May 11, 1965 J. B. SHORE 3,182,724

ORIENTING APPARATUS AND ITS MANUFACTURE

Original Filed April 21, 1960 2 Sheets-Sheet 1

Fig. 1

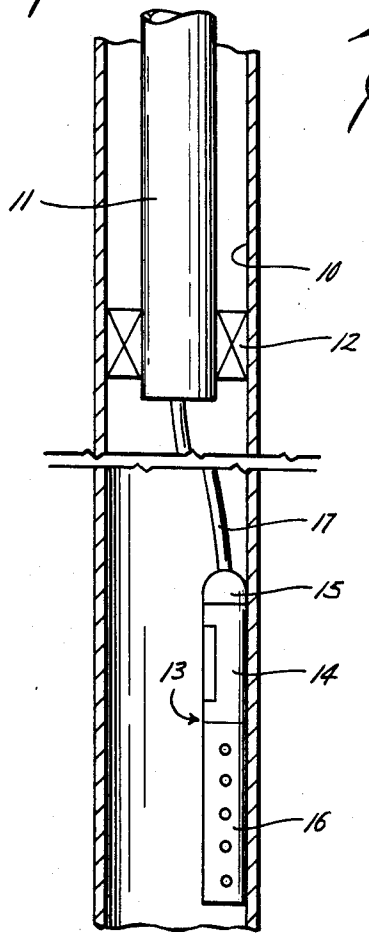


Fig. 2

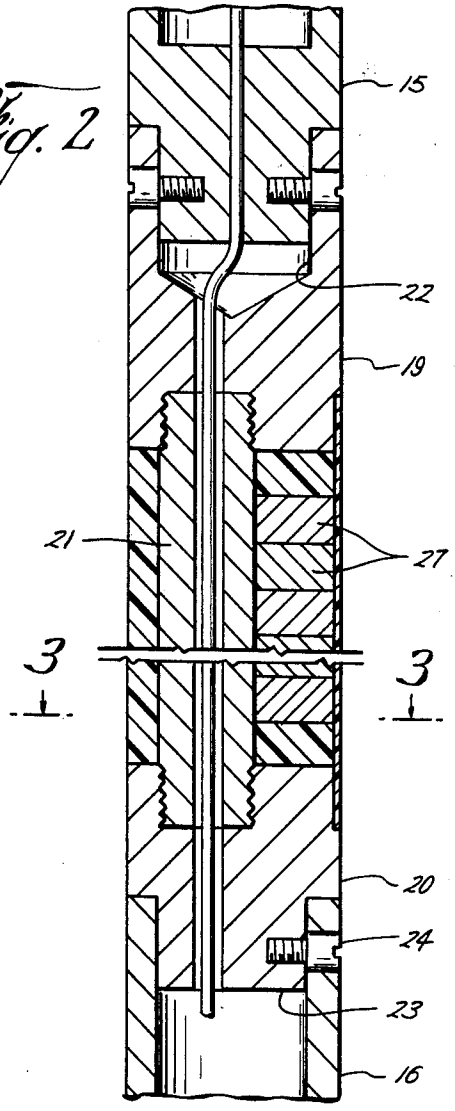
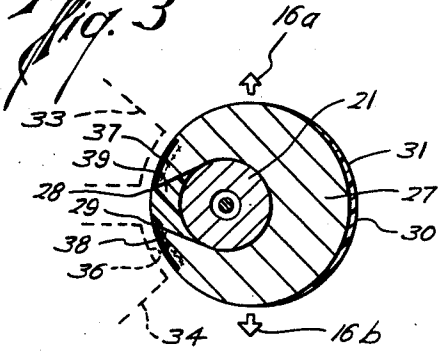


Fig. 3



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May 11, 1965 J. B. SHORE 3,182,724

