No. 665,664. Patented Jan. 8, 1901.

C. D. RAAB.

SYSTEM FOR HEATING CONDUCTORS OF THE SECOND CLASS.

(Application filed Apr. 30, 1900.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1.

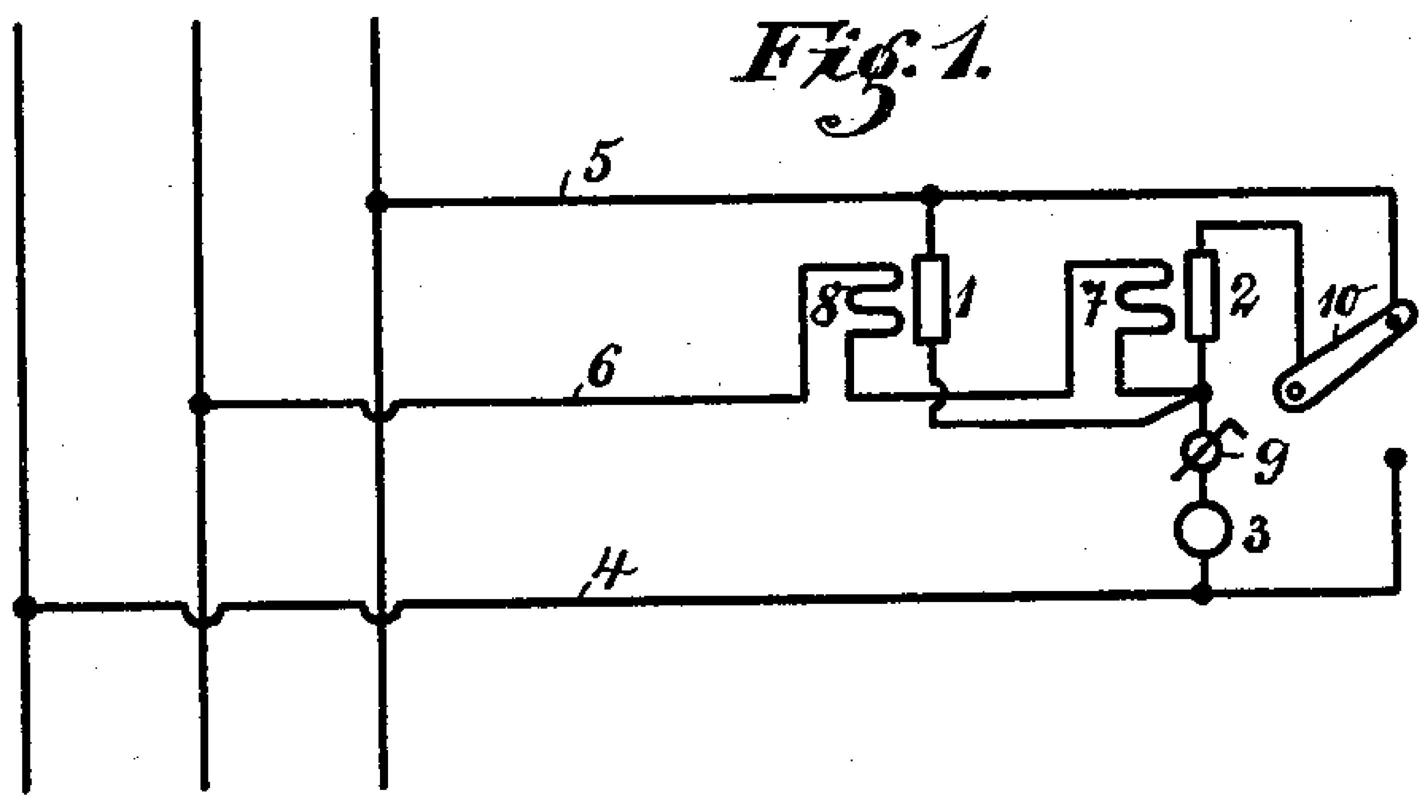


Fig. 5.

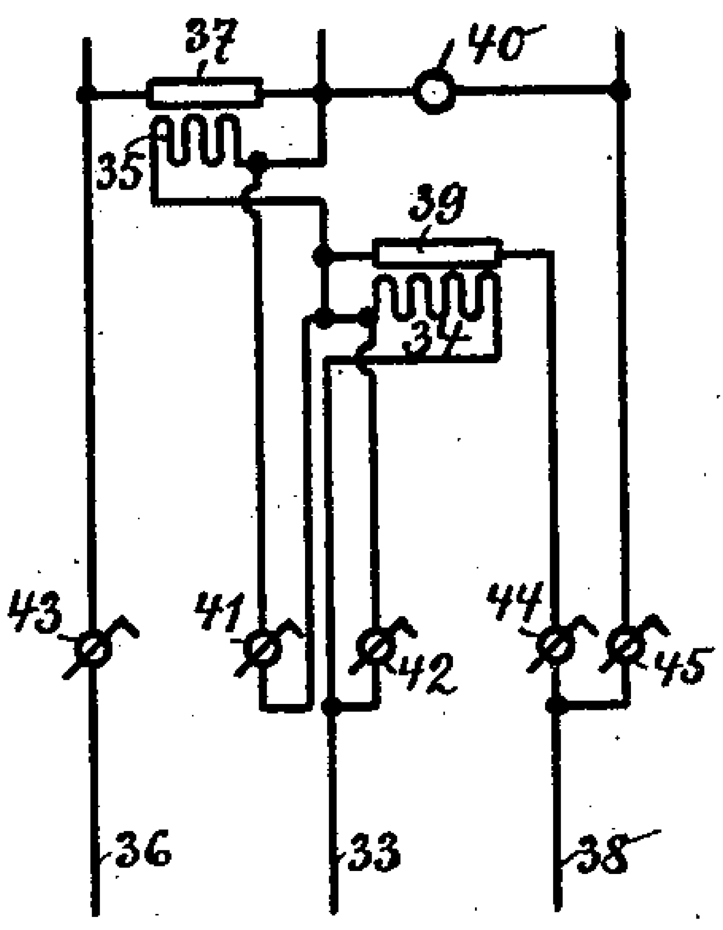


Fig. 2

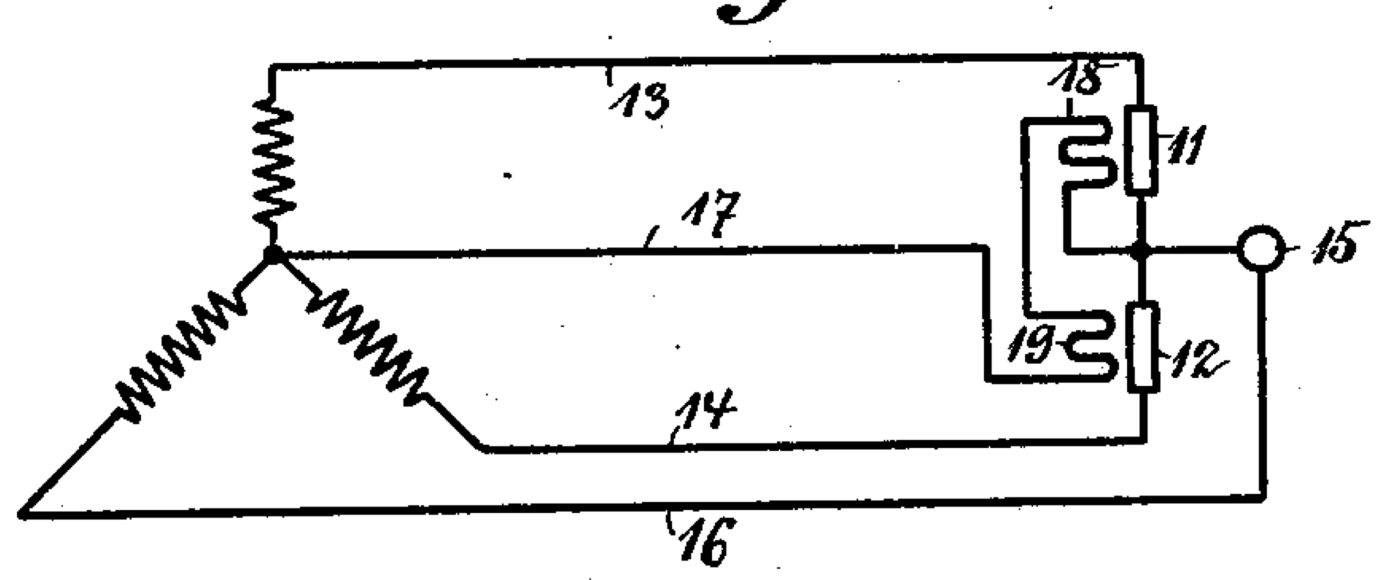


Fig. 6.

