Oct. 1, 1963 W. G. OWNBY 3,105,548

TUBING NIPPLE AND SELECTOR TOOL

Filed March 24, 1960 5 Sheets-Sheet 1

Fig. 1

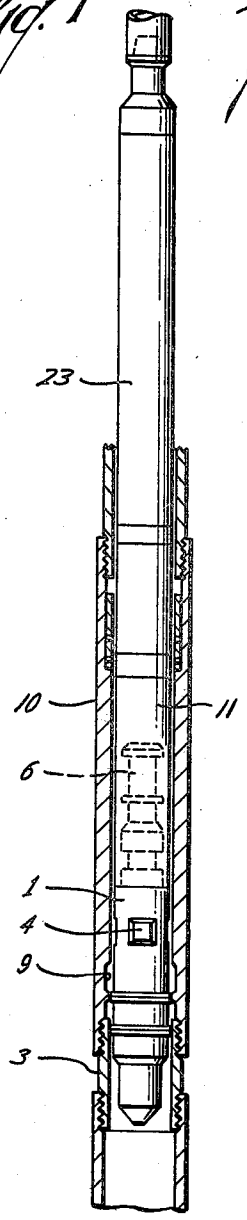


Fig. 2

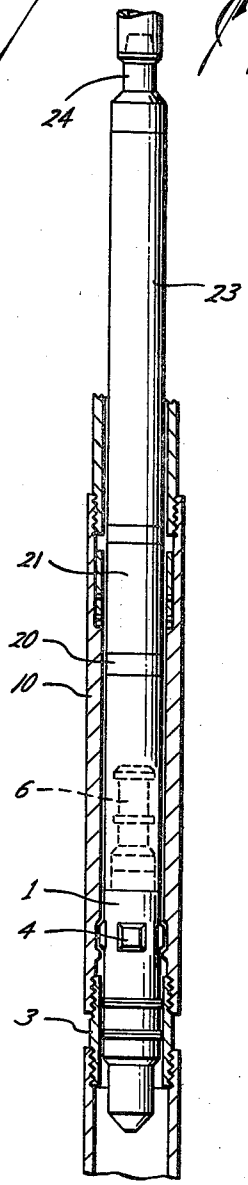
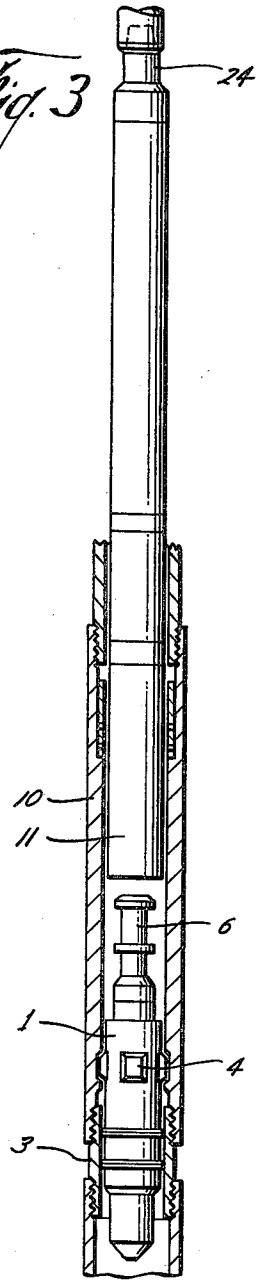


Fig. 3



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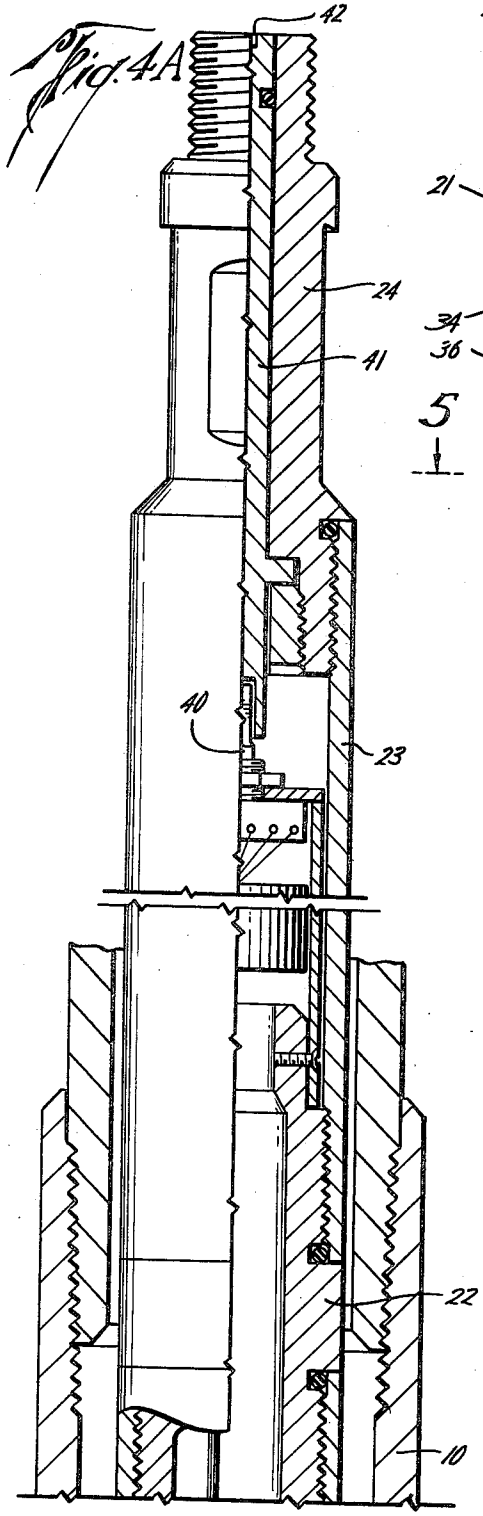
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TUBING NIPPLE AND SELECTOR TOOL

