

Aug. 12, 1924.

1,504,303

H. A. AFFEL

METHOD OF AND MEANS FOR REDUCING STATIC DISTURBANCES

Filed June 3, 1921

3 Sheets-Sheet 1

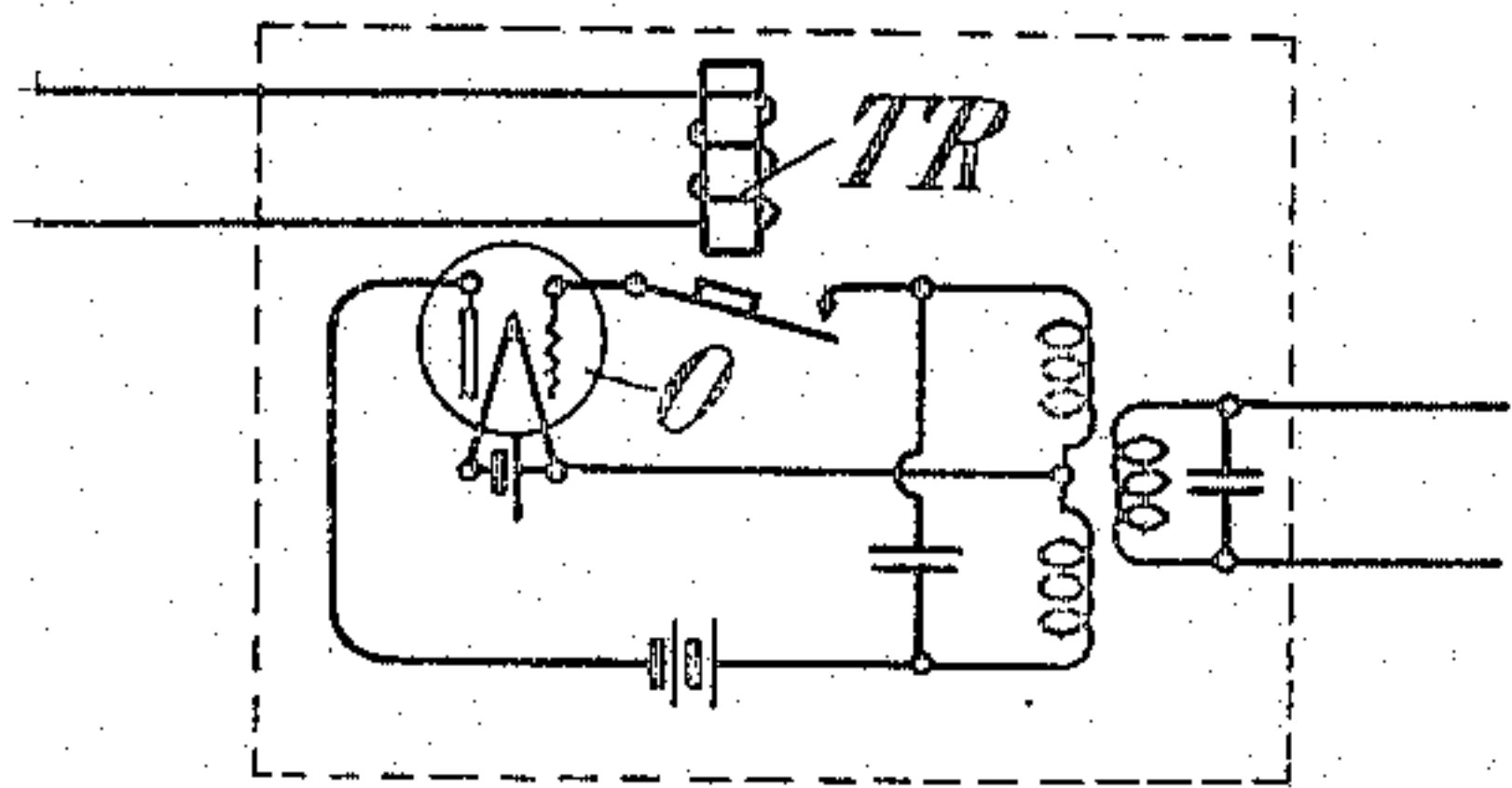


Fig. 1(a)

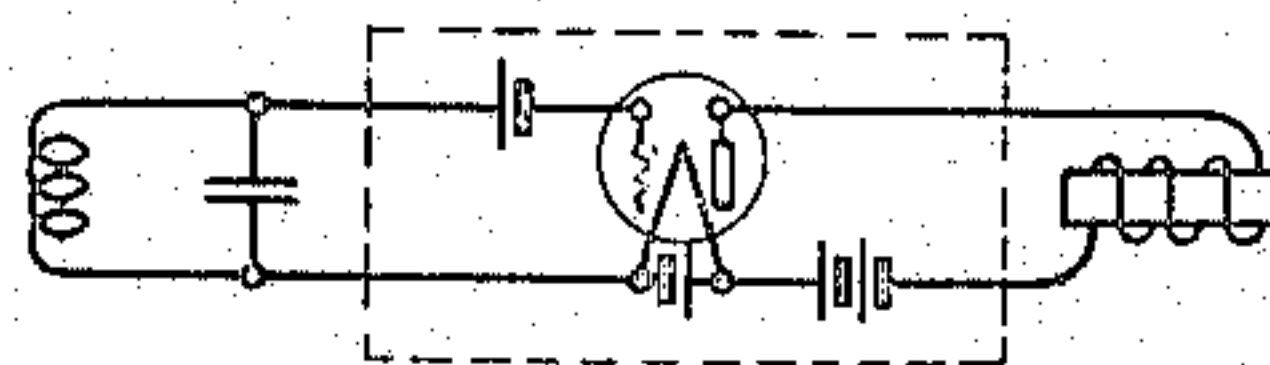


Fig. 2(a)

