Nov. 21, 1961 J. I. JONES ET AL 3,009,727

PERMANENT MAGNET LIFTING DEVICE

Filed Nov. 27, 1957 3 Sheets-Sheet 1

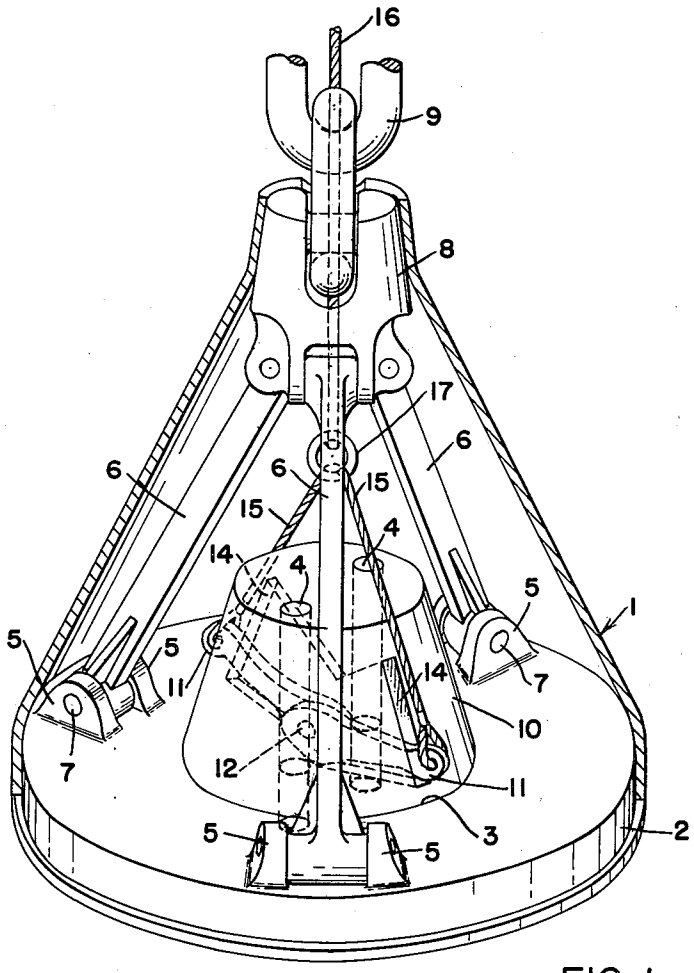

FIG. 1

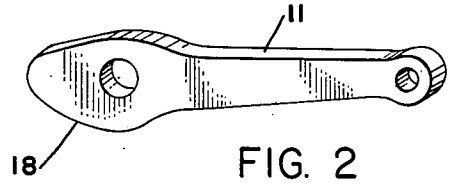

FIG. 2

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Filed Nov. 27, 1957 3 Sheets-Sheet 2

