June 28, 1938. L. K. SWART 2,121,935

AMPLIFYING SYSTEM

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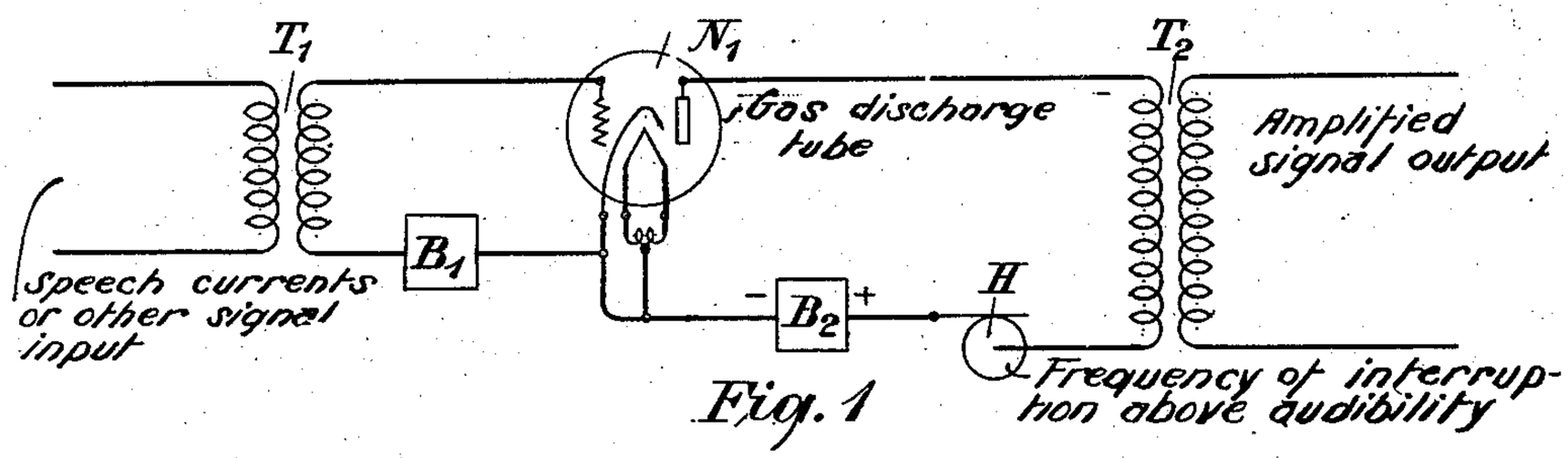

