

June 5, 1934.

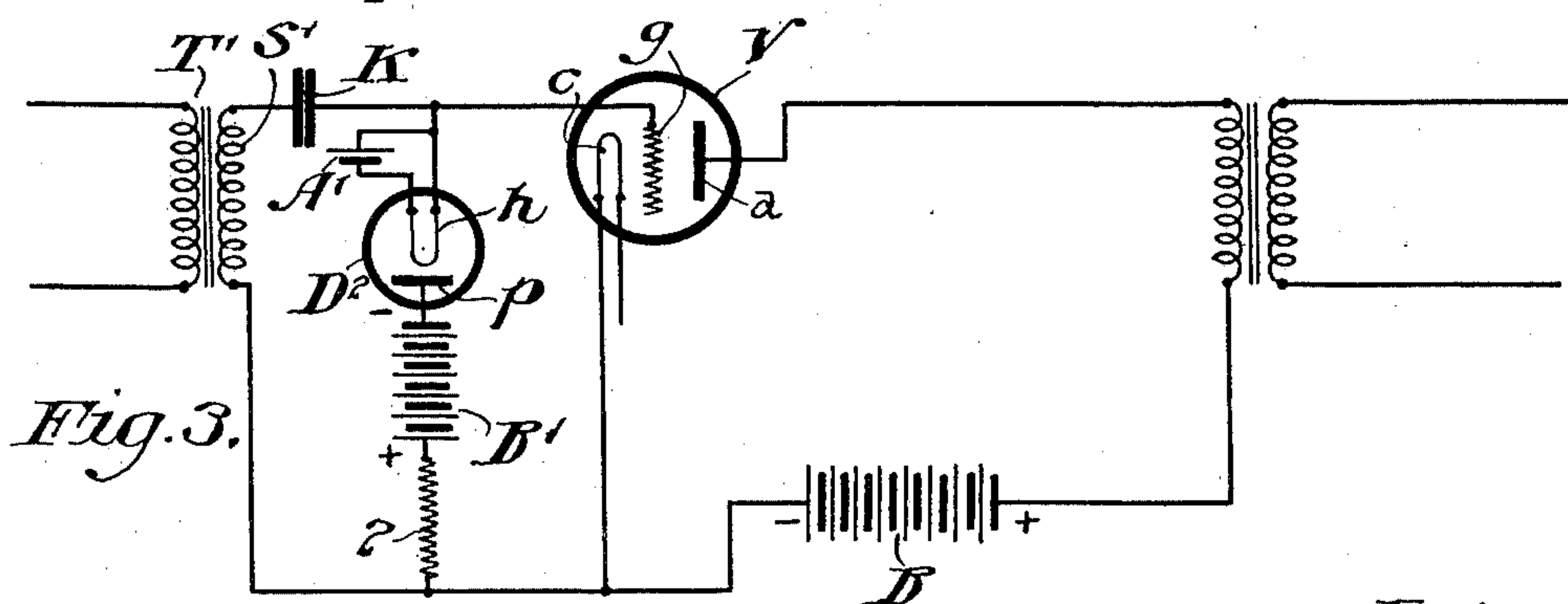
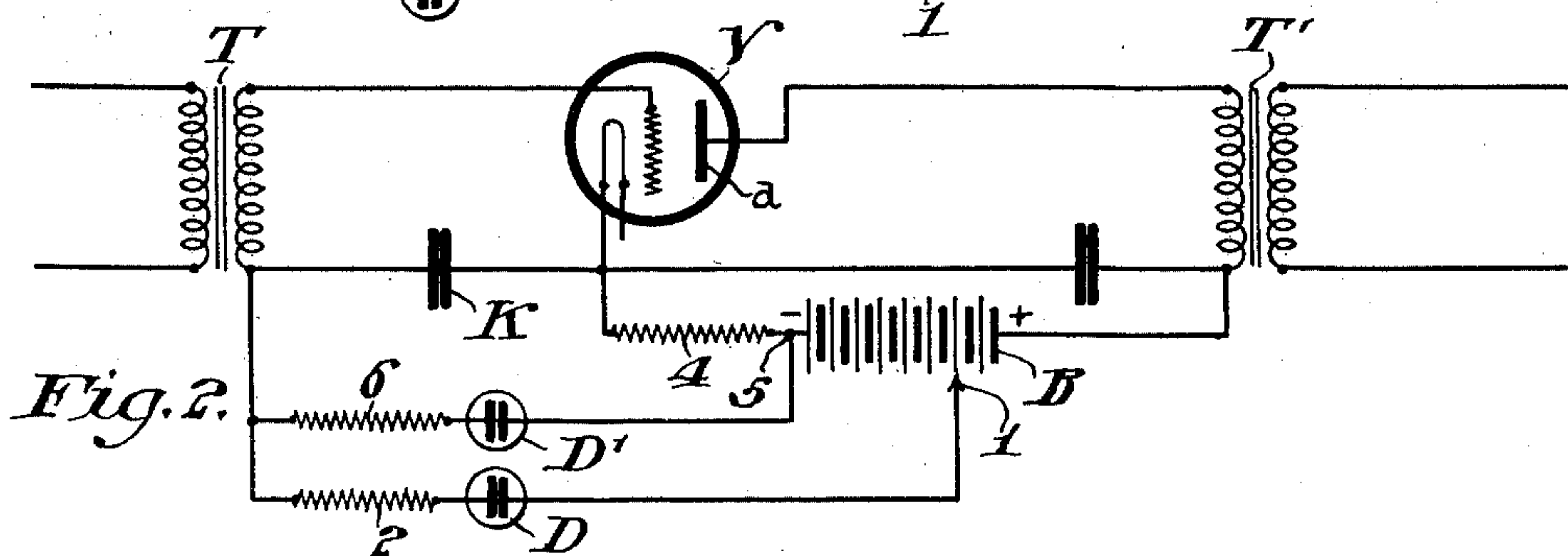
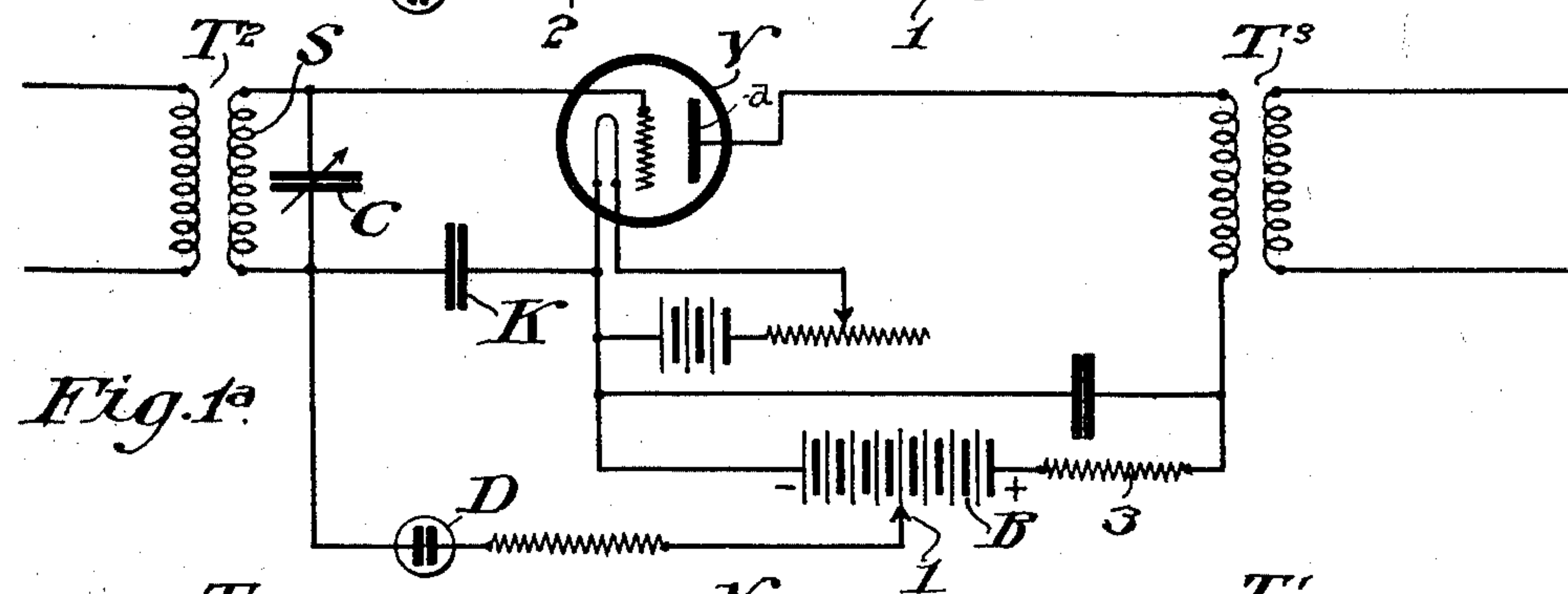
