PUBLISHED
MAY 25, 1943.
BY A. P. C.

W. KUMMERER
ARRANGEMENT TO DISCONNECT TRANSMITTER TUBES IN CASE OF FLASHOVERS OR SHORT-CIRCUITS
Filed July 8, 1941

Serial No. 401,473

Fig. 1

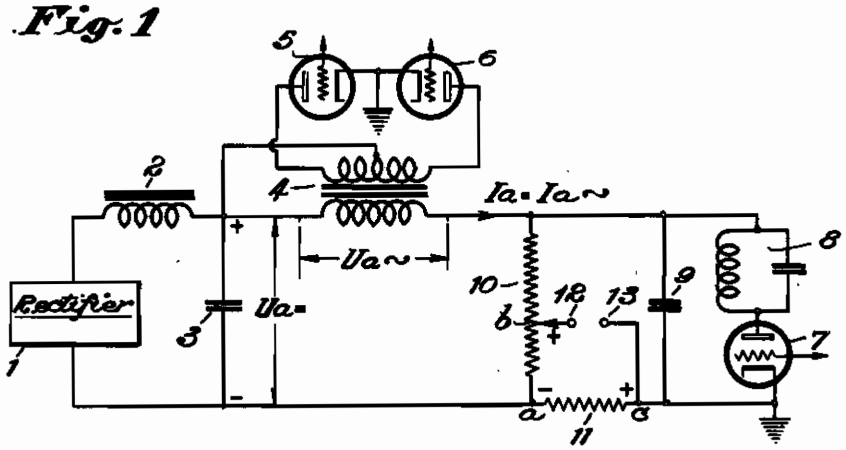
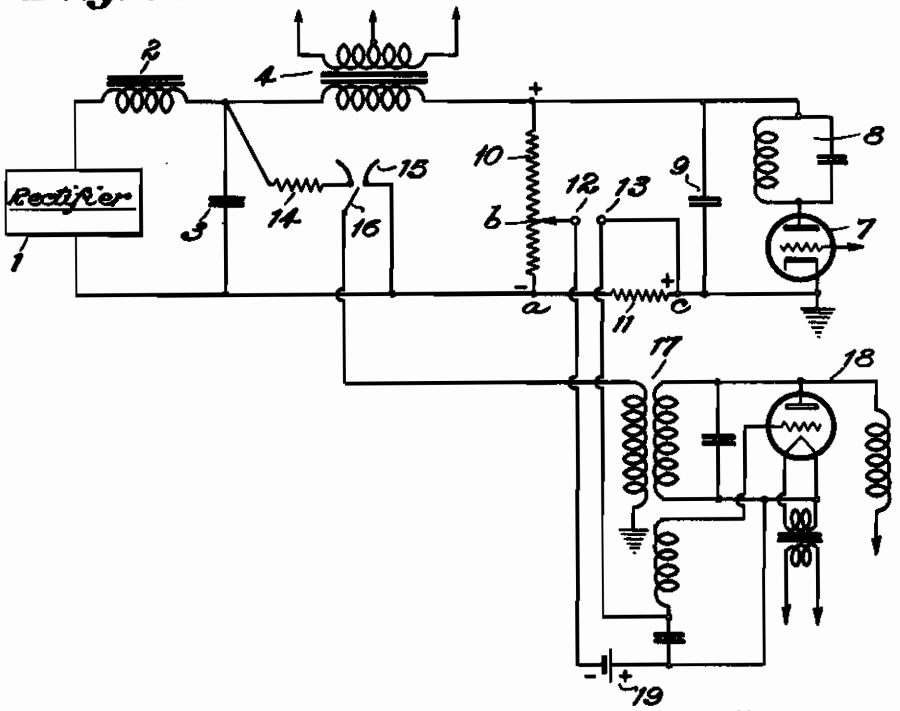


Fig. 2.



