Jan. 7, 1941. J. L. FINCH 2,227,493

CATHODE RETURN BIAS CIRCUIT

Filed Nov. 9, 1937 2 Sheets-Sheet 1

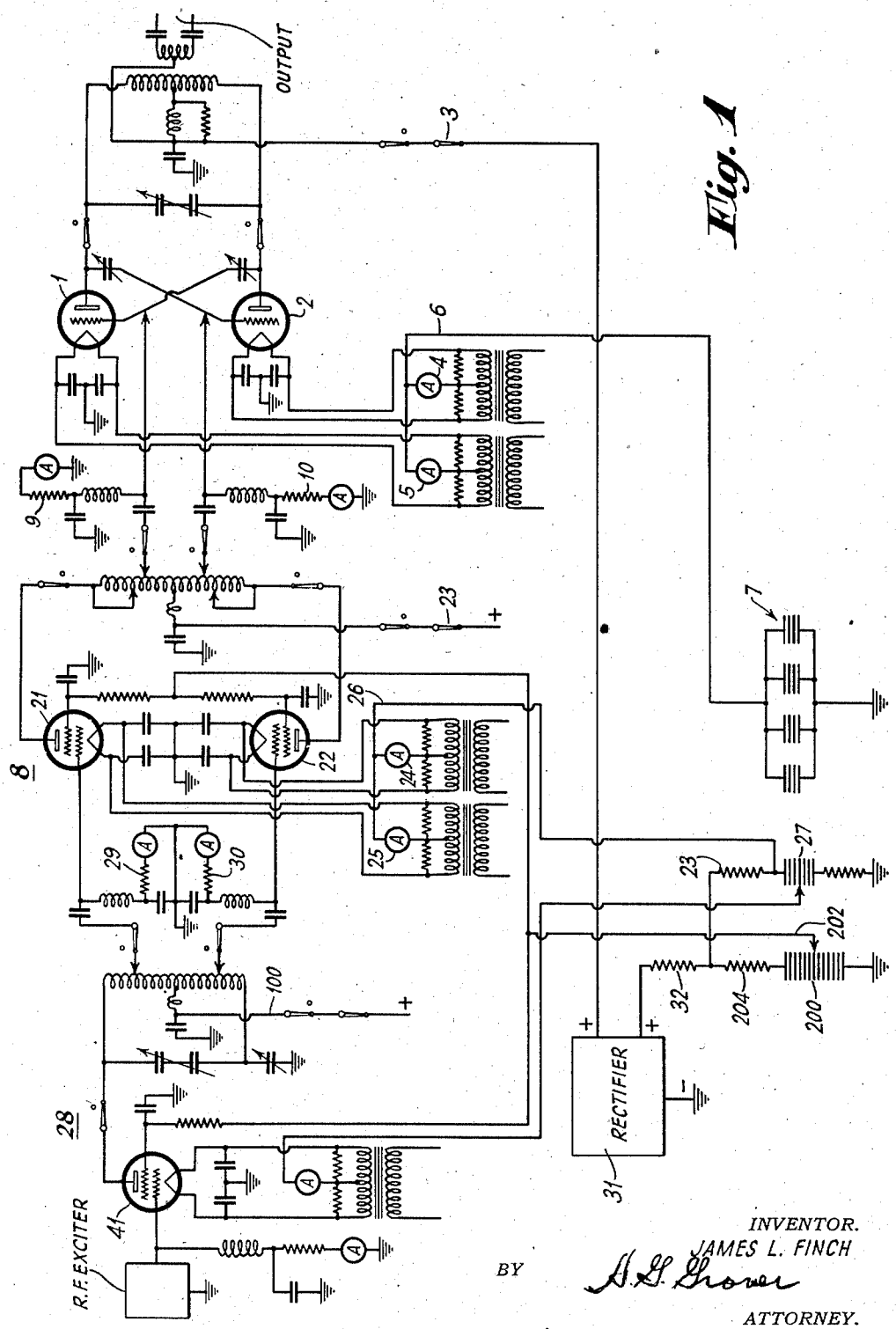


Fig. 1

INVENTOR.
JAMES L. FINCH

BY

ATTORNEY.