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Fig. 4A



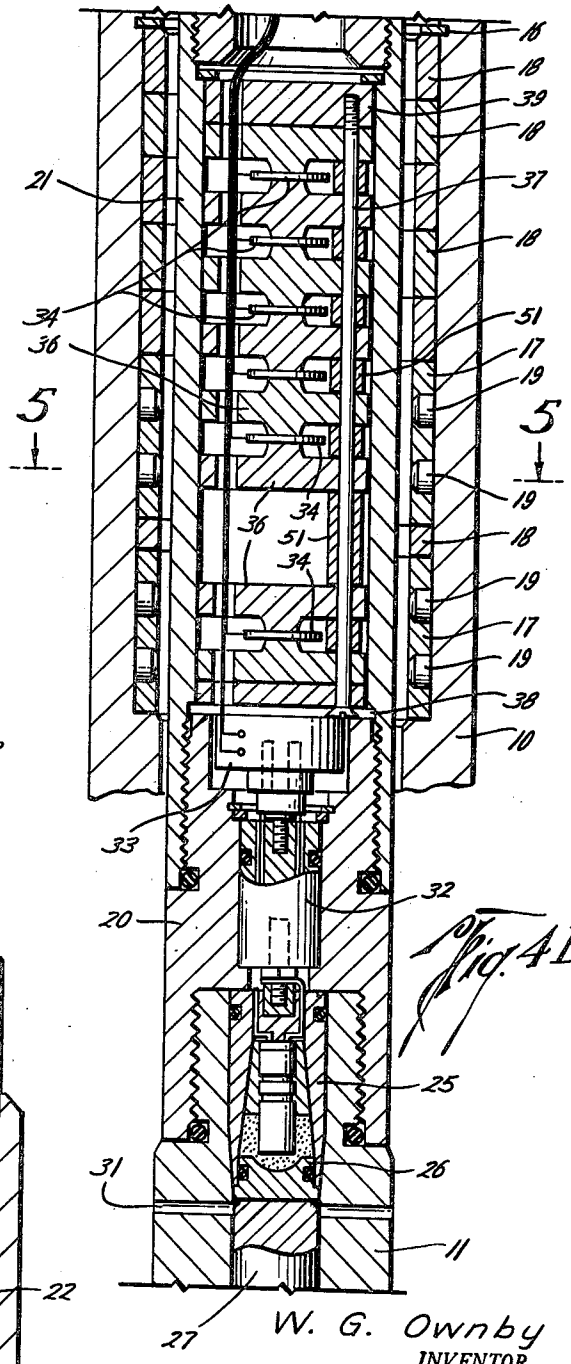


Fig. 4B

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Fig. 4C

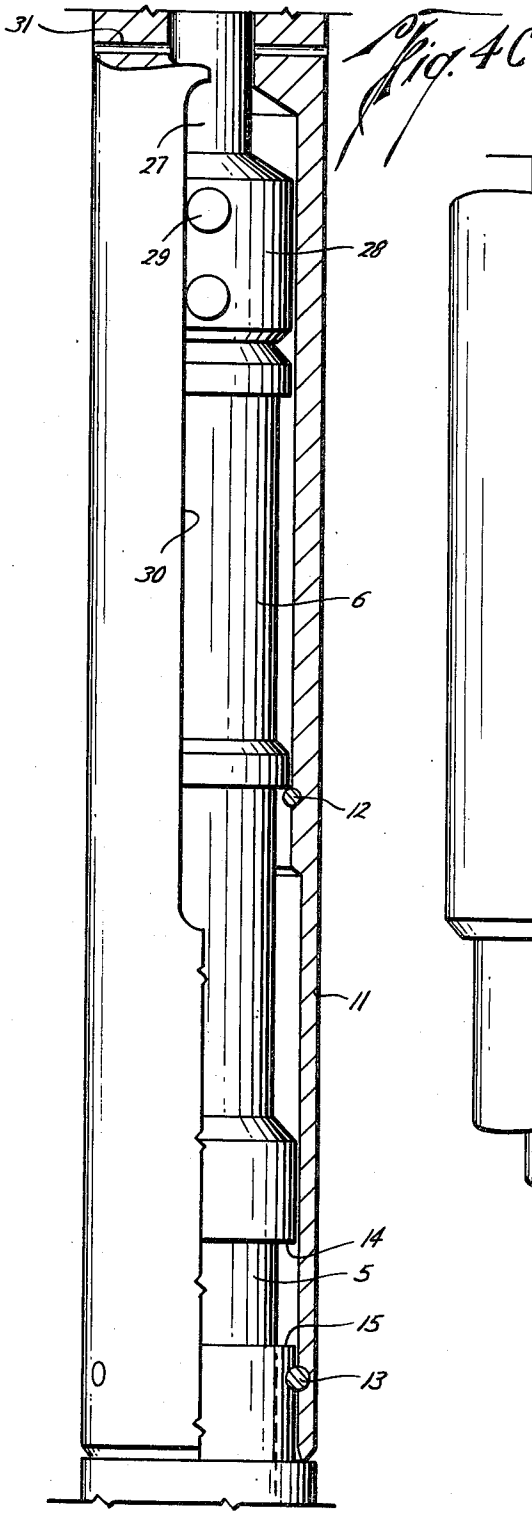
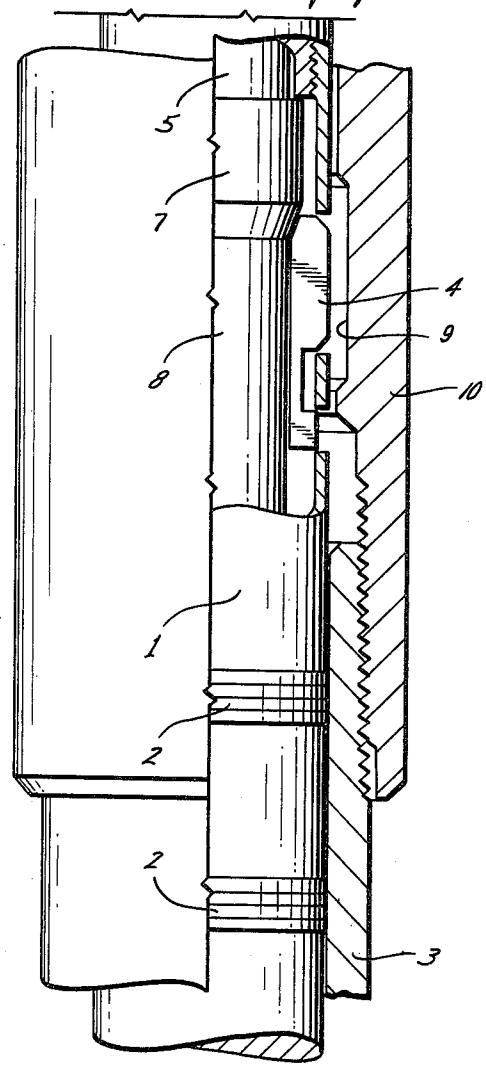