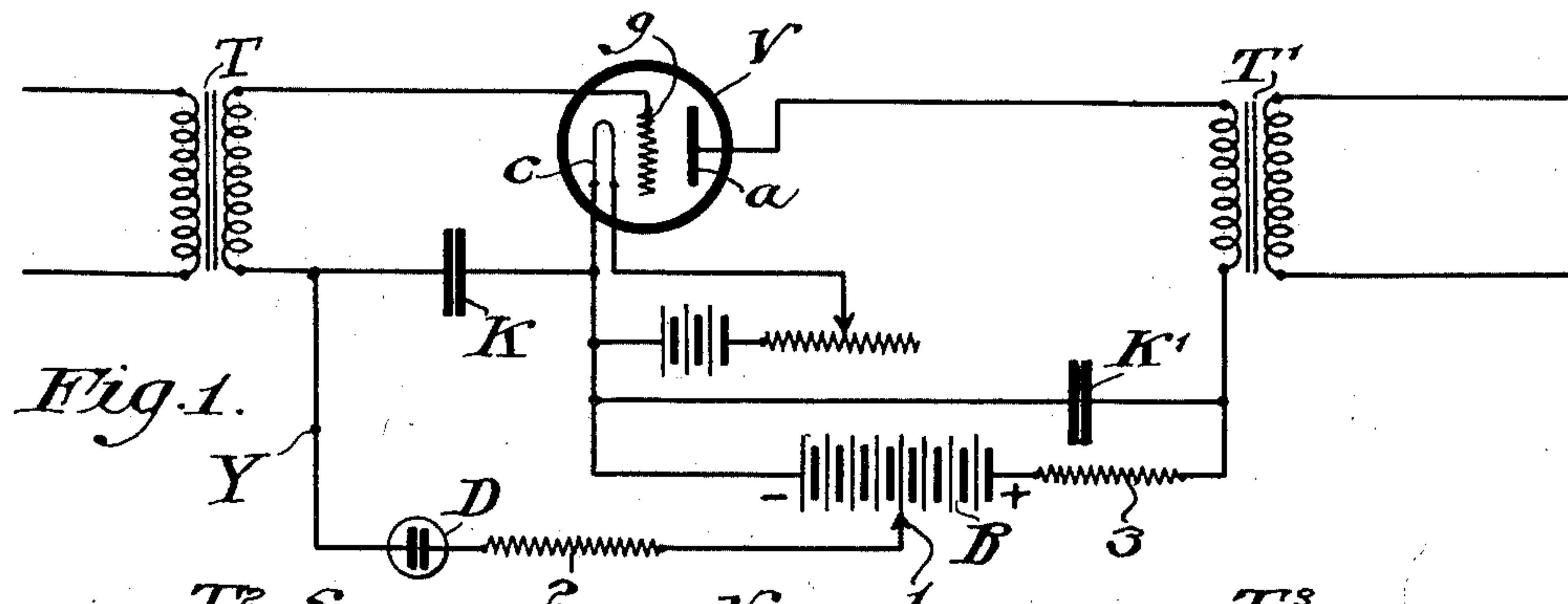
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1,961,937