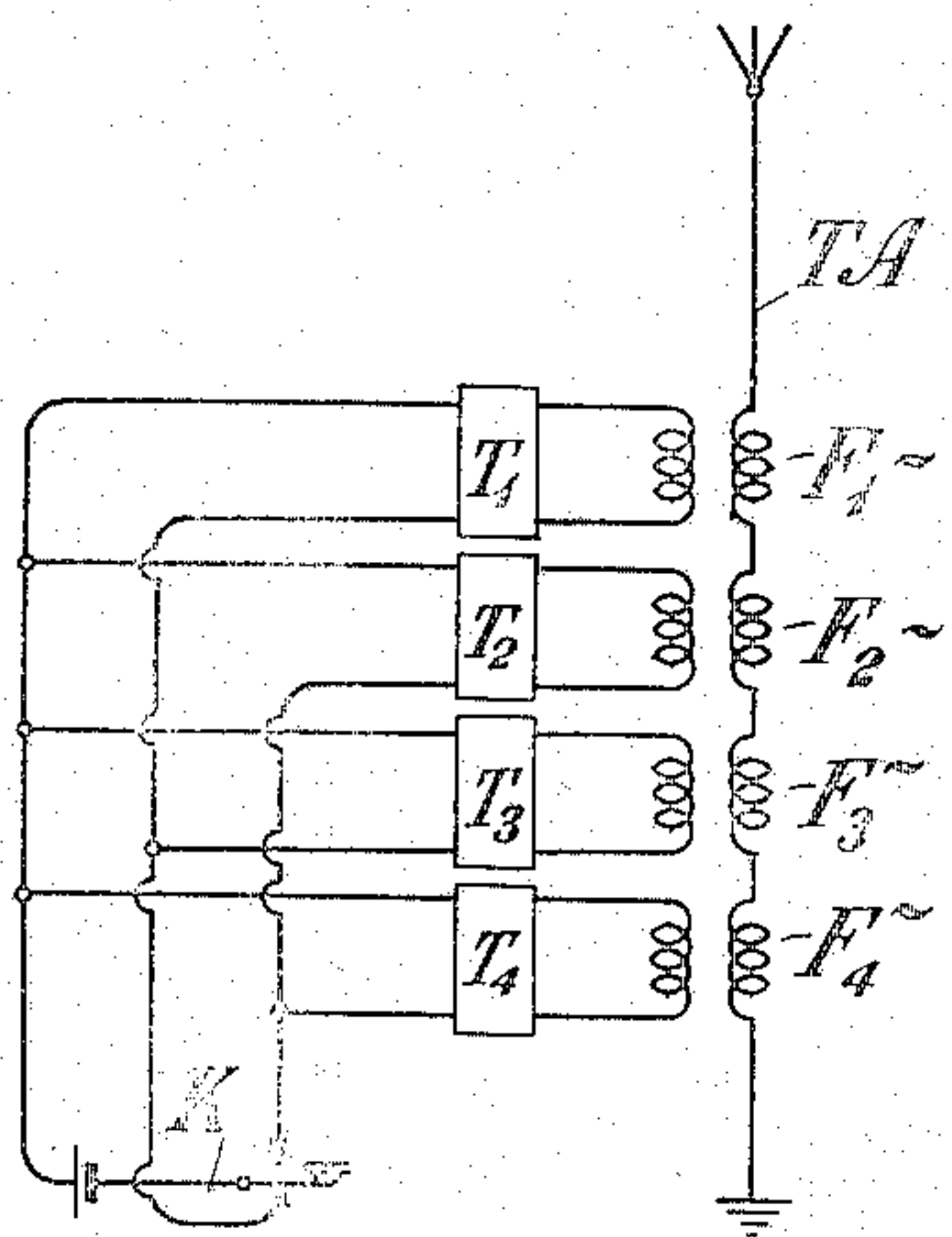


Fig. 1

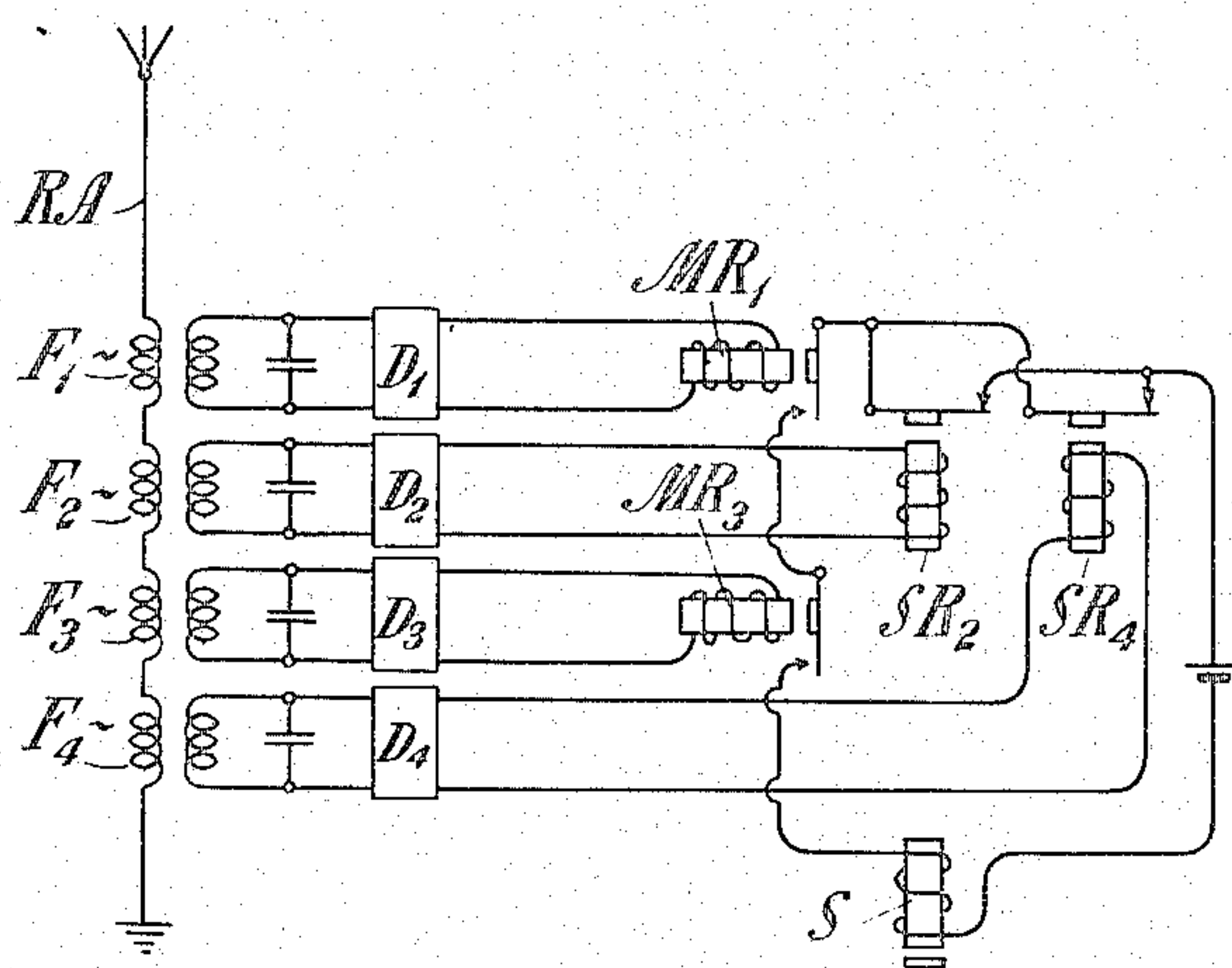


Fig. 2

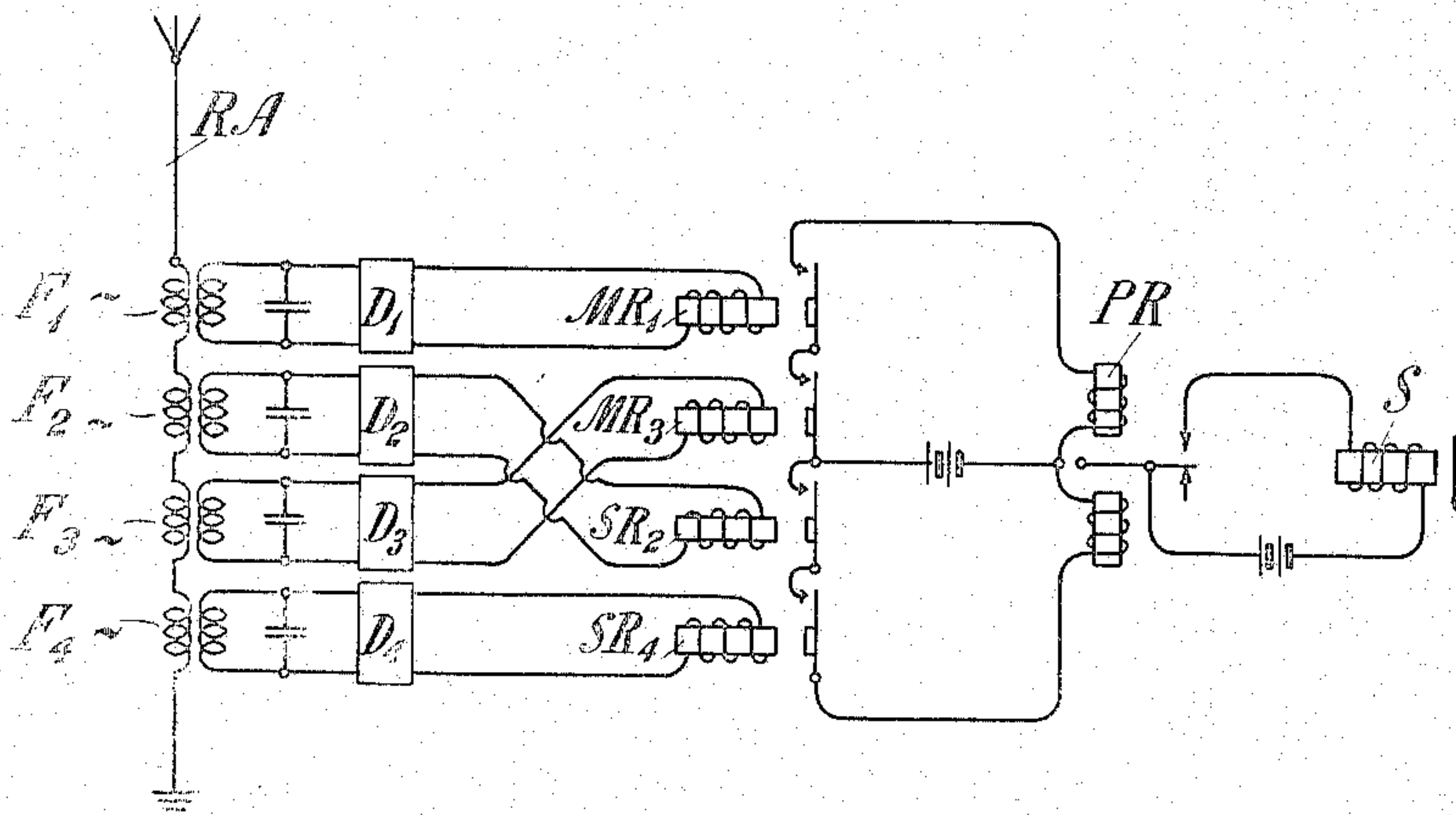


Fig. 3

Inventor
H. A. Affel

By his Attorney

g. e. yolk

Aug. 12, 1924.

