main electromagnet ME_2 of the receiving relay R_2 is included in the plate circuit of the rectifier to operate the main armature MA_2 of the receiving relay.

In the system as illustrated, it is assumed that carrier current is transmitted during the marking interval and that no carrier current is transmitted during the spacing interval. Normally, when no signaling is taking place, the carrier current is continually on the circuit so that a steady direct current flows through the electromagnet ME_2 to hold the armature of the receiving relay R_2 upon its marking contact. Each time a spacing signal is transmitted by interrupting the carrier current, the rectified current through the electromagnet ME_2 ceases and the armature MA_2 is shifted to its spacing contact by some biasing means, such as a biasing winding or a spring. For purposes of illustration a spring is shown.

The effect of a lightning or other atmospheric discharge upon the system so far described is as follows: If, at the time the lightning discharge occurs, a spacing signal is being transmitted so that normally no carrier would be present, the selecting device T_2 of the channel will pick up one of the component frequencies of the lightning discharge which corresponds to the frequency of the channel, so that this wave will be amplified and impressed upon the rectifier D_2 to produce a short pulse of direct current tending to shift the armature MA_2 of the receiving relay from its spacing contact to its marking contact, thereby causing a false signal. If the lightning discharge should occur during the transmission of a marking signal, the effect will depend upon the magnitude of the energy of the static discharge at the frequency corresponding to the channel. If this energy is not so large as to overload the tubes of the system, it merely tends to produce a larger rectified current in the plate circuit of the rectifier D_2 so that the electromagnet ME_2 of

the receiving relay increases the pull, tending to hold the armature MA_2 upon its marking contact. If, however, the energy of the static discharge is very large, so as to overload some parts of the system, the carrier current for each or any channel may be reduced in amplitude. This reduction in the carrier current of the particular channel under consideration may result in a decreased current in the plate circuit of the rectifier D_2 so that the electromagnet ME_2 may release the armature MA_2 . This would cause a false space signal. On the other hand, if the disturbance occurs just as the marking signal is about to cease, its effect may be to cause the armature MA_2 to hold over against the marking contact until the interfering discharge ceases, thereby prolonging the marking impulse but not necessarily causing a false signal.

In order to correct for these false signals, an extra (bucking) channel is associated with the bus-bars 11, this channel comprising a selecting circuit T_x , amplifiers A_x and V_x , and a rectifier D_x . These elements are all similar to the corresponding elements of the regular signaling channels. The selecting device T_x is so adjusted as to select a frequency different from that of any of the signaling channels but reasonably closely related thereto, as, for example, a frequency just below or just above the regular range of signaling carrier frequencies. No carrier current is, however, transmitted from the distant station corresponding to the frequency assigned to the bucking channel, and consequently, under normal conditions, no space current flows in the plate circuit of the rectifier D_x .

Each of the receiving relays, such, for example, as R_2 , is provided with an auxiliary electromagnet AE_2 mounted within the relay casing. These auxiliary electromagnets for the several receiving relays are connected in series in the plate circuit of the rectifier D_x . Each auxiliary electro-magnet as, for example, AE_2 , controls an auxiliary braking or locking armature AA_2 . The main armature MA_2 , which controls the signals to the subscriber's loop, terminates in a knife edge and the armature is preferably somewhat flexible. The auxiliary armature AA_2 is provided with a wedge-shaped projection P_2 , as shown. If the main armature is upon either its marking or spacing contact and the auxiliary armature is attracted by the auxiliary electromagnet AE_2 , the projection P_2 engages the end of the main armature and locks or brakes it in its assumed position.

The operation is as follows: Assume that a spacing signal is being received in channel No. 2 and that a lightning discharge occurs. The effect of this discharge upon channel No. 2 is, as has already been stated, to produce a false marking signal tending to shift the main armature of the receiving relay R_2 from its spacing contact to its marking contact.

The bucking channel, however, picks up some of the energy of the lightning discharge corresponding in frequency to the frequency assigned to the bucking channel and thereby causes a rectified current to flow in the plate circuit of the rectifier D_2 . This rectified current flows through the auxiliary electromagnets of the various receiving relays, including the auxiliary electromagnet AE_2 of the relay R_2 , thereby causing the auxiliary armatures to be attracted and to lock or bias the main armatures in the position which they then occupy. In the case of the armature MA_2 of channel No. 2, which is resting against its spacing contact, the effect of the correcting pulse through the electromagnet AE_2 is to cause the projection P_2 upon the auxiliary armature to engage the main armature and hold it against its spacing contact notwithstanding the pull due to the false signal through the electromagnet ME_2 which tends to shift the main armature to its marking contact.