ORIENTING APPARATUS AND ITS MANUFACTURE

Original Filed April 21, 1960 2 Sheets-Sheet 2

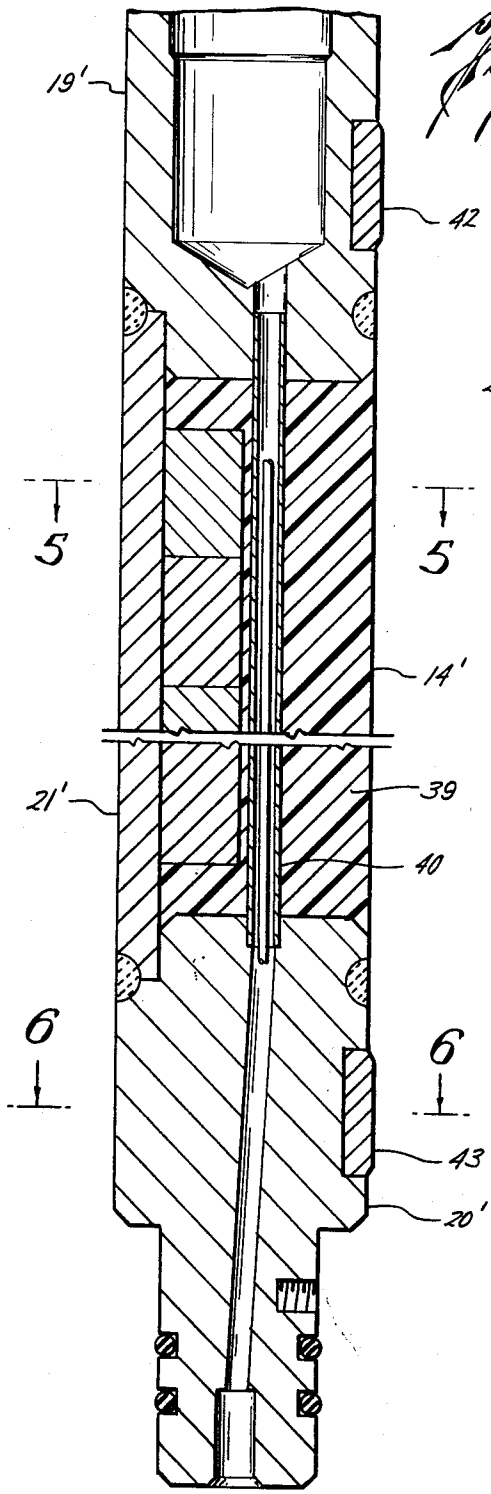

Fig. 4

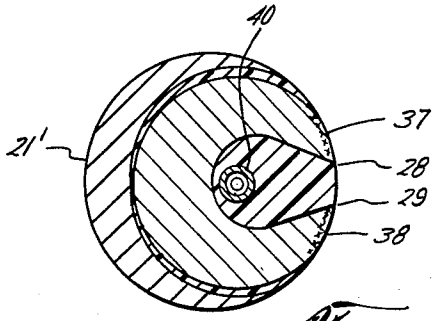

Fig. 5

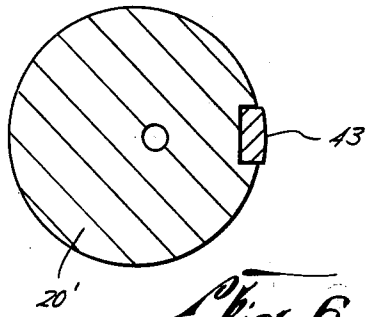

Fig. 6

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United States Patent Office 3,182,724 Patented May 11, 1965

3,182,724 ORIENTING APPARATUS AND ITS MANUFACTURE

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Original application Apr. 21, 1960, Ser. No. 23,825. Divided and this application Mar. 1, 1963, Ser. No. 262,010

10 Claims. (Cl. 166—55.1)

This invention relates to orienting apparatus and its manufacture and, more particularly, to apparatus requiring passage through a small diameter string of tubing for orienting perforating apparatus in a preselected manner within a cased well bore and methods for manufacturing such apparatus.

Recent developments in perforating have been directed towards controlled perforating techniques wherein the perforating apparatus may be accurately located in a section of the well and oriented so that the shaped charges will give an optimum performance by providing proper clearance. One of the inherent difficulties and drawbacks presented by this type of perforation is a need for orienting means which is reliable and sufficiently rugged to withstand the shocks encountered in a perforating operation and yet may be reliably retrieved from the borehole.

Accordingly, an object of the present invention is to provide new and improved orienting means for perforating apparatus which is adapted to pass through a small diameter tubing and accurately locate the perforating apparatus in a large diameter string of casing.

This application is a division of my copending application Serial No. 23,825, filed April 21, 1960.

