May 29, 1928. 1,671,300

A. S. MACDONALD ET AL

ELECTRICAL HEATING APPARATUS

Filed May 17, 1923 2 Sheets-Sheet 1

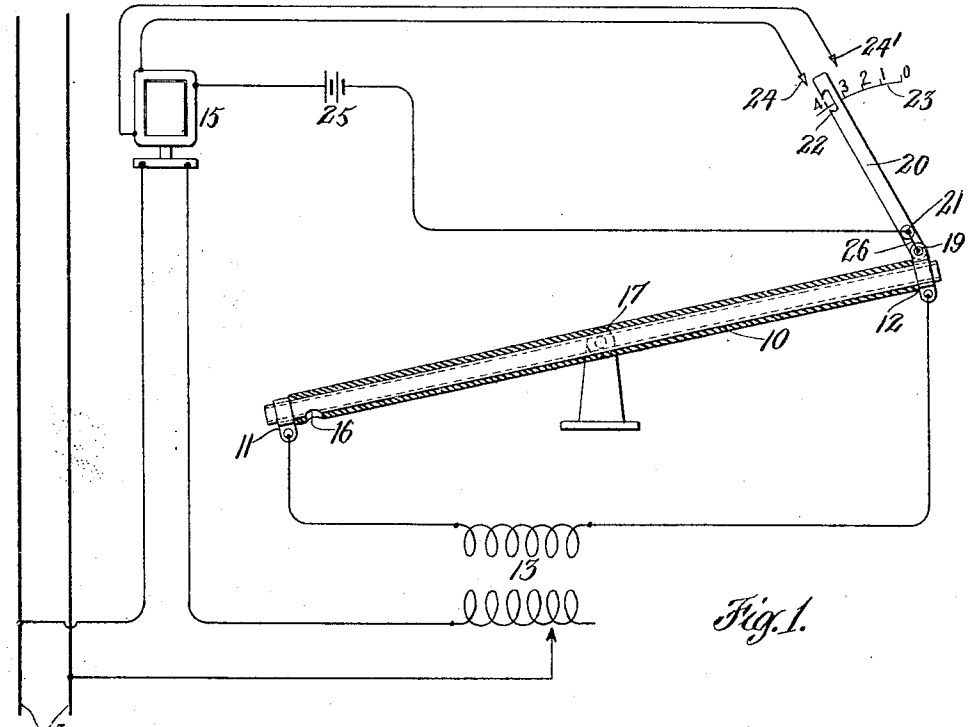


Fig. 1.

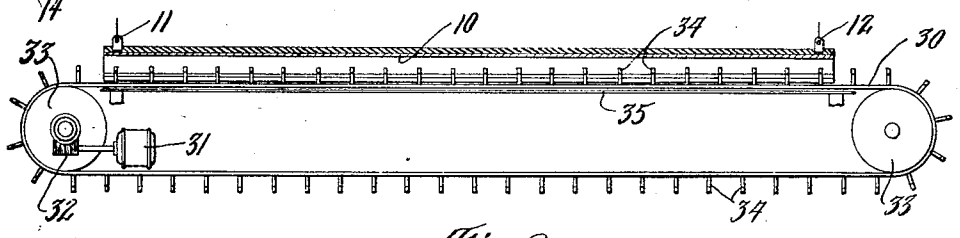


Fig. 2.

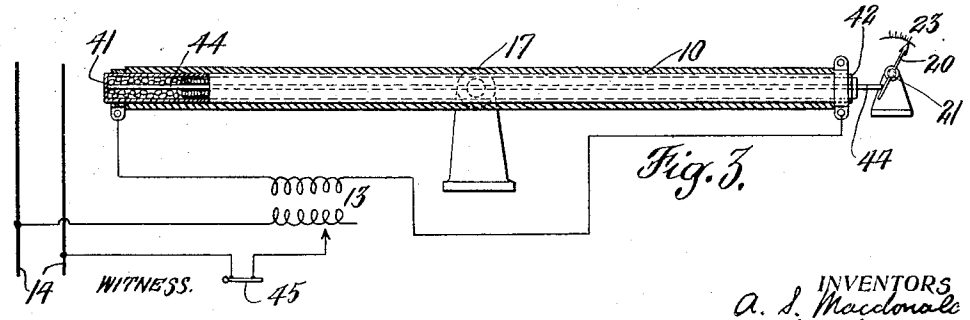


Fig. 3.

