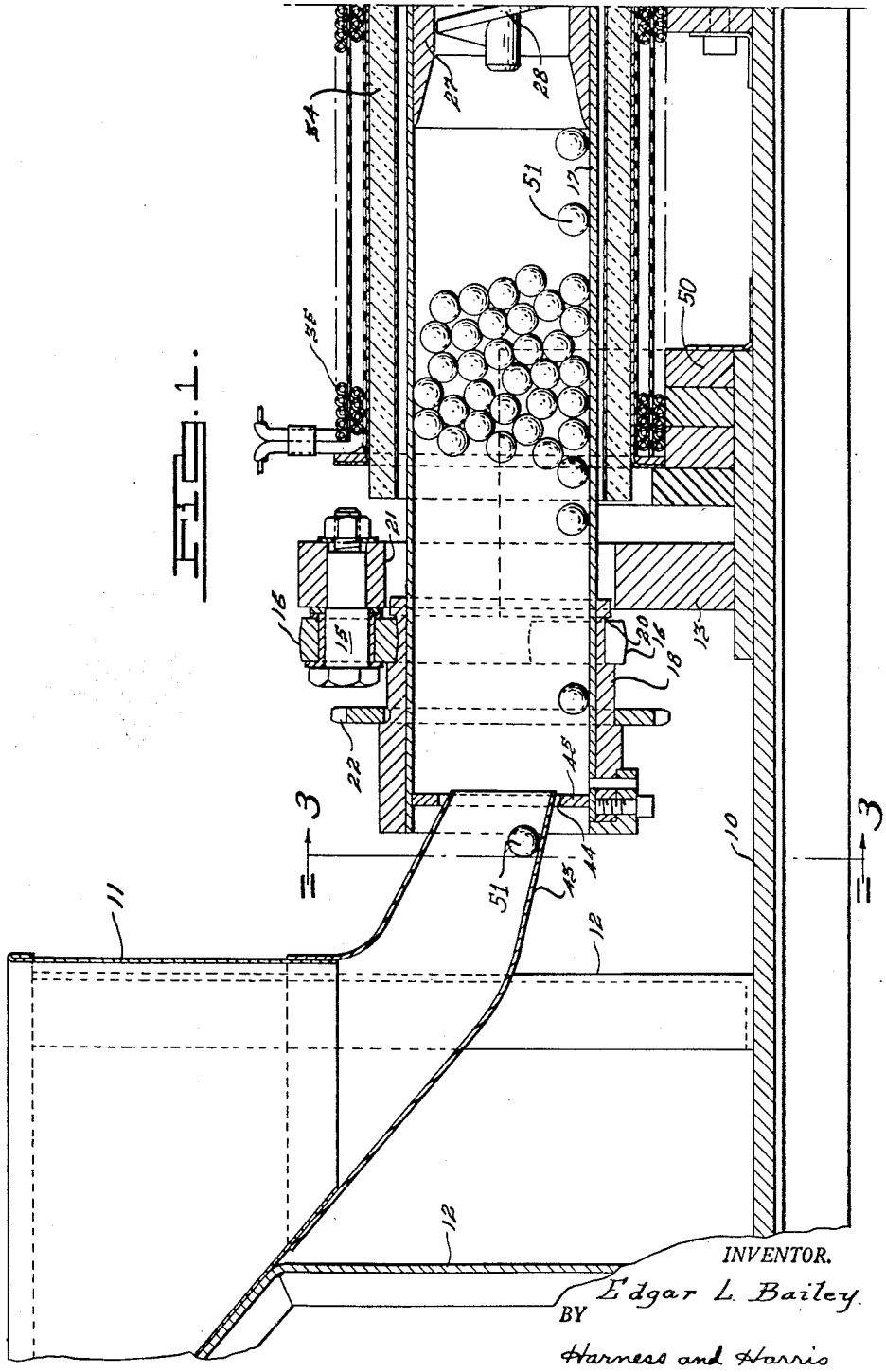
July 4, 1950 E. L. BAILEY 2,513,778

HEAT-TREATING APPARATUS

Filed Nov. 9, 1946 2 Sheets-Sheet 1

FIG. 1.



INVENTOR.
Edgar L. Bailey
BY
Harness and Harris
ATTORNEYS.

