

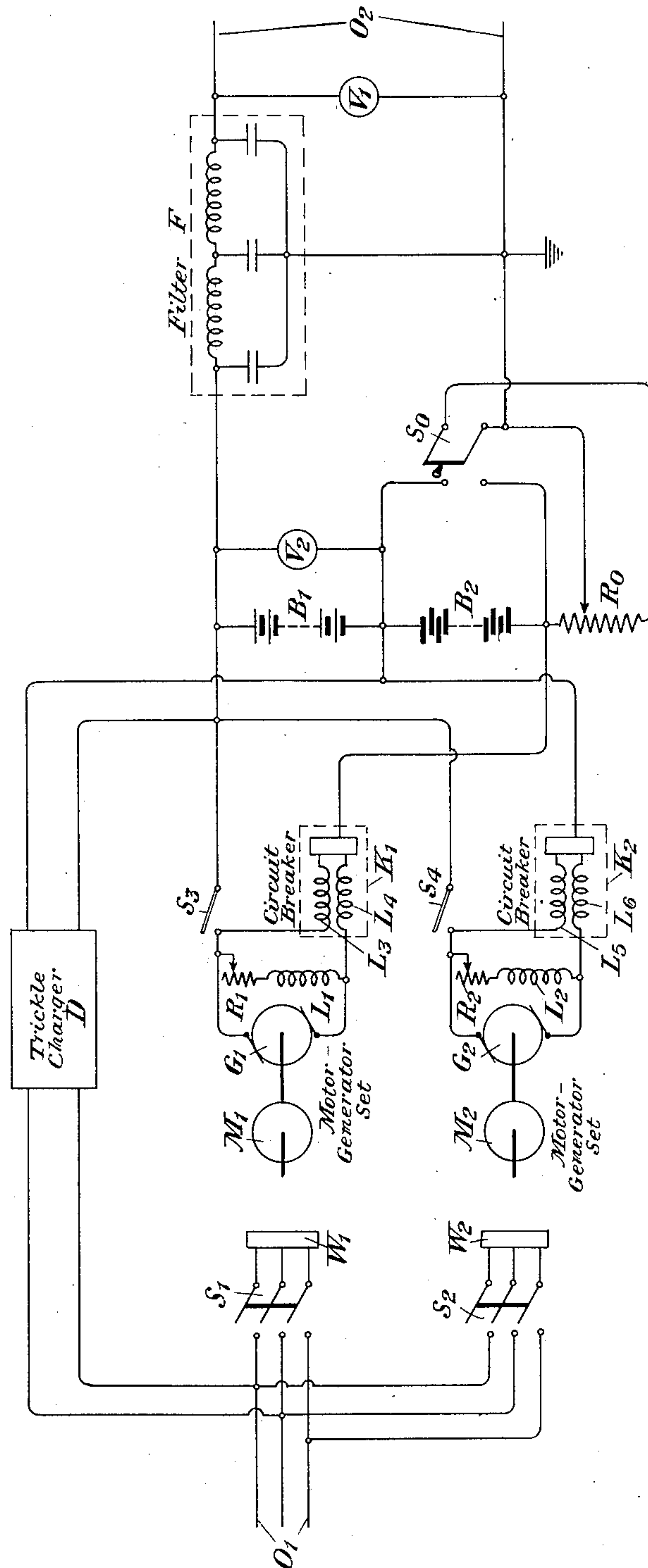
July 4, 1933.

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1,916,316

BATTERY CONTROL CIRCUIT

Filed March 17, 1930



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BATTERY CONTROL CIRCUIT

Application filed March 17, 1930. Serial No. 436,545.

This invention relates to circuits and apparatus for producing substantially constant direct current voltages. More particularly, this invention relates to control circuits and apparatus for a storage battery whereby abrupt changes in the voltage at the beginning and end of charge and discharge may be eliminated.

This invention will be described in connection with the accompanying drawing showing one embodiment thereof merely for the purpose of illustration.