H. A. AFFEL

1,504,303

METHOD OF AND MEANS FOR REDUCING STATIC DISTURBANCES

Filed June 3 1921

3 Sheets-Sheet 2

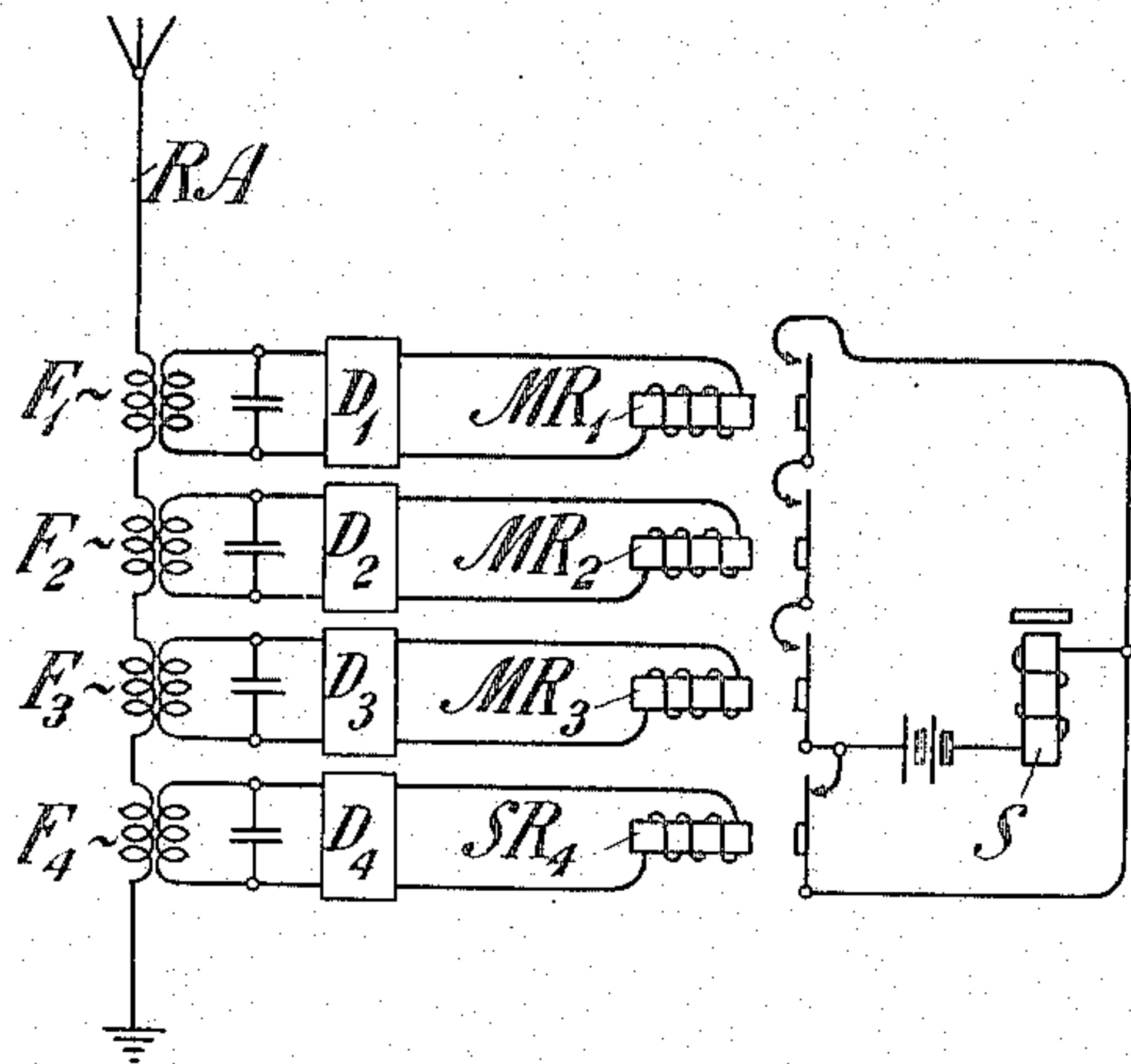


Fig. 4

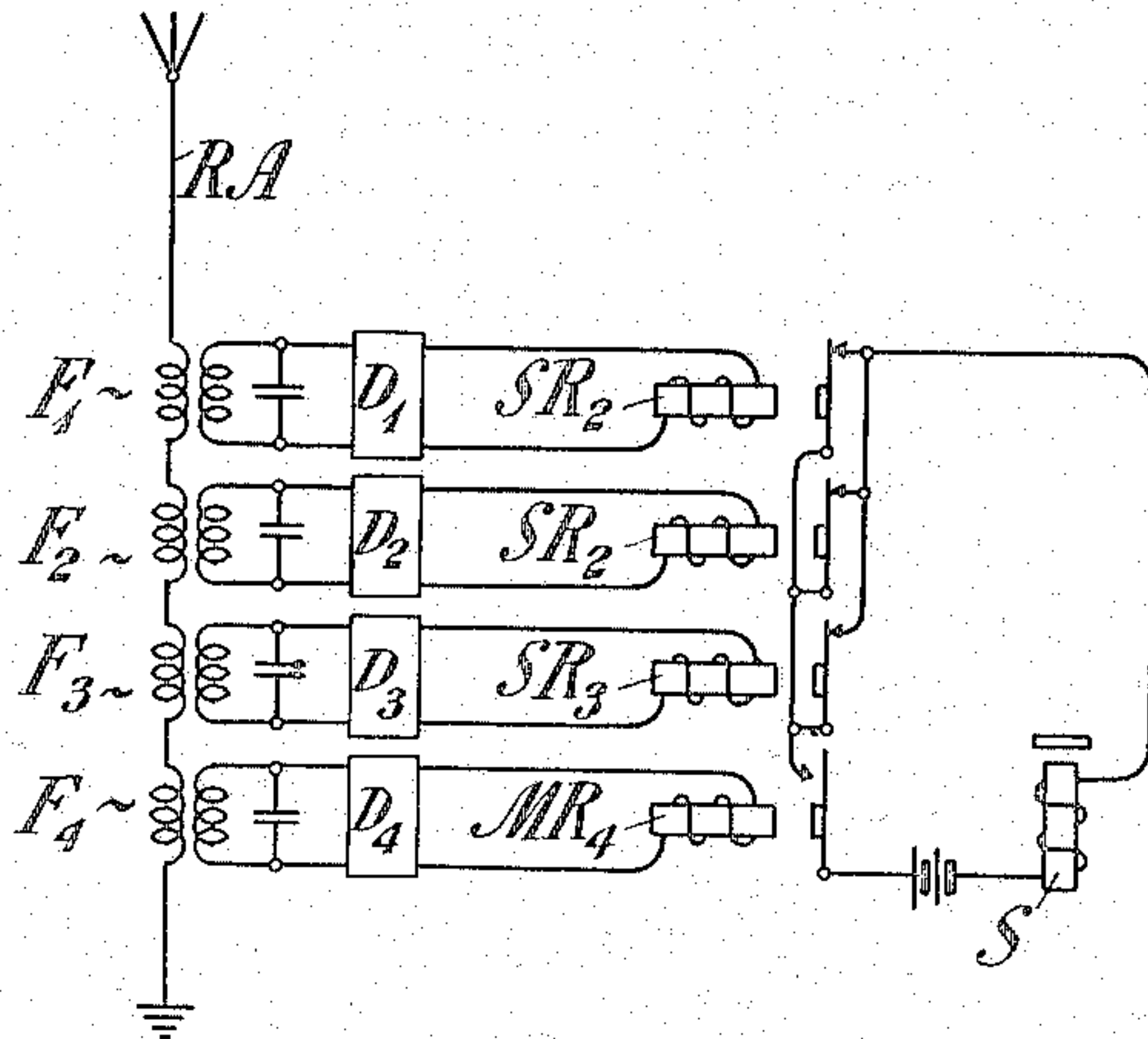