Fig. 4D



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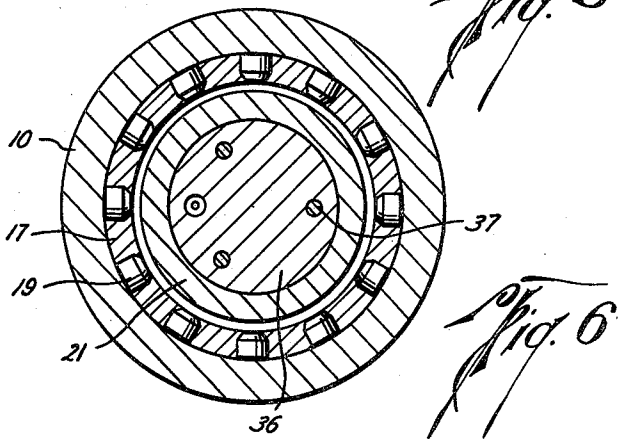


Fig. 5

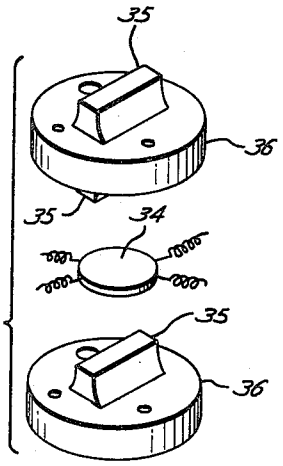


Fig. 6

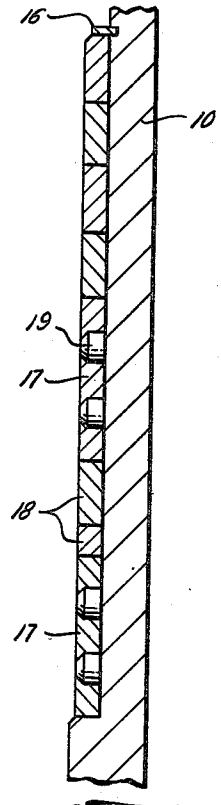


Fig. 7

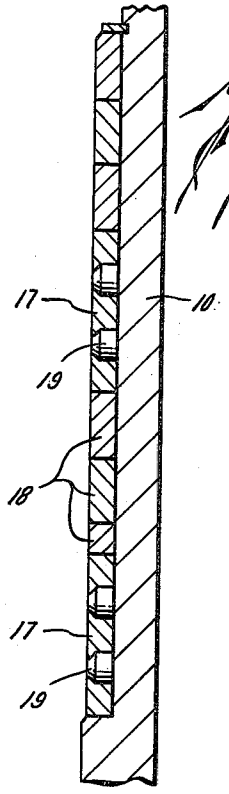


Fig. 8

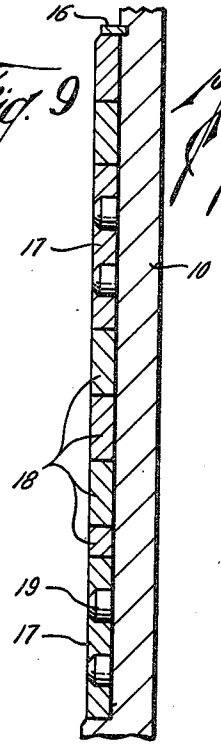


Fig. 9

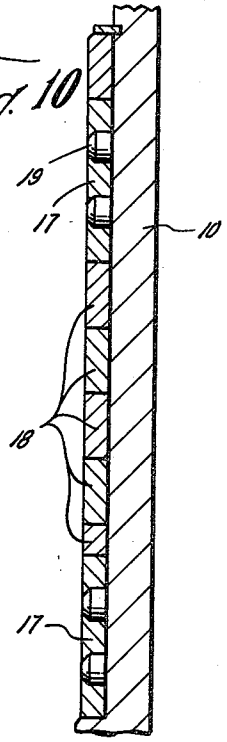


Fig. 10

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Fig. 11

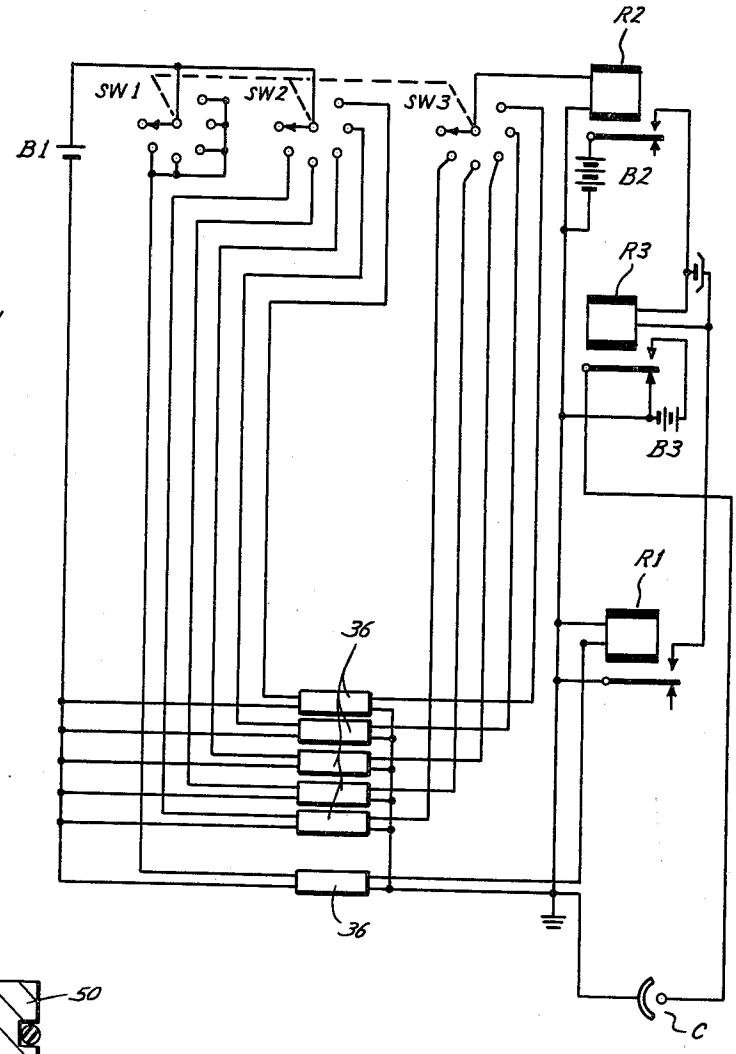
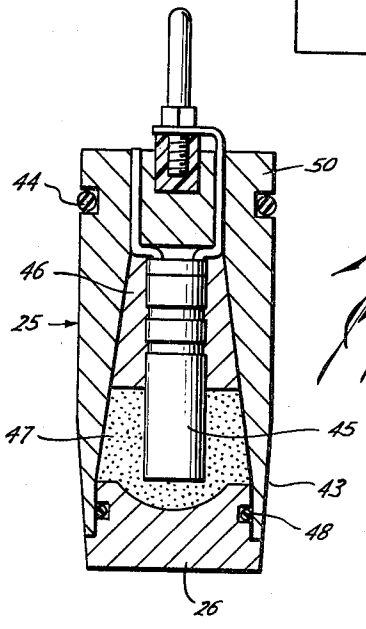


