MAGNETIC APPARATUS AND METHOD FOR DISLODGING AN OBJECT

Filed May 19, 1964

Fig 1

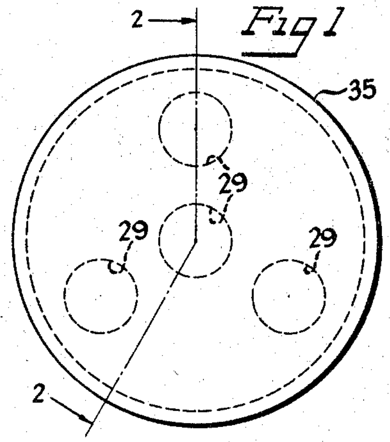


Fig 4

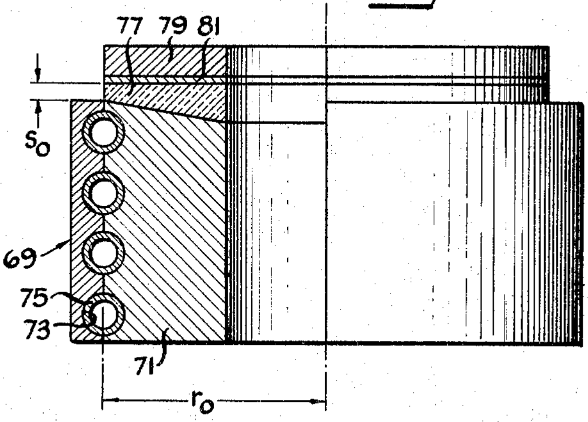


Fig 2

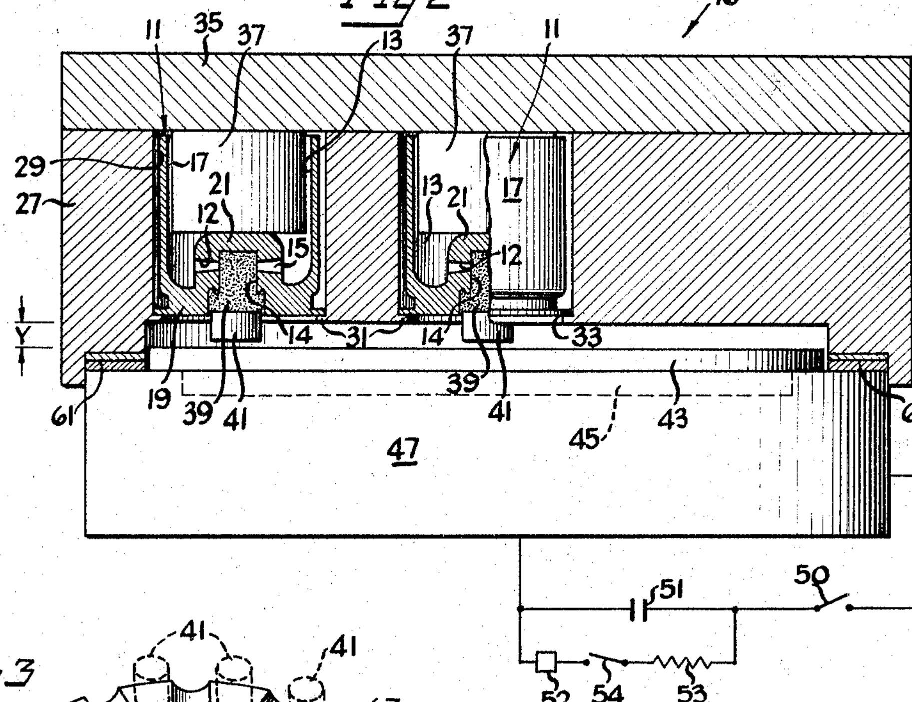
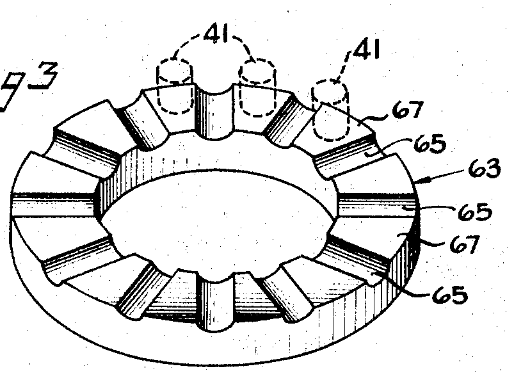


