

April 21, 1936.

A. J. AIKENS

2,037,846

REDUCTION OF DISTURBING VOLTAGES IN ELECTRIC CIRCUITS

Filed Sept. 20, 1933

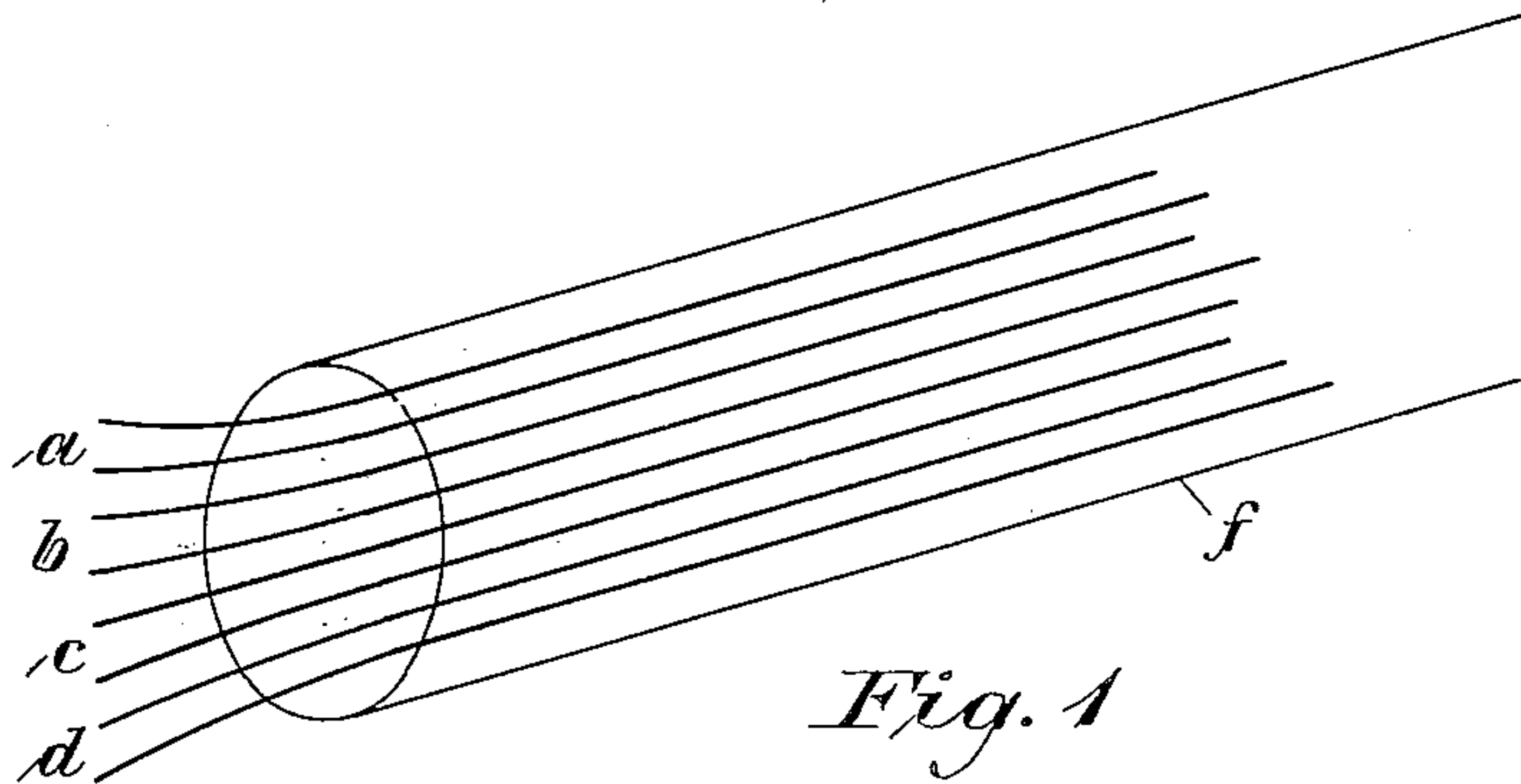


Fig. 1

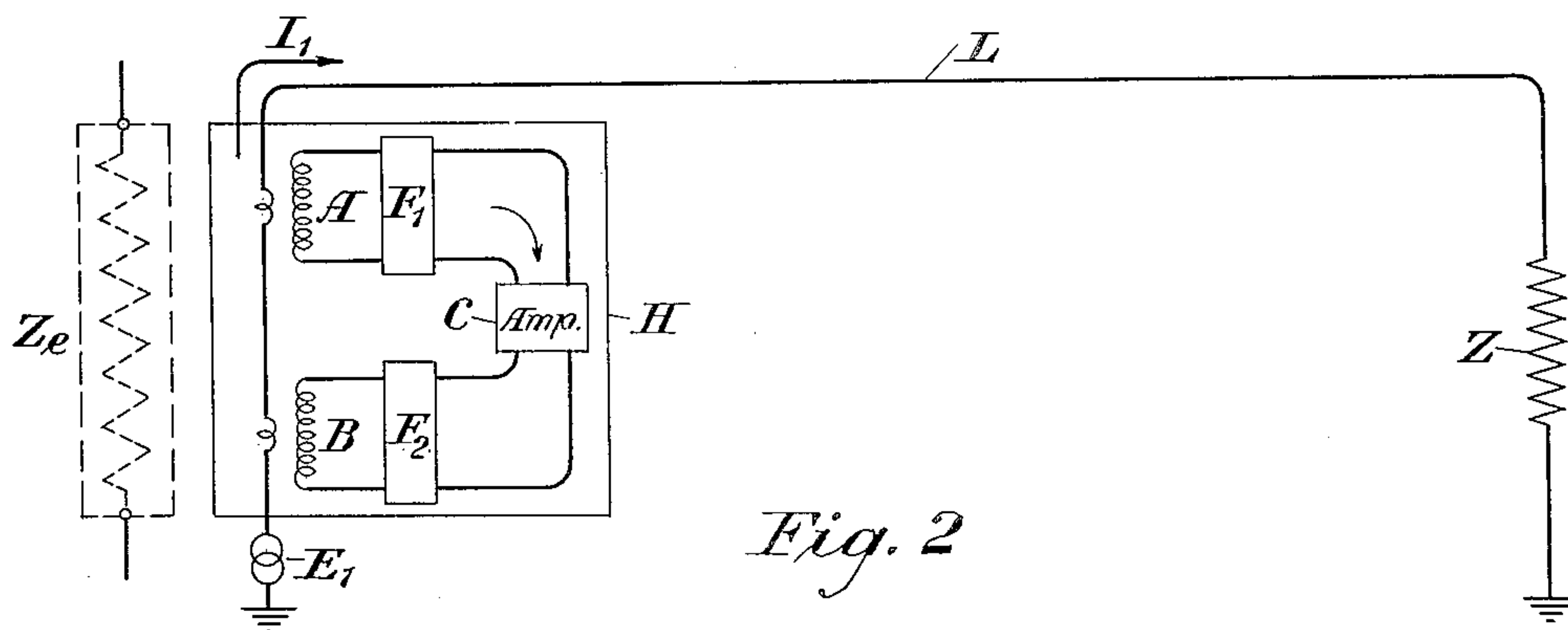


Fig. 2

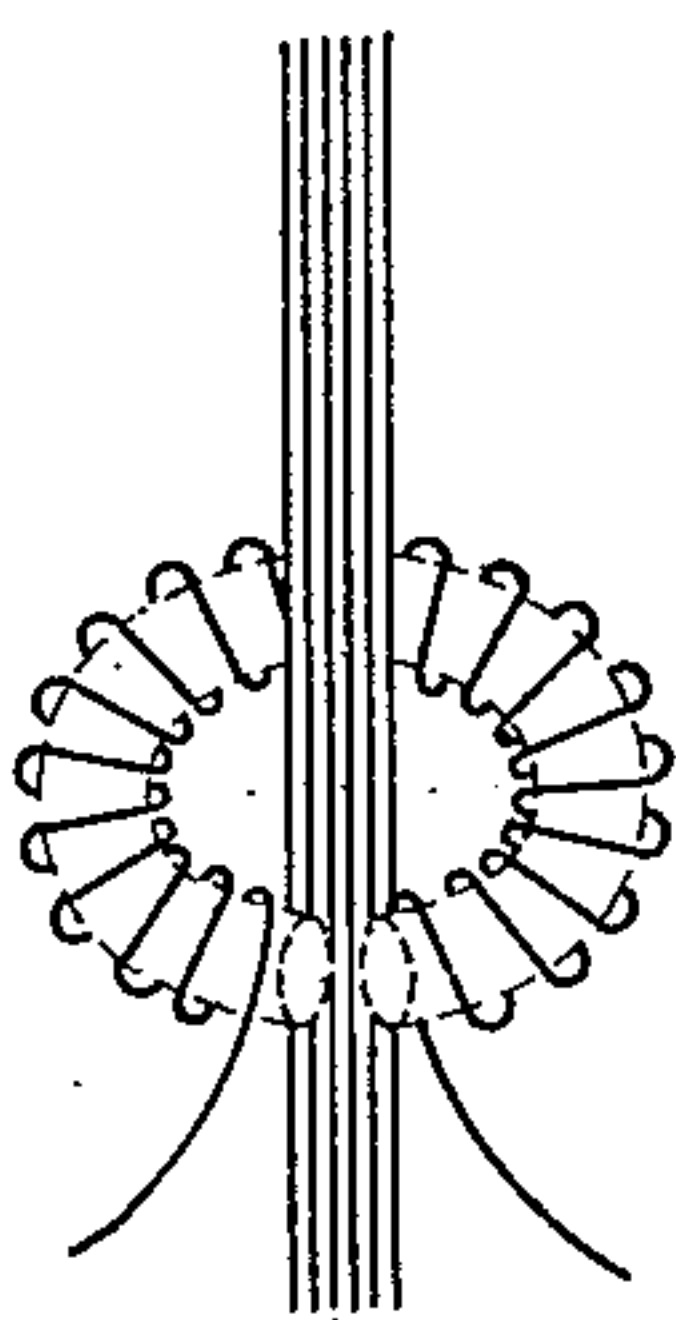


Fig. 3

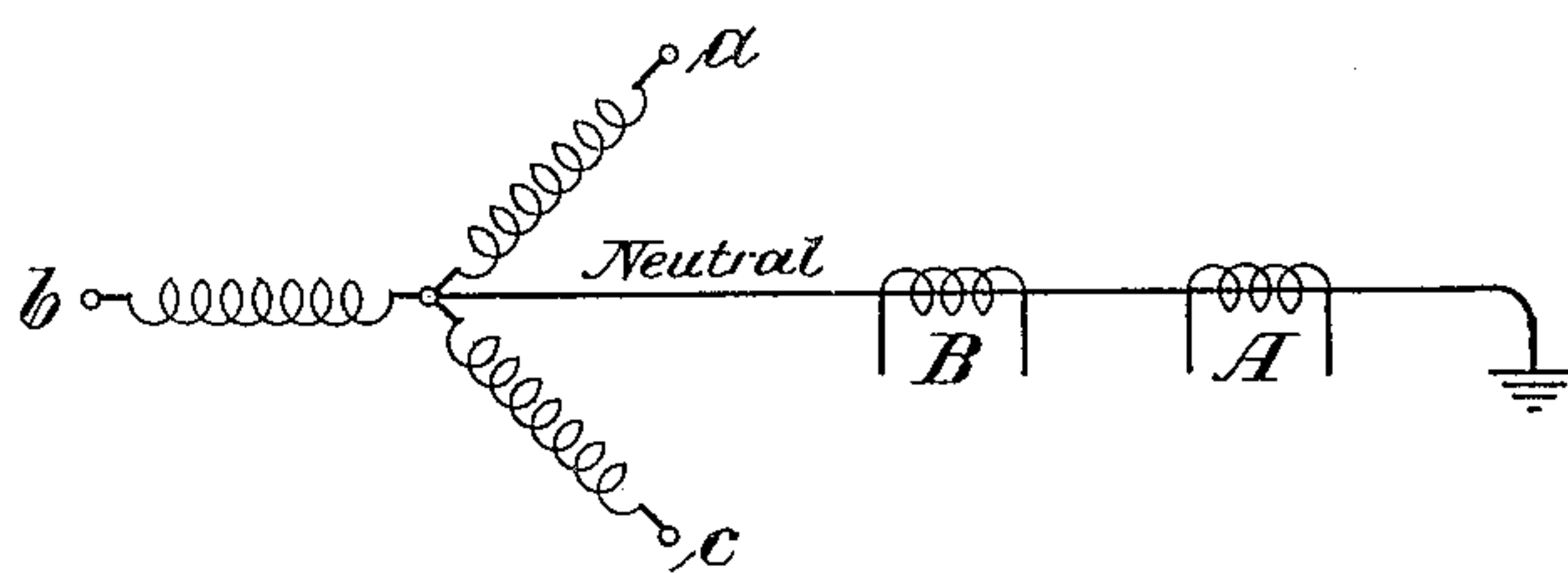


Fig. 4

INVENTOR
A. J. Aikens
BY *g m c*
ATTORNEY

UNITED STATES PATENT OFFICE

2,037,846

REDUCTION OF DISTURBING VOLTAGES IN
ELECTRIC CIRCUITSAndrew J. Aikens, Rutherford, N. J., assignor to
American Telephone and Telegraph Company,
a corporation of New York

Application September 20, 1933, Serial No. 690,268

8 Claims. (Cl. 178-78)

This invention relates to reduction of disturbing voltages and currents in electric circuits and more particularly to the reduction or elimination of such disturbing voltages and currents as may arise in connection with communication circuits.

