No. 670,316.

Patented Mar. 19, 1901.

# R. A. FESSENDEN.

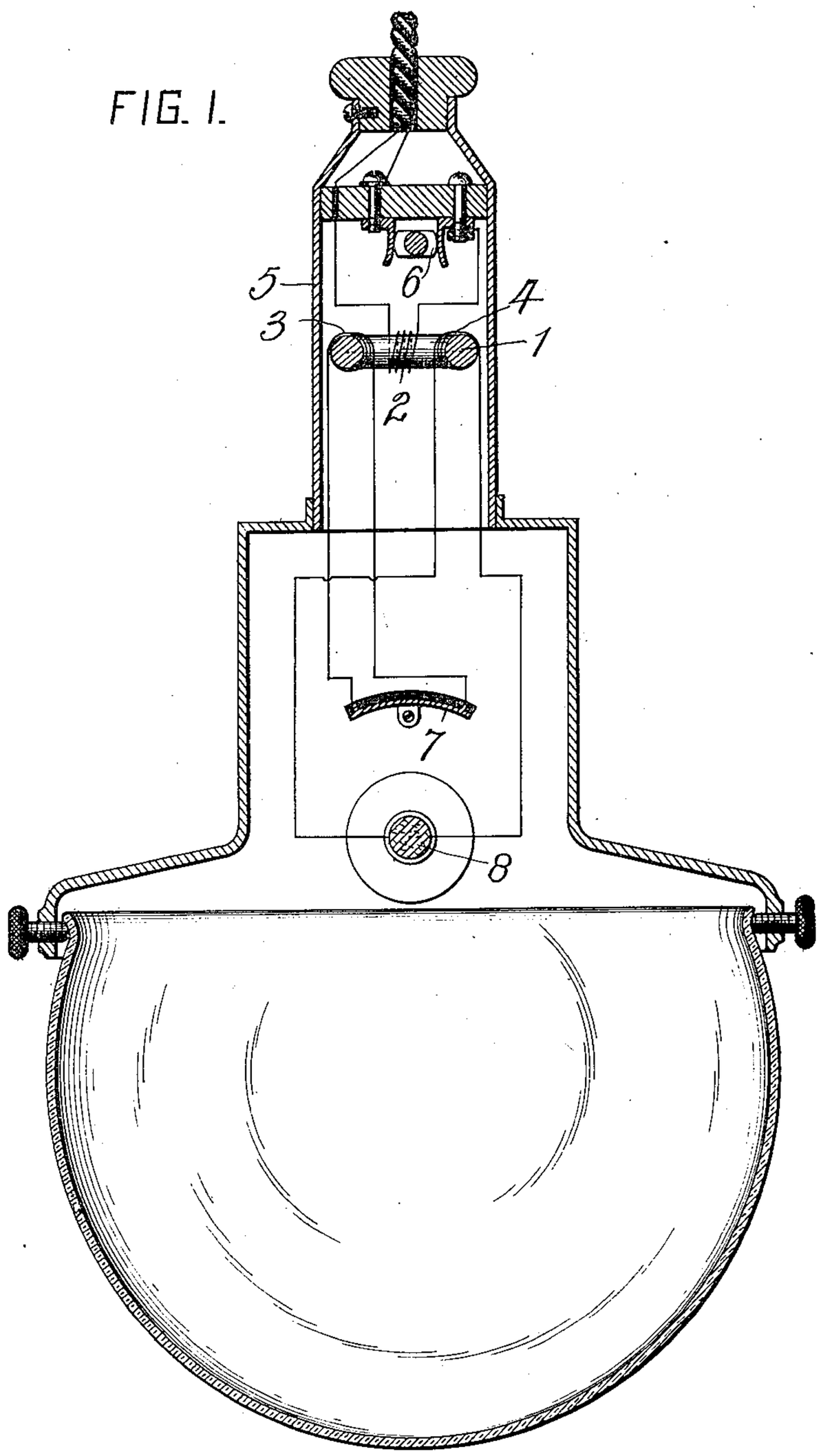
## INCANDESCENT LAMP.

(Application filed Nov. 27, 1900.)

(No Model.)

5 Sheets—Sheet 1.

FIG. 1.

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(No Model.) 5 Sheets—Sheet 2.

FIG. 2.

