

Sept. 28, 1965

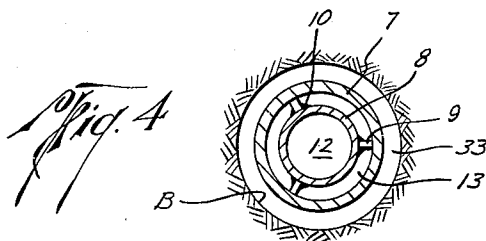
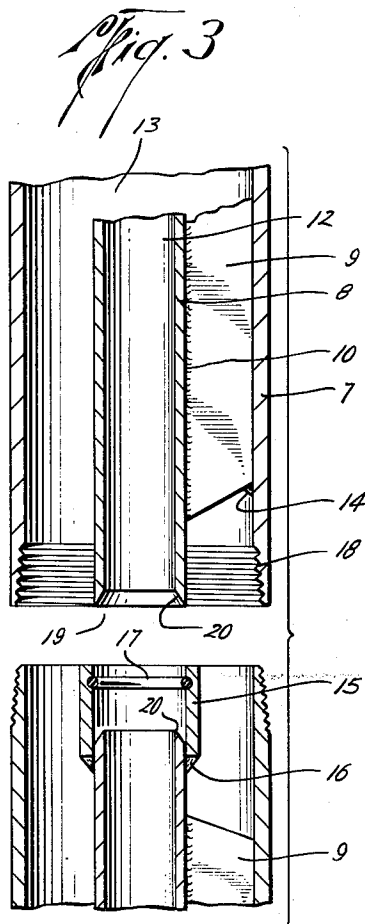
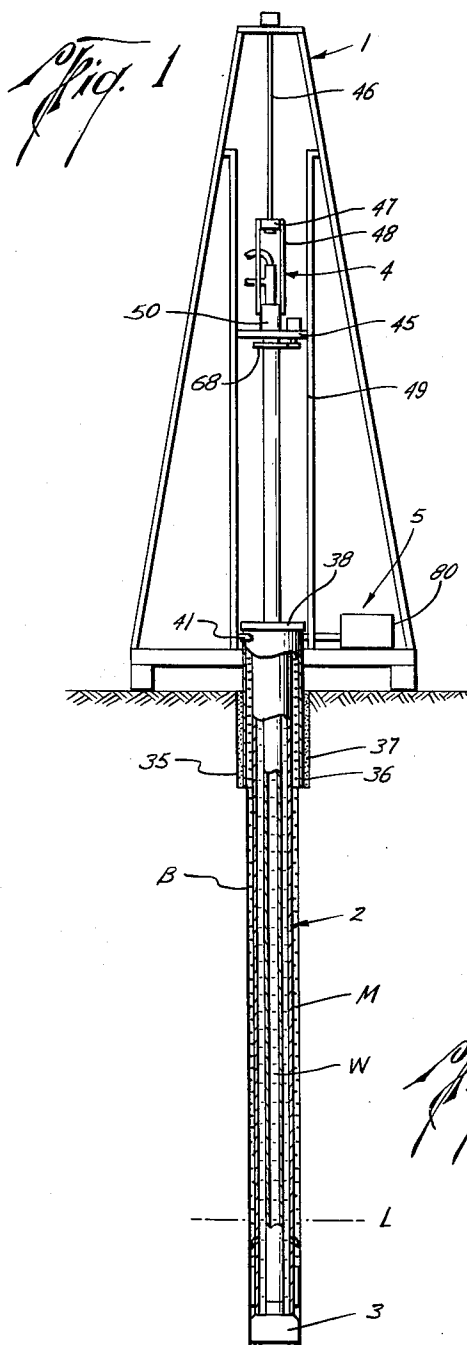
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3,208,539