Fig. 1

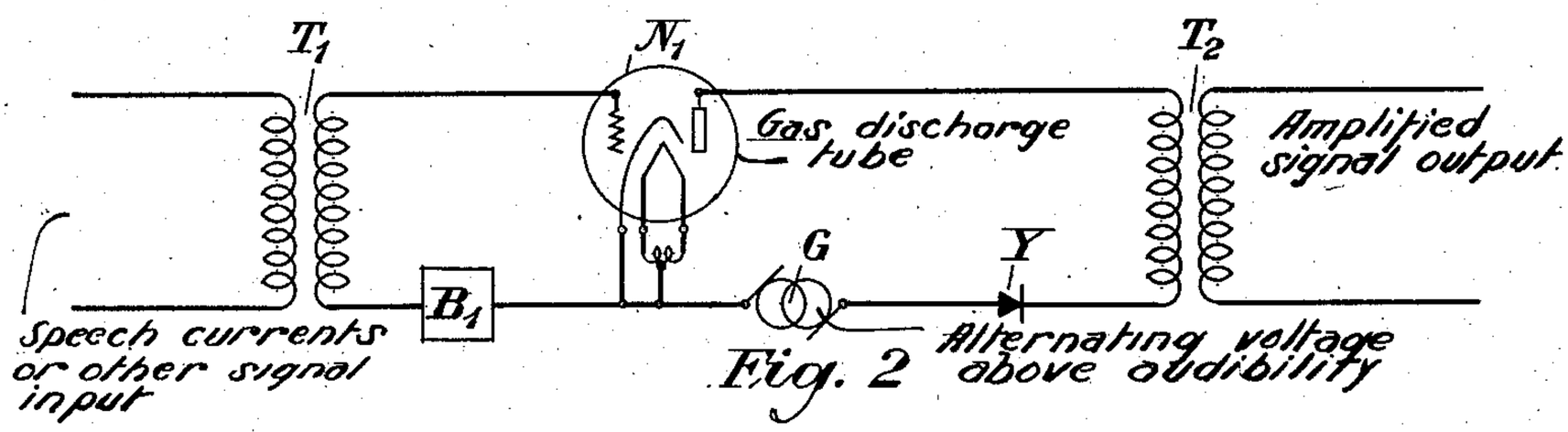

Fig. 2

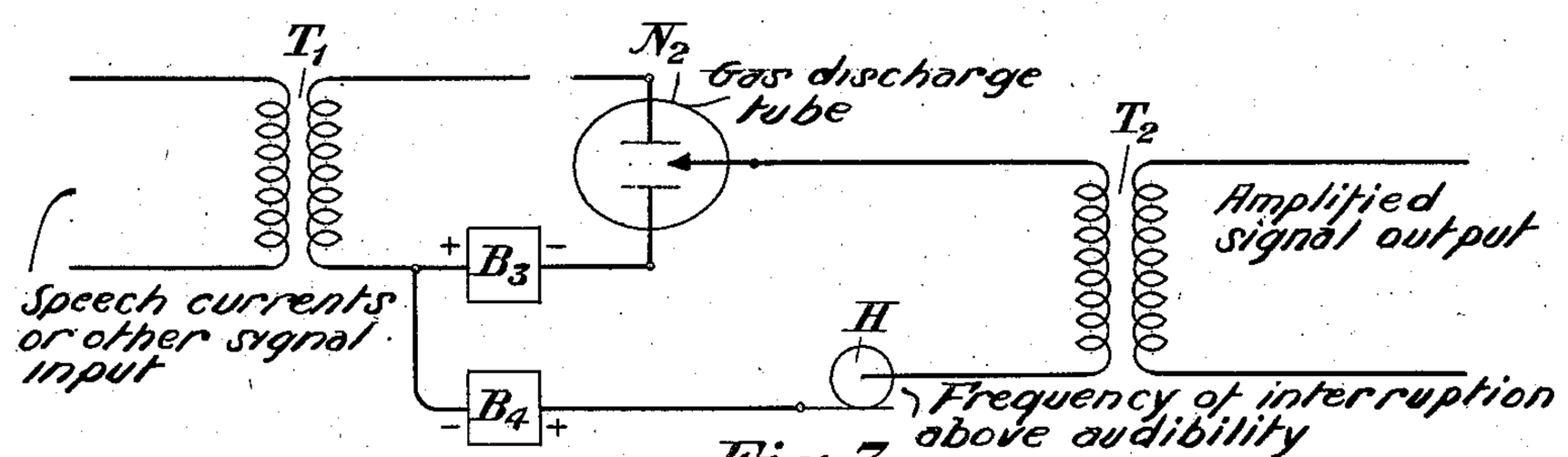

Fig. 3

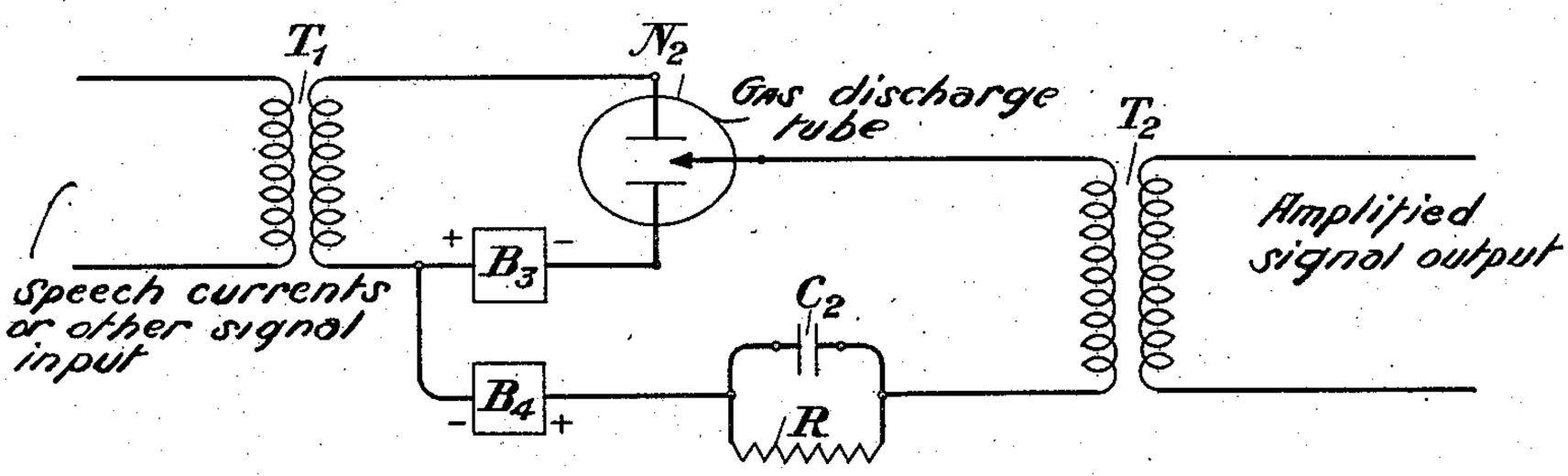

Fig. 4

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AMPLIFYING SYSTEM

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9 Claims. (Cl. 179—171)

This invention relates to amplifying systems. More particularly, this invention relates to amplifying systems employing a gas tube as the amplifying element.

This invention is applicable, among other uses, to telephony, for the purpose of obtaining in an outgoing or output circuit an amplification of voice currents originating in an incoming or input circuit. It is also applicable to telegraphy and signaling systems generally, and where amplification is necessary, as for example, for receiving, recording, and for reproducing impulses of electrical energy.

In the tube of this invention a gas such as neon, argon, helium or krypton, or any combination of such gases and nitrogen at low pressure is employed. The tube includes three or more electrodes, two of which are connected to the input or incoming circuit and a third electrode and one of the other electrodes are connected or coupled to an outgoing or output circuit. It is a property of a tube of this type to exhibit a high impedance between any two of the electrodes when the gas is in a deionized condition. When the gas of the tube becomes ionized, however, the impedance between any two electrodes becomes reduced to a few hundred ohms.

According to this invention the input circuit of the tube may be continuously or periodically or otherwise supplied with current having a frequency, or frequencies, preferably within the voice range. Ordinary speech currents or any component of speech currents may be applied to the input circuit. The gas of the tube will be ionized according to the application of such currents to the input circuit of the tube and regularly deionized at a very high speed, that is, at a frequency well above that of audibility. In the output circuit of the tube will be found highly amplified current or currents.

