Sept. 26, 1961 J. K. LANCASTER ET AL 3,002,083

HEAT TREATMENT OF METALS IN AN ELECTROLYTIC BATH

Filed Oct. 22, 1959 2 Sheets-Sheet 1

FIG.1

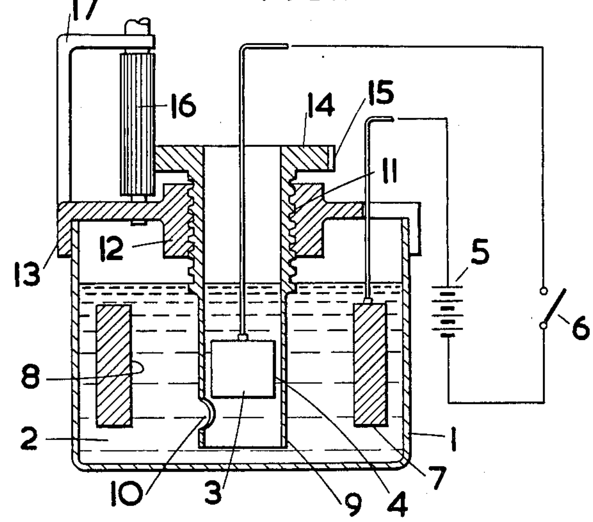
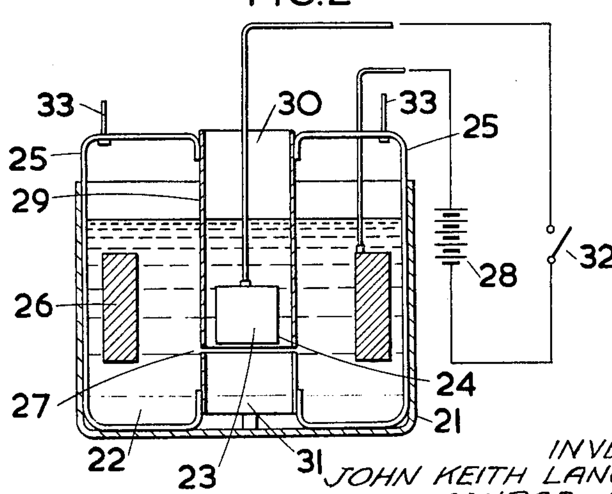


FIG.2



INVENTORS
JOHN KEITH LANCASTER
DAVID CONRAD MILNER
WALLACE HIRST
ATTORNEY

HEAT TREATMENT OF METALS IN AN ELECTROLYTIC BATH

Filed Oct. 22, 1959 2 Sheets-Sheet 2

FIG.3

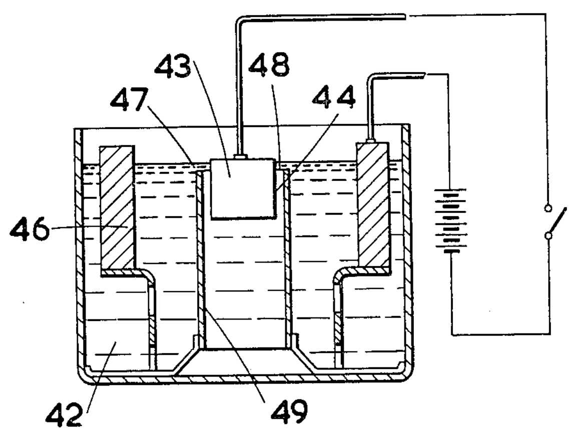
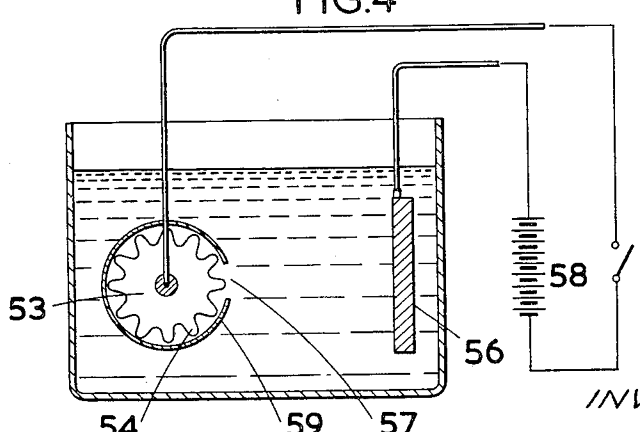


