Feb. 6, 1962 W. MAYALL 3,019,845

MAGNETIC RETRIEVING TOOL

Filed June 15, 1959 3 Sheets-Sheet 1

Fig. 1.

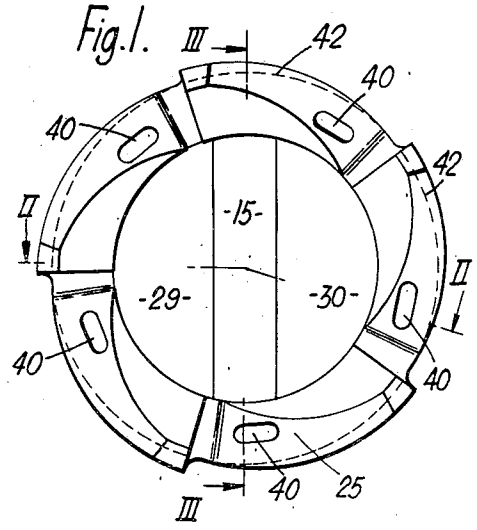


Fig. 4.

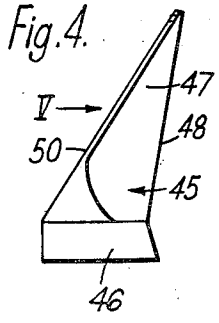
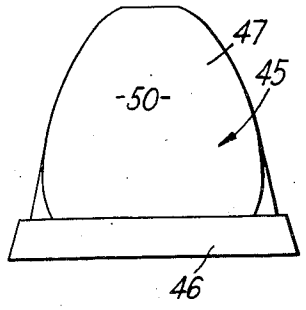


Fig. 5.



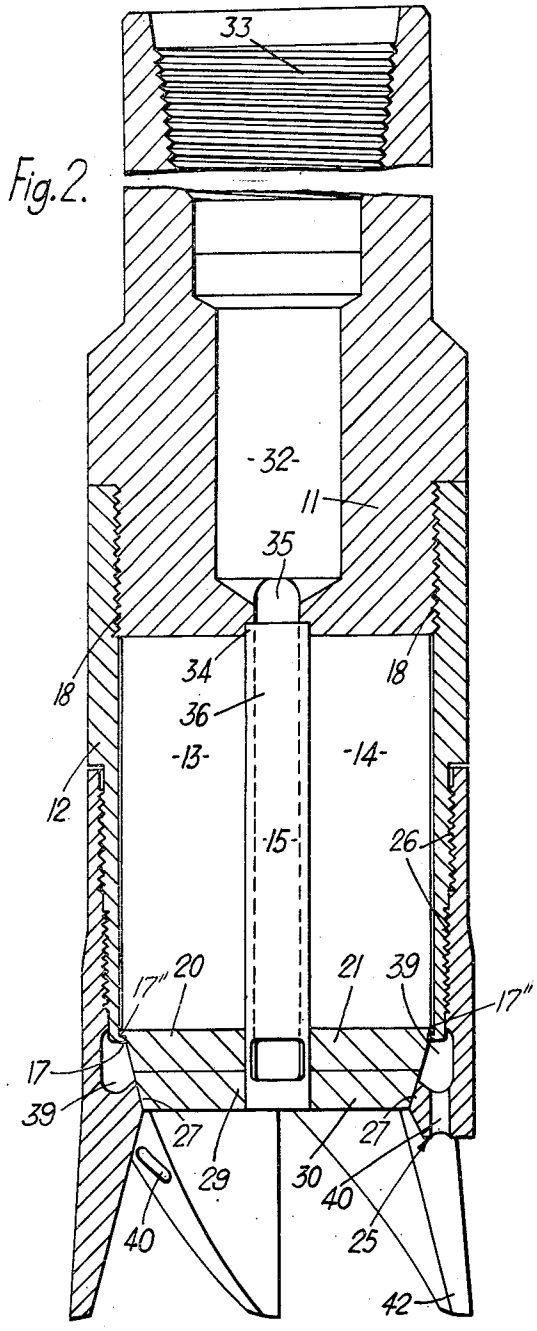
Inventor
William Mayall
by Pierce, Scheffler & Parker
Attorneys

Feb. 6, 1962 W. MAYALL 3,019,845

MAGNETIC RETRIEVING TOOL

Filed June 15, 1959 3 Sheets-Sheet 2

Fig. 2.