APPARATUS FOR DRILLING WELLS

Filed Sept. 17, 1958

4 Sheets-Sheet 1



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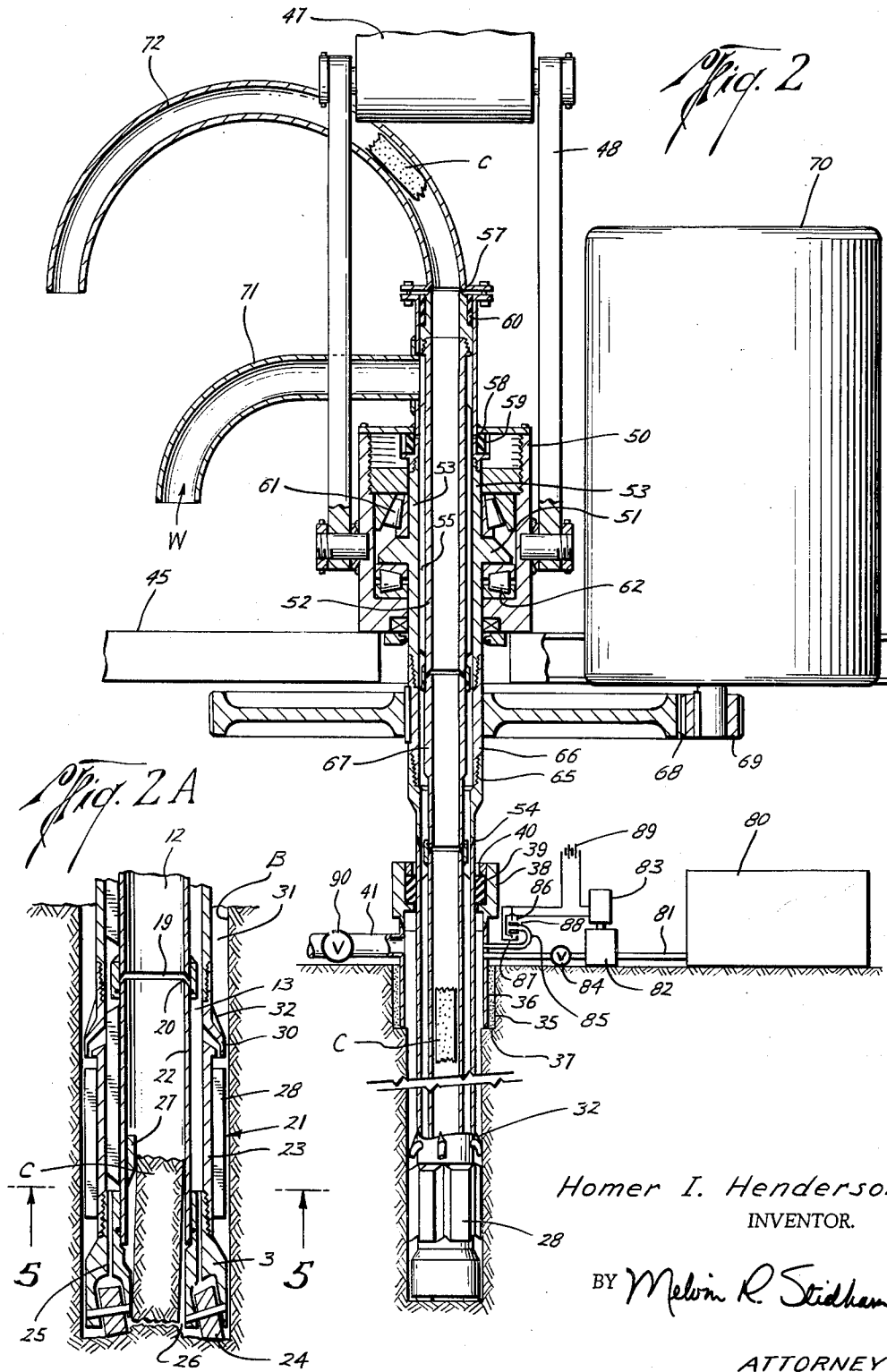
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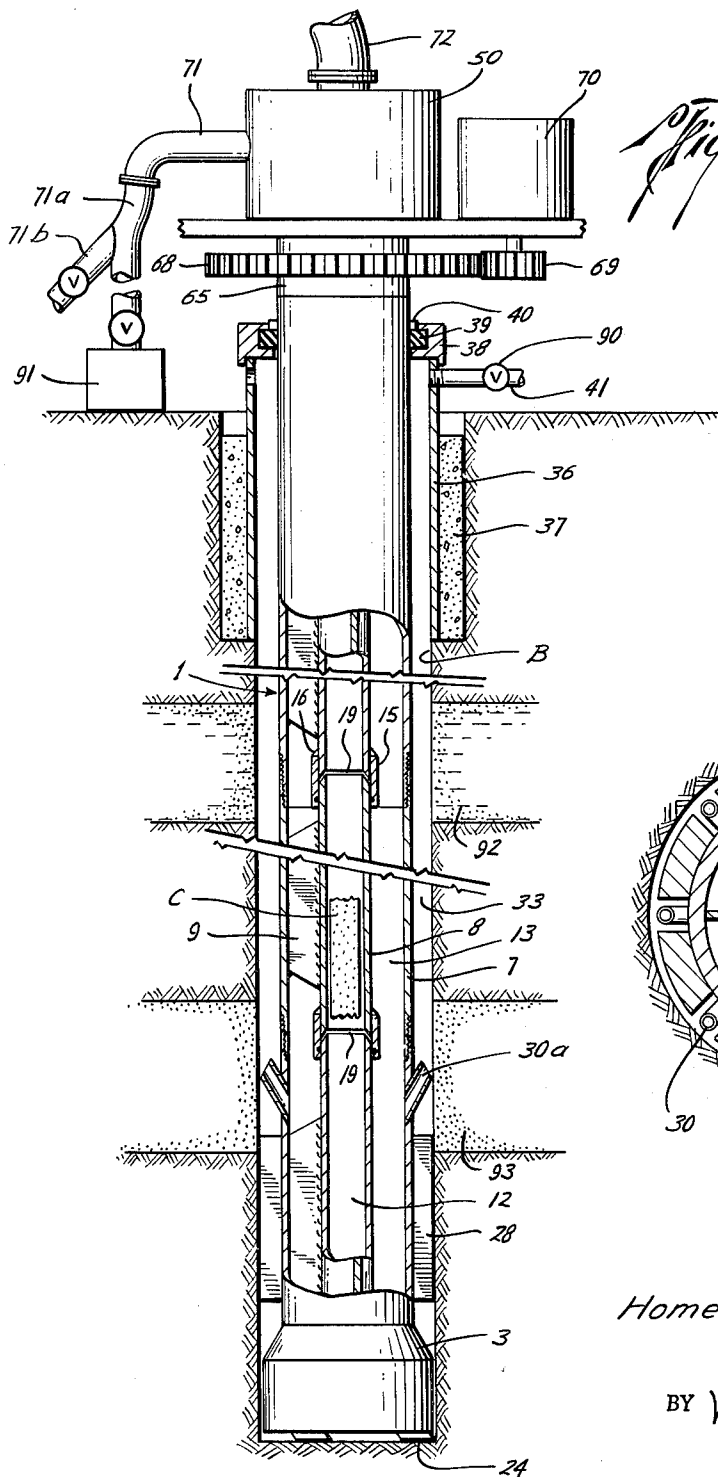


