ELECTRICAL CIRCUIT FOR SYNTHETIC TESTING OF CIRCUIT INTERRUPTERS AND METHOD OF OPERATION

13 Claims, 17 Drawing Figs.

ABSTRACT: The application relates to a high voltage generator for the so-called synthetic testing of circuit interrupters operating at high and very high voltages, such generator being used more particularly in a testing circuit of the current injection type, and capable of providing successively an injection current waveform and a transient recovery voltage waveform. The generator comprises an injection branch providing the injection current waveform and a regulating branch providing the transient recovery voltage waveform. The injection branch is formed by at least two groups of elements, each comprising a capacitance, an inductance and a spark gap in series forming a unit, and by a switching system for interconnecting the units in series, or in parallel, or in a combined series-parallel connection. The regulating branch is formed by at least two groups of elements, each comprising at least one capacitance and at least one resistor forming a unit, and by a switching system for interconnecting the units in series, or in parallel, or in a combined series-parallel connection.
ELECTRICAL CIRCUIT FOR SYNTHETIC TESTING OF CIRCUIT INTERRUPTERS AND METHOD OF OPERATION

This invention relates to electrical circuits used for testing circuit interrupters, and more particularly to electrical circuits used for testing the breaking capacity of circuit interrupters by the so-called synthetic testing methods.

As is well known in the art, the synthetic testing circuits comprise two circuits: The first one providing, in the interrupter under test, the required current in principle until the time of the opening of the interrupter and is called the high current source, the second one providing the required voltage across the terminals of the circuit interrupter in principle after the interruption of the current and is called the voltage source. In certain known circuits, the operation of the two circuits mentioned above overlap partially in the neighborhood of the passage of the current through zero in such a way that the input of current from the high current source is transferred to the voltage source before the passage of the current through zero. These circuits are known under the name of synthetic testing circuits of the current injection type. The invention relates to the voltage source of such synthetic testing circuits which comprises an injection branch for providing the injection current and a regulating branch for providing the transient recovery voltage.

In the prior art, the voltage source of the synthetic circuits of the current injection type consisted of a concentrated capacitance, a concentrated inductance and a spark-gap. This solution was possible by the means known in the art for voltages up to 400 or 500 kv. Nevertheless, even at these voltages and more particularly at higher voltages, serious problems have been encountered in the design of the inductances and of the spark-gaps caused by the critical potential distribution along the windings of the inductances and the prolonged firing time of the spark-gaps at very high voltages. Similarly, for a very high power at intermediate voltages, the discharge current of the spark-gaps is so great that burning of the electrodes is a limiting factor.

The object of the invention is to overcome the extreme difficulties accompanying the design of the elements of the testing circuits for very high voltages and very high powers while being also useful in the intermediate range of voltages and powers.

The high voltage generator, in accordance with the invention, is composed of the so-called synthetic testing of circuit interrupters, and more particularly with a testing circuit of the current injection type capable of providing successively an injection current wave and a transient recovery voltage wave. The generator comprises an injection branch providing the injection current wave and a regulating branch providing the transient recovery voltage.

The basic idea of the invention is to form the injection branch by means of at least two groups of elements, each comprising a capacitance, an inductance and a spark-gap in series forming a unit, and to provide the injection branch with a switching system capable of connecting the units in series, in parallel, or in a combined series-parallel connection. Similarly, the regulating branch is formed by at least two groups of elements, each comprising at least one capacitance and at least one resistor forming a unit. A switching system is used to connect the units in series, in parallel, or in a combined series-parallel connection in a way similar to the injection branch.

It is also advantageous to have the same number of units in series or in parallel in the injection branch and in the regulating branch and to form integrated units comprising the elements of both branches. This way, a single switching system may be used for connecting the integrated units in series, in parallel or in a combined series-parallel connection.

In the integrated units, the regulating branch may be connected in parallel with the inductance, or with the inductance-spark-gap group, or with the capacitance-inductance-spark-gap group of the injection branch. Finally, the connection of the regulating branch with the injection branch may be formed by a combination of the above-mentioned connections.

There are two ways of charging the capacitances in each of the units: In the first one, the units are connected in parallel by means of the switching systems and the required connections to obtain the number of units in series or in parallel are done subsequently prior to effecting the test. In the second one, the required connections of the units in series or in parallel are done and the capacitances are subsequently charged through a system of charging resistors having a very high ohmic value. A firing system is used for operating the spark-gaps, this system being capable of firing all the spark-gaps or a predetermined portion of the spark-gaps only at the same time.