Fig. 5

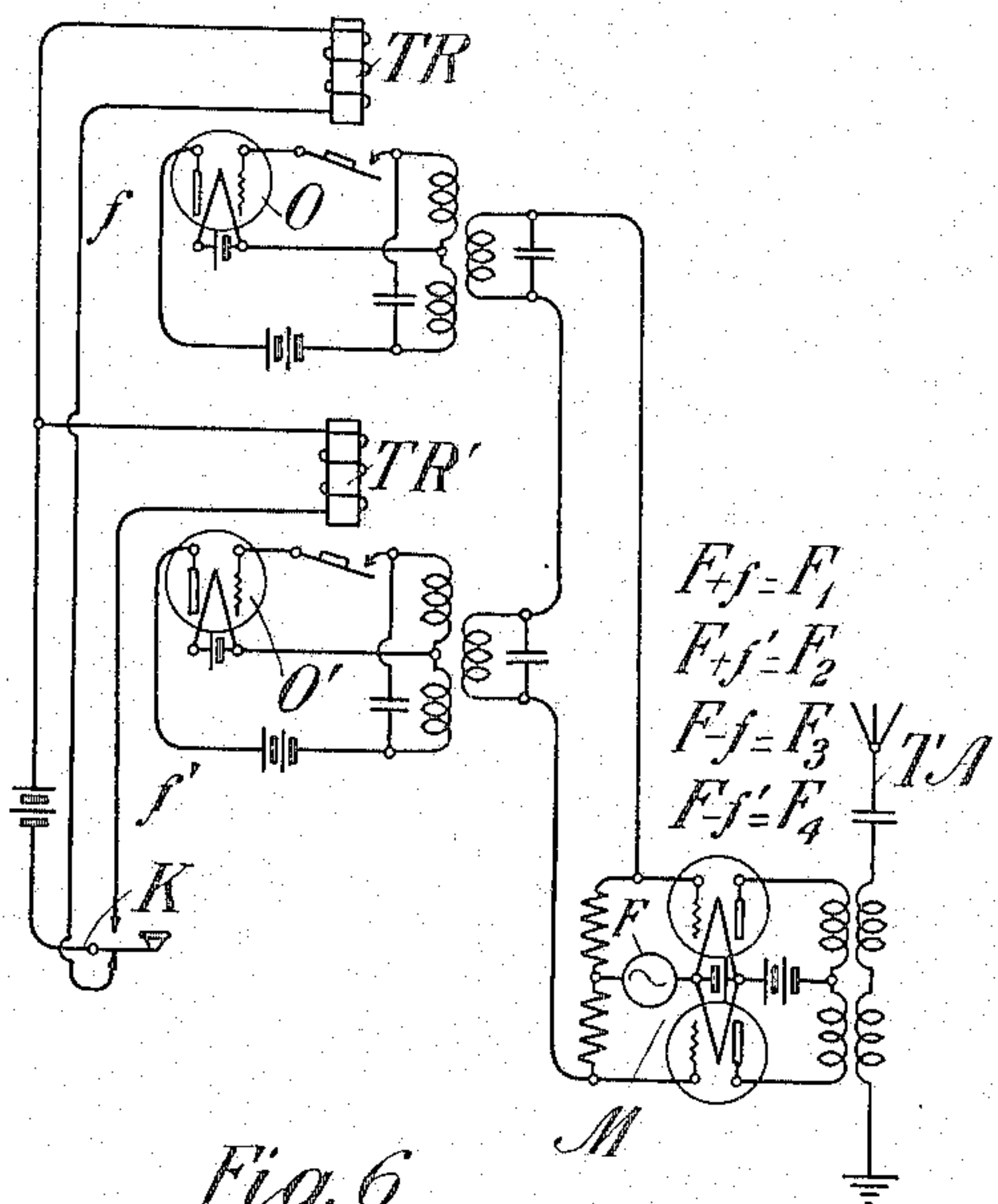


Fig. 6

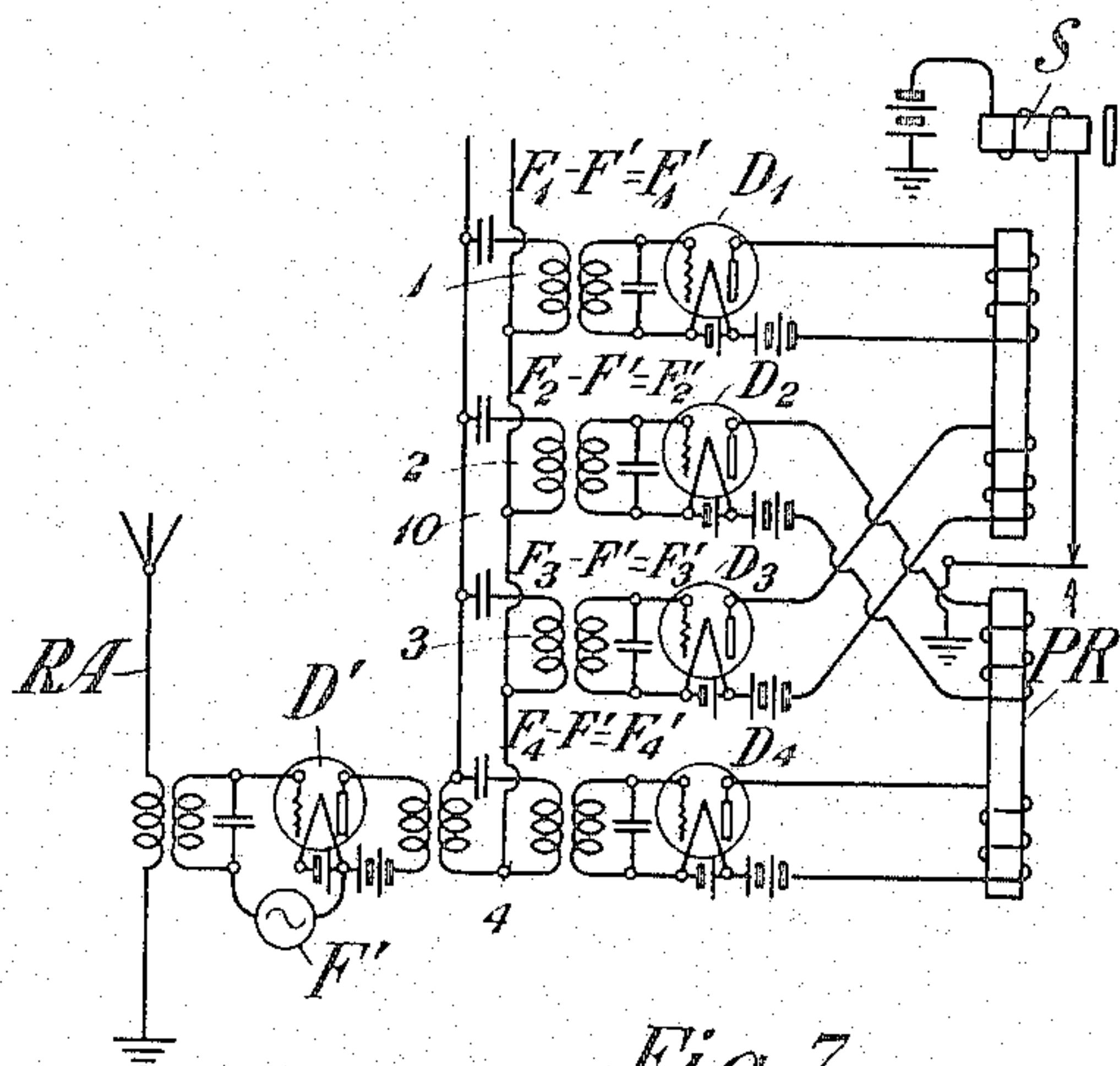


Fig. 7

Inventor
H. A. Affel

By his Attorney

John

Aug. 12, 1924.