The application of carrier systems to wire or radio signaling circuits introduces the problem of reducing noise on the various circuits to tolerable values. In such circuits a considerable part of the noise may originate in repeater station and central office apparatus and may be introduced into the circuits by way of closely associated voice frequency telephone and direct current telegraph or other auxiliary circuits. The disturbances exist on these circuits mainly as longitudinal currents and voltages, that is, as currents and voltages which flow in the same direction in any given pair of conductors. The disturbances may also arise from sources quite external to the telephone equipment, such, for example, as harmonic disturbances in power plants or earth currents from other sources.

The purpose of this invention is to devise a circuit arrangement which may be readily associated with one or more circuits and which will so react on the circuit or circuits as to oppose and effectively reduce the disturbing effects referred to above. A second purpose is to accomplish this without direct connection to the physical circuits on which the disturbances are to be eliminated. The invention is of the general type of circuit disclosed in patent to Berthold, 1,773,772, August 26, 1930, and this invention represents certain improvements over such circuits which arise from using what may be termed a series-series connection.

The invention will be better understood by reference to the following specification and the accompanying drawing, in which Figure 1 illustrates a group of circuits such as a cable to which the invention is applicable; Fig. 2 shows in detail the circuit arrangement constituting my invention; Fig. 3 shows one specific way of associating the circuit arrangement of my invention with the group of circuits on which it is to operate; and Fig. 4 shows my invention as applied to one arrangement of power station equipment.

Referring more particularly to Fig. 1, there is shown a group of pairs of wires, *a*, *b*, *c*, and *d*, enclosed in cable *f*, which cable may contain any number of pairs of such conductors, any and all of which are subject to longitudinal currents arising from disturbances of one kind or another. No restriction is to be placed on the use of these

pairs of conductors for it is to be understood that some may be used for telephone communication at the ordinary speech frequency, some may be used for telegraph purposes and still others for carrier frequency signaling. It would be possible to associate with each pair of conductors apparatus for counteracting the effects of the disturbances referred to, but in my invention I propose to correct for the disturbances in all the conductors together at one time and with one set of apparatus.