The invention also relates to a method of operating the above-described generator in which the units are in a parallel connection for a predetermined voltage but in which it is desired to make successive tests at different powers. In accordance with the invention, the number of units required for providing the necessary power for each test is obtained by firing the spark-gaps of the corresponding units only, the other units remaining unoperated.

Following the same basic idea, plural identical generators adjusted for various testing powers may be used and, for successive test, these generators may be energized individually or in parallel depending upon the power required by firing the spark-gaps of the corresponding generators only.

In another method of operating the above-mentioned generator, plural generators having identical powers but charged by voltages of opposite polarities may be used, and the generators having alternate opposite polarities may be operated successively in the successive passages through zero of the high current source by firing the spark-gaps of the corresponding generators.

Finally, in a further mode of operation of the above-mentioned generator, two identical groups of generators charged with voltages of opposite polarities may be used, and such generators may be fired simultaneously in series in a synthetic testing circuit so as to provide a double transient recovery voltage on the terminals of the interrupters under test.

The present invention will be more clearly understood by means of the following description which refers to the accompanying drawings by way of example only. In the drawings:

FIG. 1 illustrates a known synthetic circuit comprising a concentrated capacitance, a concentrated inductance and a spark-gap,

FIGS. 2A and 2B illustrate the path of the currents and of the voltages respectively in the synthetic circuit of FIG. 1 during a test,

FIG. 3 illustrates a detailed diagram of the injection branch in accordance with the invention,

FIG. 4 illustrates a detailed diagram of the regulating branch in accordance with the invention,

FIGS. 5A and 5B illustrate respectively a synthetic circuit in which the injection branch is combined with the regulating branch,

FIG. 6 illustrates a synthetic circuit having integrated units and a single switching system,

FIGS. 7 to 11 illustrate other arrangements of integrated units in accordance with the invention,

FIG. 12 illustrates a generator comprising six units in series in which the two upper units use a different method of regulating the transient recovery voltage,

FIG. 13 illustrates a method of operation of a high voltage generator having plural units in parallel,

FIGS. 14 and 15 illustrate a method of operation of a high voltage generator formed of plural generators in parallel.

FIG. 1 illustrates a diagram of a conventional synthetic circuit comprising a high current circuit at the industrial frequency composed of a current source 1, a closing switch 2, an aux-
illary circuit breaker 3 and a circuit breaker under test 4. The current source 1 illustrated here as being a transformer may, of course, be an alternator, a power system, or an oscillating circuit LC providing the induced frequency current. To the terminals of the circuit breaker under test is connected a second circuit, called a high voltage source, which comprises an injection branch 5 and a regulating branch 6. In the illustrated example, the injection branch 5 comprises a capacitance C, and inductance L and a spark-gap E in series and the regulating branch 6 comprises a resistor R and a capacitance C also connected in series.

The operation of this simplified circuit is illustrated in FIGS. 2A and 2B in which the current waveforms may be seen on the time axis of FIG. 2A and the voltage waveforms may be seen on the time axis of FIG. 2B. Before starting the test, the current source 1 is energized, the closing switch 2 is opened, the circuit breakers 3 and 4 are closed, and the concentrated capacitance C of injection branch 5 is charged by means of a charger which is not shown. When closing switch 2 is closed, a current at the industrial frequency of 60 Hz. starts to flow in the high current circuit. The curve 7 of FIG. 2A illustrates the last half-period of this current before the opening of the circuit breaker 4. At a predetermined location before point 8 on the time axis, the contacts of the two circuit breakers 3 and 4 are opened and two arcs in series are formed in the high current circuit. At point 9 which represents a suitable time before point 9 representing the passage to zero of current 7, the spark-gap E of the injection branch 5 illustrated in FIG. 4 is fired and a second current 11, called the injection current, starts to flow in the injection branch and through the circuit breaker 4 under test. The two currents are added in the circuit breaker 4 to produce the waveform 12 between points 8 and 9 on the time axis, while current 7 only flows through the auxiliary circuit breaker 3. The auxiliary circuit breaker 3 cuts the current waveform 7 at point 9 so that the high current circuit is separated from this point from the high voltage circuit. At the time interval 9-10 before the passage to zero of current waveform 11, the current in the circuit breaker 4 under test is provided by the high voltage source only, that is by the injection branch 5.