1,504,303

H. A. AFFEL

METHOD OF AND MEANS FOR REDUCING STATIC DISTURBANCES

Filed June 3, 1921

3 Sheets-Sheet 3

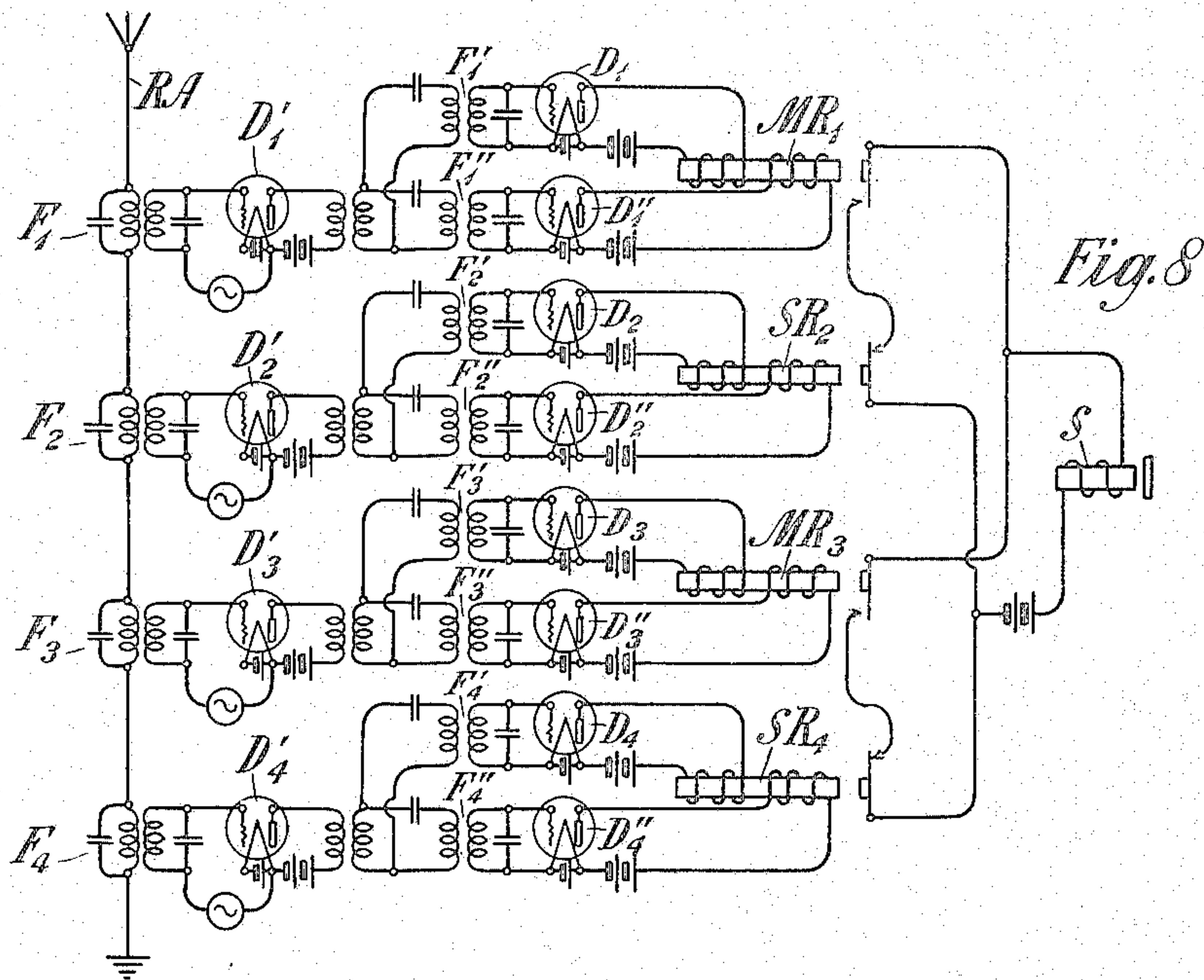
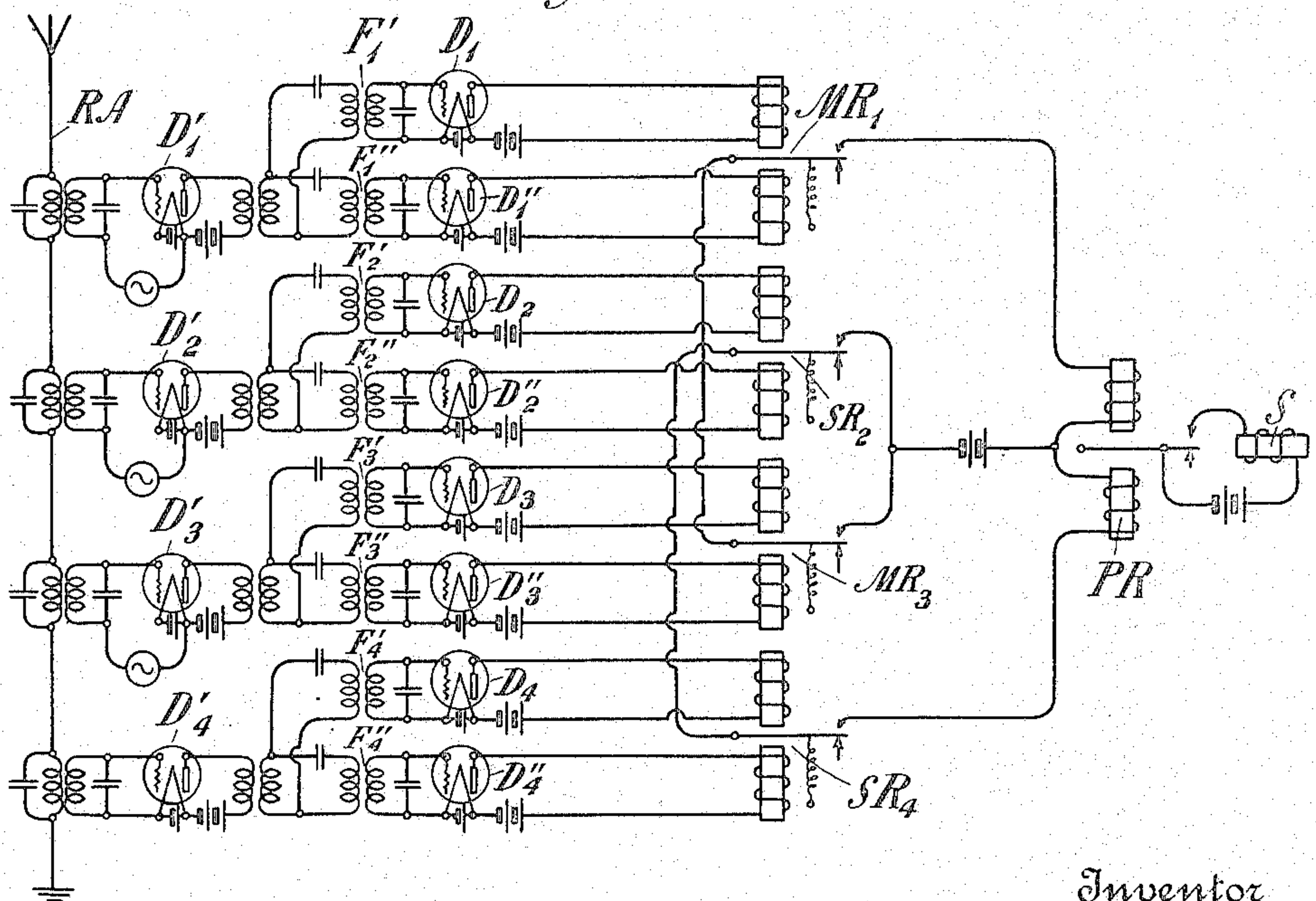


Fig. 9



Inventor
H. A. Affel

By his Attorney

J. W. Zerk

UNITED STATES PATENT OFFICE.

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

METHOD OF AND MEANS FOR REDUCING STATIC DISTURBANCES.

Application filed June 3, 1921. Serial No. 474,824.

To all whom it may concern:

Be it known that I, HERMAN A. AFFEL, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Methods of and Means for Reducing Static Disturbances, of which the following is a specification.

This invention relates to radio signaling, and more particularly to methods of eliminating static interference.

The obvious and most simple method of reducing static interference in radio transmission is to increase the transmitting power, thereby increasing the strength of the received signal, as compared with the interfering noise due to static. This is ordinarily done by simply increasing the amount of energy transmitted on a single wave length.

In accordance with the present invention it is proposed to transmit an equivalent amount of energy at several different wave lengths transmitted simultaneously, the amount of energy transmitted at each wave length being, of course, considerably less than the amount radiated at a single frequency in accordance with the scheme above mentioned, and in fact the total amount of energy radiated at all of the different frequencies need be no greater than that radiated at a single frequency under the previous method. The present scheme has the advantage that it is unnecessary to construct complicated apparatus for transmitting the large amounts of power that would be involved in the first scheme, and has the further advantage that more favorable effects with regard to eliminating static interference may be obtained by using the element of chance that a particular interfering impulse will not occur simultaneously on all receiving channels.

Static is generally conceived of as covering a wide range of varieties of disturbances varying between two extreme types. One of these extreme types may be termed "mono-frequency static," having characteristics of more or less definite frequency, and capable therefore, of impressing itself on different selecting circuits to a varying degree. The other extreme type may be termed "impulse static" and may be likened to a wave which approaches an infinitely steep wave front which would tend

by shock excitation to induce comparable currents in several selecting circuits.

In accordance with the present invention, means are provided to improve the receiving conditions as regards either or both of the two general types of static interference just defined, said means being so arranged as to obtain the advantages of the use of several transmitting frequencies previously described. The arrangements of the present invention are designed for the employment of several simultaneous transmitting channels at different wave lengths, using separate transmitting waves for making the spacing as well as the marking signals.

The invention may be more fully understood from the following description when read in connection with the accompanying drawings in which:

Figure 1 is a simplified diagram of a transmitting arrangement for use in connection with a system for eliminating mono-frequency static;

Fig. 1 (a) is a diagram of the translating device utilized in each channel of the transmitting system of Fig. 1;

Fig. 2 is a simplified diagram of a receiving circuit to be used in connection with the transmitter of Fig. 1;

Fig. 2 (a) is a diagram of the translating circuit used in each channel of Fig. 2;

Figs. 3, 4 and 5 are modified forms of circuits embodying the same general principle as that of Fig. 2;

Fig. 6 is a simplified diagram of a type of transmitting apparatus which may be used in a system for eliminating either mono-frequency static or impulse static, or both.