Referring to the drawing, reference character O_1 designates a source of three-phase alternating current of any frequency which may be, for example, 60 cycles per second. A triple-pole single-throw switch S_1 may be operated to connect this source with the field windings W_1 of a motor M_1 which is mechanically coupled to a generator G_1 . Another triple-pole single-throw switch S_2 may be similarly operated to connect the source O_1 with the field windings W_2 of a motor M_2 which is mechanically coupled to a generator G_2 . The armature of the generator G_1 is shunted by a field winding L_1 and a rheostat R_1 , which are connected in series relationship. The armature of the generator G_2 is shunted by a similar arrangement including a field winding L_2 and a rheostat R_2 . The rheostats R_1 and R_2 may be manipulated in order to control the voltages derived from generators G_1 and G_2 , respectively.

Circuit breakers K_1 and K_2 are associated with the generators G_1 and G_2 , respectively. The circuit breaker K_1 includes two windings L_3 and L_4 , which are in inductive relationship. Winding L_3 is connected in shunt with the armature of the generator G_1 , while winding L_4 is in series with the armature of this generator. These windings produce similarly poled magnetic fields while the generator G_1 is supplying current to its connected circuits, yet when the direction of the current is reversed, the magnetic fields of these windings become mutually opposite, operating an armature or other movable element so as to break the circuit. The circuit breaker K_2 includes similar mutually reactive windings L_5 and L_6 which function in the same manner

as windings L_3 and L_4 just described. Thus, as current begins to flow into either of the generators G_1 or G_2 , the associated circuit breaker will operate so as to open the circuit in order to prevent the destruction of the generator armature.

The reference character B_1 designates a battery of secondary cells or other sources of electromotive force, and this may be a storage battery each of the cells of which may include a plurality of lead plates immersed in a solution of sulphuric acid, as is well known in the art. The reference character X will be employed to represent the number of cells forming battery B_1 . A battery B_2 is composed of a plurality of sources of counter-electromotive force, each of which consists of two or more electrodes, which may be of nickel, immersed in a fluid conductor, which may be an alkaline solution. The reference character Y will be employed to designate the number of cells forming battery B_2 .

Before proceeding with the specification, it may be well to compare the properties of each of the cells of battery B_1 with each of those of battery B_2 . Current may only pass between the electrodes of each of the cells of battery B_2 upon decomposition of the electrolyte into ions. This current cannot be established until the electromotive force impressed across the terminals of the cell is sufficient to perform the work of decomposition, and a current having a smaller electromotive force than that required to perform such work (the latter being termed the "critical voltage") cannot be transmitted through the electrolyte. Thus, the counter-electromotive force of each cell opposes the passage of current, and in a cell of the nickel-alkaline type the critical voltage is approximately 1.75 volts. This counter-electromotive force is comparatively constant and of course, its critical value may be changed by the use of electrodes of different material, or by the inclusion of a different fluid conductor, or by changing the spacing of the electrodes. The difference between each cell of counter-electromotive force of battery B_2 and each secondary cell of battery B_1 is that, while the former is able to offer the counter-

force to the passage of a current through it in either direction, it is unable per se to create or maintain a current. The secondary cell, on the other hand, offers a counter-force to the passage of a current in only one direction and it adds its current-producing capacity to a current passing through it in the opposite direction, the latter direction being the one corresponding to that of the current which the battery itself is capable of creating and maintaining.

Proceeding now with the specification, it will be seen that the upper terminal of a rheostat R_0 is connected to the lower terminal of the battery B_2 , while the other terminal of the rheostat is connected to one of the blades of a double-pole single-throw switch S_0 . The other blade of the switch S_0 is connected to the movable arm of the rheostat R_0 . The remaining two terminals of the switch S_0 are connected to the outer terminals of the battery B_2 . So, it will be seen that when the switch S_0 is open, the rheostat R_0 will be in series with batteries B_1 and B_2 and that when it is closed, rheostat R_0 will be in shunt with the battery B_2 .

