

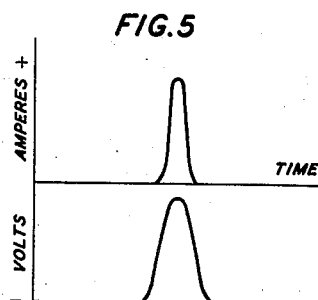
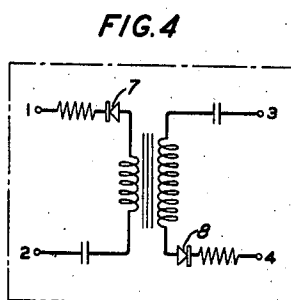
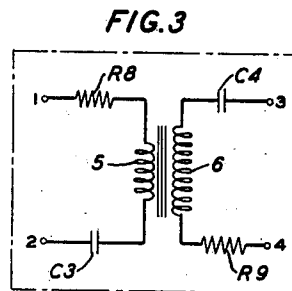
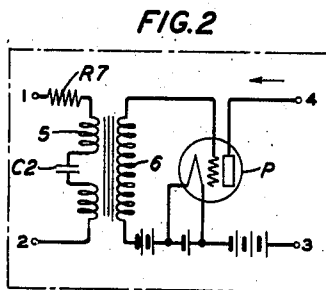
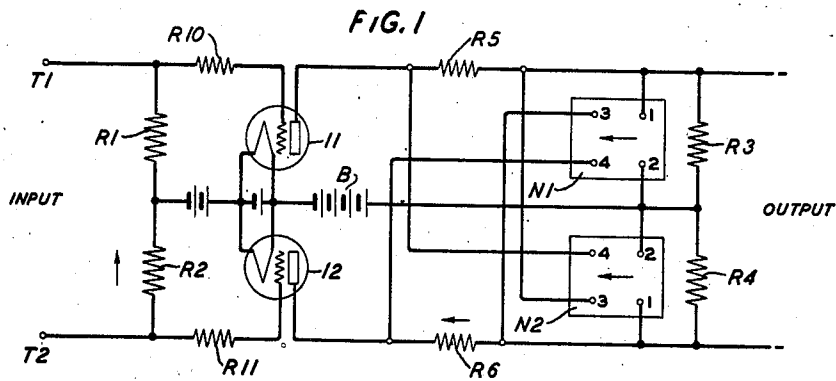
Sept. 7, 1943.

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2,328,671

IMPULSE REPEATER

Filed Nov. 13, 1941



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## UNITED STATES PATENT OFFICE

2,328,671

## IMPULSE REPEATER

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Application November 13, 1941, Serial No. 418,982

8 Claims. (Cl. 250-27)

This invention relates to amplifying, repeating and reshaping instrumentalities for low frequency current impulses of the type used in direct current telegraphy.

There have previously been proposed various arrangements of gas discharge tubes for repeating or amplifying low frequency impulses.

One of the objects of the present invention is to improve the operation of such arrangements by providing modified and improved circuits therefor.

A feature of improvement consists in arrangements whereby the form of the output wave may be improved by an over-shooting effect which increases the amplitude of the front end of the outgoing impulse.

Another feature of improvement is with respect to wave shaping in general.

Still another feature consists in circuits designed to minimize or reduce so-called "telegraph thump" or "receiving end thump." This phenomenon results in the use of electromagnetic relays and some other types of relays by the production of an induced voltage which feeds back into the line which constitutes the input circuit. This is objectionable on telegraph systems composited with telephone systems.

Other features and objects of the invention will appear from the following description taken with the accompanying drawing in which:

Fig. 1 comprises a generalized schematic arrangement in accordance with the invention;

Fig. 2 discloses an arrangement which may be connected to each of the sets of terminals 1, 2 of the circuit of Fig. 1 to supply a quenching voltage to each of the sets of terminals 3, 4 thereof;

Figs. 3 and 4 illustrate modifications which may be substituted for the arrangement of Fig. 2; and

Fig. 5 is a diagram illustrating the type of quenching voltage supplied to the output circuit of each tube when the arrangement of Fig. 2 is employed in Fig. 1.

In Fig. 1, the input circuit labeled "input" may comprise terminals of a telegraph line or other circuit which supplies polar impulses, that is, impulses a part of which are in one direction and a part of which are in another direction, to be amplified. Currents incident to these impulses flow through resistances R1 and R2, thereby applying voltages to the input circuits of the tubes 11 and 12 which are of a well-known type so designed that a certain magnitude of positive or reduction of negative potential applied to the grid thereof causes a discharge between the an-

ode and cathode. By virtue of ionization which takes place in the tube, the grid very largely loses control over the tube in the discharging condition and the discharge continues to flow independently of all potentials of the grid within the normal working range so long as a suitable potential is applied between the anode and the cathode.

The anode circuit of tube 11 passes from positive battery through the resistances R3 and R5. The anode circuit of the other tube passes from the same positive battery through the resistances R4 and R6. The resistances R3 and R4 are included in an outgoing line or output path labeled "output."