FIG.4



INVENTORS
JOHN KEITH LANCASTER
DAVID CONRAD MILNER
WALLACE HIRST

Miles A. Gillam

ATTORNEY

United States Patent Office

3,002,083

Patented Sept. 26, 1961

1

3,002,083

HEAT TREATMENT OF METALS IN AN ELECTROLYTIC BATH

John Keith Lancaster, Tilehurst, Reading, David Conrad Milner, Reading, and Wallace Hirst, Tadley, England, assignors to The British Thomson-Houston Company Limited, London, England, a British company

Filed Oct. 22, 1959, Ser. No. 847,922
Claims priority, application Great Britain Oct. 24, 1958
10 Claims. (Cl. 219—121)

This invention relates to the heat treatment of a metal object in an electrolytic bath.

It is known that when a metal object is made the cathode in an electrolytic bath containing an aqueous solution of a suitable salt, e.g. a 10% sodium carbonate solution, and a sufficiently high voltage is applied to the anode, a high current discharge will occur across a thin gas or vapour envelope which forms around the cathode. To obtain this discharge, the cathode area must be smaller than that of the anode. The heat liberated during the discharge is transferred mainly to the cathode and the method can be used for effecting rapid heat treatment of metals since rates of heating can be achieved in excess of those which can be produced by conventional means, such for instance as flame-heating. One disadvantage of this electrolytic method of heat treatment is that the electrical power required to provide a given rate of heating increases with the area of metal to be heated. Another disadvantage is that if the heat treatment is to be confined to the surface layers of the object being treated, as required for example in surface hardening, it is necessary that the electrical discharge should be maintained for only a relatively short time of the order of a few tenths of one second or less. This requirement has hitherto necessitated the use of complex high power electrical switching equipment.

According to the present invention, in a process for the heat treatment of a metal object as a cathode in an electrolytic bath containing an anode, there is interposed between the object and the anode an insulating shield the shape and/or position of which is such as to leave unshielded from the anode a relatively small area of the object through which a heating discharge can take place.

The invention also includes apparatus for carrying out such a process comprising an electrolytic bath in which an object can be immersed in a suitable electrolyte, an anode in said bath, a terminal to which said object can be connected as cathode and an insulating shield interposable between said anode and said object and effective by virtue of its shape and/or position to leave unshielded from the anode a relatively small area of the object through which a heating discharge can take place.

Thus as will be more fully considered later the shield may be formed with a small aperture, or may be constituted by two shielding members with a small gap between them, or may be positioned slightly below the surface of the electrolyte to define said area between the shield and the electrolyte surface.

By using an insulating shield in this way, it becomes possible to heat objects of various sizes using a relatively small source of electrical power, and at the same time to control the depth of heat penetration into the metal object without requiring the use of complex switching equipment.

The insulating shield may be made from Pyrex glass, or from impervious refractory materials such as recrystallised alumina, mullite and others. It is not necessary for the inner surface of the insulating shield around the edge of the unshielded area to be in contact with the cathode as constituted by the object being treated. It

2

is found that the distance of separation may be as much as three-eighths of an inch, although a smaller distance of about one-tenth of an inch may be preferable. The actual size of the unshielded area depends upon the total power available for maintaining the discharge, but it appears that its least dimension should preferably be several times the distance between the cathode and the outer surface of the insulating shield. There also appears to be a lower limit to the size of the area below which resistance heating in the electrolyte impedes the formation of a stable gas or vapour envelope and prevents the establishment of a continuous discharge. For a circular aperture in the shield and a 10% sodium carbonate electrolyte solution, this lower limit appears to be about one-quarter of an inch in diameter. The shield should be so arranged that bubbles forming in the liquid escape readily, otherwise such bubbles may increase the resistance of the electrolyte causing the discharge to become unstable. It is convenient for this purpose to provide an insulating shield that is as thin as possible and to arrange the insulating shield to be vertical and open at its upper end. Alternatively, arrangements can be made to agitate or circulate the electrolyte to facilitate the escape of excess bubbles to the surface of the electrolyte.

The invention will now be more fully described with reference to the accompanying drawing in which FIGS. 1 to 4 show, by way of example, alternative forms of the apparatus for carrying the invention into effect.