In FIG. 2B, which illustrates the voltage path, the DC voltage of the concentrated capacitance C in injection branch 5 is shown by the straight portion of curve 13. If the spark-gap E is fired at point 10, voltage is inverted corresponding to the half-period of the injection current 11 due to the oscillating circuit LC of the injection branch 5, so that the voltage of the concentrated capacitance C of the injection branch 5 is given by point 14 at time 10. The voltage on the terminals of circuit breaker 4 until time 10 was practically zero because, with modern circuit breakers operating at very high voltages, the arc voltage is only about 1 to 2 percent of the nominal voltage. At point 10 on the time axis, the injection current loop is opened by circuit breaker 4 and the regulating branch 6, which is short-circuited by the arc at the terminals of circuit breaker 4, comes into play. A new oscillating circuit is formed by the injection branch 5 and the regulating branch 6 in series. The equilibrium condition of the two branches gives the oscillations of the transient recovery voltage 16 on the circuit breaker 4 under test. The transient recovery voltage 16 is superposed on the voltage 13, and the hatched surface 15 between the two curves gives the voltage on the concentrated inductance L of injection branch 5.

FIG. 3 illustrates an example of a detailed connection of the injection circuit in accordance with the invention. There is shown, by way of example, six identical units 31 to 36 each composed of a capacitance 37, an inductance 38 and a spark-gap 39 in series. Between each pair of units 31 to 36, is located a system of switches 40, 41 and 42 which permit to connect the units in series, or in parallel, or in a combined series-parallel connection. If the switches 40 and 42 are closed, the units are connected in parallel; if switches 41 only are closed, the units are connected in series. This way, there may be obtained a number of connections such as, for example, six units in parallel, three units in parallel in series with three other units in parallel, three series circuits of two units in parallel, or finally six units in series. It is obvious that the number of units illustrated in FIG. 3 may vary and that, by operating predetermined switches, four or five units in series may be obtained by shunting two or one units respectively. The use of the three elements in each unit, that is of capacitance 37, of inductance 38 and of spark-gap 39, as well as the injection frequency is always the same whatever may be the connection of the units.

The groups capacitances-inductances 37-38 in all the units 31 to 36 are connected in parallel through charging resistors 43 and 44 having a very high ohmic value. The whole assembly is grounded at point 45 and connected to a charger at terminal 47 through a further resistor 46.

The simultaneous firing of spark-gaps 39 in all the units is done by means of a system 48, illustrated in dash lines, which does not form part of the present invention.

The operation of the injection circuit disclosed in FIG. 3 is as follows:

First of all, the capacitances 37 in all the units are charged by means of a charger connected to terminal 47. Charging of the capacitances may be done in two ways: The first one consists in connecting the units in parallel by means of switches 40 and 42 to charge the capacitances. Subsequently, the preselection of the connection of the units 31 to 36 is done by means of the system of switches 40 to 42. The second one consists in effecting the required connections and then to charge the capacitances through the charging resistors 43 and 44. At a suitable time 8 (FIGS. 2A and 2B), a pulse is simultaneously applied to all the spark-gaps 39 by firing system 48 and arcs are triggered between the electrodes of the spark-gaps. At this time, the preselected connection is realized and the circuit starts to furnish a half-period of the injection current in the circuit breaker under test as shown by curve 11 in FIG. 2A.

FIG. 4 illustrates a detailed diagram of the regulating branch 6 of FIG. 1. By way of example, there is shown the same number of units as in FIG. 3, that is six units identified by reference numerals 51 to 56. Also by way of example, it is seen that the six units are composed each of a capacitance 57 in series with a resistor 58, this group being shunted by another capacitance 59. The different units 51-56, 52-53 etc. are connected for a system of switches 60, 61 and 62 in the same way as in FIG. 3, permitting a series, parallel, or series-parallel connection of the units.

As it has been mentioned previously, the purpose of the regulating branch is to influence the form of the transient recovery voltage (FIG. 2B) and more particularly its frequency, its amplitude and the steepness of the waveform thereof. At the time of making the connections of this branch, as it has been illustrated previously, the values of the capacitances and of the resistors are adjusted coarsely to the respective testing voltages. Only a fine regulation remains to be done within desired limits for a predetermined testing voltage. At the same time, an alternate arrangement of the resistors and of the capacitances gives a more regular distribution of the voltage along the branches, which permits a more economical design.

