# (12) UK Patent Application (19) GB (11) 2 344 220 (13) A

(43) Date of A Publication **31.05.2000**

(21) Application No **9825675.3**

(22) Date of Filing **24.11.1998**

(71) Applicant(s)
**Eclipse Magnetics Limited**
**(Incorporated in the United Kingdom)**
**Unit 3B, Nunnery Drive, Sheffield, S2 1TA, United Kingdom**

(72) Inventor(s)
**Ian Asquith**

(74) Agent and/or Address for Service
**Hillgate Patent Services**
**No 6 Aztec Row, Berners Road, Islington, LONDON, N1 0PW, United Kingdom**

(51) INT CL$^7$
**H01F 7/04 // B23Q 3/15**

(52) UK CL (Edition R)
**H1P PGZ**

(56) Documents Cited
**GB 2038560 A** **GB 1545566 A** **GB 1520758 A**
**EP 0254939 A1** **EP 0109011 A2**

(58) Field of Search
UK CL (Edition P) **H1P PGXB PGXC PGZ**
INT CL$^6$ **B23B 31/28, B23Q 3/15, B25B 11/00, B66C 1/04, B66F 9/18, H01F 7/02 7/04**
**Online: WPI**

(54) Abstract Title
**Magnetic holding device**

(57) A magnetic holding device comprises a plurality of permanent magnets 12 arranged with their magnetic axes parallel to a common plane and at least one electromagnetic arrangement 14 for adjusting the magnetic field produced. The permanent magnets 12 may be of a rectangular plate-like shape with the narrow side of the magnets being parallel (and adjacent) to a base 16 and a working surface 20. The working surface 20 may be a smooth continuous homogenous ferromagnetic plate. The working surface 20, base 16 and sides 18 may be bolted together with epoxy resin to secure and seal the assembled members of the device. The magnets 12 may be made of a neodymium alloy and arranged in a parallel or orthogonal formation such that the pole pieces 10 are polarised in a chess board fashion. The working surface 20 and pole pieces 10 may be formed from a thick slab of ferromagnetic material with a grid work of channels for receiving the permanent magnets 12. An electromagnet 14 may be associated with each pole piece 10 and may be pulsed to divert the flux such that a work piece is released.