Fig. 6

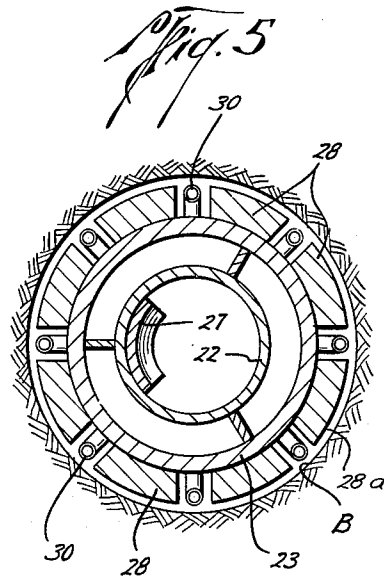


Fig. 5

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APPARATUS FOR DRILLING WELLS

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Filed Sept. 17, 1958, Ser. No. 761,502
16 Claims. (Cl. 175-215)

This application is a continuation-in-part of my parent application Serial No. 284,739, filed April 28, 1952 for "Multiple Conduit" and since abandoned. The invention of this application relates to an apparatus for drilling wells and, more particularly, to an apparatus for performing rotary drilling operations.

In conventional rotary drilling, a long string of drill pipe having a cutting bit at the lower end thereof is rotated at the surface to cut and grind its way through the earth. For purposes of cooling and lubricating the drill pipe and bit and removing chips and cuttings from the bottom of the bore hole, a drilling fluid is customarily pumped through the drill pipe to flow out through the drill bit and impinge upon the cutters and/or the bottom of the bore hole. At the bottom of the hole, the drilling fluid picks up chips and cuttings and flows upward in the annulus around the drill pipe back to the earth's surface.

One major problem in conventional rotary drilling resides in the tremendous pump pressures required to maintain continuous and proper circulation of the drilling fluid. This results naturally from the fact that the cross-sectional area of the annulus outside the drill pipe is normally many times greater than the area of the drill pipe interior. A minimum mud velocity must be maintained in the bore annulus in order properly to transport the bit cuttings. Since the cross-sectional area of the drill pipe is appreciably less than that of the well bore annulus, a much higher velocity must be delivered by the pumps to the drill pipe. Moreover, to the already great pump requirement must be added an output necessary to overcome friction loss which is proportional to the square of the flow rate. Moreover, bore holes frequently cave in leaving an enlarged zone of much greater cross-sectional area than the normal annulus, further resulting in corresponding reduction of the mud velocity often causing chips and cuttings to drop and clog up the annulus below, sometimes causing the drill pipe to become lodged. In such instances, it is the standard practice to use highly viscous drill fluid and higher velocities in order to insure sufficient chip removing capacity in the enlarged zone. This puts an additional load on the pumps and occasions further pump horsepower loss. More important, it puts an extremely high drill fluid pressure on the subterranean formations sometimes resulting in fracturing thereof with subsequent loss of the drilling fluid.

A further load is imposed on the pump when drilling is interrupted as when another joint of drill pipe is added. This is caused by the resistance to flow of the heavy, thixotropic drill fluid having sufficient gel strength to support the chips and cuttings and prevent them from dropping to the bottom of the well which is commonly used when circulation is interrupted. Also, when drilling in an area of high gas pressure, a further load is imposed on the pump when a drill fluid of high density is used in order to insure that the hydrostatic pressure of the column of drill fluid will always exceed the reservoir pressure of any gas accumulation and prevent the gas from blowing out through the annulus with accompanying cratering and other disastrous results.

