

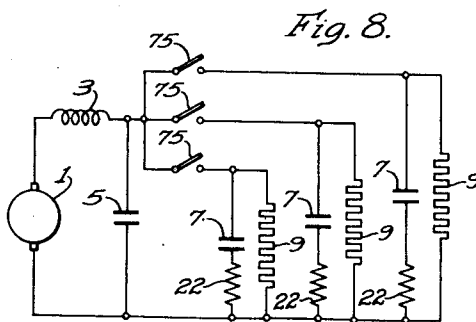
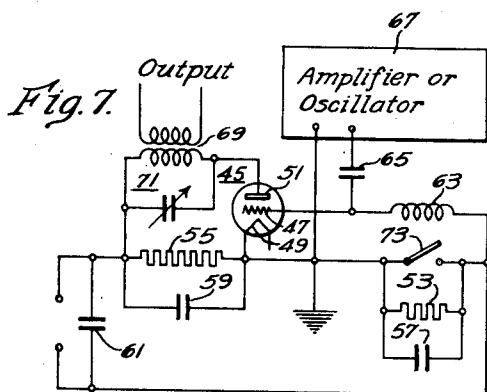
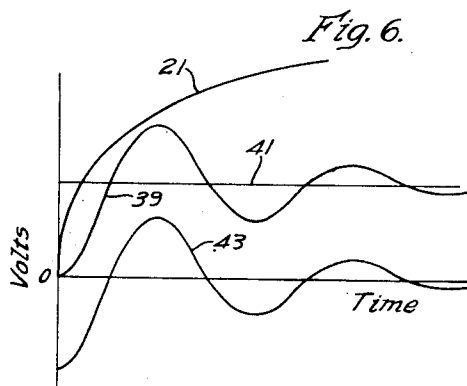
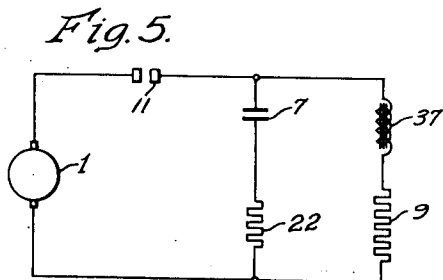
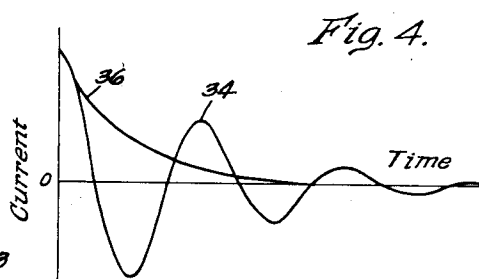
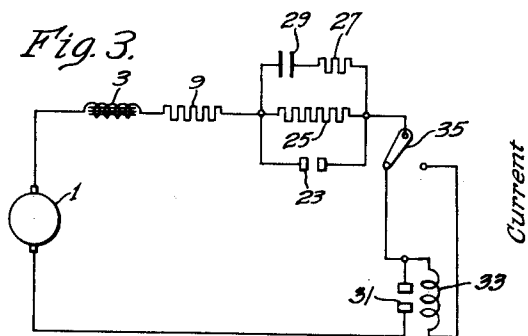
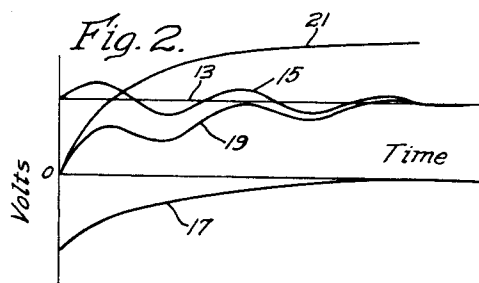
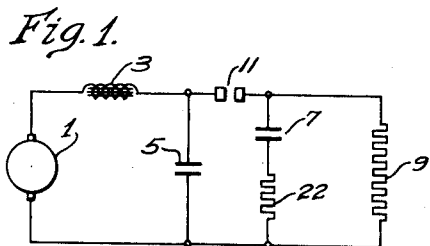
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R. LEE

2,094,361

HIGH VOLTAGE DIRECT CURRENT CONTACTOR

Filed July 16, 1935



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## UNITED STATES PATENT OFFICE

2,094,361

HIGH VOLTAGE DIRECT CURRENT  
CONTACTOR

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3 Claims. (Cl. 175-294)

My invention relates to high voltage direct current circuits and more particularly to a method and means for opening such circuits without the accompaniment of destructive arcing across the switch contacts.