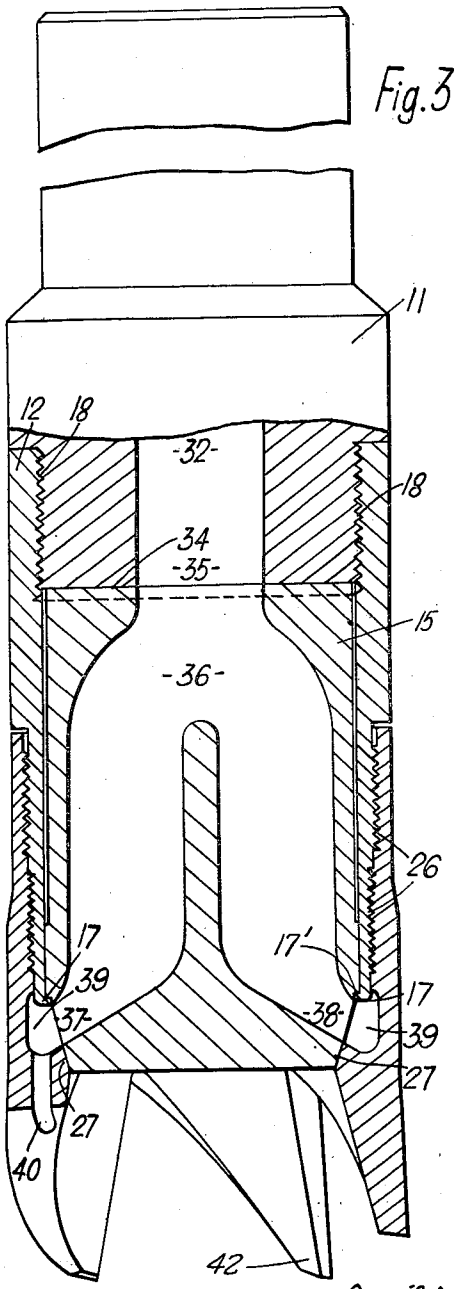
Inventor
William Mayall
by Pierce, Scheffler & Parker
Attorneys

Feb. 6, 1962 W. MAYALL 3,019,845

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Filed June 15, 1959 3 Sheets-Sheet 3

Fig. 3



Inventor
William Mayall
by Pierce, Scheffler & Parker
Attorneys

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MAGNETIC RETRIEVING TOOL

William Mayall, Chessington, England, assignor to Kingston Instrument Company Limited, Chessington, England, a British company

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This invention relates to a magnetic retrieving tool for removing magnetizable material such as broken tools or parts thereof from oil wells and like bore holes.

Magnetic retrieving tools are known and comprise one or more permanent magnets enclosed in a body through which a liquid or mud is pumped in operation via a drill pipe supporting the tool. The liquid or liquid suspension, hereinafter referred to generally as liquid, serves to render more fluid the earthy matter at the bottom of the well bore so that such matter will not hinder the tool from picking up metal objects sought to be removed.

It is one object of the invention to provide an improved magnetic retrieving tool.

According to the invention, therefore, there is provided a magnetic retrieving tool for removing magnetizable material from oil wells and like bore holes comprising at least one permanent magnet enclosed within a body, a cap member of magnetic material and a hollow cutter, the cap member and the cutter being detachably secured to the body, and the cap member being in magnetic contact with at least one pole of said magnet and serving in operation to engage thereon such magnetizable material, said cutter having one or more ports therein which communicate with a passage in the body for the delivery of liquid during operation to the cutter.

The cap member of magnetic material need not of course be a permanent magnet, but should have a high magnetic permeability.