A further and extremely important disadvantage of conventional drilling techniques resides in the fact that large chips and cuttings from the well bore are delayed by inadequate lifting capacity of the fluid and thus mixed

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with fast rising smaller chips subsequently removed by the drill bit. With the chips so mixed and heterogeneously scattered throughout the returning mud column, and particular depth from which they were taken cannot be ascertained. Hence they are for all practical purposes, useless as indicators of the nature of formations through which the drill bit passes at any particular time.

A still further disadvantage of conventional rotary drilling resides in the fact that one and only one channel for circulation of drilling fluid is provided. The drilling mud is pumped down through the drill pipe to be forced up through the hole annulus. Since only one mud can be used at any time, it is obvious that sacrifices and compromises must be made in order to select a fluid that will perform to some degree a maximum number of the many diverse functions which it is desired to accomplish under ideal conditions. For example, a low viscosity fluid is desirable to reduce friction flow losses and, hence, to reduce pump pressure and relieve pressure on the formation; to give turbulent scouring action under the bit to remove cuttings effectively; to facilitate separation of gas and cuttings therefrom; and to form a thin filter cake or coating in the well bore. On the other hand, a high viscosity fluid is desirable to carry out cuttings effectively; to prevent rapid settling of cuttings when circulation of the fluid is interrupted; and to form filter seal of porous formations.

Similarly a fluid low in density is desirable to reduce mud pump requirements and pressure on formations as well as to permit quick separation of cuttings, while a high density fluid is desirable to transport cuttings, prevent gas blow-outs and to hold pressure on the bore wall to prevent cave-ins. Other parameters of the drilling fluid such as thixotropy, must be compromised because more than one widely divergent value therefor is desired. Since a single drilling fluid cannot at the same time be thick and thin, heavy and light, viscous and non-viscous or thixotropic and non-thixotropic, it is obvious that something considerably less than an ideal circulating fluid must be selected.

Another particular problem involved in rotary drilling is the excessive time lost in drilling through cuttings already removed by the bit. This results from the poor scouring action of the drilling fluid circulated in the conventional manner and to a greater degree, because it is necessary to raise the drill bit off the bottom of the well to remove and replace the Kelly section each time a section of drill pipe is inserted below the Kelly section at the surface. With circulation interrupted, the loosened chips and cuttings fall to the bottom of the well bore and, hence, below the elevated bit. Thus, when drilling is resumed the bit has to cut through the loosened cuttings before it can begin "making hole."

For years the drilling industry has experimented with the use of natural gas or air as a circulating fluid in order to avoid the above named disadvantages of water or mud conventionally used for that purpose. Tests have shown that, under ideal circumstances, wells can be drilled faster by this method and are generally better and more durable producers. However, certain disadvantages now encountered render rotary drilling with air or gas as a circulating medium to be generally commercially impractical. For example, one of the greatest disadvantages in air drilling is encountered in water sands. When air drilling is employed by conventional methods, the cuttings and chips rise to the surface in a stream of dust through the annulus between the drill pipe and the wall of the well. When the bit penetrates through water sand, these chips and cuttings become wetted and form a cement which is distributed, rolled and compacted over the surface of the well by the rotating drill pipe to form a pro-

gressively thickening hard layer of compacted cuttings which reduces the effective area of the annulus and often closes off fluid flow completely, lodging the drill pipe firmly in the hole. This problem has been combated with slight degree of success by use of chemicals, such as emulsifiers, foaming agents and the like but, in addition to being relatively ineffective they are extremely costly in time and materials.

A second problem in air drilling by conventional methods is created by the large increase in volume of the conduit through which the air is passed on its return to the surface requiring the use of extremely large and costly equipment to deliver the initial air supply through the small diameter drill pipe. Even so, large cuttings are often suspended above the bottom of the hole until broken up by agitation so that cuttings from many different depths are mixed when received at the surface. It is unusual to recover cuttings larger than dust particles which are almost valueless as geological or paleontological markers. Of course, even when large chips are recovered geophysical and geological analysis as a guide to drilling operations is practically useless the chips can be identified as originating from a particular depth and formation.

An additional disadvantage is the hazard of explosion of drilling with air through a gas zone. When the conventional drill penetrates a gas zone, gas is released into the annulus between the drill pipe and the wall of the well and, when air and gas reaches an explosive mixture ratio, a spark generated by the steel pipe striking the wall of the well or a rock cutting may set off a violent explosion often followed by fire.

The technique of core drilling has heretofore been recognized as an efficient and valuable means of securing samples from the well bore and carrying them to the surface for analysis. According to such techniques, an annular bit is employed to cut out a central core which is gripped within the casing and carried to the surface for analysis. However, efforts to use such techniques to complete a well of ordinary depth have heretofore met with no success.

