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S. A. OAKLEY

2,546,315

ELECTRIC HEATER

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Fig. 1.

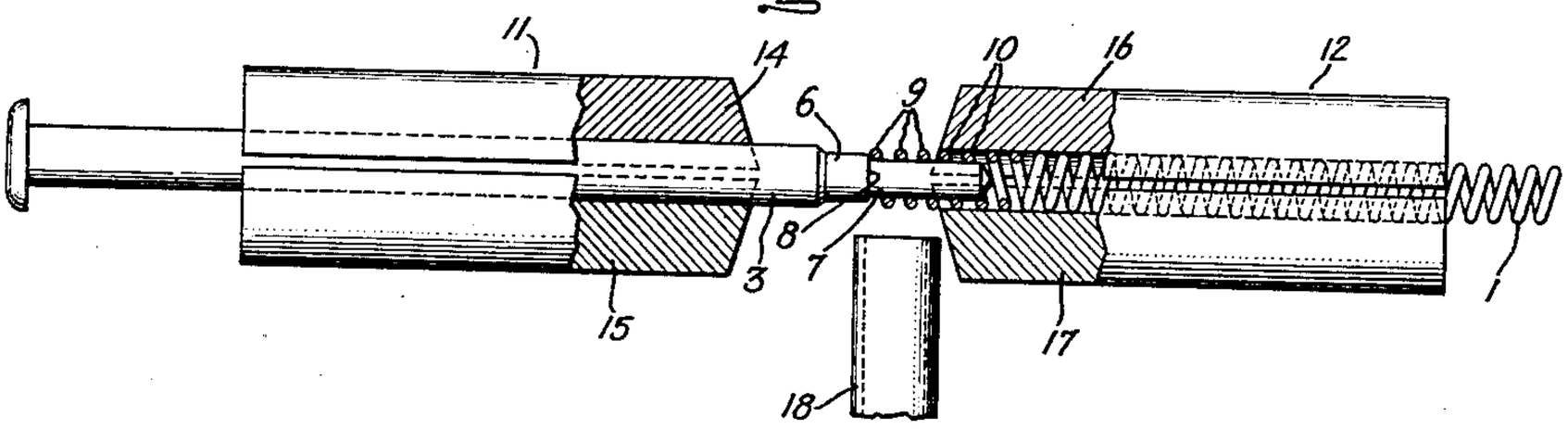


Fig. 2.

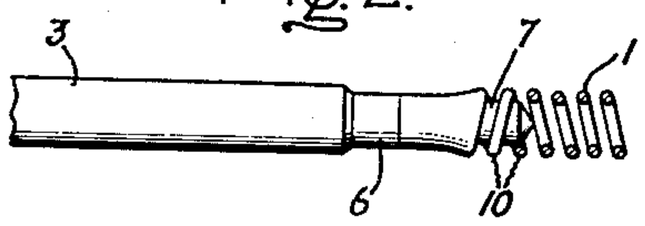


Fig. 3.