Since the cap member is detachable, it can be readily replaced as soon as it becomes damaged in use. If only one magnet is used in the tool in the form of a straight bar magnet, the cap member could comprise a disc for example, which covers the pole of the magnet at the forward end of the tool.

Preferably, however, the cap member comprises two portions of magnetic material which are separated by a non-magnetic separator member, the separator member and the magnet(s) being so disposed and arranged that the part of the magnetic circuit formed thereby which lies within the confines of the tool is of horse-shoe form, each leg of which terminates in a respective portion of the cap member.

If desired, the cap member can be detachably secured to the magnet(s) for example, by means of screws, but preferably, the cap member and separator are so shaped as to define a conical wall portion against which a similarly shaped internal wall portion of the cutter abuts to hold the cap member securely in position in the tool, and abutting against the magnets.

The body of the tool can be fabricated in any convenient way. For example, the body may be an integral structure, or may comprise as is preferred, a tubular portion screwed onto a rear body portion, the magnet(s) and separator member being disposed in the tubular portion.

In such a construction of the body, it may be desirable to provide means for retaining the magnet(s) in the tubular portion when the cap member is removed. This may be achieved by means of two D-shaped plates of magnetic material which are disposed on opposite sides of the separator member to form therewith an assembly having a circular cross-section, an internal flange at the forward

end of said tubular portion engaging an annular rim on said assembly. Such D-shaped plates can then form in effect, auxiliary cap members which serve further to protect the expensive permanent magnets against damage should the first mentioned cap member become worn out during use.

The passage for liquid from the body to the ports in the cutter can be of any suitable form. Preferably, the passage extends axially through the rear body portion, through the separator member in which the passage divides symmetrically, and out of the separator member beyond the magnet(s) into an annular passageway defined externally by the cutter and internally by the D-shaped plates, the two cap portions and the separator member, the ports in the cutter communicating with said annular passageway. Alternatively, the passage for liquid through the tool need not extend through the separator member at all, but may extend through the magnet(s) and into an annular groove in the cutter with which said ports are in communication.

One purpose of the cutter is to cut through and break up any loose earthy matter at the bottom of the well-bore which might cover such broken metallic pieces which have to be retrieved. The cutter should be suitably shaped so that this end can be achieved, for example, by giving the teeth of the cutter a saw-toothed profile. One or more ports may be provided in each tooth, and preferably the ports open on the rear faces of the teeth, for example, mid-way between the tip and the rear root of the tooth. The ports may be shaped as slots or circular holes, for example.

It may be advantageous to provide at least one of the two portions of the cap member with an integral blade which extends forwardly within the cutter head. Preferably, such a blade has a surface which is inclined outwardly from adjacent the separator member towards the forward end of the cutter head so that the effective pole area of the respective cap portion is increased. If the tool is to be used in a well-bore of large diameter, the blade can also be provided with a portion which extends towards the centre of the cutter to enclose partially the interior of the cutter.

The blade can be protected by the cutter to a certain extent by designing the blade so that its outer surface makes a close fit with the inner surfaces of the tooth or teeth of the cutter adjacent thereto.

There will now be described by way of example only, one preferred embodiment of the invention, this embodiment being illustrated in the accompanying drawings in which:

FIG. 1 is an end view of a magnetic retrieving tool,

FIG. 2 is a cross-sectional view of the tool shown in FIG. 1 taken on line II—II,

FIG. 3 is a cross-sectional view of the tool shown in FIG. 1 taken on the line III—III,

FIG. 4 is an end elevation of a bladed cap portion which may be mounted within the head of the tool shown in FIG. 1 so that its blade extends adjacent the inner surface of one of the cutter teeth, and

FIG. 5 is a side elevation of FIG. 4 taken in the direction of the arrow V.