This invention will be better understood from the detailed description hereinafter following, when read in connection with the accompanying drawing, in which Figure 1 shows the invention applied to a hot cathode type of gas tube in the output circuit of which direct current potential is applied and periodically interrupted at a high speed; Fig. 2 is a modification of Fig. 1 in which the output circuit is energized by a high frequency potential; Fig. 3 shows the invention applied to a gas-filled tube of the so-called cold cathode type, the output circuit of which is energized by direct current potential interrupted at high frequency; and Fig. 4 is a modification of the arrangement of Fig. 3 in which the interrupter is of an electrical type involving no moving parts.

Referring to Fig. 1 of the drawing, a current within the audible frequency range or a plurality of such currents or ordinary speech signals may be applied through a transformer T_1 to the input circuit of a gas-filled tube designated N_1. The input circuit of the tube includes a grid and cathode and the grid is normally biased from a source of direct current potential designated B_1, which is connected in series with the secondary winding of the transformer T_1 between the grid and cathode of the tube. The output circuit of the tube is formed by the cathode and anode and includes the primary winding of a transformer T_2, an interrupter H and a source of direct current potential B_2. The secondary winding of the transformer T_2 may be connected to any device or circuit to which the amplified currents are to be supplied.

The cathode of the tube N_1 is raised to an electron-emitting temperature by means of a heater which is shown connected to a winding which may be one of the windings of a transformer, the other winding of which (not shown) may be connected to an alternating current generator of any well known type. The midpoint of the winding connected to the heater may be connected to the cathode as shown.

The source B_2 will have a terminal voltage which is less than the breakdown voltage between the anode and cathode of the tube N_1 but which is greater than the voltage required to sustain ionization of the gas between those electrodes. The interruption of this potential at high speed by the interrupter H, which may be any form of circuit breaker, will reduce the voltage between the anode and cathode substantially to zero, and hence deionize the gas of the tube at a frequency corresponding to the frequency of interruption of the device H.