Referring in the first instance to FIG. 1, a bath **1** contains an electrolyte **2** formed by an aqueous solution of a suitable salt, for example a 10% sodium carbonate solution. A cylindrical metal object **3** the annular surface **4** of which is to be heat treated is submerged in the electrolyte **2**, and is connected to the negative pole of a direct current source **5** by way of a switch **6**. A hollow cylindrical electrode **7** is also submerged in the electrolyte **2** with its inner surface **8** surrounding and spaced apart from the annular surface **4** of the object **3**. The electrode **7** is connected to the positive pole of the direct current source **5**. Interposed between the electrode **7** and the object **3**, and closely surrounding the latter, is a hollow cylindrical shield **9** of insulating material, for example Pyrex glass, said shield **9** having a small circular aperture **10** therein. The outer annular surface of the shield **9** is provided with a riser thread **11** arranged to co-operate with a threaded portion on the inner surface of a cylindrical bush **12** formed integral with a cylindrical bath cover **13**. The upper end of the shield is provided with a flange **14**, carrying gear teeth **15**, arranged to co-operate with a driving gear spline **16** rotatably supported between the cover **13** and an L-shaped bracket **17** fastened thereto.

To heat treat the surface of the metal object **3** the switch **6** is closed causing an electric discharge to occur between the electrode **7** which forms an anode and the object **3** which forms a cathode, said discharge occurring across a gaseous envelope which is then formed around that portion of surface **4** which is in the immediate vicinity of the aperture **10**. The driving gear spline **17** is then rotated causing the shield **9** to rotate, so that the riser thread co-operates with the threaded portion of the bush **12**. The aperture **10** pases over successive portions of the surface **4** in a substantially helical path so that the whole of the surface **4** is eventually subjected to the heating effect of the discharge.

Referring now to FIG. 2, a cylindrical metal object **23** the annular surface **24** of which is to be heat treated, is submerged in an electrolyte **22** contained in a bath **21**, with the surface **24** vertically disposed and surrounded by an insulating shield **29** formed by two tubular insulating members **30** and **31** which are supported by thin but rigid spiders **25** so that there is a small gap **27** between the adjacent ends of the members **30** and **31**. An annular electrode **26** is submerged in the electrolyte **22** surrounding said shield **29** and connected to the positive pole of a source of direct current **28** the negative pole of which is connected to the object **23** by way of a switch **32**. Lifting pins **33** are attached to the spiders **25** to enable the shield **29** to be moved axially with respect to the object **23**.

In order to heat treat the surface **24** the shield **29** is moved axially by means of the lifting pins **33** until the gap **27** is opposite to the lower end of the object **23**. The switch **32** is then closed causing an electric discharge to take place across a gaseous envelope which then forms about that portion of the surface **30** in the immediate vicinity of the gap **27**. By raising the shield **29** by means of lifting pins **33** the discharge is caused to traverse the whole of the surface **30** so that successive portions of the surface **30** are subjected to the heating effects thereof. It will be appreciated that the shield may be suitably shaped to treat objects having cross sections other than circular, for example triangular, rectangular, polygonal or irregular figures.

In the arrangement shown in FIG. 3 a tubular insulating shield **49** is interposed between the object **43** and annular electrode **46**, and is supported with its upper end **48** just below the surface of the electrolyte **42** to leave a gap **47** through which a discharge can take place. The whole of the surface **44** to be heat treated is subjected to the heating effects of the discharge by raising the object **43** relative to the gap **47**.

An arrangement for heat treating the teeth of a gear wheel is shown in FIG. 4. The gear wheel **53** is rotatably mounted within an insulating shield **59** having an aperture **57** in its annular surface of suitable size to expose one of its teeth **54**. An electrode **56** is positioned opposite to the aperture **57** and a direct current source **58** applied between the electrode **56** and gear wheel **53** to cause an electric discharge to occur across a gaseous envelope which then forms around the exposed tooth **54**. By rotating the gear wheel **53** each tooth **54** may be subjected to the electrical discharge for a given time, the length of time determining the depth of heating. At the end of this time the heated tooth **54** is quenched both by conduction of heat away through the base of the tooth and also by collapse of the gaseous envelope which permits contact with the relatively cold electrolyte **42**. It is possible in this way either to surface harden or to completely harden the teeth of gear wheels of relatively large size, for example gear wheels used in marine engineering, using only a moderate source of electrical power.

It has been found advantageous to agitate or circulate the electrolyte to facilitate the escape to the surface of the electrolyte of bubbles which might otherwise congregate around the gap or aperture. Such bubbles if permitted to remain in the vicinity of the gaseous envelope may increase the resistance of the electrolyte and cause the discharge to become unstable. A preferable method of assisting the escape of the bubbles is to employ a pump to circulate the electrolyte through the gap or aperture as the case may be, the direction of flow of the electrolyte being from anode towards the cathode.