With reference to FIGS. 1, 2 and 3, a magnetic retrieving tool is provided with a rear body portion **11** of mild steel, and a tubular portion **12** of non-magnetic stainless steel in which two D-shaped permanent magnets **13** and **14** are disposed. Each of the magnets **13, 14** may comprise one or more bar magnets placed end to end or side by side, the particular arrangement depending on the casting difficulties of the material from which the magnets are made. The magnets **13, 14** are separated by a separator member **15** of non-magnetic stainless steel, and the separator member and the magnets are retained

within the tubular portion 12 of the body of the tool by means of an internal flange 17 on the tubular portion which when the tubular portion 12 is screwed fully along threads 18 of the rear body portion 11, engages on an annular flange formed by arcuate flange portions 17' on the separator member 15 and by similar arcuate flange portions 17'' formed on two D-shaped plates or auxiliary cap members 20, 21, of mild steel placed on either side of the separator member at the forward end of the magnets 13, 14.

A tubular cutter 25 of non-magnetic stainless steel is screwed onto threads 26 on the tubular portion 12 of the body, and a conical portion 27 on the internal surface of the cutter bears against a complementary conical surface formed on a main cap member comprising two D-shaped cap portions 29, 30 of mild steel and also bears against a complementary conical surface formed on separator member 15 which is located between the cap members 29, 30, thereby holding the cap portions 29, 30 in close contact with the D-shaped plates 20, 21.

An axial passage 32 is formed in the rear body portion 11, and is provided with a flared portion 33 which is threaded and into which is screwed piping for supporting the tool in operation.

The axial passage 32 terminates in a generally rectangular opening 35 which communicates with a passage 36 formed in the separator member 15. The separator member is accurately located over the opening 35 by means of groove 34 formed in the forward face of the rear body portion 11, the groove forming a seat for the separator member.

The passage 36 divides in the separator member and leads to two opposite openings 37, 38 adjacent the forward end of the separator member. The openings 37, 38 communicate with an annular passageway 39 formed on the internal surface of the cutter, which passageway is to the rear of the conical portion 27 of the cutter.

Also in communication with the passageway 39 are five ports 40 which extend parallel to the axis of the cutter and which open on the rear faces of the cutter teeth 42. Instead of shaping the ports 40 as slots as shown, each slot can be replaced by one or more circular holes. The teeth 42 have a saw-toothed profile and the ports 40 open on the rear faces of the teeth intermediate the tip and rear root of each tooth. The cutting parts of the teeth are strengthened in a manner known per se.

In operation the tool is lowered into a well-bore by means of connected lengths of pipe section, the end section of which is screwed into portion 33 of the rear body portion 11. A suitable liquid or mud is forced down the pipe sections and through the tool, from which it issues at the ports 40.

The pipe sections are rotated in a direction such that threaded connections therein and threaded connections in the tool tighten. When the tool reaches the earthy matter at the bottom of the well-bore, the earthy matter is broken up and rendered fluid by the liquid from the tool so that it can be forced up the well-bore round the side of the tool.

When the tool reaches some magnetizable material, e.g. broken drilling tools which it is desired to remove, the material will be attracted by the magnets in the tool and will generally be drawn to the interior of the cutter 25 to form a bridge between the two cap portions 29, 30 of the tool. The magnetic circuit which within the confines of the tool is of horse-shoe form, the rear body portions 11 bridging the magnets 13, 14 at the rearward end, is thus completed through the magnetizable material which is, therefore, securely held on the cap portions 29, 30.

The teeth of the cutter which surround the magnetizable material on the cap portions serve to shield such material and to reduce the risk of the material being brushed off the cap portions when the tool is being withdrawn up the well-bore. The cutter also assists in initially centralizing the magnetizable material on the cap portions.

The ports 40 which open on the rear faces of the cutter teeth have two advantages over ports which for example, open only in the cap portions 29, 30 or the forward face of the separator member 15. Firstly, liquid from the ports is fed directly into the path of on-coming teeth of the cutter, and secondly, the risk of blocking the ports is reduced. Mud or sludge can, for example, pass from the interior of the cutter to the exterior through each space adjacent the rear root of a tooth and the forward face of the following tooth, so that flow of liquid from the ports is not diverted away from the following teeth.