As the input voltage within the range of audibility is applied through transformer T_1 to the grid or input circuit of the tube N_1, the gas within the tube will become ionized and during ionization a large current will flow between the anode and cathode of the tube as well as through the primary winding of the transformer T_2. A correspondingly large current will flow through the secondary winding of the transformer T_2 to the load or other apparatus connected thereto. But the potential applied to the anode will soon be withdrawn by the action of the interrupter H. When this occurs there will be an absence of current in both windings of the transformer T_2.

If the input voltage or voltages continue to be applied to the grid or input circuit of the tube N_1, currents will again flow through the windings of the transformer T_2 and be interrupted according to the speed of the interrupter H. The current in the secondary winding of the transformer T_2, however, will closely resemble the input voltage or voltages although it will be a highly amplified current. The high speed interruptions of that current will only slightly affect the intelligibility of these amplified currents or the signals carried thereby. It is, therefore, important that the interrupter be of very high speed so as to considerably reduce the effect of the interruptions upon the intelligibility of the signals carried by the current but at the same time act to regularly deionize the gas within the tube.

When no signals or other current is present in the grid or input circuit of the tube N_1, the gas within the tube will remain deionized. No current will then flow through the anode or output circuit of the tube. Thus the tube and its circuits act to amplify applied impulses only when such impulses are present and the circuits are at other times inert. The applied impulses themselves initiate the operation of the circuits.

In Fig. 2 the anode or output circuit of the tube N_1 is supplied with current from the generator G of a frequency well above audibility. This generator G may have a peak voltage approximating that of the source B_2 of Fig. 1, that is, a voltage between the breakdown and sustaining voltage values of the tube. A rectifier Y is connected in series with the generator G for permitting only positive potential to be applied to the anode of the tube. It will be understood, however, that this rectifier is by no means necessary to the operation of the circuit and may be entirely eliminated if so desired.

Fig. 3 shows the invention applied to an arrangement including a cold cathode-gas-filled tube N_2 of the three-electrode type. The flat plates or cathodes of this tube are connected to a circuit which includes the secondary winding of the transformer T_1 and a source of potential B_3. The anode of the tube is connected to the lower cathode through a circuit which includes the primary winding of the transformer T_2, a high frequency interrupter and sources of potential B_3 and B_4, as shown. The sources B_3 and B_4 may, if desired, be a single source of battery tapped so as to present the effect of two individual sources.

In the arrangement of Fig. 3, current or currents of the voice frequency range may be applied between the cathodes of the tube N_2 and there will be produced highly amplified currents in the anode or output circuits of the tube. These amplified effects will be transmitted to the load or other device connected to the secondary winding of the transformer T_2. These amplified currents, moreover, will be interrupted at the frequency of interruption of the device H. This frequency will be sufficiently high, however, so as not materially to affect the character or intelligibility of the currents or signals thus transmitted and amplified. The interrupter H acts as in Fig. 1 primarily to remove potential from the anode of the tube N_2 so as to definitely deionize the gas of the tube at regular intervals.

Fig. 4 is a modification of the arrangement shown in Fig. 3 but in place of the interrupter H of Fig. 3, a condenser C_2 and a resistor R, connected in parallel relationship, are substituted therefor. The condenser and resistor are so chosen that they will effectively interrupt the flow of current in the anode or output circuit of the tube N_2 at regular intervals. This may be accomplished, for example, as follows:

When the gas of the tube becomes ionized, the condenser C_2 will be charged to a voltage which sufficiently opposes that of the sources B_3 and B_4 that it will reduce the net effect of these voltages so applied to the anode below the sustaining voltage value of the tube. When the sustaining voltage is no longer applied to the anode of the tube, the gas of the tube will become deionized. The condenser C_2 will then discharge through the resistor R to a substantially lower voltage. When a sufficiently low voltage at condenser C_2 is reached, the voltage on the anode of the tube will be again raised above the voltage required to maintain ionization of the gas within the tube. Condenser C_2 will again be charged by current from sources B_3 and B_4 to a voltage sufficiently high so as again to reduce the effective potential at the anode below that required for sustained ionization, and so this continues.