July 4, 1950 E. L. BAILEY 2,513,778

HEAT-TREATING APPARATUS

Filed Nov. 9, 1946 2 Sheets-Sheet 2

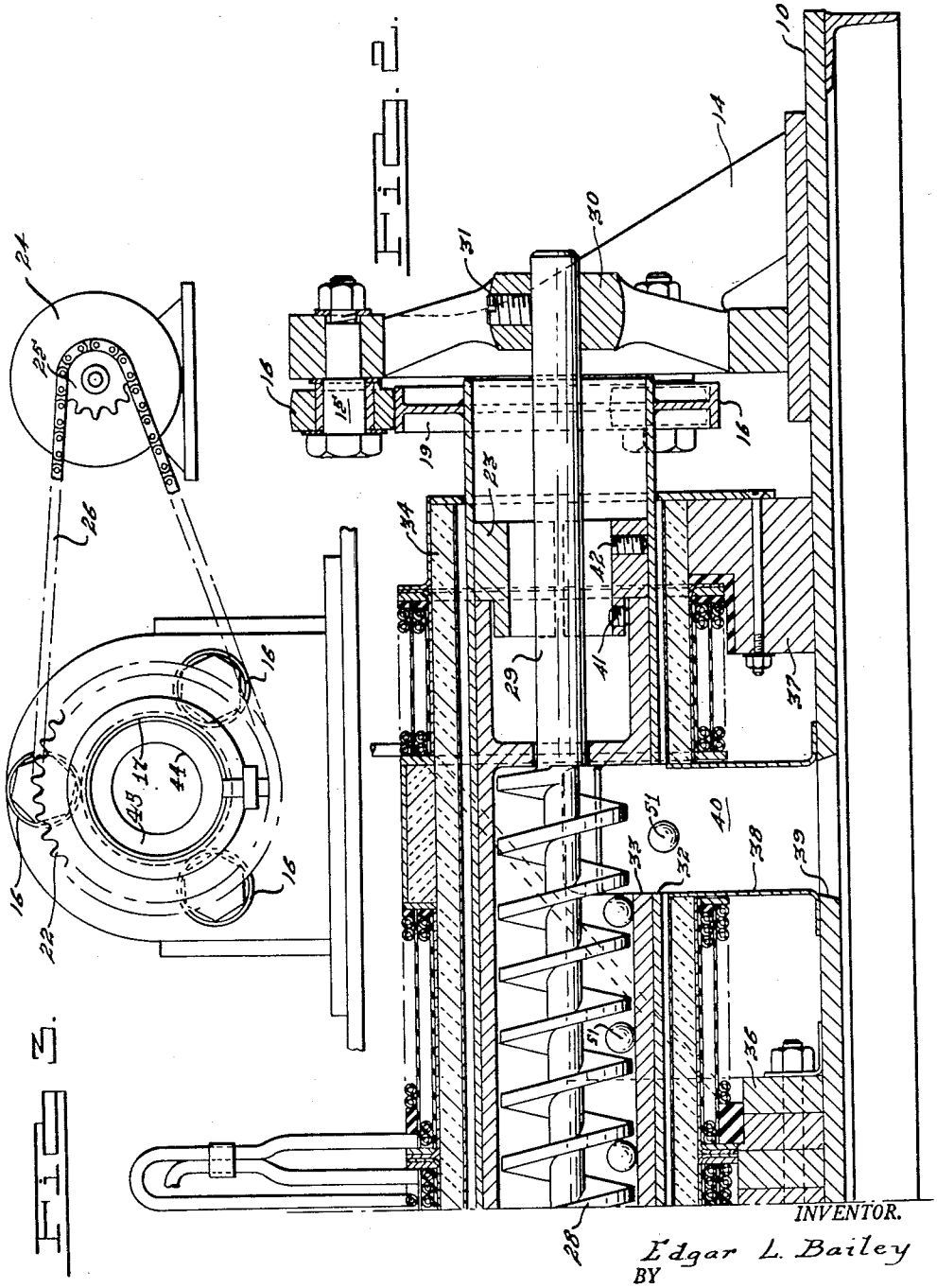


Fig. 2.

Fig. 1.

INVENTOR.
Edgar L. Bailey
BY
Harness and Harris
ATTORNEYS.