If, at the time the lightning discharge occurs, channel No. 2 is receiving a marking signal, the armature MA_2 will be resting upon its marking contact. Just before the disturbance occurs, the bucking channel is idle as no carrier frequency is being transmitted from the distant station corresponding to this channel. When the disturbance occurs, however, the bucking channel picks up the component frequency of said discharge corresponding to said channel, thereby causing a rectified current to flow through the windings of the auxiliary electromagnets such as AE_2 , as before. Again the auxiliary armatures are attracted, and in the case of the relay R_2 , the projection P_2 engages the main armature to hold it against the marking contact. If the lightning discharge were sufficient to reduce the plate current in the rectifier D_2 so as to tend to release the armature MA_2 of the receiving relay R_2 , such action is prevented by the action of the auxiliary electromagnet. If, however, the lightning discharge were not of a character to produce such an effect, its tendency would be to produce an additional current flow through the electromagnet ME_2 to hold the armature against its marking contact, and so no objectionable effect would be produced. The action of the bucking channel is in this instance an assisting one as it also tends to hold the armature against its marking contact. In this respect the present system differs from the usual balance methods which have been suggested from time to time, in that the bucking impulse does not balance the disturbing impulse in the signaling channel in the case last assumed, but actually aids it.

It will, of course, be evident that if the lightning discharge occurs just as the main armature of the receiving relay is about to shift from one contact to the other, the cor-

recting impulse produced in the bucking channel will cause the armature to be mechanically held over against the contact upon which it is then resting and thereby slightly prolong the marking or spacing signal, as the case may be. This, however, does not necessarily produce a false signal, and in any event would occur only at rare intervals so as to constitute a relatively small factor in the operation of the system. It will also be evident that under certain conditions lightning discharges might produce pulses in the bucking channel without producing any effect upon certain of the signaling channels, due to the fact that the lightning discharge comprises no component frequencies corresponding to those particular channels. In such case the correcting pulse would tend to hold the armature of the receiving relay against the contact upon which it then rested but in no case would it produce any undesirable effect unless, as just stated, the disturbing impulse should occur when the armature is about to shift from one contact to the other, which would rarely occur, and would not in general cause a false signal.

It will also be apparent that under certain conditions the disturbance will comprise frequencies corresponding to some or all of the signaling channels, but will not include a frequency corresponding to the bucking channel. In such a case the bucking channel will, of course, be without effect and false signals will occur. This also rarely happens, particularly if the frequency assigned to the bucking channel is closely related to that of the carrier channels. This possibility, while of small consequence, may be overcome by providing additional bucking channels, as will be described later.

In order to enable the auxiliary electromagnets to act upon the auxiliary armatures of the various receiving relays in response to the correcting pulse produced by the bucking channel before the disturbing pulse manifests itself in the main electromagnets of the receiving relays, a delay network of known type may be inserted between the various signaling channels and the circuit L_2 , as indicated at N.

Fig. 2 illustrates an arrangement in which some improvement in operation may be attained through the provision of an additional bucking channel. The channel apparatus of the various signaling channels, aside from the receiving relays, is the same as that of Fig. 1 and need not be further described. Likewise, the channel apparatus of the bucking channel X is similar to that of the bucking channel described in connection with Fig. 1. In other words, the bucking channel is a spacing channel inasmuch as no carrier frequency corresponding to this channel is normally transmitted from the distant signal station. This bucking channel, as before, controls aux-

iliary electromagnetic, such as AE_2 , of the various receiving relays. The additional bucking channel Y likewise comprises apparatus similar to that of the channel X, but in this instance a different frequency f_y is assigned to the channel so that if the disturbing lightning discharge should comprise no frequency corresponding to the channel X, it would ordinarily include a frequency corresponding to the channel Y, particularly where the frequencies f_x and f_y are arranged with respect to the receiving signaling channel so that one frequency is immediately above the channel frequency and the other is immediately below the channel frequency in the frequency spectrum.

The plate circuit of the rectifier of the second bucking channel Y includes serially additional auxiliary electromagnets, such as AE_2' , for the various receiving relays. This additional auxiliary electromagnet is arranged to operate upon the auxiliary armature which is also controlled by the auxiliary electromagnet, such as AE_2 . A carrier frequency f_y corresponding to the channel Y is transmitted from the distant station at all times and the effect of this in the channel Y is to produce continuous current flowing through the various electromagnets, such as AE_2' , tending to hold the auxiliary armature away from the main armature. The effect of a lightning discharge, so far as the bucking channel X is concerned, is to cause the auxiliary electromagnet, such as AE_2 , to pull up the auxiliary armature AA_2 to bias or hold the main armature against the contact upon which it is then resting. If the lightning discharge produces a crowding action in the signaling channels, a corresponding crowding will ordinarily occur with respect to the current of frequency f_y , so that it will be reduced in magnitude, thereby causing the electromagnets, such as AE_1' , AE_2' , etc., to tend to release the auxiliary armatures, thereby holding the main armatures locked against false signals, even though no component of frequency f_x is received.