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Fig. 2

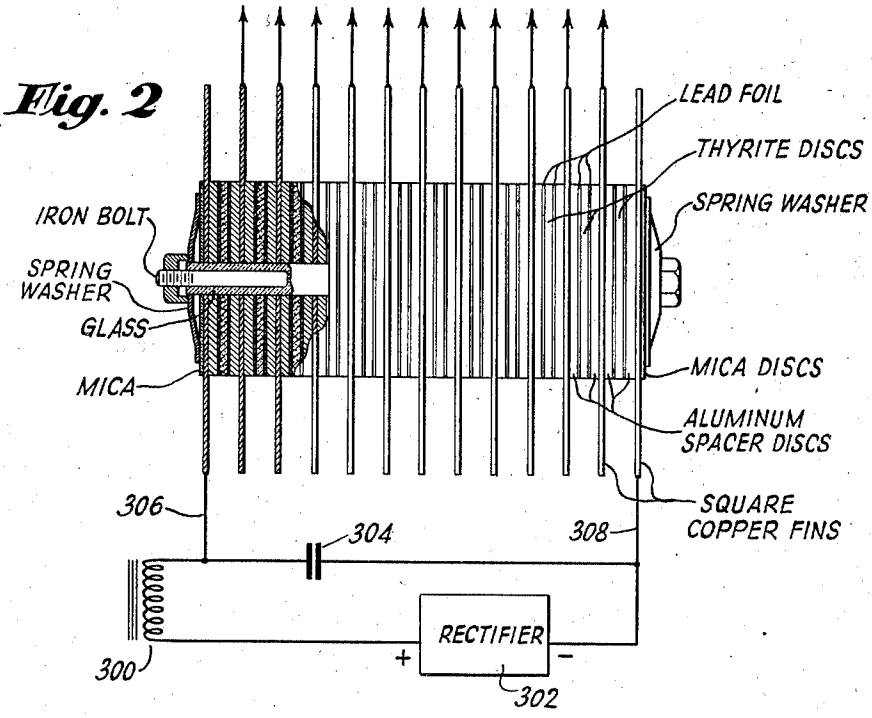
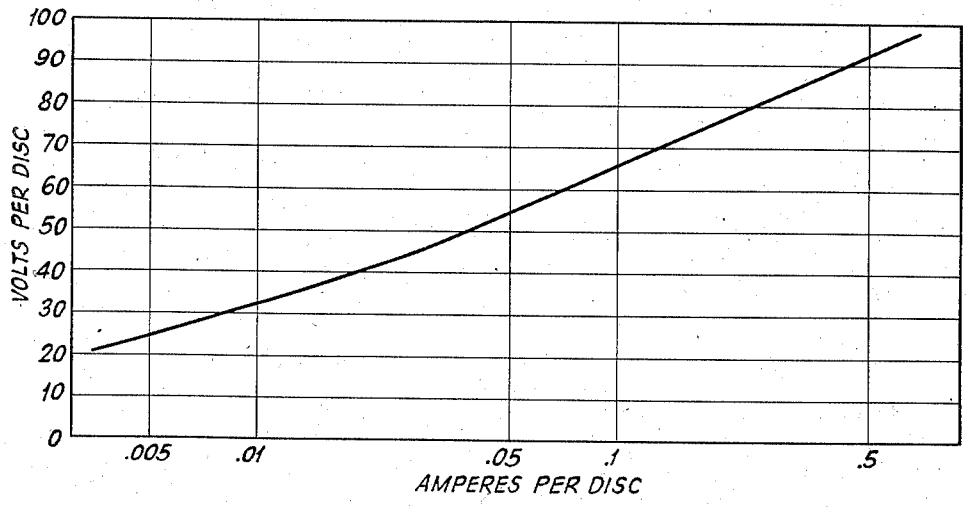


Fig. 3



INVENTOR.
JAMES L. FINCH

BY

ATTORNEY.

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CATHODE RETURN BIAS CIRCUIT

James Leslie Finch, Patchogue, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

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3 Claims. (Cl. 178—66)

This invention relates to a means of biasing thermionic tubes in circuits such as oscillators and amplifiers. Generally, it utilizes the variable resistance characteristics of "Thyrite."

"Thyrite" is a material which was developed by the General Electric Company for lightning arresters and has the distinctive characteristic that the current rises very rapidly with very small increases in voltage impressed across it. When the voltage is doubled the current goes to something like 14 times the initial value.

References to this material will be found in the General Electric Review for February, 1930; June, 1930; April, 1934; and May, 1934; and in the Transactions of the American Institute of Electrical Engineers for April, 1930.

In the past bias voltage has been obtained from separate voltage supplies such as rectifiers, motor generators or batteries. These are expensive and introduce additional possibilities of failure.