Patented July 4, 1950

2,513,778

UNITED STATES PATENT OFFICE

2,513,778

HEAT-TREATING APPARATUS

Edgar L. Bailey, Birmingham, Mich., assignor to Chrysler Corporation, Highland Park, Mich., a corporation of Delaware

Application November 9, 1946, Serial No. 708,960

7 Claims. (Cl. 13—26)

1

This invention relates to heat treating apparatus and more particularly to apparatus designed to combine inductive and conductive heating.

It is a well known phenomenon that when certain temperatures are attained in metals their magnetic properties diminish. The temperature at which this occurs is commonly referred to as the Curie point. It is an object of this invention to utilize this phenomenon and by the selection of a proper frequency of magnetic field to inductively heat objects to their Curie point and then transport them to a conductive heating means adapted to heat them to still higher temperatures. The fact that the magnetic properties of the objects diminish at their Curie point is utilized to release them from the induction heating system so that apparatus may carry them into a conductive heating zone for conductive heating to a temperature above their Curie point.

The initial heating by induction is desirable because inductive heating is generally faster than conductive heating and the size of the furnace required is less than that of a wholly conductive heating furnace.

A further object of the invention is to provide a conductive heating apparatus that has a controlled maximum temperature and to provide interchangeable liners by which this furnace temperature may be altered.

In the drawings:

Fig. 1 is a vertical elevation of a portion of a furnace embodying my invention;

Fig. 2 is a continuation in vertical elevation of Fig. 1; and

Fig. 3 is an end view taken on the line 3—3 of Fig. 1 with the hopper omitted.

A base 10 has a hopper 11 supported thereon by members 12. Spaced supports 13 and 14 are mounted on base 10. Supports 13 and 14 are each provided with a plurality of laterally extending shafts 15 preferably three in number. Each shaft 15 has a roller 16 rotatably mounted thereon. A cylindrical furnace element 17 is provided with collars 18 and 19 which are concentric thereto. The collar 18 is provided with a track 20 which is adapted to receive the rollers 16 of the support 13. Collar 19 is provided with a circular periphery adapted to engage the rollers 16 of the support 14. The support 13 is provided with a central opening 21 which is adapted to receive the furnace element 17. The cylindrical furnace element 17 is thus rotatably mounted.

A sprocket or gear 22 is keyed to the collar 18 and adapted to be operatively connected to suitable driving means to rotate the cylindrical furnace element. Fig. 3 illustrates a motor 24 as driving a sprocket 25 and chain 26. The chain 26 is in driving engagement with the sprocket 22.

2

A cylindrical liner 27 is mounted inside the cylindrical furnace element 17 in concentric relationship therewith and is secured thereto by a sleeve 23 and the set screws 41 and 42. The liner 27 has an axial dimension which is less than the axial dimension of the furnace element 17 and is preferably positioned adjacent one end thereof. In Figs. 1 and 2 this is illustrated as the right end. A screw element 28 is positioned within the liner 27 in coaxial relationship therewith and has an extension 29 which is mounted in a hub 30 formed on the support 14. A suitable set screw 31 is positioned in engagement with the hub 30 and the extension 29 to prevent rotation of the screw element 28. The construction thus far described provides a rotatable furnace element 17 and a liner 27 and a stationary screw element 28. The furnace element 17 is provided with a lateral opening 32 adjacent the right end thereof in Fig. 2. The liner 27 is provided with a similar opening 33 which is aligned with the opening 32. A cylindrical insulating element 34 surrounds the furnace element 17. This insulating element is preferably stationary.

Suitable electric conductors, preferably in the form of coils of wire 35, are arranged in cylindrical form and positioned around the insulating element 34. This wire is supported by members 36, 37, and 50 which are supported by base 10. A chute 38 is supported by the base below the aligned openings 32 and 33 and a similar opening 39 is provided in the base 10. The openings 32, 33, chute 38 and opening 39 form a discharge passage 40 from the furnace. Any desired quenching apparatus such as oil tanks may be placed below the base 10 in alignment with the opening 39 so that objects which have been heated and discharged from the furnace will be directed by discharge passage 40 toward the quenching apparatus.