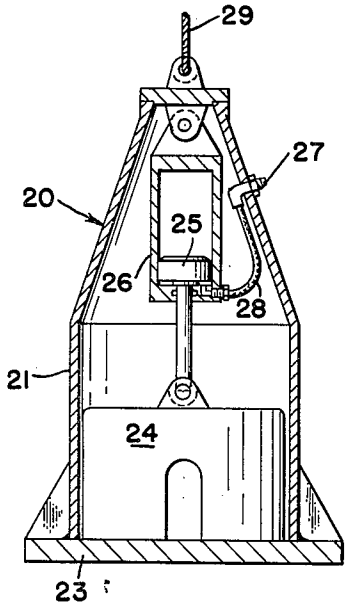

FIG. 3

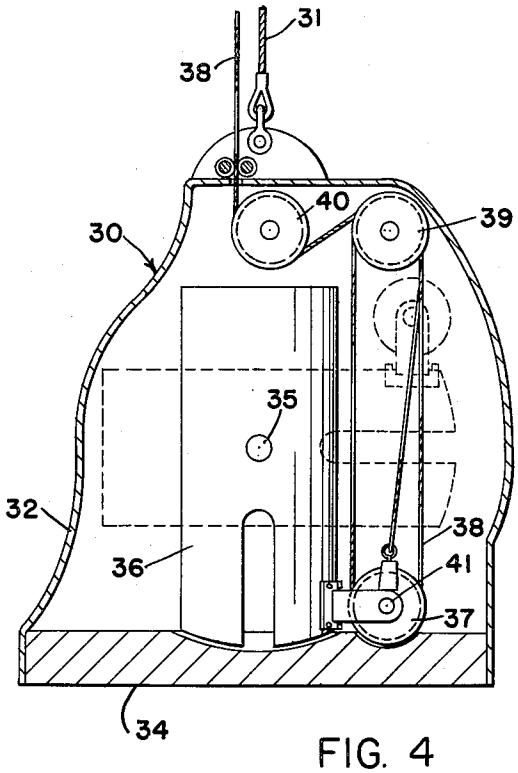

FIG. 4

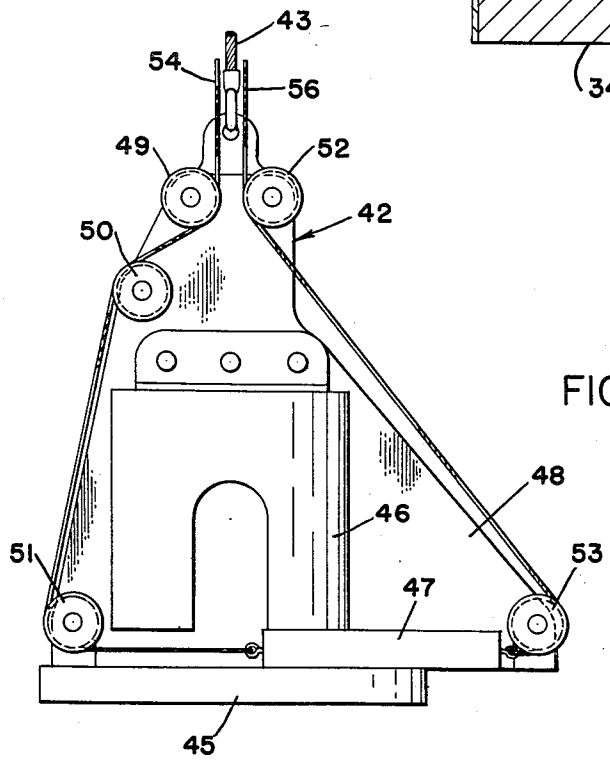

FIG. 5

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Nov. 21, 1961 J. I. JONES ET AL 3,009,727

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Filed Nov. 27, 1957 3 Sheets-Sheet 3