WITNESS.

Gustav Genzlinger

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A. S. Macdonald
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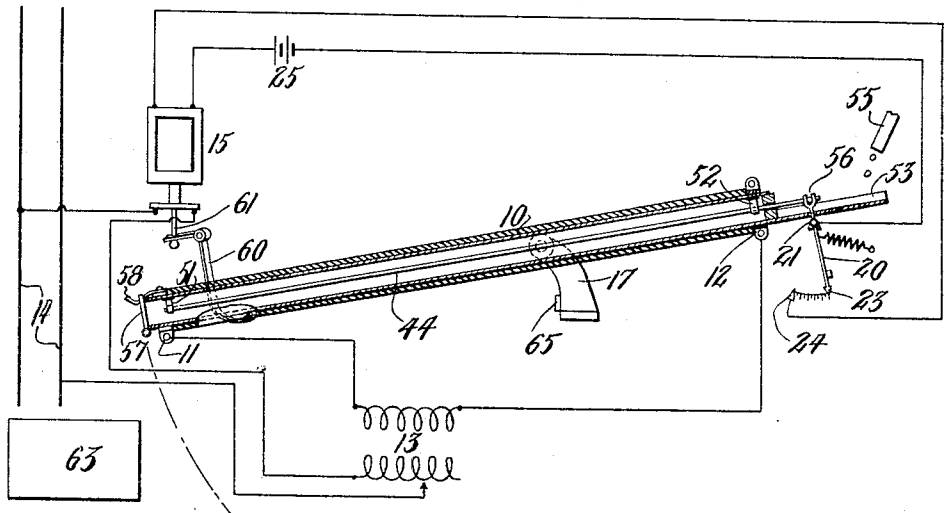


Fig. 4.

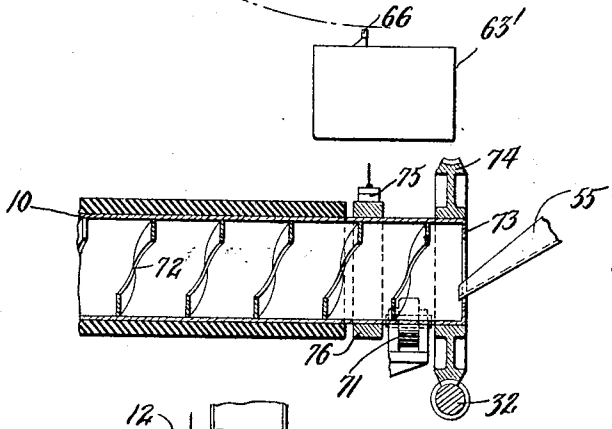


Fig. 5.

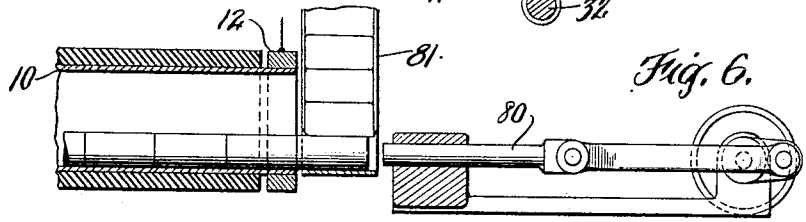


Fig. 6.

WITNESS.

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Patented May 29, 1928. 1,671,300

UNITED STATES PATENT OFFICE.

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ELECTRICAL HEATING APPARATUS.

Application filed May 17, 1923. Serial No. 639,514.

