

April 1, 1958

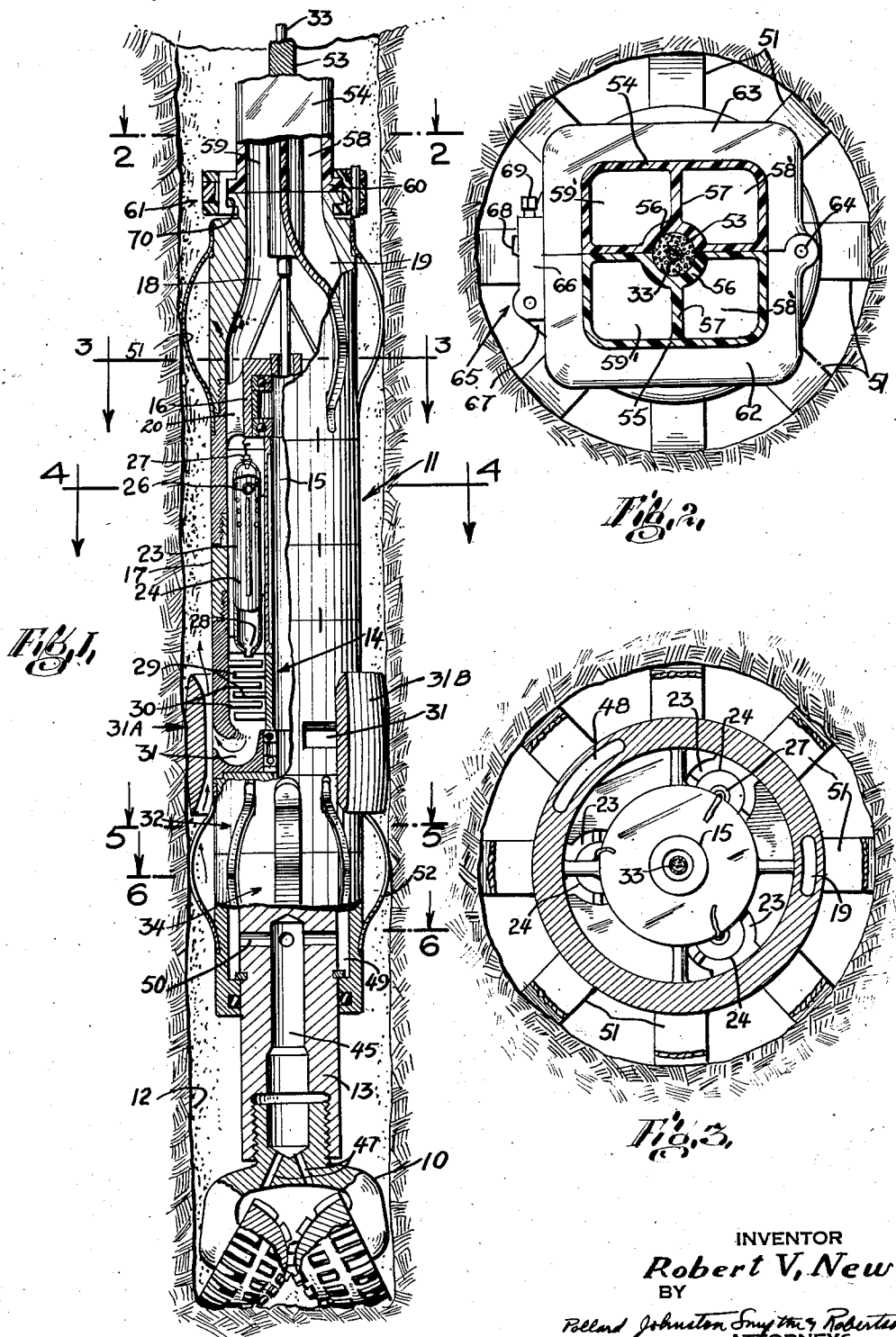
R. V. NEW

2,828,945

OIL AND GAS WELL DRILLING AND APPARATUS THEREFOR

Filed July 22, 1955

5 Sheets-Sheet 1



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5 Sheets-Sheet 2

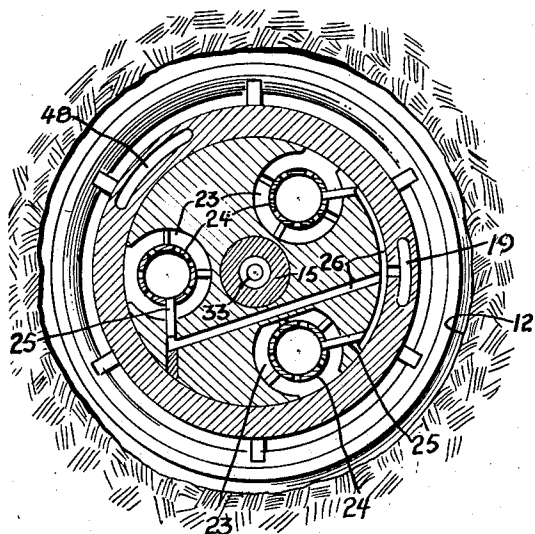


Fig. 4.

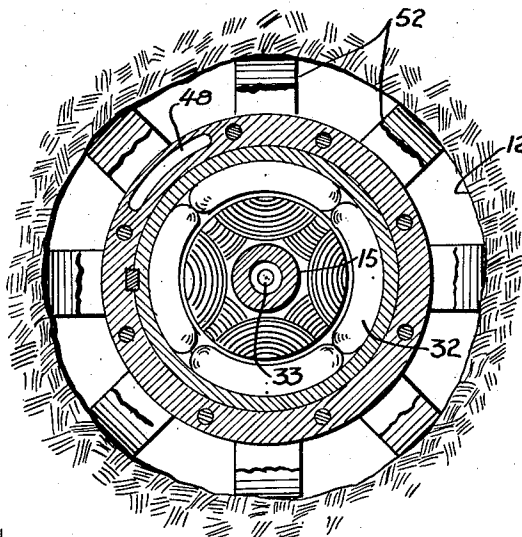


Fig. 5.

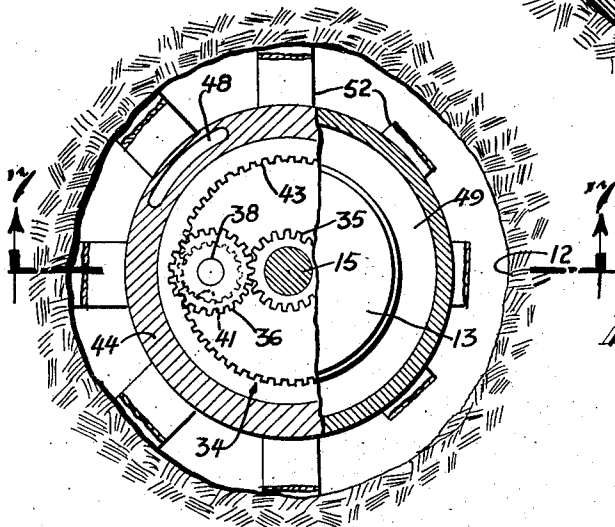


Fig. 6.