FIG. 5A illustrates the injection branch and the regulating branch of FIGS. 3 and 4 interconnected together, but free of all the technical details, and shows the principal elements connected in series. The two branches represent the high voltage source corresponding to branches 5 and 6 of FIG. 1. FIG. 5B illustrates a diagram of an equivalent circuit with the concentrated elements. The following lines will establish a comparison between some voltage values which influence the spacing of the elements in the circuits of FIG. 5A and FIG. 5B respectively, assuming that the testing voltage and power are the same for both circuits.

Before triggering the spark-gap in FIG. 5B, the point 70 and consequently the whole regulating branch is at ground potential because the circuit breaker under test has not yet extinguished the electric arc between its contacts. The battery of capacitances 71 is charged at full voltage, so that the insu-
lating distances between the terminal 72, the inductance 73, the electrode 74 of the spark-gap and the remaining elements of the circuit must be maintained.

During the injection period, the potential of point 70 of the regulating branch remains at a potential which is near ground potential. In the injection branch, the electrodes of the spark-gap being shunted by an electric arc, an oscillating current flows producing a voltage drop in inductance 73 always equal to that across capacitance 71. This means that during the injection period an oscillating voltage having a peak value equal to the charge voltage of capacitor 71 remains between terminal 72 and the rest of the circuit. The conditions for the insulating distances are thus substantially the same as during the preceding period.

After the opening of the current loop in the circuit breaker, the voltage equilibrium occurs as illustrated in FIG. 2B. The curve 16 of FIG. 2B represents the potential of point 70 of FIG. 5B, the curve 13 the potential of point 72, while the hatched surface 15 represents the voltage between the terminals of inductance 73 in FIG. 5B. Consequently, during this period also, the insulating distances must be maintained between the various points of the circuit. It is only after the expiration of the transient period that the situation is simpler, points 70 and 72 being then at the same potential. In conclusion it is shown that, in Figure 2, the insulating distances must be maintained between certain points of the circuit which impose severe conditions on the space occupied by the circuit.

For the diagram illustrated in FIG. 5A, which is composed of identical units, points 81 to 85 are almost at ground potential, if the arc voltage across the circuit breaker under test is negligible during the full period until the point where the spark-gap is triggered. In the injection branch, the capacitances of the different units are all charged by a voltage equal to one-sixth, in our example, of the potential which exists at point 72 of FIG. 5B. This means that points 86 to 90 which are normally connected by charging resistors (see FIG. 3) are at ground potential, and that points 91 to 96 which are also connected by charging resistors (see FIG. 3) are at potential higher than ground potential but equal between each other, that is one-sixth of the total voltage. In conclusion, all the points 81 to 90 are practically at ground potential and it is not necessary to maintain any insulating distances between them.

During the injection period, the situation does not change very much. The regulating branch remains always short-circuited by the circuit breaker under test and the potential along the six units is substantially equal to ground potential. In the injection branch, the spark-gaps being shunted by the arcs across their terminals, a current flows through all the capacitances and through all the inductances, the circuit being closed by the circuit breaker under test. This current causes the formation of positive voltages on the capacitances and of negative voltages on the inductances which are equal in value but are of opposite sign. By adding these positive and negative potentials, it may be seen that the voltages are cancelled on each pair of capacitance-inductance and that the potentials of points 86 to 90 are always the same and equal to ground potential. We must then come to the conclusion, which may seem odd, that the potentials of all the points 81 to 85 of the regulating branch and the ones of points 86 to 90 of the injection branch are equal.

Finally, during the period after the opening of the current loop in the circuit breaker under test, a new oscillating circuit is formed comprising only the two branches illustrated in FIG. 5A. An oscillating current flows in the circuit producing the total voltage of point 80 with respect to ground illustrated by curve 16 in FIG. 2B. But, whatever may be the instantaneous voltage between point 80 and ground, such voltage is divided in the same proportions along the units of the regulating branch as along the units of the injection branch, so that the potentials of points 81-86, 82-87, 83-88, 84-89 and 85-90 correspond while increasing with respect to ground potential.

