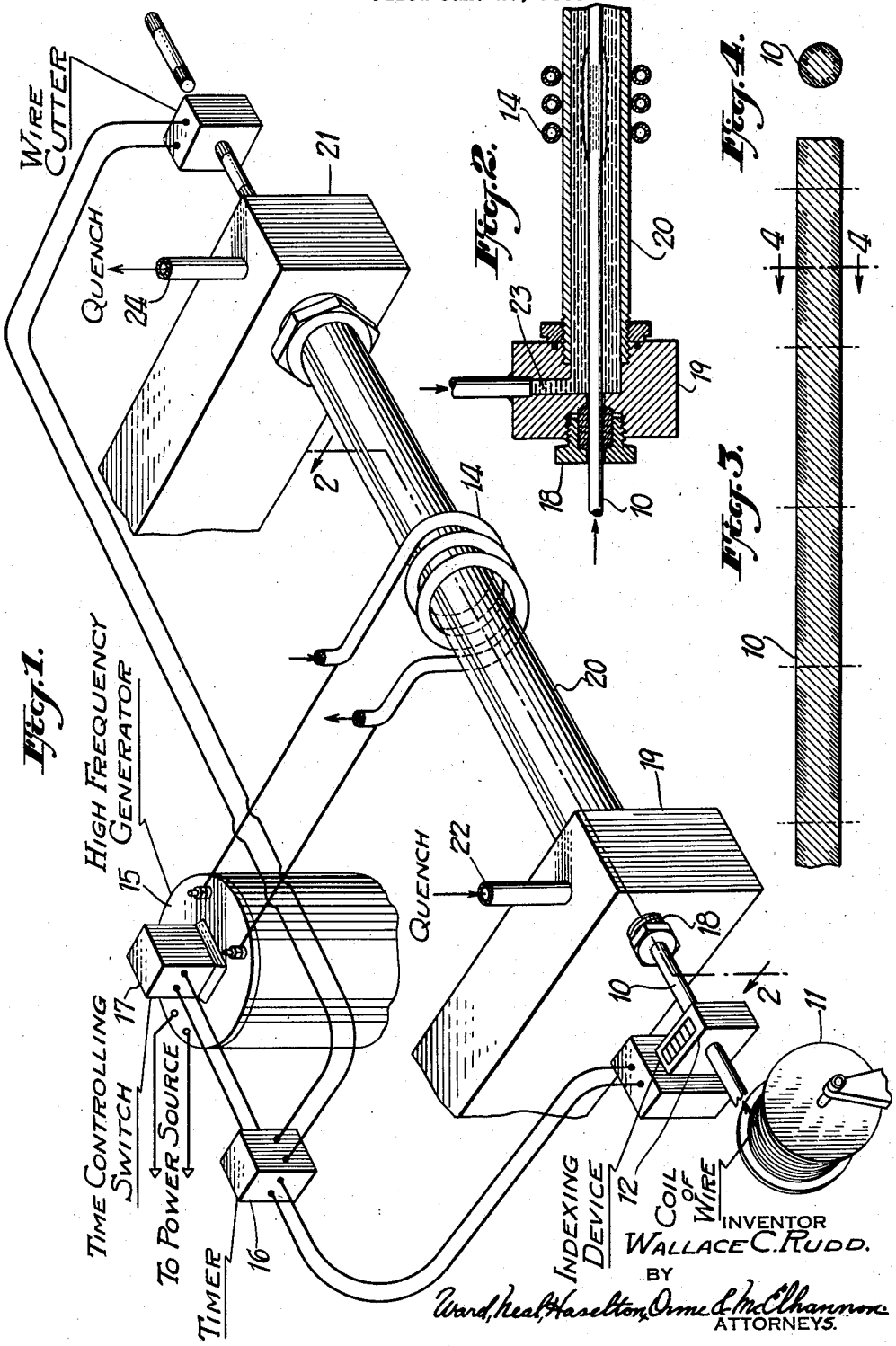
March 29, 1960 W. C. RUDD 2,930,724

PROCESS FOR INDUCTION HEATING AND QUENCHING OF METAL

Filed Jan. 27, 1958



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United States Patent Office 2,930,724
Patented Mar. 29, 1960

2,930,724

PROCESS FOR INDUCTION HEATING AND QUENCHING OF METAL

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Application January 27, 1958, Serial No. 711,357

2 Claims. (Cl. 148—150)

This invention relates to the heat treating of metal members or objects by electromagnetic induction, the invention among other possibilities being particularly adapted for the heat treating to a desired limited depth of spaced-apart areas on metal objects such as wires, strips or the like which are advanced through the apparatus.

