Dec. 8, 1942. C. W. HANSELL 2,304,164

KEYING FILTER

Filed July 21, 1939

Fig. 1

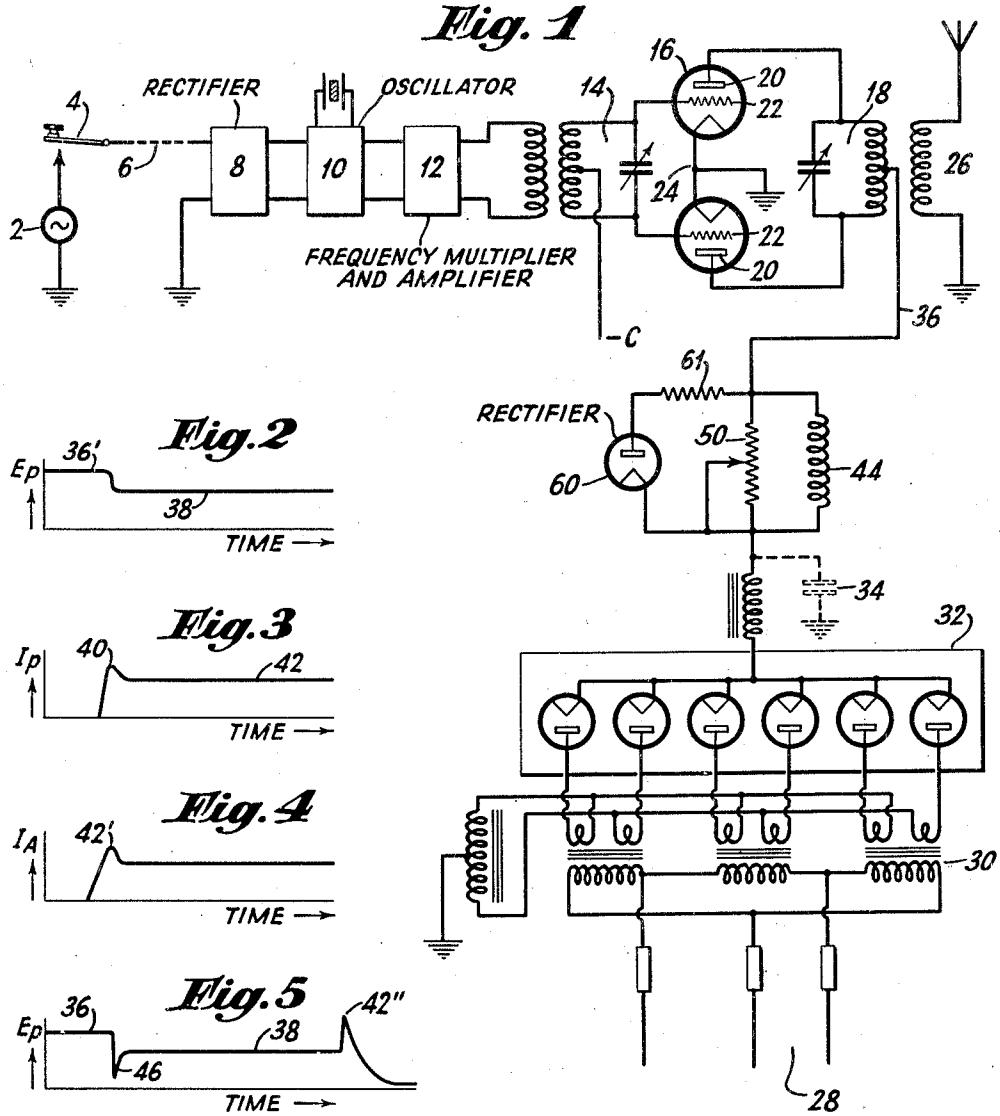


Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

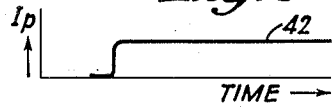
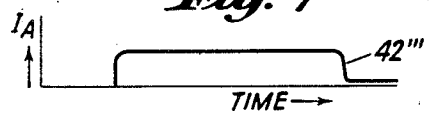


Fig. 7



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2,304,164

KEYING FILTER

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Application July 21, 1939, Serial No. 285,691

10 Claims. (Cl. 178—66)

This invention relates to energy supply circuits for amplifiers and especially to a new and useful method and means for supplying anode potential to a high power amplifier.