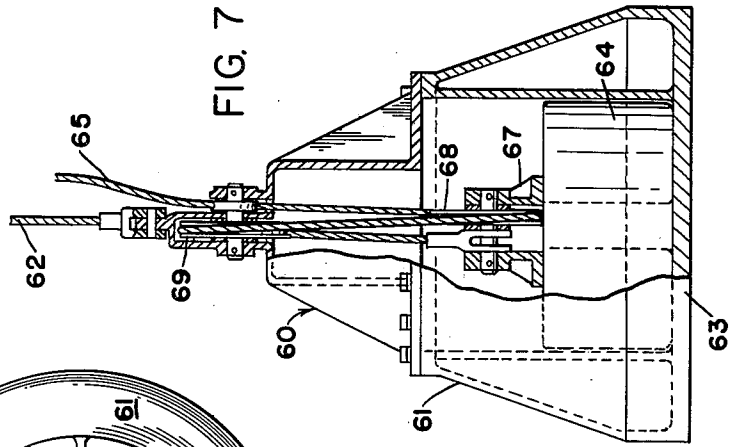

FIG. 7

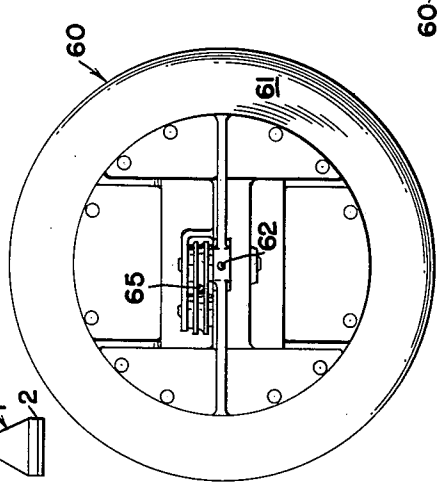

FIG. 8

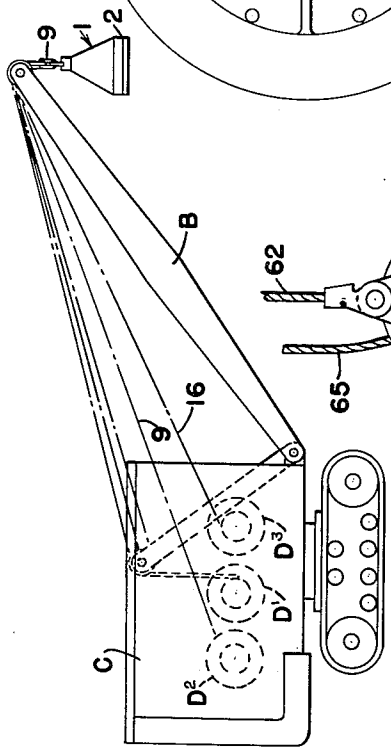

FIG. 9

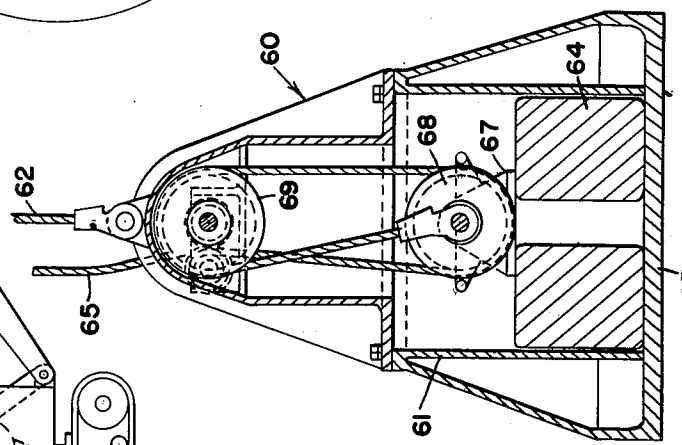

FIG. 6

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PERMANENT MAGNET LIFTING DEVICE

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Filed Nov. 27, 1957, Ser. No. 699,361

8 Claims. (Cl. 294—65.5)

The present invention relates generally as indicated to a permanent magnet lifting device and more particularly to a lifting magnet for cranes for handling magnetic materials such as pig iron, scrap iron, castings, billets, tubes, rails, plates, and the like.

At the present time substantially all of the lifting magnets for cranes that are in use are of the electromagnetic circular or bipolar type for respectively handling pig iron, scrap, and similar detached material, or for handling rails, beams, and similar products.

Circular type magnets comprise a steel case inside of which is placed strap copper or like windings, a brass or like non-magnetic bottom plate to make the joint watertight, and a non-magnetic wear plate as of manganese steel. Furthermore, particular care must be used not only at the bottom plate joint but also at the terminals in order to seal the electromagnets from the elements; since such crane magnets are most often employed out of doors in unprotected areas. Circular magnets can be used for underwater service, but obviously extra precautions are required at the terminals and elsewhere to exclude water.

Moreover, electromagnets, whether of the circular type or of the bipolar type, require the employment of a high grade and expensive flexible electric cable, and associated cable take-up means and switch gear.

The electromagnets of the character indicated usually are operated on direct current of relatively high voltage, for instance, 230 volts and in the case of large size magnets the power consumption may be 15 kilowatts or more. Aside from the necessity of providing the high voltage electric power source there is the inherent danger of the electric cable being tangled or broken, which presents a hazard not only with reference to the possibility of electric shock but also with reference to property damage and personal injury due to dropping of the load in the event of electric cable breakage.

With the foregoing in mind, it is a principal object of this invention to provide a permanent magnet lifting device that is characterized by its simplicity and lightweight construction.

Another object of this invention is to provide a permanent magnet lifting device in which the magnet carrier is mounted on a flexible suspension means (a chain or cable, for example) for raising and lowering with respect to the crane boom and in which the permanent magnet is rendered operative to lift and to release the load irrespective of the elevation of the carrier.

Another object of this invention is to provide a permanent magnet lifting device in which the magnet carrier is mounted on a flexible suspension means for raising and lowering with respect to the crane boom, in which the permanent magnet is movably mounted on the carrier, and in which means are provided to react against the carrier itself to move the magnet to load releasing position with respect to the carrier.