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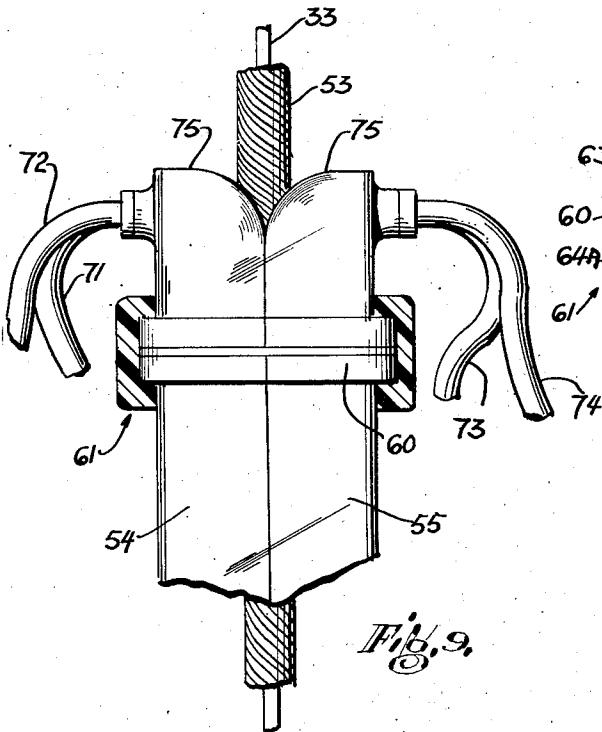
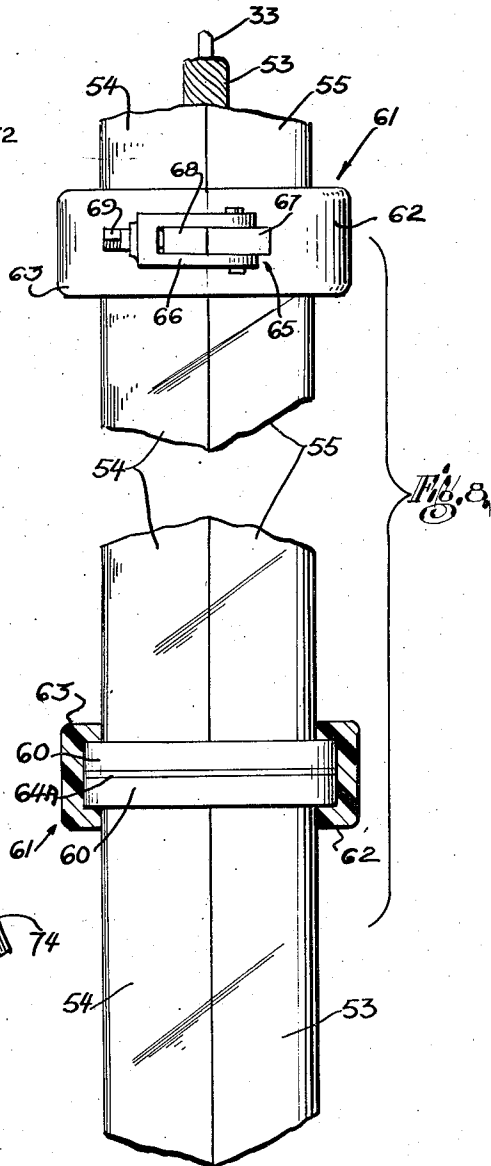
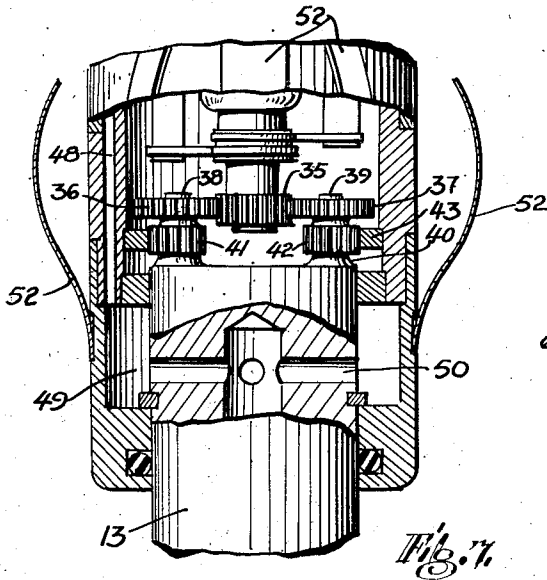
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OIL AND GAS WELL DRILLING AND APPARATUS THEREFOR