In radio signaling systems it is common to use a rectifier, generator or other power supply source having a considerable fluctuation or ripple in its voltage, for supplying anode potentials to amplifiers. In order to smooth out the uni-directional anode energy, condensers or filters containing condensers are placed across the output circuit of the power source which have very low impedances for the ripple energy and so cause currents to flow through the internal impedance of the rectifier or generator of such value that the ripple voltage is substantially eliminated from the output.

The power sources used in practice also have a considerable amount of voltage regulation. In other words, their output voltages decrease when the load current increases. The presence of the smoothing condensers slows up the change of voltage when the load current is changed. In a telegraph transmitter, where the load current fluctuates between zero and full load in accordance with the keying, the voltage at the beginning of each dot or dash is higher than the final value by the amount of the regulation. Consequently, when keyed energy is first applied to the input side of the amplifier there is often as much as a 25% overload voltage existing in the amplifier relative to the steady marking voltage. Because of this, the peak electrical stresses on the amplifier tubes and circuits are greatly increased, tending to cause more rapid deterioration, and the total power output rating of the amplifier must be reduced to provide the extra safety factor demanded by the difference between the maximum voltage and the steady load value. There is also a marked tendency for the vacuum tubes to develop parasitic oscillations during the overvoltage period, which not only increase the voltage and load stresses still more, but which also cause interference in other radio circuits.

It was an object of my invention as described in my United States Patent #1,921,858, dated August 3, 1933, to overcome the foregoing difficulty and this I did by reducing the anode potential applied to the amplifier when energy is first introduced in the input circuit thereof. More specifically, I reduced this potential by inserting in the lead between the anode of the amplifier and the rectifier an impedance, preferably a resistance, which, as soon as signal energy is supplied to the amplifier, reduces to a predetermined value, the anode potential. For best operation I preferred to make this impedance of a value such that when there is a tendency for momentary overloads, under the conditions outlined above, plate voltage is reduced to a value below that used for steady marking or steady "key down" position.

In order to increase the anode voltage during the remaining portion of the marking period, I shunted the resistance by a reactance, in the form of an inductance having low resistance which controlled the rate of transfer of current from the resistance to itself and hence the voltage to the amplifier anode. However, when energy was removed from the amplifier input, the inductance tended to increase anode potential.

An increase at this time is less harmful than at the beginning of a signal because the radio-frequency voltages are removed, but, it is undesirable, and in some cases can result in sufficient increase in voltage to be destructive. This presents a disadvantage in that, by virtue of the added potential, stresses in the tubes and circuits are increased. Therefore, the overcoming of this defect was a further object of my patented invention and I did this by resistively dissipating the inductive potential surge which follows the removal of the load on the power source and which results from the removal of the energy from the input circuit of the amplifier. Consequently, the impedance formed of the resistance and inductance prevents momentary overloads on the amplifier tubes when signaling energy is first introduced therein and prevents excessive plate voltages when signaling energy is removed from the input circuit of the amplifier.

In connection with the use of the resistance, it is to be noted that it presents other advantages in that it lessens relatively slow oscillations in plate voltage caused by the cyclic charge and discharge of the smoothing condensers, connected across the rectifier output circuit, through the inductance of the power source and filter circuits. In other words, it damps out resonance effects in the power circuit which may cause large voltage fluctuations at certain keying speeds or modulating frequencies.