When an electric current of the proper frequency is sent through the coils 35 and the magnetic field created thereby is used to inductively heat the objects, heat will be imparted to them faster than the heat is lost by radiation. Extremely low frequencies are objectionable for they impart heat to the objects so slowly that the heat lost by radiation prevents a sufficient temperature rise. When the proper frequencies are used, the temperature will rise until the metal reaches its Curie point and the magnetic proper-

ties diminish. This current of the proper frequency coupled with the diminished magnetic properties in the objects is then incapable of overcoming radiation sufficiently to heat the objects further. Too high a frequency will impart energy to the objects so rapidly that even the diminished magnetic properties and radiation are insufficient to prevent a continued, if less rapid, temperature rise. It has been found that frequencies in the range of 180 to 500 cycles per second are satisfactory with a frequency in the neighborhood of 360 cycles per second giving the best results.

In operation, the coils 35 are energized and the motor 24 started. The motor 24 drives the sprocket 22 and rotates the collar 18, furnace element 17, and liner 27. The work pieces which it is desired to heat treat, are preferably ferrous metal and may be dumped into hopper 11. These work pieces may be of various shapes such as ball bearings, nuts, bolts, etc. Ball bearings 51 have been illustrated. Objects 51 to be heat treated will fall by gravity and be drawn by the magnetic field through the spout 43 and through the opening 44 provided in the end plate 45 of the furnace into the interior of the cylindrical furnace element 17. These objects will be magnetized by their presence in the magnetic field created by the electrical conductors 35. The magnetized objects when agitated by the rotation of the furnace element 17 will tend to accumulate in a large mass in the furnace element 17. This mass of objects is in the magnetic field of the conductors 35 and will be inductively heated. The magnetic attraction of the objects will retain them in the mass during this heating in spite of the rotation of the furnace element 17. This induction heating will continue until the objects are heated to their Curie point. Induction heating beyond the Curie point cannot occur because of the diminished magnetic properties of the objects at this temperature. As an incident to the diminished magnetic properties, some of the objects will separate from the mass and be carried around the screw element 28 by rotation imparted to them from the rotation of the liner 27. The screw element 28 will define a path for the objects through the interior of the liner 27. This path may be of calculated length so that conductive heating may be timed. The conductors 35, which are concentric with the liner 27, cause an inductive heating of the liner 27. The liner 27 is formed from a material such as a cobalt alloy which has its Curie point at a considerably higher temperature than the Curie point of the objects being heat treated. The inductive heating of the liner 27 may attain temperatures impossible in the inductive heating of the objects. The high temperature of the liner 27 will by conduction heat the objects as they move around the screw element 28 to a temperature that is higher than the temperature which they possessed upon entering the screw element 28. At intervals when the opening 33 in the liner and the opening 32 in the furnace element are rotated into position below the screw element 28, objects which have completed their passage through the furnace will drop therethrough and out of the discharge path 40.

The liner 27 is formed from material which possesses a higher Curie point than iron. Cobalt iron alloys have been found to be very satisfactory materials. Variations in the percentage of cobalt included in the alloy change the Curie point of the liner 27. A plurality of interchangeable liners 27 having different percentages of cobalt therein may be selectively used to obtain the desired temperature of the liner since the temperature is dependent upon the Curie point.

I claim:

1. In an apparatus for heat treating metal objects possessing magnetic properties, the combination of an elongated furnace element forming a passage, said furnace element having an inlet adjacent one end of said passage and an outlet adjacent the other end of said passage, means to deliver said objects to said inlet, a second means forming a first zone in said furnace element adjacent said inlet, said second means being adapted to simultaneously subject a plurality of said objects to a magnetic field, magnetize and inductively heat said objects until the objects have attained a temperature substantially corresponding to their Curie point at which time said objects separate from each other and are no longer effected by said magnetic field, means forming a second zone in said furnace element positioned between said first zone and said outlet, means to transport said objects through said second zone from said first zone to said outlet and means to conductively heat said objects during their travel through said second zone.

2. In an apparatus for heat treating metal objects possessing magnetic properties, the combination of an elongated furnace element forming a passage, said furnace element having an inlet adjacent one end of said passage and an outlet adjacent the other end of said passage, means to deliver said objects to said inlet, an electrical conductor, means to furnish electrical energy to said conductor, said electrical conductor being disposed around said furnace element and comprising means to induce a magnetic field in a portion of said passage adjacent said inlet whereby objects in said portion are retained therein by the magnetic field and are inductively heated until they have attained a temperature substantially corresponding to their Curie point when their magnetic properties diminish and they are released from the magnetic field, means to transport said released objects from said first portion of said furnace and to deliver said objects to said outlet and supplemental heating means adapted to heat said objects during their travel from said first portion to said outlet and to materially raise the temperature of the objects above their Curie point.