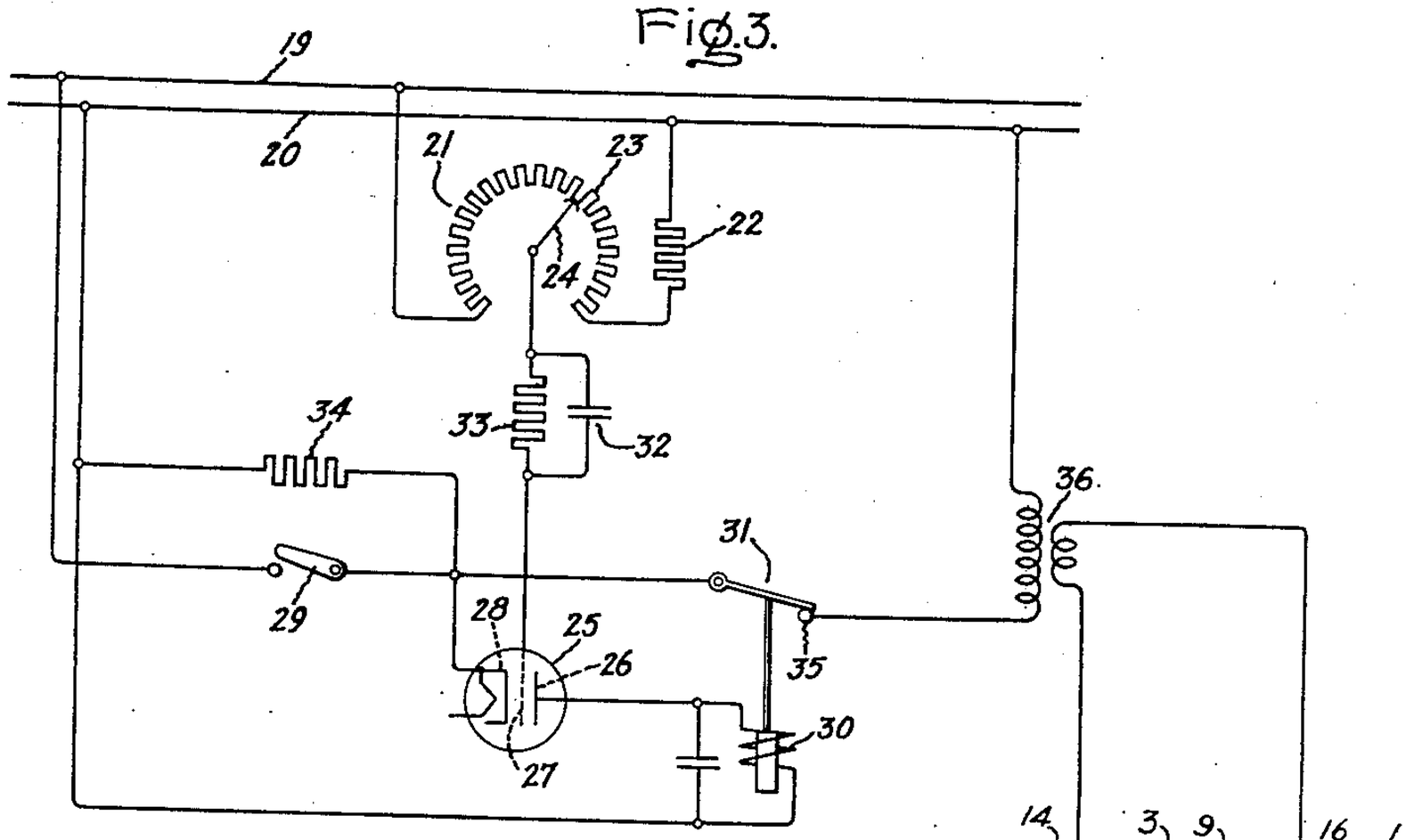
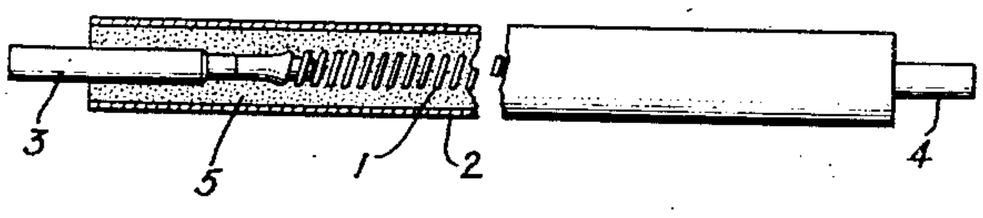


Fig. 4.



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UNITED STATES PATENT OFFICE

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ELECTRIC HEATER

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Application May 25, 1945, Serial No. 595,721

5 Claims. (Cl. 201—67)

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This invention relates to electric heaters having a resistance conductor and a terminal therefor, and it has for its object the provision in such a heater of an improved terminal structure for connecting the resistance conductor to its terminal, and also an improved method of making the terminal structure.

While this invention has more general application, it is particularly useful in connection with electric heaters of the sheath-wire type wherein a resistance conductor is encased in a metallic sheath and is supported in spaced relation with the sheath by a compacted mass of powdered heat conducting and electrically insulating material, such as magnesium oxide.

In a certain heater of the sheath-wire type heretofore known, a terminal structure is provided which consists of a terminal that is provided with a threaded portion; and the resistance conductor is provided with a plurality of turns which are secured onto this threaded portion in order to mechanically and electrically connect the conductor to the terminal. In the main, this construction has proved to be quite satisfactory. However, some difficulty has been experienced with it, especially in connection with conductors formed of very fine wires, for example, those used on relatively lower voltages, such as 12 or 27.

This invention contemplates the provision of an improved terminal structure which is of universal application in the sense that it may be applied to heaters having very fine wires as well as to those having coarser ones. And it further contemplates an improved terminal construction which is very effective both mechanically and electrically, and is inexpensive to make.