Fig. 12



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Patented Oct. 1, 1963

3,105,548
TUBING NIPPLE AND SELECTOR TOOL

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Filed Mar. 24, 1960, Ser. No. 17,385
13 Claims. (Cl. 166—65)

This invention relates to subsurface well tools and more particularly to improved equipment including a device to be run down a well hole and to effect work automatically upon reaching a preselected depth location.

An object of the invention is to provide a well installation having at spaced apart predetermined depths a number of signaling stations whose signals are distinctly different each from others, and a running tool having signal sensing means preset for responsive action when brought within the distinctive signal field of a selected station.

A further object of the invention is to provide an improved signal responsive assembly which discriminates between signaling stations and is influenced by the signal of a particular station for triggering a work performing operation into action.

Another object is to provide signaling stations having sets of adjacent co-operating permanent magnets arranged in the well tubing wall with the end poles of the sets respectively facing inwardly and of opposite polarity for the protrusion into the interior of the well tubing of magnetic lines of force as a concentrated field between the opposite polarity faces inwardly of adjacent magnets.

A still further object is to provide a group of signaling stations spaced apart downwardly in a well and each comprising a set of spaced apart magnetic fields whose spacing differs from the spacing between the fields of other stations and a lowering tool having a stack of conductors spaced apart in relation to the spacing of the magnetic fields at the several stations whereby the conductors when combined in different sets are spaced to match the field spacing of the stations respectively so that flow of current through any selected set of conductors and when the conductors of that selected set are concurrently within the magnetic fields of a given station, results in voltage output concurrently at the conductors and influences relays for simultaneously closing series connected switches in a control circuit for thereby actuating a work performing mechanism.

Another object of the invention is to provide a work performing mechanism having an improved cartridge assembly for an explosive charge whose ignition gives an instantaneous buildup of high power energy to initiate a quick work action with force relief means timed into effect after a predetermined response of the mechanism.

Other objects and advantages will become apparent from the following specification having reference to the accompanying drawing illustrating a preferred but not necessarily the only embodiment of the invention and wherein FIGS. 1, 2 and 3 respectively show a tubing fragment in section with a running tool received therein in relatively different relations; FIGS. 4A, 4B, 4C and 4D are complementary views partly in section showing on a large scale the co-operative relation of a running tool and a nipple coded to one another as they would be for a response of the working mechanism but showing the working mechanism still in its initial inactive relationship; FIG. 5 is a transverse section on line 5—5 of FIG. 4B; FIG. 6 is a detail perspective view of a sensing element and a pair of co-operating pole pieces therefor; FIGS. 7, 8, 9 and 10 are fragmentary sectional views showing a pair of magnet carrying rings alternately positioned for providing fields differently spaced apart; FIG. 11 is a wiring diagram of an igniting circuit for an explosive charge and the controls therefor; and FIG. 12 is

a detail sectional view of an improved explosive charge unit.

According to the invention, the usual well tubing string is made up at the time of installation in a well bore such as one which penetrates oil and gas sands, with any desired number of signaling stations at predetermined spaced apart depths and each station comprises a pair of separate magnetic fields protruding inwardly from the tubing in longitudinally spaced apart relation. Such longitudinal spacing between signaling fields differs at each station whereby a tool incorporating a pair of magnetic field responsive or signal sensing devices coded or matched to the twin fields of any given station can be run through the tubing string and only when its signal sensing devices are concurrently responsive to the selected stations traversed by the tool will they effect an automatic actuation of a work performing mechanism at the desired well depth location.

As magnetic field sensing elements, there is here proposed the use of small units of crystalline semiconductory compound of high carrier mobility and which when conducting electric current and upon being subjected to a magnetic field, respond to produce a Hall-effect output voltage. Such output voltage produced at a pair of sensing elements at the same time is used to actuate electrical relays in controlling battery power for effecting work in a well. Semiconductors having high mobilities, such as the relatively new intermetallic compounds including indium antimonide and indium arsenide, are suitable for sensing element use. Eements using indium antimonide are commercially available in the form of small thin wafers having four polarized electrical leads, two for current bias and two for Hall-output voltage. A number of the wafer elements can be suitably spaced apart in a compact stack which also includes a pair of pole pieces for each element and by electrical switching the elements of the multiple assembly can be made active two at a time in selected pairs physically spaced apart to correspond with magnetic field spacings of the tubing string stations. Accordingly, a running tool incorporating a stack of sensing elements can be preset for responsive action at any station selectively.

Signal transmission can be utilized for various well working operations and for convenience of disclosure the drawings illustrate positioning of a conventional fluid flow control device including a hanger assembly to be latched in a tubing nipple. The hanger assembly has an outer tubular body 1 carrying annular packing rings 2 for sealing bearing on the interior surface of a well tubing sting 3 and also having side windows to receive laterally movable latching dogs 4. Slidably fitted within the body 1 is a downwardly retractable hollow plunger 5 terminating upwardly in a spool-shaped fishing neck 6 and having in the region of the latch dogs 4 a stepped diameter portion providing in end to end succession an annular enlargement 7 above a smaller diameter zone 8. In its upwardly projected position of FIG. 4D, the plunger 5 presents its smaller diameter zone 8 in lateral alignment with the latch dogs 4 for the inward nonlatching retraction of the dogs but upon downward plunger travel at any time when the dogs are aligned with an internal annular keeper groove or notch 9 in a tubing nipple 10, the expander enlargement 7 moves behind and outwardly cams the latch dogs and then holds the dogs projected into latching reception within the keeper groove 9, as seen in FIGS. 2 and 3.