Fig 3



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MAGNETIC APPARATUS AND METHOD FOR DISLODGING AN OBJECT

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The present invention relates to methods and apparatus for applying a high energy impact to an object and, more particularly, to such methods and apparatus which utilize a pressure-transmitting material to effect the displacement or dislodgement of a secured object.

Energy produced by an intense, varying magnetic field has heretofore been utilized to perform work on various types of workpieces. For example, in U.S. Patent No. 2,976,907, a method and apparatus are disclosed for forming a conductive workpiece by utilizing an intense, varying magnetic field to induce an electromotive force in the workpiece itself. Siimilarly, a magnetic field has been utilized to form non-conductive materials by providing these materials with a conductive coating.

In other applications, the forming of a workpiece is accomplished by placing a pressure-transmitting medium intermediate the workpiece and a conductive force-applying member and a magnetic field is utilized either to move the conductive member, the medium and the workpiece as a unit toward a die, or is utilized to exert a force on a conductive member in contact with the medium, which force is transmitted directly through the medium to the workpiece. In the former instance, the conductive member, the medium and the workpiece all move in the direction of the die; in the latter instance, all of these elements remain relatively stationary.

It is occasionally desirable to transfer a large amount of energy to an object substantially instantaneously, as in the form of a sharp impact. An instance in which such an effect is desirable is, for example, in the displacement or dislodgement of objects from secured positions.

The present invention has for its principal object the provision of a method and apparatus for utilizing high intensity magnetic fields to achieve the substantially instantaneous transfer of a large quantum of energy between a workpiece and another object.

A further object of the invention is to provide an improved method and apparatus for displacing objects through the transfer of a large quantum of momentum effected through the use of high intensity magnetic fields.

Other objects and advantages of the invention will become apparent with reference to the following description and the accompanying drawings.

In the drawings:

FIGURE 1 is a plan view of a device showing various of the features of the invention;

FIGURE 2 is a partially schematic sectional elevational view taken generally along line 2—2 of FIGURE 1;

FIGURE 3 is a perspective view of an alternate form of a conductive element forming part of the device of FIGURES 1 and 2; and

FIGURE 4 is a sectional elevational view of a field-producing means particularly adapted to be utilized in the device of FIGURE 1.

Very generally, the illustrated embodiment of the invention is adapted to effect the substantially instantaneous transfer of a large quantum of energy, as in the form of momentum, to a given object or workpiece. In the illustrated embodiment, this energy is distributed uniformly to a surface of several workpieces.

In accordance with the invention, a mass of semi-rigid pressure transmitting material is disposed closely adjacent

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the object and a rigid element is disposed immediately adjacent to the mass. A body formed at least partially of a conductive material is disposed adjacent an exposed surface of the rigid element but spaced therefrom, and means are provided adjacent the conductive body for establishing an intense varying magnetic field which intersects the body and which is effective, when the field is established, to cause the body to move into engagement with the exposed surface of the rigid element. The body is relatively light in weight and the distance between the body and the rigid element is such that the body is capable of achieving a high momentum in traversing this distance. This energy is then transferred to the rigid element to and through the semi-rigid mass to the object upon engagement between the body and the rigid element.

In order to facilitate a clear understanding of the invention, there is illustrated in the drawing a specific application which has been found to be particularly advantageous in the manufacture of cartridge cases. As will be explained in further detail shortly, these cases, represented in the drawing by the numeral **11**, normally include a plurality of apertures **12** which extend between a chamber **13** for containing a principal charge and a cavity **14** for receiving a detonator. The apertures are formed by means of tapered pins **15** molded into the casing. These pins are subsequently removed to provide the apertures **12**, but their removal has always been a problem.