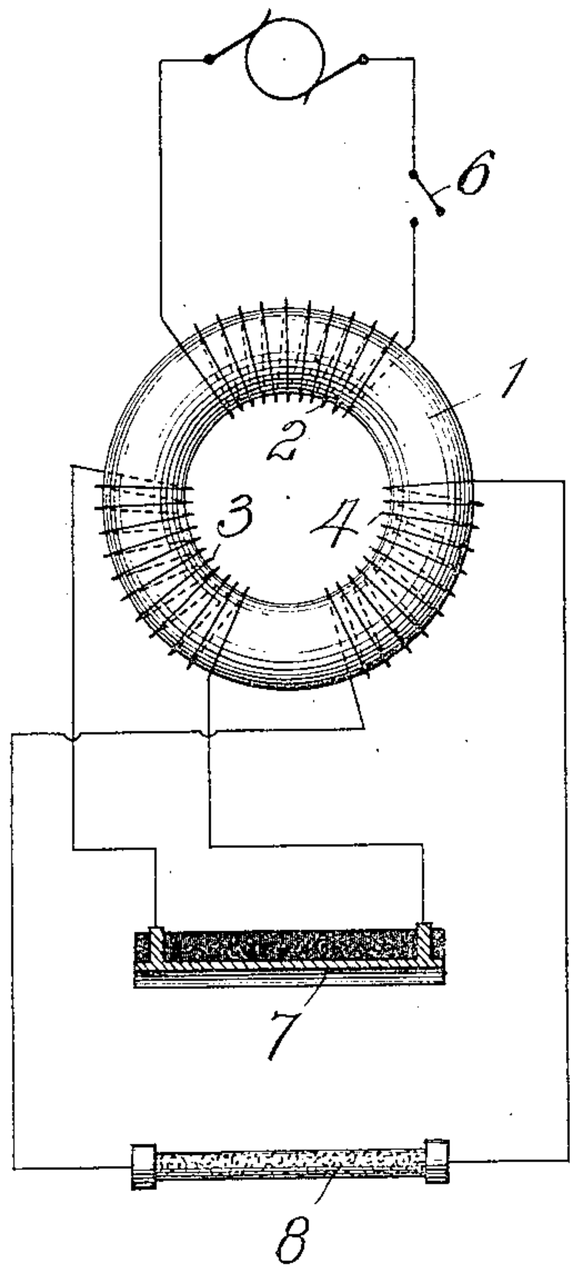



FIG. 3.

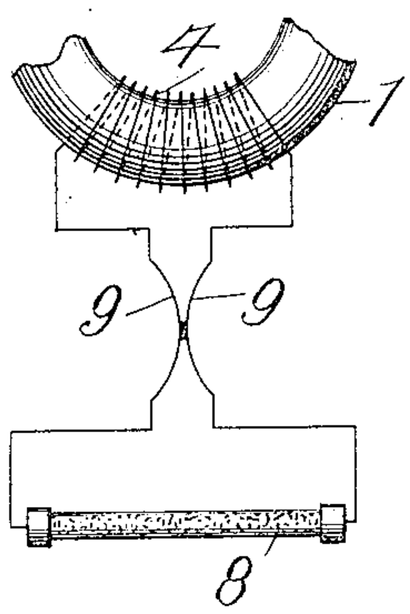
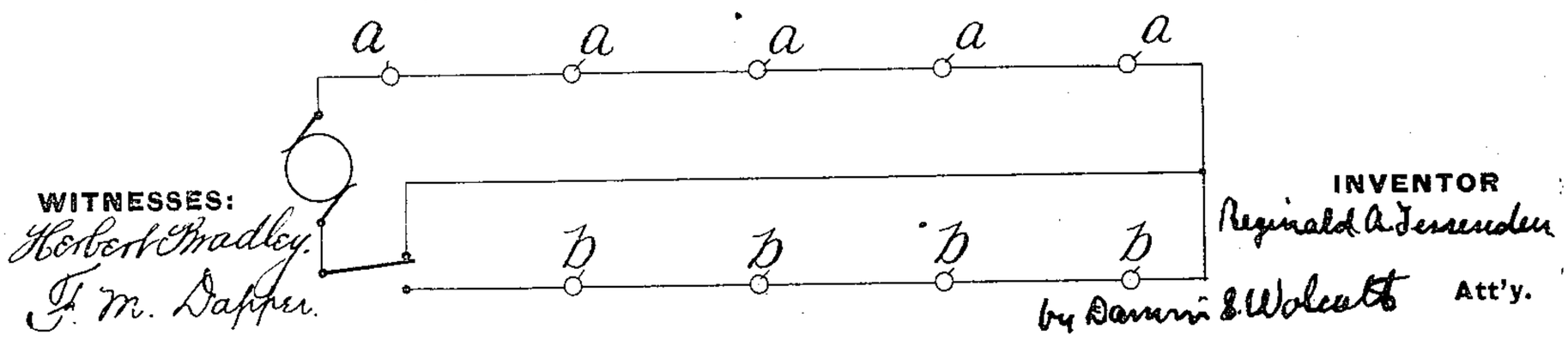



FIG. 6.

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(No Model.) 5 Sheets—Sheet 3.

FIG. 4.