My invention finds its principal application in the field of radio where a plurality of transmitters are fed from a common source of energy. It is often desirable to be able to switch one or the other of these transmitters in or out of the circuit without interrupting or cutting in on the operation of the other transmitters.

According to prior practice, a plurality of transmitters derive their high voltage direct current potentials from a common source of low frequency alternating current, the voltage of the alternating current system or source being stepped up by means of a transformer to the desired high voltage and subsequently rectified and filtered and applied to the transmitters. In switching one or the other of a plurality of transmitters into or out of the supply circuit, it is necessary to open the supply circuit on the low voltage alternating current side, thus for the time being rendering the remaining transmitters inoperative, since removal of the alternating current supply source resulted in the loss of high potential direct current to the transmitters.

It has previously been impractical to switch the transmitters individually on their high voltage direct current side, by reason of the destructive arcing which was apt to develop across the opening contacts.

It is an object of my invention to provide means whereby a high voltage direct-current circuit may be opened without arcing across the opening contacts.

It is a further object of my invention to provide means whereby a plurality of apparatus fed from a common type voltage direct current source may be individually cut in or out of the supply circuit.

An additional object of my invention resides in a method for eliminating arcing upon the opening of a high voltage direct-current circuit.

Additional objects of my invention will be brought out in the following description of the same, taken in conjunction with the accompanying drawing wherein:—

Figures 1, 3, and 5 are circuits illustrating various embodiments of my invention whereas Figures 2, 4, and 6 are curves depicting the transient conditions existing respectively in the circuits of Figures 1, 3, and 5.

Fig. 7 is a circuit embodying my invention as applied to a keying circuit of a radio transmitter.

Fig. 8 is a circuit diagram illustrating the application of my invention to a system, wherein a plurality of loads are supplied from a common potential supply source.

A more specific description of these circuits and operating characteristics follows.

In Fig. 1 I have shown a source of high voltage direct current potential 1 followed by a filter comprising a series choke 3, a pair of condensers 5 and 7 connected in parallel, the filter feeding a load 9 which may represent practically any type of load but in this case might indicate a transmitter. The direct current source of high voltage shown in the form of a direct-current generator is merely representative of any source of high voltage direct-current and, therefore, may be considered the equivalent of a low voltage alternating current source feeding a step-up transformer, the output of which is rectified and fed to the filter disclosed in Fig. 1. The two parallel connected condensers 5 and 7 may be considered the equivalent of one condenser and would normally comprise a single condenser in the customary filter circuit. I have found, however, that by splitting this condenser up into two parallel connected condensers of equivalent value, as shown, it would be possible to open the circuit at a point in the main line between the two condensers, without obtaining arcing across the contacts 11, upon opening of the circuit.

The theory involved in preventing the occurrence of arcing may be understood by a brief reference to the curves of Fig. 2 wherein the horizontal line 13 represents the value of the applied direct current potential from the generator 1, the superimposed oscillating transient curve 15 representing the alternating current component of potential superimposed upon the direct current value due to the oscillations initiated by the discharge of the first filter condenser 5 through the inductance 3 in series therewith plus whatever inductance may be present in the generator. In some cases the inductance of the generator windings alone constitutes the sole inductance of the circuit, in which cases, the inductance 3 would be omitted as a separate element.

In series with the direct current potential but of opposite polarity thereto, considering the right hand contact as a reference point, we have at the instant of breaking of the circuit, a voltage across the second condenser 7 of a value comparable to that of the applied potential from the

source 1. A transient condition is set up by the potential bound up in this condenser resulting in a gradual discharge and consequently a gradual decrease in the series opposing voltage. As represented by the condenser discharge curve 17 of Fig. 2, the voltage across the condenser approaches the value of zero at which moment the voltage across the open contacts 11 will approach that of the applied direct current potential.

