Dec. 25, 1934. H. A. RHODES 1,985,353

REDUCTION OF DISTURBING VOLTAGES IN ELECTRIC CIRCUITS

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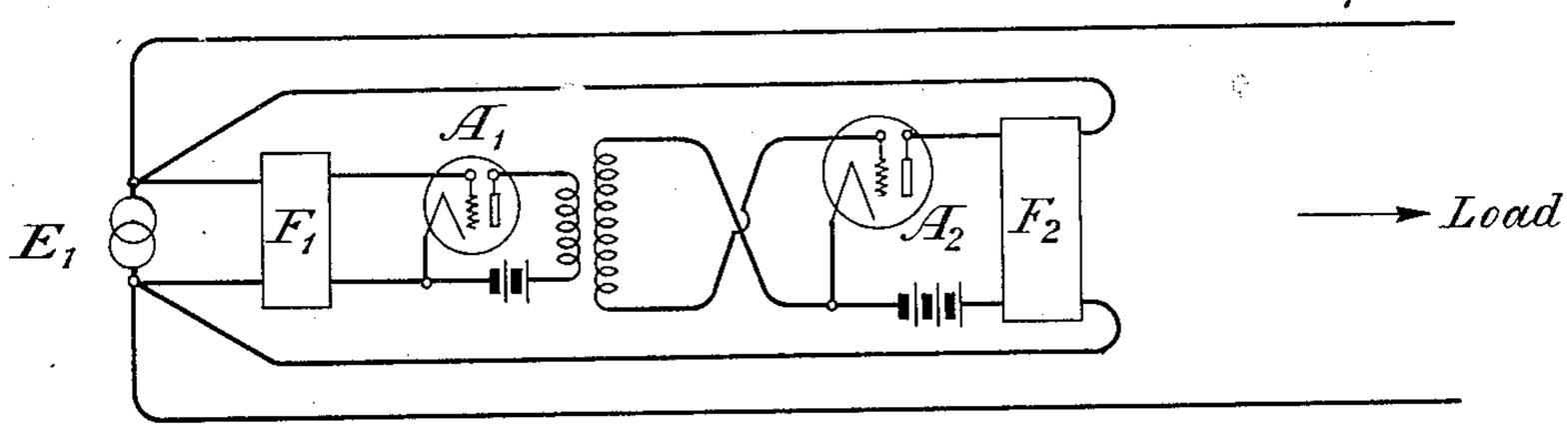