Consequently, direct connections may be made between the above-mentioned points as illustrated in dash lines in FIG. 5A. This way, the two branches may be combined and form integrated units comprising an injection branch and a regulating branch in each unit.

The formation of integrated units causes the automatic elimination of a separate switching system for the regulating branch because the required switching may be done by the system of the injection branch. Two units in accordance with the above-mentioned proposition, with a single switching system is illustrated in FIG. 6 in which the thick lines represent the injection branches and the fine lines the regulating branches. By means of switches 100 and 101, the two units illustrated may be connected in parallel or in series. By adding a suitable number of units, there may be obtained a complete high voltage source for effecting the synthetic tests.

FIGS. 5A and 6 illustrate an example of high voltage source based on the unit concept for the regulation of the transient recovery voltage by means of a regulating branch connected in parallel with the full injection branch composed of a capacitance, an inductance and a spark-gap. However, the other known regulating methods may equally use the unit concept in accordance with the invention. FIG. 7 illustrates a regulating branch comprising a capacitance 104 and a resistance 105 in series and another capacitance 106 in parallel which is connected in parallel with inductance 107 only of the injection branch.

FIG. 8 illustrates another embodiment of a regulating branch comprising a capacitance 108 and a resistor 109 in series and another capacitance 110 connected in parallel which is connected in parallel with the group inductance-spark-gap of the injection branch. This circuit offers a more economical solution because the regulating capacitances 108 and 110 are precharged with capacitance C of the injection branch through the circuit breaker under test. The amount of energy contained in the circuit is consequently higher and provides a testing power which is greater. It is obviously possible to combine the regulating methods illustrated in FIGS. 6, 7 and 8. An example of such a combination of the regulating method of FIG. 6 together with the regulating method of FIG. 8 is illustrated in FIG. 9.

In FIG. 10, the regulating branch comprises a first portion including a capacitance 111 and a resistor 112 connected in parallel with an inductance 113 of the injection branch and a second portion including a capacitance 114 connected in parallel with the group inductance-spark-gap of the injection branch. In FIG. 11, the regulating branch comprises a first portion including a capacitance 115 and a resistor 116 connected in parallel with an inductance 117 of the injection branch, and a second portion including a capacitance 118 connected in parallel with the group capacitance-inductance-spark-gap of the injection branch.

Up to now, there has been disclosed a unit concept for a high voltage source composed of identical units. However, the unit concept disclosed permits to obtain other results which were not obtainable with conventional circuits, or which presented problems which were difficult to resolve. With the unit concept, it is possible to connect in series two groups of units such as illustrated in FIGS. 6 to 11 having two different inherent frequencies, or even to use, in two groups, units having different methods of regulating the transient recovery voltage. For example, there is illustrated in FIG. 12 a circuit composed of six units 121 to 126. The two upper units 121 and 122 use a method of regulating the transient recovery voltage which is different from the units 123 to 126. Infact, the injection branches comprising the spark-gap and the capacitances are exactly the same in each unit, but concerning the regulating branches, the capacitances are smaller in the two upper units than in the four lower units. The two parts of the high voltage source form two independent oscillating circuits producing a superposition of two oscillations, and the result is a peculiar transient recovery voltage path composed of two different frequencies. In the example illustrated,
the circuit having a higher frequency is however more complex to facilitate the adjustment of the shape of the transient recovery voltage immediately after the opening of the current path through the circuit breaker under test.

It is to be understood that, to obtain a transient recovery voltage having two or plural natural frequencies, different types of units such as disclosed in FIGS. 6 to 11 may become combined, or even other connections which may be simpler or more complex may be used.

The basic idea of the invention has been disclosed based on the diagram of a testing circuit such as in FIG. 1 which is known under the name of parallel diagram. In a similar fashion, it is possible to apply the concept of the invention to other known testing methods such as the series testing diagram.

The unit concept in accordance with the invention presents different other possibilities which also form objects of the invention. For example, FIG. 13 illustrates a diagram of a high voltage generator for synthetic testing comprising six units 141 to 146 having an internal connection such as illustrated in FIGS. 6 to 11, and a triggering system 147 for the spark-gaps. The units are connected in parallel and may be operated as follows:

If the power generated by the complete generator is 100 percent, the test may be started with one-sixth of this power by sending a firing impulse to one spark-gap only, for example to the spark-gap of unit 141. By sending two firing pulses at the same time for a following test, there may be obtained one-third of the power, three pulses giving half of the power, etc. until the full power is generated. The above method of using the circuit is more economical because the power output of the generator may be changed by simply turning a button in the control room. Without this possibility, it would be necessary to change the connections in the high voltage circuit, which, in the case of voltages in the order of a few hundreds of kilovolts, is extremely laborious.