In accordance with the present invention, an orienting device coupled to a perforating apparatus provides a resultant force of magnetic attraction to position the perforating apparatus in a preselected position in a cased well bore. The magnetic orienting device includes magnets having an outer, cylindrical configuration substantially the same as the configuration of the perforating apparatus and having short, curved pole pieces so as to grip a cylindrical surface. A supporting member connects upper and lower support heads between which the magnets are disposed in a solid and rigid connection thereby preventing undesirable loss of the device in the hole. Portions of the magnets remote from their pole pieces are shielded to minimize any possible force of magnetic attraction other than in the direction of the resultant force.

FIG. 1 illustrates a typical well set up where the present invention may be employed;

FIG. 2 is a view in cross-section of one embodiment of the present invention;

FIG. 3 is a view taken along line 3—3 of FIG. 2;

FIG. 4 is a view in cross-section of another embodiment of the present invention;

FIG. 5 is a view taken along line 5—5 of FIG. 4; and

FIG. 6 is a view in cross-section taken along line 6—6 of FIG. 4.

Referring now to FIG. 1, a typical well setup wherein the present invention may be employed involves a string of casing 10 of ferromagnetic material which is conventionally secured within a borehole (not shown) in a customary manner and traverses earth formations (not shown). A production tubing 11 having a diameter of, say, 2" is shown disposed in the casing 10 and suitably packed off by packing means 12 in a conventional manner so that formation fluid may be produced through the tubing in the customary manner.

Apparatus 13 embodying the present invention, includes a magnetic orienting device 14 which may be suitably coupled between a connector head 15 and a perforating apparatus 16, the connector head 15 being coupled to a cable 17 to permit the conventional suspension of the apparatus 13 in the casing. The entire apparatus 13 has a substantially uniform, cylindrical configuration with, of course, a diameter small enough to permit passage through the small diameter tubing 11. As will hereinafter become more apparent, the magnetic orienting device 14 is adapted to produce a directional force of magnetic attraction or flux density bisected by an axis extending parallel to the central axis of the assembly. By orienting the force of the magnetic attraction with respect to the directions of firing of the perforator, the assembly can be magnetically latched to the casing so that the directions of firing are oriented relative to the casing.

Referring now to FIGS. 2 and 3, the magnetic orienting device 14 includes upper and lower cylindrical support heads 19 and 20 which are coupled together by a supporting rod member 21 and permanent magnets 27 are disposed intermediate of the heads. The upper head 19 has an upper socket end 22 which is arranged for coupling to the connector head 15, which, for example, may include a casing collar locator of the type illustrated in the Fagan Patent No. 2,558,427. The depending lower head 20 has a cylindrical projection 23 of reduced diameter which is sized or arranged to be received in the tubular end of the perforating apparatus 16 and suitably attached thereto, for example, by screws 24. Rod member 21 is preferably of non-magnetic material and has a passageway therethrough so that wires or the like for energizing the perforator can easily be passed through the assembly.

The arrangement of the magnets 27 may best be understood by a consideration of methods of construction of the orienting device 14. Thus, one end of the supporting rod member 21 is suitably threaded into the upper head member 19 and silver soldered thereto. Magnets 27 are formed from horseshoe-shaped, non-magnetized magnet stock. For use with the present invention, the horseshoe magnets are subjected to a grinding operation to provide magnets 27 with a generally cylindrical outer configuration with a diameter slightly less than the diameter of the cylindrical profile of the entire assembly. The ground magnets 27, therefore, have an essentially crescent shaped cross-section with tips 28 and 29 of the crescent configuration formed at the airgap of the magnets. The length and diameter of the supporting rod member 21 is sized with respect to the diameter of the opening in the magnets 27 so that a number of magnets may be slidably mounted on the supporting rod member to provide an elongated magnetic structure. The number of magnets used in an assembly may vary according to the particular magnetic strength necessary to attach the perforating apparatus 16 to the sidewall of the casing. Of course, this number of magnets required depends upon the particular weight of the entire assembly, but, in general, the magnets required should permit the assembly to slide readily through the tubing 11 and along the side of the casing 10 and yet firmly affix the assembly to the sidewall of the casing when the motion of the cable 17 is stopped.