Another object of this invention is to provide a permanent magnet lifting device in which the magnet carrier is mounted on a flexible suspension means for raising and lowering with respect to the crane boom, in which the permanent magnet is fixedly mounted in the carrier, and in which a magnetic field short-circuiting member is movably supported by the carrier for insertion between the magnet and the carrier to release the load.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of a few of the various ways in which the principle of the invention may be employed.

In said annexed drawings:

FIG. 1 is a perspective view of one form of permanent magnet lifting device which includes cam links for shifting the permanent magnet from load-lifting position to load-releasing position;

FIG. 2 is a perspective view of one of the cam links employed in the FIG. 1 embodiment;

FIG. 3 is a central vertical cross-section view of another embodiment of this invention in which the magnet is shifted from load-lifting to load-releasing position by means of a hydraulic motor, the arrangement being such that even if the fluid hose were broken the load would not be accidentally released;

FIG. 4 is a similar central vertical cross-section view of yet another embodiment of this invention wherein the permanent magnet is swung from vertical lifting position to horizontal load-releasing position;

FIG. 5 illustrates still another embodiment of the invention wherein a magnetic flux short circuiting plate is shifted under the magnet when it is desired to drop the load;

FIG. 6 is a central vertical cross-section view of an embodiment of the invention that is similar to FIG. 3 except that a cable and pulley arrangement is employed for vertically moving the magnet from load-lifting to load-releasing position;

FIG. 7 is a side elevation view as viewed from the right-hand side of FIG. 6;

FIG. 8 is a top plan view as viewed from the top of FIG. 6; and

FIG. 9 is a schematic line drawing of a crane embodying the present invention.

Referring now more particularly to the drawings and first to the form of the invention illustrated in FIGS. 1 and 2, and also in FIG. 9, the same comprises a carrier 1 that includes a nonmagnetic contact plate 2. The contact plate 2 may be formed with a central recess or depression 3 from the bottom of which guide posts 4, 4 project upwardly, said plate 2 at uniformly spaced points therearound being formed with ears or lugs 5 for connection of links 6 thereto as by means of the pins 7. These upwardly converging links 6, in turn, have their upper ends pinned to a lifting head 8 to which the lower end of the suspension means 9 is secured. The other end of the suspension means 9 is connected to the tip of a crane boom (see FIG. 9) in such manner that the carrier 1 may be raised or lowered either by raising or lowering the boom B by operation of boom hoist drum D^1 on the crane cab C or by drawing in or letting out the means 9 by operation of drum D^2.

A permanent magnet 10 has its lower end fitted into the recess 3 of the plate 2 and has holes that are vertically slidably fitted on the respective posts 4, 4.

Normally, the permanent magnet 10 by its own weight rests on the bottom of the recess 3 and when the contact plate 2 is lowered down to come into contact with the load to be lifted, the magnetic flux holds the load against the bottom surface of the plate 2. Thus, the carrier 1 as a whole may be raised and shifted laterally by manipulation of the chain 9 and the crane boom.

When it is desired to release or drop the lifted load, all that it is necessary to do is to move the permanent magnet **10** upwardly with respect to the contact plate **2** to thus form an air gap which so reduces the flux density at the bottom surface of the plate **2** that the load is released.

In FIGS. 1 and 2 such upward movement of the permanent magnet **10** with respect to the plate is effected by the cam links **11** which have their inner ends pivotally connected to the magnet **10** by the pin **12** for swinging in a vertical plane in the respective slots **14** formed in the magnet. Each link has its outer end hingedly connected to a rod or cable **15** and, in turn, the rod **15** is secured to a cable **16** through the connecting ring **17**. As best shown in FIG. 2 each link **11** is formed with a cam surface **18** which engages the bottom of recess **3** and which is of a form to initially produce a high mechanical advantage responsive to upward swinging thereof to thus readily break the contact of the magnet **10** away from the bottom of the recess **3** in the plate **2** . As is well-known, the force required to continue the breaking away decreases in inverse proportion to the square of the distance and therefore, after the initial break-away, the cam surfaces **18** are shaped to cause greater movement but with less mechanical advantage. By reason of this arrangement only a relatively small upward force on cable **16** is required to move the magnet **10** to load releasing position. This upward force being much less than the weight of the carrier **1** and of the lifted load, if any, permits load release at any elevation of the carrier **1** without requiring a stop for the latter or a rigid connection with the boom. The cable **16** may be manipulated as by operation of drum D^3 as shown in FIG. 9.