Fig. 7 is a simplified diagram of a receiving arrangement adapted to eliminate the effects of impulse static.

Fig. 8 is a similar diagram of a receiving apparatus adapted to eliminate both mono-frequency static and impulse static; and

Fig. 9 is a diagram of a modified arrangement for performing the same functions as the circuit of Fig. 8.

Referring to Fig. 1, a transmitting arrangement is illustrated in which signals are transmitted at four frequencies, two frequencies being used to make the marking signal and two frequencies being used

for the spacing signal. TA represent a transmitting antenna which is coupled to four channels including translating devices T_1 , T_2 , T_3 and T_4 , which may be controlled by means of the key K. When the key K is in the position indicated in the drawing the translating devices T_1 and T_3 will be actuated to transmit frequencies F_1 and F_3 for the marking signal and when the key is shifted to its alternative position, translating devices T_2 and T_4 will be actuated to transmit frequencies F_2 and F_4 for the spacing signal. The translating devices T_1 , T_2 , etc., may be of any well known character, but for purposes of illustration one embodiment of these devices is shown in Fig. 1 (a), in which a vacuum tube oscillator O is controlled by means of a transmitting relay TR, so that when the relay TR is actuated by means of the key K, the oscillator will generate oscillations at a frequency determined by its controlling circuit.

The corresponding receiving station is illustrated in Fig. 2, and comprises a receiving antenna RA, coupled to four channels having resonant circuits tuned to the frequencies F_1 , F_2 , F_3 and F_4 . Detectors or rectifiers D_1 , D_2 , D_3 and D_4 are included in the several channels, and these detectors may be of the type illustrated in Fig. 2 (a), which shows a vacuum tube detector controlling a relay in its output circuit. The circuit of the detector is so arranged that under normal conditions no current or substantially no current flows through the relay, but when high frequency oscillations are impressed upon the grid circuit a direct current will flow through the relay, thereby energizing its winding. In Fig. 2 detectors D_1 and D_3 control the marking relays MR_1 and MR_3 , and detectors D_2 and D_4 control the spacing relays SR_2 and SR_4 . These relays jointly control the circuit of the sounder S, the contacts of relays SR_2 and SR_4 being in parallel, and the contacts of relays MR_1 and MR_3 being in series.

In the operation of this circuit, when marking frequencies F_1 and F_3 are received by the antenna RA, the relays MR_1 and MR_3 respond to close their contacts, thereby energizing the sounder S. When the marking frequencies cease and the spacing frequencies F_2 and F_4 are transmitted the relays SR_2 and SR_4 respond to open the circuit of the sounder S. It will be apparent from the arrangement of this circuit that if, when the spacing signal is received, mono-frequency static disturbances should actuate either the relay MR_1 or the relay MR_3 , or both, the spacing signal would not be interfered with because the circuit of the sounder would be opened by the relays SR_2 and SR_4 . On the other hand, during the transmission of a marking signal, the relays MR_1 and MR_3 will be actuated to close a

circuit for the sounder, and this signal will not be interfered with by mono-frequency static actuating either the relay SR_2 or SR_4 . Interference could only occur when both relays SR_2 and SR_4 are actuated simultaneously, a condition which would rarely occur under mono-frequency static conditions.

In Fig. 3 is illustrated an alternative receiving arrangement which is more nearly independent of mono-frequency static disturbances than that of Fig. 2. In this arrangement the marking relays MR_1 and MR_3 are arranged to jointly control the circuit of one winding of a polar relay PR, while the spacing relays SR_2 and SR_4 jointly control the circuit of the other winding of the same polar relay. The sounder S is controlled by the contact of the polar relay PR. When a marking signal is received frequencies F_1 and F_3 actuate the relays MR_1 and MR_3 to complete the circuit through the upper winding of the polar relay PR, so that the circuit of the sounder S is closed. When the space signal is received frequencies F_2 and F_4 operate the relays SR_2 and SR_4 to complete a circuit through the lower winding of the relay PR, so that the circuit of the sounder is opened. It will be apparent that during the continuance of either a spacing or marking signal no amount of mono-frequency static disturbance can defeat the signal, for when one of the windings of the polar relay PR has been energized to shift its armature, deenergization of the other winding will be without effect to shift its armature in the opposite direction, so long as deenergization of the first winding continues. The only time that an interfering disturbance can affect the signal is when an interfering disturbance occurs just at the moment the change-over from marking to space signal occurs.

For example, let us suppose that the marking signal is just ceasing and the spacing signal beginning. Relays MR_1 and MR_3 are deenergized and relays SR_2 and SR_4 are energized, and at the instant this occurs the armature of the polar relay PR is in its upper position with the circuit of the sounder closed. Deenergization of the relays SR_2 and SR_4 completes the circuit of the lower winding of the polar relay and tends to shift the armature thereof to the lower position, but if at just this moment mono-frequency static disturbances should actuate both the relays MR_1 and MR_3 , the shifting of the armature would be defeated, thereby continuing the marking signal and obliterating the spacing signal. If only one of the relays MR_1 and MR_3 are actuated, however, the signal will not be interfered with, as the circuit of the upper winding of the relay PR will not be maintained closed at the time the spacing signal

commences. Similar conditions will obtain during the change-over from spacing to marking signal and it will be apparent therefore, that in order to interfere with the signal, two mono-frequency static disturbances of such frequencies as to operate the two non-signaling relays must occur at just the moment when the change-over takes place.

Fig. 4 shows another modification in which the marking signal is received at three frequencies F_1 , F_2 and F_3 , and the spacing signal is received at frequency F_4 . This would, of course, involve a slight change in the transmitting station of Fig. 1, so that the key K would, in one position, control translators T_1 , T_2 and T_3 , and in the other position control only the translator T_4 . The marking relays MR_1 , MR_2 and MR_3 have the contacts connected in series to close the circuit of the sounder S . The circuit of the sounder S is also closed over the back contact of the spacing relay SR_4 . In the normal operation of this circuit the reception of frequencies F_1 , F_2 and F_3 completes the circuit of the sounder S for the marking signal. Incidentally, at the same time the spacing relay SR_4 releases its armature and the circuit of the sounder is independently closed over the back contact of the spacing relay. When the marking signal ceases and the frequency F_4 is received, the spacing relay SR_4 opens the circuit of the sounder S , the marking relays having released their armatures at the same time. When the spacing relay is energized in response to a spacing signal, it would be necessary for mono-frequency static disturbances to operate all three marking relays in order to defeat the spacing signal by closing the sounder circuit. When the marking signal is being received actuation of the spacing relay by a static disturbance is without any effect whatever.

In Fig. 5 an arrangement is shown which is substantially the reverse of that illustrated in Fig. 4. In this case spacing signals are received at frequencies F_1 , F_2 and F_3 , and the marking signal at frequency F_4 . The spacing relays have their contacts connected in parallel with each other, and the contacts of the marking relay are in series with the contacts of the spacing relays. When a marking signal is received at the frequency F_4 , the marking relay MR_4 is actuated to close the circuit through the sounder S over the several contacts of the spacing relays in parallel, and in order to defeat this signal it is necessary that a mono-frequency static disturbance actuate all three spacing relays simultaneously. When a spacing signal is received at frequencies F_1 , F_2 and F_3 , the actuation of the three spacing relays opens a circuit of the sounder S and the actuation of the marking relay MR_4 by a static disturbance is without

any effect whatever in defeating the spacing signal.

Fig. 6 illustrates a modified form of transmitting a circuit which may be utilized in connection with arrangements for preventing mono-frequency static disturbances, as previously described, or may be used in connection with a circuit for defeating impulse static disturbances, or both. The final frequencies to be radiated in accordance with this scheme are generated by a process of modulation. For this purpose, two oscillators O and O' are arranged to oscillate at frequencies f and f' which may, if desired, be audible, and the circuits of these oscillators being controlled by relays TR and TR' , which relays are in turn controlled by the key K . The output circuits of the oscillators O and O' are associated with the input circuit of a vacuum tube modulator M and the input circuit of said modulator is also supplied with a frequency F which in general will be higher than the frequencies f and f' , generated by the oscillators O and O' . As a result of the action of the modulator M , frequencies $F+f=F_1$, $F+f'=F_2$, $F-f=F_3$, and $F-f'=F_4$, will appear in the output circuit of the modulator. The frequencies F_1 and F_3 correspond to the side frequencies produced by the interaction of the frequency f and the frequency F , and these two side frequencies may be used in transmitting the marking signal. The frequencies F_2 and F_4 correspond to the side frequencies produced by the interaction of the frequencies f' and F and may be used for transmitting the space signal. The frequency F is eliminated by means of the balanced circuit of the modulator M , so that only the four frequencies F_1 to F_4 inclusive are radiated. The advantage of this method of producing the frequencies is that the frequencies may be much more closely spaced than is generally possible by other methods of generating the frequencies.