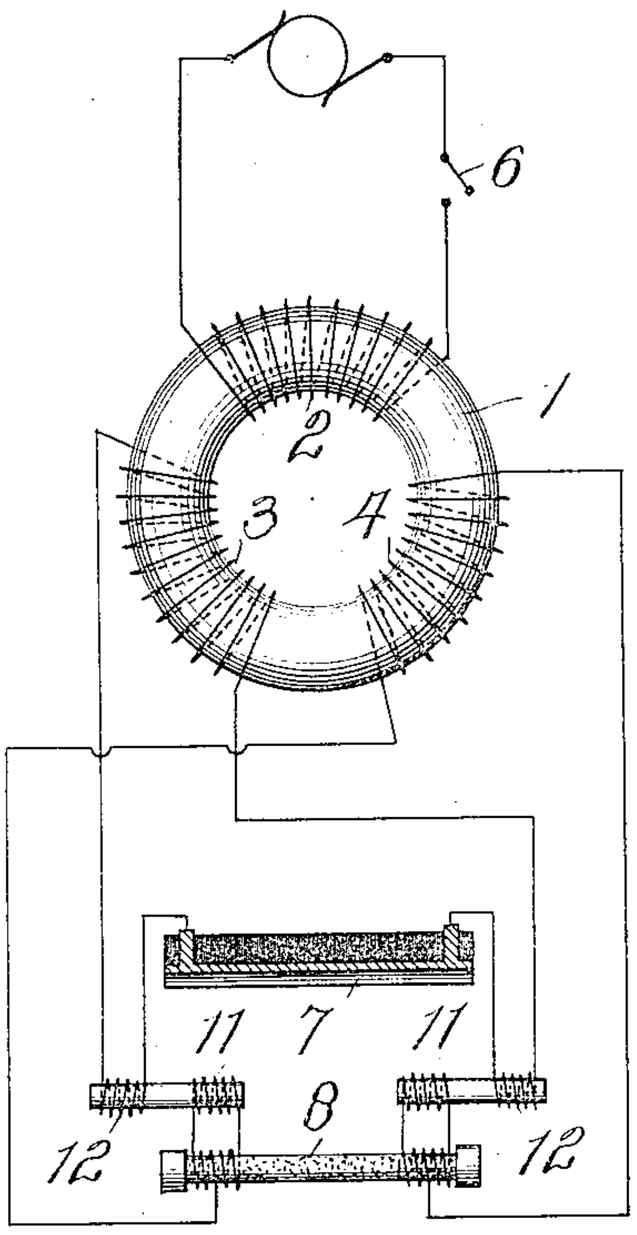
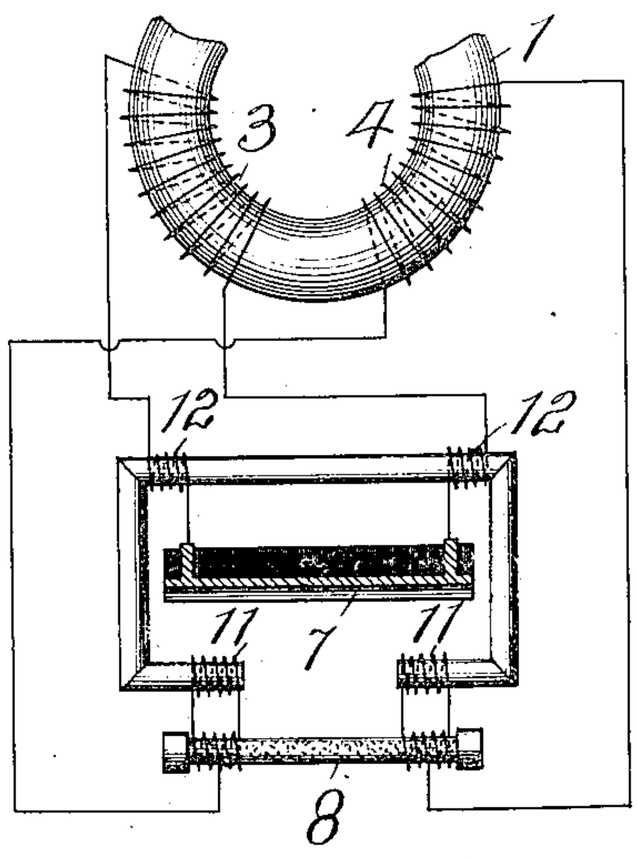



FIG. 5.

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(No Model.) 5 Sheets—Sheet 4.

FIG. 8.