The removal of the pins **15** can be readily accomplished through the application of a high momentum impact thereto which, in the principal embodiment, is provided by a device **16** representing one embodiment of the present invention. It should be understood, however, that the device **16** as well as the invention has other applications, of which the one hereinafter described is merely illustrative.

Referring now in greater detail to the drawing, the cartridge cases **11** can be seen best in FIGURE 2 and each includes a generally cylindrical side wall **17** open at one end and closed at its opposite end by an end wall **19** to define the chamber **13** which will contain the principal charge (not shown). The end wall **19** includes an inwardly offset central portion **21**, the outer surface of which defines the cavity **14** to accommodate a detonator (not shown). Communication is provided between the detonator cavity **14** and the main chamber **13** by the plurality of apertures **12** which extend through the side walls of the offset central portion **21**. As previously mentioned, these apertures are formed by casting the pins **15** into the cartridge case and then subsequently removing them.

It will be appreciated that the pins **15** are not readily accessible, either from the cavity **14** or from the main chamber **13**, and that they are normally tightly held in place. Consequently, their removal is quite difficult. Heretofore, the removal has been accomplished by applying a pressure to a hydraulic fluid contained within the detonator cavity **14** to thus force the pins out of the apertures. While this method of pin removal has proven to be of reasonable utility in certain circumstances, it failed completely if one of the pins was relatively loose or became loosened before the others since this would allow the hydraulic fluid to escape through the single opened aperture. The remaining pins were, of course, then quite difficult to remove.

Referring now more specifically to the illustrated embodiment, in the utilization of the device **16** to effect removal of the pins **15**, the cartridge cases **11** are supported in a cylindrical holder **27** which is formed of a relatively heavy material so as to have a substantial inertia and which is provided with four generally cylindrical vertical holes **29**, one of which is located centrally of the holder and the remainder of which are spaced radially from the central hole and spaced circumferentially and in a uniform manner from one another. Each of the holes **29** is designed to receive one of the cartridge cases **11**, thereby rendering the device capable of removing the pins **15** from at least four of the cartridge cases **11** substantially simultaneously. In this regard, each hole is open at its upper end to permit insertion of one of the cylindrical cartridge cases, and is provided with an annular lip **31** at its lower end defining an upwardly facing shoulder **33**, thereby permitting the case **11** to be supported in a manner which leaves the greater portion of its end wall **19** exposed. The lower surface of the holder **27** is recessed to receive an impact applying means hereinafter described.

In order to secure the cartridge cases in place within the holes **29** and to prevent their displacement therefrom when a force is applied to the pins **15**, a hold down plate **35** is provided in overlying relation to the upper surface of the holder **27** and has four generally cylindrical holding plugs **37** depending from its lower surface and positioned so that one of the plugs extends downwardly into each of the holes **29** and rests upon the upper surface of the inwardly offset central portion **21** of the end wall **19**. The plugs **37** need not be secured to the plate **35**, of course, but when so secured, prevent lateral shifting of the plate.

In the illustrated embodiment, the removal of the pins **15** is accomplished by filling the cavity **14** of each of the cartridge cases with a pressure-transmitting material or medium **39** and by subsequently placing the material under a pressure through the application of a high momentum impact to the medium. Various deformable pressure-transmitting materials such as silicone rubber, beeswax, paraffin or a hydraulic fluid may be utilized and, of these, paraffin has been found to be preferable. A fluid such as water or oil may also be used but is not as desirable because of its greater tendency to escape through the apertures **12** and because of the necessity of providing seals.

The energy of the impact places the medium under intense pressure which transfers the energy in an instantaneous surge to the pins **15**, which are thus displaced. To facilitate the application of the impact to the paraffin, a small cylindrical piston **41** is positioned at the outer end of the cavity so as to be driven inwardly by the force of the blow. When a liquid is used as the pressure transmitting medium, seals may be placed around the pistons **41**.