AMPLIFIER BIASING SYSTEM

Filed April 1, 1932

2 Sheets-Sheet 1



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AMPLIFIER BIASING SYSTEM

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2 Sheets-Sheet 2

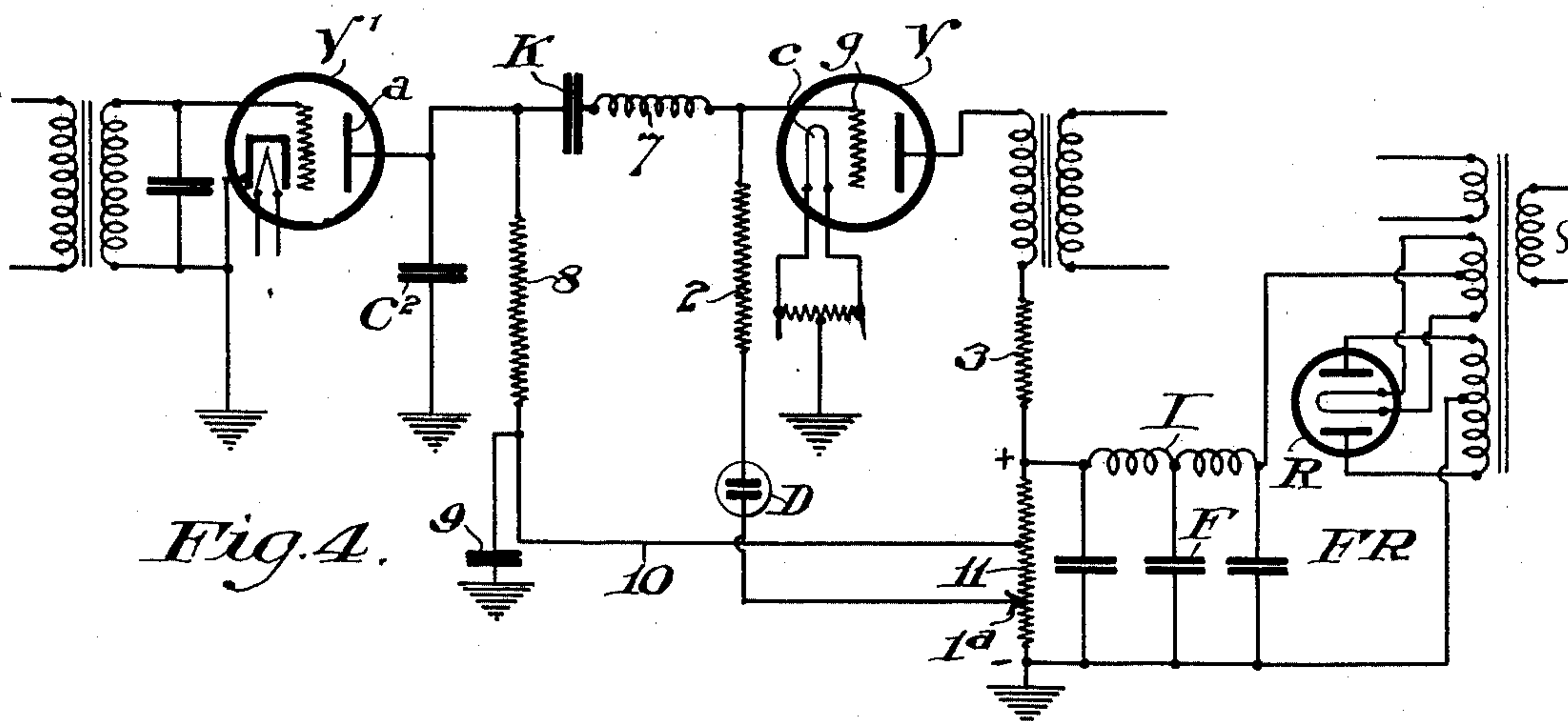


Fig. 4^a.

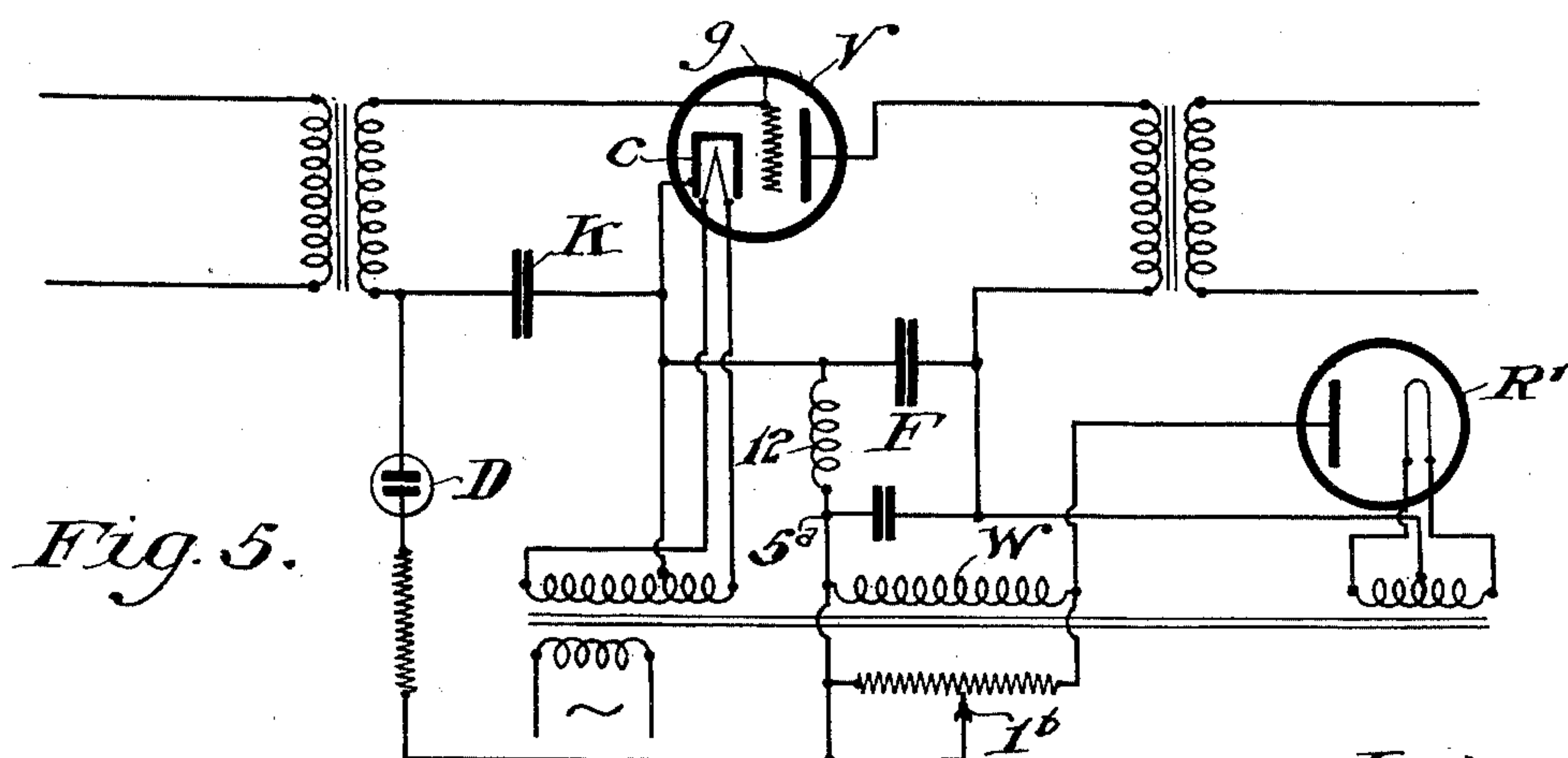
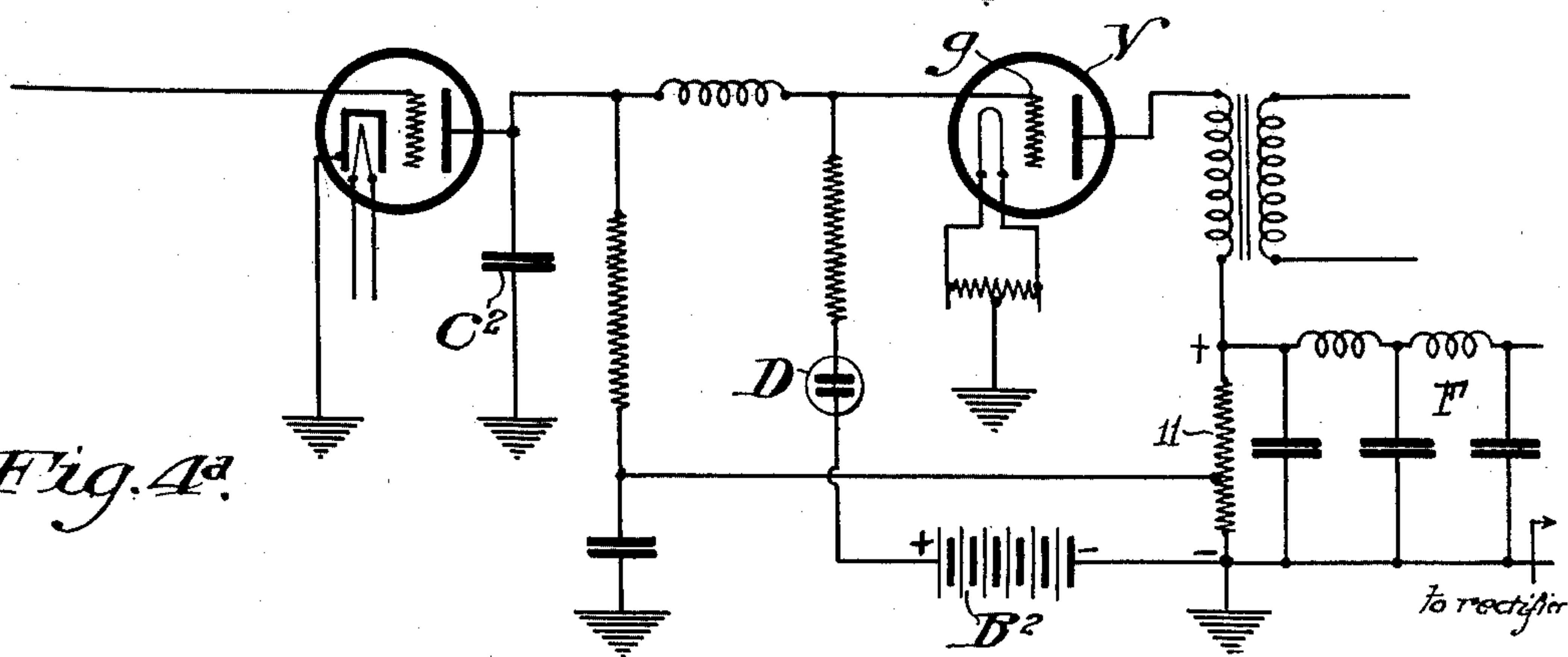