Fig. 1

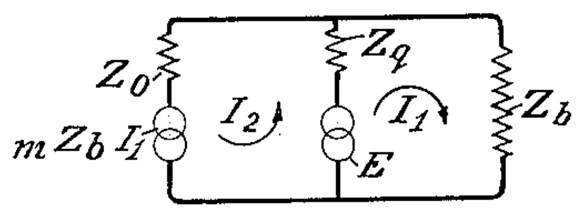


Fig. 1a

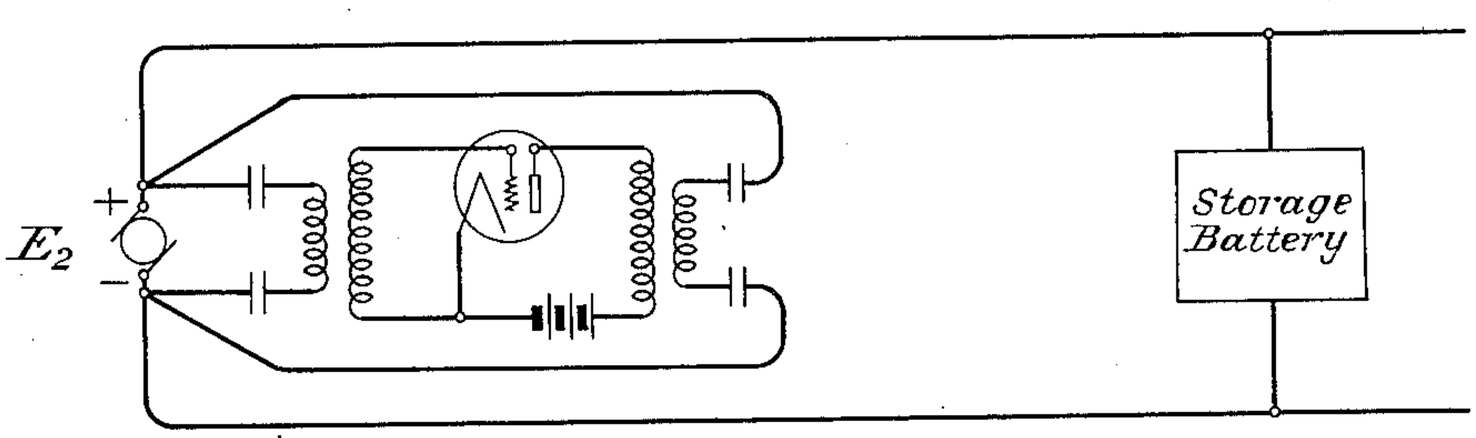


Fig. 2

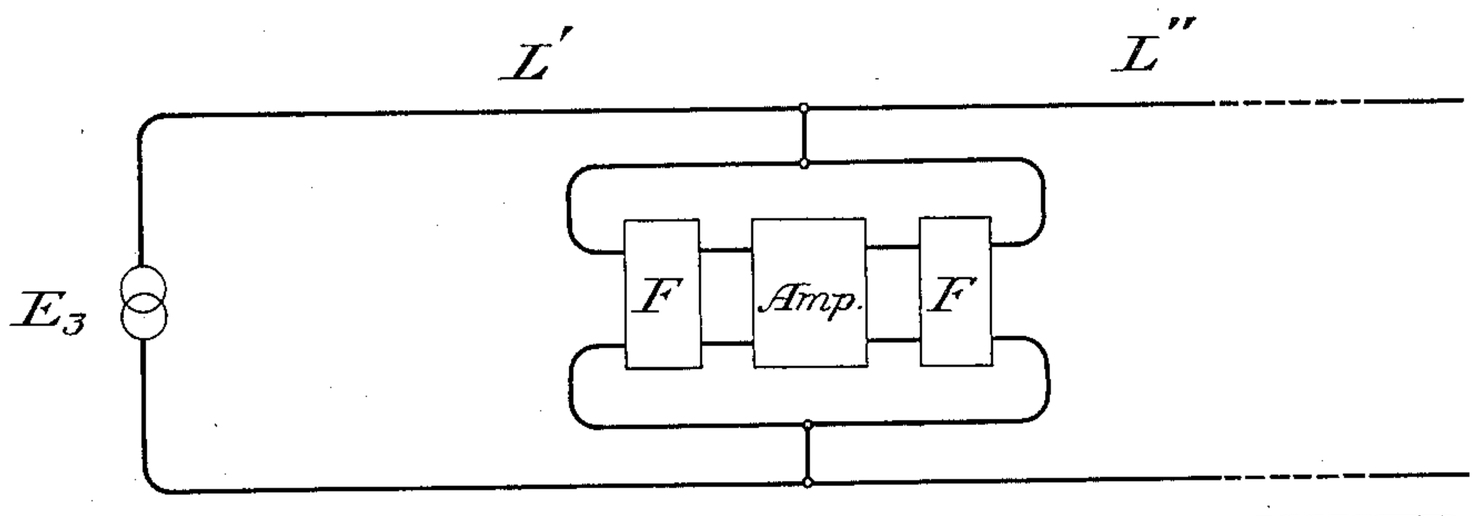
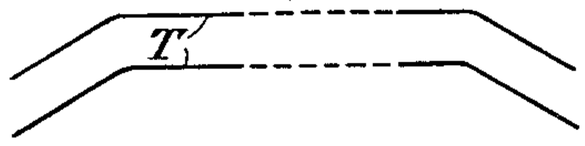


Fig. 3



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REDUCTION OF DISTURBING VOLTAGES IN ELECTRIC CIRCUITS

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5 Claims. (Cl. 171—97)

This invention relates to reduction of disturbing voltages and currents in transmission lines and, more particularly, to means for reducing noise frequency voltages and currents in signaling and other circuits by means of amplifiers with feed-back connections.