If the lightning discharge comprises a frequency corresponding to f_x and no frequency corresponding to f_y , the channel apparatus X will energize the auxiliary electromagnet AE_2 to attract the auxiliary armature against the normal pull due to the electromagnet AE_2' under the control of the channel Y. In order to insure this result, the armature AA_2 is normally pulled against the attraction of the electromagnet AE_2' by means of a spring. If the lightning discharge comprises a frequency corresponding to that of the channel Y and no frequency corresponding to the channel X, the crowding of the carrier frequency normally supplied to the channel Y may reduce the rectified current flowing through the auxiliary electromagnet, such as AE_2' , and thereby cause the auxiliary arma-

ture to be released after locking the main armature in the position it then occupies.

If desired, the holding actions of the spacing and marking bucking circuits X and Y may be made independent by the use of two separate holding armatures for each receiving relay, as illustrated in Fig. 3. Here the spacing bucking channel X includes a winding of one auxiliary electromagnet, such as AE_2 , of each receiving relay, and controls an auxiliary armature, such as AA_2 . The marking bucking channel to which is assigned the frequency f_y in turn controls windings of additional auxiliary electromagnets, such as AE_2' , of each receiver. Each electromagnet such as AE_2' in turn controls a second auxiliary armature, such as AA_2' .

If a spacing signal is being received by channel No. 2 and a disturbance occurs, the frequency f_x is picked up by the bucking channel X, thereby causing the electromagnet AE_2 to attract the armature AA_2 and lock the main armature against its spacing contact. If, however, a marking signal is being received by channel No. 2 and a disturbance (having no components of frequency f_x) causes crowding, with its consequent reduction of the carrier current of channel No. 2, tending to cause a false spacing signal, the bucking channel Y comes into play. This channel is normally supplied with carrier current of frequency f_y from the distant sending station, and this current is reduced in amplitude by the overloading action of the disturbance. The current flowing through the winding of the electromagnet AE_2' under the control of the bucking channel Y, is decreased so that the armature AA_2' is retracted to lock the main armature against its marking contact.

As has been previously pointed out, the possibility of false signals, due to the lightning discharge having no frequency corresponding to a given bucking channel, may be reduced by providing additional bucking channels having other frequencies. Fig. 3 also shows the application of this idea to an arrangement in which separate auxiliary armatures are controlled by the marking and spacing bucking channels. To accomplish this result, an auxiliary spacing channel X' is provided, the frequency assigned thereto being preferably so related to that assigned to the channel X that the one will be above the frequencies of the signaling channels and the other below said frequencies. The apparatus of the channel X' is in all respects similar to that of the channel X and its rectifier includes in its plate circuit aiding windings upon each of the auxiliary spacing electromagnets, such as AE_2 , of the various receiving relays. Likewise, an auxiliary marking channel Y' is provided similar in all respects to the marking channel Y except that the carrier frequency transmitted there-

to from the distant station will be different from that of the channel Y, the two frequencies being preferably so related that one may be above and the other below the frequencies of the various receiving channels. The rectifier of the channel Y' includes aiding windings on each of the auxiliary marking electromagnets, such as AE_2' , of the various receiving relays.

It will be evident that since the winding controlled by the channel X' aids the winding controlled by the channel X, the proper effect upon the armature AA_2 will be produced if the disturbing lightning discharge includes a frequency corresponding to either or both of the spacing channels. Consequently, the provision of an additional spacing channel tends to insure against false operation, due to the fact that one spacing channel happens to be ineffective, and this is true whether the purpose of the relay AE_2 is to lock the main armature in its spacing position, as in Fig. 3, or to lock it in either its marking or spacing position, as in Fig. 1.

Also, it is apparent that the marking channels Y and Y', since they control aiding windings of the auxiliary electromagnets, such as AE_2' , tend to supplement each other so that if one of these channels be ineffective to control the auxiliary armature AA_2' , the other channel may still be relied upon. Of course, in the case of a marking channel, such as Y, since it depends for its effect upon the crowding action of the disturbing discharge, and such crowding action will in general occur regardless of whether or not the lightning discharge contains any frequency corresponding to the channel Y, there is less necessity for providing an auxiliary marking channel such as Y'. Considerations of economy would, therefore, in general dictate that this additional channel be not provided.