Our invention relates to electrical heating apparatus and heating, and especially to the heating or treating of small objects,—such, for example, as steel balls for bearings of various sorts, or materials in granular or other state of division. We aim to provide a simple and convenient apparatus for heating such articles or materials; to provide for accurate control over the heating operation; and to safeguard against overheating. How these and other advantages can be realized through our invention in a novel manner will appear from our description hereinafter of the best forms of apparatus known to us for the purposes of the invention.

In the drawings, Fig. 1 is a somewhat diagrammatic side view of one form of heating apparatus, with a wiring diagram of electrical connections.

Fig. 2 is a fragmentary mid-sectional view, illustrating the provision of a positive mechanical feed for passing articles through the apparatus.

Fig. 3 is a view similar to Fig. 1, illustrating an apparatus with a thermostatic control member separate from the heating tube.

Fig. 4 is a view similar to Fig. 1, illustrating an apparatus in which the principal features of Figs. 1 and 3 are combined.

Figs. 5 and 6 are fragmentary diagrammatic mid-sectional views, illustrating various arrangements for positively feeding objects through a heating tube.

In the apparatus shown in Fig. 1, there is a tubular heating element 10 to receive and contain the articles to be treated. This heating element 10 may preferably be made of metal tubing of suitable electrical resistance, which can be heated by passing electric current directly through it. For this purpose, metal strap or ring terminals 11, 12 clamped about the ends of the metal tube 10 may be connected across the secondary of a transformer 13. As shown, the primary of this transformer 13 is adjustable or variable, and is connected across the A. C. power circuit 14. The primary circuit connection of the transformer 13 includes a relay switch 15, whose function will presently be explained.

The apparatus of Fig. 1 is adapted for continuous operation to heat small articles or objects fed or passed through it, preferably at a definite rate (or period of exposure in the tube) such as to give just the right duration of heating. Provision for thus passing objects through the tube 10 may be made by mounting it at an inclination, so that objects introduced into its higher end in any suitable manner may slide or roll through by gravity. As shown, the tube 10 has a discharge opening 16 in its bottom (close to its lower end), whence the hot articles may drop into any appropriate receptacle, such as a box, a pan of sawdust or shavings, or a quenching or tempering bath of water or oil. As one means of regulating and varying the time of passage of articles through the tube 10, its inclination may be adjusted: as shown, it is provided with a swivel or pivoted clamp mounting 17 (located about at its middle) for this purpose.

As shown in Fig. 1, one of the end clamps on the tube 10 (in the present instance, the right-hand clamp 12) has a lug which is pivoted at 19 to the lower end of an arm 20 itself pivotally mounted or fulcrumed at 21. This arm 20 has an index 22 that cooperates with a suitably graduated scale-arc 23, thus affording a visible indication of the expansion of the tube 10, and hence of the temperature developed from time to time. The arm 20 is also adapted to cooperate with stationary contacts 24, 24′ (that may be set at any desired point along the scale 23) to control and operate the double relay switch 15 for the heating current. For this purpose, one side of the branching relay circuit (which circuit includes or is connected to a source 25 of current at relatively low voltage) is connected to the contacts 24, 24′, while its other side is connected (as through a flexible lead 26) to the arm 20 itself. When the tube 10 expands sufficiently for the arm 20 to make contact at 24, the relay will be energized to open the switch 15 and thus prevent further rise in temperature of the tube 10. When the tube 10 has cooled and contracted sufficiently for the receding arm 20 to make contact at 24′, the relay will be energized to reestablish the heating circuit. This double relay arrangement has the advantage over a single-acting, self-closing re-

lay that the switch is not continually opening and closing as the tube 10 heats or cools two or three degrees. Preferably, the two contacts 24, 24' are placed as far apart (e. g., 50° F.) as is consistent with substantial continuity of heating for the work in hand, so as to minimize the making and breaking of the heating circuit.

It will be seen, therefore, that the apparatus of Fig. 1 affords ample and varied control or regulation for the heating operation: as to its duration, by the adjustment of the tube slope and the expansion of the tube 10 itself; and as to the temperature developed, by the expansion of the tube and the adjustment of the transformer primary at 13. Thus the tube 10 itself serves as a thermostatic actuating member for gauging, controlling and limiting the temperature developed; and by proper setting of the contact 24, the temperature can be gauged and controlled exactly as desired.