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5 Sheets-Sheet 3



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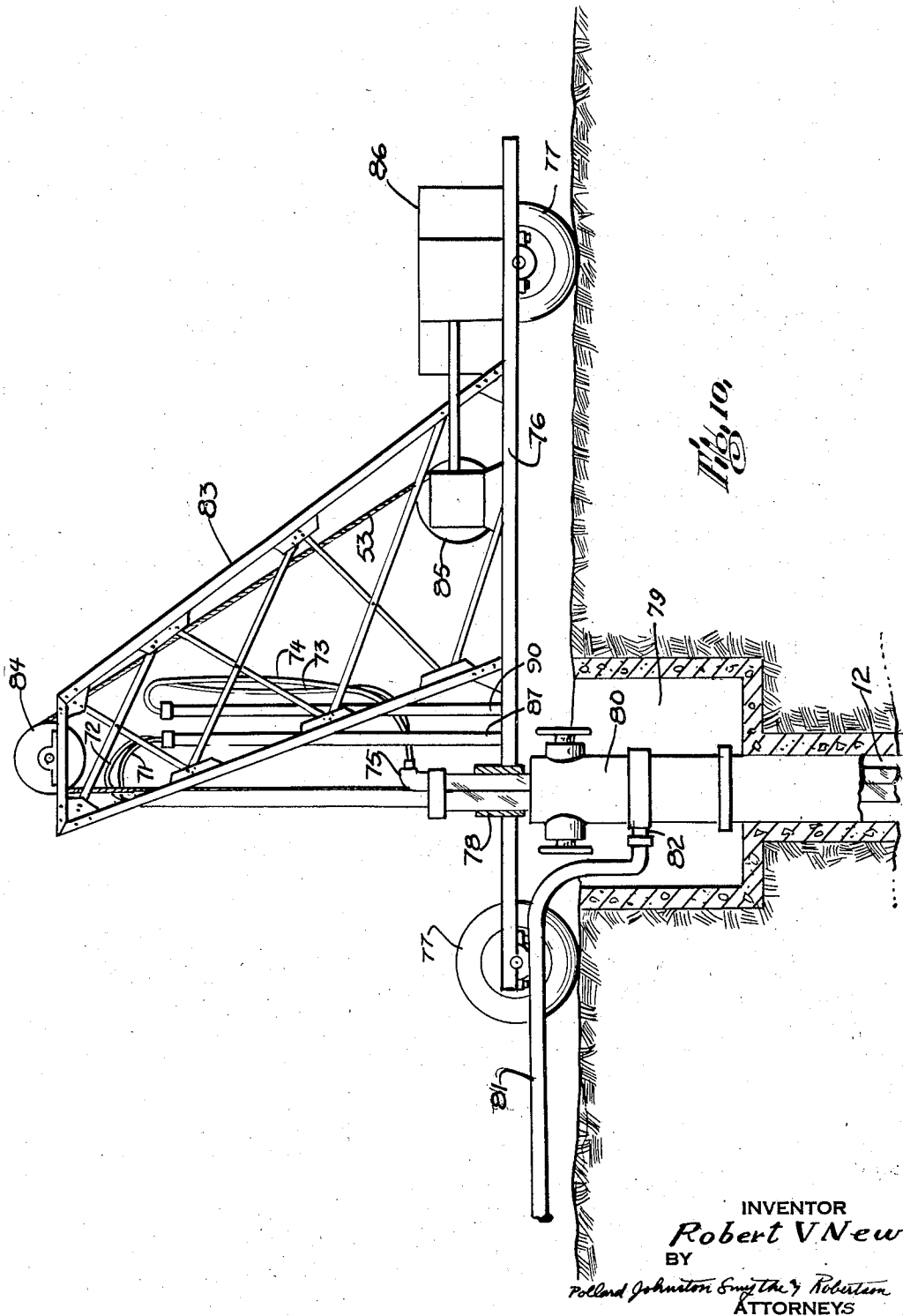
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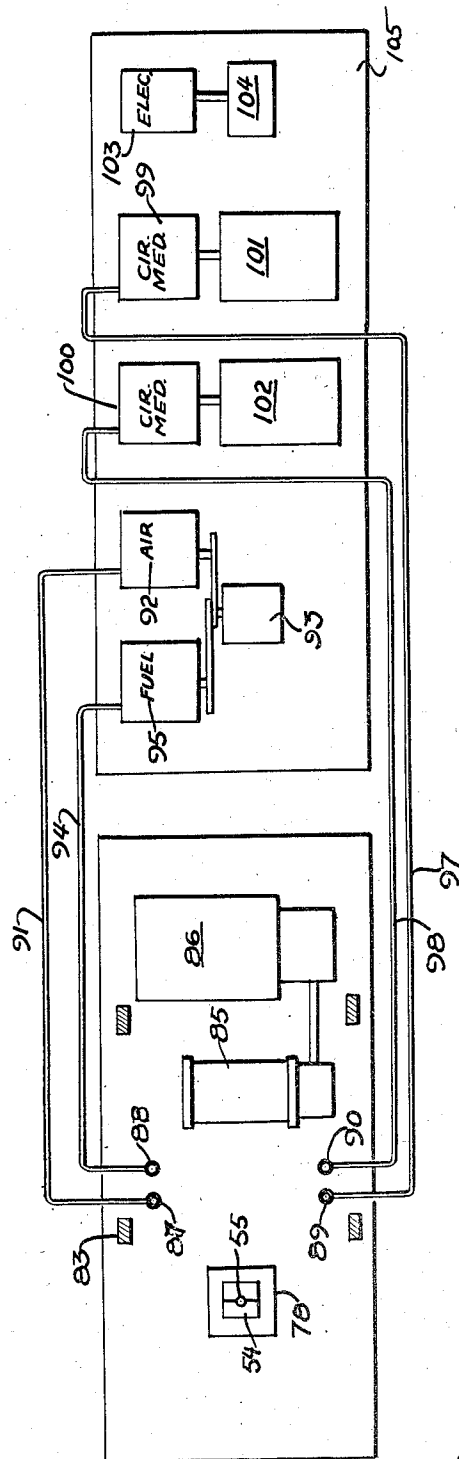


Fig. 11.

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OIL AND GAS WELL DRILLING AND APPARATUS THEREFOR

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Application July 22, 1955, Serial No. 523,888

12 Claims. (Cl. 255—4)

This invention relates generally to oil and gas well drilling, and is particularly directed to the drilling of oil and gas wells by the rotary method and employing a vapor or gas as the circulating medium to effect removal of the cuttings from the bore hole.

Generally speaking, oil or gas wells are drilled either by the cable-tool method, wherein the drilling tools suspended from a cable are churned or reciprocated vertically within the bore hole to accomplish the abrasion of the material at the bottom of the bore hole and the material loosened by the drilling tools is removed from the hole by a bailer; or by the rotary method, wherein the rock mass through which the well is drilled is abraded and chipped away by the downward pressure and the cutting and grinding action of a revolving steel bit which is suspended from a drill stem, and water or mud is pumped down through the drill stem and bit to issue from the latter and sweep away the material or cuttings loosened by the bit and to carry the cuttings to the surface through the annular space between the drill stem and the walls of the well. With a view toward securing the best features of both the cable-tool and rotary methods of drilling, "combination" rigs have been developed which include all the essential equipment pertaining to each of the two methods under one derrick. Most recent drilling has been almost exclusively by the rotary method which is generally more rapid in that the drilling may be continuous without interruption for bailing and with a smaller number and variety of fishing jobs.

In the standard rotary drilling rig, the drill stem extends from the bit to a point some distance above the derrick floor. At the level of the derrick floor, the drill stem passes through a gripping device in a rotary table which is mounted over the mouth of the well and suitably driven so that the drill stem performs the dual functions of conveying the water or mud circulating medium to the bottom of the bore hole and of transmitting the rotation of the rotary table to the drill bit. Since the pressures employed in connection with mud or other liquid circulating media are often as great as 2000 p. s. i. and considerable torque is required to rotate the bit, it is apparent that the pipe sections and couplings, making up the drill stem in the standard rotary rig, are subjected to great stresses and, accordingly, are of heavy and relatively massive construction.

Drilling of oil and gas wells by the rotary method with a vaporous or gaseous circulating medium holds great promise for the industry in that, potentially, the costs of drilling can be thereby substantially reduced. The use of a vaporous or gaseous circulating medium in place of the usual mud or other circulating liquid media has been found to result in increased drilling rates; in very substantial increases in the footage that can be drilled with a bit before the latter has to be replaced, and hence in a decrease in bit costs; in large savings in the consumption of mud materials where serious lost circulation problems prevail, thereby avoiding excessive mud costs and probably damage to well productivity resulting

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from the usual lost circulation recovery methods; and in permitting the determination of gas producing intervals during drilling, for example, by uncontaminated gas count or drill-stem testing, so that productive zones may be found which would be overlooked when drilling with mud as the circulating medium.

Although it has been found that the pressures employed in connection with a vaporous or gaseous circulating medium need not exceed approximately 100 p. s. i., as compared with the pressures of up to 2000 p. s. i. required when mud is the circulating medium, all of the existing applications of a vapor or gas as the circulating medium have employed conventional drilling rigs, wherein air compressors are substituted for the usual mud pumps and suitable adaptations have been made in the blow-out preventers, flow nipples, discharge pipe and other auxiliary apparatus, but the basic arrangement for rotating the bit is unchanged and still relies upon the drill stem to transmit the rotation of the rotary table at the surface to the bit deep in the bore hole. Thus, the drill stem must be constructed to withstand the high torsional stresses imposed thereon during driving of the bit, and there is no reduction in the weight of the drill stem, or of its components, as a result of the relatively low pressures used in connection with a gaseous or vaporous circulating medium.