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 multiplex carrier system comprising a plurality of receiving channels each including a receiving relay, the method of reducing false signals due to interference, which consists in selecting from the interfering energy a component whose frequency differs from the carrier frequencies assigned to the channels, translating the energy of the selected component into mechanical energy, and applying said mechanical energy to restrain the movement of the armatures of the receiving relays of the channel.

2. In a carrier system having receiving apparatus including a receiving relay, the method of reducing false signals due to interference, which consists in selecting from the in-

terfering energy a component whose frequency differs from that of the carrier frequency to which the receiving apparatus is responsive, translating the energy of the selected component into mechanical energy, and applying said mechanical energy to restrain the movement of the armature of the receiving relay.

3. In a carrier transmission system, receiving apparatus including means to detect from an alternating carrier current a telegraph signal current and a receiving relay responsive to detected current; an auxiliary channel comprising means to select from interfering energy a component of a frequency different from that of said alternating carrier current, and means to translate said component into a direct current pulse; said receiving relay including means adapted to mechanically restrain the movement of its armature; and means responsive to said direct current pulse to operate said restraining means.

4. In a carrier transmission system, a plurality of receiving channels each including means to detect from an alternating carrier current a telegraph signal current and a receiving relay responsive to detected current, an auxiliary channel comprising means to select from interfering energy a component of a frequency different from the frequencies of the carrier currents assigned to said receiving channels and means to translate said component into a direct current pulse, each receiving relay including means adapted to mechanically restrain the movement of its armature; and means responsive to said direct current pulse to operate each of said restraining means.

5. In a carrier transmission system, receiving apparatus including means to detect from an alternating carrier current a telegraph signal current and a receiving relay responsive to detected current; an auxiliary channel comprising means to select from interfering energy a component of a frequency different from that of said alternating carrier current and means to translate said component into a direct current pulse; said receiving relay including an auxiliary electromagnet with an armature adapted to restrain the main armature of said relay; and means whereby said direct current pulse will operate said auxiliary electromagnet to restrain said main armature.

6. In a carrier transmission system, a plurality of receiving channels each including means to detect from an alternating carrier current a telegraph signal current and a receiving relay responsive to detected current; an auxiliary channel comprising means to select from interfering energy a component of a frequency different from the frequencies of the carrier currents assigned to said receiving channels and means to translate said

component into a direct current pulse; each receiving relay including an auxiliary electromagnet with an armature adapted to restrain the main armature of the relay; and means whereby said direct current pulse will operate each of said auxiliary electromagnets to restrain the main armature of the relays.

7. In a carrier transmission system, a receiving channel; said receiving channel including means to select an alternating carrier current of a particular frequency, means to detect from said current a telegraph signal current, and a receiving relay including a main armature; an auxiliary channel; said auxiliary channel including means to select from interfering energy a component of a frequency different from that of said carrier current, and means to rectify the selected components; said receiving relay including an auxiliary electromagnet with an armature adapted to restrain the main armature of said relay; and circuit connections from said rectifying means to said auxiliary electromagnet whereby the latter may be operated to restrain said main armature.

8. In a carrier transmission system, a plurality of carrier receiving channels; each receiving channel including means to select an alternating carrier current of a different frequency, means to detect from the selected current a telegraph signal current, and a receiving relay including a main armature; an auxiliary channel; said auxiliary channel including means to select from interfering energy a component of a frequency different from that of the various carrier currents selected by said receiving channels, and means to rectify the selected component; each receiving relay including an auxiliary electromagnet with an armature adapted to restrain the main armature of said relay; and circuit connections from said rectifying means to each of said auxiliary electromagnets whereby each auxiliary electromagnet may be operated to restrain the corresponding main armature.

9. In a carrier transmission system, a plurality of receiving channels; said receiving channels each including means to select a carrier current of a different frequency from that of the other channels, means to detect from the selected carrier current a telegraph signal current, and a receiving relay responsive to detected current; a plurality of auxiliary channels; said auxiliary channels each including means to select from interfering energy a component of a frequency differing from the frequencies of the receiving channels and of any other auxiliary channel, and means to translate the selected component into a direct current pulse; each receiving relay including means adapted to restrain the movement of its armature; and means under the joint control of the translating means of the auxiliary channels to operate the restrain-

ing means of the relays of the receiving channels.

In testimony whereof, I have signed my name to this specification this 14th day of November, 1928.

HERMAN A. AFFEL.

70

75

80

85

90

105

110

115

120

125

130