The filters serve to reduce the voltage on transmitter tubes at the beginning of marking periods but increase the supply voltage just after the end of each marking period. The transient increase in voltage after marking periods tends to make the tubes draw anode current momentarily when they should not and after the fre-

quency guiding effect of the radio-frequency input is removed. Under these circumstances, unless the circuits are correctly adjusted, parasitic oscillations sometimes take place during the transient period of high voltage, thus producing spurious radiations at incorrect frequencies. Such spurious radiations are known as "key click parasitics."

To reduce the transient voltage increases after marking periods in accordance with the present invention, I shunt the keying filter with a rectifier. This rectifier is so connected and poled that little or no current flows through it while the load current through the keying filter is increasing. Now, when the load current is decreasing, current will flow through the rectifier to reduce the voltage surge due to the keying filter inductance.

My invention is defined with particularity in the appended claims; however, it may best be understood both as to its method of operation and structural organization by referring to the accompanying drawing, in which

Fig. 1 illustrates a transmitting system incorporating the features of my invention, and

Figs. 2 to 7 inclusive are given by way of explanation thereof.

Referring to Fig. 1, relatively low frequency alternating current supplied by source 2 is keyed or otherwise modulated at some centrally located point 4, and transmitted over land line 6 to radio transmitting apparatus.

The received keyed energy is rectified in a rectifier 8 the output of which is used to control the output of a high frequency oscillator 10, for example, of the crystal controlled variety, or of one of the radio-frequency amplifiers or frequency multipliers between a crystal controlled amplifier and the power amplifier. The keyed output of the oscillator or amplifier may then be fed into suitable frequency multipliers and amplifiers 12 which, in turn, supply their energy to the tuned input circuit 14 of a power amplifier 16 having a tuned output circuit 18, anodes 20, control electrodes 22 and cathodes 24. Output of the power amplifier 16 is fed from its output circuit 18, to, for example, an antenna 26 and transmitted to a receiving station (not shown).

Anode potential for the power amplifier, is derived from a source of alternating current 28 coupled through transformer 30 to rectifier 32. For smoothing purposes condensers are connected across the output circuit of the rectifier and, for the sake of simplicity, they have all been represented as a dotted capacity 34. The lead 36 between the rectifier and the anodes of the power amplifier supplies the anodes of the amplifier with positive potential.

Because of the inherent regulation of the rectifier, in the absence of keyed energy in the input circuit 14 of high power amplifier 16, the voltage applied to the anodes of the amplifier is given by the value 36' of Fig. 2. During steady key down position, the anode potential is represented by value 38. Now, at the instant when keyed energy is first introduced into the power amplifier, capacity 34 tends to maintain high voltage on the anodes resulting in the amplifier current input and output overload peak 40 of Fig. 3 which indicates the excessive plate current flowing at that time. Shortly thereafter, this current drops to its normal value 42, but during the short time that current flows as at point 40 of Fig. 3, the tubes and circuits are subjected to abnormally high stresses and loads. Not only is this poor from the apparatus point of view but from the aspect of signaling the increased current introduces at point 42, Fig. 4, an increased antenna current giving rise to undesirable energy modulation which appears as a click in the receivers.

To overcome the foregoing difficulty in accordance with my invention disclosed in the aforesaid patent, I inserted in series with the anode lead 36 a filter or impedance composed of inductance 44 and resistance 50 which reduced the plate voltage to a value 46 (Fig. 5) much below the normal plate voltage 38 representing the normal marking plate potential. In this manner, plate current flow was as shown in Fig. 6, and antenna current as indicated in Fig. 7, free from peaks and their attendant evils.

The value of resistance 50 was so adjusted that, at the instant the load was thrown on, the voltage drop in the resistance would give the desired maximum reduction of voltage on the anodes of the amplifier. It is to be noted that, at the first instant, no current flows in the inductance 44 because a potential must be applied for a finite time to build up a current in an inductance.