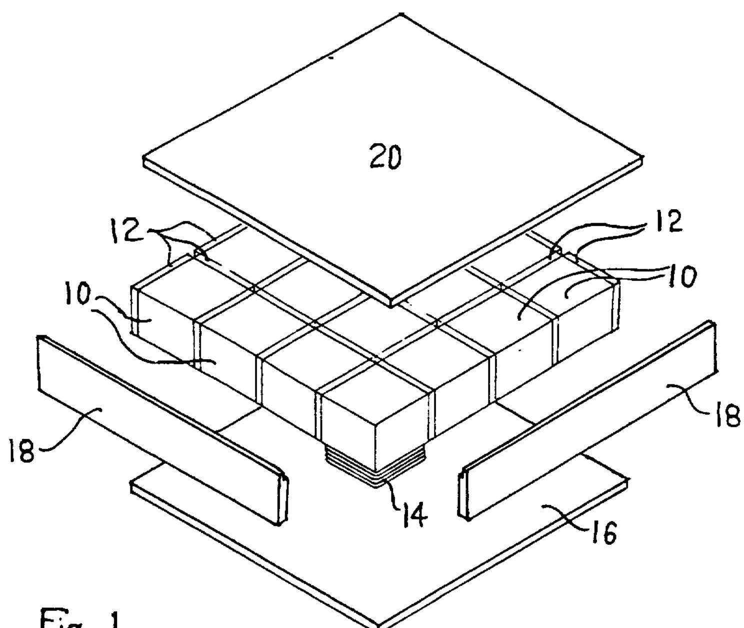


Fig. 1

GB 2 344 220 A

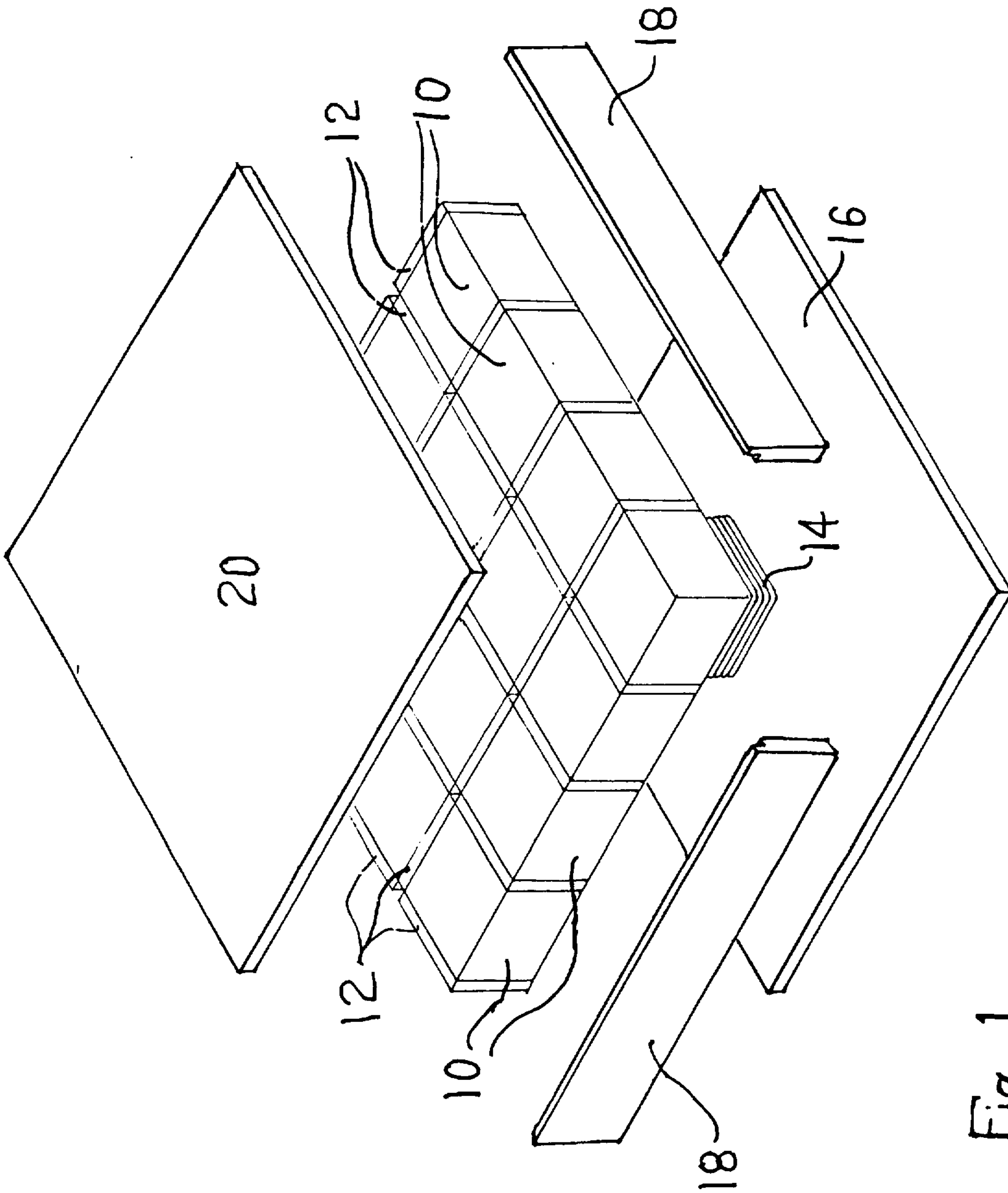


Fig. 1

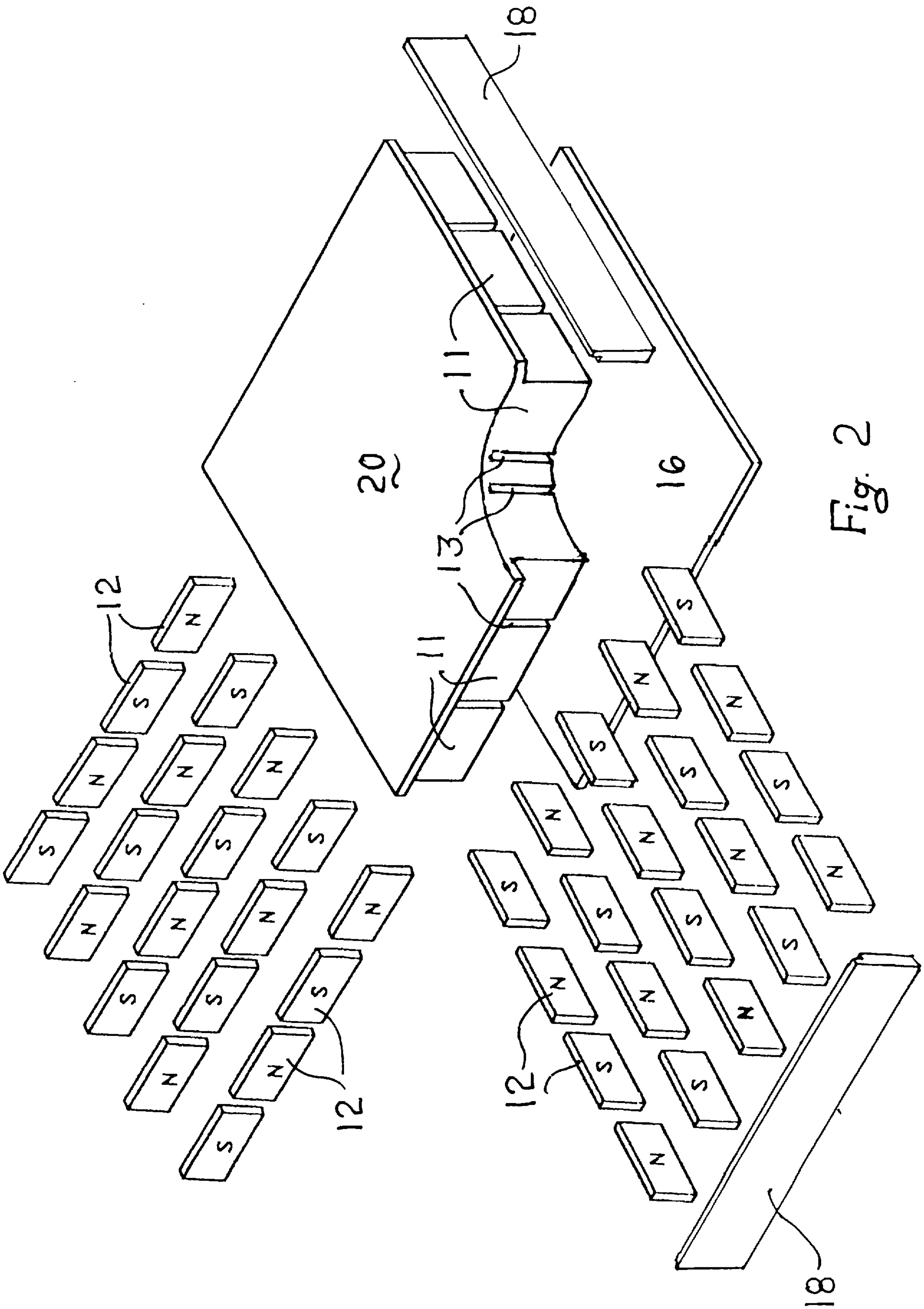


Fig. 2

# Magnetic Holding Device

The present invention relates to magnetic holding devices, that is, devices for releasably securing workpieces by magnetism.

Magnetic holding devices, or magnetic chucks as they are also known, are often used in preference to mechanical clamping means because of the ease and speed with which the workpiece may be secured to the chuck, and the improved access afforded to the workpiece by not having clamping means extending over the sides and upper surfaces of the workpiece.

The magnetic chuck's magnetism may be derived from permanent magnets, electromagnets, or from electropermanent magnets; electropermanent magnets are preferred. Permanent magnets require mechanical positioning in order to grip and release the workpiece, and to release the workpiece requires the magnets to be pulled away in opposition to the attractive force. Electromagnets are capable of being switched on and off at will, but in the event of a power failure, the workpiece will be released, as electricity must be constantly supplied to the magnets.