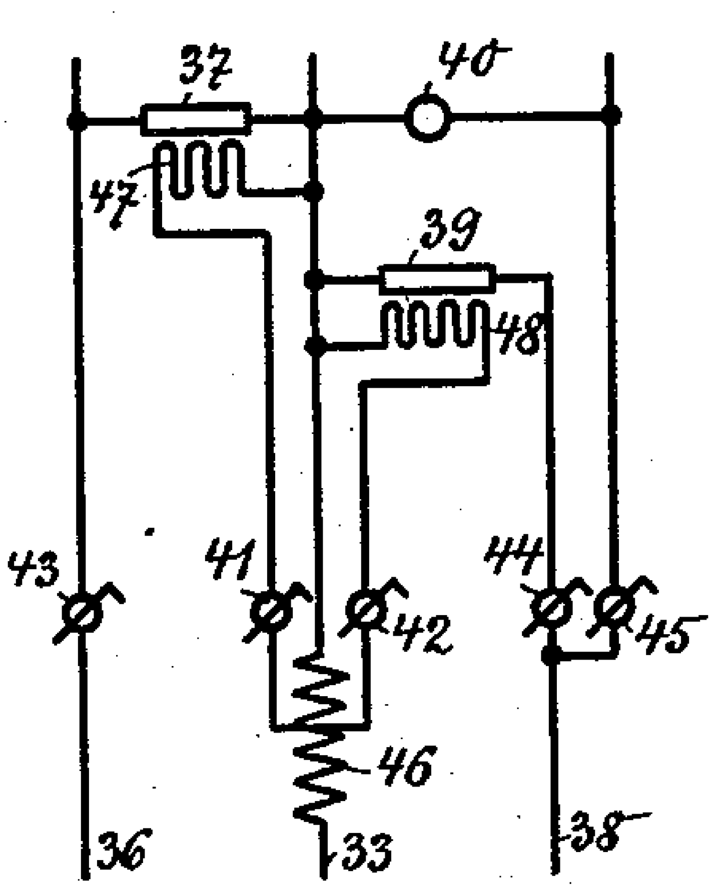


Fig. 3.

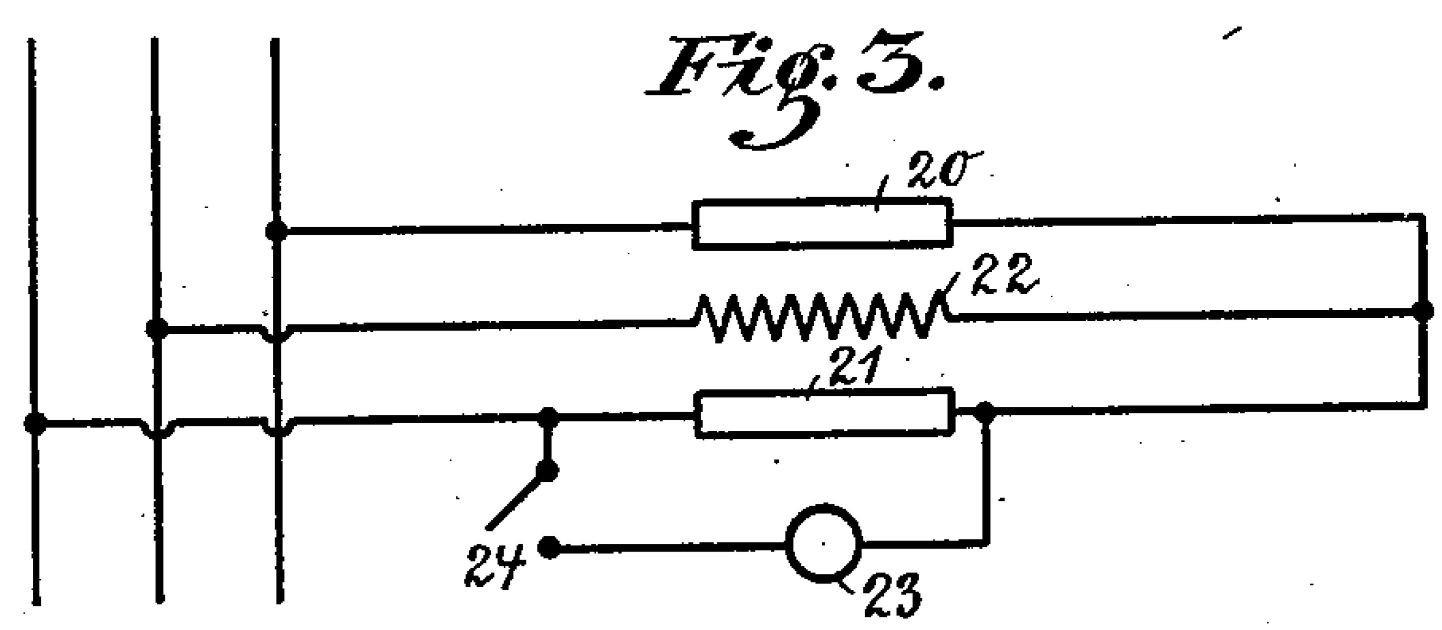
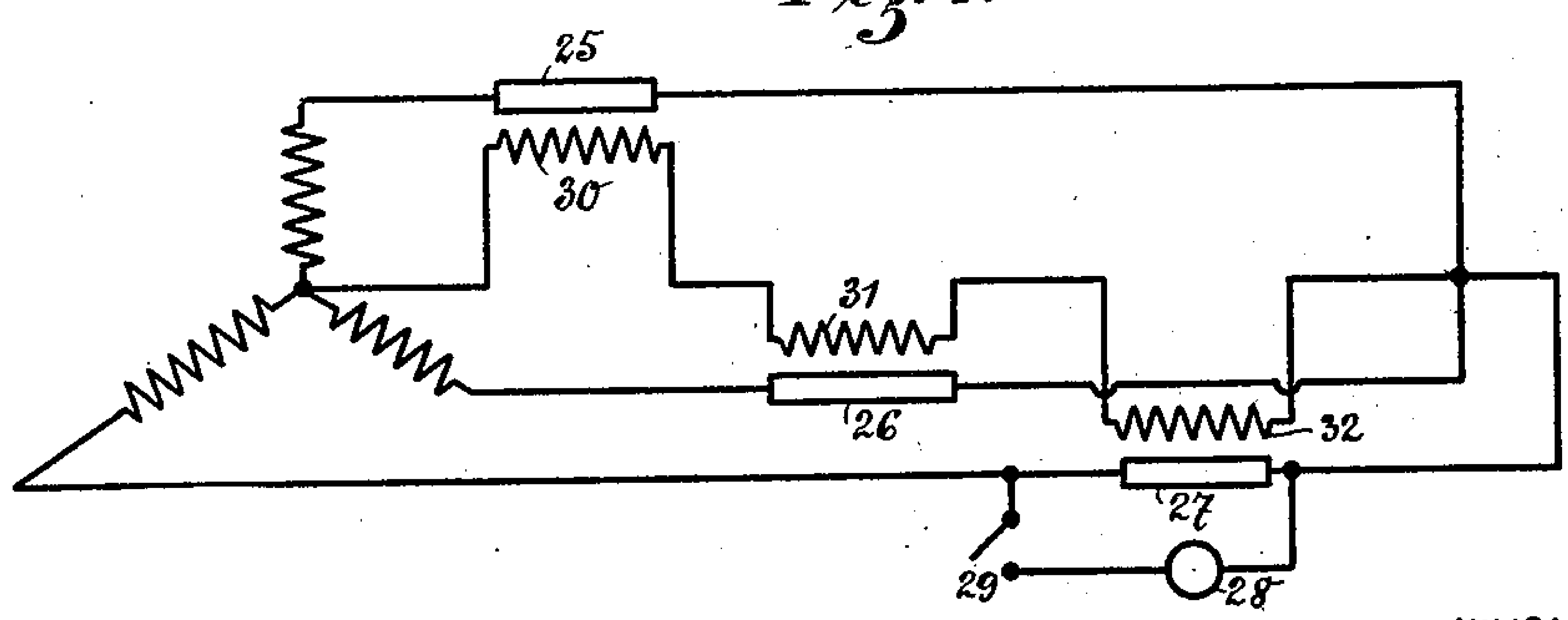


Fig. 4.