In accordance with this invention, a portion of the terminal is inserted into end turns formed on the conductor, and the outermost of the turns which embrace the terminal portion are integrally united with the terminal while the remainder of these turns are free from rigid connection therewith. I make the rigid connection between the outermost turns and the terminal by welding, and I do this by placing an electrode in contact with the terminal and another electrode in contact with the innermost of the turns that surround the terminal. I electrically connect the electrodes with a suitable source of electrical supply and thereby cause welding current to pass in order to heat the outermost turns surrounding the terminal to the welding temperature. During the welding process I drain heat away from the innermost turns so as to prevent them from fusing, and also so as to avoid annealing them. This

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is accomplished in one form of the invention by making the electrode in contact with them of high thermal mass and conductance.

For a more complete understanding of this invention, reference should be had to the accompanying drawing in which Fig. 1 illustrates a terminal and resistance conductor in position for connection with each other, together with certain elements of welding apparatus used to weld the two elements together, all in accordance with this invention; Fig. 2 is a fragmentary view illustrating the finished welded connection between the terminal and the resistance conductor; Fig. 3 is a diagrammatic representation of a welding system used to connect the resistance conductor and terminal; and Fig. 4 is an elevation of a finished electric heater embodying the terminal structure of this invention, parts being broken away so as to illustrate certain details of construction.

Referring more particularly to Fig. 4, this invention has been shown as applied to an electric heater of the sheath-wire type comprising a helical resistance conductor 1 which is mounted in the axis of a cylindrical metallic tube 2. Terminals 3 and 4 are connected to the ends of the resistance conductor 1, and the inner ends of these members are mounted within the sheath 2, as shown. A compacted mass 5 of heat refractory and conducting, and electrically insulating material, such as magnesium oxide, is compacted within the sheath 2 and embeds the resistance conductor 1 and the inner ends of the terminals 3 and 4 so as to hold the conductor and terminals in spaced relation with reference to the sheath and to electrically insulate them from the sheath. It will be understood that in making the heater thus far described, the resistance conductor 1 is assembled with its terminals 3 and 4 and then the assembly is mounted in the center of the sheath. After this, the sheath is loaded with the powdered magnesium oxide 5, and after it is loaded it is elongated so that its diameter is reduced to highly compact the oxide in any suitable way as by rolling or swaging.

In the prior heater referred to above wherein the resistance conductor is threaded onto the terminal, some difficulty has been experienced with the conductor pulling away from the terminal during the operations of loading the sheath with the powdered magnesium oxide and the subsequent operations of elongating the sheath to compact the oxide. This is especially true where very fine resistance conductors are involved. Also, in some instances, the insulating powder is forced

in between the conductor and the terminal threads and thereby impairs the electrical connection between the terminal and the conductor.

In accordance with this invention, a terminal structure is used which obviates these difficulties, and it effects uniform and very strong and positive electrical and mechanical connections between the terminals and the conductor by a reliable, simple and inexpensive construction.

The two terminals 3 and 4 in so far as this invention is concerned may be of identically the same construction, and the terminal 3 therefore only is shown in detail. The end 6 of the terminal which is shown connected with the helical resistance 1 has a reduced diameter, and preferably and as shown, this portion of the terminal has a further reduced extremity 7, the two sections 6 and 7 having a shoulder 8 between them. The reduced section 7 is inserted into a number of the end turns of the helix 1. It has a diameter which is about the same as the internal diameter of the turns, but preferably it will be slightly larger so that there is a line or slight interference fit when it is inserted in the end of the helix 1.

The outermost bank of turns 9 of those which surround the terminal section 7 is integrally united with the terminal, whereas the innermost bank of turns 10 is free from rigid connection with the terminal. For the purpose of uniting the turns 9 with the terminal, I cause a welding current to flow through the terminal in order to raise the turns to a welding temperature to cause them to fuse with the terminal. For this purpose, I use welding apparatus having a pair of electrodes 11 and 12 which preferably will be of the jaw type, the electrode 11 having its upper and lower jaws 14 and 15 clamped to the outer section of the terminal, while the electrode 12 has its upper and lower jaws 16 and 17 clamped about the bank of turns 10, as more clearly shown in Fig. 1.

Now when the two electrodes 11 and 12 are electrically connected with a suitable source of electrical supply, current flows from one to the other through the assembly and causes the bank of turns 9 to melt and fuse with the terminal 3 at that point. The significance of the reduced sections 6 and 7 will now be understood: When current flows between the electrodes through the assembly of the terminal and the resistance conductor the terminal 3 becomes heated because of its resistance to the flow of electrical current through it. If the terminal were of uniform diameter from end to end it would tend to become heated uniformly throughout its length. However, because the section 6, 7 has a smaller cross section than the remainder of the terminal its I^2R loss is greater than that of the remainder of the terminal which is larger. That is, the heat is concentrated in the reduced section of the terminal. In so far as the principle of the invention is concerned the second reduced section 7 is not necessary but has been provided in order to establish the shoulder 8 which acts as a stop for the coil, but its presence does further concentrate the heat in it and as a result the highest temperature in the assembly occurs near the shoulder 8. This causes the turns about this section to melt and fuse and form a welded joint as shown in Fig. 2. The foregoing effects are accentuated by the electrodes 11 and 12 which are constructed to have a relatively great thermal mass and high heat conductivity. Their mass as compared with that of the terminal and helix