For running-in purposes, the lower tubular skirt 11 of a running tool as seen in FIG. 4C is sleeved over the upper ends of the upwardly projecting plunger 5 and of the hanger body 1 and is releasably secured to both of them by shear pins 12 and 13, respectively. As the lowering operation brings the latch dogs 4 into proximate align-

ment with the keeper groove 9 of a selected nipple, a sharp downward jar or hammer blow on top of the plunger 5 causes the pin 12 to shear and pushes or depresses the plunger to its downward retracted position defined by stop abutment of a downwardly facing shoulder 14 on the upper end 15 of the body 1 and also pushes the enlargement 7 into dog projected latching position within the keeper groove. With an explosive expansion furnishing the jar to effect plunger depression and latched securement of the tool hanger to the tubing string, the concurrent upward reaction on the running tool relative to the hanger shears the pin 13 and releases the running tool for free withdrawal from the well.

The latch setting downward jar on the plunger 5 occurs upon detonation of an explosive charge loaded in the running tool whenever the signal sensing elements are influenced upon their traverse of magnetic fields to which the elements are coded at a particular signal sending station conveniently embodied in the keeper groove containing nipple 10. The length of the running tool with the hanger secured thereto is determined so that the longitudinal distance between the latch dogs 4 and the signal sensing elements is co-operatively related to or is substantially the same as the longitudinal spacing between the keeper groove 9 and the signaling fields for insuring latch dog and keeper groove alignment at the instant the plunger receives a downward jar as a consequence of signal response.

FIG. 1 shows the wire line suspended running tool in descent within a tubing string and with the latch dogs retracted and just above the keeper notch of a nipple. Considering that the signal sensing elements of the running tool are preset for simultaneous response to the magnetic fields of that particular nipple, then the response times detonation of the explosive charge and plunger retraction with outward projection of the latch dogs into the keeper notch aligned therewith, as seen in FIG. 2. FIG. 3 shows the running tool separated and raised above the latched-in hanger.

Provision of a station comprising a set of multiple signals in longitudinally spaced apart zones and in the form of inwardly protruding field patterns of concentrated flux paths is afforded, as seen in FIGS. 4B and 5, by mounting within the nipple 10 a number of permanent magnets in the form of short bars having their magnetic axes disposed substantially radially and being grouped in spaced apart relations, both longitudinally and circularly of the nipple, to constitute four circular rows of magnets and with the magnets in the two lowermost rows and those in the two uppermost rows co-operating in each case in yielding a magnetic field by the fact that the inner ends of all magnets in each row are alike in polarity in relation to one another but are unlike in polarity to the inner ends of all magnets in the other row of each of the two pairs of rows.

At its upper end the nipple 10 is shown in FIG. 4B as being counterbored to receive a stack of rings held in place by split retainer ring 16 overlying the ring stack and snap-fitted within an annular groove in the nipple wall. By mounting the rings within the counterbored pocket, a full open bore through the nipple is maintained for free passage of well working equipment. The ring stack includes two magnet carrying rings 17 of nonmagnetic material and a number, as, for example, six spacer rings 18 which, like the nipple 10, are of steel or other magnetic material and whose spacer length in the case of all but one ring is uniform for convenience of interchangeability and placement of selected numbers of rings above and below the upper nonmagnetic ring 17 in establishing desired spacing between the two magnet carrying nonmagnetic rings. Thus, if up to five signaling stations are to be located in a well hole, the tubing string is assembled with the desired number of nipples 10 for placement at predetermined depths and each will have a different spatial relationship to the two nonmagnetic rings 17 according to the disposition of the spacer rings 18. By way of illustration, FIGS. 4B, 7, 8, 9 and 10 show respectively one, two, three, four and five intervening rings 18 between the pair of magnet carrying rings 17.

Magnet carrying ring subassemblies are made up by first drilling radially through each nonmagnetic ring two spaced apart rows of circularly spaced apart holes and fitting thereto the bars 19 of permanent magnet material and of lengths corresponding to ring wall width. These bar inserts, with their end faces flush with the ring outer peripheral and inner surfaces, are then cemented or otherwise fixed in place and are charged magnetically to present the south seeking pole inwardly in the case of magnets in one circular row and the north seeking pole inwardly in the case of all magnets in the other row. When installed in a nipple, as in FIG. 4B, the radially spaced apart ends of each magnet in a lower row will be opposite in polarity to the similarly positioned opposite ends of the magnets in the companion upper row. For example, the outer faces of the upper row of magnets and the inner faces of the lower row of magnets in each ring 17 may be north poles and the remaining poles will be south seeking poles. The outermost north and south poles are isolated by the nonmagnetic ring and are joined through the nipple wall through their face contact therewith, while lines of force will protrude inwardly of the ring 17 between the inwardly facing north and south poles. Some lines of force will also extend downwardly around the bottom of the nonmagnetic ring and between north and south poles of the lower magnets, and similarly upwardly around the top of the nonmagnetic ring and between the north and south poles of the upper magnets but a major concentration of flux will extend between the inner faces of the upper and lower magnets. Two of such magnet carrying ring subassemblies spaced apart provide twin spaced apart field patterns within the bore of the nipple and the relative spacing as controlled by the number of spacer rings 18 interposed between the magnet carrying rings marks the particular nipple as distinguished from others for signaling action of twin detectors of the running tool.

The running tool has its components housed within a long tubular body which for convenience of manufacture comprises a number of separately formed tubes threaded together in end to end succession. In addition to the lower tubular skirt 11, the housing includes a plug containing coupling portion 20, a tubular nonmagnetic section 21 enclosing a stack of signal sensing elements and, as seen in FIG. 4A, a coupling element 22, a tubular element 23 enclosing batteries, relays and switches electrically interconnected, as best seen in the FIG. 11 diagram, and a coupling head 24 terminating upwardly in a threaded pin for connection to the end coupling joint of a conventional wire line.