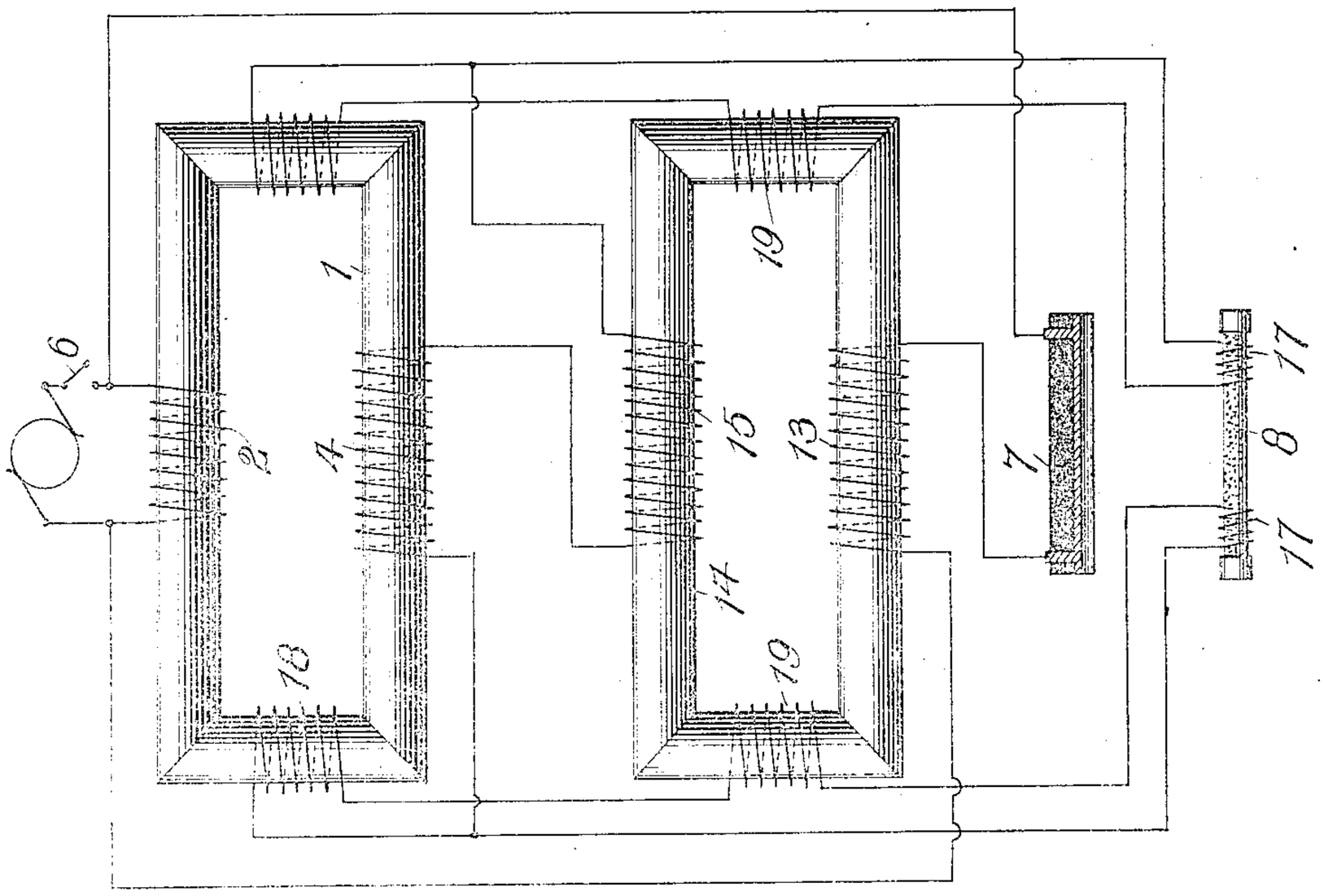
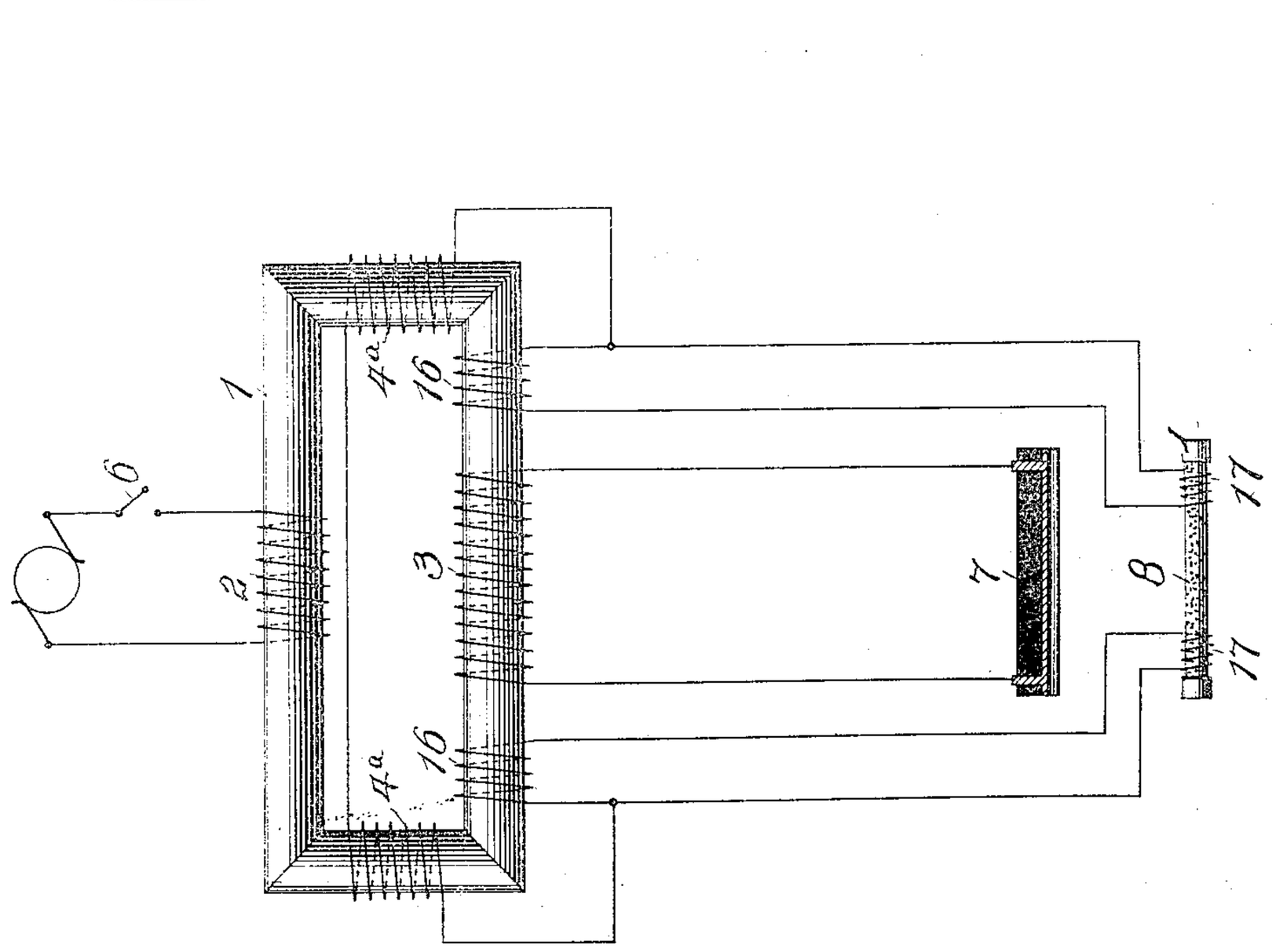