INVENTOR
Wilhelm Kummerer
BY H. S. Grover
ATTORNEY

Published May 25, 1943 **Serial No. 401,473**

ALIEN PROPERTY CUSTODIAN

ARRANGEMENT TO DISCONNECT TRANSMITTER TUBES IN CASE OF FLASHOVERS OR SHORT-CIRCUITS

Wilhelm Kummerer, Berlin, Germany; vested in the Alien Property Custodian

Application filed July 8, 1941

This invention is concerned with an arrangement adapted to cause disconnection of the plate potential of transmitter valves upon the occurrence of flashovers or short-circuits.

It happens occasionally that flashovers are produced in high-vacuum tubes while they are in actual operation, say, as a result of gas release, and this is liable to result in arcing. Unless such an arc is speedily broken, it will destroy parts of the electrodes with the result that the tube is rendered unserviceable. It is therefore necessary to disconnect the potential as fast as feasible from such a tube immediately after the production of an arc or flash-over or internal breakdown.

Now, safety and protection devices have been disclosed in the prior art which are predicated for their operation upon a relay which is traversed and energized by the plate current, the relay responding to the sudden rise of the current as a result of a flashover in a tube thereby causing disconnection of the plate potential rectifier. In the direct current circuit of the plate supply is included, moreover, a resistance in circuit organizations of this kind which is designed to limit the short-circuit current. From the instant the flashover of the tube happens until the oil-break switch is opened, there is an appreciable lapse of time inherent in the time mechanical switches take for response; and throughout this entire period the entire short-circuit current flows through the flashover or arc and this is likely to eventuate in destruction of the tube.

To avoid this difficulty, it is possible to use grid-controlled rectifiers upon the grid of which a blocking potential is impressed in case of a short-circuit. To be sure, in this arrangement, the cut-off of the rectifier is produced inside a few thousandths of a second; however, the flow of current through the flashover or arc ceases only when the phase of the rectifier which happens to burn passes through zero. Quite apart from this shortcoming, however, this mode of insuring disconnection inheres the further drawback that the energy stored up in the filter is also drained by way of the arc. Where transmitters of extremely large power are concerned, this alone may cause damage to the tube or render it completely unserviceable.

There is known in the prior art another arrangement designed to cause disconnection of the plate potential of large-power transmitters upon the production of flashover or arcing in which between filter and transmitter tube is arranged an inertialess or non-sluggish disconnecting device operating with thyratrons for high potential direct current. Tripping of the disconnecting arrangement occurs by way of a transformer included in the plate circuit; the said transformer upon the sudden production of a rise of current ignites an auxiliary discharge device from which a counter-acting potential is impressed upon a grid-controlled rectifier included in the plate circuit to compensate the "burning" potential thereof, with the result that the discharge ceases.

Now, all of these disconnecting or circuit opening means responding to increase of current upon flashover do not operate satisfactorily whenever the plate circuit of the transmitter valve contains an inductance, say, the output winding of a modulation transformer. If the plate circuit includes such a modulation transformer, then this high-speed relay or the impulse transformer must be so proportioned that no disconnection will be ocsasioned when the plate current atains twice the normal direct current value, for it will be noted that upon the direct current $I_{a=}$ is superimposed by the modulation a tonal frequency a. c. I_a the crest value of which, in the presence of 100 percent modulation, is equal to the direct current. If, then, the transmitter tube experiences a flashover, so that the drop of potential across it becomes suddenly very small, the sudden rise of the current will nevertheless be very small inasmuch as the internal resistance of the modulator tube transferred to the output end of the modulation transformer is rather high. Then, the plate current through the inductance of the output end of the modulation transformer begins to rise at a delayed rate and the relay or the disconnecting device will respond only after the current has gone sufficiently far beyond the level $2I_{a=}$. However, in the meanwhile, the flashover in the tube may have already resulted in damage to the tube. This shortcoming of the scheme will become so much more apparent where more rather than only one tube are used. For in that case, the particular tube that has suffered flashover or arcing will immediately take the plate current of all of the other tubes, and it is only when the aggregate current has surpassed the value $2I_{a=}$ that the relay and thus the disconnecting switch are able to respond.