The invention, for example, has been found to be well adapted for the surface hardening of spaced-apart areas on wire, such that the treated wire at points between the hardened areas may be cut into separate lengths each having soft ends but with surface-hardened mid-portions. The thus formed separate pieces of the treated wire may be used as pins, for example in the manufacture of certain types of chain, in which it is desired to have the main body portion of the pin surface-hardened, while leaving the ends soft so that they may be "peened over" to hold the pins in place in use. The forming of such pins heretofore has commonly been accomplished by carburizing the stock, plating it where it is not desired that it be hardened, and then going through an involved and expensive series of steps to secure the desired product.

One of the problems of such surface-hardening of metal, particularly if the hardening is to extend only to a predetermined shallow depth and the object is not large in cross-section or diameter, arises from the necessity of imparting to the object a great amount of heat rapidly enough for heating the surfaces to the desired degree without heating the core of the metal to hardening temperature, and then almost immediately quenching the metal object before the hardening temperature penetrates beyond the desired limited depth. And such problem becomes even more difficult where the metal object is to be surface-hardened only at predetermined spaced areas, or where the objects are small and inexpensive and for economy must be annealed uniformly in rapid succession.

In accordance with the present invention, these problems are overcome in a relatively simple and inexpensive way. For example, in a case where it is desired to form surface-hardened metal pins as above referred to, this may be done by longitudinally moving a wire of which the pins are to be formed step by step so that spaced-apart areas thereon will be successively positioned for a short interval in an induction heating arrangement as hereafter described, and in which, after quickly heating the desired areas, the same are immediately quenched and the treated wire is thereafter automatically advanced from the apparatus and cut into lengths at points between the surface-hardened areas to form the pins with hardened surfaces at their mid-portions but with soft ends. Such induction heating arrangement in accordance with the invention comprises an insulation tube through which a quenching fluid, such as water, is caused to flow and, while the wire is passed in such quenching fluid through the tube step by step, the tube being surrounded by a high frequency induction heating coil of one or preferably several turns. In this way, the successive short lengths of wire which become positioned in the quenching fluid within the tube and within the induction heating coil, may be quickly heated but in their surface portions only, by momentarily supplying the heating coil with high frequency current. This causes the cooling fluid which is flowing past the heated areas on the wire momentarily to become volatilized. That is, in case the cooling fluid is water, the heated areas will immediately and momentarily be surrounded with substantially an envelope of steam, but this will condense and collapse the moment the heating current is cut off, thereby causing the heated area to be immediately quenched by the flowing stream, thus limiting the penetration of the heat to the depth of the desired surface hardening, even before the wire is advanced the next step. As the treated wire emerges from the apparatus, it may be automatically cut into blanks at points intermediate the treated areas to form the desired pins.

With the form of the apparatus of the invention here shown, the wire or rod to be treated is advanced stage-by-stage generally horizontally straight through an insulation tube surrounded by an induction heating coil and containing the flowing stream of cooling liquid, the wire passing through stuffing boxes where it enters and leaves the flowing stream. However, it will be understood that the apparatus may take various other forms which may or may not require such stuffing boxes and in which, for example, the wire may be advanced in a generally vertical direction or be suitably supported to follow a curved path in the flowing stream. Also, the invention may be used for surface hardening separate elements carried through the apparatus on any suitable strand or the like.

Various further and more specific objects, features and advantages of the invention will appear from the description given below, taken in connection with the accompanying drawings, illustrating by way of example a preferred form of the invention.

In the drawings:

Fig. 1 is a somewhat schematic perspective view of a presently preferred form of the apparatus for carrying out the invention;

Fig. 2 is a view, partly broken away, showing a section taken substantially along the line 2—2 of Fig. 1;

Fig. 3 is a longitudinal sectional view of the treated wire; and

Fig. 4 is a sectional view taken along line 4—4 of Fig. 3.

Referring to the drawings in further detail, a continuing length of wire as at 10 is drawn in any suitable manner from a reel 12 and advanced through the apparatus step-by-step by any suitable known form of indexing device located, as indicated, at 12, which will grip the wire and advance it for a distance equal to the length of a desired pin and preferably allow it to remain stationary for a short predetermined time and then similarly advancing it successively by additional steps through the heating apparatus and finally to any suitable known form of automatic cutting device as at 13 which will cut the wire into desired lengths to form the pins.

An induction heating coil of several turns is indicated at 14, this coil being preferably formed of hollow tubing for containing cooling liquid, as is customary for high frequency induction heating coils. The coil is connected to a high frequency generator of a suitable known type as at 15, preferably of a type to supply current of a frequency of the order of 100,000 cycles per second or higher, such as 450 kilocycles, which has been found satisfactory in a typical case.

As indicated at 16, a suitable known form of timing device may be provided with electrical connections to control the timing of the operation of the indexing device

12 and also to control, in proper phase relationship, a time-control switch as at 17, which in turn acts to turn on and shut off the high frequency current supply of the generator to the coil 14. The timer as indicated may also be connected to control the actuations of the cutting-off device. If the generator is of the type embodying oscillator tubes, the timer which may be a suitable known type of electronic timer, may be connected to control the grids of the oscillator tubes so as to provide a very short period of current supply amounting to a fraction of a second at the time when a surface area to be heated on the wire is lodged within the heating coil.