An output circuit O_2 is connected between the variable arm of the rheostat R_0 and the upper terminal of the battery B_1 through a filter F which is of the low-pass type and includes equal series inductances and equal shunt capacitive elements. The output circuit O_2 is shunted by a voltmeter V_1 . A similar voltmeter is connected in shunt with the battery B_1 . One side of the output circuit O_2 may be grounded, as shown:

A trickle-charger D , of any well known type, is connected between two of the conductors leading to the source O_1 and the battery B_1 . The current supplied normally by the trickle-charger D has an amplitude of between one-half and one per cent of the eight-hour charging rate of the battery B_1 . A current of this amplitude will compensate for the losses in the cells of the battery B_1 resulting from local action, leakage and self-discharge.

A switch S_3 may be operated for the purpose of connecting the generator G_1 in series with batteries B_1 and B_2 through the circuit breaker K_1 . A similar switch S_4 may be operated to connect the generator G_2 with the battery B_1 through the circuit breaker K_2 .

The number of secondary cells required for battery B_1 may be determined from the voltage assigned to the output circuit O_2 and from the voltage of each of these cells when it is completely discharged. If it be assumed that each secondary cell is completely discharged when its terminal voltage is about 1.75 volts, the number of cells required may be roughly obtained by dividing the voltage assigned to the circuit O_2 by 1.75. It is interesting here to note that when the

battery B_1 is being properly floated under normal conditions, each cell will exhibit about 2.15 volts, and that each cell may exhibit approximately 2.6 volts or more when it is fully charged and the charging current is flowing.

Each of the cells of counter-electromotive force of battery B_2 presents a large resistance when the impressed voltage per cell is less than the critical voltage (1.75 volts per cell). If the voltage of the generator G_1 becomes greater than the voltage of the battery B_1 by an amount which is less than the value obtained by multiplying the critical voltage of each cell (1.75 volts) forming battery B_2 and Y , which represents the number of cells in battery B_2 , then substantially no current will flow from battery B_1 into the output circuit O_2 , nor will current flow from generator G_1 into battery B_1 . In that case the voltage across the output circuit O_2 , as indicated by the voltmeter V_1 , will be approximately equal to the voltage produced by generator G_1 .

When the power service fails so that the armature of the generator G_1 is unable to rotate, switch S_0 being open and the movable arm of rheostat R_0 being at its uppermost position, the voltage across the output circuit O_2 , as indicated by the voltmeter V_1 , will be reduced to that voltage corresponding to the difference in the voltage drops across batteries B_1 and B_2 . Upon the closure of switch S_0 , the rheostat R_0 will be connected in parallel with the battery B_2 and the voltage V_1 at the output circuit O_2 may be maintained constant by controlling the rheostat R_0 . As soon as the potential drop across the rheostat becomes less than the critical voltage of battery B_2 , practically all of the current will flow through the rheostat and the voltage at the output circuit O_2 will be approximately equal to the difference between the voltage of battery B_1 and the drop in voltage across the rheostat, through which practically all of the current transmitted to circuit O_2 will flow. It will be necessary to gradually reduce the resistance of the rheostat R_0 as the battery B_1 discharges, and at full discharge all of the resistance of the rheostat R_0 will be cut out.

The rheostat R_0 should include resistance of such a value that when all of its resistance is connected across the battery B_2 under normal conditions, the potential drop across the rheostat will be somewhat greater than the critical voltage of the battery B_2 . If the voltage drop across the rheostat under these conditions exceeds, for example, the value 1.75 Y volts, the rheostat will then be properly designed, and when the switch S_0 is closed upon the discharge of battery B_1 , only a part of the current from battery B_1 will flow through the rheostat. It will be apparent that if the switch S_0 is closed immediately

upon the discharge of battery B_1 , proper manipulation of the rheostat R_0 will prevent any appreciable variation in the voltage across the circuit O_2 .