Rectangles N1 and N2 each include four terminals designated 1, 2 and 3, 4 to which various kinds of circuits may be attached.

One such circuit is illustrated in Fig. 2 in which the network N1 or N2 comprises an amplifying high vacuum or other suitable amplifying tube preferably designed to handle considerable power. The input circuit comprises a transformer primary 5, a resistance R7 and a capacity C2 and the secondary winding 6 of the transformer is connected directly to the grid of the power tube P. The output circuit may be connected to the terminals 3, 4 of Fig. 1. Thus, it is connected directly across resistance R5 or R6 as the case may be.

In considering the operation let it be supposed, for the purpose of establishing an initial condition, that neither tube 11 nor 12 is discharging. Then assume an impulse arriving over the input circuit causes current to flow through the resistances R1 and R2 in such a direction as to make the grid of tube 11 positive. This causes the current to flow in the anode cathode circuit to said tube and, consequently, through the resistance R3 which results in the impression of a voltage drop upon or the flow of a corresponding current in the output circuit. Upon the initial discharge of the tube 11 the current rises suddenly and a large voltage is applied across the terminals 1, 2 which is amplified by the power tube P and applied in amplified form to terminals 3, 4. The lower curve of Fig. 5 shows the form of voltage impulse applied to the grid of tube P and the upper curve shows the form of current wave or impulse flowing through the resistance R6. Inasmuch as we have assumed that tube 12 was not discharging, this current impulse will have no particular effect upon tube 12. Now let us assume that the incoming impulse reverses sign in such a manner as to make the grid of

tube 12 positive and cause it to have a large current flow in the anode-cathode circuit. The initiation of this current flow causes an impulse having the form illustrated in Fig. 5 to be applied across the resistance R5 and the direction of this current is such as to induce a large voltage drop which largely or entirely overcomes the terminal electromotive force of the battery B. This will cause the tube 11 to become extinguished; that is, the discharge therein will cease.

Because of the amplifying power of the tube P, the energy in the impulse illustrated in the upper part of Fig. 5 will be considerable, thereby applying a large and consequently an effective quenching voltage to the tube. Moreover, since at this time the grid of tube 11 has become negative and remains negative so long as the impulse which initiated the discharge in tube 12 is continuing, there will be no further discharge in tube 11. The output current will be substantially a series of relatively square-top positive and negative impulses corresponding to the incoming impulses. The amount of energy taken from the output circuits of either tube 11 or tube 12 to quench the other tube is relatively small.

A significant feature of the invention resides in the fact that the impedance of resistances R3, R4, R5 and R6 is almost entirely dissipative and that the quenching voltage is not derived from a condenser. This results in much more rapid building up of the impulses and a more effective extinguishment of the tubes than occurs in the case where condensers are utilized as the coupling impedance. It may be shown that with the arrangement disclosed the initial portion of an outgoing impulse is of increased amplitude as a result of a kind of over-shooting effect incidental to the quenching of one tube by the beginning of current flow in the other. This may be beneficially employed for wave shaping because it is known that in some types of telegraph transmission a transmitted impulse of which the initial or head end has an increased or excessive amplitude is often needed and employed.

In accordance with Fig. 3, the networks N1 and N2 may consist of a primary circuit having a resistance R8, the primary of the transformer having a small number of turns and the condenser C3, and the secondary circuit may consist of the secondary winding 6 of a transformer having a large number of turns in series with a condenser C4 and a resistance R9. If the resistances R8 and R9 are properly proportioned, it may be possible to obtain sufficient energy from the outputs of the transducers or networks N1 and N2 to extinguish the gas tubes and at the same time avoid prolonged transient impulses. For example, suppose tube 12 draws current and 11 does not. Then a reversal of polarity of the input signal suddenly causes tube 11 to fire. Therefore, the current in resistance R3 jumps to a higher value. The transient current in R3 produces a transient voltage across terminals 1 and 2 of Fig. 3 which is stepped up by the transformer, so that the voltage which it transmits to R6 is sufficient to reduce the plate potential of tube 12 to zero or below, thus extinguishing the latter. When the transformer is ideal the transient is not prolonged. In a practical transformer having leakage reactance, the series resistors R3 and R9 and the condensers C3 and C4 can be proportioned so as to reduce the delay of the transient. If the resistances R5 and R6 are large, a fairly small current flowing therein will

create a voltage drop sufficiently large to produce the desired extinguishment of the tubes.

In all such arrangements a battery source B of ample capacity is desirable. In fact, in order to secure the overshooting and wave shaping effect mentioned above, it is preferable that the current supplying capacity of the source B be at least twice that required to supply the normal current flow through one tube.