If one or both of the cap portions 29, 30 becomes damaged during use, it can readily be replaced on unscrewing the cutter. As is evident from FIG. 2, when it is desired to replace one or both of the cap members 29, 30 due to wear, the cutter 25 is unscrewed from its threaded connection 26 with the tubular member 12 thus releasing the cap members 29, 30. However, it will be observed that the auxiliary cap members 20, 21 which are applied to the end faces of magnets 13, 14 respectively, as well as magnets 13, 14 are retained in their positions notwithstanding removal of the cutter 25 and cap members 29, 30 due to the fact that these cap members 20, 21 are held by the flange 17 of the tubular member 12 which remains threaded upon the main body 11. The advantage of this arrangement is that the permanent magnets 13, 14 are better enabled to retain their high magnetic field strength to which they are initially charged when the cap members 29, 30 subject to wear and damage are required to be replaced.

In FIGS. 4 and 5 there is shown a modified cap portion 45 which can be used in a magnetic retrieving tool of the type shown in FIGS. 1, 2 and 3 in place of one of the cap portions 29, 30 the cutter being replaced by another cutter having longer teeth.

The base 46 of the cap portion 45 is of the same shape as each cap portion 29, 30, and a blade 47 projects from its forward surface. To mount a modified cap portion 45 in the tool shown in FIGS. 1–3 in place of one or the other of the cap portions 29, 30, the tool is assembled with the base 46 occupying the position formerly occupied by the cap portion 29 or 30 which it replaces. A curved surface 48 of the cap portion 45 is so shaped that when the cap portion 45 is assembled in the tool, the surface 48 conforms with the shape of the internal surface of the cutter teeth so as to make a close fit with the tooth or teeth of the cutter which come adjacent thereto.

A planar surface 50 of the cap portion 45 in the assembled tool is inclined outwardly from adjacent the separator member towards the forward end of the cutter, the area of the planar surface 50 being greater than the area of the forward surface of the cap portions 29, 30. This general arrangement improves the ability of the tool to engage magnetizable objects in a bore since the larger surface area formed by two surfaces at an angle to each other assists in engaging awkwardly shaped objects such as are frequently encountered.

When using a cap portion of the type shown in FIGS. 4 and 5, the angle at which the surface 50 is inclined to the axis of the tool varies with the diameter of the tool in order to obtain the best results. In the assembled tool, the teeth of the cutter should extend at least as far as the tip of the blade 47 so that the blade will be protected to a certain extent by the cutter. Also, the cutter preferably has such a number of teeth spaced round it that regardless of the relative positions of the blade 47 and the cutter, the cutter will always afford good protection for the blade and yet not unduly affect the ability of the tool to retain magnetizable material thereon. It is then unnecessary to provide means for maintaining a predetermined relative disposition of the blade and the cutter such as would afford the best possible protection of the blade, whilst the various threaded connections of the tool

are tightened during use of the tool in a well-bore. It has been found that four teeth on a cutter of the kind shown in FIGS. 1, 2 and 3 afford satisfactory protection for the blade 47 compatible with leaving the retrieving action of the tool unimpaired.

It will be appreciated that variations and modifications may be made to the embodiments that have been described without departing from the scope of the invention. For example, in the tool shown in FIGS. 1, 2 and 3, the cutter may only have one tooth which extends round approximately half of the circumference of the cutter, ports being provided in the cutter which open on the rear face of the tooth and on the remainder of the circumference not occupied by the tooth. Also, the separator member, the magnets, the D-shaped plates and the cap member, could be secured together into an assembly, the separator member being so designed that in any position it occupies relative to the rear body portion of the body, a passage for liquid is always established through it from the rear body portion. By keying the assembly to the cutter, the assembly can be made always to occupy a predetermined position relative to the cutter so that should a bladed cap portion be used in the tool, it will always be afforded the best possible protection by the cutter. With this type of tool, a cutter having one tooth could be used, the bladed cap portion serving in operation to stir earthy matter at the bottom of the well-bore. As an optional feature, in addition to the ports in the cutter, further ports may be provided, for example in the separator member or in the cap portions, for delivery of liquid to the forward end of the tool.