The wire, in passing into the apparatus, may first pass through a stuffing box, as at 18, mounted in a supporting bar 19. Thence the wire passes on through a length of tubing 20, preferably, although not necessarily, formed entirely of insulating material such for example as polytetrafluorethylene, the wire then passing on through another supporting bar 21 containing the outlet and a like stuffing box. Cooling liquid such as water is introduced through an inlet as at 22 to pass through a cavity as at 23 in the arm 19 and thence through the tube 20 to a like cavity in the arm 21 and finally to an outlet tube 24. The cooling liquid may be supplied at an adjustable pressure to permit suitable adjustment of its velocity through the tube.

With this apparatus, various sizes of wire strips or rods may be treated, the equipment as shown being adapted for treatment of wire of various sizes for example from one-tenth of an inch up to three-eighths of an inch or more in diameter, the stuffing boxes and tubing, of course, being made of suitable sizes to accommodate members of such diameters. In a typical case, which has proven highly successful in operation, a 50 kilowatt generator was used, providing current at a frequency of 450 kilocycles with the timer and time control switch adjusted to provide for a heating time of 0.05 second for a wire of a diameter of about 0.183". In this case, the depth of the surface hardening was between about 0.03" and 0.05", with the length of the heated sections varying from five-eighths inch to one inch or more. The indexing device was so adjusted that the apparatus produced from about fifty to sixty heat-treated pieces per minute.

Fig. 3 is a sectional view through a piece of wire with the shaded areas showing the portions which have been surface-hardened, Fig. 4 being a cross-section through one of such portions.

In operation, the indexing device is so adjusted as to advance the length of the wire which is to be treated to a position within the coil 14, whereupon the timer and time control switch are adjusted to turn on the high frequency current for an interval of time on the order of 0.05 second. With the above-indicated amount of power available, this causes the wire surfaces within the coil to become immediately heated, although initially surrounded with the flowing stream of cooling fluid. As the wire surface areas are almost immediately brought to the desired temperature, same will become substantially enveloped in steam, and since steam is a good thermal insulator, only a small portion of the heat from the surface of the wire will be conducted away by the liquid, but the wire will promptly become heated to the desired depth, when the power is shut off and thereupon immediately the steam envelope moves on and collapses so that the flowing cooling liquid quenches the heated area before sufficient time has elapsed for the penetration of heat to greater than the desired depth in the wire. The indexing device then advances the wire for another fixed distance, whereupon the above-described operations are repeated. As above explained, the wire, upon emerging from the apparatus, or afterwards, may be cut into lengths at the desired points to form pins or the like having the desired portions hardened and with other portions still relatively soft.

With the arrangement as described, it will be apparent that it is possible to subject the desired areas of heating to a great amount of heat quickly and because of the envelope of stem which forms, the heating is highly efficient in that very little heat is conducted away despite the close proximity of the quenching fluid, and yet the heating may be interrupted so quickly and be so quickly followed by the quenching step, that the depth of penetration of the hardening is limited to the desired predetermined distance. Since, after the power is cut off, quenching follows immediately, this avoids any appreciable "soaking" period which might be prohibitive, particularly for a relatively small wire, the core of which is not desired to be hardened.

Although a certain particular embodiment of the invention is herein disclosed for purposes of explanation, further modifications thereof, after study of this specification, will be apparent to those skilled in the art to which the invention pertains. Reference should accordingly be had to the appended claims in determining the scope of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. Method for surface-hardening a succession of spaced areas on an elongated metal member by the use of high frequency induction heating, which method comprises: advancing such member in a succession of steps to predetermined positions within a flowing stream of volatilizable cooling liquid; and subjecting each such area at one of said positions momentarily to a high frequency magnetic field of sufficient intensity quickly to heat only the surface thereof to hardening temperature, each heated area acting to volatilize the liquid contacting therewith, thus momentarily substantially covering same by a heat-insulating layer of volatilized liquid, which layer collapses due to the flowing of said stream upon discontinuance of the field, thereby allowing each such area immediately to be quenched by such flowing stream.

2. Method for surface-hardening a succession of spaced areas on an elongated metal member by the use of high frequency induction heating, which method comprises: advancing such member in a succession of steps to predetermined positions within a flowing stream of volatilizable cooling liquid; and subjecting each such area at one of said positions momentarily to a high frequency magnetic field of sufficient intensity quickly to heat each such area to hardening temperature but only to a predetermined depth, each heated area acting to volatilize the liquid contacting therewith, thus momentarily substantially covering same by a heat-insulating layer of volatilized liquid, which layer collapses due to the flowing of said stream upon discontinuance of the field, thereby allowing each such area immediately to be quenched by such flowing stream, thus preventing further penetration of the heat towards the core of the member.

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