Another example is illustrated in FIG. 14. There is shown three generators 148, 149 and 150, the internal connection of which may be series, parallel, or a combined series-parallel connection but identical in the three generators. We may proceed as follows in this example:

First, the three generators are adjusted at different testing powers, for example 10 percent of the full power for generator 148, 30 percent of the full power for generator 149 and 60 percent of the full power for generator 150. Then, by selecting suitable triggering pulses, the generators may be operated individually, or in parallel, depending on the required power. Consequently, there may be obtained a series of successive powers for the test, for example 10 percent, 30 percent, 60 percent and 100 percent as requested in the international regulations. Naturally the percentages and the number of generators used is disclosed by way of example only. It is obvious that other combinations are available.

Second, there may be used a certain number of generators, for example three such as illustrated in FIG. 14 in another fashion. Let us assume that the three generators 148, 149 and 150 are adjusted at the same power but have alternate polarities, for example that generator 148 has a positive charge, 149 a negative charge and 150 a positive charge. The three generators may be operated successively during three successive passages of the high current through zero while changing the polarity. This way, a circuit breaker may be tested with an arc lasting three half-periods. It is obvious that the number of generators, which has been disclosed as being three, and that the number of successive zeros of the current, which have also been mentioned as being three, has been chosen by way of example only and that a higher or a lower number may be used.

Another use of the generators is illustrated in FIG. 15. There is illustrated a synthetic testing circuit whereby it is possible to test circuit breakers having a nominal voltage which is twice the voltage of the generators. The high current circuit is composed of a source 151 at the industrial frequency, of two auxiliary circuit breakers 152 and 153 and of a single circuit breaker under test 154, having a nominal voltage which is twice the voltage of circuit breaker 152 and 153. Two synthetic generators 155 and 156 or two groups of generators, the first one being charged with a positive potential, the second one being charged with a negative potential, are used. At a suitable time before the passage of the high current through zero, exactly as illustrated in FIG. 2A, the spark-gaps in the two generators 155 and 156 are triggered and an injection current (11 FIG. 2A) is circulated in circuit breaker 154 by the two generators in series. The interruption of the current in the circuit breaker under test is exactly the same as in FIG. 2A. After the interruption of the current, the two generators produce two oscillations of the transient recovery voltage which are the same or different depending on the case under consideration, but have a different polarity which in being superposed give a double transient recovery voltage on the terminals of the circuit breaker under test.

In concluding this description, the following advantages may be mentioned concerning the generator in accordance with the invention:

1. By the application of the basic idea of the invention, there is obtained a synthetic testing circuit, and more particularly a high voltage injection branch for such synthetic testing circuit, while avoiding the difficulties concerning the dielectric insulation of the inductances and spark-gaps used in the construction thereof.

2. By the application of the basic idea of the present invention, there is obtained an injection branch which may be used for very high powers at intermediate voltages, while obviating the excessive burning of the electrodes of the spark-gaps.

3. By applying the basic idea of the invention, there is obtained an important advantage by choosing the voltage and the current in each unit in such a way as to correspond to the optimum use of the materials of the unit. There is then obtained not only a solution which was not obtainable for extreme voltages and currents, that is in the field where such solution was not obtainable by the means known to now, but also a solution which is usable with a higher safety and a higher economy in a field where such solution was usable by the means known up to now.

It may be also seen that by using a unit concept in the regulating branch, there may be obtained plural advantages on top of the ones mentioned above which are as follows:

1. First, by the series-parallel connection of the units, there is obtained a coarse regulation of the power of the concentrated elements, it would have been necessary to have a separate switching system for each element, that is, for the example disclosed, a switching system for the capacitances and a switching system for the resistors. The first advantage of the proposed solution is consequently a switching system which is more simple and consequently more economical.

2. Second, the regulating branch being composed of identical elements, it permits a more economical manufacture.

3. Third, the alternative arrangement of the resistors and the capacitances give a more regular distribution of the voltage along the regulating branch, which also results in a more economical construction.