FIG. 7.

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## INCANDESCENT LAMP.

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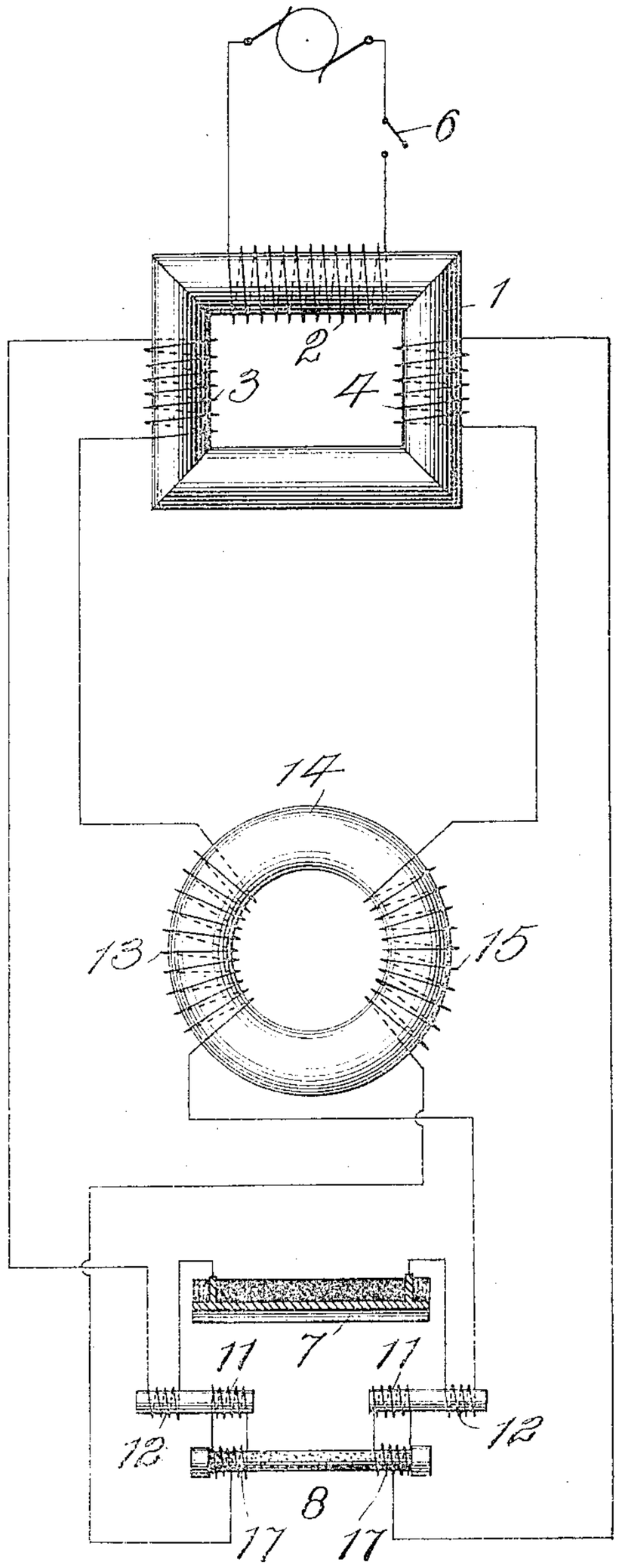
(No Model.) 5 Sheets—Sheet 5.

FIG. 9.

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# UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF ALLEGHENY, PENNSYLVANIA.

## INCANDESCENT LAMP.

SPECIFICATION forming part of Letters Patent No. 670,316, dated March 19, 1901.

Application filed November 27, 1900. Serial No. 37,902. (No model.)

*To all whom it may concern:*

Be it known that I, REGINALD A. FESSENDEN, a citizen of the United States, residing at Allegheny, in the county of Allegheny and State of Pennsylvania, have invented or discovered certain new and useful Improvements in Incandescent Lamps, of which improvements the following is a specification.