It is interesting to note, however, that due to the presence of a series bucking voltage of approximately the value of the direct current applied voltage, there will be no voltage drop impressed across the contacts at the instant of opening. This is an ideal condition for opening a high voltage circuit. The voltage across these contacts, however, begins to build up to a value approaching that of the high direct current voltage, but it should be borne in mind that during the time, during which this voltage is building up, the contacts are moving apart very rapidly and the voltage necessary to produce breakdown, therefore, increases greatly in value over what it was at the start. By proper design of the circuit constants, it will be possible to so prolong the building up of the voltage across the contacts 11 during opening that the voltage at any instant will never reach the breakdown value for any instantaneous position of the contacts. This can readily be determined by oscillograph methods or by calculation and the plotting of curves such as shown in Fig. 2.

The condenser 5 performs an important function in this circuit in that it serves to prevent high inductive voltages from being developed across whatever inductance may be in the circuit, such as the inductor 3 or the inductance of the direct current source 1.

Curve 19 of Fig. 2 which may be obtained by adding curves 15 and 17, represents the changes in voltage across the contacts during and after opening, whereas curve 21 indicates breakdown voltages throughout this same period for a given speed of opening of the contacts. It is apparent from these curves that arcing across the contacts cannot occur as long as the curve 19 lies wholly below the curve 21.

Should it be desired that the circuit be opened only on overloads, the inductance and capacities of the circuit may be designed to take care of the situation and prevent arcing in the same manner as described above.

A small resistor 22 may be added to advantage in series with the second condenser 7, its purpose being to prevent too heavy a charging current upon closing the contacts 11 which would ordinarily throw the condenser directly across the source of high voltage direct-current. This resistor should be small enough so as not to interfere with the filtering action of the condenser 7 with which it is in series.

The circuit of Fig. 1 makes use of already existing circuit elements and opening the contacts between the filter condensers thoroughly isolates the load circuit represented by the resistor 9, but which resistor may constitute one of many transmitters fed from the same power source.

In some cases, there may be no filter present such as disclosed in Fig. 1. It has been the practice in such cases to merely shunt the opening contacts of the circuit with a condenser, the function of which was to absorb a large amount of the energy which would normally go into build-

ing up a high voltage across the opening contacts, causing breakdown or arcing.

In Fig. 3, I have shown such a circuit modified to the extent of improving the same materially. This circuit comprises a source of high voltage direct current which may constitute a high voltage direct current generator 1 or a source of low voltage alternating-current stepped up and rectified to give high voltage direct-current. The output of this high voltage direct current source is fed to a load represented by the resistor 9 through a series inductance 3. Serially included in this load circuit are two pairs of series connected contacts, one pair of which, 23, is shunted by a resistor 25 in parallel with a series connected resistor 27 and condenser 29.

Upon opening the shunted contacts 23, the entire circuit is forced into oscillation due to the presence of the inductance 3 in series with the condenser 29, thus causing the current in the circuit to pass through a zero value during oscillations as depicted by curve 34 of Fig. 4. Upon opening the second pair of contacts 31, the formation of an arc thereacross is avoided by reason of the fact that an oscillatory current has now supplanted the direct current which formerly existed, and this oscillatory current passes through zero value twice every cycle; and at the same time, its peak values are decreasing and approaching zero; as this oscillatory condition which has been set up as a result of opening contacts 23 is of a transient character. Thus at any moment that the contacts 31 may be opened during this transient condition, the current across these contacts is bound to pass through a zero value and thus overcome any tendency for an arc to form. The decreasing amplitude of the current is also an aid toward this end.

Should there be no inductance in the circuit, there will be no oscillatory transients occurring therein and in lieu thereof, there will be a gradual decay of current from a maximum value to a zero value as illustrated by curve 36 of Fig. 4, the current at no time changing its direction of flow and consequently never passing through the zero value. The presence of the inductance, therefore, is essential to obtain zero values of current at the instant of opening the second pair of contacts.