After the magnets 27 are mounted on supporting rod member 21, the lower head member 20 is threaded to the lower end of the supporting rod member 21. The length of the supporting rod member 21 between the head members 19 and 20 is related to the total thickness and the number of magnets 27 so that the total length of the assembled magnets is about 1" less than the spacing between the head members 19 and 20. The relative spacings thus afford space to silver solder the remaining threaded connection between the support member 21 and head 20 for a fluid-tight connection.

Because the magnets 27 are non-magnetized, the alignment of the tips 28 and 29 of the magnets is easily accom-

plished, and it should be noted that position of the supporting rod 21 is eccentered with respect to heads 19, 20 such that the cylindrical configuration of the magnets is slightly eccentered with respect to the cylindrical configuration of the heads 19 and 20. Hence, the tips 28 and 29 of the magnets may be aligned generally on the cylindrical profile of the head members 19 and 20 thereby displacing the rearward portion 30 of the magnets 27 inwardly of the cylindrical profile.

A sheet of thin, woven fiberglass 31 is then wrapped fully about magnets 27 to fill in the rearward portion 30 of the magnets 27 to the diameter of the cylindrical profile of the upper and lower connecting heads. Following this, a bonding material 39, such as an epoxy resin, in impregnated into and through the fiberglass to fill the voids in and around the magnets 27, the resin thereafter being cured so that the magnets 27 are securely fixed in a rigid position by the extremely hard epoxy composition. It will be appreciated that the fiberglass wrapping extends outwardly of the cylindrical profile of heads 19 and 20 about the tips 28 and 29 of the magnets 27. Thus, the device is now subjected to a grinding operation to conform the bonding material on the magnetic device to the cylindrical profile of the heads 19 and 20 so that the portion of the epoxy coated fiberglass adjacent the tips 28 and 29 of the magnets 27 is removed while the rearward portions 30 of the magnets remain shielded.

At this time, the assembly of the device 14 is completed and magnetizers 33, 34 with short cylindrical faces 35 and 36 are disposed adjacent to the tip of the magnets 27 to magnetize the magnets 27 with like poles on respective sides of the gap between the poles and unlike poles on opposite sides of the gap and produce transversely short, curved pole pieces 37 and 38 along a section of outer surface of the tips and extending over an arc of less than 90° (indicated by the crossed lines).

It will be appreciated from the foregoing that the use of fiberglass wrapping 31 increases the ease of forming of the shielding surface but that it is not essential, since a mold or form would permit casting of only an epoxy bonding material to the cylindrical profile of the assembly.

The perforating apparatus 16 may be of the shaped charge type wherein shaped charges are disposed within a tubular housing. The phasing (or angular displacement of the firing planes) of the shaped charges may be, for example, 180°, so that the charges are arranged to fire in opposite directions in the same plane as shown by arrows 16*a* and 16*b* in FIG. 3. With this arrangement it will be readily appreciated that the resultant force of magnetic attraction may be arranged at an angle of 90° relative to the directions of firing (or bisecting the included angle). Thus, when the magnetic device 14 latches to the casing, the spacing of the charges is always uniform with respect to the casing and the perforating axes are aligned in a preselected manner with respect to the force of magnetic attraction.

Referring now to FIGS. 4–6, in this embodiment, for use in, say, 2½" tubing, the assembly and magnetic device 14′ may have an increased diameter. Because of the increased diameter permitted, head members 19′ and 20′ can be coupled together by a crescent shaped, half-shell connecting member 21′ preferably comprised of non-magnetic material. The connecting member 21′ may be suitably coupled to the head members by welding or the like. The interior of member 21′ is sufficient to accommodate magnets 27, as above described, which are inserted into the interior of connecting member 21′. A small diameter tube 40 for conductors is silver soldered eccentrically to the heads 19′ and 20′ and extends through the centers of the magnets 27. An epoxy resin bonding material 39 is then used to secure or pot the magnets 27 in connecting member 21′ and with tips 28 and 29 of the magnets facing outwardly from the opening of member 21′. Pole pieces 37 and 38 are produced on magnets 27 as described heretofore. Along the axis in which the force of magnetic attraction is the greatest, the heads 19′ and 20′ are provided with hard metal inserts 42 and 43 such as tungsten carbide which extend a slight distance outwardly of the cylindrical profile of the assembly thereby spacing the assembly slightly away from the wall of the casing to prolong the life of the tool by minimizing wear on the magnets 27.