In order to achieve heating throughout the body of a metal object, it is necessary to scan its surface at a relatively low speed of the order for instance of one-tenth of an inch per second or less. The actual speed used will depend upon the shape and size of the object and of the unshielded area, upon the thermal conductivity of the metal, and upon the electrical power available. When applying the method of the invention to surface heating however, for which the depth of heat penetration has to be controlled, it is necessary to employ a greater speed of relative movement between the metal object and the unshielded area. As the speed increases, the depth of heat penetration decreases, but for given power input the surface temperature also decreases. As a typical

example, using a rectangular aperture of one square centimetre for a steel object which, in comparison, is relatively large in size, an increase in relative speed of movement between them from 0.1 cm./sec. to 1 cm./sec. would require a threefold increase in the power input to maintain the same surface temperature. Theoretically, if the power input was adjusted to maintain the steel surface at 900° C. the depth below the surface at which the temperature is 600° C. would decrease from 0.6 cm. at a speed of 0.1 cm./sec. to 0.04 cm. at 10 cm./sec. It is evident that by controlling the power input in conjunction with the speed of movement between the object and the unshielded area to which the discharge is restricted, it is possible to vary the depth and intensity of heating over a considerable range.

A particular advantage of heating in an electrolyte is that the heating occurs in a non-oxidising atmosphere. If at the end of the required heating period the anode-cathode voltage is reduced to a small finite value, for example fifty volts, rather than zero, the resultant liberation of hydrogen at the cathode prevents appreciable oxidisation during quenching. It therefore becomes possible if so desired, to dispense with the final descaling treatment usually necessary after hardening by other heat treatment methods.

What we claim is:

1. A process for the heat treatment of a metal object, comprising the steps of immersing said object in an electrolytic bath containing an anode, interposing between said object and said anode an insulating shield so as to leave unshielded from the anode only a relatively small area of said object, and thereafter applying a sufficiently high voltage between said anode and said object to cause an electric discharge to be produced across a gas or vapour envelope that is then formed at the unshielded area, said discharge being effective to heat said area to a high temperature.

2. A process according to claim 1 in which relative movement is effected between said shield and said object to cause successive areas of said object to be subjected to said discharge.

3. Apparatus for the heat treatment of a metal object comprising an electrolytic bath in which an object can be immersed in a suitable electrolyte, an anode in said bath, a terminal to which said object can be connected as cathode, and an insulating shield interposed between said anode and said object and defining within the electrolyte a gap through which a relatively small area of the object is unshielded from the anode and through which a heating discharge can therefore take place.

4. Apparatus according to claim 3 in which means are provided for effecting relative movement between said shield and said object.

5. Apparatus for the heat treatment of a metal object comprising an electrolytic bath in which an object can be immersed in a suitable electrolyte, an anode in said bath, a terminal to which said object can be connected as cathode, and an insulating shield interposed between said anode and said object, said shield being formed with an aperture through which a relatively small area of the object is unshielded from the anode and through which a heating discharge can therefore take place.

6. Apparatus as claimed in claim 5 in which means are provided for effecting relative movement between said shield and said object.

7. Apparatus for the heat treatment of a metal object comprising an electrolytic bath in which an object can be immersed in a suitable electrolyte, an anode in said bath, a terminal to which said object can be connected as cathode, and an insulating shield interposed between said anode and said object, said shield comprising two shielding members positioned to define between them a gap through which a relatively small area of said object is unshielded from the anode and through which a heating discharge can therefore take place.

8. Apparatus as claimed in claim 7 in which means are provided for effecting relative movement between the object on the one hand and the two shielding members of the shield on the other hand.

9. Apparatus for the heat treatment of a metal object comprising an electrolytic bath in which a object can be immersed in a suitable electrolyte, an anode in said bath, a terminal to which said object can be connected as cathode and an insulating shield interposed between said anode and said object and having its upper extremity positioned just below the electrolyte surface so as to form a gap within the electrolyte through which a relatively small area of the object is unshielded from the anode and through which a heating discharge can therefore take place.

10. Apparatus as claimed in claim 9 in which means are provided for moving said object relatively to said shield.

References Cited in the file of this patent

UNITED STATES PATENTS

537,402	Burton	Apr. 9, 1895
2,202,758	Denneen	May 28, 1940
2,426,053	Roberds	Aug. 19, 1947
2,809,905	Davis	Oct. 15, 1957