5 When the power service is restored, the switches S_3 and S_4 may be closed so that the effects of generators G_1 and G_2 may be respectively impressed upon the attached circuits. In that event, the switch S_0 may at
10 first be maintained closed and the rheostat increased in resistance until the voltage across battery B_1 , as indicated by the voltmeter V_2 , is greater than the value attained by multiplying 2.15 by X , the number of cells in bat-
15 tery B_1 . Further increase in the voltage of the battery B_1 beyond the value just determined will cause current to flow from generator G_2 into the output circuit O_2 because the difference between the voltages of bat-
20 teries B_1 and B_2 will be substantially greater than the voltage assigned to the output circuit O_2 . This may be overcome by increasing the voltage of generator G_1 , which, of course, may be accomplished by the adjust-
25 ment of the rheostat R_1 . The voltage of generator G_1 should be so large as to maintain the voltage drop across battery B_2 below the critical value.

30 In order to prevent the voltage of the output circuit O_2 from increasing too greatly, the switch S_0 may be opened so as to connect the rheostat R_0 in series with batteries B_1 and B_2 and with the circuit O_2 . The resistance of the rheostat R_0 may then gradually
35 be increased in order to maintain the voltage V_1 across the output circuit O_2 substantially at the assigned value.

40 When the battery B_1 becomes fully charged, at which time the voltage V_2 will be greater than the product of 2.6 and X , then the switch S_4 may be opened so as to disconnect the charging generator G_2 from the bat-
45 tery B_1 . The trickle-charger D will continue to supply current to the battery B_1 , the voltage of which will then slowly drop to the normal floating voltage of 2.15 volts per cell. The voltage of the floating generator
50 G_1 may then be gradually reduced and the resistance of the rheostat R_0 also gradually reduced until all of its resistance has been cut out. It is to be noted that the generator
55 G_2 should be able to produce a voltage somewhat higher than that of the floating generator G_1 , and the generator G_2 should be able to charge battery B_1 at the normal eight-hour rate.

60 It will be apparent that the generator G_1 is arranged to supply current to the output circuit O_2 under ordinary conditions and that this generator, while connected across batteries B_1 and B_2 , runs as long as power is available at the input circuit O_1 . The generator G_2 will ordinarily remain unoperated, the switches S_2 and S_4 being normally open,
65 and the trickle-charger D will continually

supply the usual energy losses encountered by battery B_1 , which remains idle particularly because its voltage is less than the voltage V_1 of the output circuit O_2 . However, after
70 a power failure has occurred and service has been subsequently restored, the battery B_1 will be in a partially discharged condition and the generator G_2 will be connected to its associated circuits by the closure of
75 switches S_2 and S_4 . The generator G_2 is employed to recharge the battery B_1 to its normal voltage. While this is being done, it will be necessary to slowly raise the voltage of the generator G_1 and this, of course, may be accomplished by reducing the magnitude
80 of the resistance R_1 . Furthermore, the voltage of the generator G_1 must not be raised so high as to be greater than the additive values of the normal charging voltage of the bat-
85 tery B_1 and the critical voltage of the battery B_2 ($1.75 \times Y$); for if this value should be exceeded, current will flow from the generator G_1 into the battery B_1 and the generator G_1 will become overloaded. At the
90 same time the voltage of the battery B_1 will have risen to its normal charging voltage, and the voltage of this battery, which is V_2 , will be greater than the voltage at the output circuit O_2 if the generator G_1 is not in-
95 creased in voltage as above described. Current may then also flow from the battery B_1 through the battery B_2 to the generator G_1 , and therefore the circuit-breaker K_1 will be operated to disconnect the generator G_1 from
100 its associated circuits. The generator G_2 will then supply the entire load to the output circuit O_2 as well as the current required to charge the battery B_1 .

105 It will be apparent that the battery control circuit shown and described in this application permits the voltage at the output circuit O_2 to be maintained highly constant at some predetermined value while the main battery B_1 is being either charged or discharged.

110 The filter F is employed for the purpose of suppressing alternating currents which may be superimposed upon and introduced into the system due to commutator ripples, etc., from generators G_1 and G_2 . This filter may
115 have a cut-off frequency of, for example, 70 or 80 cycles. It is also to be noted that this filter will present crosstalk in the output circuit O_2 which may occur because of the common impedance presented by the rheostat R_0 .