Known electropermanent magnets include arrangements of electromagnets and permanent magnets. A number of permanent magnets, with their poles aligned with the plane of the working surface of the chuck, usually surrounds a magnetic switching unit whose axis is perpendicular to the working surface. The magnetic switching unit consists of a head element made from steel known as a pole piece, and an electromagnetic coil surrounding a magnetic core placed beneath this. The magnetic core may have its polarity reversed by the action of the electromagnet, but when the electromagnet is off the magnetic core is permanent. That is, the magnet core retains the magnetization induced by the current pulse, the applied field from the permanent magnets around the pole piece being insufficient to change the magnetization of the core. An arrangement of such magnetic switching units is repeated across the chuck, and all the magnets and pole pieces are secured in a tray, comprising sides and a steel base, held together and securing the components by bolts.

The polarisation of the pole piece is set by the action of the electromagnet, so that when the magnetic chuck is in the 'on' setting to hold the workpiece, flux flows in a circuit from each permanent magnet, through the associated pole piece, out of the working surface, back into an adjacent pole piece and back to the opposite pole of the same or another magnet. When a ferrous workpiece is placed sufficiently closely, this magnetic flux will flow through the workpiece during its circuit, causing the workpiece to be securely held to the working surface.

A short pulse of current through the coil of the electromagnet is sufficient to reverse the polarisation of the magnetic switching unit's pole piece and solenoid core, after which the current may be discontinued. To turn the chuck to an 'off' setting, that is, to stop flux flowing up through the working surface, a short pulse is sent through the electromagnet's coil in the reverse direction, causing a field of a sufficient strength to reverse the polarity of the core. The whole of the flux from the permanent magnets is then directed downwards through the pole piece away from the working surface, so releasing the workpiece. The electromagnet, the pole piece and the electromagnet's core together form a means of switching the direction of the magnetic field of the permanent magnets between flowing up through a magnetic switching unit, out of the working surface and back down through a neighbouring magnetic switching unit, and flowing down through a magnetic switching unit, through the base plate and thence upwards into a neighbouring magnetic switching unit.

The magnetic material of the magnetic switching unit must therefore be chosen so that the coercive force necessary to change the magnetization is more than that supplied from permanent magnets, but less than that from the electromagnet, and have a sufficiently high remanance when the electromagnet is switched of. The details of this type of electropermanent magnetism are well known in the art.

In order to maximise the 'throw' of the magnetic flux, that is the amount of flux extending beyond the magnets and corresponding to the force with which the workpiece will be held, the pole pieces, and sometimes the permanent magnets, are arranged flush with the working surface of the magnetic chucks. Where the magnets do not extend to the working surface, the pole pieces are separated by a filler such as epoxy resin. In time this epoxy resin becomes brittle and cracks form. Such a surface is vulnerable to incursion by cooling and lubricating fluid between the gaps between the pole pieces and the magnets, or epoxy resin, as the case may be.

For flux to be entirely directed downwards, the permanent magnets must be balanced with the solenoids' magnetic cores and each other, otherwise some stray flux will leak upwards through the pole piece and thence through the workpiece when the chuck is in the 'off' setting, causing the working surface to grip the workpiece to some degree when release is required.

Permanent magnets however are rarely manufactured within the magnetic tolerances required for balancing, so the magnets must be altered during the construction of the chuck, usually by locating unbalanced magnets, chipping pieces off and retesting the working surface. Since altering one magnet will change the flux of surrounding magnets, such balancing of the magnets is a difficult procedure and stickiness is seldom eliminated.

It is desirable to improve the characteristics of the working surface, and also to reduce the tendency for the workpiece to stick to the surface in an efficient manner. The object of the present invention is to alleviate either or both of these problems.

According to the present invention there is provided a magnetic holding device including a continuous plate shaped on its upper surface to engage a workpiece, a plurality of permanent magnets having their magnetic axes substantially aligned with the plane of the upper surface of the plate, and at least one magnetic switching unit to alter the direction of the magnetic field from the permanent magnets.

Preferably the continuous plate is composed of a ferromagnetic material.

Preferably pole pieces are included to separate the permanent magnets.

In an alternative embodiment, there is preferably provided on the ferromagnetic plate a lower surface adapted so as to locate the permanent magnets.

A magnetic holding device embodying the invention will now be described, by way of example, with reference to the drawings, of which;

Figure 1 shows an exploded perspective view of a magnetic holder device, and

Figure 2 shows an exploded perspective view of another embodiment of a magnetic holder device, with a cut-away showing internal structure.