Now, in an arrangement designed to cause disconnection of the plate potential for transmitter tubes, in case of flashovers or short-circuits according to the present invention, two potentials are impressed upon a relay, one thereof being proportional to the plate direct current voltage acting at the tube, while the other one is proportional to the plate direct current of the tube, these potentials being chosen of such a value that under normal operating conditions, there will arise no pd at the relay. According to a further object of the invention, means are provided designed to prevent a discharge of the energy contained in the filter means through and across the tube flashover point or arc.

The invention will now be described in more detail by reference to the two exemplified embodiments illustrated in the appended drawing.

Fig. 1 shows the basis circuit diagram of a plate B type modulated transmitter. Referring to this figure, 1 denotes the grid-controlled multi-phase rectifier which produces the plate potential Ua= of the transmitter power stage and usually also of the AF power stage. In the rectifier circuit are including the filter choke-coil 2 and the smoothing capacity 3. The two power tubes 5 and 6 of the push-pull class B amplifier work upon the modulation transformer 4, the output winding of which is connected in series with the transmitter tube, the output potential Ua~ thereof being superposed upon the plate direct current voltage Ua= so that the transmitter stage comprising elements 7, 8, 9, is subjected to plate potential modulation. Instead of a tube 7, it would also be feasible to parallel a plurality of tubes. 8 denotes the plate oscillatory circuit, while 9 stands for the plate blocking condenser of the power stage which is chosen only of such a size that the resistance thereof for radio frequency turns out to be sufficiently low.

To produce the two poctntials required for the operation of the relay, a voltage divider 10 is connected in parallel relation to the plate blocking condenser 9. The potential taken off at points or terminals *a* and *b* of this voltage divider is proportional to the superposed audio frequency potential Ua~. Furthermore, a resistance 11 is cut in the cathode lead of the transmitter tube or tubes. The drop of potential which arises across the said resistance is proportional to the plate direct current Ia= and the plate current Ia~. The size of the said drop of potential, according to the invention, is chosen so high that the potential across terminals *a* and *b* is equal to the drop of potential across resistance 11. Then, no potential difference will arise across terminals 12 and 13 which are connected with points *b* and *c*. Between these points is connected according to the invention a high-speed relay. Now, as soon as a flashover occurs in the tube 7, the voltage of the transmitter stage, that is, across 9 and 10, collapses immediately and thus also the voltage across points *a* and *b* so that instantaneously a voltage arises across points 12, 13 which is equal to the drop of potential across resistance 11. The high speed relay connected between 12 and 13 is able to respond immediately and the rectifiers producing the plate direct current voltage as a consequence are cut off. The arrangement here disclosed offers the advantage, as can be seen from what precedes, that in case off a tube flashover the high-speed relay will be caused to become operative and respond even when the supplied current has not yet suffered any alteration.

In actual operation and service, there is no need to make the high-speed relay too sensitive. On the contrary, means to adjust the sensitiveness may be expedient and to set the relay so that, in the case of small load fluctuations associated with alterations of the plate current such as may be occasioned, say, by variations of the tuning or the coupling in any of the circuits of the transmitter equipment, there will be no response. In some instances, for instance, in transmitters modulated in one of the earlier stages, it will be preferable to use a polarized relay which will be caused to respond only upon the electrical quantities being changed in a definite sense.

Where transmitters involving very high powers are dealt with, the protection afforded by the relay responding upon a flash over of a tube will not be adequate if it merely blocks the grids of the multi-phase rectifier in Fig. 1. The capacity 3, as will be seen, is so high where transmitters of extra large power are concerned that even by immediate cut-off of rectifier 1, the energy of condenser 3 becoming discharged through tube 7 will suffice to occasion destructive actions in the tube. Hence, according to a further object of this invention, additional means are provided designed to preclude discharge of the condenser through a flashover or arc in case this has been produced in a tube. In the case of large-power transmitters, therefore, according to the invention, the relay connected between 12 and 13 fulfills this further purpose to initiate instantaneous discharge of the condenser through a resistance upon the occurrence of a tube flashover. Such an example is schematically illustrated in Fig. 2.