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(No Model.) 3 Sheets—Sheet 2.

Fig. 7.

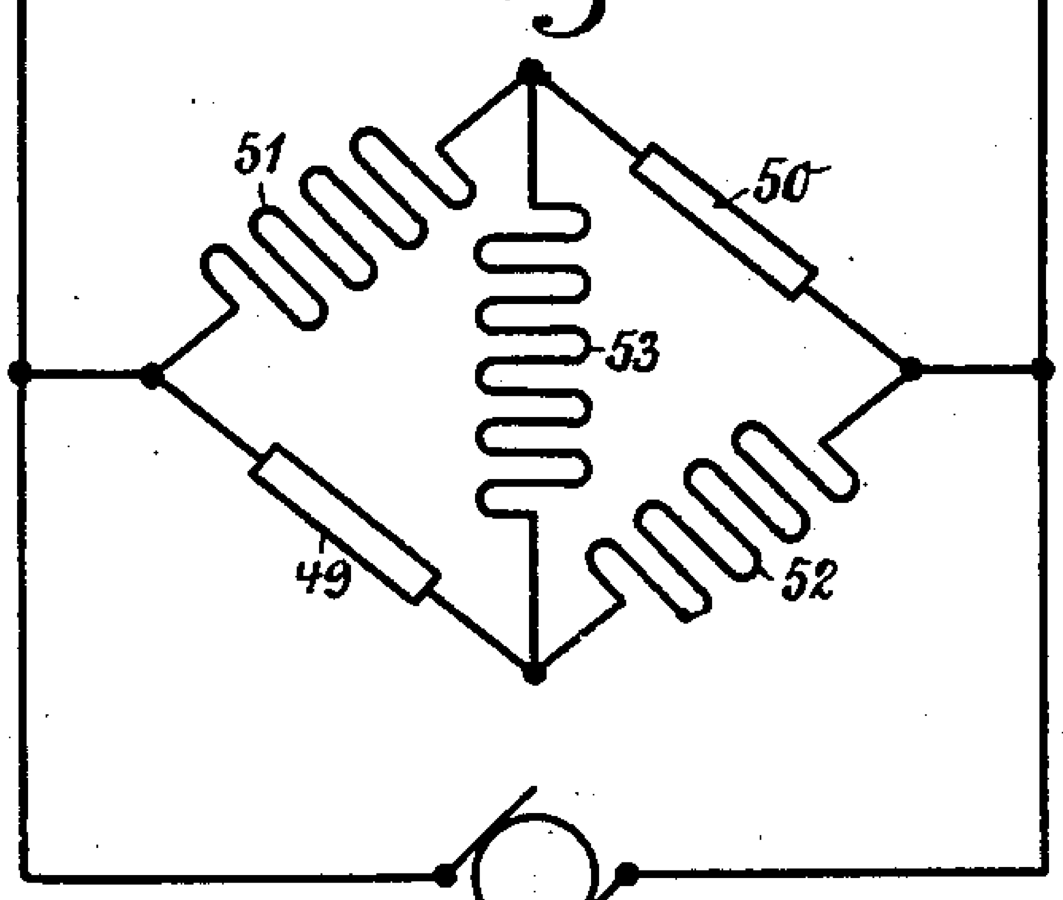


Fig. 8.

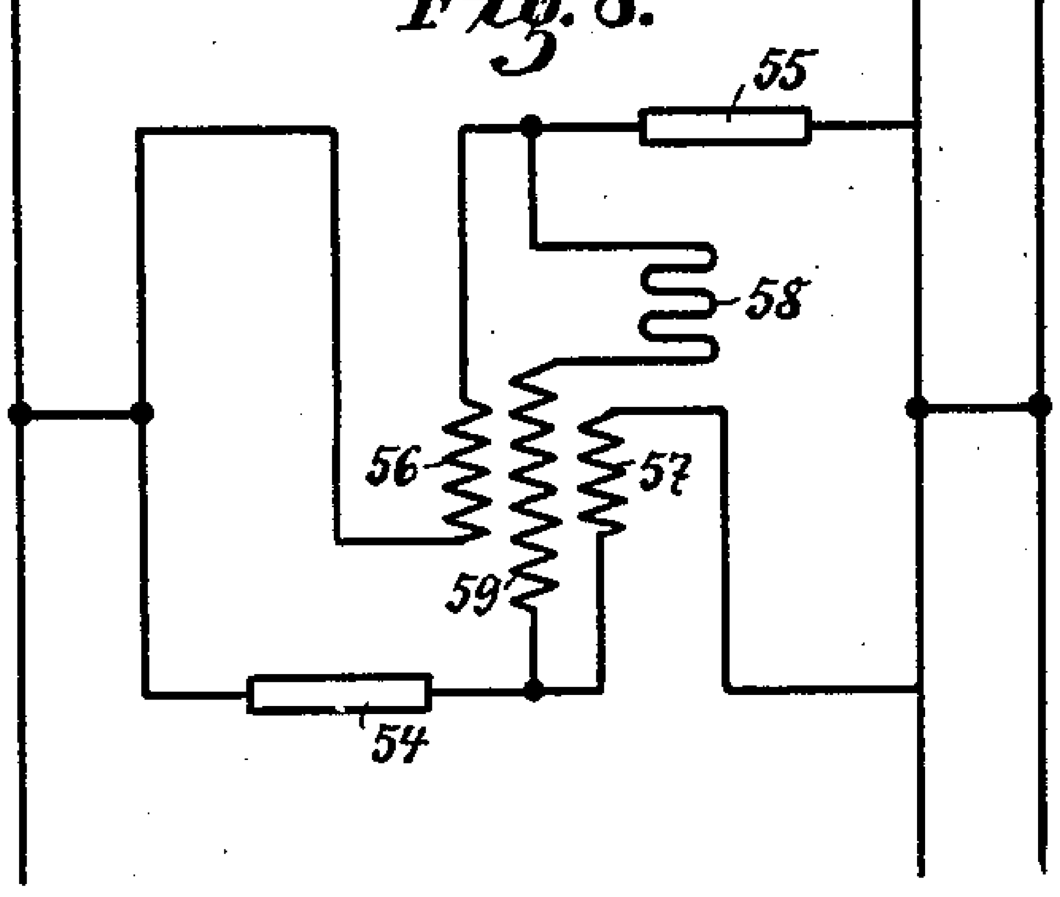


Fig. 9.