120 It will be understood that while this invention has been shown in one particular embodiment merely for the purpose of illustration, the general principles of this invention may be applied to other and widely varied organizations without departing from
125 the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. In a system transmitting current from an input circuit to an output circuit, the com- 130

5 combination of a plurality of secondary sources
of electromotive force connected in series
with each other, a plurality of sources of
counter-electromotive force connected in se-
ries with each other and with said secondary
sources, the series circuit of said sources be-
ing connected in shunt with the input and
output circuits, a variable resistance, means
for connecting said resistance in series with
10 all of said sources and in series with said
output circuit, and means for connecting
said resistance in parallel with all of the
sources of counter-electromotive force.

15 2. The combination of a storage battery, a
battery of cells of counter-electromotive
force, a first direct current generator con-
nected to said storage battery, and a second
direct current generator connected in series
with both batteries.

20 3. The combination of a first battery of
secondary cells, a second battery of cells of
counter-electromotive force, a first direct
current generator connected to the storage
battery, a second direct current generator
25 connected in series with both batteries, and
a trickle-charger also connected to said stor-
age battery.

30 4. The combination of a source of alter-
nating current, first and second motor gener-
ator sets connected in parallel with said
source, a storage battery, a battery of cells
of counter-electromotive force connected in
series with said storage battery, a trickle-
35 charger coupled to said alternating current
source, the generator of the first set and said
trickle-charger being connected in parallel
with said storage battery, the generator of
the second set being connected in series with
both batteries.

40 5. The combination of a source of alter-
nating current, first and second generators
operated from said source, a storage battery,
a battery of counter-electromotive force cells
in series with said storage battery, an output
45 circuit connected across both batteries, and
a trickle-charger coupled to the alternating
current source, the first generator and the
trickle-charger being connected in parallel
with the storage battery, the second gener-
50 ator being connected across the output cir-
cuit.

55 6. In a battery control system, a load cir-
cuit to be supplied with current, a battery,
counter-electromotive force cells in series

arrangement with said battery and across
said load circuit, a rheostat, and manual
means for connecting said rheostat in paral-
lel with said counter-electromotive force
cells or in series with said load circuit.

70 7. In a system for supplying current to a
translating circuit, the combination of a sec-
ondary battery, a battery of counter cells,
said batteries being connected in series with
each other and in shunt with the translating
75 circuit, and a rheostat connected in shunt
across said battery of counter cells.

80 8. In a system for supplying current to a
translating circuit, the combination of a
storage battery, a battery of counter cells
connected in series with the storage battery,
said series batteries being connected in shunt
with the translating circuit, a rheostat, and
means for connecting said rheostat in shunt
85 with said battery of counter cells or in series
with said translating circuit.

90 9. The combination of a source of direct
current, a translating circuit, a storage bat-
tery connected in shunt with said source of
direct current, a battery of counter cells, said
batteries being connected in series with each
other and in shunt with said translating cir-
cuit, and a rheostat connected in shunt with
the battery of counter cells.

95 10. In a system for supplying current to
a translating circuit, the combination of a
storage battery, a battery of counter cells, a
generator connected in series with both the
storage battery and the battery of counter
cells, said generator being also connected
100 across the translating circuit, and a rheostat
connected in shunt with the battery of coun-
ter cells.

105 11. Apparatus for connection across an
input circuit and an output circuit which is
to be supplied with current from said in-
put circuit comprising, in combination, a
source of direct current potential, a battery
of counter cells connected in series with said
source of direct current potential, and a
110 rheostat connected in shunt with said bat-
tery of counter cells and having a resistance
which will normally produce a voltage drop
greater than the critical voltage of said bat-
tery of counter cells.

115 In testimony whereof, I have signed my
name to this specification this 15th day of
March, 1930.

WILLIAM H. T. HOLDEN.