While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects, and therefore the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. A perforator orienting device comprising a magnetic device having generally cylindrical upper and lower connecting portions defining a cylindrical profile and an interconnecting portion of reduced cross section, an elongated permanent magnet assembly of crescent shape cross-section received between said upper and lower portions and interfitted with respect to said interconnecting portion, said magnet assembly having a pair of pole pieces with generally cylindrical outer configurations of opposite polarity extending over an arc of less than 90° and spaced apart to define a non-magnetic gap, said pole pieces being substantially the only portions of said magnet assembly extending into conformance with said cylindrical profile, and non-magnetic means for securing said magnet assembly to said device.

2. A cylindrical magnetic device for use in a cased well bore below the lower end of a string of small diameter tubing and sized for passage through the string of tubing comprising: an upper cylindrical head, a lower cylindrical head and an elongated supporting member fixed to said heads, said heads having ends arranged for coupling in a tool assembly, a number of substantially crescent shaped magnets with a generally cylindrical outer surface disposed between said head and a bonding material in said device to secure said magnets in a fixed position, said magnets in said fixed position having short, curved pole pieces aligned lengthwise of said device to develop a force of magnetic attraction in a radial plane between said pole pieces, said outer surface of said magnets being within the cylindrical profile of said heads, and upper and lower spaced inserts of wear resistant material secured to said device along the axis of magnetic attraction and extending slightly outwardly of the cylindrical profile of said device to space said pole pieces from the cased well bore.

3. A cylindrical magnetic device for use in a cased well bore below the lower end of a string of small diameter tubing and sized for passage through the string of tubing comprising: an upper cylindrical head, a lower cylindrical head and an elongated tubular supporting member fixed to said heads, said heads having ends arranged for coupling in a tool assembly and longitudinally extending openings in communication with said tubular support member, a number of substantially crescent shaped magnets with a generally cylindrical outer surface disposed between said heads and a bonding material in said device to secure said magnets in a fixed position, said magnets in said fixed position having short, curved pole pieces aligned lengthwise of said device to develop a force of magnetic attraction in a radial plane between said pole pieces, said outer surface of said magnets being within the cylindrical profile of said heads, and upper and lower spaced inserts of wear resistant material secured to said device along the axis of magnetic attraction and extending slightly outwardly of the cylindrical profile of said devices to space said pole pieces from the cased well bore.

4. A cylindrical magnetic device for use in a cased well bore below the lower end of a string of small diameter

tubing and sized for passage through a string a tubing comprising: an upper cylindrical head, a lower cylindrical head and an elongated supporting rod member fixed to said heads, said heads having ends arranged for coupling in a tool assembly, a number of substantially crescent shaped magnets with a generally cylindrical outer surface of lesser diameter than the diameter of said heads disposed between said heads with the openings of said magnets being disposed about said rod member, a bonding material in said device to secure said magnets in a fixed position, said magnets in said fixed position having short, curved pole pieces aligned lengthwise of said device to develop a force of magnetic attraction in a radial plane between said pole pieces, said pole pieces lying substantially on the cylindrical profile of said heads to space the rearward portions of said magnets inwardly of the cylindrical profile thereby forming a rearward space, and a bonding material disposed in said rearward space to conform to the cylindrical profile of said heads.

5. A cylindrical magnetic device for use in a cased well bore below the lower end of a string of small diameter tubing and sized for passage through a string of tubing comprising: an upper cylindrical head, a lower cylindrical head and an elongated supporting cylindrical rod member fixed to said heads, said heads having ends arranged for coupling in a tool assembly, a number of substantially crescent shaped magnets with a generally cylindrical outer surface disposed between said heads with the openings of said magnets being sized to the diameter of said rod member, and a bonding material in said device to secure said magnets in a fixed position, said magnets in said fixed position having short, curved pole pieces aligned lengthwise of said device to develop a force of magnetic attraction in a radial plane between said pole pieces, said outer surfaces of said magnets being within the cylindrical profile of said heads.