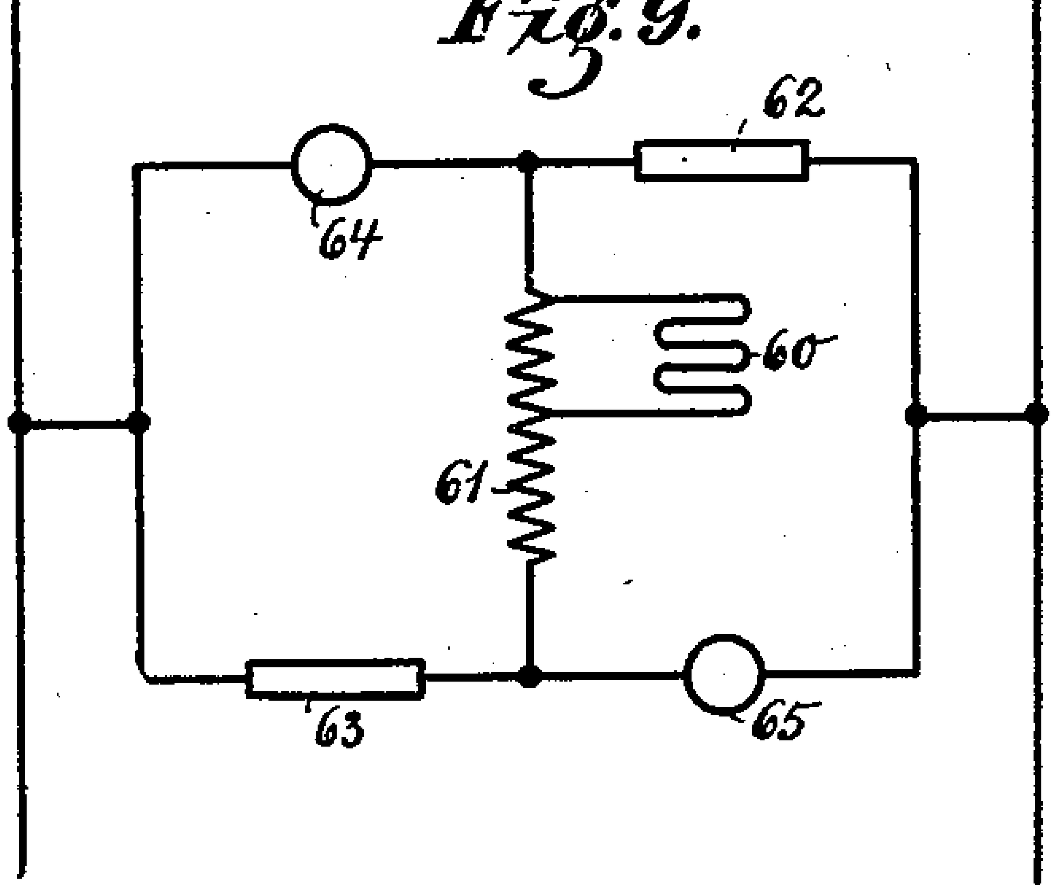


Fig. 10.

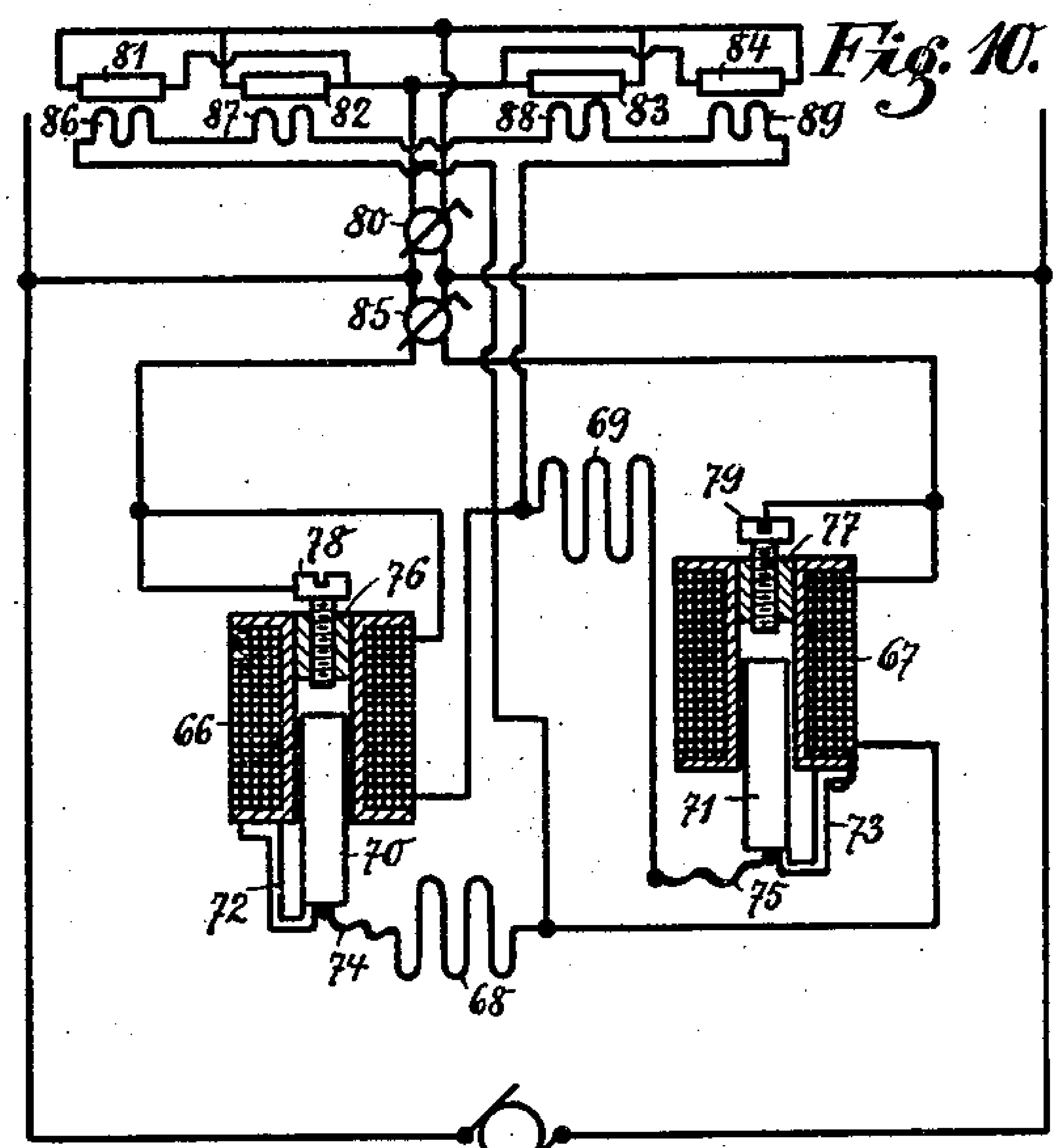
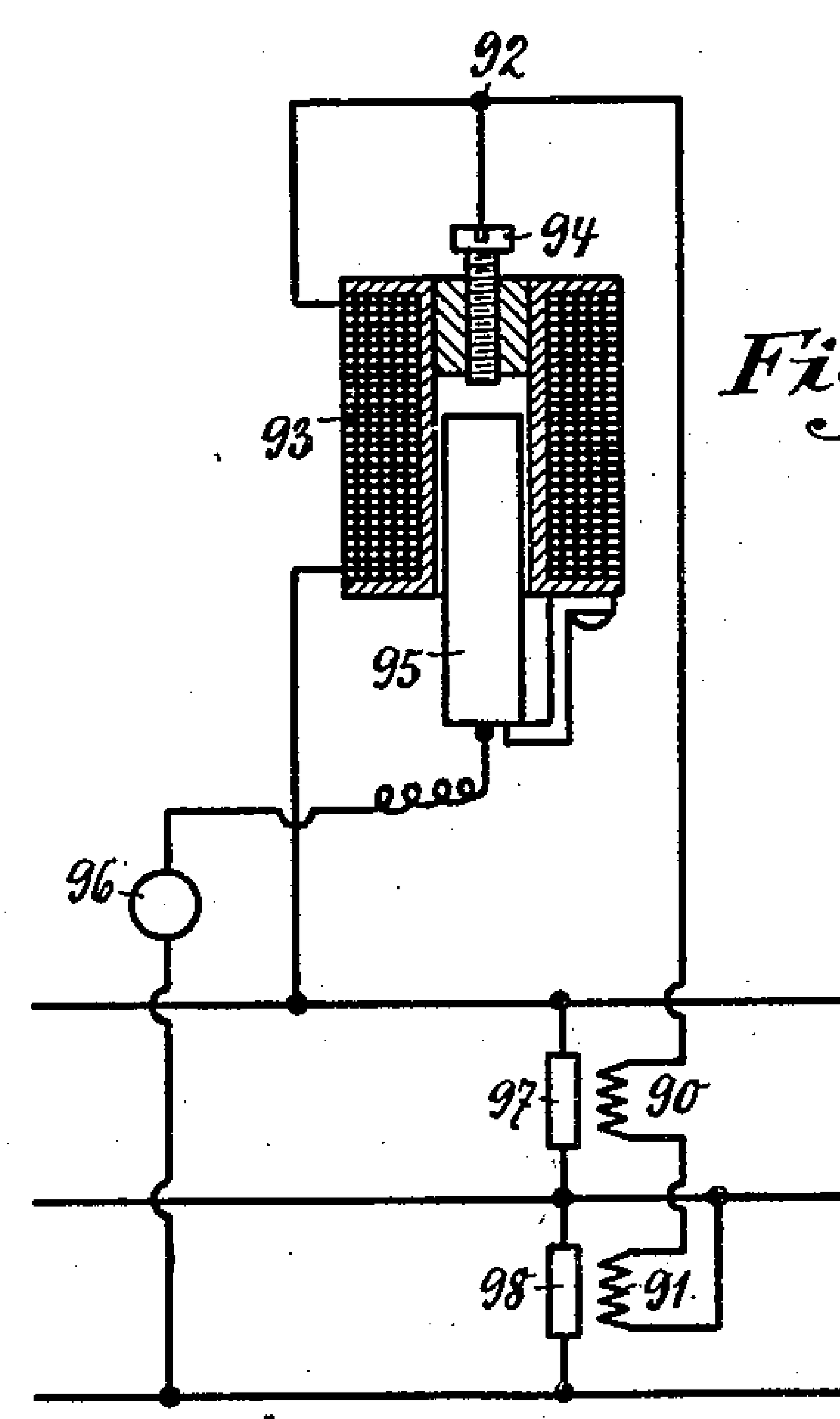