Obviously with the core located within the center of the drill bit and drill pipe, the circulation of the fluid must be reversed, i.e. directed up through the center of the pipe, in order to carry the cores and chips to the surface. Others have considered the use of two concentric pipes with all of the circulation taking place within the two drill pipes, but this has resulted in other problems. Probably the most important of these is the fact that the inner and outer pipes are exposed to streams of drilling fluid appreciably different in temperature since the fluid flowing upward through the central pipe has absorbed much of the heat from the drill pipe and bit and subsurface well hole temperatures. Uneven heating of the inner and outer pipes causes unequal thermal expansion and a bending of the pipe resulting in serious deviations of the well bore and causing excessive drill pipe flexing often resulting in drill pipe failure.

It is, therefore, an object of my invention to provide an apparatus for drilling a well bore wherein samples of the formations through which the bit penetrates are continuously being carried to the surface.

It is a further object of my invention to provide an apparatus for drilling wherein the cross-sectional areas of the drilling fluid conduits can be established as constant factors for more efficient estimate of pump requirements.

It is a further object of my invention to provide drill pipe which, when its sections are connected together in great length, provides fluid tight connection between inner and outer channels while permitting relative thermal expansion therebetween.

It is a further object of my invention to provide an apparatus for drilling which eliminates the necessity of interrupting drilling in order to conduct electric log surveys and other conventional means of testing characteristics of subterranean formations.

It is a further object of my invention to provide a bore drilling apparatus including concentric pipes to conduct separate streams of fluid at different temperatures with provision for relative thermal expansion.

It is a further object of my invention to provide concentric drill pipes wherein the inner pipe has a cross-section area equal to or somewhat less than the cross-section area of the annular space between the inner and outer pipes.

It is still a further object of my invention to provide inner and outer concentrically arranged pipes, the inner and outer pipes of each length being secured together at only one pair of adjacent ends to accommodate differences in thermal expansion throughout the length thereof.

It is a further object of my invention to provide a drill pipe comprising inner and outer concentrically arranged pipes, the inner pipe being supported within the outer pipe by rigid webs to increase the rigidity of the entire structure.

It is a further object of my invention to provide an apparatus for drilling wherein a light drilling fluid such as water can be used to perform the normal function of a circulating well fluid while a specially adapted heavier thixotropic fluid can be used to prevent the accidental release of well gases; to hold a hydrostatic pressure on the formations drilled through; to provide lubrication to facilitate rotation of the drill pipe; and to seal porous formations.

It is a further object of my invention to provide an apparatus for core drilling which permits continual contact of the drill bit with the bottom of the hole.

It is a further object of my invention to provide an apparatus for drilling which permits the lowering of formation testing apparatus without requiring removal of the drill string and bit from the hole.

It is still a further object of this invention to provide an apparatus for drilling using a gas, such as air, for purposes of circulation while permitting maximum lifting capacity for carrying cores and cuttings to the surface for analysis.

The further object of this invention is to provide an apparatus for air drilling designed to overcome problems created by passage of the drill bit through gas or water zones.

The further object of this invention is to provide apparatus for drilling using air as a circulation fluid while minimizing the possibility of explosion.

The further object of my invention is to provide an apparatus for drilling a bore using air as circulating fluid that is efficient and productive in operation.

It is a further object of my invention to provide an apparatus for drilling a well bore that is efficient and rapid in operation and economical in construction and maintenance.

In carrying out my invention I provide an annular cutting bit secured at the lower end of a composite drill pipe made up of inner and outer tubular pipe sections. Each pipe section has an outer pipe and a concentrically mounted inner pipe secured thereto at one end. Spacers secured to either of the inner and outer parts are provided to lend rigidity and to maintain proper association with free inner and outer passageways but to permit relative sliding between the inner and outer pipes. Adjacent pipe sections are connected by threading together the adjacent ends of outer pipe sections while a sleeve mounted on the end of one of the inner pipes slides over the end of the adjacent inner pipe to provide a sealed expansion joint and permit uneven longitudinal thermal expansion of the inner and outer pipes. The string of pipe made up by connecting such pipe sections are secured at the surface to a power swivel mounted on a traveling block which can move as a unit up and down the drilling rig derrick. Thus, the traveling block can start at the top of the derrick with the swivel attached to the upper-most

pipe section and rotate and move downwardly as the hole

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is drilled until the derrick floor is reached. Thereafter, the connection is broken and the traveling block and swivel is moved upwardly to accommodate another pipe section.