The resistance 25 connected in shunt to the condenser 29 serves to relieve the condenser of any charge which will build up therein upon opening of the contacts 11 and the low resistance 27 in series with the condenser 29 merely serves to prevent too heavy a charging current thereto, upon closing of the contacts 31 in the circuit, the contacts being preferably closed in the reverse order of their opening.

The circuit of Fig. 3 just described, is satisfactory where the load is more or less constant in nature and the time of opening of the second pair of contacts may be predetermined, so that opening will occur when the transient oscillatory current in the circuit reaches approximately a zero value.

Where the load is apt to be of a varying character, it might be preferable to so control the opening of the second pair of contacts that they can open only when the current in the circuit reaches a predetermined low value. This can be very conveniently accomplished by placing in series with the contacts a relay coil 33 so designed that it will not open its associated contacts until the current has reached the desired low value, this relay coil controlling the operation of the

second pair of contacts 31. In the circuit of Fig. 3, I have shown this alternative arrangement by means of a switch 35 adapted to alternatively connect to the second pair of contacts directly or through the relay control coil 33.

As an additional method for opening high voltage direct current circuits without the introduction of arcing across the opening contacts, reference is made to the circuit of Fig. 5. According to this modification, the load 9, if not already inductive may be made so by the introduction of an inductance 37 in series therewith and in shunt to this inductive load, I place a condenser 7 on the load side of the contacts 11. The voltage across the contacts at any instant will be the difference between the generator direct current voltage and the voltage across the condenser 7 or inductive load circuit. Upon opening of the contacts, the load circuit will be set into oscillation, transient in character, due to the presence of the shunting condenser 7, and the voltage across the opening contacts will vary in accordance with the oscillatory curve 39 of Fig. 6 which represents the instantaneous difference between the applied direct current voltage from the source 1, represented by the horizontal line 41 and the oscillatory voltage generated or developed across the condenser 7 as illustrated by curve 43. It will be noted that the curve 39 which represents the voltage across the contacts at the instant of opening the circuits is zero in value which is the ideal value to prevent the formation of any arcs or discharges.

For the set of conditions illustrated by the curves of Fig. 6, the contacts must be completely opened within approximately a quarter of a cycle, in order to keep the voltage across the opening contacts from ever extending into the region above the breakdown value curve 21. It will be apparent from a study of these curves that slower opening of the contacts may be obtained by either highly damping the oscillator circuit or reducing the frequency thereof.

The constants of the circuit and the speed of operation or opening of the contacts will, therefore, necessarily depend upon the predetermined value of the applied direct current potential and the constants of the load, but once these factors are known, the rest may readily be determined.

The circuit of Fig. 7 illustrates the manner in which my invention may be applied to prevent key clicks in a keying circuit of a transmitter, key clicks being usually the result of transients caused by arcing at the key contacts. The circuit comprises an electron discharge device 45 having a grid 47, filament 49 and a plate electrode 51, plate potential being supplied from a source of direct current voltage which may either constitute a battery, direct-current generator, or an alternating-current supply in combination with a rectifier and filter. Across the power supply source is a potentiometer or voltage divider comprising the resistors 53 and 55 with the filament of the discharge device connected to a point therebetween. That portion of the potentiometer 55 toward the positive terminal of the supply source constitutes the portion from which the anode potentials may be derived, whereas that portion of the resistor 53 toward the negative end of the supply source provides bias potential for the tube. Condensers 57 and 59 are provided in shunt with these portions of the voltage divider, and a filter condenser 61 is connected across the terminals of the supply source. The

input circuit includes, in addition to the biasing resistor, an inductor 63 in series therewith, and this input circuit may be capacitively coupled by means of a condenser 65 to a source of carrier frequency 67 which may either be a preceding amplifier or an oscillator. The output from this keying circuit may be derived by transformer coupling 69 from a tank circuit 71 in the plate circuit of the tube.

Keying of the carrier frequency energy may be conveniently obtained by means of a key 73 connected in shunt to the biasing resistor 53, the biasing resistor being sufficient to bias the tube beyond cut-off with the key in its up position. Closing of the key shunts out the biasing resistor, thus rendering the tube operative during the interim in which the key is held in its down position.