While this invention has been described in connection with the amplification of applied currents of the audible range of frequencies, the invention is not limited to applications of such currents alone. This amplifying system may be applied to currents below the audible range of frequencies as well as to currents exceeding the upper limits of audibility.

While this invention has been shown and described in certain particular arrangements merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. An amplifying system comprising a gas tube having at least three electrodes, means for simultaneously applying a plurality of voltages of frequencies within the range of audibility to two of the electrodes of the tube, all of said voltages corresponding to speech signals, an output circuit connected to the third electrode and one of the other electrodes of the tube in which the applied voltages in amplified form are present, and a source of interrupted voltage of a frequency outside the range of audibility, said source being connected in said output circuit for periodically deionizing the gas within the tube.

2. An amplifying system comprising a cold cathode gas tube having two cathodes and an anode, a source of alternating voltages corresponding to speech signals, all of said voltages being applied simultaneously to the two cathodes of the tube, a circuit connected between the anode and one of the cathodes of the tube in which will flow alternating voltages corresponding to the signal voltages applied to the cathodes but considerably amplified, and means for periodically deionizing the gas within the tube, the frequency of deionization being different from the frequency of the alternating voltages of said source.

3. The combination of a gas-filled tube having input electrodes and output electrodes, a source of telephone signals coupled to the input electrodes of the tube, said source emitting a plurality of voltages simultaneously which together have a complex wave form, a source of potential exceeding the sustaining voltage of the tube and con-

nected between the output electrodes of the tube, means for interrupting the flow of current in the output circuit of the tube at a frequency greater than any frequency contained within the telephone signals of the source, and means for translating the amplified currents of the output circuit of the tube.

4. The combination of a gas tube having three electrodes, a source of voice frequency signals corresponding to ordinary speech transmitted over a circuit coupled to two of the electrodes of the tube, a source of periodically interrupted potential connected between the third electrode and one of the other electrodes of the tube, the peak voltage of said latter source exceeding the sustaining voltage of the tube, the impedance in the circuit of the third electrode periodically varying from a high value to a negligible value, this voltage variation being comparable with the degree of amplification of the voice frequency signals, and means for utilizing the amplified signals.

5. An amplifying system comprising a gas tube having at least three electrodes, a source of voice frequency signals corresponding to ordinary speech, a transformer coupling said source to a circuit including two of the electrodes of the tube so as to simultaneously apply to said two electrodes substantially all of the components of said signals, a circuit interconnecting the third electrode and one of the other electrodes of the tube, the latter circuit including a source of potential exceeding the breakdown voltage of the gas within the tube and an interrupter having a frequency of interruption which is above audibility.

6. A telephone repeater comprising a gas tube having input and output circuits, means responsive to telephone currents applied to the input circuit for initiating ionization of the gas within the tube, means responsive to the continuous application of telephone currents to the input circuit of the tube to deionize the gas within the tube at a frequency above the telephone range of frequencies, and a load circuit coupled to the output circuit of the tube.

7. A telephone amplifier comprising a gas-filled tube having at least three electrodes forming input and output circuits, a source of telephone speech signals coupled to the input circuit, and a source of voltage connected to the output circuit, said latter source being interrupted at a rate such that the interrupted time will be greater than the deionization time of the gas of the tube, the magnitude of the voltage of said latter source being less than that required to initiate ionization of the gas of the tube but greater than that required to sustain ionization after it is initiated.

8. A telephone amplifier comprising a gas-filled tube having at least three electrodes forming input and output circuits for the tube, a source of telephone signals coupled to the input circuit, a circuit coupled to the output circuit for receiving the amplified signals, said input circuit including means responsive to said telephone signals to ionize the gas between the input electrodes of the tube during the application of said signals, and means independent of said telephone signals for periodically deionizing the gas between the output electrodes of the tube.

9. An amplifying system for a band of frequencies corresponding to telephone signals comprising a gas-filled tube having three electrodes, means for applying all of said frequencies to the path of two of said electrodes for ionizing the gaseous path between said electrodes during the application of said frequencies, a source of voltage connected between the third electrode and one of the other electrodes, the voltage of said source being not greater than the voltage required to initiate ionization of the gas between the two last mentioned electrodes but greater than that required to sustain ionization after it is initiated, means for periodically interrupting the voltage of said source, and means for observing said amplified frequencies.

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