3. In an apparatus for heat treating ferrous metal objects having magnetic properties the combination of an elongated furnace element forming a passage, said furnace element having an inlet adjacent one end of said passage and an outlet adjacent the other end of said passage, means to deliver said objects to said inlet, means disposed around said furnace element to create an alternating magnetic field in a portion of said passage adjacent said inlet whereby objects in said portion are retained therein by said magnetic field and are inductively heated until they have attained a temperature substantially corresponding to their Curie point when their magnetic properties dimish and they are released, means to transport said released objects from said first portion of said furnace and to deliver said objects to said outlet and means to further

heat said objects by conduction during their travel from said first portion to said outlet.

4. In an apparatus for heat treating metal objects possessing magnetic properties, the combination of an elongated furnace element forming a passage, said furnace element having an inlet adjacent one end of said passage and an outlet adjacent the other end of said passage, means to deliver said objects to said inlet, second means forming a first zone in said furnace element adjacent said inlet, said second means being adapted to subject said objects to a magnetic field, magnetize and inductively heat said objects until the objects have attained a temperature substantially corresponding to their Curie point, third means forming a second zone in said furnace element positioned between said first zone and said outlet, said third means including an element formed from a metal having a higher Curie point than the objects, means to inductively heat said element to a temperature higher than the maximum temperature obtainable in the first zone, means to transport said objects through said second zone in close proximity to said element and to deliver said objects to said outlet whereby said objects are heated by conduction from said element during their travel from said first zone to said outlet.

5. In an apparatus for heat treating various metal objects having magnetic properties, the combination of a cylindrical furnace element forming a passage, said furnace element having an inlet and an outlet displaced axially from said inlet, a cobalt alloy liner positioned within said cylindrical furnace element adjacent said outlet whereby a first axial portion adjacent said inlet of said cylindrical furnace element extends beyond said cobalt alloy liner and a second axial portion of said cylindrical furnace element is concentric with said cobalt alloy liner, means to deliver said objects to said inlet, electrical conductors concentrically disposed around said cylindrical furnace element, means to transmit an alternating current through said conductors whereby a first magnetic field is formed in said first axial portion and said objects are drawn from said inlet into said portion and inductively heated until they have attained a temperature substantially corresponding to their Curie point and their magnetic properties diminished, means to transport said objects through said cobalt alloy liner from said first axial portion to said outlet, said electrical conductors being adapted when energized to create a second magnetic field in said cobalt alloy liner whereby said liner is inductively heated

to its Curie point and the objects being transported through said liner are further heated by conduction from said liner.

6. A method of heat treating a plurality of metal objects which have magnetic properties comprising feeding individual objects into a magnetic zone, magnetizing said objects in said zone and simultaneously agitating said objects to accumulate a mass of said individual objects therein, inductively heating said mass of objects in said magnetic zone with a current frequency between 180 to 500 cycles per second, continuing said heating until the individual objects become magnetically nonadherent and separate from said mass, and then positively moving the objects out of said zone.

7. A method of heat treating a plurality of metal objects which have magnetic properties comprising feeding individual objects into a magnetic zone, magnetizing said objects in said zone and simultaneously agitating said objects to accumulate a mass of said individual objects therein, inductively heating said mass of objects in said magnetic zone with a currrent frequency between 180 to 500 cycles per second, continuing said heating until the individual objects become magnetically nonadherent and separate from said mass, then positively moving the objects out of said zone into and through a second zone, inductively heating the second zone, and conductively heating the individual objects to a predetermined temperature above their Curie points while moving said objects through said second zone.

EDGAR L. BAILEY.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
686,836	Ruthenburg	Nov. 19, 1901
995,636	Ruthenburg	June 20, 1911
1,296,896	Wright	Mar. 11, 1919
1,412,484	Mordley	Apr. 11, 1922
1,538,365	Willson	May 19, 1925
1,687,656	Brown	Oct. 16, 1928
1,732,917	Summey	Oct. 22, 1929
1,734,536	Sorrel et al.	Nov. 5, 1929
1,747,934	Heidenhain	Feb. 18, 1930
1,782,359	Linnhoff	Nov. 18, 1930
1,799,102	Kelley	Mar. 31, 1931
2,286,024	Tama et al.	June 9, 1942