In the form of the invention illustrated in FIG. 3, there is provided carrier **20** in the form of a hollow casing **21** which has a nonmagnetic contact plate **23** and in which is vertically reciprocable the permanent magnet **24**. The magnet **24** is connected to the lower end of the piston rod of a piston **25** which piston is reciprocable in the cylinder **26**, the latter being connected at the upper end of the casing **21**. In the present case, the cylinder **26** is of the single acting type, whereby, when fluid under pressure is admitted through fitting **27** and hose **28** underneath the piston **25**, the magnet **24** will be lifted away from the contact plate **23** to thereby release the load. It is to be noted that when the load is lifted the permanent magnet **24** remains down in its operating position by its own weight, whereby there is no danger of inadvertent release of the load even through the fluid pressure system becomes inoperative.

It is to be understood that in the FIG. 3 embodiment it will be preferred to employ a hose reel on the crane boom for reeling in the hose as the carrier **20** is raised, and for this purpose a conventional form of reel may be employed in which fluid under pressure is supplied through a hollow shaft upon which the reel is journalled, whereby fluid may be conducted to the cylinder **26** regardless of the position of the carrier.

An important feature of the FIG. 3 embodiment, and the other embodiments as well, is that the carrier **20** supplies the reaction to the force required to move the magnet **24** whereby the carrier **20** may be suspended from the boom as by the flexible suspension means or cable **29** and load release may be effected at any elevation of the carrier **20**.

With reference to the embodiment shown in FIG. 4, there is provided a carrier **30** suspended from cable **31** and formed as a hollow casing **32** having a nonmagnetic contact plate **34** and swingably mounted on the pivot **35** and inside the casing **32** is the permanent magnet **36**. To one side, adjacent the lower end of said magnet **36** is mounted a pulley **37** with a cable **38** trained thereover and over the pulleys **39** and **40** fixedly mounted in the casing in a manner such that when upward pull is applied on the cable **38**, the magnet **36** is swung to its load-releasing position, as shown in dotted lines in FIG. 4. The end of cable **38** is secured to the bracket **41** for

pulley **37** and, as evident, the cable and pulley arrangement provides a mechanical advantage so that the upward force on cable **38** is less than the weight of the carrier **30** and the load, if any, whereby load releasing movement of the magnet **36** may be effected at any elevation of the carrier **30**. Moreover, the lower end of the magnet **36** is moved generally perpendicular to the magnetic flux to reduce the break away force. Since the pivot **35** is above the center of gravity of the magnet **36**, the latter will return by gravity to load lifting position when the upward force on cable **38** is released.

In the form of the invention illustrated in FIG. 5, the carrier **42** of the lifting device is suspended from the cable **43** and comprises a nonmagnetic contact plate **45** above which is fixedly mounted a permanent magnet **46**, the space between the lower end of the magnet **46** and the bottom surface of the plate **45** being such that a load of desired magnitude may be safely lifted. In this case there is provided a magnetic short circuiting plate **47** which preferably is made of soft iron or other highly magnetic material, and when said short circuiting plate **47** is shifted to the left from the position shown to a position interposed between the permanent magnet **46** and the contact plate **45**, the magnetic flux short circuits through said plate **47** thereby releasing the load. In this case, the lifting device is provided with side plates **48** that carry a plurality of pulleys **49**, **50**, **51**, **52**, and **53** for the cables **54** and **56**. When the cable **54** at the left is pulled upwardly the short circuiting plate **47** will be pulled toward the left to its load-releasing position and when the cable **56** at the right is pulled upwardly the short circuiting plate **47** will be pulled to the right to the position shown in FIG. 5. Since the upward forces on cables **54** and **56** is small in comparison with the weight of the carrier **42** and magnet **46** and of the load, if any, the plate **47** is easily shifted to load releasing position at any elevation of the carrier **42**.