In accordance with Fig. 4, the networks N1 or N2 may include rectifiers 7, 8 of the copper-oxide type either in the primary circuit, in the secondary circuit, or in both. The effect of these is to make networks N1 or N2 substantially unidirectional and, by poling the rectifiers properly, impulses of sufficient power to extinguish the gas-filled tube which is to be extinguished will be available without wasting so much of the available power in the other network which has its input circuit associated with the tube which is not to be extinguished. Furthermore, the rectifiers serve to reduce the transient impulse flowing in an undesired direction.

The condensers C2, C3 and C4 are more or less optional. However, they prevent the passage of continuously flowing direct current through the windings and they have a beneficial effect upon the transient impulses which are to be produced.

Between the input terminals T1 and T2 and the source of telegraph impulses or other equivalent signaling impulses to be repeated a filter may be connected. In general, this filter when employed will be for the purpose of making the amplifier still less susceptible to small amounts of interference, more especially interference consisting of pulses relatively short as compared to the signaling impulses. For this purpose the filter may be designed to give the line an over-all transfer admittance for telegraph signals and still have a cut-off at or near the top frequency necessary for the required speed of signaling so that very brief impulse disturbances will not be submitted sufficiently so as to cause undesired reversals of polarity to be applied to the input circuits of the tubes 1 and 2. Information with respect to the requirements of such a filter may be obtained from a paper entitled "Certain topics in telegraph transmission theory" published in Transactions of the American Institute of Electrical Engineers, vol. 47, pages 617-644, April, 1928; other known information on filter design may be employed to supplement this information, if necessary.

If the variation of impedance of the input circuits of tubes 1 and 2 is considerable, it will be undesirable and the resistances R10 and R11 will be employed. These may be high resistances. Thus the impedance of the repeater as viewed from terminals T1 and T2 will be substantially equal to the sum of resistances R1 and R2.

As previously discussed, the networks N1 and N2 have their input circuits connected to terminals 1, 2 and their output circuits connected to terminals 3, 4. However, if the circuit elements are properly proportioned, these networks may have their input circuits connected to the terminals 3, 4 and their output circuits connected to terminals 1, 2. In so far as it is practical to give the resistances R3, R4, R5 and R6 suitable values, the general effects of this modified arrangement will be the same as in the principal arrangement described.

In Fig. 1 the networks N1 and N2 might be connected to receive their input voltages from

the potential drops across R3 and R5 in the case of N1 or across R4 and R6 in the case of N2, respectively. Their outputs might be arranged so that N1 applies voltage across R4 and R6 while N2 applies voltage across R3 and R5.

What is claimed is:

1. A repeater consisting of a plurality of gaseous discharge tubes each having an anode, a cathode and a control element connected in push-pull relation, and incoming line connected oppositely to the cathode-control element paths of said tubes, connections whereby a discharge through one of said tubes impresses a potential upon the output circuit of the other thereof to interrupt any existing discharge therethrough, said connections including impedance means in the output circuits of one of said tubes whereby the beginning of current discharge in one of said tubes produces a sudden change of voltage across said impedance means, an amplifier having its input circuit connected to have said change of voltage applied thereto, and a coupling between the output circuit of said amplifier and the output path of the other tube to impress a large negative voltage upon the anode thereof as an incident to said sudden change.

2. A repeater for voltage or current waves of the direct current impulse type, comprising a pair of gaseous breakdown discharge tubes arranged in push-pull relation, amplifiers each having its input circuit connected to impedance means in the output path of one tube to supply amplified reversed voltages to the output path of the other tube in a direction to quench or suppress any existing current flow therein.

3. A repeater consisting of a pair of gaseous discharge tubes each having an anode, a cathode, and a control element connected in push-pull relation, an incoming line connected oppositely to the cathode-control element paths of said tubes and connections whereby a discharge through one of said tubes impresses a potential

upon the output-anode circuit of the other to interrupt any existing discharge therethrough, said connections comprising an essentially pure resistive impedance for deriving the potential from one tube and an essentially pure resistance impedance for impressing the potential upon the other tube.

4. A repeater for voltage or current waves of the direct current impulse type, comprising a pair of gaseous discharge tubes arranged in push-pull relation, each tube being provided with a circuit comprising a primary path including a series condenser and a primary transformer connected across impedance means in the output circuit of one tube, a secondary winding of the transformer being inductively coupled to the primary and being in series with an impedance element of substantial impedance so connected and poled as to supply a reverse extinguishing voltage to the anode-cathode circuit of one tube upon the initiation of a discharge in the other.

5. A repeater for voltage or current waves of the direct current impulse type, comprising a pair of gaseous breakdown discharge tubes arranged in push-pull relation, and a circuit including reverse transformer couplings from a resistance in the output path of each tube to the output circuit of the other, with a rectifier included in the coupling circuit poled in a direction whereby the initiation of a discharge in one tube applies a pulse flowing in the conductive direction of the rectifier tending to extinguish the other.

6. A system in accordance with claim 5 in which the rectifier is in the primary circuit.

7. A system in accordance with claim 5 in which the rectifier is in the secondary circuit.

8. A system in accordance with claim 5 in which rectifiers are included in both the primary and secondary circuits.

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