may be readily seen by reference to Fig. 1, and they are formed of copper which has a high thermal storage capacity and heat conductivity. Because of this the terminal is cooled by the electrode 11 while the bank of turns 10 is cooled by the electrode 12. In view of the foregoing, it will be understood that while heat is drawn from the large section of the terminal 3 and from the bank of turns 10 during the welding process a large amount of heat is concentrated at the bank of turns 9 which are elevated to their fusing temperature and thereby welded to the terminal. The turns in the bank 10 do not fuse at all and are physically free from the terminal in the sense that they are not in any way attached to it.

Because of the foregoing method of welding, annealing of the bank of turns 10 is obviated; and in addition to this, because of the fact that this bank of turns remains free of the terminal, it acts as a means of alignment to keep the helical conductor in line with the terminal. And also these free turns can be "stretched out" somewhat when the sheath 2 is elongated and reduced in diameter to thereby avoid concentrating pull at the point of the weld as would be likely if all of the turns are welded to the terminal out to its end.

During the welding process, it is preferable to cause a stream of a shielding gas, such as hydrogen, to be maintained around the parts where fusion occurs in order to prevent oxidation. The hydrogen is fed to the elements by means of a tubular supply pipe 18.

The current supplied to the electrodes 11 and 12 is of such magnitude that the proper welding heat is obtained in turns 9 in a very short interval of time such as 0.1 to 1 second. In order to time the current supplied to the electrodes, I prefer to use a time delay system substantially the same as described and claimed in Patent No. 2,171,347 to E. D. Schneider, dated August 29, 1939. Briefly, this system comprises a source of alternating current supply 19, 20 which, for example, may be a sixty cycle lightning circuit at 110 volts. Connected across this source of supply is a voltage divider 21 having a resistor 22 and a potentiometer 23 having an adjustable contact 24. An electrode discharge device 25 is provided arranged to be energized from the source 19, 20; this device having an anode 26, a control grid 27 and a cathode 28. The cathode 28 is connected directly with the supply conductor 19 through a single throw switch 29. The anode 26 is connected with the conductor 20 of the supply source through the winding 30 of a contactor 31. The grid 27 connects with the movable contact 24 of the potentiometer through a capacitor 32 which capacitor is shunted by a resistor 33 which forms a leakage path through which the capacitor may lose its charge at a predetermined rate. The cathode 28 in addition to its connection with the conductor 19 through switch 29 has a permanent connection with the other conductor 20 of the supply source through a resistor 34. The relay 31 normally closes its contact 35, and is arranged to open this contact when energized. The system further comprises welding transformer 36 connected in the circuit of the electrodes 11 and 12, as shown.

In operation: When the switch 29 is closed a circuit is completed for the transformer 36 through the closed relay contact 35, whereby the electrodes 11 and 12 are energized and a welding current flows between them and the assembly of terminal 3 and resistance helix 1. The system

just described causes the current to flow for a predetermined interval at the end of which the relay **31** is energized to open contact **35**, thereby to open the circuit of the transformer **36**.

More specifically, when the switch **29** is in its open circuit position, as illustrated, no current flows in the anode-cathode circuit of the discharge device **25** and the relay **31** will be deenergized and its contact **35** closed. At this time there will be a grid current flow during those half cycles which for convenience, will be termed the negative half cycles at which the conductor **20** is negative with respect to the conductor **19**. This grid current, namely the electron flow which takes place during the negative half cycles from the conductor **20** through the resistor **34**, to the cathode **28**, to the grid **27** and to the adjacent plate of the capacitor **32**, is that due to the potential difference between the potentiometer contact **24** and the conductor **20** in such a manner that the terminal thereof which connects with the grid is negative, it being noted that the only connection of the cathode with the source at this time is through the resistor **34** to the conductor **20**. That is, while the switch **29** is open, the negative half cycles of the supply voltage keep the capacitor **32** in a charged condition.

When the switch **29** is closed the anode-cathode circuit of the device **25** is closed, whereby the device functions to pass current during the positive half cycles to operate the relay **31** under the control of the grid **27**. When the relay **31** is energized, it operates as described above to open contact **35** which de-energizes the transformer **36** and effectively opens the circuit to the electrodes **11** and **12**.