The high momentum impact capable of displacing the pins **15** is applied to the pistons **41** by a hammer in the form of a flat plate **43** composed at least partially of a conductive material and preferably light in weight so as to enable it to achieve a high velocity over a short distance. Underlying the hammer **43** is a means **45** for establishing an intense magnetic field which intersects the hammer **43** and causes the hammer to be driven against the pistons **41** with sufficient energy to create the desired impact.

More specifically, the illustrated part holder **27** is supported upon a housing **47** which encloses a flat pancake-type coil which, in turn, provides the high intensity varying magnetic field desired. Various forms of coil constructions may be utilized but one which has been found to be satisfactory is that described in United States Patent No. 2,976,907. The coil **45** is connected by an appropriate switch such as an ignitron **50** to a capacitor bank **51**, which is charged by a high voltage source **52** connected across the capacitor bank **51**. A current limiting resistor **53** and switch means **54** are connected in series with the voltage source **52**.

As previously mentioned, the movable hammer **43** is in the form of a flat plate having a sufficiently small diameter to enabel it to fit comfortably within the recessed lower surface of the holder **27**. This recessed area of the holder is disposed above the coil **45** and the hammer rests upon the upper surface of the insulated coil when the device is not being utilized.

The distance between the upper face of the hammer plate **43** and the lower surface of the piston **41** of the cartridge case **11** is preferably sufficient to allow the plate to reach a high velocity and is designated by the letter Y. The space may be provided in part by recessing the lower surface of the holder **27**, as previously described, and may be varied by the use of spacers **61** between the part holder **27** and the coil **45**.

In the operation of the device, a high intensity current pulse is passed through the coil **45** and causes the hammer **43** to travel upwardly with a high velocity and, hence, to transfer a high momentum to the pistons **41**. The momentum imparted to the pistons **41** and then transmitted through the mass **39** of deformable material to the production pins **15** causes the pins to be ejected substantially instantaneously and, hence, simultaneously. The holding plugs **37** and the hold down plate **35**, of relatively high inertia, absorb the upwardly directed forces and prevent only appreciable upward movement of the cartridge cases **11** on impact. Thus the problem of the prior removal or loosening of one of the pins so as to dissipate the effectiveness of the device in removing the remaining pins is not present.

The mass of the hammer **43** and the amplitude of the current pulse are generally chosen so that the force exerted by the hammer **43** is large in comparison with the frictional resisting forces on the pins **15** for consistent and dependable removal of all pins. This is particularly important when a hydraulic fluid is used so that the initial impact forces will dislodge all of the pins substantially simultaneously, even if one pin is loose.

Since the impulse of force, although relatively high in magnitude, is only applied for a brief instant, the part holder **27** and the holddown plate **35** do not ordinarily require any additional support to withstand the force resulting from the hammer **43** striking the piston **41** as long as they are constructed of heavyweight materials and thus possess a relatively high inertia.

FIGURE 3 shows a modified form of hammer plate **63** which is in the form of a ring for use in applications in which the surfaces to be engaged by the hammer are not coextensive with the available surface of a flat hammer. Such an instance arises when a part holder is used which positions the cartridge cases with their centers on a circle. In the illustrated embodiment of the hammer **63**, portions of the upper surface of the plate or ring **63** are relieved so as to provide alternate valleys **65** and lands **67**. The hammer plate **63** and pistons **41** are so disposed with respect to each other that a land **67** is provided beneath each piston and a valley **65** between pistons. Thus, the mass of the hammer **63** is reduced in the area between the pistons, preventing buckling of the ring at these areas and concentrating the force applied to the pistons.

The illustrated hammer plate or ring **63** is made of a strong lightweight material. If a material such as titanium, which is not a good conductor, is used, the lower surface of the hammer is made up of a thin layer of lightweight conductive material such as aluminum.