Fig. 5.

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UNITED STATES PATENT OFFICE

1,961,937

AMPLIFIER BIASING SYSTEM

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Application April 1, 1932, Serial No. 602,461

20 Claims. (Cl. 179—171)

My invention relates to systems for applying biasing potential to the grid structure of one or more amplifier tubes, particularly in radio receiving systems.

5 In accordance with my invention, the negative biasing potential applied to the grid of an amplifier tube is derived from the voltage of the signal itself, as received or as received and amplified, as distinguished from a voltage of or
10 derived from a local source of energy; and the grid potential is prevented from becoming excessively negative during reception of strong signals. More particularly, so long as the voltage of the signal impressed upon the amplifier
15 input circuit does not exceed a predetermined magnitude, the grid of the tube is left substantially free or isolated, in the sense there is no external conductive connection therefrom to the cathode, to permit a condenser in the grid circuit to accumulate negative charges flowing to
20 the grid from the cathode during the positive swings or half waves of the signal voltage, thereby to provide a negative biasing voltage, of or due to the signal, affording faithful or good
25 quality of reproduction of the signal; but when, due to higher signal voltages, heavy crashes of static, or the like, the biasing voltage becomes excessively high, a conductive discharge path is temporarily provided to drain from the grid its
30 excess negative charge to prevent distortion of reproduction or blocking of the tube; preferably, the discharge path includes a resistance of magnitude to ensure the rate of discharge shall not be high enough to cause audible or other low
35 frequency disturbances in a reproducing device associated with the amplifier output system.

More specifically, a device having a critical or threshold breakdown voltage, as a tube containing neon or equivalent, forms upon occurrence of discharge therethrough a conductive
40 path from grid to cathode whenever the grid-biasing voltage tends to become excessively negative; alternatively, the anode of a thermionic tube, connected between grid and cathode of the amplifier, with its cathode presented to the grid
45 of the amplifier, may be negatively biased so that a conducting path from grid to cathode external to the amplifier tube exists upon reception of strong signals to prevent excessive negative
50 grid bias.

Further in accordance with my invention, the direct current component of the plate circuit current of the amplifier tube is prevented from becoming excessively high when there is no signal or when the signal is of low magnitude; for

example, a ballast resistance may be included in the plate circuit to limit the current rise; the plate current supply system may be constructed or designed to have a voltage characteristic which is decidedly drooping; or the increase in
60 plate current may be utilized to increase the grid-biasing voltage of the amplifier tube whenever it falls below a predetermined minimum.

In one form of my invention, the discharge device, besides reducing as aforesaid the biasing
65 voltage of the grid when built up to excessively high magnitude, as by strong signals, is also operative when the bias is less than a predetermined minimum, to permit recharge of the aforesaid condenser independently of the signal current until the desired minimum bias voltage is
70 restored; more specifically, when the sum of the break down voltage of the discharge device and the grid-biasing voltage is less than the sum of a predetermined unidirectional voltage and the
75 positive peak voltage of an alternating current source, small current impulses flow through the device to the condenser, diminishing in amplitude until finally the biasing voltage has increased to such extent that the discharge device no longer to substantial extent conducts
80 and the impulses no longer flow.

My invention resides in the methods and apparatus hereinafter described and claimed.

For an understanding of my invention and
85 for illustration of some of the various forms it may take, reference is to be had to the accompanying drawings in which:

Fig. 1 illustrates an audio frequency amplifier stage utilizing the invention. 90

Fig. 1a is similar to Fig. 1 except that the amplifier is for radio frequencies.