Fig. 11.



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(Application filed Apr. 30, 1900.)

(No Model.) 3 Sheets—Sheet 3.

Fig. 12.

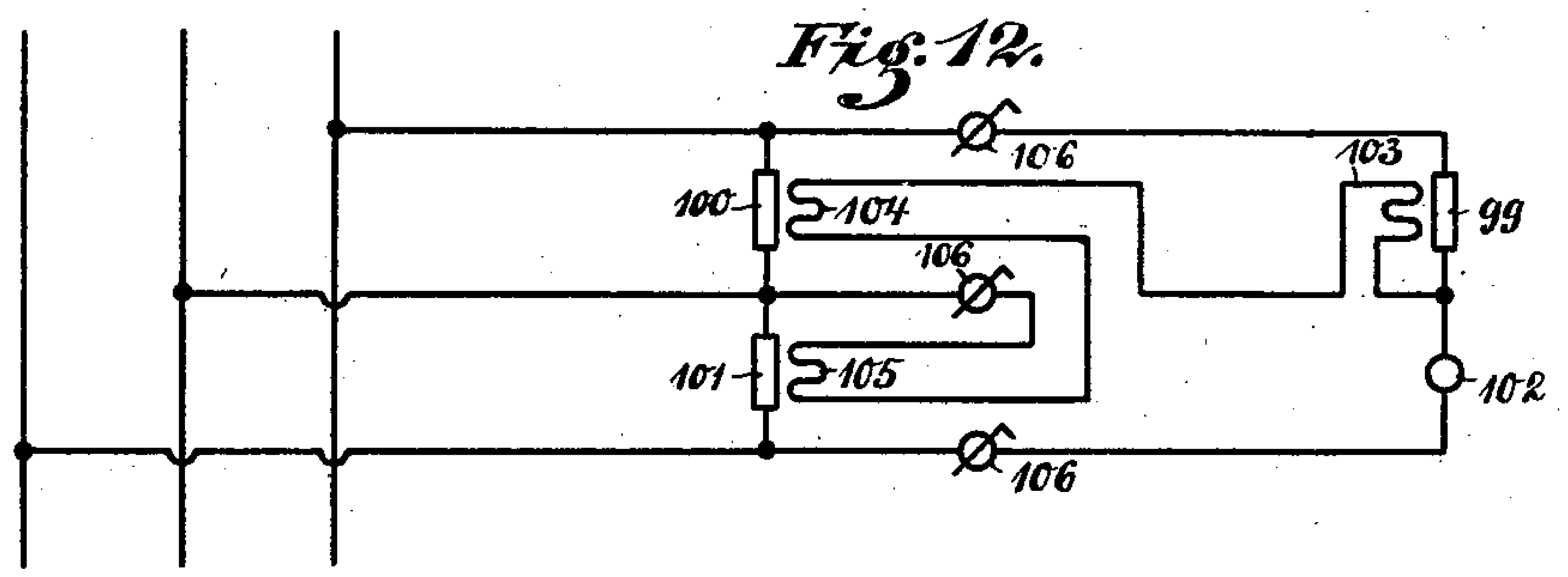


Fig. 13.