Grid leak bias has been used in the past when the tube in question draws grid current. In the case of an oscillator or amplifier this type of bias may endanger a tube since if for any reason the oscillator stops oscillating or the drive to the amplifier fails, the bias is removed and the tube will draw successive plate current.

Bias is sometimes provided by causing the anode current of the tube to flow through a resistance connected between the cathode and the negative of the anode current supply source, the grid circuit being connected to the negative of this supply source. This system of bias is very often unworkable in connection with tubes working class C when used in services such as telegraph. In this case when the telegraph key is up and no excitation is furnished to the amplifier a relatively high value of anode current must flow to produce the bias and the power represented by this current is all dissipated in the tube. If a higher resistance is used then the bias is excessive when the key is closed.

To overcome these difficulties is the main object of my invention.

In the drawings:

Fig. 1 shows a transmitter.

Fig. 2 shows a "Thyrite" bank.

Fig. 3 is an explanatory graph.

The accompanying drawings show schematically the circuits of a class C telegraph transmitter in which my invention has been incorporated. 1 and 2 are tubes in an amplifier stage, the plate current being supplied through switch 3 and returning through ammeters 4 and 5, lead 6 and "Thyrite" resistor bank 7 to ground and to the negative side of the anode supply. Excitation is supplied from earlier stages marked 8 to the grids of 1 and 2. The excitation is keyed in any suitable way through lead 100 in the earlier stage 28 in accordance with the telegraph signals. For the marking condition excitation causes grid current to flow through grid leaks 9 and 10, which result in a negative grid bias on the grids of tubes 1 and 2.

For the spacing condition no excitation is supplied and, accordingly, no grid current flows and therefore no bias is supplied from this source. This tends to allow a current to flow through the anodes of tubes 1 and 2 and through the "Thyrite" resistor 7. The voltage drop across 7 causes the cathode to be held at a positive voltage with respect to ground. Since the grids are maintained at ground potential by virtue of being connected to ground through grid leaks 9 and 10 their potential is negative with respect to that of the cathode. A condition of equilibrium is reached in which the bias voltage built up across 7 allows just the required amount of anode current to flow through tubes 1 and 2 to produce this bias voltage.

Under the conditions assumed in the drawing, which is illustrative of a transmitter which I have constructed, this equilibrium occurs when the voltage across 7 is 129 volts and when the current flowing through 7 is 34 milliamperes. At the voltage assumed this represents an anode dissipation of 102 watts in each tube. For the marking condition the excitation allows more anode current to flow. This is assumed to equal one ampere total.

Now if "Thyrite" 7 had a constant resistance this one ampere would build up a voltage across it of 3800 volts. The peculiar properties are such that as the voltage across it is increased the resistance drops in accordance with a definite law. By virtue of this drop in resistance one ampere actually builds up a voltage of only 309 volts across 7. This voltage plus the bias obtained by the grid leak action gives a total bias of the value for best operation.

The characteristics of the "Thyrite" 7 and the value of resistors 9 and 10 can be adjusted as required.

One modification of my invention is shown in the stage immediately preceding the stage 1, 2. In this stage marked "8", 21 and 22 are tubes in an amplifier, the plate current being supplied through switch 23, and return through ammeters 24 and 25, lead 26 and "Thyrite" resistor bank 27 to ground and to the negative side of the plate supply. Excitation is supplied from earlier stages 28 to the grids of 21 and 22. This excitation is keyed in stage 28. For the marking condition excitation causes grid current to flow through grid leaks 29 and 30. This current results in a negative grid bias.

For the spacing condition the output of stage 28 is not entirely stopped. To prevent a residual wave from coming through stage 8 tubes 21 and

22 must be biased beyond cutoff. Cathode return bias and grid leak bias alone cannot maintain these grids at a voltage beyond cutoff. To give this bias voltage, current from the 3000 volt source 31 is supplied to 27 through resistors 32 and 33. For the spacing condition 20 milliamperes flows through 27, building up a voltage of 212 volts.

In order for this to be true the resistance of 27 must be 10,600 ohms. If this were ordinary resistance then for the marking condition, when the anode current flows through this resistance the voltage would be excessive. When "Thyrite" is used the voltage only rises from 212 volts for the spacing condition to 376 volts for the marking condition.

A tap is provided on "Thyrite" bank 27 which supplies bias for tube 41 by making its cathode 106 volts positive with respect to its grids for the spacing condition. This protects this tube from excessive anode current which it might otherwise draw if its excitation failed.