Fig. 2 is a modification for maintaining the grid-biasing potential between predetermined limiting values. 95

Fig. 3 illustrates a further modification of my invention, using a thermionic tube as a discharge device.

Figs. 4, 4a and 5 illustrate further modifications of the invention. 100

Referring to Fig. 1, the grid *g* of the audio amplifier tube *V* is isolated from its cathode *c* by the blocking condenser *K*; accordingly there is no conductive or direct current path except as hereinafter provided, between the grid and cathode external to the tube. When signals of audio frequency are impressed upon the input circuit of the tube, through transformer *T* or otherwise, as by transfer from a prior amplifier stage, a detector, transmission line, phonograph pick-up, or 110

the like, the potential of the grid follows the signal voltage. When under influence of the signal the grid is positive with respect to its cathode for at least part of the signal voltage cycle, electrons
 5 flow from the cathode to the grid within the tube, giving it a negative charge. As the grid circuit is open for direct currents by virtue of the blocking condenser K, these charges do not leak off but are stored or accumulated in the condenser
 10 K which so becomes a source of negative grid biasing potential. The magnitude of capacity of condenser K is not critical; it may be of from one to four microfarads, or even as low as .03 microfarad, more or less.

15 The grid is therefore free to accommodate itself to the strength of the incoming signal; the stronger the signal, the greater the charge accumulated by the condenser K and the greater is the negative grid bias. The biasing potential is
 20 therefore derived from or produced by the signal voltage itself; and the amplifier automatically adjusts itself to the proper operating condition.

If the signal voltage is of constant magnitude, and inherent leakage resistance is neglected, the
 25 grid assumes a potential more negative than the cathode by an amount corresponding to the peak value of the signal voltage wave applied to it. Under such conditions the tube no longer draws grid current, the plate current is limited by the
 30 negative charge on the grid, and in all respects the tube properly functions as an amplifier. If the signal voltage increases in amplitude, for example, so that the grid again becomes positive for the positive peaks of the signal waves, additional negative charges flow to the grid increasing the condenser charge and so increasing the
 35 negative biasing potential until the tube again no longer draws grid current.

However, under conditions of operation the
 40 signal voltage impressed upon the grid may be far from uniform in amplitude, and in some cases it may assume very excessive values for short periods of time, as for example, during crashes of static in radio reception. With abnormally high
 45 values of input voltage, the negative charge built up on the grid may be so high as to cause serious distortion, and in extreme cases may to such extent bias the grid negatively that the plate current is cut off, in which event the tube is said
 50 to be "blocked". The tube, once blocked, remains inoperative until the excessive negative charge leaks off the grid through very high resistance leakage paths inherent in the tube itself, the tube socket, wiring and the like. Until the excess
 55 charge drains off, which may require a substantial period of time, the plate current does not flow and the tube is inoperative.

To insure continuous functioning of the tube and yet procure high quality of reproduction, a
 60 discharge device D is employed to prevent blocking of the tube, or, in general, to prevent excessively high grid biasing voltages. The discharge device may be one dependent upon ionization of a gas, as neon, argon, mercury-vapor, etc., or it
 65 may depend upon electro-chemical action, as in electrolytic condensers or rectifiers, or it may be electronic in nature.

In the arrangement specifically shown in Fig. 1, the discharge device is a neon glow tube of a
 70 well known type, specifically, it may be a half-watt type G10 manufactured by the General Electric Company, having a break-down or threshold discharge voltage of about 120 volts. The tube D is connected in a path between the grid
 75 g and cathode c which is normally open because

the potential difference between the electrodes of the tube D is less than the break-down voltage of the tube. When, however, the signal or input voltage is excessively high, as under the abnormal condition above mentioned, a conductive path is formed within the tube so that the excess negative charge is drained off the grid preventing the tube from "blocking" or causing distortion.

As the break-down potential of the tube D is generally substantially higher than the signal voltages usually encountered in normal operation of the amplifier, the electrode of the discharge tube D presented to the amplifier cathode c is not directly connected thereto, but connects to a positive terminal 1 of a battery B, or equivalent, whose negative terminal is connected to the cathode of tube V. The effect is the same as if the break-down voltage of the tube D were in fact lower and more nearly equal to or comparable with the maximum permissible negative grid voltage. While in this instance the source B is used for other purposes as well, it shall be understood a separate source, of suitable voltage, may be placed anywhere, as at X or Y, in series with the tube D between grid g and cathode c of tube V.

Or if the tube D should have a break-down voltage substantially less than the maximum desired negative grid-biasing voltage, a source of uni-directional voltage, such as B, may again be used in like positions, but poled reversely to the foregoing cases.

Using a UX245 tube as an audio amplifier, and a plate potential of 250 volts, it was found that when the negative grid bias exceeded 60 volts, distortion resulted. For this case, the tap 1 from the discharge tube D to source B should be connected to a point or terminal of the latter which is about 60 volts positive with respect to the cathode c. With this connection, the grid circuit remains open and the grid is free to assume any negative potential up to 60 volts in accordance with the strength of the impressed signal. When, however, the positive peaks of the signal or input waves exceed 60 volts, the potential across the tube D is greater than its break-down voltage of 120 volts, the tube D conducts, and the excess negative grid charge is drained off.

To prevent the rapidity of action of tube D and its circuit from creating an audio frequency disturbance, a resistance 2, of relatively high magnitude, as of the order of 1 megohm, is connected in series with the discharge device D. When the tube breaks down, the resistance 2 prevents such disturbance and besides limits the amplifier grid current to a very small magnitude so that the distortion is not serious. However, if the signal or input voltage is so strong that the tube D continuously flashes, the signal lever should be reduced in any suitable manner, as by a usual volume control which reduces the intensity of the signal voltage impressed upon the input of tube V.

Under conditions of no signal, or of reception of weak signals, the negative grid charge, though tube D is then not conducting, gradually leaks off from condenser K, and the grid of the amplifier therefore very slowly approaches cathode potential. Particularly if the tube V is of the so-called "power" type, and the voltage of the plate current source B is of proper value for normal operation of the tube, the plate current under the conditions of no or weak signals, or low or no negative grid bias, will tend to be excessive, with likelihood of damage to the tube and of ab-

normal current drain on the source of anode current B. In the system shown in Fig. 1, such undue rise of plate current is prevented by the ballast resistance 3 of suitable magnitude, and preferably of material having a high positive resistance-temperature coefficient. With the grid *g* approaching or at cathode potential, the increase in anode current through resistor 3 reduces the difference in potential between the anode or plate *a* of the tube and its cathode *c*, with reduction of plate current through the tube to safe values. As shown, source B and resistor 3 may be shunted by an audio-frequency by-pass condenser K1.