This circuit is so designed as to embody the advantages of arc-preventing feature described in connection with the circuits of Fig. 1 in combination with the condenser resistor shunted contacts of Fig. 3. That portion of the circuit involving the plate circuit of the tube bears similarity to Fig. 1 in that the tank circuit and plate to cathode impedance constitutes the equivalent of the load of Fig. 1, which in turn, is shunted by a condenser 59, which is the equivalent of the condenser 7. The inductance 3 of the circuit of Fig. 1 finds its counterpart in the inductance of the supply source which may either be the inductance in the windings of the generator, if a generator be used, or it may be the inductance in the filter should the energy be derived from a rectified and filtered alternating-current supply.

The key shunted by the resistor 53 and a parallel connected condenser 57 is similar to that portion of the circuit of Fig. 3, which discloses the contacts 23 as being shunted by a resistor 25 and a parallel connected condenser 29.

The combined action of these two means for avoiding the formation of arcs across the key contacts will result in a keying circuit free of the undesirable key clicks which normally occur in circuits, in which no provision is made to prevent or avoid the formation of arcs across the key contacts during keying.

In the circuits of Figs. 1, 3 and 5, the invention was described in connection with the opening of a high voltage direct current circuit to a single load. To fulfill the additional objects of my invention, wherein a plurality of loads may be connected to a common source of high voltage direct current, I have illustrated in Fig. 8 a source of high voltage direct current feeding a plurality of independent loads 9 which may represent different transmitters or other loads for that matter. The direct current source may comprise any of the forms described above in connection with Figs. 1, 3 and 5, feeding energy through a filter comprising the series inductance 3 and shunt condenser 5, which correspond to the similar elements of the circuit of Fig. 1. Across each load is placed a shunting condenser 7 which corresponds to the shunting condenser of the load in the circuit of Fig. 1. Between each of these shunting condensers and the common filter condenser 5 is placed a switch 75 corresponding to the opening contacts 11 of the circuit of Fig. 1. Charging current limiting resistors 22, similar to that discussed in connection with the circuit of Fig. 1 may also be embodied in this circuit and would be connected one in series with each of these shunting condensers 7.

The circuit of Fig. 8 is similar in all respects

to that of Fig. 1, except in that a number of loads with their corresponding shunting condensers and opening contacts are connected in parallel. From a description of the theory of operation of the circuit of Fig. 1, it becomes apparent now that any one or more of the individual loads which may represent different transmitters may be disconnected from the power supply without in any way interfering with the operation of the remaining loads connected in the circuit. It no longer is necessary to open the power supply circuit itself, thereby rendering all of the loads inoperative during the time when one or more are being removed from the circuit.

From the above discussion it becomes apparent that these circuits and modifications described above fulfill the objects of my invention. Various modifications may be apparent to those skilled in the art, and it is my desire that my invention be not limited to the specific details described and disclosed but that it shall be limited only by the prior art and the appended claims.

I claim as my invention:

1. In combination, a source of direct-current power, a load circuit connected thereto, means for opening the circuit so as to effectively disconnect the load from the power source, a condenser connected to the load for maintaining a voltage across the load during the interim of opening said circuit, a condenser connected across the source of direct-current power, and a resistor in series with said first condenser.

2. In combination, a source of direct-current power, a load circuit therefor, a switch for opening the circuit so as to effectively disconnect the load circuit from the power source, a condenser connected to the load circuit to maintain voltage across the load circuit during the interim of switch opening, a condenser connected across said direct-current power source, the difference between said load voltage and the voltage of said second condenser during opening of said circuit being always less than a value which would cause arcing across the contacts of said switch and a current limiting device in series with said condenser.

3. In combination, a source of direct-current power, a load circuit therefor, a switch for opening the circuit so as to effectively disconnect the load circuit from the power source, means connected to the load circuit to maintain voltage across the load circuit during the interim of switch opening, and means connected to the power source to prevent high inductive voltages during the interim of switch opening, the difference between said load voltage and the voltage of said source during opening of said circuit being always less than a value which would cause arcing across the contacts of said switch, and means for limiting the charging current to said load voltage maintaining means upon the closing of said switch.

REUBEN LEE.