The circuit arrangements for accomplishing such results are shown in Fig. 2, in which *L* represents a conductor, or groups of conductors in a cable, to which the correction is to be applied. For convenience in description I show this conductor as grounded at its two ends, thus representing its longitudinal circuit current path. At the one end there is shown a source of E. M. F. E_1 and at the other end there is shown an impedance *Z* which is taken to represent the impedance of the longitudinal circuit. The generator E_1 may be taken to represent the sources of the disturbances which are to be eliminated, and while here shown as localized at one point, it is to be understood that they may be impressed on the circuit at numerous points. Such E. M. F.'s give rise to the longitudinal current I_1 and the purpose of this invention is to devise a system by which to reduce I_1 to a small part of the value which it would otherwise have. This may be done by employing the device shown at *H*, which may be looked upon as equivalent to impressing in series with the longitudinal circuit *L*, E. M. F.'s which oppose those which operate on the device *H* or may be looked upon as the equivalent of an impedance *Z*, introduced in series in the longitudinal circuit and effective for those frequencies only which enter an amplifier hereinafter described. The circuit *H* consists of two transformers *A* and *B*, coupled to the longitudinal circuit, and an amplifier *C*, connected between the secondaries of the transformers *A* and *B*. The operation of the device is as follows: The original current I_1 sets up a flux in *A* and induces a voltage V_1 across its terminals. This voltage is applied through filter F_1 to the amplifier *C*, causing a voltage V_2 to appear across its output. This voltage, operating through a filter F_2 , drives current in the secondary of transformer *B* which induces a voltage E_2 across the low side of the transformer *B*. The phase of E_2 can be adjusted by the proper circuit connections to oppose E_1 , thus reducing the current I_1 . The extent to which reduction occurs will de-

pend, among other things, upon the degree of coupling in the transformers A and B and on the gain of the amplifier. If the gain of the amplifier could be made infinite, the current could be reduced to zero and this would be equivalent to introducing an infinite impedance in the longitudinal circuit.

The quantitative relationships in the circuit may be expressed by the following equations:

Let Z_t = total impedance of longitudinal circuit including equivalent impedance of H;
 Z_1 = mutual impedance at

$$A = \frac{V_1}{I_1}$$

Z_2 = mutual impedance at B;

Z_3 = plate impedance of amplifier + impedance of the filter + the impedance of the secondary of B;

$m = \frac{V_2}{V_1}$ = voltage gain of amplifier, including the effects of the filters.

Then

$$V_1 = I_1 Z_1$$

$$V_2 = m I_1 Z_1$$

$$E_2 = m I_1 Z_1 \frac{Z_2}{Z_1}$$

Also

$$E_1 = I_1 Z + m I_1 Z_1 \frac{Z_2}{Z_1}$$

$$\frac{E_1}{I_1} = Z + m Z_1 \frac{Z_2}{Z_1} = Z,$$

Whence

$$Z_e = Z_t - Z = m Z_1 \frac{Z_2}{Z_1}$$

The effectiveness of this device in reducing the longitudinal currents may be found as follows: If I is the current which would ordinarily flow without the device, then we may set down the relation:

$$\frac{I_1}{I} = \frac{Z}{Z_e} = \frac{1}{1 + m \frac{Z_1 Z_2}{Z_t}}$$

In general there will be disturbance of quite definite frequencies which are to be eliminated and at the same time there may be other frequencies which it is not desired to affect. In that case the filters F_1 and F_2 may be introduced, one before and one after the amplifier, to pass those frequencies only which it is desired to suppress.