Although transformers T and T1 have been shown for coupling the input and output circuits of the tube V respectively, to the immediately preceding and following circuits or devices, it is of course understood that any other form of coupling device, such as resistance, auto-transformer, etc., may be used.

The invention is not limited to use with audio-frequency amplifiers, for, as shown in Fig. 1a, it may also be used with high or radio-frequency amplifying systems.

Fig. 1a is in general identical with Fig. 1, except the coupling transformers T2, T3 are of the radio-frequency type. When the input circuit of the amplifier tube is to be tuned, as by a condenser C, variable or not, the blocking condenser K, the discharge device D, and its appurtenances, are preferably outside of the tunable loop formed by the secondary S of the transformer and the tuning condenser C. The input circuit of the tube V may be coupled to an antenna, to a preceding amplifier stage, to a carrier frequency transmission system, or the like, and the output circuit may be coupled to another amplifier, to the input of a detector, etc. The magnitude of capacity K may be lower than for the audio frequency system of Fig. 1, although again that magnitude is not critical, and may, for example, be of the order of .03 microfarad.

The system shown in Fig. 2 is generally similar to the system of Fig. 1, differing principally in that it utilizes a different arrangement for limiting the anode current under conditions of no signal or low signal voltage. In this modification, an impedance 4 of suitably high resistance is connected between the negative terminal of the battery B, or equivalent, and the cathode *c* of the tube, so that the point 5 is more negative than the cathode due to the flow of anode current through resistance 4. The magnitude of resistance 4 is so chosen that when the plate current flowing through it is somewhat less than the permissible maximum for the tube, the drop of potential across the resistance exceeds the breakdown voltage of a second discharge device D1, so that there is a surge which charges condenser K again to provide a negative grid-biasing potential. This action may repeat from time to time as the grid charge slowly leaks off, or until a sufficiently strong signal is impressed upon the input circuit of the tube which thereupon operates in the normal manner described in connection with tube D of Fig. 1. The second discharge device D1 may be of the same character as device D, and preferably there is included in series with D1 a suitably high resistance 6. This anode current limiting arrangement may in like way be applied to the radio frequency amplifier system of Fig. 1a, or in any of the other systems herein described.

In the system shown in Fig. 3, the condenser K is connected between the grid and the high-po-

tential side of the transformer secondary S1, but insofar as the operation of either this arrangement or the arrangement shown in Fig. 1 is concerned, the condenser K may be either in the grid lead or cathode lead. For normal amplitudes of signal voltage, the system operates as described in connection with Fig. 1, the condenser K storing the negative charges flowing to the grid to provide a negative grid biasing potential. In this modification, however, an electronic tube, as a two element thermionic tube or valve D2, preferably of very high vacuum or substantially pure electron discharge, is used instead of an ionization discharge tube D or the like. The cathode *h* of the tube D2 is presented to the grid *g* of the amplifier tube V. The anode *p* of tube D2 is connected through battery B1 and resistance 2 to the cathode *c* of the amplifier tube V. The battery B1 has its negative pole connected to the anode *p* of the tube D2, this being contrary to the usual practice for an anode battery. The voltage of battery B1 is chosen equal to the maximum negative bias which is to be permitted for the grid *g* of the amplifier tube V. No electrons can flow from cathode to anode of tube D2 until the cathode becomes more negative in potential than the anode, which is to say until the input signal voltage has built up a negative charge on grid *g* of amplifier tube V which is greater than the potential of battery B1. When such a charge has been built up tube D2 becomes a unidirectional conductor and the excess charge on grid *g* is drained off. Resistance 2 limits the rate of discharge through tube D2 and thus prevents sudden disturbances in the output of the amplifier.

The tube D2 may be of the uni-potential cathode type, as an UX227, in which event the source of heater current A1, whether a battery or a transformer winding, need not be at high potential with respect to the cathode of the amplifier tube V.

Fig. 4 illustrates the invention as embodied in a resistance coupled amplifier system, and in which the anode current is supplied by a rectifier-filter network FR. The condenser K for providing the negative biasing potential for the grid of amplifier tube V may be connected between the grid of tube V and the anode of the preceding tube V1, so that it also serves as a coupling condenser between the tubes. Under these circumstances it should be suitably large to afford low impedance to audio frequencies; for example, it should be of the order of .1 microfarad or larger.

Particularly when the preceding tube V1 is functioning as a detector a radio-frequency choke coil 7 is preferably connected between the condenser K and grid *g* of the amplifier tube V, and a radio-frequency by-pass condenser C2 connected between the anode and cathode of the detector tube. The usual coupling resistance 8 is included in the anode circuit of the tube V1, the condenser 9 affording a path of low impedance to ground or cathode in shunt to the power supply. The direct current component of the anode current of tube V1 flows through the conductor 10 which may, as shown, be connected to a tap on the resistance 11 in the output of a filter rectifier system FR.

The usual grid leak between the grid *g* and the cathode *c* of the amplifier tube V is omitted, so that the negative charges flowing to the grid for positive swings or half waves of the signal voltage are stored by the condenser K to negatively bias the grid *g* of the amplifier tube. As in Fig. 1,

the discharge device D, in series with a suitably high resistance 2, is connected between the grid of the amplifier tube and its cathode. As in Fig. 1, if the break-down voltage of the discharge device D is higher than the permissible maximum swing of the signal voltage, the device D, instead of being connected directly to cathode, connects to a point or tap 1a which is suitably positive with respect to cathode; for example, to a tap or slider on the bleeder resistance 11 in the power supply system FR, or more generally, to any point in the anode supply system which is to proper extent positive with respect to the amplifier cathode. When the impressed signal is so great that the sum of the voltage built up on condenser K by the signal, and the voltage from point 1a to cathode is greater than the breakdown voltage of the discharge device D, a leakage path is formed between the grid and cathode through device D to remove the excess of negative grid charge.

Under conditions of no or low signal, the plate current tends to increase. To prevent the anode current rise from becoming excessive, the filter rectifier system FR may be designed or chosen to have a drooping voltage-load characteristic; that is, the supply transformer, the rectifier tube R, and/or the conductive impedances I of the filter F, may have such characteristic that the plate current of tube V is limited to safe values even though the grid *g* should assume cathode potential. Alternatively, or in addition, a ballast resistor 3 may be included in the plate circuit of tube V for this purpose, as described in connection with Fig. 1.

While it is more convenient to obtain the supplemental voltage for discharge tube D from the power supply system, a separate battery B2 may be used, as shown in Fig. 4a; the positive terminal of the battery B2 is presented to the grid *g* of the amplifier tube V, but the path is normally open because of the intervention of the discharge device D. As in the preceding figures, the grid circuit is normally open, but upon occurrence of excessively strong signals or input voltage, the conductive path from grid to cathode is formed through tube D, to drain off or neutralize the excess negative grid charge.