The integrated unit concept of the injection branch and of the regulating branch permits to interconnect these two branches and to obviate the insulating distances which would be necessary with the arrangement known to now and so result in a space saving, which represents another advantage of the invention.

Finally, numerical other advantages of the generator in accordance with the invention have been mentioned in the application and it would be obviously superfluous to give a complete list thereof because they have already been mentioned.

I claim:

1. High voltage generator used for the synthetic testing of high voltage circuit interrupters, and more particularly for a testing circuit of the current injection type, and capable of providing successively an injection current waveform and a transient recovery voltage waveform, comprising:
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a. an injection branch providing said injection current waveform and a regulating branch providing said transient recovery voltage waveform;

b. the injection branch being formed by at least two groups of elements, each composed of a capacitance, an inductance and a spark-gap in series and forming a unit, and by a switching system for effecting a preselected connection of the units in series, or in parallel, or in a combined series-parallel relationship prior to the test of the interrupters for providing an injection current waveform of a desired form;

c. the regulating branch being formed by at least two groups of elements, each composed of at least a capacitance and at least a resistor forming a unit, and by a switching system for effecting a preselected connection of the units in series, or in parallel, or in a combined series-parallel relationship prior to the test of the interrupters for providing a transient recovery voltage waveform of a desired form.

2. High voltage generator as defined in claim 1, in which the corresponding units of the injection branch and of the regulating branch are interconnected to form integrated units comprising each the elements of an injection branch and of a regulating branch whereby a single switching system is provided for connecting the integrated units in series, in parallel, or in a combined series-parallel connection.

3. High voltage generator as defined in claim 2, in which, in the integrated units, the regulating branch is connected in parallel with the inductance of the injection branch.

4. High voltage generator as defined in claim 2, in which, in the integrated units, the regulating branch is connected in parallel with the group inductance-spark-gap of the injection branch.

5. High voltage generator as defined in claim 2, in which, in the integrated units, the regulating branch is connected in parallel with the group capacitance-inductance-spark-gap of the injection branch.

6. High voltage generator as defined in claim 2, in which, in the integrated units, the regulating branch comprises a first portion connected in parallel with the inductance of the injection branch and a second portion connected in parallel with the group capacitance-inductance-spark-gap of the injection branch.

7. High voltage generator as defined in claim 2, in which, in the integrated units, the regulating branch comprises a first portion connected in parallel with the inductance of the injection branch and a second portion connected in parallel with the group capacitance-inductance-spark-gap of the injection branch.

8. High voltage generator as defined in claim 2, in which, in the integrated units, the regulating branch comprises a first portion connected in parallel with the group capacitance-inductance-spark-gap of the injection branch.

A testing circuit including two identical generators as defined in claim 1, charged with potentials of opposite polarities and connected in series with a high current source through separate auxiliary interrupters, the interrupter under test being connected between two terminals of opposite polarities of said generators, the generators being triggered simultaneously so as to form a double transient recovery voltage on the terminals of the interrupter under test.

10. High voltage generator as defined in claim 1, in which the regulating branch is formed of at least two groups of units in which the capacitances are different producing at least two transient recovery voltages having their own inherent frequencies.

11. High voltage generator as defined in claim 1, comprising a system for triggering the spark-gaps which is capable of firing all the spark-gaps or a predetermined portion of the spark-gaps only at the same time.

12. Method of simulating the required power for the synthetic testing of high voltage circuit interrupters using a plurality of generators each including a plurality of generator units of the current injection type, and capable of providing successively an injection current waveform and a transient recovery voltage waveform, comprising the injection branch and the regulating branch, the regulating branch being formed each by at least two groups of elements forming each a generator unit, and by a switching system for connecting the generator units in series or in parallel, said method consisting in connecting in parallel plural identical generators and for successive tests energizing a different number of generators to provide the required power by triggering the spark-gaps of the corresponding generators only.

13. Method of simulating the required power for the synthetic testing of high voltage circuit interrupters using a plurality of generator units of the current injection type, and capable of providing successively an injection current waveform and a transient recovery voltage waveform, and comprising an injection branch and a regulating branch, the injection branch and the regulating branch being formed each by at least two groups of elements forming each a generator unit, said method consisting in connecting the units in parallel, and in energizing a suitable number of units to provide the required power for the test by triggering the spark-gaps of the corresponding units only.