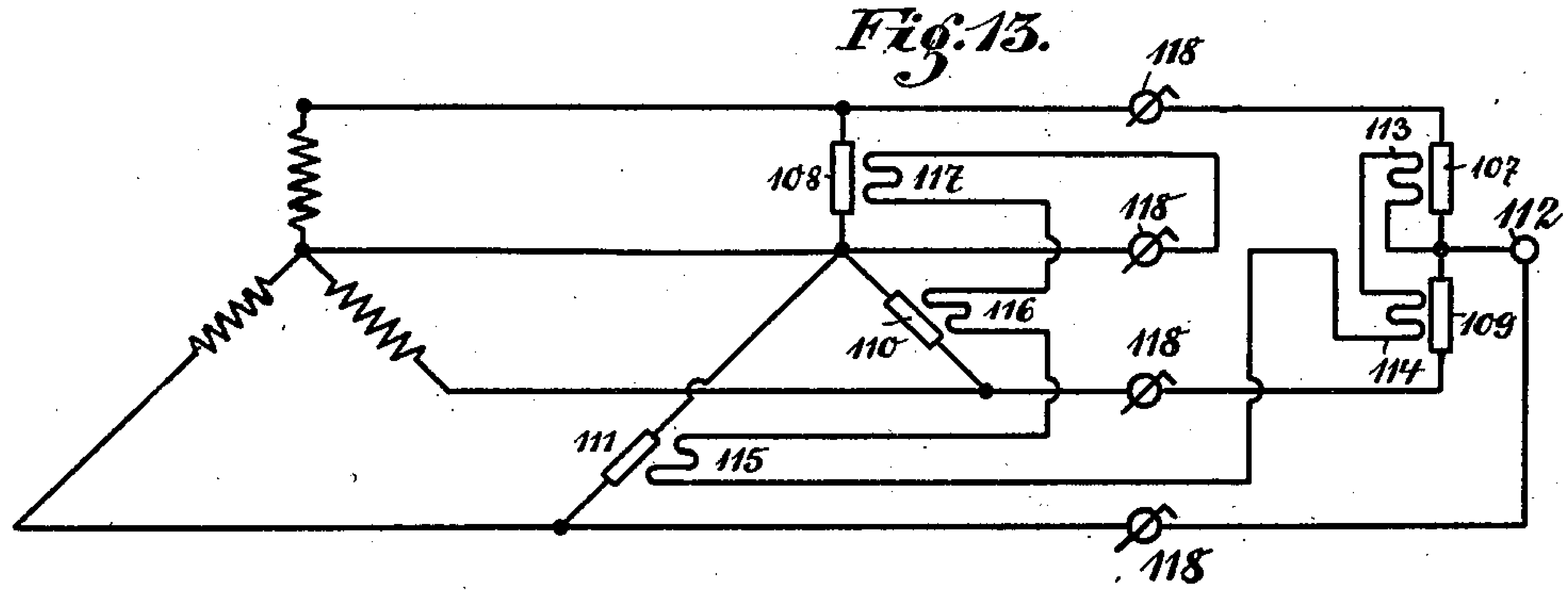
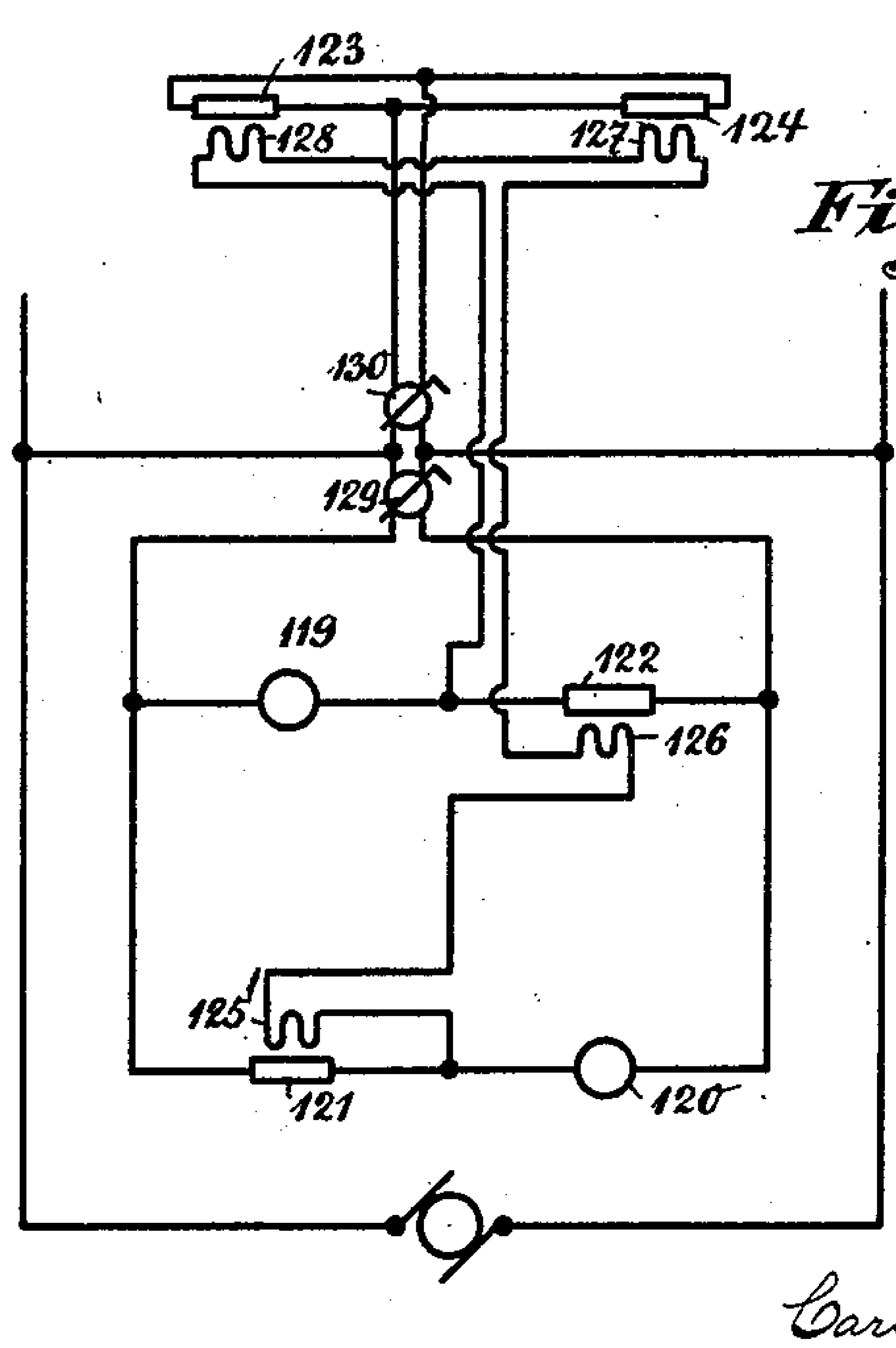


Fig. 14.



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UNITED STATES PATENT OFFICE.

CARL DANIEL RAAB, OF KAISERSLAUTERN, GERMANY.

SYSTEM FOR HEATING CONDUCTORS OF THE SECOND CLASS.

SPECIFICATION forming part of Letters Patent No. 665,664, dated January 8, 1901.

Application filed April 30, 1900. Serial No. 14,970. (No model.)

To all whom it may concern:

Be it known that I, CARL DANIEL RAAB, a subject of the King of Prussia, German Emperor, residing at the city of Kaiserslautern, in the Kingdom of Bavaria, German Empire, have invented certain new and useful Improvements in Systems for Heating Conductors of the Second Class, of which the following is a full, clear, and exact description.

The present invention relates to a system for heating conductors of the second class, which consists in interpolating conductors of the first class and such of the second class between the separate lines and one or more heating devices in the compensating or neutral wire of a current-distributing system. This is effected in such a manner that after heating the heating device or devices become deënergized or the current flowing through is reduced to a very small amount.

In this invention the system for heating conductors of the second class applies generally to all systems of distribution in which compensating or neutral lines are possible. It applies, therefore, also to multiple-wire systems, certain forms of which are particularly described hereinafter as examples, as well as to the ordinary bridge arrangement. The heating resistance can be of various kinds. It may, for instance, consist of a thin platinum wire wound around a mica plate secured in the immediate neighborhood of the incandescent body.

In the present invention by means of suitably-planned arrangements of cut-outs and change-over switches the consumption of energy can be reduced and the heating simplified. Moreover, the devices designed according to the present invention for heating may also be used merely as means for heating incandescent bodies attached directly to the current-wires. After incandescence results the said auxiliary device can be simply switched off again and can then serve for igniting other incandescent bodies.

In the accompanying drawings several forms of construction are illustrated by way of example.

Figure 1 shows the application of the new heating device in the ordinary three-wire system. Fig. 2 shows the same applied to the so-called "star" connection with neutral wire. Fig. 3 shows another form of the heating device in the ordinary three wire system. Fig. 4 shows the like modification as applied to the star system. Fig. 5 illustrates the special arrangement of cut-outs in the three-wire system for the purpose of heating. Fig. 6 illustrates the application of a small transformer for producing a large current for heating. Fig. 7 shows the application of the new heating device to a simple bridge system. Figs. 8 and 9 show modifications in which there is a greater current applicable for heating. Figs. 10 and 11 illustrate modifications in which a balancing-circuit is automatically closed a suitable time after the current is switched on. Figs. 12, 13, and 14 illustrate the application of the new heating arrangement merely as an auxiliary device for incandescent bodies which are joined to the various wires of the distribution system and after the auxiliary device has been switched off remain alone in operation.

The system shown in Fig. 1 is suitable for direct current and for alternating current. 1 and 2 indicate conductors of the second class or incandescent bodies. 3 is a conductor of the first class—for instance, an incandescent lamp. 4 and 5 are the outer wires, and 6 the central or neutral wire, in which are located the heating devices 7 and 8. The incandescent lamp 3 can be switched out of circuit by means of a cut-out 9, and the incandescent body 2 be disconnected from the one outer line 5 and connected to the other outer wire 4 by means of the switch 10. If the cut-out 9 is closed when the current is switched on and the switch 10 so placed that the incandescent body 2 is joined to the outer wire 5, current will flow first through the lamp 3 and the neutral wire 6 with the heating devices 7 and 8. Consequently the incandescent bodies 1 and 2 are heated and conduct current, while 7 and 8 are deënergized as soon as the outer lines 5 and 4 possess equal load. For this purpose the electrical resistance of 3 must equal the electrical resistance of 1 and 2 after they have become lightening in parallel arrangement. Body 2 is preferably then connected by aid of the switch 10 to the other outer wire 4 and resistance 3 cut out by means of the switch 9. After this the consumption of energy is reduced because resistance 3 is cut out. In working with alternating current the resistance 3 can also be constructed as an inductive resistance or as a condenser.