In FIGURE 4 there is illustrated a coil **69** for use in the device **16** and which has been found to be particularly advantageous when used with a hammer in the form of a ring such as the hammer **63**. The coil **69** includes an annular core **71** having a helical groove **73** in its outer cylindrical surface to receive a hollow conductor **75** through which a coolant may be circulated. The upper annular surface of the core is tapered downwardly from its outer toward its inner periphery to provide a uniform field under the annular or ring-shaped hammer. The space between the hammer and the tapered surface of the core is filled with an insulator **77** such as plastic impregnated fibre glass which is formed so as to provide the coil with a flat upper surface upon which a hammer **79**, illustrated as provided with a conductive layer **81** on its lower surface, may rest.

Preferably, the spacing between the hammer and the top of the annular core varies by the relationship

$$S=\frac{s_0 r_0}{r}$$

where r_0 equals the radius defined by the conductor 75 of the coil, r equals the distance of any point on the upper surface of the annular core 71 from the center line of the coil, s_0 equals the vertical distance between the upper surface of the annular core 71 and the hammer 79, at a distance r_0 from the centerline of the coil, and S equals the vertical distance between the upper surface of the annular core 71 and the hammer 79 at a distance r from the centerline of the coil.

Various modifications and changes may be made in the illustrated structures without departing from the scope of the invention.

What is claimed is:

1. An apparatus for performing work on a relatively stationary object comprising a mass of deformable pressure-transmitting material disposed adjacent said object, a relatively rigid element movably disposed immediately adjacent said mass of deformable material, a conductive member movably disposed adjacent said relatively rigid element but spaced therefrom in a direction away from said mass, and means for establishing an intense varying magnetic field which intersects said member and which is effective, when said field is established, to cause said member to be driven in the direction of said element and said mass and to engage said element in such a manner that a sufficient degree of energy is transferred to and through said mass to said object to effect the desired work on said object.

2. An apparatus for displacing an object from a relatively stationary supported position, said apparatus comprising a mass of deformable pressure-transmitting material disposed adjacent said object, a relatively rigid element movably disposed immediately adjacent said mass of deformable material, a conductive member movably disposed adjacent said relatively rigid element but spaced therefrom in a direction away from said mass, and means for establishing an intense varying magnetic field which intersects said member and which is effective, when said field is established, to cause said member to be driven in the direction of said element and said mass and to engage said element in such a manner that a sufficient degree of energy is transferred to and through said mass to said object to effect the desired displacement of said object.

3. An apparatus for simultaneously displacing at least two objects from secured positions through the application of an intense, momentary impulse of force, said objects being adjacent to one another but requiring forces in different directions to displace them, said apparatus comprising a member formed at least partially of a conductive material and disposed so as to be adjacent to, but spaced from, each of said objects, a mass of confined deformable pressure-transmitting material disposed adjacent each of said objects to be displaced and intermediate said objects and said member, means for establishing an intense varying magnetic field which intersects said member and which is effective, when said field is established, to cause said member to be driven in the direction of said objects with a sufficient degree of energy to cause the desired displacement, and means for transferring said energy to said masses of deformable material so as to place said material under pressure and effect displacement of said objects.

4. A method for causing the sudden displacement of an object from a given position, which method comprises placing a movable member formed at least partially of a conductive material adjacent said object but spaced therefrom, establishing an intense, varying magnetic field which intersects said member and which is effective, when said field is established, to rapidly drive said member in the direction of said object with a sufficient degree of energy to cause the desired displacement, and interposing between said object and said member means for effecting transfer of said energy from said member to said object.

5. A method for simultaneously displacing at least two objects through the application of an intense, momentary impulse of force, the objects being disposed in relatively close proximity to one another and being subject to displacement by forces in different directions, said method comprising the steps of placing a mass of pressure-transmitting material adjacent to the objects which are to be displaced with the mass of material being substantially confined, placing a movable member formed at least partially of a conductive material adjacent said mass of pressure transmitting material but spaced therefrom, and providing an intense, varying magnetic field which intersects said member and which is effective, when said field is established, to rapidly drive said member against the pressure-transmitting mass so as to place the mass under pressure and thereby displace all of the objects substantially simultaneously.