In the system shown in Fig. 5, the condenser K, as in the preceding modifications, provides a biasing potential from the signal or other input voltage for grid-biasing purposes. In addition, in this case, the tap or contact 1b is connected to a potentiometer resistance across the winding W of the supply transformer for the tube V, or instead it may connect to a tap on the winding W itself. In either event, the voltage between the point 5a of the filter network and contact 1b is an alternating current voltage; it is in series with the direct current voltage drop across the impedance or resistance 12 in the negative conductor of the filter F so that the point 5a is negative with respect to cathode *c*, and the point 1b is alternately positive and negative with respect to cathode *c*.

For simplicity of explanation, it is assumed that the breakdown voltage of the discharge device D is 120 volts and the desired minimum negative biasing potential for grid *g* is 30 volts; it is also assumed that under normal conditions the voltage drop across the filter reactor 12 is 40 volts, and that the contact 1b has been adjusted so that the peak alternating current voltage between it and point 5a is 110 volts. Under conditions of normal signal strength, the condenser K stores the negative charges, due to the signal

alone, flowing to the grid for grid biasing purposes. However, under conditions of no signal or low signal voltage, as previously pointed out, the grid potential gradually drifts toward that of the cathode. The grid is also substantially at cathode potential if the amplifier is put into operation after a fairly protracted period of non-use. Under these circumstances, the tube D is subjected to a difference of potential equal to the algebraic sum of the 40 volt drop across the filter reactor 12, and the alternating potential difference of 110 volts between contact 1b and point 5a. For the positive half waves of the power cycle, the sum of these voltages is 70 volts, which is less than the break-down or critical voltage of the tube D. For the negative half waves of the power cycle, however, the sum is 150 volts, which is sufficient to break down the tube D, and to permit the condenser K to acquire a charge. As soon as the charge is built up to a value of 30 volts negative on its plate presented to the grid, the tube D no longer breaks down, for the sum of its breakdown voltage and the biasing voltage is not less than the sum of the filter reactor drop and the negative peak voltages picked off by contact 1b. If the charge leaks off after a time, the tube D again breaks down and the cycle repeats until the desired minimum of 30 volts negative grid bias is reestablished.

If a signal having a peak voltage in excess of 30 volts is impressed upon the amplifier input circuit, the grid becomes more and more negative for stronger and stronger signals as in the prior modifications. When very large signal or other voltages are impressed on the amplifier input, the grid becomes more and more negative, until under the conditions above assumed, it reaches a negative potential of 50 volts. When this condition is exceeded, the tube D will again break down, and the excess negative grid charge will be drained off. The tube breaks down because the sum of the bias voltage built up on condenser K and the algebraic sum of the aforesaid voltages in the power supply system for the positive halves of the power cycles is in excess of 120 volts.

Briefly, in this arrangement, for the assumed values, the grid is permitted to float freely and to adjust itself to signal voltages between the limits of 30 and 50 volts. If the upper limit of biasing voltage, 50 volts, is exceeded, the excess charge at once leaks off through the path afforded by break-down of the tube D. If signal voltages less than the minimum, 30 volts, are applied for long enough time to allow the charge on the condenser K to leak off, through paths inherent in the condenser, tube, wiring, and appurtenances, to such extent that the condenser charge falls below the minimum of 30 volts, a new charge is applied to condenser K from the power supply system as previously described until the minimum of 30 volts is again established. It is understood, of course, that the foregoing numerical values are used for illustrative purposes, and not in a limiting sense. If, for example, the contact 1b is set to pick off a peak alternating current voltage of 115 volts instead of 110 volts, the limits of free grid operation is then from 35 volts negative to 45 volts negative.

In the foregoing description, the secondary effect of the grid bias upon the amplifier plate current which in turn affects the voltage drop across the filter reactor 12 has been omitted for simplicity of explanation. Actually, this secondary effect tends to narrow the range of free

grid operation for a given setting of the potentiometer contact 1b.

The voltage drop across the filter reactor, or more generally between the point 5a and cathode c, should equal the normal or optimum biasing voltage of the tube, i. e., if the tube is of the UX247 pentode type usually operating with a negative grid bias of 16 volts, the voltage drop across the reactor 12 should be 16 volts. If the total voltage drop across the reactor is greater than that amount, the desired value can be obtained by using a potentiometer resistance shunting the reactor or by tapping the reactor. On the other hand, if the drop across the reactor is not sufficient, the desired voltage may be obtained by taking the voltage drop across the reactor and a resistance in series therewith between cathode c and point 5a.

For brevity in the appended claims the term signal voltage is utilized generically to include all input voltages of or from external sources as distinguished from local sources of current or power supplies; and the signal voltage may be that of or representing any type of transmission, at either radio, audio or other frequency, including telegraphy, telephony, television and the like.

What I claim is:

1. The method of biasing the grid of an amplifier, which comprises impressing a signal voltage upon the grid circuit of the amplifier, accumulating negative charges flowing to the grid under the influence of said signal voltage to effect a negative grid biasing potential, applying said negative potential to an electrode of a discharge device having another electrode connected to the cathode of said amplifier, and separately producing an opposing potential difference between said electrodes whose magnitude is selected to bear a predetermined relation to the maximum desirable negative grid-biasing potential so that when the said biasing voltage exceeds a predetermined magnitude, the conductivity between said electrodes, external to the tube and between grid and cathode thereof, is increased to reduce said biasing voltage.

2. The method of biasing the grid of an amplifier, which comprises impressing a signal voltage upon the grid circuit of the amplifier, accumulating negative charges flowing to the grid under the influence of said signal voltage to effect a negative grid biasing potential, applying said negative potential to an electrode of a discharge device having another electrode connected to the cathode of said amplifier, and separately producing an opposing potential difference between said electrodes whose magnitude is selected to bear a predetermined relation to the maximum desirable negative grid-biasing potential so that only when said biasing voltage exceeds a predetermined magnitude, conductivity is established, external to the tube, between grid and cathode thereof, to reduce said biasing voltage.

3. The method of biasing the grid of an amplifier, which comprises impressing a signal voltage upon the grid circuit of the amplifier, accumulating negative charges flowing to the grid under the influence of said signal voltage to effect a negative grid biasing potential, applying said negative potential to an electrode of a gaseous discharge device having another electrode connected to the cathode of said amplifier, and applying to said electrodes an opposing potential difference whose magnitude is selected to be substantially equal to the difference between the ionizing potential of the gas and the maximum de-

sirable negative grid-bias so that when said biasing voltage exceeds a predetermined magnitude, the excessive biasing voltage ionizes the gas to conduct the excessive charge from the grid and so reduce said biasing voltage.