In Fig. 2 the transformers A and B are shown as being definitely made up of a primary winding and a secondary winding. This is a thoroughly possible arrangement but I find that a much more convenient and sufficiently effective manner of obtaining coupling from the longitudinal circuit to the amplifier circuit is that of merely enclosing the group of conductors comprising the longitudinal circuit by a toroidal coil, as shown in Fig. 3. This toroidal coil may have an air core or an iron core in accordance with the requirements of the particular situation and may be associated permanently with the coil or, as I have found convenient, may merely be clamped around the cable or group of conductors. The coupling may be made sufficient in this case to bring about the desired results either by clamping over the cable sheath of Fig. 1 itself or over the group of conductors prior to their entry into the cable sheath.

It sometimes occurs that disturbances from power stations become serious in communication circuits running through the general territory of such a power station and it is possible to eliminate many of these effects by the use of my invention. This may be illustrated, for example, in Fig. 4 in which a Y-connected three-phase generator is shown with a neutral return, this return ordinarily being grounded at or near the generator. Such a generator may give rise to disturbing harmonics in the neighborhood of say 1,000 cycles, and it would be desirable to suppress these as completely as possible. Two such coils as those shown in Fig. 3 and corresponding to the secondaries of transformers A and B of Fig. 2 may be clamped or otherwise associated with the neutral in the manner indicated in Fig. 4 and all this without in any manner whatsoever affecting the physical circuit or installation. The introduction of this connection to the neutral is equivalent to introducing a large impedance Z_e in series with the line and effective only for those frequencies which are passed by the filters F_1 and F_2 .

It is evident that the circuit arrangement of my invention will find many other applications and that it may be readily installed not only in such places as already mentioned but wherever disturbing effects arise, and it is to be understood that the specific applications given above are for illustrative purposes only.

What is claimed is:

1. A communication system comprising a plurality of circuits and means for eliminating therefrom the effects of longitudinal disturbing voltages and currents, said means comprising an amplifier with its input circuit and its output circuit both inductively connected in series with the circuits.

2. A communication system including a plurality of conductors carrying longitudinal disturbing currents, means for reducing the effects of said disturbances, said means comprising an amplifier with its input circuit and its output circuit inductively connected in series with said conductors, a filter in the input circuit and a filter in the output circuit of the amplifier to pass the undesired frequencies.

3. A communication system including a plurality of conductors subject to disturbing currents, means for suppressing such disturbances comprising an amplifier, a series transformer connection from said conductors to the input of the amplifier, and a series transformer from the output circuit of the amplifier to said conductor, the distance between the transformers being short as compared to the conductor to be protected from disturbances.

4. A device for eliminating disturbances on a group of adjacent transmission lines, said device including two coils adjacent to the lines in such manner as to link the magnetic flux of said lines but physically separate therefrom, each and all of said lines being in like relation to each of said coils, an amplifier in said device with its input connected to one of the said coils and its output connected to the other of said coils.

5. A device for eliminating disturbances on a plurality of transmission lines adjacent to each other at one point, said device including two toroidal coils and an amplifier, the one coil being connected in the input and the other coil being connected in the output of the amplifier, the coils being so designed that they may be mag-

netically associated with the lines at two adjacent points but without physical association.

5 6. A device for eliminating disturbances of various frequencies on a group of transmission lines in the form of a cable, said device including two toroidal coils adapted to be clamped about the group of transmission lines within the cable at two adjacent points, an amplifier, the input of said amplifier being associated with one of said
10 coils and the output being associated with the other of said coils.

7. A cable including a plurality of conductor pairs, each pair consisting of an outgoing and return conductor for a circuit, two toroidal coils

surrounding said cable, and an amplifier and a filter serially connected, one of said coils being connected on the input side of the amplifier-filter combination and the other said coil being
5 connected on its output side.

8. In combination, a plurality of conductor
pairs side by side, each pair comprising the outgoing conductor and the return conductor of a circuit, an amplifier and a filter serially connected, a series inductive connection from the said
10 conductor pairs to the input of the amplifier-filter combination and a like connection to its output side.

ANDREW J. AIKENS.