The invention is related to such a circuit as shown in Patent No. 1,773,772 to Berthold of December 30, 1926, in which a shunt series or a series shunt connection of a vacuum tube to a line is made in a manner therein fully described. I find certain advantages in what may be called a shunt-shunt connection, one of which is freedom from concern as to phase and amplitude adjustment inasmuch as the circuit which I will disclose automatically takes care of these.

The invention will be better understood by reference to the following specification taken in connection with the accompanying drawing, in which Figure 1 shows a circuit arrangement for reducing or eliminating disturbing effects which may arise in a source of E. M. F.; Fig. 1*a* shows an equivalent circuit to Fig. 1; Fig. 2 shows an application of this circuit arrangement with slight modifications to eliminate disturbances which may originate in a generator used for such a load as a storage battery; and Fig. 3 shows an arrangement in connection with disturbances which may originate in a circuit loop such as a transmission line or a portion thereof.

Referring more particularly to Fig. 1, there is shown a generator E_1 associated with line L_1 going to any suitable load. Such a generator as E_1, which may be a D. C. or an A. C. generator, will ordinarily have present in it certain undesired frequencies such as harmonics which may be of serious disturbance in connection with the load, and the purpose of this invention is to very substantially reduce the effects of such disturbances. I accomplish this by the network which is shown as connected in parallel to the line L_1. This network is shown as consisting of a filter F_1 connected directly in shunt to the line or across the terminals of the generator and feeding into the input of an amplifier A_1. If desired, this may then feed into a second and additional amplifiers A_2, although these additional amplifiers may not be necessary. The output of the last amplifier is connected directly in shunt to the line or across the terminals of the generator, thus providing, if one wishes to look upon it in that way, a feedback arrangement from the input to the output of the amplifier. Also, in the output circuit I would, in general, desire to introduce some filtering circuit such as that indicated at F_2.

In operation, the filters F_1 and F_2, used separately or together, are of such a character as to offer a high impedance to the fundamental frequency of the generator E_1, or such other frequencies from the generator as it may be desired to transmit along the line L_1. On the other hand, the filters readily transmit those frequencies which it is desired to suppress. These will then operate on the tube or series of tubes, in such a manner that the output circuit of the last tube A_2 represents a low impedance shunt across the generator terminals for those frequencies which passed through the filters F_1 and F_2. It is apparent that the effectiveness of this shunt depends upon the generator and load impedances as well as upon the overall amplification of the series of tubes. At the same time it is ineffective as a shunt so far as the fundamental or other frequencies which it is desired to transmit down the line L_1. The circuit as a whole then may be looked upon as a variable shunt across the generator, selective for those frequencies which pass the filter F_1.

The operation of the circuit may be more clearly set forth through a simple analytical expression which is now derived. The circuit of Fig. 1 may be represented conventionally in Fig. 1*a*, in which the effective voltage set up in the output of the amplifier is given by

$$mZ_bI_1$$

where m represents the ratio of the open circuit voltage at the circuit terminals of the output filter to the voltage impressed at the circuit side of the input filter. An application of Kirchoff's laws will readily yield the value of the current I_1 as

$$I_1=\frac{E}{Z_b+Z_g+\frac{Z_gZ_b}{Z_0}(1+m)}$$

where Z_0 is the passive impedance of the amplifier output circuit, Z_g is the impedance of the generator, and Z_b the impedance of the circuit and load. It will be seen that as m is increased without limit, the current I_1 and voltage Z_bI_1 in the frequency range passed by the filter, tends to approach zero. If the disturbance eliminator were not connected to the circuit, then the disturbing currents which would flow would be given by