Fig. 7 illustrates a receiving circuit adapted to eliminate disturbances due to impulse static, and is intended to cooperate with the sending station of the type of Fig. 6, although the type of sending station illustrated in Fig. 1 may be used if desired. The circuit of Fig. 7 is arranged to perform the detecting operation in more than one step so that the selection of the several frequencies involved in the transmission of the signal may take place at lower frequencies, thereby rendering it possible to select frequencies which are very closely spaced, a feature which would be practically impossible of accomplishment if the selection were to take place at the radio frequencies. Assuming that four frequencies F_1 , F_2 , F_3 and F_4 may be impressed upon the receiving antenna RA , these frequencies will be transmitted to a demodulator D' which may be

of the well known vacuum tube type, and has its input circuit energized from a locally generated source of relatively high frequency F' . The action of the demodulator D' is to produce sum and difference frequencies in its output circuit. The sum frequencies will be much higher than the radio frequencies received and may be disregarded as the selecting arrangements hereinafter described will eliminate them. The difference frequencies $F_1 - F' = F_1'$, $F_2 - F' = F_2'$, $F_3 - F' = F_3'$, and $F_4 - F' = F_4'$ will be transmitted to the circuit 10, and will be selected by the tuned circuit arrangements 1, 2, 3 and 4, respectively, so that the individual frequencies will be applied to the detectors or rectifiers D_1 , D_2 , D_3 and D_4 . The output circuits of these detectors are provided with individual windings of a polar relay PR, whose armature controls a circuit of the sounder S. The windings associated with the output circuits of the detectors D_1 and D_3 , when energized, tend to draw the armature of the polar relay in one direction and the two windings associated with the other two detectors, when energized, tend to draw the armature in the opposite direction.

If now, a marking signal is received at frequencies F_1 and F_3 , frequencies F_1' and F_3' will appear in the output circuit of the detector D_1' and these frequencies will be selected by the circuits 1 and 3, so that the windings in the output circuits of the detectors D_1 and D_3 attract the armature of the polar relay PR to its upper position to close the circuit of the sounder. Similarly, when the spacing signal is received at frequencies F_2 and F_4 the two windings in the output circuits of the detectors D_2 and D_4 draw the armature in the opposite direction to open the circuit of the sounder S.

If an impulse static disturbance occurs, the general effect of such a disturbance upon the antenna RA is to set up oscillations determined by the natural period of the circuit. These oscillations may involve a fairly wide band of frequencies, and the effect produced will depend upon the width of the band. The width of the band of frequencies reacting in the antenna circuit will, when stepped down by the demodulator D' , be the same as before, but it will occupy a lower position in the frequency spectrum. If the width of this band and its position is such that the step-down range of frequencies extends from the frequencies F_1' to F_2' , the windings in the output circuits of the detectors D_1 and D_2 will be equally energized and no effect due to the static impulse will be produced upon the polar relay PR. The action of the polar relay will, under these circumstances, be determined by the received signal, whether it be a marking signal or a spacing signal. The same thing also holds true for

a band in the neighborhood of the frequencies F_3' and F_4' .

If the band is wider so that it extends from frequency F_1' to frequency F_4' all the windings of the polar relay will be equally energized and no disturbance will result. If, however, the width of the band is such as to involve only three of the channels a disturbance will result due to the fact that two of the windings of the polar relay are energized on one side, as against one winding energized on the other side, so that if this effect is equal to or greater than that of a signal tending to energize the other side of the polar relay, the signal would be interfered with.

Fig. 8 illustrates a receiving arrangement adapted to reduce the effects of both monofrequency and impulse static. This circuit may be used with a sending arrangement of the type illustrated in either Fig. 1 or Fig. 6. In this case, the four frequencies F_1 to F_4 inclusive are separately selected from the antenna and applied to demodulators D_1' , D_2' , D_3' and D_4' respectively. Each of these demodulators is supplied with a local source of alternating current for the purpose of stepping the frequencies down in the frequency scale. The output circuit of the demodulator D_1' has associated therewith tuned branches, one branch being tuned to the step-down signaling frequency F_1' , and the other tuned branch being resonant at a frequency F_1'' not far remote from the frequency F_1' . The frequency F_1' is impressed upon a detector or rectifier D_1 , whose output circuit controls one winding of the marking relay MR_1 . In a similar manner the tuned circuit which selects the frequency F_1'' is associated with a detector D_1'' , whose output circuit controls a balancing winding of the marking relay MR_1 . Similar pairs of tuned circuits are associated with the output circuits of each of the other demodulators, so that the step-down signaling frequency appearing in the output circuit thereof will be transmitted through the one tuned circuit, the associated tuned circuit being tuned to a frequency slightly different and not very remote therefrom. The other marking relay MR_3 and the corresponding spacing relays SR_2 and SR_4 are similar to the marking relay MR_1 , and have their circuits controlled by detectors associated with corresponding circuits in a manner similar to that already described. The marking relays MR_1 and MR_3 independently control the circuit of the sounder S, each having a contact in series with the contact of a corresponding spacing relay so that the actuation of a given marking or spacing relay may be defeated by the simultaneous actuation of the corresponding spacing or marking relay, but in order to defeat the signal it is necessary in the case of a mark-

ing signal that both spacing relays be actuated, and in the case of a spacing signal, that both marking relays be actuated.

If a marking signal at frequencies F_1 and F_3 is received, these frequencies will be reduced by the demodulators D_1' and D_3' to frequencies F_1'' and F_3'' , so that the detectors D_1 and D_3 will actuate the marking relays MR_1 and MR_3 to close the circuit of the sounder. If mono-frequency static disturbances occur at frequencies which, when translated down, will correspond to F_2' and F_4' , both spacing relays will be actuated to defeat the signal. If the mono-frequency disturbances when stepped down correspond to frequencies F_2'' and F_4'' , both spacing relays would be actuated to again defeat the signal. If only one of these frequencies occur, however, the signal would not be defeated as only one spacing relay would be actuated. If the mono-frequency disturbances, when stepped down, correspond to frequencies F_2' and F_2'' , no effect would be produced on the spacing relay SR_2 , as the effects would be balanced. The same would hold true for the frequencies F_4' and F_4'' , and it is equally obvious that no effect would be produced if all four of these mono-frequency disturbances occurred at once. A similar situation will occur during the operation of receiving a spacing signal, and it is therefore evident that there is a relatively small chance that the signal will be interfered with due to mono-frequency disturbances.

With regard to the effect of impulse static it should be noted that if the width of the disturbing band, when stepped down extends from frequencies F_1' to F_1'' , no disturbing effect would be produced as the two effects would balance with respect to the relay MR_1 . If the disturbing band when stepped down, extends from F_1' to F_2' the relay SR_2 would be energized, but the marking signal could not be interfered with because the other spacing relay SR_4 would not be actuated and the sounder would be controlled by the marking relay MR_3 . If the band of frequencies extends from F_1' to F_2'' , no disturbing effect would be produced owing to the balanced condition of the relays MR_1 and MR_2 . So also, if the width of the band is increased to include successively each of the remaining frequencies involved, no disturbances would be produced because where the number of channels involved is even, all of the signal receiving relays will be balanced, and where the number of channels involved is odd, only one relay will be unbalanced. In the case that the disturbing band extends from frequencies F_1'' to F_3' , relay SR_2 will be balanced, but relays MR_1 and MR_3 will be unbalanced, and therefore energized. This would not, however, defeat a spacing signal as the circuit of the sounder might be opened

by the energization of the relay SR_4 in response to the signal, and the energization of the relay SR_2 which would be unbalanced by the superposition of the spacing signal upon the static disturbance. However, a disturbance may occur if the band extends from frequency F_2'' to frequency F_4' , for in this case while the relay MR_3 will not be affected by the disturbance due to the balanced condition, relays SR_2 and SR_4 will both be unbalanced and by opening their contacts would defeat a marking signal.

It will thus be seen that there is a relatively small chance of disturbance due to mono-frequency static, and an even smaller chance of disturbance due to impulse static.

A modified receiving arrangement is illustrated in Fig. 9, which is also designed to eliminate both impulse and mono-frequency static disturbances. This arrangement differs essentially from that of Fig. 8 in that the marking and spacing relays, instead of being differential relays, are polar relays. Each of these polar relays has one winding in circuit with the detector which is responsive to the signaling frequency, and another winding which is associated with the detector responsive to the associated disturbing frequency. The armature of each polar relay is normally biased so that the contact controlled thereby is also opened by means of a suitable spring. The contacts of the marking and spacing relays are connected in such a manner as to control the sounder through an intermediate polar relay PR in the same manner as in Fig. 3.