At its upper end the lower skirt 11 provides a pocket to receive the shell 25 which, as best seen in FIG. 12, encloses an explosive charge and is closed by a projectable disk or end cap 26. Immediately below the shell 25, the central bore through the skirt 11 forms an expansible cylinder or variable volume chamber in co-operation with the cap projectile 26 and a slidable rod or plunger 27 fitted within the cylinder. In the initial position of these parts, the upper end of the plunger rod 27 engages with the cap projectile 26 and at its lower end the rod has an enlarged head 28 in seating engagement with the latch expander plunger 6 of the hanger assembly. It follows that upon detonation of the exposive charge, the force of expanding gas is transmitted to and depresses the latch expander 6.

One or more laterally projecting pins 29 on the slide head 28 provide a key formation for vertical sliding reception and interlocking relation within an elongated slot 30 through the side wall of the skirt 11. Among other things, this elongated slot 30 accommodates fluid displacement from within the skirt 11 and incidently affords

a large relief opening for free escape of residual expanding gases at the end of the plunger stroke. More especially, gas relief immediately following projection of the cap 26 is by way of one or more chamber vent ports or openings 31 drilled radially through the cylinder wall at selected longitudinally spaced points in the travel range of the cap 26. Cartridge force and projectile responsive travel determine initial energy build-up, its duration and cessation of pressure application. The side ports 31 are located for controlled gas escape and without its passage beside the plunger 27. They provide fast reduction and cessation of pressure application and minimize or prevent corrosive burning of the plunger and skirt bore surfaces.

By controlling the size of the lateral openings 31, there will be a metered relief of pressure, which is of importance in controlling sudden application of downward force on the plunger rod, desirable for overcoming resistance to the start of movement, but with quick pressure relief after movement has been initiated for reducing force transmission when high energy application no longer is required.

The arrangement is of special importance where fairly light work such as the setting of latches is involved, where the force required for first shearing the connector pin 12 exceeds the smaller push needed to start and shift the released latch expander plunger 5. High initial energy is immediately available for a sharp quick force application for releasing the expander plunger. Then follows an almost immediate gradual relief of expanding gas pressure as the plunger is depressed and a final cessation of pressure application by complete gas escape at the end of the stroke to avoid destructive action. In other words, when the running tool is used for setting a light well device under low pressure, it provides a quick energy build-up whose peak energy duration is short. On the other hand, when a heavy well device is run in a deep high-pressure and fluid-filled well, the same explosive unit and slide plunger and cylinder assembly still provides a quick energy build-up with peak energy maintained to overcome inertia of the massive parts and until they build up momentum and start on their way. Only thereafter is the projectile plug 26 moved sufficiently for releasing excess energy by venting pressure gas into the well bore.

An electrical coupling 32 mounted in the housing coupler 20 provides detachable plug and socket connectors with both the explosive charge unit and a wiring connector 33 at the lower end of a stack of signal sensing units contained within the nonmagnetic housing tube 21. These sensing units include a number of spaced apart semiconductor disks or wafers 34, each sandwiched between and centrally clamped by oppositely projecting bosses 35 of a pair of disks 36 of high magnetic permeability material providing spaced apart pole pieces adapted for alignment with a set of co-operating magnets 19 whereby to extend a magnetic field between such magnets through the semiconductor which is between the patricular pair of pole pieces 36. Conveniently, the assembly of detectors and pole pieces is held together by means of a series of three long tie rods 37 extending through equally spaced apart openings in the several pole pieces with enlarged heads at the lower ends of the rods 37 fitted in a bottom connector plate 38 clamped between opposing end faces on the housing parts 20 and 21 and with screw threaded portions at the upper end of the rods threaded into an end coupling disk 39. Sleeved on the rods between neighboring pole pieces 36 are distance or spacer tubes 51. All spacer tubes, end plates and tie rods are of nonmagnetic material. Additional openings aligned with one another through the pole pieces 36 and the end clamping plates 38 and 39 permit the passage of a wire bundle by which the various parts are connected in the necessary circuitry system.

The wiring includes conductors for selectively placing

each semiconductor 34 in circuit with a battery and for leading the Hall-effect output voltage to relay switches in control of battery connections with the energy storing explosive charge unit. The batteries and the several relays are mounted within the upper housing tube 23, as is also a selector multiple switch unit having an upwardly extending actuating shaft 40. Connected to this shaft 40 as by means of a polygonal pin and socket is the lower end of an actuating rod 41 extending through the upper coupling 24 and having a terminal screw driver slot 42 through which the rod can be rotated for setting the selector switch unit.

The selector switch unit as diagrammed in FIG. 11 comprises the ganged switches SW1, SW2 and SW3, all shown in an off position and whose switch blades can be rotated together, each for engagement with any one of five active contacts. All of the contacts of switch SW1 are connected to the lowermost sensing element 36 for directing current therethrough from the battery B1. The five active contacts of the switch SW2 are joined to the remaining five semiconductors so that as the switch blade engages any one of these switch contacts, a particular one of the semiconductors 36 will receive current from the battery B1. Whichever one of the semiconductors to which current flow is directed through the selector switch SW2 will also be connected for output voltage led through the switch SW3 to the coil of a relay switch unit R2. A similar relay switch unit R1 has its coil connected to receive output voltage from the lowermost semiconductor 36 and when the switch blades of R1 and R2 are concurrently actuated by their respective coils, a circuit is closed from the battery B2 and through a relay switch unit R3. In other words, the relays R1 and R2 have their switch contacts in series relation with the battery B2 and the coil of the relay R3 and the relay R3 is actuated only at a time when relays R1 and R2 concurrently receive actuating voltage. When that does occur, the closing of the switch of the relay unit R3 directs current from the battery B3 to the connector C for the exposive squib for igniting the explosive charge.