6. A method for dislodging at least one object that is securely supported in an aperture in the wall of a chamber having a passageway extending thereinto, the aperture extending transversely to the passageway into the chamber, said method comprising the steps of disposing a mass of deformable pressure-transmitting material within the chamber, disposing a body formed at least partially of a conductive material adjacent to the deformable material but spaced therefrom, establishing an intense, varying magnetic field which intersects said body and which is effective, when said field is established, to rapidly drive the body in the direction of said mass of deformable material, and effecting transfer of the energy of said driven body to said mass of deformable material so as to pressurize same and dislodge the object from the aperture.

7. A method for dislodging at least two objects securely supported in apertures in the wall of a chamber having a passageway extending thereinto, the apertures extending transversely to the passageway into the chamber, said method comprising the steps of disposing a quantity of deformable pressure-transmitting material within the chamber, disposing a body including a conductive face adjacent the chamber and the deformable material and movable through the passageway of the chamber against the material, establishing an intense, varying magnetic field which intersects the conductive face of the body and rapidly drives the body against the material to pressurize it and dislodge all of the objects substantially simultaneously.

8. An apparatus for displacing at least two elongated objects from elongated spaced-apart apertures in side walls of a cavity that is open at one end, the apertures extending generally transversely to the side walls, said apparatus comprising a mass of deformable pressure-transmitting material adapted to be displaced in the cavity, a piston disposed in said open end of said cavity outwardly of said deformable material and movable toward said deformable material, a hammer plate spaced from said piston opposite said deformable material and having a conductive face and means adjacent to said hammer plate for establishing an intense, varying magnetic field which rapidly drives the hammer plate against said piston with a momentary, intense impact, said deformable material being thereby pressurized to transmit an impulse of force to said objects substantially at the same time and in directions transverse to said impulse of force, whereby all of said objects are displaced from their respective apertures.

9. An apparatus for displacing a plurality of objects from relatively stationary positions, said apparatus comprising means positioning said wall structures with their centers lying in a circular pattern, a mass of deformable pressure-transmitting material disposed adjacent each such wall structure in the vicinity of said object, a relatively

rigid element movably disposed immediately adjacent each mass of deformable material, a conductive member including a ring having an outer diameter greater than the diameter of the circular pattern defined by the centers of said wall structures and having a surface formed to define at least one raised portion for each of said rigid elements, said ring being movably positioned adjacent said relatively rigid elements but spaced therefrom with its raised portions disposed so as to engage said rigid elements when said member is moved to said elements, and means for establishing an intense varying magnetic field which intersects said member and which is effective, when said field is established, to cause said member to be driven in the direction of said elements and objects and to engage said elements in such a manner that a sufficient degree of energy is transferred to and through said mass to said objects to effect the desired displacement of said objects.

10. In an apparatus for moving an annular conductive member into engagement with a stationary object to accomplish work, means for establishing a uniform high intensity magnetic field for moving the member comprising a core of annular configuration, the surface defining one end of the core being tapered inwardly from the outer cylindrical surface toward the longitudinal axis thereof, said tapered portion being filled with an insulating material to provide said core with an end lying substantially in a flat plane, and a conductor surrounding said core.

11. In an apparatus for moving an annular conductive member into engagement with a stationary object to accomplish work, means for establishing a uniform high

intensity magnetic field for moving the member comprising a core of annular configuration, and a conductor surrounding said core, the surface defining one end of the core being tapered inwardly from the outer cylindrical surface toward the longitudinal axis thereof according to the relationship

$$S=\frac{s_0 r_0}{r}$$

where r_0 equals the radius defined by the conductor of the coil, r equals the distance of any point on the upper surface of the annular core from the center line of the coil, s_0 equals the vertical distance between the upper surface of the annular core and the annular conductive member at a distance r_0 from the centerline of the coil, and S equals the vertical distance between the upper surface of the annular core and the annular conductive member at a distance r from the centerline of the coil, said tapered portion being filled with an insulating material to provide said core with an end lying substantially in a flat plane.

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