In order to design a drill string or stem which takes advantage of the low pressures that can be used with a vaporous or gaseous circulating medium, it is necessary to provide an arrangement wherein there is also little or no torque on the drill string so that the pipe sections and the joints or couplings therebetween can be of relatively light weight construction and materials sufficient to withstand the relatively low pressures of the circulating medium. Such removal of torque from the drill string can be achieved by applying the power to turn the bit at a location immediately above the latter but the desired result, namely the possibility of designing the drill string to withstand only relatively low pressures, can be obtained only when such application of power immediately above the bit does not involve the transmission of a high pressure fluid from the surface to the power applying means. Heretofore, for example, in United States Letters Patents No. 1,072,964 to J. Maher et al.; No. 2,254,641 to C. E. Bannister; No. 2,044,349 to W. L. Diehl; and No. 2,591,488 to L. Yost, it has been proposed to drive the drill bit by a pressure fluid driven turbine disposed immediately above the bit. However, in all such previous proposals, of which the above identified patents are exemplary, the power for driving the turbine is generated at the surface and transmitted to the turbine by a motive fluid, which may be either the mud or other circulating medium or a fluid employed especially for power transmission, and, in any case, such motive fluid must be under a relatively high pressure, surely greater than the pressures at which gaseous or vaporous circulating media can be employed, in order to effect any substantial power transmission. Thus, the piping or conduit carrying the motive fluid must be designed to withstand the relatively high pressures of the latter and, in most cases, heavy pipe sections and complex tool joints therebetween, as in the usual drill string of a rotary drilling rig, are the only satisfactory arrangement for conveying the motive fluid to the turbine within the bore hole.

Accordingly, it is an object of this invention to provide a rotary drilling rig wherein the bit is rotated without imposing high torque or torsional stresses or internal pressures upon the drill string so that the latter can be formed of light weight pipe sections and simple joints or couplings therebetween, thereby facilitating the handling

of the pipe sections and the coupling and uncoupling thereof.

A specific object of the invention is to provide a rotary drilling rig wherein power is applied to the bit at a location immediately above the latter and such power is also generated adjacent the bit, with the materials necessary for the generation of the power being supplied under low pressure from the surface to the power generator within the bore hole so that said materials, as well as a vaporous or gaseous circulating medium, can be conveyed through a hollow drill string of light weight construction.

Another object is to provide a rotary drilling rig of the described character wherein the power for turning the drill bit is generated within the bore hole immediately above the bit by a heat energy or gas turbine to which the constituents of a combustible mixture are separately supplied and the exhaust from the turbine is discharged into the bore hole in a suitable manner where it combines with the upwardly flowing vaporous or gaseous circulating medium carrying the cuttings from the bit and thereby dries the hole and the cuttings to prevent "balling up" of the latter so that rotary drilling is effected under conditions most favorable to that drilling method. Further, in accordance with the invention, the gaseous or vaporous circulating medium required in addition to the exhaust from the turbine is supplied through the drill string separately from the constituents of the combustible mixture for the heat energy or gas turbine, so that the additional circulating medium may be a non-explosive gas to act with the carbon dioxide of the turbine exhaust in reducing explosive tendencies when hydrocarbon gas enters the bore hole.

In one aspect of this invention, a heat energy or gas turbine is suspended from a cable and adapted to be lowered into the bore hole. The power generated within the turbine is transmitted through a suitable speed reducing means to a rotary drill bit disposed immediately below the turbine, and the latter is held non-rotatably within the bore hole. The constituents of the combustible mixture for the turbine, for example, a liquid or gaseous hydrocarbon and air, and the vaporous or gaseous circulating medium, for example, methane, air, nitrogen or carbon dioxide, are separately conveyed to the bottom of the bore hole through hollow, light weight, preferably glass fibre reinforced plastic pipe sections embracing the cable from which the turbine is suspended and held together by simple and easily manipulated joints or couplings. The light weight construction of the pipe sections and the simplicity of their couplings are made possible by the fact that the drill string formed thereby is non-rotatable, that is, is not relied upon for transmitting rotary movement from the surface to the drill bit at the bottom of the bore hole, and by the fact that the substances conveyed through the hollow pipe sections are all under relatively low pressures of approximately 100 p.s.i.

The above arrangement, which, as indicated, permits the use of light weight pipe sections and simple, easily manipulated couplings in the non-rotated drill string, makes it possible to reduce the size, strength and weight of the derrick and other auxiliary equipment located at the surface, as compared to the corresponding parts of the conventional rig for rotary drilling of an oil or gas well. Thus, in the usual rotary drilling rig, each pipe section of the rotated drill string has a length of approximately 30 feet and the pipe sections are coupled together by high pressure, high torque tool joints which are difficult to assemble and disassemble. In order to limit the length of time and amount of work required for removing the drill stem or string from the bore hole and for returning the string into the hole, whenever replacement or changing of the bits or tools or any other service work in the bore hole is required, it has become standard procedure to leave several of the pipe sections coupled to

gether to form a stand as the string is removed from the hole, thereby reducing the number of joints that have to be uncoupled and then recoupled when the string is returned into the bore hole. The derrick used with a conventional rotary drilling rig must therefore have a height which is greater than the combined height of the stand of pipe sections remaining coupled together and the length of the block and hook by which the string is hoisted. Accordingly, it is common in conventional rotary drilling operations to provide a derrick having a height of from 90 to 180 feet. However, with a rotary drilling rig embodying this invention, the light weight of the pipe sections and the simplicity of the couplings therebetween make it possible to uncouple all of the joints between the successive pipe sections as the drill string is withdrawn from the bore hole without involving too much time or work so that, when using pipe sections of 30 foot lengths, a derrick having a height of no more than 60 feet can be employed. Such a relatively short derrick is much lighter, less expensive, and more easily portable than the tall derricks used with conventional rotary drilling rigs. Further, because of the light weight of the pipe sections, automatic machinery may be provided and synchronized with the movements of the cable, around which the pipe sections are arranged, for hanging, stacking or racking the pipe sections as they are uncoupled and come away from the cable during the withdrawal of the drill string from the bore hole. It is also to be noted that the lightness of the pipe sections that may be employed in connection with this invention greatly facilitate the transportation of such pipe sections to the site of the drilling operation.