The double control over the temperature afforded by the adjustment of the transformer primary and the thermostatic action is of advantage in allowing sufficient current to be passed through the tube 10 to heat adequately a rapid and uninterrupted stream of steel balls or other articles, without danger of overheating if and after such stream is temporarily interfered with. In such a case, the thermostatic action limits the rise of temperature of the tube naturally consequent upon the cessation of the cooling by the stream of objects to be heated, so that when objects once more begin to pass through the tube, they will not be overheated and perhaps injured.

In Fig. 2, the tube 10 of Fig. 1 (or of Fig. 4 hereinafter described) is shown as provided with means for positively feeding or passing objects therethrough in a definite manner, as at a uniform rate of speed. As shown, this mechanical feed is in the nature of an endless conveyor 30 with one run through the tube 10. In this case, the rate of travel and duration of heating of the objects may be controlled by suitably regulating the speed of the conveyor 30, which is shown as driven by a variable speed electric motor 31 connected through worm reduction gearing 32 to the shaft of one of the sprockets or drums 33 around which the flexible member of the conveyor extends. As shown, the flexible conveyor member is provided with outstanding engagement members or devices 34 for positively and definitely engaging and pushing along the objects to be treated. In the present instance, the flexible belt or chain member extends along below the tube 10, and the wide-ended carrier fingers 34 extend up and move along through a longitudinal slot in the bottom of the tube. In order to keep the active finger ends from scraping or binding on the tube wall, a subjacent supporting plate 35 may be provided for the active run of the flexible cable of the conveyor.

Where the apparatus is thus provided with a mechanical feed, the tube 10 may, of course, be mounted or set in a substantially horizontal position (zero slope) as shown, since gravity need no longer play the same decisive part.

In Fig. 2, various parts and features are marked with the same reference characters as in Figs. 1 and 4, as a means of dispensing with merely repetitive description.

The form of apparatus shown in Fig. 3 is adapted for heating objects in batches or charges, one batch after another. As shown, the tube 10 is loaded full from end to end, being provided with a closure 42 at the right and stoppered with a porcelain or other insulating plug 41 at the left. Here the adjustable mounting 17 serves as a convenient means for turning the tube from the horizontal operating position shown to a vertical one, to permit its contents to run out quickly at the end of the heating period. In the present instance, the tube 10 no longer serves as the sole or principal thermostatic actuating member of the temperature-gauging means 20, 23: on the contrary, a separate member 44 is provided for this purpose. This member 44 consists of a rod arranged centrally inside the tube 10, secured to its bottom closure 41 and projecting out through a hole in the plug 42 to engage the movable arm 20. If annular, like nuts or washers, for example, the objects to be treated may be "strung" around the rod 44; and if of granular or other such form, they may be packed around it,—both conditions being illustrated. However, since the rod 44 extends through the objects in both cases, so that the heat reaches it mainly or entirely by "soaking" in from the hot tube wall, through the mass of the objects, the rod will respond to the actual heat and temperature of the objects themselves under either condition.

As shown, the switch 45 in the primary heating circuit is a simple hand switch; no contact 24 or relay circuit is provided; and the vigilance of the operator is depended on to make effective the gauging of the heating by the thermostatic member 44.

In Fig. 3, again, various parts and features are marked with the same reference characters as in Fig. 1, as a means of dispensing with merely repetitive description.

In the apparatus of Fig. 4 (as already mentioned) are combined various features of Figs. 1 and 3. As shown, the thermostatic rod 44 is supported by slender brackets 51, 52 from the top of the tube 10, one of which (at least) is preferably insulatively mounted to obviate heating of the rod by flow of current through it. As shown, the