Having arrived at the desired value of resistance 50 the inductance 44 is adjusted to give the desired rate of increase on the anodes of the amplifiers from the minimum value up to the normal steady load value. If it were desired to have the signal as nearly square as possible then the time constant of the inductance 44 and resistance 50 could be made substantially the same as the time constant of discharge from the smoothing condenser under the conditions imposed. In practice some of the radio-frequency energy output from the amplifier could be rectified and observed with an oscillograph. The values of inductance 44 and resistance 50 were then adjusted for the desired signal shape. Usually the building up of the signal was slowed down as far as possible consistent with the highest signaling speed to be used. After the values were determined for one transmitter they could be simply duplicated for similar transmitters. The resistance offered an additional advantage in that if there were any tendency for smoothing reactors or internal inductance of the rectifier transformers to introduce surges of potential on plates 30 of amplifier 16, the energy causing the surges would be at least partly dissipated by it. As previously explained, the resistance also absorbs the surge in inductance 44 when the load current is interrupted.

The filter comprising components 44 and 50 serves as described above to reduce the voltage on the tubes at the beginning of the marking condition initiating current flow in the antenna smoothly, but due to their reactance they increase the supply voltage when the marking condition is terminated. This transient increase of voltage indicated at 42'', Figure 5, tends to make the tubes draw anode current momentarily when they should cut off and after the frequency guiding effect of the radio-frequency supply to their input is removed. This may cause spurious radiations on incorrect frequencies to take place, a form of spurious radiation sometimes known as "key click parasitics." To prevent the reactance of the circuits including 44 from increasing excessively the voltage of marking value after the marking operation has ended, I now shunt the inductance 44 and resistance 50 by a rectifier 60. The rectifier as poled passes little or no current during

the time the transmitter is in marking condition and while the current through 44 and 50 is increasing. However, when the load current is decreasing, current flows through the rectifier 60 to thereby reduce the voltage surge due to the inductive reactance of the filter.

In practice it may be undesirable for the rectifier 60 to have near zero resistance when it is conducting curent because then the energy in the reactor may not be used up before marking starts again and the filter would not be fully effective in reducing the transient overloads in the manner intended when it is used. Therefore, I propose to insert some resistance 61 in series with the rectifier to cause the energy in the inductance of the filter to be dissipated more rapidly at the end of marking periods.

The irregularity in the voltage supply at 42'' is thus smoothed out relieving overvoltage stresses and at the end of marking the antenna current falls smoothly to zero or its minimum value, as indicated at 42''', Figure 7.

Any form of rectifier may be employed at 60, provided it has sufficient ability to pass current in the desired direction and can withstand the potentials developed across it. High vacuum, mercury vapor, neon and other such types of rectifiers known in the art may be used. Copper oxide and similar barrier layer rectifiers might be used, particularly at the lower voltages.

The resistance 61 in series with the rectifier may be made of Thyrite or similar materials having decreasing resistance with increasing potential across them and will reduce surge voltage across the reactor 44.

What is claimed is:

1. Means for absorbing energy stored in a reactor, through which passes an interrupted direct current, comprising a rectifier connected across the reactor and a non-linear passing resistor connected in series between said rectifier and said reactor.

2. Means for absorbing energy stored in a reactor, through which is passed an interrupted direct current, comprising a rectifier and a "Thyrite" resistance in series connected across the reactor.

3. Means for absorbing energy stored in a reactor, through which is passed a direct current which is then interrupted, comprising a rectifier and an automatically variable resistance in series with said rectifier of material having decreasing resistance with increasing potential, said rectifier and said variable resistance being connected in shunt with the reactor.

4. Means for reducing the increase of current into a frequently applied and interrupted electrical load comprising a resistance and a reactance in parallel connected in series with the load, said rectifier-resistance combination being connected in parallel, and means for reducing the increase in potential when the load is interrupted comprising a rectifier, with series resistance of material having decreasing resistance with increasing potential, connected in parallel with the resistance and reactance.