The system shown in Fig. 2 is suitable for three-phase current. The conductors of the second class or incandescent bodies 11 and 12 are located in the branch circuits 13 and 14, and the resistance 15 (which may be an incandescent lamp) in the branch circuit 16 of a system, in the neutral wire 17 of which are interpolated the heating devices 18 and 19. When the current enters, the only current present is that which passes through branch wire 16, resistance 15, and neutral wire 17, with the heating devices 18 and 19. After the incandescent bodies 11 and 12 have become conducting, the heating devices 18 and 19 become deënergized, provided the three branch wires 13, 14, and 16 are of equal load, which is easily attained by a suitable arrangement of the resistances 11, 12, and 15. For reducing the consumption of energy an incandescent body made conducting in any manner preferred can be switched in the branch wire 16 instead of the resistance 15.

In the arrangements illustrated in Figs. 1 and 2 the conductors of the second class 1, 2, 11, and 12 can of course be supplemented by others. Likewise the heating resistances 7, 8, 18, and 19 can be arranged in any other suitable manner instead of in series without departing from the principle of this invention. After the heating of all the conductors of the second class, the neutral wires can be switched off or the heating devices short-circuited in order to prevent current flowing through them if an incandescent body should fail or burn out.

The system shown in Fig. 3 is suitable for direct current and for alternating current. One incandescent body 20 or 21 is connected, respectively, in the outer wire and the heating resistance or heating device 22 in the neutral wire of a three-wire system. To the incandescent body 21 is applied a conductor of the first class—for instance, an incandescent lamp 23—as a shunt, which can be disconnected by means of a cut-out 24 after the incandescent body 20 has become conducting. If the cut-out 24 is closed when the current is switched on, the latter flows first through the incandescent lamp 23 and the heating resistance 22, which gives off its heat to the incandescent bodies 20 and 21. When the incandescent body 20 possesses sufficient conductivity the cut-out 24 is opened. Current will then pass through the heating resistance 22 until it passes equally through both the incandescent bodies 20 and 21. Instead of operating the cut-out 24 by hand this can be effected automatically by means of the current flowing through the incandescent body.

The system shown in Fig. 4 is suitable for three-phase current. The three incandescent bodies 25 26 27 are connected in the three branches of the three-phase star system, in which again an incandescent lamp 28 is arranged, with the incandescent body 27 as a shunt, which can be disconnected by the cut-out 29. The heating resistances 30 31 32 are inserted in the neutral wire. The action which takes place when the current is switched on and the cut-out 29 is closed is exactly similar to that described for Fig. 3 and need not be further explained.

Instead of the separate heating resistances shown in Fig. 4 a common heating resistance, as shown in Fig. 3, could of course also be employed, and vice versa. Also the automatic breaking of the circuit of the resistance by aid of the energy of the branch currents can be effected in various ways without exceeding the scope of the invention.

The system shown in Fig. 5 is suitable for direct current and for alternating current. The heating resistances 34 and 35 are inserted in the central wire 33, while to the outer wire 36 is joined the incandescent body 37. To the other outer wire 38 is joined an incandescent body 39 and a conductor of the first class—for instance, an incandescent lamp 40. The heating resistance 35 can be short-circuited by means of the cut-out 41 and the heating resistance 34 by means of the cut-out 42, while the switches 43, 44, and 45 serve for inserting the lighting-bodies 37, 40, and 39. If when the switches 43 44 45 are closed the switch 41 is opened and switch 42 closed, current will flow through the lamp 40 and the heating resistance 35. Consequently the incandescent body 37 becomes conducting and the heating resistance 35 deënergized as soon as the current flowing through 37 has reached the same amount as that flowing through 40. If now the switch 41 is closed and the switches 42 and 45 are opened, current will flow through 37 and 34, so that the incandescent body 39 is conducting. As soon as the amount of current in 39 is equal to that in 37 the heating resistance 34 is deënergized. For preventing injury—for instance, if the incandescent body 37 should burn out—the heating resistance 34 is short-circuited. In order that the heating resistance 35 should not receive current at the same time as its incandescent body 37, whereby it might be injured under certain circumstances, the switches 41 and 45 are united into a single switch in such a manner that switch 41 short-circuits the resistance 35 before switch 45 cuts out the incandescent lamp 40. For this reason switch 45 is also united with switch 42 in such a manner that the resistance 34 remains short-circuited for a short time after the incandescent lamp 40 has been cut out. When current of normal strength passes through the incandescent bodies 37 and 39, another incandescent body between the branch wires 33 and 36 can be heated by repeatedly inserting the lamp 40 or by unequally loading the outer lines.

The heating devices mostly require a relatively large current, which can always be easily obtained by transformers. An arrangement of this kind suitable for alternating current is illustrated in Fig. 6, in which a small transformer 46 is inserted in the central wire 33. The transformer 46 induces secondary currents in the heating resistances 47 and 48, whereby a part of the primary winding acts in the meantime as secondary coil. The heating devices lie in shunts to said part of the winding 46. In other respects the connection corresponds to that shown in Fig. 5. Instead of effecting the transformation according to this method a special secondary coil can of course be provided.

The system shown in Fig. 7 is suitable for direct current and for alternating current. The two incandescent bodies 49 and 50 and the two resistances 51 and 52 are inserted in the four branches of the bridge, while the heating resistance is located in the bridge-conductor. The resistances 51 and 52 may be of any preferred form—for instance, incandescent lamps, inductive resistances, or condensers. When the bridge connections have been made as described, current first only flows through resistances 51 52 and the heating resistance 53, which heats the latter and by giving off heat makes the incandescent bodies 49 and 50 conducting. Consequently the strength of the current in the heating resistance 53 decreases and the heating resistance is either entirely or nearly entirely deenergized by arranging such resistances in the branches of the bridge as shall balance the resistances of the conductors of the second class 49 50 after they have become conducting. By employing two separate lamps each incandescent body possesses a heating resistance. If two incandescent bodies are united in each lamp, both can be heated by means of a common heating resistance. The incandescent bodies can also have different resistances or they may also have several connected in parallel. If the resistances 51 and 52 are constructed as inductive resistances, they may be arranged on a common magnetic circuit. In this case both resistances reinforce each other, so that consumption of energy is saved.

The system shown in Fig. 8 is suitable for alternating current. The two incandescent bodies 54 55 and the two inductive resistances 56 57 are inserted in the branches of the bridge, while the heating resistance 58, with an inductive resistance 59, is inserted in the bridge-wire. The inductive resistances 56, 59, and 57 have a common magnetic circuit. The currents in the coils 56 and 57 produce a magnetic flux in one direction, while the current in the coil 59 tends to produce a magnetic flux in the opposite direction. In consequence of this arrangement when the heating resistance 58 is inserted in the circuit there will be present only the relatively small ohmic resistances of 56, 59, and 57 and a small inductive resistance. Consequently a relatively large current will flow in the heating body 58. After the incandescent bodies 54 and 55 have become conducting and the current in the bridge-line is reduced to a small amount the branch wires 56 and 57 of the bridge become effective as inductive resistances. In the arrangement described there is consequently at disposal for heating the incandescent bodies a current of any desired strength, according to the size chosen for the inductive resistance 59, which is very desirable on technical grounds.