rod is fixed to the left-hand bracket 51 and extends loose through the right-hand bracket 52 as a guide support. The lower half of the tube 10 extends some distance to the right beyond the bracket 52, to serve as an open-topped intake chute or trough 53 for objects to be treated dropped thereinto from the superjacent supply means 55. The gauge arm 20 is reversed as compared with Fig. 1, extending downward instead of upward; and the positions of the parts 21, 23, 24 are correspondingly altered. The relay switch 15 is of the single-acting, self-closing type, with only the one contact 24 for the arm 20, and correspondingly simpler relay circuits than in Fig. 1. The connection 56 between the rod 44 and the short upper end of the arm 20 (forked around the trough 53) is of the pin and slot type, so as to allow ready disengagement and reengagement. The swivel-clamp mounting 17 for the tube 10 is located near its right-hand end. To the left-hand end of the tube 10, at its bottom, is pivoted a closure plate or "trap-door" 57, for which a leaf spring catch 58 is mounted on the top of the tube. Also, a sort of pivoted hook crank support 60 is provided for the left-hand end of the tube 10, being connected by a link 61 to one of the movable parts of the relay switch 15 for the heating current.

When the apparatus is to be used for treating a continual succession of objects, the door 57 is left hanging open, the hooked catch 60 is out of action, the tube 10 is set at the desired inclination, as in Fig. 1; and the arm 20 functions in the same manner as in Fig. 1, under actuation by the rod 44 as in Fig. 3,—the articles discharged from the open left-hand end of the tube 10 dropping into a receptacle 63 that may contain sawdust, shavings, or a quenching or tempering bath, etc. In this case, of course, the member 44 responds more to the heat radiated from the tube than to that of the objects themselves.

On the other hand, when the apparatus is to be used for treating objects in successive batches, as in Fig. 3, the door 57 is closed; the tube 10 is charged full and stoppered at its other end with a porcelain plug 42; the swivel clamp 17 is left loose, so that the tube can pivot and swing thereon freely; and the latch 60 is hooked under the left-hand end of the tube to keep it about level, as shown. When the switch 15 is operated by the expansible member 44, the catch 60 is withdrawn, and the loaded tube 10 swings downward by gravity until arrested by a buffer 65,—the pin and slot connection at 56 permitting the member 44 to disengage from the arm 20 quite readily. Ordinarily, the jar as the tube 10 strikes the buffer 65 will cause the door 57 to fly open and discharge the contents of the tube into the subjacent receptacle 63'; but if a more positive and definite action is desired, a trip or cam member 66 may be arranged in the path of the catch 58 to depress it and release the door just about as the tube strikes the buffer.

In Fig. 4, again, various parts and features are marked with the same reference characters as in Figs. 1 and 3, so as to dispense with repetitive description.

In such apparatus as here illustrated and described, it is generally desirable to make the tube 10 and the thermostatic member (if separate from the tube) of material unsusceptible to permanent alteration by the temperatures developed,—such as the substantial oxidation or the high temperature growth of ordinary iron and steels. On this account, some of the well-known non-oxidizing high-resistance alloys of nickel and chromium may be used, such as nichrome. For the rod 44, especially, may sometimes be used a material like so-called "stainless steel" (containing about 14% chromium), which will stand heating and cooling a great many times and still exhibit the critical range movements without diminution. The thermostatic member must, of course, be proportioned and calibrated with due reference to the critical temperatures of the objects to be treated, as well as with reference to its own.

It is, of course, to be observed that the thermostatic action in Figs. 3 and 4 is in a sense "differential with a time-lag" when the tube 10 is packed full of objects or material to be treated. That is to say, the portion of the tube 10 to the left of the clamp 17 expands first and moves the rod 44 bodily to the left, so that in the course of a heat the arm 20 may at certain earlier stages move toward or beyond the zero end of the scale 23. Ultimately, on the other hand, the heat "soaks" through to the rod 44 and the latter expands rather rapidly and moves the arm 20 the other way the full range of its movement. In any case, however, the only practical result of the differential action is to make the scale 23 shorter than it would otherwise be.

In cases where the apparatus is used to heat a continual stream of objects, a variation or graduation of temperature in the length of the tube 10 may be secured by suitably varying the thickness of the tube wall. In Fig. 1, the thickness increases toward the right, and the temperature, therefore, toward the left, in Fig. 4, the reverse variations of thickness and temperature are illustrated. In this latter case, the greater temperature of the tube at the loading end helps to bring the objects treated up to the desired or critical temperature range more quickly. In either case, the temperature scale for the tube can be calibrated by practical methods instead of being calculated.