While the rotary drilling is being accomplished, a light drilling fluid adapted for efficient removal of cuttings is circulated down through the annulus between the inner and outer pipe and through jets in the drill bit to the bottom of the well and thence up through the inner pipe to the surface. Because an annular drill bit is provided, a core, as well as cuttings, is received within the drill bit and drill pipe as the bit progresses through the formation. When the formation has sufficient strength to hold together, a continuous core is formed which moves upwardly through the drill pipe. The core is broken off into short lengths at the bottom of the drill pipe so that the core lengths may be carried upwardly through the drill pipe by the circulating fluid. Thus, the cores when received at the surface can be identified at the depth at which they were taken and analyzed for geological and geophysical data. Also, as part of my method, I provide for the introduction of a specially prepared mud in the annulus between the outer pipe and the well bore to perform other advantageous functions, such as lubrication of the drill pipe, maintenance of a static pressure head on the bore hole, and prevention of the sudden release of gas which might otherwise escape from formations and rise to the surface in a damaging blow-out creating a fire hazard and the like.

My apparatus is also peculiarly adapted for the use of air or other gas as a circulating fluid. In such case, the annulus between the drill pipe and the wall of the well is sealed off at the top of the well to prevent flow of air or gas out through the annulus except under controlled circumstances. A flow dividing orifice is opened from the outer tubular member near the drill bit at the bottom of the well so that air being circulated through the annular space between the inner and outer tubular member may enter the bore hole annulus outside the drill pipe maintaining a sufficient pressure in the annulus to direct most of the flow up through the inner tubular member. Should a gas or water zone be encountered suitable valves opening into the bore hole annulus seal may be opened so that a controlled portion of the flow from the flow dividing port will move upwardly through the annulus sweeping any water or gas with it and immediately and appreciably reducing the hazards thereof.

Other objects and advantages of my invention will become apparent from the specification following when read in view of the accompanying drawings wherein:

FIG. 1 is a schematic diagram showing my apparatus in operating condition;

FIG. 2 is a view partially in section of my apparatus as it is adapted for liquid circulation;

FIG. 2A is an enlarged partial section view of the lower drill pipe and bit forming a part of my invention;

FIG. 3 is a partial section view of adjacent drill pipe sections embodying features of my invention;

FIG. 4 is a view in cross-section of my drill pipe in place in a well bore;

FIG. 5 is a section view taken along line 5—5 of FIG. 2A;

FIG. 6 is a partial section view of my apparatus particularly adapted for use with gas circulation; and

FIGS. 7 and 8 are views in cross-section of optional forms of complete drill pipe sections.

Referring now to the drawings and particularly to FIGS. 1 to 5, my well drilling apparatus comprises a derrick 1, a drill string 2 carrying a drill bit 3, driving apparatus 4 and a fluid circulating system 5.

The drill string 2 is made up of a plurality of pipe sections each comprising an outer pipe 7 and an inner pipe 8 concentrically disposed within the outer pipe by means of spacer ribs 9 which are preferably welded at 10 along their lengths to the inner pipe (FIGS. 3) and

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frictionally secured within the outer pipe 7 by assembly in a light pressed fit. With the inner and outer pipes coaxially disposed they form a central fluid passage or conduit 12 within the inner pipe 8 and an annular outer conduit 13 between the inner and outer pipes. The inner and outer pipes are rigidly connected together at only one end as, for example, by spot welding the ribs to the outer pipe 7 at 14 so that throughout substantially all of the length of the dual pipe except for the length of the weld itself, the inner and outer pipes are movable relative to each other to accommodate differences in thermal expansion occasioned by the flow of fluids at different temperatures through the central and outer conduits.

A sleeve 15 is secured over one end of each inner pipe section as by welding at 16, each sleeve being adapted to receive the inner pipe of an adjacent pipe section fit in telescopic relationship with a seal provided by an O-ring 17 or the like. The inner tubular members are of such length that when the drill pipe string 2 is made up with the outer pipes fully engaged by means of the threads 18 a small gap 19 separates adjacent inner tubular members to accommodate thermal or tensile expansion or compression or other effects that may cause variation in the relative longitudinal depositors of the inner and outer pipe ends. Preferably, the ends of the inner tubular member are tapered upwardly at 20 in the same direction so that no sharp corners are existent in the small gap 19 which might otherwise cause the rising cores or cuttings to become lodged.

The threaded joint 18 between adjacent outer pipe sections 7 is merely illustrated generally, and this invention is not restricted to the particular form of joint shown. That is, the form of outer pipe 7 may be selected from the many forms of drill pipe available that will achieve a rigid joint for transmission of torque. Similarly, as shown in FIGS. 7 and 8, the spacer ribs may take on a variety of forms as long as they maintain the relative radial position, preferably centralized, of the inner pipe 8. It is simply a matter of choice whether each rib or web 9 extends nearly the full length of the inner pipe as shown in FIG. 7 or several shorter web 9' are spaced along the length as shown in FIG. 8 in my parent application of which this is a continuation-in-part.

Further, the O-rings 17 may be carried in either of the inner pipe ends, although they are preferably carried within the sleeves 15 because it is not then necessary to make the entire inner pipe of metal thick enough to form the O-ring groove. Since the inner pipes 8 transmit no torque and support no load, the pipe manufacturer may use metal of very thin gauge in forming the inner pipe.