From the above it will be seen that the lowermost semiconductor of the stack may be combined with any one of the remaining semiconductors to provide a pair of signal sensing units which are capable of discriminating between signaling stations and to have no effect on the main control circuit unless the pole pieces for the sensing elements selected by the presetting of the selector switch simultaneously come into the influences of the twin signaling fields of a signaling station. If, for example, the sensing element next above the lowermost element has been selected, then when the two sets of pole pieces come into substantial alignment with the inwardly facing north and south poles of the two sets of magnets, as shown in FIG. 4, the output voltage would effect the simultaneous closing of the series connected switches of the relay units R1 and R2 for triggering ignition of the explosive charge. On the other hand, if the selector switch has brought the topmost semiconductor into current flow relation with the battery B1, then the position of the parts in FIG. 4B would influence only the bottom semicondutcor for actuating the relay R1 which would be ineffective inasmuch as the relay R2 at that time is ineffective and both relays would be actuated only when the running tool traverses a nipple whose spacing of the magnets, as seen in FIG. 10, matches that of the semiconductors selected for response to spaced apart fields, as in FIG. 10. Likewise, the selector switch can set the signal sensing units for co-action in pairs in matched relation to the field settings indicated in FIGS. 7, 8 and 9.

The electrically detonated explosive type energy source 25 is a specially designed assembly including an outer cartridge or shell 43 whose outside diameter throughout its major extent is cylindrical and has a lower downwardly tapering portion 43. This outside configuration conforms to the internal shape at the upper end of the

body skirt 11 to permit easy insertion and withdrawal, as well as the properly located and sealed fitment of the parts. Additionally, for sealing against blow-by of expanding gases, the cartridge 50 near its upper end has an annular groove to receive an O-ring 44 for bearing engagement with the interior surface of the body skirt 11. The cartridge is a cup-shaped case and centrally disposed within the chamber of the case is a tubular primer or electric squib 45 having conductors extending through the closed end of the case for detachable plug connection with the bulkhead feed-through connector 32. Surrounding the squib 45 and filling the chamber space are a backfill body 46 adjacent the closed end and an explosive charge 47 held near the open end by the projectable cap or head 26 closely fitted interiorly of the open end and preferably sealed by an O-ring 48 carried within an annular groove in the closure cap end piece 26. The electric squib acts to detonate the explosive charge which supplies expanding energy gas for the working operation. The backfill body 46 comprises an epoxy resin plus a suitable curing agent and a filler such as plaster of Paris. It guards against excessive gas blow-back and prevents damage to the chamber and the bulkhead feed-through connector. The relative amounts of epoxy compound backfill 46 and explosive powder 47 are carefully selected and accurately metered so that after the charge is tamped into place there will be no void when the closure cap 26 is set in place. To prevent contamination of the explosive charge by volatile liquids and gases such as those in which it may become submersed, it is here proposed to employ special precautions in final assembly of the cartridge. These include thorough cleaning of all components, including a cleaning operation after the epoxy fill has been set and cured. It should be here mentioned that fillers employing solvents and requiring their evolvement for hardening should be avoided and instead suitable epoxy compounds have been selected with careful compounding and treatment for insuring that the curing agent is fully reacted without any contaminating remainder. In the final step of setting the end cap 26 over the explosive charge, the assembly is placed in a vacuum chamber or bell jar with the cap just resting on the powder charge, whereupon the production of vacuum extracts air from inside the cartridge and pressure is then applied to force the cap into final position for compacting the powder charge and sealing the container under vacuum. Not only does this procedure void air from within the cartridge but atmospheric pressure after removal from the vacuum chamber will hold the cap tightly in assembly with the cartridge.

From the above description it will be apparent that there has been provided a selectively operable tool which can be switched to activate selective sensing elements to match the signal of a particular nipple and that the tool will safely pass through other coded nipples regardless of the speed of tool travel, and which enables a fast running operation with assurance of proper response at the selected depth location.

While the invention has been described with reference to a particular detail embodiment, its scope is not to be limited other than set forth in the appended claims.

What is claimed is:

1. A station selector work performing well tool, including a housing for travel in a well and traverse of one or more of a series of stations each comprising a pair of magnetic fields spaced apart differently in each station, a bank of spaced apart Hall-effect semiconductors within the housing, pole pieces located by the housing to provide each semiconductor with a pair of pole pieces through which a magnetic circuit is completed through the semiconductor upon traverse of the magnetic field of any station by the pair of pole pieces, a source of electric current, selector switch means operably connecting said current source with pairs selectively of semiconductors for current flow therethrough, a pair of relay switches connected for response to voltage from the selected pair of semiconductors, an electric circuit controlled by said relay switches and closed thereby when both relay switches simultaneously respond to voltage output at the semiconductors and work performing means responsive to the closure of said electric circuit.

2. A station selector work performing well tool, including a housing for travel in a well, a plurality of pairs of pole pieces carried by the tool for transitory inclusion within a magnetic field during tool travel, a Hall-effect semiconductor positioned between and joined to each pair of pole pieces, selector means for directing electric current to selected semiconductors according to predetermined semiconductor groupings differing one from another, means responsive to voltage output at the selected semiconductors when they are simultaneously influenced by magnetic fields and work performing means controlled by the voltage responsive means.

3. A work performing tool for travel through a tubing string and active in response to the influence of a magnetic field presented at a predetermined depth in the tubing string, said tool including energy releasing means, an electric circuit control therefor and means to influence voltage in said circuit and thereby render effective said energy releasing means and comprising a source of current, a Hall-effect semiconductor connected in said circuit and coupled to said source for the flow of current through the semiconductor and a pair of pole pieces connected to said semiconductor for transmitting thereto a magnetic field and operative upon being carried into a magnetic field to impress such field on said semiconductor and thereby vary voltage in said control circuit.

4. For use with a tubing string having a number of spaced apart sets of signaling stations spaced apart differently in each set, a tool adapted for travel through the tubing string, initially inactive work performing mechanism forming part of said tool, means actuatable in resonse to a control therefor and operative on and thereby rendering active said work performing mechanism, said control including a plurality of signal sensing devices spaced apart and combinable selectively in any of several different sets of differently combined sensing devices having coded relationships spatially each to a different set of signaling stations, a selector operable to render said devices signal sensitive in any selected combination and means responsive to a simultaneous sensing of signals by a selected set of signal sensing devices and thereby effecting actuation of said means.

5. A well tool for travel through a tubing string having a number of sets of signaling devices spaced apart longitudinally of the tubing string and differently in each set, said tool including a stack of longitudinally spaced apart elements whose spacing is such that the elements are combinable selectively in sets in which the elements of respective sets are coded spatially each to a different set of signaling devices, means connectable with said elements and thereby rendering the same signal-sensitive, a selector controlling the connection of said means with said elements in sets selectively, means responsive to the simultaneous sensing of signals by the elements of a selected set and work performing mechanism connected with and controlled by the response of the last mentioned means.