Figs. 5 and 6 illustrate other methods of

positively feeding material or articles through the tube 10 at a definite regular rate in order to secure a uniform and accurately determinable duration of heating. In both of these latter figures, various parts and features are marked with the same reference character as in the preceding figures, as a means of dispensing with merely repetitive description.

As shown in Fig. 5, the horizontal tube 10 is supported on one or more rolls 71 for rotation about its own longitudinal axis, and is provided with an internal helix 72 for feeding articles along screw-conveyor wise. The loading end of the tube 10 has an internal annular flange 73 to prevent articles from rolling or falling out after delivery within the tube by the supply chute 55 projecting within its end. The tube is driven by a helical gearing connection 32, 74. Current connections may be of any suitable type,—here indicated by brush 75 and contact ring 76.

In Fig. 6, the tube 10 may be stationary, and the objects to be treated (here shown as short cylinders in form) are pushed through by a reciprocatory feed device, such as a crank and pitman actuated plunger 80, whose throw may preferably exceed the individual length of the objects. As shown, the objects are fed down to the receiving end of the tube 10 by gravity, through a closed-bottomed supply chute 81 whose edges or sides are cut away to allow the plunger 80 to push out only the bottom one, endwise, at each active movement. During the relative dwell of the plunger 80 after each return, the objects feed or are fed down the chute 81.

In all the arrangements and constructions described, the tube 10 is shown well thermo-insulated with a heavy layer or sheathing of some highly refractory insulating material,—such as that known as "silocel," which can be had in either brick or powder form.

What we claim is:

1. Electrical heating apparatus of the character described comprising a tube for receiving objects to be treated, means for passing current through the tube to heat it and for controlling its temperature, and means controlled by the temperature developed for additionally controlling the temperature of the tube.

2. Electric heat treating apparatus, comprising a tube for passage of objects to be treated, means for passing a heating current through the tube, means for controlling the rate at which the objects pass through the tube, and means actuated by expansion incident to heating for controlling the temperature of the tube.

3. Electrical heating apparatus of the character described comprising a tube for receiving objects to be treated, with means for passing heating current through the tube, and provision for automatically controlling the heating of the objects including an actuating member thermostatically responsive to the temperature developed but unsusceptible to permanent alteration thereby.

4. Electrical heating apparatus of the character described comprising a tube for receiving objects to be treated, means for passing current through the tube to heat it, and means for gauging the heating including a thermostatic member responsive to the heat of the objects themselves.

5. Electrical heating apparatus of the character described comprising a tube for receiving objects to be treated, means for passing current through the tube to heat it, and means for gauging the heating including a longitudinal thermostatic member for extending through the objects in the tube, so as to respond to the heat of such objects themselves.

6. Electrical heat treating apparatus comprising a receptacle for receiving objects to be treated, means for passing a current through the wall thereof to heat it and means actuated by expansion resulting from the heating for controlling the temperature of the receptacle.

7. Electrical heat treating apparatus comprising a receptacle for receiving objects to be treated, means for passing a heating current therethrough and means actuated by expansion resulting from the heating for indicating the temperature of the receptacle.

8. Electrical heat treating apparatus comprising a receptacle for receiving objects to be treated, means for passing a heating current therethrough and a single means actuated by expansion resulting from heating the receptacle for indicating and also controlling the temperature of the receptacle.

9. Electrical heat treating apparatus comprising a receptacle for receiving objects to be treated, means for passing a heating current therethrough and means indicating expansion incident to heating the receptacle.

10. Electrical heat treating apparatus comprising a receptacle for receiving objects to be treated, means for passing a heating current therethrough and temperature controlling means actuated by expansion incident to heating the receptacle.

In testimony whereof, we have hereunto signed our names.

ANGUS S. MACDONALD.
CHARLES G. WAITE.