It will be understood in view of the foregoing, that after the switch **29** is closed the relay **31** will be operated only after the lapse of a predetermined time interval, this interval being the time required for the capacitor **32** to discharge through the resistor **33**. The setting of the potentiometer contact **24** adjusts this time interval.

After the power to the electrodes is shut off, the switch **29** is reopened, and another cycle is effected by reclosing it.

While the resistance conductor **1** is made of 80 nickel-20 chromium alloy, and the terminals **3** and **4** are made of steel in the specific embodiment of the invention illustrated, it is to be understood that this invention is not limited to such materials, but that other suitable metals may be used. And where others are used, it is necessary only to adjust the timer rheostat contact **24** to set the proper time interval to obtain the proper welding temperature for the outer turns **9** of the resistance conductor.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention in its broader aspects and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of making a terminal structure for an electric heater having a metallic conductor and a metallic terminal therefor, which method comprises forming a portion of said conductor into a plurality of turns, inserting a portion of said terminal into said turns in frictional engagement therewith, and bringing the outermost only of said turns that are remote from the body

of said conductor and the part of said terminal surrounded by them to a temperature sufficiently high to fuse them to said terminal, while holding the innermost of said turns which are adjacent to said body and the terminal portion surrounded thereby at a temperature below the fusing point of said innermost turns so that said innermost turns are free from rigid connection with said terminal although frictionally connected thereto.

2. The method of making a terminal structure for a heater provided with a metallic conductor and a rod-like metallic terminal therefor, which method comprises forming a number of turns on the end of said conductor, inserting the inner end of said rod-like terminal into said turns so that the outermost and the innermost of said turns respectively surround and frictionally engage adjacent first and second sections of said inner end of said terminal, passing a fusing electric current through said turns and said terminal, and simultaneously cooling the outer end of said terminal and said innermost turns and said second section of said inner end of said terminal so that only said outermost turns and said first section of said inner end of said terminal reach a fusion temperature in order to cause fusion therebetween.

3. The method of making a terminal structure for a sheath-wire heater provided with a metallic conductor, a rod-like metallic terminal therefor, a sheath for encasing said conductor and said terminal, and a powdered heat conducting and electrically insulating mass within said sheath embedding said conductor and said terminal and compacted into engagement therewith, which method comprises forming one end portion of said conductor into a plurality of turns, inserting one end of said terminal into said turns in frictional engagement therewith, bringing electric current carrying electrodes into contact with the other end of said terminal and with the innermost of said turns on said one end of said terminal, and passing a fusing electric current between said electrodes through said innermost turns and said terminal, said electrodes being formed to remain relatively cool in order to keep said innermost turns and said other end of said terminal relatively cool while the remainder of said turns surrounding said one end of said terminal become heated to a fusion temperature and fuse to said one end of said terminal in order to form a welded joint therebetween.

4. The method of making a terminal structure for a sheath-wire heater provided with a metallic conductor, a rod-like metallic terminal therefor, a sheath for encasing said conductor and said terminal, and a powdered heat conducting and electrically insulating mass within said sheath embedding said conductor and said terminal and compacted into engagement therewith, which method comprises forming a number of turns on the end of said conductor, forming a reduced end on said rod-like terminal, inserting said reduced end into said turns in frictional engagement therewith, bringing a pair of electrodes of considerable thermal mass and good heat conductivity into good electrical and mechanical contact with the innermost only of said turns and with the enlarged part of said terminals to pass electric current through said terminal which is heated due to its electrical resistance to the passage of current through it, said enlarged part of said terminal and said innermost turns, however, remaining relatively cool due to the presence of said electrodes, while the heat concentrates in

a section of said reduced end surrounded by the outermost of said turns both due to its relative size and consequent relatively high electrical resistance and due to its remoteness from said electrodes and until its temperature rises sufficiently high to fuse said outermost turns to said section of said reduced end.

5. The method of making a terminal structure for an electric heater provided with a metallic conductor and a rod-like metalic terminal therefor, which method comprises forming a number of turns on the end of said conductor, inserting one end of said terminal into said turns so that the outermost and the innermost of said turns respectively surround and frictionally engage adjacent first and second sections of said one end of said terminal, passing a fusing electric current through said terminal, simultaneously cooling the other end of said terminal and said innermost turns and said second section of said one end of said terminal so that only said outermost turns and said first section of said one end of said terminal reach a fusion temperature, and enveloping said outermost turns and said first section of said one end of said terminal with a reducing atmosphere while fusion therebetween takes place.

STERLING A. OAKLEY.

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