6. A station selector work performing well tool including a group of longitudinally spaced apart signal pick-up elements, actuating means connectable selectively with the elements and rendering selected sets of the elements signal sensitive in any one of various combinations of differently spaced apart elements, means responsive to simultaneous sensing of signals by all elements of any selected set and work performing means arranged for actuation upon response of the second mentioned means.

7. Means for performing work in a well, including a tubing string having a series of spaced apart sections of

magnetic material, permanent magnets fitted within each tubing section and disposed each with its opposite pole faces radially spaced apart in relation to the tubing section, said magnets being arranged in longitudinally spaced apart pairs of co-operating magnets whose outer faces are of opposite polarity one to another, as are also their inner faces, nonmagnetic carrier rings positioning each pair of magnets, spacer rings of magnetic material interposed between the carrier rings of the respective tubing sections and arranged to position the pairs of magnets in the several tubing sections in relatively different longitudinally spaced apart relationship each to the other and a tool for travel through the tubing string comprising a housing, a series of longitudinally spaced apart pole pieces mounted in the housing and arranged for co-operation in pairs with the magnets of any pair traversed thereby in extending the field from between such magnets and into the housing, a series of Hall-effect semiconductors arranged each within the field influence of a different pair of pole pieces, selector means directing electric current to selected pairs of said semiconductors, means responsive to voltage output occurring simultaneously at the selected pair of semiconductors and a work performing device connected with and controlled by the response of the last mentioned means.

8. Well equipment including a work performing device, an electric control circuit therefor having a pair of voltage responsive relay switches connected in series in the circuit, a series of Hall-effect conductor elements, a series of spaced apart pole pieces arranged to provide a pair of pole pieces connected across each element, a current supply selector device connectable with said conductor elements to direct current through selected pairs of elements, means for impressing voltage output from one of the selected pair of elements on one of the relay switches, other means for impressing voltage output from the other of the selected pair of elements on the other of the relay switches, spaced apart sets of permanent magnets located in a well hole in co-operating pairs spaced from one another with the magnets of each pair spaced apart differently from the spacing between magnets of other pairs and related to the spacing between the pole pieces of the conductor elements whereby selection of a pair of elements codes the spacing of their pole pieces to the spacing of a predetermined pair of magnets for concurrently impressing magnetic fields on the selected conductor elements.

9. Means for performing work in a well, including a tubing string having a series of tubing sections of magnetic material at spaced apart predetermined depths, a stack of spacer rings internally positioned in each of said tubing sections and comprised of a pair of rings of nonmagnetic material and a series of spacer rings of magnetic material of which a selected and different number in each tubing section are placed between said pair of nonmagnetic rings, a pair of circular rows of permanent bar magnets embedded in each nonmagnetic ring to extend on substantially radial axes with the end faces of the magnets in one row opposite in polarity to the faces at the corresponding ends of the magnets in the other row for an inwardly protruding magnetic field therebetween, a tool for passage through the tubing and provided with an electrically actuated work performing device, an actuating circuit therefor having a pair of relay switches connected in series therein, means responsive to the influence thereon of magnetic fields to supply operating voltage to said relay switches and comprising a stack of Hall-effect semiconductors having pole pieces arranged in sets relatively spaced apart for combining the sets in different pairs whose spacings respectively conform each to the spacing between the inwardly protruding magnetic fields at said tubing sections selectively, means supplying current to said semiconductors in pairs thereof selectively and conditioning the same for response to the impression thereon of magnetic fields traversed thereby and means to deliver

relay switch operating voltage output from the semiconductors for closing said actuating circuit when the selected semiconductors simultaneously are within magnetic fields.

10. Means for performing work in a well, including a series of spaced apart signaling stations each constituted by two spaced apart pairs of spaced apart bar magnets positioned with their magnetic axes extending substantially radially and with the magnets of each pair having their inwardly disposed pole faces of opposite polarity for inwardly protruding a field therebetween and with the spacing between the two pairs of different dimension in each station, a tool for passage through the well and carrying a series of magnetic field influenced current conductors provided with pole pieces spaced apart to present sets of pole pieces selectively within the fields of predetermined station magnets upon traverse thereof by the tool, a selector device supplying current to said conductors in pairs thereof selectively, a pair of relay switches, one connected to and responsive to voltage output from one of said conductors and the other connected to and responsive to voltage output from the other of said conductors, an electric switch arranged to be closed when both of said relay switches are concurrently closed, a source of work performing energy and activating means therefor in circuit with said switch and responsive to current supply upon closure of said switch.

11. A magnetic signaling well tubing insert comprising a tubular nipple having an internal wall portion of magnetic material, a stack of rings lining said internal wall portion and including a pair of rings of nonmagnetic material and other rings of magnetic material and said rings being interchangeably positioned in the stack for selective spaced apart relations of the nonmagnetic rings, a series of permanent magnets spaced apart in the axial direction of the nipple and arranged to present two pairs of magnets with those of one pair spaced from one another by one of the nonmagnetic rings and those of the other pair spaced from one another by the other of the nonmagnetic rings and with the opposite pole faces of each magnet spaced apart radially of the nipple and located respectively one adjacent said magnetic wall portion and the other adjacent the inward face of the stack of rings and the inner pole faces of the magnets of each pair being unlike in polarity for protruding a magnetic field inwardly of the nipple between such unlike pole faces of each pair of magnets.

12. A magnetic signaling device of the character described, including a ring of nonmagnetic material and a plurality of permanent bar magnets embedded in the ring and arranged in upper and lower longitudinally spaced apart rows of circularly spaced apart magnets, each having its magnetic axis extending substantially radially within the ring, the inwardly and outwardly disposed ends of the magnets in the upper row being opposite in polarity to the correspondingly disposed opposite ends of the magnets in the lower row and providing magnetic lines of force therebetween.

13. In a magnetic signaling system, a pair of rings of nonmagnetic material, upper and lower rows of permanent bar magnets embedded in each ring with their magnetic axes extending substantially radially within the ring and with the north poles of the magnets of one row aligned longitudinally of the ring with the south poles of the magnets of the other row for establishing magnetic fields therebetween, a tubing string section of magnetic material mounting said rings in longitudinally spaced apart relation and a series of magnetic spacer rings interchangeably positioned by the tubing string section for selective location between the nonmagnetic rings in establishing the predetermined spacing therebetween.

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