The invention described herein relates to certain improvements in electric incandescent lamps of the Nernst type employing as the source of light a pencil formed of a material which requires a preliminary heating in order to render it conductive of the electric current, whereby the pencil is raised to and maintained at incandescence.

One object of the invention is to provide for the automatic reduction or cutting off of the current through the heating body or bodies as soon as the pencil becomes conductive.

It is a further object of the invention to provide for the preliminary heating of the light-giving body by radiation and conduction from bodies heated by the passage of an electric current.

The invention is hereinafter more fully described and claimed.

In the accompanying drawings, forming a part of this specification, Figure 1 is a sectional elevation of one form of my improved lamp. Fig. 2 is a diagrammatic view illustrating the invention. Fig. 3 is a detail view illustrating a manner of short-circuiting the pencil. Fig. 4 is a diagrammatic view illustrating the manner of simultaneously heating all parts of the pencil. Fig. 5 is a view similar to Fig. 4, illustrating a modification. Fig. 6 is a diagrammatic view illustrating the manner of arranging the lamps in lighting groups. Fig. 7 illustrates a further modification of the arrangement shown in Figs. 4 and 5. Figs. 8 and 9 are diagrammatic views illustrating the construction and arrangement for lamps for constant-voltage currents.

In the practice of my invention I employ in this form of apparatus a transformer consisting of core 1, a primary coil 2, which is connected to an alternating-current dynamo or other suitable source furnishing a current of unvarying amperage or having a constant value, and two secondary coils 3 and 4. This transformer is preferably arranged in the socket 5 of a lamp, and the circuit from the generator is controlled by a switch 6, of any suitable construction, also located in the lamp-socket or adjacent thereto for house-lighting.

A heater 7, of any suitable construction, is included in the circuit of the secondary coils 3 of the transformer, and the pencil 8, preferably formed of magnesia, kaolin, or other material conductive of electric currents only when heated above normal temperature, is included in the circuit of the secondary coil 4 of the transformer. The secondary coil 3 is constructed to give a current of either low or high voltage, in accordance with the character of heater employed—*i. e.*, whether a high or low voltage current is required to raise it to the desired temperature—and the winding of this secondary coil is so proportioned that the whole heater-circuit has a relatively large effective impedance, so that when the heater is operating alone—that is, before the pencil has been sufficiently heated to render it conductive and the pencil-circuit is therefore broken—the flux of magnetic lines in the core is relatively large—*e. g.*, one hundred—and the voltage on the primary coil 2 is relatively large—*e. g.*, five hundred.

The windings of the secondary coil 4 are so proportioned as to have a relatively small effective impedance, so that when the normal current is flowing through the pencil which is fed by it the current generated acts so as to reduce the magnetic lines in the core 1 to a relatively small fraction—*e. g.*, ten—of what they were prior to the establishing of the current through the pencil by heating the same. Consequently the voltage on 2 will be reduced in practically the same proportion—*e. g.*, to fifty. It is characteristic of this construction that when the current flows through the primary coil 2 on the closure of the switch 6 it will induce a large magnetic flux in the core 1, and the voltage thus induced in the secondary coil 3—say five volts if the heater is constructed for low voltage—will drive a current through the heater 7. In this construction the energy spent in the heater will be approximately ten times that required to operate the heater, and hence the heating will be very rapid. At the same time the large magnetic flux thus produced in the core will produce a voltage in the secondary coil 4, and

therefore on the pencil, such voltage being approximately ten times that required to normally operate the pencil. Hence a current will be established through the pencil much sooner than with an ordinary current as now used. As soon, however, as the current begins to flow through the pencil the current generated in the secondary coil 4 will exert a demagnetizing effect on the core 1 and the magnetic flux will gradually drop until a normal current is flowing through the pencil, when the flux will be reduced, as above mentioned, to ten. The flux being thus reduced the voltage on the secondary coil 3 will be reduced to but one-tenth, and consequently the current being reduced in the same proportion only about one per cent., approximately, of the energy formerly used in the heater will now be effective therein. This small waste may be neglected, and it can be made as small as desired by proper proportioning.

The reduction of the magnetic lines in the core, as above stated, will effect a corresponding reduction of the voltage on the secondary coil 4 and also on the primary coil 1. Thus the lamp is to a very considerable degree self-regulating, any excessive current in the pencil automatically acting to reduce the voltage on the primary coil and in the current through the pencil.

As any accidental opening of the pencil-circuit in this form of lamp would cause a high voltage to be continuously kept up in the heater-circuit, and as at the same time there would be a great strain on the insulation through the continuous heating of the heater and the secondary coil 3, means should be provided whereby an automatic closing of the circuit of the secondary coil 4 would be effected under such conditions. A convenient means to this end consists in so arranging two parts, as 9, of the circuit of the pencil so that they would tend to spring together and form contact with each other and interposing between such parts 9 a suitable non-conducting material, as wax, which will become soft at comparatively low temperatures and permit of the meeting of the two parts 9, thereby establishing a short circuit for the secondary coil 4. The short circuit of this secondary coil would practically reduce the voltage on the primary coil to zero.