4. The method of biasing the grid of an amplifier, which comprises impressing a signal voltage upon the grid circuit of the amplifier, accumulating negative charges flowing to the grid under the influence of said signal voltage to effect a negative grid biasing potential, applying said negative potential to an electrode of an electronic device having another electrode connected to the cathode of said amplifier, and applying to said electrodes an opposing potential difference selected to be of such magnitude as to prevent electronic conduction between said electrodes except when the negative biasing potential becomes undesirably high.

5. The method of biasing the grid of an amplifier which comprises leaving the grid circuit open as to unidirectional current, impressing a signal voltage upon the grid circuit, accumulating the negative charges flowing to the grid from cathode to provide a negative grid biasing potential, applying said negative potential to an electrode of a discharge device having another electrode connected to the cathode of said amplifier, and applying an opposing potential difference to said electrodes selected to be of such magnitude that under conditions of excessively high signal voltage, the grid circuit is intermittently completed to drain off the excess grid charge, and selecting the resistance of the drainage path to be of such high magnitude that the drainage is at sub-audible rate to avoid disturbing low frequency variations of the anode current of the amplifier.

6. In the operation of a thermionic amplifier, the method which comprises impressing a signal voltage upon the grid circuit of the amplifier, accumulating negative charges flowing to the grid to effect negative grid biasing potential, and limiting the anode current of the amplifier under conditions of low signal voltage or of no signal.

7. In the operation of a thermionic amplifier, the method which comprises impressing a signal voltage upon the input circuit of the amplifier, accumulating the negative charges flowing to the amplifier grid to provide a biasing potential therefor, and, under conditions of no signal or low signal voltage, increasing the impedance of the anode circuit of the amplifier to limit its anode current.

8. In the operation of a thermionic amplifier, the method which comprises impressing a signal voltage upon the input circuit of the amplifier, accumulating the negative charges flowing to the amplifier grid to provide a biasing potential therefor, temporarily providing a leakage path to drain off part of the grid charge when the biasing potential is excessive, and, when the biasing potential is low, temporarily accumulating a charge derived independently of signal voltage, to restore the biasing potential.

9. In the operation of a thermionic amplifier, the method which comprises impressing a signal voltage upon its input circuit, accumulating the negative charges flowing to the amplifier grid to provide a biasing potential therefor, temporarily providing a leakage path when the biasing potential is excessive, and, under conditions of no or low signal voltage producing by the resultant increase in plate current a voltage to restore the

grid biasing potential to magnitude for which the plate current is not excessive.

10. An amplifier system comprising a thermionic tube, an input circuit therefor open as to unidirectional current and including in series a condenser for storing the negative charges flowing under the influence of the signal voltage to the grid from cathode to derive a negative biasing potential for the grid, and a discharge device for closing said grid circuit for unidirectional current during reception of strong signals thereby to prevent distortion.

11. An amplifier system comprising a thermionic tube, an input system therefor open as to unidirectional current and including a condenser for storing the negative charges flowing to the grid from cathode to derive a negative grid biasing potential from the impressed signal, a discharge device between grid and cathode of said tube for closing said grid circuit for unidirectional current upon reception of strong signals to drain off the excess grid charge otherwise causing distortion, and a high resistance in series with said discharge device to ensure that the rate of discharge shall be at a frequency other than audible.

12. An amplifier system comprising a thermionic tube, an input circuit therefor open as to unidirectional current and including a condenser for storing the negative charges flowing to the grid from cathode to derive a negative grid biasing potential from the impressed signal, a normally open path in shunt to said condenser, a discharge device in said path, and a source of direct current in said path having its negative pole presented to the cathode of said tube and its positive pole to the grid of said tube, the sum of the voltage of said source and of the negative biasing voltage built up on said condenser by said strong signals being greater than the breakdown voltage of said device.

13. An amplifier system comprising a thermionic tube, a blocking condenser between the grid and cathode of said tube for accumulating the negative charges flowing to the grid from cathode to derive a negative grid biasing potential from the signal, a unidirectional current system for supplying the anode current of said tube, and a normally open direct current path from grid to cathode including a discharge device connected between the grid and to a point in said anode supply system whose potential is substantially positive with respect to cathode.

14. An amplifier system comprising a thermionic tube, an input circuit therefor including a condenser between grid and cathode for deriving a negative grid biasing potential from the impressed signal, a discharge device forming a normally open direct current path in shunt to said condenser and intermittently closing said path during reception of strong signals to prevent distortion by excessive biasing potential, and means for limiting the plate current of the tube during conditions for which the grid approaches the cathode in potential.

15. An amplifier system comprising a thermionic tube, a condenser in the input circuit of said tube for deriving negative grid biasing potential from the impressed signal, a source of direct current having its negative terminal connected to cathode, and a glow tube connected between the grid and a positive terminal of said source.

16. An amplifier system comprising a thermionic tube, a condenser in the input circuit of said tube for deriving negative grid biasing potential from the impressed signal, a system for supplying the anode current of said tube, and a glow tube connected between the grid and a point in said system more positive than the cathode of said thermionic tube.

17. An amplifier system comprising a thermionic tube, a condenser in the input circuit of said tube for deriving a negative grid biasing potential from the impressed signal, a normally open path between the grid and cathode of said tube, a thermionic tube in said path having its cathode connected to the grid of said first tube and its anode to the cathode of said first tube, and a source of voltage in said path negatively biasing the anode of said second tube with respect to its cathode.

18. An amplifier system comprising thermionic tubes, a blocking condenser coupling the anode circuit of one tube to the input circuit of the next tube and deriving negative grid biasing potential from the impressed signal for the grid of said second tube, a system for supplying the anode current of said tubes, and a normally open path comprising a discharge device connected between the grid of said second tube and a point in said supply system more positive than the cathode of said second tube.

19. An amplifier system comprising thermionic tubes, a blocking condenser coupling the anode circuit of one tube to the input of the next and deriving negative grid biasing potential from the impressed signal for the grid of said second tube, a system for supplying the anode current of said tubes having a falling voltage-load characteristic, a glow tube connected between the grid of said second tube and a point in said supply system more positive than cathode potential, and a high resistance in series with said glow tube.

20. An amplifier system comprising a thermionic tube, a blocking condenser in the input circuit thereof between grid and cathode, a rectifier-filter system for supplying the anode current of said tube, and a discharge device connected between the grid of said tube and a point in said system between which and cathode there are two sources of electromotive force in series, one a source of unidirectional force with the positive terminal presented to cathode, and the other a source of alternating electromotive force alternately positive and negative with respect to cathode.

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