The operation of this circuit from the standpoint of prevention of mono-frequency static, will of course be the same as that in Fig. 3, and need not further be described. With regard to the effect of impulse static, it will be apparent that step-down band extending from frequency F_1' to F_1'' , will energize both windings of the polar relay MR_1 and will not affect the armature of said relay whatever. The action of the polar relay MR_1 will therefore be determined by whether or not a marking frequency is being received, the effect of the marking frequency being to energize the upper winding to a greater extent than the lower winding, so that the armature will be shifted to its upper position. The same operation will hold true for any other range of frequencies which will coincide with an associated pair of frequencies arranged to operate a single one of the polar signal relays. A step-down frequency range extending from F_1'' to F_2' would have the effect of energizing the lower winding of the polar relay MR_1 to hold open the armature of said relay, and of energizing the upper winding of relay SR_2 to close the contact controlled thereby. This would not interfere with the spacing, but might

result in defeating the marking signal since the circuit of the upper winding of the polar relay PR would be held open at the contact of the marking relay MR₁.

5 The result of a disturbing band of sufficient width to extend over three of the channels, for example, from F₁' to F₂' would be to operate one signal relay but to have no effect upon adjacent signal relay. In the
10 case of the example given, the marking relay MR₁ would not be affected but the upper winding of the spacing relay SR₂ would be deenergized to shift the armature thereof to its upper position. This would not affect
15 the signals, however, as the marking signals would be received as before, both marking relays responding to the marking frequency. During the continuance of the marking signal the spacing circuit would be held open
20 at the contact of the spacing relay SR₄, and the closure of the contact of the spacing relay SR₂ would therefore be without effect. Should the width of the band extend from frequency F₁'', however, to F₂'', the mark-
25 ing signal would be defeated owing to the fact that the lower winding of the marking relay MR₁ would be energized to hold open the marking circuit of the polar relay PR.

Similarly, the result of a band of frequencies sufficiently wide to encompass four
30 channels will be to produce no effect if the band coincides with four channels controlling four windings of two polar relays. If, however, the band encompasses four chan-
35 nels, two of the windings of which are associated with one polar relay and the other two of which are associated with two other polar relays, the signal may be defeated; for example, a band extending from fre-
40 quency F₁' to F₂' would operate polar relay MR₁ to hold open its armature and polar relay MR₂ to close its armature, while relay SR₂ would be unaffected. This would
45 defeat the marking signal but not the spacing signal.

Without considering in detail all of the other possible conditions that might arise, it will be apparent that, regardless of the width of the band, under certain conditions
50 the signal will not be defeated, and under other conditions the signal will be defeated, but in all cases the condition for defeating the signal must occur at just the moment when the change-over from marking to spac-
55 ing, or spacing to marking occurs. Any disturbing condition which may arise during the continuance of a marking or spacing signal will be without effect. It will therefore be apparent that disturbances due to
60 static, whether of the mono-frequency or impulse variety, will be of relatively small effect upon a circuit of this character, owing to the arrangement of the polar relay PR, and its controlling circuit.

65 It will be obvious that the general prin-

ciples 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.

70

What is claimed is:

1. The method of reducing static disturbances which consists in transmitting a plurality of wave frequencies, producing a marking signal of a telegraph code at a
75 receiving station by the conjoint action of certain of said frequencies, and producing the spacing signal of a telegraph code by the conjoint action of other of said frequencies, whereby static disturbances producing fre-
80 quencies less in number than the number required to produce a signal will be without effect.

2. The method of reducing static disturbances which consists in transmitting a
85 plurality of wave frequencies, separately impressing said frequencies at a receiving station upon individual translating devices, producing by the conjoint action of certain of said translating devices a marking signal
90 of a telegraph code and producing by the conjoint action of other of said translating devices the spacing signal of a telegraph code, whereby the actuation by static disturbances of a lesser number of said trans-
95 lating devices than is required to produce one of said signals will be without effect.

3. In a signaling system, means to transmit a plurality of wave frequencies for the marking signals of a telegraph code, means
100 to produce a plurality of wave frequencies for the spacing signals of a telegraph code, means at a receiving station responsive to the conjoint action of said marking frequencies for producing a marking signal
105 and means at said receiving station responsive to the conjoint action of said spacing frequency for producing a spacing signal.

4. In a signaling system, means for transmitting a plurality of wave frequencies for
110 the marking signals of a telegraph code, means for transmitting a plurality of wave frequencies for the spacing signals of a telegraph code, a plurality of translating devices at a receiving station, certain of
115 which are individually responsive to marking frequencies and others of which are individually responsive to spacing frequencies, means to produce a marking signal by the conjoint action of said first group of trans-
120 lating devices and means to produce a spacing signal by the conjoint action of the second group of translating devices.

5. In a signaling system, means to transmit a plurality of wave frequencies com-
125 prising a modulator supplied with a carrier wave frequency, means to impress a plurality of signaling wave frequencies upon said modulator, thereby producing sum and difference frequencies, and a single trans-
130

mitting key arranged to selectively and alternately apply said frequencies to the modulator, thereby determining the sum and difference frequencies to be transmitted.

5 6. In a signaling system, a modulator, means to supply a carrier wave frequency thereto, an auxiliary wave frequency source, a single transmitting key arranged in one position to control the application of a frequency from said source to said modulator
10 in accordance with a marking signal, a second auxiliary wave source, said key in another position controlling the application of a wave frequency from said second source
15 to said modulator in accordance with the spacing signal.

7. In a signaling system, the method of reducing static disturbances which consists in producing by said disturbances a plurality of wave frequencies, certain of which
20 correspond to signaling frequencies and others of which do not correspond to signaling frequencies, selecting said frequencies in pairs and annulling the effect of one frequency of a pair by the effect of the other
25 frequency of the pair.

8. In a signaling system, the method of reducing static disturbances which consists in producing by said disturbances a plurality of wave frequencies, selecting from said
30 frequencies a pair of frequencies, one of which corresponds to a signaling frequency and the other of which is a foreign frequency, and annulling the effect of the foreign frequency by the effect of the signaling frequency.
35

9. In a signaling system, the method of reducing static disturbances which consists in transmitting a plurality of wave frequencies, producing signals at a receiving
40 station by the conjoint action of said frequencies and producing, at said receiving station, by static disturbances, wave frequencies, some of which correspond to said
45 signaling frequencies and others of which are foreign thereto, and annulling the effect of the foreign frequencies by the effect of the signaling frequencies.

10. In a signaling system, the method of reducing static disturbances which consists in transmitting a plurality of signaling
50 wave frequencies, producing signals at a receiving station by the conjoint action of said frequencies, producing by means of static disturbances at said station a plurality of
55 wave frequencies, some of which correspond

to the signaling frequencies and some of which are foreign thereto, stepping down the frequencies thus produced to a lower range in the frequency spectrum, selecting
60 the stepped-down frequencies in pairs and neutralizing the effect of one frequency of a pair by the effect of the other frequency of said pair.

11. In a signaling system, means for
65 transmitting a plurality of wave frequencies, translating devices at a receiving station individually responsive to said frequencies, means for producing a signal by the conjoint action of said translating de-
70 vices, and means whereby translating devices responsive to neighboring wave frequencies will produce annulling effects.

12. In a signaling system, means for receiving a plurality of wave frequencies,
75 means for selecting said frequencies and means for individually selecting foreign wave frequencies closely adjacent to the signaling frequencies, translating devices individually responsive to the signaling fre-
80 quencies and translating devices individually responsive to the foreign frequencies, means to produce a signal by the conjoint action of the translating devices responsive to signaling frequencies and means
85 whereby the effect of a translator responsive to a foreign frequency will be annulled by the effect of a translator responsive to a closely adjacent signal frequency.

13. In a signaling system, means for receiving a plurality of signaling wave frequencies and for receiving foreign wave frequencies produced by static disturbances,
90 means for stepping down said frequencies in the frequency spectrum, means for individually selecting said signaling frequencies and means for individually selecting a foreign frequency for each signaling frequency, translating devices individually responsive
95 to the selected signaling frequencies, translating devices individually responsive to foreign frequencies, means to produce a signal by the conjoint action of the translating devices responsive to signaling frequencies and means to annul the effect of a
100 translating device responsive to a foreign frequency by the effect of a translating device responsive to a signal frequency.

In testimony whereof, I have signed my name to this specification this 2nd day of
110 June, 1921.

HERMAN A. AFFEL.