The above, and other objects, features and advantages of this invention will be apparent in the following detailed description of an illustrative embodiment, which is merely exemplary and is to be read in connection with the accompanying drawings, wherein:

Fig. 1 is an elevational view, partly broken away and in longitudinal section, of an arrangement for driving the bit in a rotary drilling rig embodying this invention;

Fig. 2 is an enlarged sectional view taken along the line 2-2 of Fig. 1;

Fig. 3 is an enlarged sectional view taken along the line 3-3 of Fig. 1;

Fig. 4 is an enlarged sectional view taken along the line 4-4 of Fig. 1;

Fig. 5 is an enlarged sectional view taken along the line 5-5 of Fig. 1;

Fig. 6 is an enlarged sectional view taken along the line 6-6 of Fig. 1;

Fig. 7 is an enlarged sectional view taken along the line 7-7 of Fig. 6;

Fig. 8 is a fragmentary, elevational view, partly in section, of a portion of a drill string associated with the arrangement of Fig. 1 in accordance with this invention;

Fig. 9 is a detail elevational view showing the connections to the upper end of the drill string;

Fig. 10 is a diagrammatic, side elevational view of a derrick and auxiliary equipment that may be used in connection with the bit driving arrangement and drill string embodying this invention; and

Fig. 11 is a diagrammatic plan view of the derrick and auxiliary equipment completing a drilling rig embodying this invention.

Referring to the drawings in detail, and initially to Fig. 1 thereof, an arrangement embodying this invention for driving a rotary drill bit 10 is there shown and generally identified by the reference numeral 10. The drive or assembly arrangement 11 including the bit 10 and motor 14 is adapted to be lowered into the bore hole 12 with the bit 10 which is secured to a driven shaft 13 extending from the lower end of the drive arrangement.

In accordance with this invention, the drive arrangement or assembly 11 both applies and generates the power to turn the bit 10 at a location immediately above the

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latter. For this purpose, the arrangement 11 includes a heat energy motor or gas turbine, generally identified by the reference numeral 14, in which a combustible mixture is burned and the products of combustion are expanded against a rotatable turbine wheel fixed on a drive shaft 15. The drive shaft 15 is elongated and journaled in suitable bearings, as at 16, within an elongated housing 17. The combustible mixture burned in the gas turbine 14 may, for example, include air and a gaseous or liquid hydrocarbon fuel, and the air enters the housing 17 through a suitable passage 18 opening at the top end of the housing, while the fuel also enters at the top of the housing into a suitable passage 19 segregated from the air passage 18.

The air passage 18 widens into an annular space 20 extending around the drive shaft 15, said annular space 20 opening at its lower end into cylindrical compartments 23 (Figs. 1 and 4) which receive the air and each accommodate a combustion chamber 24. Part of the wall of the chamber 24 is perforated to admit the air, and fuel is injected into the combustion chamber by a nozzle 25 projecting through the chamber wall. As seen in Figs. 1, 3 and 4, the fuel passage 19 extends along the housing 17 from the top of the latter to the level of the combustion chambers of the turbine and there communicates with a manifold 26 (Figs. 1 and 4) which supplies the fuel from the passage 19 to the individual nozzles 25. A suitable igniter or spark plug 27 may be provided in each combustion chamber 24 to ignite the mixture of air and fuel fed thereto, particularly during starting and before the combustion chamber walls have been heated sufficiently to effect ignition.

The lower ends of the combustion chambers 24 are in the form of nozzles 28 to emit the heated products of combustion downwardly against the blades of a turbine wheel 29 fixed on the drive shaft 15, and the usual fixed guide vanes 30 are provided above and below the turbine wheel. Thus, the products of combustion from the combustion chambers 24 are expanded against the turbine wheel 29 to drive the latter and the shaft 15. After much of the energy of the heated products of combustion has been dissipated in driving the turbine wheel, the exhaust from the turbine 14 is discharged from the housing 17 through exhaust ports 31 which are preferably formed to direct the exhaust radially outward and upwardly into the bore hole 12 through a suitable venturi arrangement 31A or similar means or directly into the bore hole, depending upon the pressures existent, venturi shroud 31B being suitably attached to housing 17 by webs (not shown).

In order to start the heat energy motor or gas turbine 14, an electric motor 32 (Figs. 1 and 5) is mounted within an extension of the housing 17 and has its armature coupled to the shaft 15. The electric current for driving the starting motor 32 and for energizing the igniters 27 is supplied through sheathed and insulated conductors 33 (Figs. 2, 3, 4 and 5).

If desired, the turbine may include an air compressor (not shown), which can be the axial flow type to permit its inclusion in a housing of relatively small diameter and which compresses the air admitted to the housing 17 as the air flows through the annular space 20. The axial flow air compressor may include the usual movable blades extending radially in one or more circular series on drive shaft 15 and may have conventional fixed guide vanes extending radially inward from the housing 17 at the opposite sides of the series of movable blades.

Since the speed at which the shaft 15 of the turbine rotates will be much greater than the desired rotational speed of the bit 10, a speed reducing assembly is interposed between the drive shaft 15 and the driven shaft 13 and is generally identified by the reference numeral 34. Although any convention speed reducing means may be employed, the drawings illustrate a particular embodiment, merely by way of example, wherein the drive shaft

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15 has a pinion 35 (Fig. 6) keyed thereto and meshing with gears 36 and 37 (Figs. 6 and 7) which are rotatably mounted on diametrically opposed axles 38 and 39, respectively, carried by a rotatable frame 40 fixed to the driven shaft 13. The gears 36 and 37 have co-axial, relatively small gears 41 and 42 fixed thereto and meshing with internal gear 43 fixed within the housing 44 of the speed reducing assembly 34 so that, as shaft 15 is rotated by the turbine 14, the shaft 13 will be rotated at a relatively slow speed to similarly rotate the bit 10 secured thereto.

Although the bit 10 illustrated in Fig. 1 is a roller bit usually employed for hardrock rotary drilling, it is to be noted that any other standard type of bit, even a core barrel, may be attached to the driven shaft 13 for rotation by the arrangement 10 embodying this invention.

Since the drive arrangement 10 is intended to take full advantage of the possibilities offered by a gaseous or vaporous circulating medium in simplifying and reducing the weight of rotary drilling equipment, a suitable vaporous or gaseous circulating medium, for example, methane, air, nitrogen, or carbon dioxide, is supplied to a longitudinal bore 45 within shaft 13 and discharged radially outward and axially downward through ports 47 so that the circulating medium sweeps under the bit 10 and carries the cuttings out from under the bit and upwardly through the space within the bore hole 12 around the drive arrangement 11.

The vaporous or gaseous circulating medium is also conveyed from the surface to the bottom of the bore hole where it enters a passage 48 in the housing 17 (Fig. 3). As seen in Figs. 3 to 7, inclusive, the passage 48 extends from the top of housing 17 downwardly through the housing 44 of the speed reducing means and, at the bottom of the latter, opens into an annular chamber 49 (Figs. 1, 6 and 7) which opens radially inward against the surface of driven shaft 13. The shaft 13 has radial passages 50 opening from the bore 45 into the annular chamber 49 so that the circulating medium is led through the passage 48, by-passing the turbine 14, motor 32 and speed reducing means 34, into the chamber 49, and from the latter through the passages 50 into the bore 45 from which the medium is discharged into the bore hole through ports 47.