Referring to Figure 1, the magnetic holding device comprises an array of magnetic switching units, separating an arrangement of permanent magnets 12, a steel base 16, four sides 18 (only the two appearing nearest the viewer are shown) and a working surface 20. Each magnetic switching unit includes an electromagnet 14 (for clarity only one is shown) and a pole piece 10. The pole pieces 10 are cuboid, having a square plan and a height less than that of the square side, the permanent magnets 12 being arranged on the four rectangular sides, the dimensions of the permanent magnets being approximately that of the rectangular side of the pole piece and of relatively thin thickness. Therefore each permanent magnet is disposed so that it is directly between two pole pieces, the permanent magnets thus forming a grid.

The poles of the permanent magnets 12 are upon the rectangular sides, the magnets being disposed so that any group of four permanent magnets making up a square or cell show the same polarity to the encompassed pole piece. Alternating pole pieces are thus surrounded in opposite senses by alternating cells of permanent magnets, so that the two types of pole pieces, those emanating flux when the chuck is in the 'on' state, and those receiving flux, are arranged in a chess board fashion.

An electromagnet consisting of a coil 14 around a permanent magnet core (not visible) is then placed beneath each pole piece 10. The components so far described are placed in this arrangement upon the base 16, and the sides 18 and working surface 20 are added. The components may be attached to the base 16 and sides 18 by bolts. The working surface 20 may be similarly secured in place by bolts extending from the base up to the working surface, though these bolts should not of course extend through the whole thickness of the working surface. The volume enclosed by the working surface, base and sides may be flooded with epoxy resin to ensure that the components are secured firmly and cannot vibrate during use.

The join between the top and the sides could be sealed by epoxy resin in the conventional fashion, the sides having a slight groove present upon one side to receive the working surface. The circuitry and other aspects of the chuck are similar to those of a conventional chuck.

During operation a workpiece is placed upon the working surface of the chuck. To secure the workpiece, a current is passed through the electromagnets' coils until the chuck has been magnetised. No further current is needed until it is necessary to remove the workpiece.

Of the flux emanating from the pole pieces, some will pass through the workpiece in order to hold it to secure it to the working surface of the chuck, but some flux which would otherwise have contributed to the securing force upon the workpiece will be diverted through the working surface itself, especially since the plate is ferromagnetic. Sufficiently strong magnets must therefore be used in order to ensure that the plate is saturated and sufficient remaining flux extends beyond the working surface to secure workpieces. Magnets such as those of neodymium alloys (such as Neodymium Iron Boron) are suitable.

When it is wished to remove the workpiece, a pulse of current through the coils is supplied in order to direct the flux circuits downwards so that the majority of the flux passes underneath the permanent magnets (the working surface being considered as being above the permanent magnets). Small amounts of flux which remain flowing above the magnets preferentially flow through the working surface rather than the workpiece, so the workpiece may be easily removed with little or no stickiness. Also, since this excess flux is diverted from the workpiece so effectively, it is no longer necessary to attempt to balance the magnets at the construction stage, and standard magnets may be used straight from manufacture.

The thickness of the ferrous workpiece should be such then that it absorbs all the flux which remains extending above the magnets when the chuck is in the 'off' setting, whilst not being so thick that too much flux is absorbed when the chuck is 'on' and it is wished to secure a workpiece to the working surface.

The continuous nature of the working surface, presenting a smooth, unbroken surface, also makes it less prone to the incursion of water and other contaminants which could corrode the internal components.

In a modification, the working surface is formed as an integral piece with the sides, and then lowered onto the base in order to secure the components.

Referring to Figure 2, in an alternative embodiment the working surface 20 is formed from a slab of ferromagnetic material, its thickness being that of the height of the sides in the previously described embodiments. A series of channels 13 is formed in the slab such that a grid is formed, that is, two orthogonal sets of equidistant parallel lines, the channels extending through the material leaving a thickness corresponding to the thickness of the working surface described in the first embodiment. Such channels can be formed by a line of equidistantly spaced milling wheels making two orthogonal passes through the working surface. Cuboid portions of ferromagnetic material 11 are left extending downwards from the working surface.