In the exemplified embodiment shown in Fig. 2, a horn-type discharge-gap 15 is connected with the two terminals of the condenser 3 by way of a discharge resistance 14, and in the neighborhood of the said horn spark-gap is a needle-point electrode 16 which is united with a high-potential coil (Tesla coil) 17. Now, as soon as a flashover happens in the transmitter tube 7, the relay connected between 12 and 13 cuts in circuit a radio frequency generator 18 which is designed to set up in the high voltage coil 17 such a high potential that the needle electrode 16 begins to exhibit corona, that the condenser 3 has a chance to discharge through resistance 14 and the sparks between the electrodes 15.

Instead of causing the relay between points 12 and 13 to start operation of the radio frequency generator for the flashing of the spark-gap, it would also be possible to use directly the potential between 12 and 13 arising upon a flashover for the purpose to initiate oscillating in the auxiliary transmitter 18. In the absence of a pd between 12 and 13, under normal operating conditions such a high negative biasing voltage will then prevail at the grid of the radio frequency generator 18, which is furnished from the source of voltage supply 19, that the said auxiliary transmitter 18 will have no chance to start oscillating. Upon the occurrence of a disturbance or trouble in the transmitter tube, a voltage arises between 12 and 13 which is in opposition to the biasing potential so that the negative biasing voltage or transmitter 18 diminishes to a point where it is able to start oscillating, with the consequence that by way of 17 discharging of condenser 3 is initiated. So far as the said auxiliary transmitter 18 is concerned, a very small power will suffice since it serves solely to flash the spark-gap. The frequency of the same is chosen so high that oscillating is started as fast as feasible.

The circuit organization for the exemplified embodiment Fig. 2 shows also that the cathode of the auxiliary transmitter 18 is not at ground potential. Hence, the tube is preferably heated by way of a transformer, while the plate potential is preferably produced by means of a dry (oxide) type rectifier. If several tubes are used in the wave generator, then the plates thereof may be fed with a multi-phase potential rather than direct current potential. All that is necessary is to choose the potential in such a way that there will always prevail a positive potential at least at one tube so that the auxiliary transmitter is able to start oscillating at any time.

In lieu of the spark-gap 15, Fig. 2, could be used also a controlled thyratron or the like, HG rectifier, which, in case of flashover in the transmitter valve, is ignited. Because of the potential difference between points 12 and 13 and the controlled thyratron it is necessary to insure insulation between the igniter circuit and points 12 and 13. For instance, the output potential of the auxiliary transmitter 18, after rectification, may be employed for starting or striking the rectifier.

Where transmitters designed for a relatively wide band are concerned, that is, transmitters working with low carrier frequency, or transmitters having a very low-damped antenna circuit or output circuit, the transmitter stage 7, 8, Fig. 1, for high modulation frequencies no longer behaves like a purely ohmic, but rather like a complex resistance. In that case, for high modulation frequencies, a phase displacement angle prevails between the alternating potential Ua~ at the voltage divider 10 and the alternating current Ia~ which flows through the resistance 11, with the result that an alternating potential arises across points 12 and 13. In other words, where transmitters of this kind are concerned, conditions must be made so as to prevent relays or protective or safety means connected across points 12 and 13 from responding. In some cases, it may suffice to set the relay to a point where it is less sensitive, in other words, in such a way that it will respond only when a certain threshold value is exceeded. The situation becomes most simple where it is permissible to narrow the band-width to a sufficient degree. If steps in that direction are not possible, or not adequate, then a low-pass filter may be cut in between the terminals 12 and 13 and the relay or other safety device designed to suppress the higher modulation frequencies for which the transmitter is no longer ohmic in nature.

Where extra large plate modulated transmitter equipment is involved, it may occasionally become necessary to destroy and suppress also the energy of the modulation transformer 4 by means of the same kind as those provided for the condenser 3. If desired, the discharge device 14, 15, 16, could be used jointly for 3 and 4.

WILHELM KUMMERER.