5. In a power amplifier, an electron discharge device having an anode, a cathode and a control electrode, a high frequency circuit connected between said control electrode and cathode, a high frequency circuit connected to said anode, a source of anode potential, and, the parallel combination of an inductance coil, and a circuit including a rectifier and a series resistance of material having decreasing resistance with increasing potential, said parallel combination being connected between said high frequency anode circuit and said source of potential, said parallel combination of coil and resistance acting to reduce overloads on said electron discharge device when energy is first introduced into said input circuit, by causing the anode current to flow through said resistance and subsequently transferring the anode current from said resistance to said inductance, which inductance in turn is of low resistance and determines the rate of transfer of current from said resistance to said inductance and said rectifier serving to pass current in a direction to reduce overloads on said device, on the termination of energy in said input circuit, due to the reactance of said parallel combination.

6. In a signaling system, a power amplifier comprising a pair of push-pull connected electron discharge devices, an input circuit with means for exciting the same by wave energy, a parallel tuned circuit connected to the anodes of said electron discharge devices, a source of anode potential, and a connection coupling said source to said parallel tuned circuit, said connection including three parallel branches, namely, an inductance coil, a resistance, and a series circuit including a rectifier and a non-linear resistance, said parallel branches acting to reduce overloads in said parallel connected pushpull electron discharge devices, the first mentioned of said resistances acting to reduce supply anode potential to said devices when energy is first introduced into said input circuit, the inductance being of low resistance acting to subsequently supply anode current to said anodes and controlling the rate of transfer of current from said resistance to the inductance, the rectifier serving to reduce parasitics by passing current in a direction to reduce the supply anode potential when excitation is removed from said input circuit.

7. In combination, a power amplifier having a high frequency anode circuit and an input circuit, a source of rectified alternating current for supplying the anode with unidirectional potential, means for supplying keyed input energy to the input circuit of the amplifier, a circuit, comprising the parallel connection of an inductance and a resistance, in series with the anode supply lead from the rectifier and between the anode circuit and rectifier for reducing anode potential when keyed energy is first introduced into the input circuit of said amplifier, and means including a non-linear passive resistance and a rectifier for reducing the tendency of the anode potential to increase on the termination of keyed energy in said input circuit due to the reactance of said parallel connection.

8. In combination, a power amplifier having a high frequency anode circuit and an input circuit, a source of rectified alternating current for supplying the anode with uni-directional potential, means for supplying keyed input energy to the input circuit of the amplifier, a circuit comprising the parallel connection of an inductance and a resistance, in series with the anode supply lead from the rectifier and between the anode circuit and rectifier for reducing anode potential when keyed energy is first introduced into the input circuit of said amplifier, and means including a resistance and a rectifier for reducing the tendency of the anode potential to increase on the termination of keyed energy in said input circuit due to the reactance of said parallel connection whereby parasitic oscillations are substantially reduced.

9. In a telegraph transmitter comprising a high frequency amplifier having an anode, a grid and a cathode, apparatus for applying keyed high frequency energy to the grid and the cathode, a source of direct current potential and a high frequency output circuit connected between said anode and cathode, a circuit for reducing parasitics in said output circuit at the end of signal character transmissions comprising a reactance coil connected in series with and between said direct current potential source and said anode, a series circuit including a rectifier connected in shunt to said coil, and a non-linear resistance, said rectifier operating to dissipate any increase in anode potential due to the reactance of said coil upon the termination of keyed high frequency energy in said input circuit.

10. Apparatus as claimed in claim 9 characterized by the fact that a resistance is connected in shunt with said reactance coil.

CLARENCE W. HANSELL.

CERTIFICATE OF CORRECTION.

Patent No. 2,304,164. December 8, 1942.

CLARENCE W. HANSELL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 40, claim 1, for "passing" read --passive--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 9th day of February, A. D. 1943.

Henry Van Arsdale,

(Seal) Acting Commissioner of Patents.

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(Seal)