Into this grid are inserted a number of permanent magnets 12, each magnet being the same length as the distance between two neighbouring parallel lines. The magnets, in the same way as in the previous embodiment, have their poles disposed upon their flat sides, and are arranged so that each square cell formed by a group of four magnets has either all north faces facing inwards, or all south faces, and these two types of cell are arranged in an alternating, chessboard type fashion. The orientation of the magnets' poles is indicated here by the marks 'N' and 'S' corresponding to the magnets' north and south poles.

Beneath each cell of magnets is placed an electromagnet in a similar way to that previous described (in this figure none of the electromagnets have been shown). A base 16 and sides 18 are then affixed to the working surface 20, for example by bolts. In this embodiment then the magnetic switching unit is made up of an electromagnet, and the portion of the working surface which extends downwards between a cell of permanent magnets. The construction of the chuck, no longer having pole pieces, is made very much simpler. The working surface 20 could alternatively be formed so that the grid of channels stops short of the side portions of the working surface, so that additional side portions are no longer necessary. Further refinements, such as altering the depth of the channels along their lengths to strengthen the working surface and help locate the magnets, could of course be introduced. The portions of the working surface extending downwards could also extend through the electromagnets.

The same principles could also easily be adapted to other arrangements of magnetic chuck, such as those having parallel lines of permanent magnets, the magnets in each line having their polarities all facing the same direction and there being no magnets disposed orthogonally.

A continuous non-ferromagnetic working surface, without alleviating the tendency of the workpiece to stick to the working surface, would however dissuade water and other contaminants from entering the chuck.

## CLAIMS

1. A magnetic holding device including a continuous plate shaped on its upper surface to engage a workpiece, a plurality of permanent magnets having their magnetic axes substantially aligned with the plane of the upper surface of the plate, and at least one magnetic switching unit to alter the direction of the magnetic field from the permanent magnets.

2. A magnetic holding device according to Claim 1 wherein the plate is of ferromagnetic material.

3. A magnetic holding device according to Claim 2, wherein the plate is of sufficient thickness to allow remanent magnetic flux to flow substantially through the plate when the magnetic holding device is in the 'off' state.

4. A magnetic holding device according to any previous claim, wherein the magnetic switching units include pole pieces.

5. A magnetic holding device according to any of Claims 1 to 3, wherein portions of the plate are included in the magnetic switching units.

6. A magnetic holding device according to any previous claim, wherein the plate is shaped on its lower surface to locate the permanent magnets.

7. A magnetic holding device according to Claim 6, wherein the shape of the lower surface includes channels for the location of the permanent magnets.

8. A magnetic holding device according to Claim 7, wherein these channels are formed by milling.

9. A magnetic holding device according to Claim 8, wherein the channels form an orthogonal grid.

10. A magnetic holding device according to any previous claim, including side elements integral with the plate.

11. A magnetic holding device according to any previous claim, including a base element bolted to the plate.

12. A magnetic holding device according to any previous claim, wherein the permanent magnets are of the neodymium alloy type.

13. A magnetic holding device substantially as herein described and illustrated.

14. Any novel and inventive feature or combination of features specifically disclosed herein within the meaning of Article 4H of the International Convention (Paris Convention).

The Patent Office

INVESTOR IN PEOPLE

**Application No:** GB 9825675.3
**Claims searched:** 1 - 13
**Examiner:** J. A. Watt
**Date of search:** 24 March 1999

## Patents Act 1977
## Search Report under Section 17

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H1P (PGXB, PGXC, PGZ)

Int Cl (Ed.6): B23B 31/28; B23Q 3/15; B25B 11/00; B66C 1/04; B66F 9/18; H01F 7/02, 7/04

Other: Online: WPI

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage | | Relevant to claims |
|---|---|---|---|
| X | GB 2038560 A | (MAGNETO TECHNICA) see figs.1 - 3 | 1 at least |
| X | GB 1545566 | (P M BRAILLON) see figs.1 - 3 | 1 at least |
| X | GB 1520758 | (M CARDONE ET AL) see figs.4 & 7 | 1 at least |
| X | EP 0254939 A1 | (TECNOMAGNETICA) see figs.1 - 6 | 1 at least |
| X | EP 0109011 A2 | (TECNOMAGNETICA) see whole document | 1 at least |

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family
A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.