In order to stabilize the driving arrangement 11 within the bore hole 12, casing spacers 51 and 52 (Figs. 1, 3 and 5) of conventional construction are arranged at vertically spaced locations on the housing of the drive arrangement 11 and resiliently hold the latter centered within the bore hole 12. The spacers 51 and 52, at least to some extent, also resist rotation of the drive arrangement 11 within the bore hole by their frictional engagement with the wall surface of the latter.

The drive arrangement 11 embodying this invention is suspended, at its upper end, from a cable 53 which is suitably attached thereto, while the air and fuel supplied to the passage 18 and 19, respectively, and the additional gaseous or vaporous circulating medium supplied to the passage 48 are conveyed from the surface to the drive arrangement 11 through pairs of pipe sections 54 and 55 (Figs. 1, 2, 8 and 9) which embrace the cable 53 and are removably coupled together to form a non-rotated drill string. As seen in Fig. 2, each of the pipe sections is of generally rectangular cross-section with a semi-cylindrical recess 56 in one side so that when the pipe sections 54 and 55 are arranged with their recesses 56 in confronting relation, as in Fig. 2, such recesses define a cylindrical passage adapted to accommodate the cable 53. Further, each of the pipe sections has a lateral partition 57 therein dividing the interior of the pipe section into two segregated passages 58 and 59 which open at the opposite ends of the pipe sections.

As seen in Figs. 8 and 9, each pair of pipe sections 54 and 55 embracing the cable 53 is removably coupled, at its opposite ends, to adjacent pairs of identical pipe

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sections in axial alignment therewith so that the passages 58 and 59 form four continuous passages extending from the top of the drill string to the bottom of the latter which, as shown in Fig. 1, is removably connected to the upper end of housing 17. The upper ends of the passages 18, 19 and 48 of housing 17 are arranged so that the passages 58 and 59 of section 54 of the lowermost pair of pipe sections opens into the passages 19 and 18, respectively, as shown in Fig. 1, while the passages 58' and 59' of the other pipe section 55 of the lowermost pair opens into the passage 48.

Since the air and fuel passing through the pipe sections 54 and the vaporous or gaseous circulating medium passing through the pipe sections 55 are all under relatively low pressures, and the torque on the non-rotated drill stem is relatively low, the pipe sections 54 and 55 can be formed of glass fibre reinforced plastic materials, such as, for example, polymerized polyester resin materials, thereby providing pipe sections of relatively low weight and great resistance to corrosion.

The drill string made up of the cable 53 and associated pipe sections 54 and 55 is held against rotation at the surface and is intended to arrest rotation of the drive arrangement 11 within the bore hole as the bit 10 is rotated against the earth stratum at the bottom of the bore hole. In order to increase the torsional resistance of the drill string, the lay of the wire strands in the cable 53 and the lay of the glass fibres in the pipe sections 54 and 55 are oriented so as to resist twisting of the drill string assembly. Thus, the cable 53 may have a left lay while the reinforcing fibres of both pipe sections 54 and 55 have a right lay, or conversely, the cable and reinforcing fibres of the pipe sections may have right and left lays, respectively. As a further alternative, the cable 53 may be a non-spinning wire rope of strands with both right and left lays, while the reinforcing fibres in one of the pipe sections have a right lay and the reinforcing fibres in the other of the pipe sections have a left lay.

In any case, it is apparent that the torsional stresses to which the non-rotated drill string is subjected in holding the casing 17 against rotation are relatively small when compared with the torsional stresses imposed upon the drill string in the usual rotary drilling rig where the drill string rotates to drive the bit at the bottom of the bore hole and the torque applied to the upper end of the drill string must also overcome the frictional resistance to turning of the drill string within the bore hole. Further, since the drill string in the illustrated embodiment of this invention is not rotated, it can have a generally square external cross section, as seen in Fig. 2, to provide large clearances between the flat outer surfaces of the pipe sections 54 and 55 and the wall surface of the cylindrical bore hole 12, which large clearances facilitate the removal of the cuttings from the bore hole by the upward flow of the circulating medium in the space around the drill string.

The low pressures behind the fluid conveyed through the pipe sections 54 and 55 and the relatively low torque that has to be resisted by the drill string made it possible to employ simple and easily manipulated couplings between the successive pairs of pipe sections 54 and 55 and between the lowermost pair of pipe sections and the top of housing 17. Thus, for example, the pipe sections 54 and 55 can be formed with flanges or rims 60 (Fig. 8) at their opposite ends adapted to be secured to the flanges at the adjacent ends of the pair of pipe sections next in line by a clamp or coupling generally identified by the reference numeral 61. The coupling 61 illustrated in the drawings includes two complementary, generally C-shaped portions 62 and 63 which are hingedly connected at one end, as at 64 (Fig. 2), and have channel cross sections to engage over and under the adjacent rims 60 with a suitable gasket 64A between the latter (Fig. 9). A quick-release latch 65 is provided for hold-

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ing together the free ends of the portions 62 and 63 and may include a bail 66 pivoted on a lug 67 extending from the end of portion 62 and engageable over a lug 68 on the free end of portion 63. Further a locking screw 69 is threaded through the bail 66 to engage the lug 68 and hold the bail in the illustrated position where the latter maintains the portions 62 and 63 in coupling condition.

As seen in Fig. 1, the housing 17 is also provided with a flange or rim 70 at its upper end around the openings to the passages 18, 19 and 48 so that a coupling 61 of the kind described above can also be employed to secure the flanges 60 at the lower ends of the lowermost pair of pipe sections 54 and 55 to the flange 70.

As the depth of the bore hole 12 increases, additional pairs of pipe sections 54 and 55 are added at the top of the drill string around the cable 53, and the air, fuel and circulating medium are supplied to the respective uppermost pipe sections through suitable flexible piping. Thus, as shown in Fig. 9, the air and fuel are respectively supplied through flexible pipes 71 and 72, while the vaporous or gaseous circulating medium is supplied through flexible pipes 73 and 74, and each flexible pipe ends in a fitting 75 adapted to be clamped on the upper end of the uppermost pipe section 54 or 55 in alignment with the related passage of the latter. Such clamping of the fittings 75 on the uppermost pipe sections can be effected by a coupling 61 of the kind described above.

The above described drive arrangement 11 and the pipe sections 54 and 55 and couplings 61 which with the cable 53 form the non-rotated drill string in accordance with this invention make it possible to greatly simplify the derrick and auxiliary apparatus required at the surface. Referring to Figs. 10 and 11, it will be seen that a derrick floor 76 may be mounted on wheels 77 to form a truck trailer that is easily towed to the drilling site. A square, non-rotatable bushing 78 is mounted in the derrick floor 76, and the pipe sections 54 and 55 of the drill string extend slidably through the bushing 78 and are normally closely engaged by the latter so that the bushing then prevents rotation of the drill string. However, the bushing 78 is longitudinally split, or otherwise capable of being laterally expanded, to permit the passage therethrough of the couplings between the successive pairs of pipe sections.