The embodiment of the invention depicted in FIGS. 6, 7 and 8, in a broad sense, resembles that disclosed in FIG. 3 in that there is provided carrier **60** formed as a hollow casing **61** suspended from cable **62** and having a nonmagnetic contact plate **63** and a vertically movable permanent magnet **64** which rests by gravity on said plate **63** when the lifting device is in its operating condition capable of lifting a load which is in contact with the bottom surface of the contact plate **63**. However, instead of employing a hydraulic cylinder **26** for raising the permanent magnet, as in FIG. 3, the permanent magnet **64** is raised by cable **65** which is secured to the pulley bracket **67** of the magnet **64** and which is wrapped around the pulleys **68** and **69**. The pulleys **68** and **69** are respectively fixedly mounted to the magnet **64** and to the upper end of casing **61** so that a mechanical advantage is achieved for raising the magnet **64** by exerting a much smaller upward force on cable **65**. Again, as in the other forms of the invention the magnet **64** may be lifted to load releasing position regardless of the height at which the carrier **60** is suspended by the suspension cable **62**.

The present invention is simple and economical both in initial and operating costs and moreover has the necessary attribute that the lifting device, even though suspended at different heights from the crane boom by flexible suspension means such as a cable or chain, for example, may be actuated to load-releasing position at any desired elevation.

The present invention has another important feature and that is that when, for instance, it is desired to lift only a predetermined number of steel plates from a stack the magnets **10**, **24**, **36**, **46**, or **64** may be shifted or rendered effective to reduce the magnetic flux to a value such that only the predetermined number of plates will be lifted. Thus, by drawing in cable **16** in FIG. 9 by operation of drum D^3 the magnet **10** in carrier **1** may be raised from contact plate **2** a predetermined amount. Similarly only a measured volume of fluid may be admitted in cylinder **26** to raise the magnet **24** a desired

distance from contact plate 23, and the cables 38, 54—56, and 65 may be actuated as by a drum D^3 (FIG. 9) to effect desired reduction in the strength of the magnetic field at their respective contact plates. Of course, once the predetermined load has been lifted, the magnet is allowed to move to its maximum load-lifting position to obviate the danger of dropping of the load or any part of it. By the same token, any part of a lifted load, as of steel plates, may be released from the lifting device simply by predetermined shifting of the magnet to release only the prescribed number of plates.

Still another important feature of the present invention is that an increased break away force may be applied to facilitate initial movement of the magnet to load-releasing position. In FIGS. 1 and 2 this is accomplished by using cam links 11 that are formed with cams 18 effective to apply a much multiplied separating force when the cable 16 is first drawn upwardly. In FIG. 3 this may be accomplished by pumping higher pressure fluid into cylinder 26 or by using a differential cylinder in which the fluid initially acts on a large diameter portion of a piston until the break away occurs and then acts on a small diameter portion of the piston to continue the raising of magnet 24. Of course in FIGS. 4 and 5 the force multiplying effect is achieved by transverse swinging and sliding of the respective magnet 36 and plate 47 and in addition by the cable and pulley arrangement (FIG. 4). In FIGS. 6, 7, and 8 force multiplication is brought about by the cable and pulley arrangement.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims, or the equivalent of such, be employed.

We therefore particularly point out and distinctly claim as our invention:

1. A permanent magnet lifting device for cranes and the like comprising a carrier having a contact plate at the bottom and flexible suspension means at the top by which said carrier may be raised and lowered with respect to the tip of a boom or the like; a permanent magnet movably mounted on said carrier from a position wherein its magnetic field is effective to hold a load of magnetic material against the bottom of said contact plate for lifting responsive to lifting of said carrier through said suspension means to a position wherein the strength of the magnetic field at said contact plate is reduced to an extent to release the load; and force increasing means operatively connected to said magnet and reacting against said carrier for so moving said magnet at any vertical position of said carrier, said force increasing means including an element providing a mechanical advantage to apply an increased break away force to said magnet relative to said contact plate initially to separate the magnet from the contact plate and load.

2. The lifting device of claim 1 wherein said permanent magnet is movable upwardly with respect to said contact plate and wherein said last-named means comprises pulleys fixedly mounted respectively on said carrier and said magnet, and a flexible cable strung around said pulleys to provide a mechanical advantage in moving said magnet upwardly by pull on said flexible cable.