This invention will be of value in connection with many types of electric power equipment, including rectifiers for radio transmitters, power distribution systems, etc.

Reference is made to Usselman application Serial No. 103,643, filed October 2, 1936, now Patent #2,201,211, granted May 21, 1940, as illustrative of a manner in which the "Thyrite" banks 7 and 27 may be constructed.

The stage 8 and the stage formed of the tubes 1 and 2 may be of the frequency multiplier type in which event the plate circuits are tuned to successively higher odd harmonics of the excitation frequency supplied from the output of tube 41 which, also, if desired, may be made to operate as a frequency multiplier. In this event the plate circuit of tube 41 is tuned to some desired harmonics of the radio frequency excited so marked on the drawings.

The "Thyrite" bank 200 and tap 202 are used to supply screen grid voltage for the tubes of the transmitter. Although the "Thyrite" bank 200 is in series with resistors 32 and 204 in some cases it will be found desirable to connect this bank directly across a rectifier source. Taps to the "Thyrite" bank may then be used to supply voltages of the same or different values to the various screen grids, plates, etc., in which case the "Thyrite" bank 200 will act as a "Thyrite" potentiometer. Such a "Thyrite" potentiometer, when connected across the output terminals of a rectifier, may be used to supply either positive bias as already described or, the positive terminal may be grounded, in which case the taps to the potentiometer may be used to supply negative bias to various grids of the tubes.

I have found that a "Thyrite" bank when used as a potentiometer across a rectifier improves the regulation of the rectifier. As heretofore used, ordinary resistors across a rectifier require a greater waste of power than that required by the "Thyrite" to obtain the same degree of voltage regulation. A further advantage in using a "Thyrite" potentiometer across a rectifier resides in the fact that greater smoothing action is obtained. This will be explained in greater detail by referring to Fig. 2.

The "Thyrite" bank, as described in the Usselman patent referred to hereinabove, is connected in series with the smoothing reactor 300 and rectifier 302. The smoothing condenser 304 is connected in shunt to the "Thyrite" bank. Either terminal 306 or 308 may be grounded. Over any one of the fins taps t may be taken to supply positive bias in the event that terminal 308 is grounded or a negative bias in the event that terminal 306 is grounded. The choke or filter reactor 300 serves to maintain a constant current flow from the rectifier.

This arrangement will be found to give much better regulation or, rather, a much better regulated voltage at the taps t as compared to a system in which an ordinary resistance potentiometer is used.

Fig. 3 is an explanatory graph on a logarithmic scale showing the change in current through the "Thyrite" bank with various changes in voltages impressed.

I claim:

1. In a telegraph system, an amplifier, including a thermionic discharge tube having an anode, a cathode and a grid and having grid-cathode and anode-cathode circuits connected thereto, said amplifier being characterized in that grid current flows in said grid-cathode circuit during marking intervals in normal operation, means for biasing said tube during marking intervals, including a grid leak and condenser combination in said grid-cathode circuit, and additional means for biasing said tube during spacing intervals including a resistor in a common portion of said grid-cathode and anode-cathode circuits, the resistance of said resistor varying inversely as the current flow therethrough whereby the bias produced by said resistor is not substantially increased during marking intervals.

2. In a telegraphy system, an electron discharge device having electrodes including an anode a cathode and a control grid, alternating current circuits connected to said control grid and cathode and said anode and cathode, means for causing alternating current the amplitude of which increases and decreases in accordance with marking and spacing respectively to flow in said circuits, a grid leak and condenser combination having a terminal connected to said control grid, a resistance the potential drop through which increases at a rate less than linearly with increase of current flow therethrough connected between said anode and cathode, a connection from another terminal of said grid leak and condenser combination to a point on said non-linear resistance, the potential drop in said grid leak due to grid current flow therethrough supplemented by the potential drop in said non-linear resistance biasing said device for class C operation in the presence of alternating current of amplitude characteristic of marking in said alternating current input circuit, the potential drop in said non-linear resistance, in the presence of alternating current characteristic of spacing in said alternating current input circuit serving to compensate for the decrease of potential drop in said grid leak resistance.

3. A system as recited in claim 2 wherein a source of potential is connected in shunt to said non-linear resistance to increase the flow of current therethrough to bias said tube to cut-off in the presence of alternating current in said input circuit characteristic of spacing.

JAMES LESLIE FINCH.