In the device illustrated in Fig. 9 and suitable for alternating current the large current in the heating device is obtained by other means. The heating device is placed in the secondary winding of a transformer, and the primary winding thereof is placed in the bridge. In this case a transformer is shown in which a part of the primary coil acts in the meantime as secondary coil. The heating device 60 is in shunt to a portion of the winding 61, located in the bridge-wire. In the bridge branches are the incandescent bodies 62 63 and the incandescent lamps 64 65, serving as conductors of the first class or resistances. After the bridge connection has fulfilled its purpose—that is, to make the incandescent bodies or conductors of the second class into relatively conductors of the first class—it can be disconnected from the circuit. The heating resistance can be cut out, whereupon the two branch resistances can be short-circuited; or, alternatively, the heating resistance can be short-circuited and then the branch resistances be cut out. If the resistance of the branch resistances becomes greater in consequence of the current passing through, the heating device acts better. This can be attained by making the branch resistances of a material with as high a temperature coefficient as possible and strongly heating them.

In the devices illustrated in Figs. 7, 8, and 9 one incandescent body can be replaced by a resistance—an incandescent lamp, for instance—so that three of the branches of the bridge contain conductors of the first class. Of course, then, only one incandescent body is heated without departing from the spirit of the invention. Under these circumstances the resistance in one or two branches is reduced from a large amount to a relatively small one, while the resistance in the other branches remains constant or increases, whereby the decreases in the current of the various branches counteract one another and their total diminishes, which causes a decrease in the strength of current in the heating resistance.

The modification illustrated in Fig. 10 is suitable for direct current and for alternating current. Instead of the conductors of the second class two conductors of the first class are arranged in two bridge branches, which become conducting by means of the energy of the bridge-current, not immediately on insertion, however, but owing to a suitable delaying device only after the lapse of a given time required for heating the incandescent body. In this case the bridge branch wires all consist of conductors of the first class—that is, of the solenoids 66 and 67 and the resistances 68 and 69. In the interior spaces of the solenoids 66 and 67 are located with but little play the iron cores 70 and 71, which have as their position of rest the bars 72 and 73 and are metallically connected with the resistances 68 and 69 by means of flexible leads 74 and 75. The other ends of the interior spaces of the solenoids have two cylinders 76 and 77, of insulating material, each having a contact-screw 78 and 79. If now by means of the switch 80 incandescent bodies 81, 82, 83, and 84 are switched into circuit and then through the switch 85 that of the bridge device is switched into circuit, the current passes first through the solenoids 66 67 and through the heating resistances 86, 87, 88, and 89, whereby the incandescent bodies 81, 82, 83, and 84 are heated and the iron cores 70 71 are drawn into the solenoids 66 67. The movement of the cores 70 71 is, however, very much delayed, because the air in the cavities of the solenoids can only escape very slowly owing to the small amount of play possessed by the cores 70 71. The resistances 68 and 69 therefore still remain out of circuit and the heating resistances 86, 87, 88, and 89 still conduct current until the cores 70 71 touch the contact-screws 78 or 79, when current passes through the resistances 68 and 69 and the heating resistances become deënergized. The movement for stopping the cores 70 71 must be calculated, so that the time between inserting the bridge and forming the contacts is sufficient to sufficiently heat the incandescent bodies 81, 82, 83, and 84. Incandescent lamps may be employed as resistances 68 and 69 and also as resistances in the bridge-wires of the solenoids 66 and 67. The current flowing through the bridge connection can be employed to make the contact, also, for instance, by means of electromagnets or by means of mechanism actuated by the heating effect of the current. The making of the contact can likewise be retarded in various ways—for instance, by delaying by liquids, (dash-pots,) or electrodynamically, or by aid of pendulum-escapement. Devices governed by the heating effects of the current require no special delaying device, because without this there is a lagging behind the current. Instead of connecting the heating resistances in series they may be connected in any other manner preferred. For practical purposes it is preferable to always make the switches 80 and 85 with a common rotating axis.

The modification shown in Fig. 11 is suitable for direct current and for alternating current. The heating resistances 90 and 91 are interposed between the neutral line of a three-line system and a terminal 92, which is connected by one line through a solenoid 93 to one outer line, while another line passes to a contact-screw 94, so arranged on the solenoid that when the core 95 of the solenoid 93 is drawn in it is connected through a conductor of the first class, 96, to the other outer line. The resistance of 96 equals the resistance of 93. The incandescent bodies 97 and 98 are inserted in the usual manner between the outer lines and the neutral line. In this arrangement current only passes at first through the solenoid 93 and the heating-wires 90 91. When the solenoid 93 has drawn in the core 95, so that it touches the contact-screw 94, this action being most easily retarded by a dash-pot, current flows from one outer wire through the solenoid 93 and the conductor of the first class, 96, to the other outer wire while the heating resistances are deënergized. The closing of the branch circuit can of course be effected in various ways—for instance, by means of thermally-actuated devices.

The arrangements for heating according to the present invention may also be used merely as an auxiliary device for heating incandescent bodies which are connected directly in the current-wires. The auxiliary device is then simply cut out again after the heating has been effected. Arrangements of this kind are illustrated in Figs. 12 and 13 with special reference to some of the arrangements described above.

The modification illustrated in Fig. 12 is suitable to direct current and to alternating current. The incandescent bodies 99 and 100 are connected between the neutral wire and one of the outer wires and the incandescent body 101 and resistance 102 between the neutral wire and the other outer wire. The heating resistances 103 104 105 are located in the neutral wire. The three wires can be broken beyond the incandescent bodies 100 and 101 by means of cut-outs 106, which are preferably combined into a single switch. When the cut-outs 106 are closed, the current at first only passes through 102 103 104 105, so that the incandescent bodies 99 100 101 are heated. The amount of the resistance is such that the heating resistances become deënergized as soon as the incandescent bodies are sufficiently heated. The heating device proper is then switched off by breaking the circuit of the outer wire at the switch 106, so that the incandescent bodies 100 and 101 alone remain operative.

The modification illustrated in Fig. 13 is suitable for three-phase current. The incandescent bodies 107 and 108 are inserted between the neutral wire and one outer wire, the incandescent bodies 109 and 110 between the neutral wire and the other outer wire, and finally the incandescent body 111 and a resistance 112 between the neutral wire and the third outer wire. The heating resistances 113, 114, 115, 116, and 117 are located in the neutral wire. The four wires can be broken beyond the incandescent bodies 108 110 111 by means of cut-outs 118 (which are preferably united in one switch) after the incandescent bodies are sufficiently heated. The incandescent bodies 108, 110, and 111 then alone remain operative. After the various heating devices have been cut out they can be used by aid of ordinary switching devices for heating other incandescent bodies. In this case, of course, a cut-out must be inserted in the wire conducting from heating resistances 103 or 114 to heating resistances 104 or 115.

The modification illustrated in Fig. 14 is suitable for direct current and for alternating current. The bridge branches consist of conductors of the first class or resistances 119 120 and the conductors of the second class or incandescent bodies 121 122. The incandescent bodies 123 124 are joined to the outer wire. Heating resistances 125, 126, 127, and 128, located in the bridge-wire, serve for heating the four incandescent bodies. 129 is a bipolar switch for the bridge connection, and 130 a similar switch for the incandescent bodies 123 and 124. For the purpose of heating connection is first made to the incandescent bodies 123 and 124 by means of switch 130, and then current is switched on to the bridge-circuit by means of the switch 129. Said current passes in the first place through the resistances—for instance, incandescent lamps—119 and 120 and the heating devices 125, 126, 127, and 128. When the incandescent bodies have thus become conducting and the heating devices deënergized, the bridge can be cut out. When after the bridge has been switched off and the incandescent bodies 121 and 122 have cooled again, it is possible by aid of the usual switching device to make other incandescent bodies conducting with the same bridge. The proportion of resistances must of course be selected so that the heating resistances are not deënergized until the incandescent bodies 123 and 124 have become sufficiently conducting.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

In a system for heating conductors of the second class, the combination of conductors of the first and second classes, and a heater, connections for said heater with the conductors of the first and second classes and a neutral conductor of the supply-circuit, whereby the potential at the heater-terminals decreases as the resistance of the second-class conductor decreases.

In witness whereof I have hereunto set my hand in presence of two witnesses.

CARL DANIEL RAAB.

Witnesses:

ALOIS GOBANZ,

OSCAR BOCK.