3. A permanent magnet lifting device for cranes and the like comprising a carrier having a contact plate at the bottom and suspension means at the top; a permanent magnet movably mounted on said carrier and disposed above said contact plate and having a magnetic field effective, in one position of said magnet, to hold a load of magnetic material against the bottom of said contact plate for lifting responsive to lifting of said carrier through said suspension means; and means operatively connected to said magnet and reacting against said carrier for moving said magnet relatively away from said contact plate thereby reducing the strength of the effective magnetic field at said contact plate to release the load at any vertical position of said carrier, said last-named means including a force increasing element providing a mechanical advantage for applying an increased break away force to said magnet relative to said contact plate to initially separate the magnet from the contact plate and the load.

4. A permanent magnet lifting device for cranes and the like comprising a carrier having a contact plate at the bottom thereof and flexible suspension means at the top by which said carrier may be raised and lowered with respect to the tip of a boom and the like; a permanent magnet in said carrier disposed above said contact plate and having a magnetic field effective to hold a load of magnetizable material against the bottom of said contact plate for lifting responsive to lifting of said carrier through said suspension means; and means operatively connected to said magnetic lifting device to vary the air gap between said permanent magnet and said magnetizable material at any position of said carrier with respect to such boom for thereby varying the strength of said magnetic field between said permanent magnet and said magnetizable material, said last-mentioned means including a force increasing element to provide a high initial force to move said permanent magnet initially away from said magnetizable material.

5. A permanent magnet lifting device for cranes and the like comprising a carrier having a contact plate at the bottom and flexible suspension means at the top by which said carrier may be raised and lowered with respect to the tip of a boom or the like; a permanent magnet movably mounted on said carrier from a position wherein its magnetic field is effective to hold a load of magnetic material against the bottom of said contact plate for lifting responsive to lifting of said carrier through said suspension means to a position wherein the strength of the magnetic field at said contact plate is reduced to an extent to release the load; and means operatively connected to said magnet and reacting against said carrier at any position thereof with respect to the boom for so moving said magnet at any vertical position of said carrier, said permanent magnet being swingable about an axis such that its lower end moves upwardly and laterally away from said contact plate.

6. A permanent magnet lifting device for cranes and the like comprising a carrier having a contact plate at the bottom and flexible suspension means at the top by which said carrier may be raised and lowered with respect to the tip of a boom or the like; a permanent magnet movably mounted on said carrier from a position wherein its magnetic field is effective to hold a load of magnetic material against the bottom of said contact plate for lifting responsive to lifting of said carrier through said suspension means to a position wherein the strength of the magnetic field at said contact plate is reduced to an extent to release the load; and means operatively connected to said magnet and reacting against said carrier at any position thereof with respect to the boom for so moving said magnet, said permanent magnet being movable upwardly with respect to said contact plate, and said last-named means comprising a cam link movably carried by said magnet and having a cam surface engageable with said contact plate to impose a multiplied vertical separating force between said magnet and said contact plate when force is applied on said link to move the same, and means independent of said suspension means for so moving said link.

7. A permanent magnet lifting device for cranes and the like comprising a carrier having a contact plate at the bottom and flexible suspension means at the top by which said carrier may be raised and lowered with respect to the tip of a boom or the like; a permanent magnet movably mounted on said carrier from a position wherein its magnetic field is effective to hold a load of magnetic material against the bottom of said contact plate for lifting responsive to lifting of said carrier through said suspension means to a position wherein the strength

of the magnetic field at said contact plate is reduced to an extent to release the load; means operatively connected to said magnet and reacting against said carrier at any position thereof with respect to the boom for so moving said magnet at any vertical position of said carrier, said permanent magnet being swingably mounted on said carrier for swinging of the lower end of said magnet upwardly and laterally with respect to said contact plate about an axis between the upper and lower ends of said magnet, said last-named means comprising pulleys fixedly mounted respectively on said carrier and said magnet, and a flexible cable strung around said pulleys to provide a mechanical advantage in swinging said magnet by pull on said flexible cable.

8. The lifting device of claim 7 wherein the axis of swinging of said magnet is above the center of gravity

thereof whereby said one end of the magnet swings downwardly toward said contact plate upon releasing of the pull on said flexible cable.

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