Since the radial webs or fins 9 offer substantially no reduction of the annular conduit cross-section, my drill pipe provides a longitudinally continuous two-way conduit between the surface and the bottom of the well bore B. The diameters of the inner and outer drill pipes 8 and 7 can be selected to provide any desirable cross-section ratio so that drilling fluid pump requirements can be predetermined. Since all of the fluid circulation, both downward and return is within the drill pipe 2 velocity loss through friction over the rough wall of the well bore and through irregularities in conduit cross-section is not a factor.

Of course, for reasons of economy it is always desirable to drill a well bore of minimum diameter. My drill pipe permits a small diameter hole to be bored. Since there is no fluid circulation in the hole annulus outside of the drill pipe 1, I do not have to concern myself with adequate annulus cross-section for fluid circulation. Consequently, I can use a larger diameter pipe, for a given hole diameter than is possible with conventional drilling methods. Obviously, the larger diameter pipe is of greater rigidity and there is less tendency for the

pipe to bend and deviate from a straight bore. Crooked holes are further avoided by the natural rigidity of the double pipe coaxial construction of my drill pipe 1.

The provision for expansion between inner and outer pipes, achieved by rigid connection therebetween at only one point 14, and absorbed by the telescopic connection of the inner pipes prevents warping or distortion due to relative thermal expansion which might otherwise be caused by conducting fluids at different temperatures through the annular and central conduits. Moreover the composite coaxial inner and outer pipe construction provides exceptional rigidity to minimize bending which frequently produces crooked bores with accompanying flexing of the drill pipe ultimately resulting in failure.

The drill bit 3 carried at the lower end of the drill string is attached by a sub housing 21 (FIG. 1A) having inner and outer tubular members 22 and 23 forming a continuous inner and outer passageway in communication with the conduit 12 and 13 of the drill pipe. At the lower end of the sub body 21 is secured the cutting shoe 3 which may be of any conventional type although cone bit cutters 24 are shown. Passageways or ducts 25 are formed through the cutting shoe 3 to direct flow of circulating fluid from the outer conduit 13 to the bottom of the well bore. While it is generally contemplated that the bit be annular, i.e. of the core drilling type, it will become obvious that, insofar as fluid circulation is concerned, the central opening 26 through the drill bit body need only be of sufficient size to provide capacity for return flow of circulating fluid to carry cuttings therewith up through the inner pipe. However, in the preferred embodiment shown adapted for core drilling, I provide a wedge or cam 27 protruding into the central duct 12 so as to be engaged by a core C rising up into the sub body 21 as the cutting shoe 3 penetrates into a subterranean formation. The lateral thrust of the cam 27 against and around the core C as the bit rotates generates a bending movement and resultant forces in tension break the core off into short lengths since minerals are notably weak in tension. The severed cores C are of sufficient length to prevent them from turning end over end in the central conduit 12, but they are freely slidable therein to function in the nature of free pistons to be carried up through the drill pipe by circulating fluid. They are received at the surface in the disposition and order in which they are severed to be analyzed for magnetic orientation.

Thus, in my preferred embodiment employing an annular bit, I can achieve continuous core drilling for the full depth of the well bore without returning to the surface except to change bits when necessary. This method of drilling has several inherent advantages in addition to those hereinbefore mentioned. For example, in rotary drilling the core is the most difficult to cut because angular movement over the bottom of the hole reduces gradually toward the center or axis of rotation. I make no effort to cut the core away but, instead, carry the core to the surface for analysis. These cores inform the driller as to the nature of the formation through which he is drilling. Thus, he can determine from known statistics the optimum weight to carry on the drill bit as well as the optimum rate of rotation. Moreover, if his rate of cutting progress is less than that which he should be achieving in the type of formation, he knows that the drill bit is worn or defective. With conventional equipment, the driller can never be sure whether the bit is dull or the formation is hard. The natural result of this lack of information is needless withdrawals and excessive waste in time and money.

Carried on the sub body 21 and extending downward substantially to the top of the bit 3 is a series of radial milling reaming cutters 28 (FIG. 5) having cutting edges 28a of tungsten carbide or the like to scrape the wall of the well bore to eliminate irregularities therein and serve

to centralize the bit 3 to produce a straighter hole and one that is diametrically full gauge. Should it become necessary to withdraw the drill pipe 2 from a caved in well bore B the milling cutters 28 permit the rig operator to cut his way out of the hole by rotating the drill string. Also there may be carried on the upper body portion of the sub 21 a circumferential series of flow divider ports or jets 30 which discharge some of the circulating fluid from the annular conduit 13 into the annulus 33 between the drill pipe 2 and the wall of the well bore. Preferably cutting heads 32 are also provided on the upper surfaces of the jets 30 to further facilitate cutting from a caved in well bore. The ports 30 are arranged to direct the streams therefrom between the milling cutters 28. This divider stream of circulating fluid will tend to fill the annulus toward the surface and also provide a very effective means for cleaning the bottom of the well bore by washing down chips and cuttings removed by the bit cutters 24 and pieces of rock sloughed from the wall of the well bore and cleaning the corners of the well bore B by flowing in the bottom of the hole from the circumference toward the center.