When a number of lamps of this character are used in series, as for street-lighting, it is preferred to light them in groups, say, of ten each, and to this end the circuit is arranged as shown in Fig. 6. By turning the switch to the position shown in the drawings the lamps *a* in one group will be started, and as soon as the pencils have reached incandescence and the lamps are working properly the switch is shifted, thereby closing a circuit not only through the lamps previously lighted, but also through the lamps *b* of the second group. It will be readily understood that any number of groups may be arranged extending from a single generator or from a station and that the switch or switches controlling such groups may be made to operate automatically or by hand, as desired.

While the heater may be of any suitable form or construction, it is preferred to employ the form or construction shown in the drawings, consisting of one or more metal strips or plates of such dimensions as to retain their shape and position when heated. By thus making the heater, as it were, self-supporting an objectionable feature of the heaters as heretofore constructed is avoided, such heaters being usually constructed of a comparatively small wire arranged upon a support, as a porcelain disk or cylinder, and connected thereto. It has been found that in practice the cement will soften, and the expansion of the wire as it is heated and cooled will cause it to become detached from and shift its position on the support, so that portions will contact, and, further, this form of heater is objectionable for the reason that the wires being in contact with the support the latter will absorb a large amount of heat and must be raised to the same temperature as the wires and simultaneously therewith, so as to render the heater effective to raise the temperature of the pencil. The heating of the support as well as the wires retards to an appreciable degree the heating of the pencil.

It is preferred to so construct the heater or the surface thereof adjacent to the pencil that the heat-waves will be caused to converge on the pencil. While not limiting myself to such construction, I have found that making the surface of the heater adjacent to the pencil to conform to the arc of a circle whose center coincides approximately with the axis of the pencil gives highly satisfactory results. It is preferred to cover the back of the heater with some non-conducting material, which will prevent the loss of heat by radiation from the surface opposite the pencil.

It has heretofore been the practice to form the terminals of the pencil of some metal; but this construction is objectionable for the reason that the ends of the pencil will not become heated as rapidly as the middle portion thereof for the reason that the metal conducts away the heat from the ends of the pencil, and the latter will be conductive as regards its middle portion, but non-conductive as regards its ends, for some time, so that the lighting of the lamp is materially delayed. In order to avoid this objectionable feature, I employ a construction similar to that shown in Figs. 4 and 5. As therein shown the heater-circuit includes one or two transformers, whose secondary coils 11 are wrapped around the ends of the pencil and serve to raise the temperature of these ends simultaneously with the heating of the middle portion by the heater proper. As shown in Fig. 4, a transformer is arranged at each end of the pencil, the primary coils 12 of each transformer being included in the circuit of the secondary coil 3 of the main transformer of

the lamp, and the secondary coils 11 of these pencil-transformers include in their circuit heaters formed by several turns of wire coiled around the ends of the pencil. These coils on the ends of the pencil serve as the terminals for the lighting-circuit of the pencil. As shown in Fig. 5, a single transformer with two secondaries, each of which includes in its circuit a heater for one end of the pencil, may be employed.

In Fig. 7 I have shown an arrangement whereby the use of a separate transformer or transformers for the heaters of the ends of the pencils is avoided. In the arrangement of apparatus for the use of constant currents illustrated in Fig. 7 the heater 7 is included in the circuit of the secondary coil 3, such arrangement corresponding to that shown in Fig. 2. One or more additional secondary coils 16 are also wound on the core 1 of the transformer, and heaters 17 for the ends of the pencil are included in the circuit or circuits of these additional secondary coils. The secondary coil for the pencil may be in one section, as shown in Figs. 4 and 5, or in two connected sections $4^a$, as shown in Fig. 7. The secondary coils 3 and 16 for the heaters are so proportioned as to have a relatively large effective impedance, and the secondary coil or coils for the pencil are proportioned to have a relatively small effective impedance. On the closure of the switch 6 a large magnetic flux will be induced in the core 1, inducing a current of the desired voltage in the secondary coils 3 and 16 for the heaters. The large magnetic flux in the core will produce a voltage on the pencil. As soon as a current is established through the pencil the current generated in the secondary coil 4 will exert a demagnetizing effect on the core 1, so that the magnetic flux will drop until a normal current flows through the pencil. This drop in the magnetic flux reduces the voltage on the secondary coils 3 and 16 to such an extent that only a very small amount of energy will be effective in the heaters.