6. A cylindrical magnetic device for use in a cased well bore below the lower end of a string of small diameter tubing and sized for passage through a string of tubing comprising: an upper cylindrical head, a lower cylindrical head and an elongated supporting cylindrical rod member fixed to said heads, said heads having ends arranged for coupling in a tool assembly, a number of substantially crescent shaped magnets with a generally cylindrical outer surface disposed between said heads with the openings of said magnets being disposed about said rod member, a bonding material in said device to secure said magnets in a fixed position, said magnets in said first position having short, curved pole pieces aligned lengthwise of said device to develop a force of magnetic attraction in a radial plane between said pole pieces, said pole pieces lying on the cylindrical profile of said heads to space the rearward portions of said magnets inwardly of the cylindrical profile, and a bonding material being disposed in said rearward space to conform to the cylindrical profile, of said heads.

7. Apparatus for use in a cased well bore below the lower end of a string of small diameter tubing and sized for passage through a string of tubing comprising: a cylindrical magnetic device having an upper cylindrical head, a lower cylindrical head and an elongated supporting rod member fixed to said heads, said heads having ends arranged for coupling in a tool assembly, a number of substantially crescent shaped magnets with a generally cylindrical outer surface disposed between said heads with the openings of said magnets being disposed about said rod member, and a bonding material in said device to secure said magnets in a fixed position, said magnets in said fixed position having short, curved pole pieces aligned lengthwise of said device to develop a force of magnetic attraction in a radial plane between said pole pieces, said outer surface of said magnets being within the cylindrical profile of said heads; and a perforating apparatus coupled to the end of one of said heads and having perforating axes aligned in a preselected manner with respect to said force of magnetic attraction of said magnetic device.

8. A cylindrical magnetic device for use in a cased well bore below the lower end of a string of small diameter tubing and sized for passage through a string of tubing comprising: an upper cylindrical head, a lower cylindrical head and an elongated crescent shaped supporting member fixed to said heads, said heads having ends arranged for coupling in a tool assembly, a number of substantially crescent shaped magnets with a generally cylindrical outer surface disposed between said heads within said crescent shaped member and a bonding material in said device to secure said magnets in a fixed position, said magnets in said fixed position having short, curved pole pieces facing outwardly of the open end of said supporting member and aligned lengthwise of said device to develop a force of magnetic attraction in a radial plane between said pole pieces, said pole pieces of said magnets being within the cylindrical profile of said heads.

9. A cylindrical magnetic device for use in a cased well bore below the lower end of a string of small diameter tubing and sized for passage through a string of tubing comprising: an upper cylindrical head, a lower cylindrical head and an elongated crescent shaped supporting member fixed to said heads, said heads having ends arranged for coupling in a tool assembly, a number of substantially crescent shaped magnets with a generally cylindrical outer surface disposed between said heads within said crescent shaped member and a bonding material in said device to secure said magnets in a fixed position, said magnets in said fixed position having short, curved pole pieces facing outwardly of the open end of said supporting member and aligned lengthwise of said device to develop a force of magnetic attraction in a radial plane between said pole pieces, said pole pieces of said magnets being within the cylindrical profile of said heads, and upper and lower spaced inserts of wear resistant material secured to said device in the plane of magnetic attraction and extending slightly outwardly of the cylindrical profile of said device to space said pole pieces from the cased well bore.

10. A cylindrical magnetic device for use in a cased well bore below the lower end of a string of small diameter tubing and sized for passage through a string of tubing comprising: an upper cylindrical head, a lower cylindrical head and an elongated crescent shaped supporting member fixed to said heads, said heads having ends arranged for coupling in a tool assembly, a number of substantially crescent shaped magnets with a generally cylindrical outer surface disposed between said heads within said crescent shaped member and a bonding material in said device to secure said magnets in a fixed position, said magnets in said fixed position having short, curved pole pieces facing outwardly of the open end of said supporting member and aligned lengthwise of said device to develop a force of magnetic attraction in a radial plane between said pole pieces, said pole pieces of said magnets being within the cylindrical profile of said heads; and a perforating apparatus coupled to the end of one of said heads and having perforating axes aligned in a preselected manner with respect to said force of magnetic attraction of said magnetic device.

References Cited by the Examiner

UNITED STATES PATENTS

2,796,023	6/57	Abendroth	166—55.8
3,032,107	5/62	Rumble	166—55.1
3,064,571	11/62	True	102—21.8
3,110,257	11/63	Lebourg	102—20

OTHER REFERENCES

P. 85, 12/60, Magnet-Type Gun Scores Better on Jet Shots, in The Oil and Gas Journal.

CHARLES E. O'CONNELL, *Primary Examiner.*