As is usual, a cellar 79 is excavated at the top of the bore hole 12 and a blow-out preventer 80 is secured to the top of the surface casing which has been cemented in bore hole 12 and is disposed within the cellar and there embraces the pipe sections 54 and 55 so that the space within the bore hole 12 around the drill string can be closed off at its upper end in the event that excessive gas pressures are developed within the bore hole. A conduit 81 extends from an outlet 82 on the blow-out preventer to carry away the circulating medium and cuttings discharged from the bore hole.

A derrick structure 83 extends upwardly from the floor 76 over the bushing 78 and, at its top, supports a single sheave crown block 84 over which the cable 53 runs from a drum or reel 85 which is driven by an engine 86 and forms the draw works of the derrick.

Since the couplings 61 of the drill string are subjected to relatively low pressures and torsional stresses and can therefore be designed for ease in assembly and disassembly thereof, the pipe sections of the drill string can be completely taken apart during removal of the drill string from the bore hole without requiring excessive time or work. Thus, the derrick 83 need be only high enough to accommodate the length of a single pipe section, as contrasted with the derrick of the usual rotary drilling rig which must be high enough to accommodate at least two joined together pipe sections since the time and work required for uncoupling the usual tool joints makes it necessary to uncouple only alternate, or more widely spaced apart, joints of the drill string. It is apparent that the shorter derrick made practical by the present invention is

less expensive and more easily transported to the site of the well to be drilled.

The flexible pipes 71, 72, 73 and 74 extend from standpipes 87, 88, 89 and 90, respectively, which are arranged on the derrick floor 76 adjacent the bushing 78. Air is supplied to the standpipe 87 through a pipe 91 (Fig. 11) extending from an air compressor 92 driven by an engine 93. Fuel is supplied to the standpipe 88 through a pipe 94 from a fuel pump 95 driven by an engine 93, and the vaporous or gaseous circulating medium is supplied to the standpipes 89 and 90 through pipes 97 and 98 extending from compressors 99 and 100 driven by engines 101 and 102, respectively. Finally, an electric generator 103 is driven by an engine 104 to supply current through the conductor 33 for the igniters 27 and starting motor 32 of the turbine 14. As seen in Fig. 11, the several pumps and compressors and the generator, as well as the associated engines, may be mounted on a truck trailer 105 for convenience in transport. Since the fuel, air and circulating medium are under relatively low pressures, the pipes 91, 94, 97 and 98 can be of the flexible low pressure type.

The fact that the pipe sections 54 and 55 of the drill string are of light weight, glass reinforced plastic construction, makes it practical to provide automatic machinery (not shown) for hanging, stacking or racking the individual pipe sections in synchronism with the movement of the cable 53 as the drill string is withdrawn from the bore hole. Further, it is apparent that the light weight of the pipe sections 54 and 55 reduces the load on the engine 86 driving the drum 85 of the draw works on which the cable 53 is wound.

It will also be noted that the rotary drilling rig embodying this invention also eliminates many costly and complex parts of the usual drilling rig, for example, the rotary table in the derrick floor and associated engine therefor, the heavy tongs, balances, links and elevators used for handling the usual heavy drill pipe, the swivel, the traveling block and latch-hook, while the crown block of 5 to 9 sheaves is replaced by a single sheave and the high pressure rotary hose carrying the circulating medium to the drill pipe is replaced by low pressure flexible pipes carrying the air, fuel and gaseous circulating medium to the pipe sections.

The generation of the power to turn the bit 10 at a location within the bore hole 12 immediately above the bit has several advantages in addition to the possibility that it provides for employing light weight pipe sections and simplified couplings in the drill stem. Thus, the exhaust from the power generator or turbine 14 dries out the bore hole and the cuttings to prevent balling-up of the latter. Further, the carbon dioxide in the exhaust forms an explosion deterring blanket, particularly when the additional gaseous circulating medium is also non-explosive, thereby minimizing the danger when hydrocarbon gas seeps into the bore hole.

Although a particular heat energy motor or gas turbine 14 has been described herein and illustrated in the accompanying drawings, it is to be understood that other power generators may be used in place thereof to drive the bit with power resulting from the combustion of the constituents of a combustible mixture fed separately to the power generator within the bore hole. The above and other departures from the structure of the described and illustrated embodiment of the invention may be effected without departing from the scope or spirit of the invention, except as defined in the appended claims.

What is claimed is:

1. In apparatus for rotary drilling of an oil or gas well; the combination of an assembly including a rotary drill bit and power generating and applying means operative to convert a combustible mixture into heat energy, means connecting said power generating means and applying means in said assembly to said bit for effecting rotation

thereof, said power generating and applying means being located adjacent said bit and adapted to move vertically with the latter within the bore hole drilled by the bit means for resisting rotation of said assembly, means for movably vertically supporting said assembly in said hole, and means extending from the surface to said power generating and applying means for supplying said combustible mixture to the latter.

2. In apparatus for rotary drilling of an oil or gas well; the combination of an assembly including a rotary drill bit connected to a heat energy turbine for rotating said bit, means for providing vertical movement of said assembly within the bore hole formed by the bit, means feeding a combustible mixture from the surface to said turbine within the bore hole, means for effecting the combustion of said mixture adjacent said turbine to produce heat energy for driving the latter, means for resisting rotation of said assembly, and means for supporting said turbine within the bore hole.

3. In apparatus for rotary drilling of an oil or gas well; the combination of an assembly unit including a rotary drill bit carried thereby and a heat energy turbine connected to said bit for rotating said bit, means for movably vertically supporting said assembly unit within the bore hole formed by said bit, a heat energy generator being disposed adjacent the turbine and in said assembly, means separately feeding the constituents of a combustible mixture to said generator, means for burning said mixture and supplying the products of combustion to said turbine to generate heat energy for driving said turbine, means for exhausting the products of the combustion of said mixture from said turbine into the bore hole where the exhaust acts as a circulating medium for removing the cuttings from the bore hole, and means for resisting rotation of said assembly.

4. In apparatus for rotary drilling of an oil or gas well; the combination of an assembly including a rotary drill bit carried thereby and a heat energy turbine connected to said bit for rotating said bit, means for movably vertically supporting said assembly within the bore hole formed by the bit, said heat energy generator being disposed adjacent the turbine on said assembly, means separately feeding the constituents of a combustible mixture to said generator, means for burning said mixture and supplying the products of combustion thereof to said turbine to generate heat energy for driving said turbine, means for feeding a gaseous circulating medium to said drill bit where the medium is discharged into the bore hole for carrying cuttings away from the bit, means for discharging the exhaust from said turbine into the bore hole to there mingle with said gaseous circulating medium and assist the action of the latter, and means resisting rotation of said assembly.

5. In apparatus for rotary drilling of an oil or gas well; the combination of an assembly including a rotary drill bit carried thereby and a heat energy turbine connected to said bit for rotating said bit means movably vertically supporting said assembly within the bore hole formed by the bit, means for feeding a combustible mixture from the surface to said turbine within the bore hole, means for burning said mixture and supplying the products of combustion to said turbine for driving the latter, and a cable from which said assembly is supported within the bore hole, the lay of said cable being arranged to resist the torque reaction of the rotation of said bit in the bore hole.