The construction shown in Figs. 1, 2, 4, and 5 is adapted for currents of constant value. Where currents of constant voltage are employed, the construction shown in Figs. 8 and 9 is preferable. In this construction the magnetic flux in the core 1 remains practically constant at all times, and to effect a regulation of or neutralization of the heater-current so soon as a current begins to flow through the pencil I employ suitable means whereby the pencil-current will control the heater-current. A convenient means for this purpose consists of a coil 13, wound on an annular core 14 and included in the generator-circuit, as shown in Fig. 8, or in the circuit of a secondary coil 3 on the main transformer, as shown in Fig. 9. The heater 7 is also included in the circuit of the coil 13. Another coil 15 is also wound on the core and is the circuit of the secondary coil 4. The terminals of the pencils are also included in the circuit of the coils 4 and 15. In this construction the coil in series with the heater-circuit will give a back voltage amounting to a certain fraction—say ten per cent.—of that generated in the main feed-circuit or in the secondary coil 3 when there is no current through the secondary coil 4. The coil 15, in series with the pencil and secondary coil 4, is so proportioned that when the normal current is passing through the pencil the coil 15 will operate on the coil 13 to produce in it a voltage equal and opposite in direction to that produced by the generator or the coil 3, and the two voltages will thus neutralize each other, preventing the flow of current through the heater. When the switch 6 is closed, a current of suitable voltage from the generator or the coil 3 flows through the heater-circuit and rapidly raises the heater to a high temperature. As an abnormally high voltage, owing to the construction described, is on the circuit of the pencil, it will begin to flow through the pencil when the latter is at a lower temperature than in the form of lamps now in use, so that the lamp becomes operative in a very short time. When the current flows through the pencil, it reacts on and neutralizes the current through the heater by generating an opposing voltage in the heater-circuit, thereby rendering the heater inoperative. This reactive effect is clearly distinguishable from the balancing or neutralizing action of two primary coils on each other. The voltage on the pencil begins to decrease as soon as the current passes through the pencil, as a part of the voltage will be used up in the coil 19.

As shown in Figs. 8 and 9, separate or auxiliary heaters may be applied to the ends of the pencil in this system, as in that using a constant current. As shown in Fig. 8, the heater 17 on the ends of the pencil are included in a circuit or circuits which include secondary coil or coils 18 on the core of the main transformer and coil or coils 19 on the core 14. The current which will flow through the pencil as soon as heated will neutralize the current in the auxiliary heaters 17 in the same manner that it neutralizes the current through the heater—*i. e.*, by the generation of voltages by the coil 15 equal to and opposing those generated in the coils 18 of the primary transformer. In the construction shown in Fig. 9 the circuit of the secondary coil 3 includes not only the coil 13 and the main heater, but also the primary coils 12 of the secondary transformer or transformers which have their secondary coils in series with the heaters 17 on the ends of the pencil. In this construction both heaters are operated by the coil 3 and controlled by the coil 15, which, as stated, will generate in the coil 13 voltages equal to and opposing those generated in coil 3 as soon as current begins to flow through the pencil.

It will be understood by those skilled in the art that my improvements may be applied to the construction of lamp wherein the heater

for the pencil consists of a conductor neutralizable by heat and extending along the pencil from terminal to terminal. Hence as regards the broader claims made herein the invention is not limited to any particular form or arrangement of heater, and, further, the means employed for heating the ends of the pencil may be used with other forms of lamp—*i. e.*, those having the heater in independent circuits—and hence that part of the invention is not limited as regards the number or arrangement of circuits for the heater and pencil.

I claim herein as my invention—

1. In an incandescent lamp, the combination of a pencil, a heater, a circuit for the pencil and a circuit for the heater, the current through the heater being reactively regulated by the current through the pencil, substantially as set forth.

2. In an incandescent lamp, the combination of a pencil, a heater, circuits for the pencil and heater and a magnetic circuit common to both circuits, said circuits being so arranged and proportioned relatively to each other, that the current in the pencil-circuit acts on the common magnetic circuit in such way as to reduce the energy used for heating in the heater-circuit, substantially as set forth.

3. In an incandescent lamp, the combination of a pencil, a heater arranged in operative relation to the pencil, a transformer having a primary and secondary coils, the pencil being included in the circuit of one of the secondary coils, and the heater in the circuit of the other secondary coil, whereby the heater-current is reactively regulated by the pencil-current, substantially as set forth.

4. In an incandescent lamp, the combination of a pencil, a heater for the pencil, a transformer having a primary and secondary coils, the secondary coils including in their circuits the pencil and heater, and means whereby the completion of the circuit through the pencil will neutralize the current through the heater, substantially as set forth.

5. In an incandescent lamp, the combination of a pencil, a heater for the pencil, a transformer having a primary and secondary coils, the secondary coils including in their circuits the pencil and heater, a core and coils on said core in series with the pencil and heater circuits, substantially as set forth.

6. In an incandescent lamp, the combination of a pencil, electric heaters arranged in operative relation to the ends of the pencil, secondary coils including said heaters in their circuits and a primary coil or coils for inducing currents in the secondary circuits, substantially as set forth.

7. In an incandescent lamp, the combination of a pencil, a circuit therefor, one or more heaters for the pencil, one or more circuits therefor, and a magnetic circuit common to the other circuits which are so related and proportioned that the current in the pencil-circuit acts on the common magnetic circuit in such manner as to reduce the energy used for heating in the heater-circuit, substantially as set forth.

8. In an incandescent lamp, the combination of a pencil, one or more transformers, electric heaters on the ends of said pencil included in the secondary coils and a main heater included in the primary circuit of the transformer, substantially as set forth.

9. In an incandescent lamp, the combination of a pencil, a heater for the pencil, a transformer having a primary and secondary coils including in their circuits the pencil and heater, and means for automatically short-circuiting the pencil-circuit, substantially as set forth.

In testimony whereof I have hereunto set my hand.

REGINALD A. FESSENDEN.

Witnesses:

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J. C. ASHTON.