I claim:

1. A magnetic retrieving tool for removing magnetizable material from oil wells and similar bore holes comprising a hollow body, at least one permanent magnet disposed within said body, a main cap member of magnetic material and a cutter having a plurality of teeth located at one end of said body, said cutter being provided with outlet ports for directing liquid onto each of said teeth during operation of the tool, means establishing a passageway for liquid through said body from one end thereof to the other, said passageway being in communication with said outlet ports in said cutter, means detachably securing said main cap member and cutter to said body end and with the outer face of said main cap member exposed to the exterior of said body for attracting magnetizable material, and an auxiliary cap member secured to said body and disposed intermediate said main cap member and permanent magnet for retaining said permanent magnet within said body, said auxiliary cap member having one face thereof in mangetic contact with at least one pole piece of said permanent magnet and the opposite face thereof in magnetic contact with the inner face of said main cap member, and said main cap member and cutter being detachable from said body without separating said auxiliary cap member from its magnetic contact witth said pole piece of said permanent magnet.

2. A magnetic retrieving tool as claimed in claim 1 in which there are two permanent magnets each having a respective main cap member and auxiliary cap member, said respective magnets, main cap member and auxiliary cap members being separated by a non-magnetic separator member, whereby the magnetic circuit formed by the magnets which lies within the confines of the tool is of horseshoe form, each leg of which terminates in the respective cap member.

3. A magnetic retrieving tool as defined in claim 2 wherein said detachable main cap members and separator are so shaped as to define a conical wall portion against which a similarly shaped internal wall portion of said cutter abuts to hold said detachable main cap members securely in position in the tool and abutting against said auxiliary cap members.

4. A magnetic retrieving tool as defined in claim 2 wherein said permanent magnets and non-magnetic separator therebetween are disposed in a tubular portion of said body which is threaded onto a solid portion of said body and which solid portion forms a magnetic bridge between the ends of said magnets opposite the ends having said auxiliary and detachable main cap members applied thereto.

5. A magnetic retrieving tool as defined in claim 2 wherein at least one of said detachable main cap members is provided with blade integral therewith and which extends forwardly within said hollow cutter.

6. A magnetic retrieving tool as defined in claim 5 wherein the inner surface of said blade on said detachable main cap member is inclined outwardly from adjacent said separator member towards the forward end of said cutter.

7. A magnetic retrieving tool as defined in claim 5 wherein the outer surface of said blade on said detachable main cap member makes a close fit with the inner surface of a tooth adjacent thereto on said cutter.

8. A magnetic retrieving tool as claimed in claim 1 in which said ports in the cutter are formed in the rear faces of the cutter teeth.

9. A magnetic retrieving tool for removing magnetizable material from oil wells and like bore holes comprising a cylindrical body of magnetic material, a pair of D-shaped permanent magnets arranged back-to-back and with their upper end faces in contact with the lower end face of said body to thereby form a composite permanent magnet of horseshoe form, a flanged D-shaped auxiliary cap member of magnetic material for each of said permanent magnets and which is placed with its upper face in contact with the lower face of its corresponding magnet, a separator member of non-magnetic material disposed between the back faces of said magnets, a flange on the lower portion of said separator member, a cylindrical tubular member of non-magnetic material surrounding said D-shaped magnets and which is secured to said cylindrical body, the lower end of said tubular member being provided with an inturned flange engaged with the flanges on said auxiliary cap members and the flange on said separator member to hold the assembly of magnets, separator member and auxiliary cap members permanently in place within said tubular member, a pair of D-shaped detachable cap members of magnetic material, and means detachably holding last said cap members with their upper faces in contact respectively with the lower faces of said D-shaped auxiliary cap members, said detachable holding means being constituted by a tubular cutter member of non-magnetic material, the upper portion of said cutter member being provided with means for detachably connecting the same to said cylindrical tubular member and the lower portion of said cutter member being provided with teeth and also with an internal surface engaging a complementary external surface on said detachable cap members.

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