6. In apparatus for rotary drilling of an oil or gas well; the combination of an assembly including a rotary drill bit carried thereby and a heat energy turbine connected to said bit for rotating said bit means for movably vertically supporting said assembly within the bore hole formed by the bit, a heat energy generator disposed adjacent said turbine and in which a combustible fluid mixture is burned to generate heat energy for driving said turbine, means connecting said generator to said turbine,

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means separately feeding the constituents of the combustible fluid mixture, under low pressure from the surface to said generator within the bore hole, said feeding means including light weight pipe sections and quick-release couplings joining together the pipe sections in end-to-end relation to form an easily assembled and disassembled drill string, means for resisting rotation of said assembly, and a cable from which said heat energy generator and turbine are suspended with the bore hole.

7. In apparatus for rotary drilling of an oil or gas well; the combination of an assembly including a rotary drill bit carried thereby and a heat energy turbine for rotating said bit connected to said bit, means for movably vertically supporting said assembly within the bore hole formed by the bit, a heat energy generator disposed adjacent said turbine and in which a combustible fluid mixture is burned to generate heat energy for driving said turbine, means for connecting said generator to said turbine, means separately feeding the constituents of the combustible fluid mixture, and a gaseous circulating medium under low pressure from the surface to said generator and said bit, respectively, within the bore hole for removing cuttings from the bit, means for resisting rotation of said assembly, a cable supporting said heat energy generator and turbine within the bore hole, said feeding means including end-to-end arranged pairs of light weight pipe sections embracing said cable and quick-release couplings holding each pair of pipe sections around said cable and in end-to-end relation to the adjacent pairs of pipe sections thereby to form an easily assembled and disassembled drill string.

8. In apparatus for rotary drilling of an oil or gas well; the combination of an assembly including a rotary drill bit carried thereby and a heat energy turbine connected to said bit for rotating said bit, means for movably vertically supporting said assembly within the bore hole formed by the bit, a heat energy generator connected to said turbine and disposed adjacent thereto and in which a combustible fluid mixture is burned to generate heat energy for driving said turbine, means separately feeding the constituents of the combustible fluid mixture, a gaseous circulating medium under low pressure from the surface to said generator and said bit, respectively, within the bore hole for removing cuttings from the bit, a cable supporting said heat energy generator and turbine within the bore hole, said feeding means including end-to-end arranged pairs of light weight pipe sections embracing said cable and having non-circular external cross-sections, releasable coupling means holding each pair of pipe sections around said cable and in end-to-end relation to the adjacent pairs of pipe sections thereby to form a drill string, and means at the top of the bore hole closely engaging around the non-circular exterior of said pipe sections to prevent rotation of said drill string.

9. In apparatus for rotary drilling of an oil or gas well; the combination of an assembly including a rotary drill bit supported thereon and a heat energy turbine connected to said bit for rotating said bit means movably vertically supporting said assembly within the bore hole formed by the bit, a heat energy generator disposed adjacent said turbine and connected therewith and in which a combustible fluid mixture is burned to generate heat energy for driving said turbine, means separately feeding the constituents of the combustible fluid mixture, and a gaseous circulating medium under low pressure from the surface to said generator and said bit, respectively, within the bore hole for removing cuttings from the bit, a cable supporting said heat energy generator and turbine within the bore hole, said feeding means including end-to-end arranged pairs of light weight pipe sections embracing said cable and quick-release couplings holding each pair of pipe sections around said cable and in end-to-end relation to the adjacent pairs of pipe sections thereby to form an easily assembled and disassembled drill string,

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and means at the top of the bore hole engaging said drill string to prevent rotation of the latter, said pipe sections being formed of glass fibre reinforced plastic material and the lay of glass fibre reinforcement of said pipe sections and of the cable being arranged to resist the torque reaction of the rotation of said bit in the bore hole.

10. In apparatus for rotary drilling of an oil or gas well; the combination of an assembly casing including a bit driving device carried thereby and adapted to be lowered into the well, means for separately feeding air and fuel under relatively low pressure to said driving device including combustion means wherein the air and fuel are mixed and burned to generate heat energy, a driven shaft on which a rotary drill bit is adapted to be mounted and means connected to said combustion means for rotating said driven shaft in response to the release of the generated heat energy thereagainst, means for exhausting the products of combustion of the air and fuel adjacent to said casing from said driving device into the well to act as at least part of a gaseous circulating medium required to remove cuttings from the well, and means for movably vertically supporting said assembly within the well.

11. A rotary drilling rig comprising a drill string made up of separably coupled together light weight pipe sections arranged side-by-side and in longitudinal alignment to define segregated continuous passages and a central space throughout the length of the drill string; a drill driving assembly suspended from a cable extending through said central space of the drill string, said driving assembly including a heat energy generator in which fluids supplied through related passages of said drill string are co-mingled to form a combustible mixture which is burned to generate heat energy, a turbine connected to and driven by the heat energy from said generator, a driven shaft adapted to support a rotary drill bit, and speed reducing means connected between said turbine and said driven shaft.

12. A rotary drilling rig comprising a drill string made up of separably coupled together light weight pipe sections arranged side-by-side in pairs with the successive pairs of pipe sections in longitudinal alignment, said pipe sections being formed to define separate continuous passages and a central space within the confines of said string extending throughout the length of said drill string; coupling means for holding said sections in assembled relationship; means for supplying air and fuel to two of said passages, respectively, and for supplying a gaseous circulating medium to other of said passages, all under relatively low pressures; a cable extending through said central space of the drill string; and a bit driving assembly suspended from said cable and including a heat energy generator carried therein receiving and burning the fuel and air supplied through said two passages to generate heat energy, a turbine connected to said generator and driven by heat energy therefrom, a driven shaft adapted to have a drill bit mounted thereon, speed reducing means connected between said turbine and driven shaft so that the latter is rotated at a speed suitable for rotary drilling, means conducting the gaseous circulating medium from said other passages of the drill string past said generator, turbine and speed reducing means for discharge adjacent the bit on said shaft so that the discharged medium carries the cuttings away from the bit, means resisting rotation of said assembly and means discharging the exhaust from said turbine into the bore hole drilled by the bit so that the exhaust acts with the circulating medium to remove the cuttings from the bore hole.

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U. S. DEPARTMENT OF COMMERCE
PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,828,945

Robert V. New

April 1, 1958

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 72, for "probably" read -- probable --; column 5, line 73, for "convention" read -- conventional --; same line, for "mens" read -- means --; column 6, line 7, for "in" read -- an --; line 57, for "passage" read -- passages --; column 8, line 16, for "hte" read -- the --; column 10, line 25, for "enery" read -- energy --; column 11, lines 12 and 13, for "for rotating said bit connected to said bit" read -- connected to said bit for rotating said bit --; column 12, line 4, for "of glass" read -- of the glass --.

Signed and sealed this 10th day of June 1958.

(SEAL)
Attest:

KARL H. AXLINE
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