$$I=\frac{E}{Z_b+Z_g}$$

from which it then develops that

$$\frac{I_1}{I}=\frac{1}{1+\frac{1+m}{\frac{Z_0}{Z_g}+\frac{Z_0}{Z_b}}}$$

To avoid singing it is assumed that the amplifier is so designed and connected that the part of the output voltage fed back to the input has no component in phase with the input. It is apparent that the effectiveness of the device may

be controlled, to an important extent, by the relative values of the impedances. Thus, if $Z_o=Z_b=Z_g$ then

$$\frac{I}{I'}=\frac{2}{3+m}$$

And, if the effective value of m for the tube or series of tubes takes on such moderate values as 30, it will be noticed that the disturbances will be reduced by a factor of approximately 16. It is understood, of course, that these values are given for illustrative purposes only.

Fig. 2 shows a modification of the circuit of Fig. 1, the application being particularly to that of a generator used for charging a storage battery, which storage battery in turn may be used for supplying power to some other circuit such as telephone circuits. Such generators as E_2, here shown as a D. C. generator, are ordinarily subject to certain fluctuations, such as harmonics due to slots and commutation, which may be particularly serious in the neighborhood of 800 or 1200 cycles. The circuit arrangement is essentially the same as that of Fig. 1, except that the filter in this case takes on the form of condensers which serve to block out the D. C. voltage from the amplifier and pass all frequencies above zero. Inasmuch as a storage battery has ordinarily a very low internal resistance, and inasmuch as the bus bars leading thereto are also of relatively low resistance, it is desirable that the shunt impedance shall be of very low value for the disturbing frequencies to be excluded. For this reason it would ordinarily be desirable to use a step-up transformer in the input of the amplifier, and a step-down transformer in the output of the amplifier in a manner, and for a reason, which will be readily understood by those skilled in the art. In this circuit only one amplifier is shown, but it is understood that a series of amplifiers may be used, as shown in Fig. 1.

Fig. 3 shows a modification of the circuit adapted for reducing disturbances such as may be picked up inductively by a signaling line T adjacent to section L'' of a power line. In this case the amplifier-filter combination of Fig. 1 is connected directly across the line and protects the section L'' from disturbances which may arise in the generator or in the section L'. The filters are designed to readily pass those frequencies which are disturbing, but to exclude those which are properly to be transmitted over the line from any A. C. source, here represented by the generator E_3.

Various modifications and applications of this circuit will now be evident to those skilled in the art without departing from the spirit of the invention as defined in the claims.

What is claimed is:

1. In an electrical system comprising a generator, a transmission line and a load, means for eliminating disturbing frequencies arising in the generator or the line, said means consisting of an amplifier with its input circuit and its output circuit bridged across the line, and means to pass to the amplifier only those frequencies undesired in the load.

2. In a system for eliminating harmonics and other disturbing effects in a transmission line, an amplifier with its input circuit and its output circuit connected directly together and in turn bridged across the line and having such gain characteristics as to offer a low shunt impedance to undesired frequencies.

3. In an electrical system, means for eliminating disturbing frequencies therefrom, said means consisting of an amplifier with its input circuit and its output circuit bridged across the system in such phase relationship as to offer a low shunt impedance to undesired frequencies, a filter in the input circuit and a filter in the output circuit of the amplifier, which filters pass the undesired frequencies and exclude the desired frequencies from the amplifier.

4. A systm for eliminating harmonics and other disturbances from a transmission line consisting of an amplifier with its input circuit and its output circuit bridged across the line, the output terminals of the filter being so poled with respect to the input terminals that the amplifier output offers a shunt across the line of low impedance for the frequencies to be suppressed, and means associated with the amplifier to pass only the undesired frequencies to the amplifier.

5. In an electrical system comprising a D. C. generator giving rise to disturbances, a storage battery to be charged thereby and signaling circuits adjacent thereto, connections from the generator to the storage battery, means for eliminating from the adjacent circuits disturbances inherent in the charging generator, said means consisting of an amplifier with its input circuit and its output circuit bridged across the generator, and condensers in the input circuit and in the output circuit to block D. C. current from the generator to the amplifier.

HAROLD A. RHODES.