Extending downward from the surface of the well bore is an enlarged bore 35 cut out to receive a length of casing 36 which may be cemented in place at 37 or sealed to the earth surrounding the enlarged bore 35 by other means such as a packer, to prevent flow of drilling fluid around the outside of the casing 36. Secured to the upper end of the casing 36 is a head unit 38 carrying an annular seal or packing 39 secured in place as by a packing nut 40. The annular seal 39 embraces the outer surface of the drill pipe while permitting rotation and axial sliding of the pipe therein. Thus, in the preferred embodiment shown the annulus is sealed off completely except through outlet or pressure release conduits 41 to be hereinafter described. With such conduit 41 normally closed, the annulus around the drill pipe will provide only limited capacity for flow of circulating fluid. When such capacity is satisfied all further flow will be directed upwardly through the central duct to carry cuttings and cores C to the surface therewith. Methods and means for controlling the circulation of drilling fluid will be described subsequently.

The driving mechanism 4 comprises a platform or carriage 45 which may be moved upwardly and downwardly within the derrick 1 by means of the conventional cable 46 and traveling block 47. The platform 45 is supported on a hanger 48 depending from the traveling block 47 and is guided vertically along rails 49 and held thereby against rotation. Mounted on the platform is a swivel housing 50 within which is rotatably carried a composite coaxial tubular shaft 51 having inner and outer tubular members 52 and 53 in longitudinal alignment with the inner and outer pipes 8 and 7 respectively of the drill pipe 2. The outer tubular member 53 of the swivel shaft is rigidly connected as by threading as at 54, to the outer drill pipe 7 so that it will rotate the drill pipe 2 therewith. The inner tubular member is secured to the outer member to rotate therewith by means of radial fins 55. Preferably the fins are welded along their lengths to only one of the tubular members and spot welded at only one point to the other member to allow thermal expansion as in the case of the drill pipe. Gaps 57 and 58 are provided between the swivel housing 50 and the inner and outer tubular members respectively to accommodate thermal expansion. Packing is provided at 59 to prevent flow of circulating fluid out of the outer pipe and at 60 to prevent leaks out of the inner pipe and also between the inner and outer pipes. Appropriate anti-friction bearings 61 and thrust bearings 62 are provided to permit rotation of the composite coaxial tubular shaft swivel within the housing 50. Threaded onto the lower end of coaxial tubular shaft 51 is a drive unit having a hub 65 made up of concentric tubular members, the outer member 66 is threadedly connected and the inner tubular

member 67 is telescopically connected to both the composite swivel shaft 51 and the drill pipe 2. A large gear 68 keyed onto the drive unit hub is driven through a suitable pinion 69 by means of a motor 70 mounted on the platform 45.

Also provided on the carriage is an inlet conduit 71 opening into the swivel housing 50 to direct circulating fluid between the inner and outer members of the composite shaft 51 to flow to the bottom of the well bore through the annular conduit 13. An outlet pipe or hose 72 opens from the swivel housing 50 in direct communication with the central conduit of the drill pipe and composite swivel shaft 51 to deliver circulating fluid and cuttings from the well bore to the surface.

Thus it is apparent that continuous drilling can be achieved with my apparatus without removing the drill bit 3 from the bottom of the well bore to add sections of drill pipe, as is necessary in conventional drilling. As the drill pipe 2 is rotated by the gear 68, the platform is lowered at the selected cutting rate. When the platform 45 makes a complete stroke, i.e. the bit penetrates down the length of one section of drill pipe 1, the motor 70 is stopped temporarily and the connection 54 with the drill pipe is broken by reversing the motor 70. While the bit 3 remains on the hole bottom the platform is raised and a new section of drill pipe is inserted between the last section of drill pipe 2 and the hub 65 of the swivel drive unit. Thus, with a minimum amount of delay drilling may progress with no loss of hole depth. As pointed out, circulation of drilling fluid is continuous during the drilling operation, the fluid being directed down through the annular conduit 13 to return through the central conduit 12.

If for any reason, it should be desirable to make electric log tests or otherwise test or treat the well bore B by lowering apparatus therein, it is necessary merely to raise the drill bit 3 a few feet above the bottom of the well bore and lower the testing apparatus down through the central conduit 13 below the bit 3 and conduct such tests or treatments.

Referring to FIGS. 1 and 2 in particular, when liquid circulating fluid is employed with my apparatus a non-viscous, watery drilling fluid W having properties selected for fast efficient drilling, is pumped from a source (not shown) through the inlet duct 71 and down through the annulus 13 to the bottom of the drill pipe 2. The circulating fluid stream is divided at the ports 30 which may be jets, with a predetermined portion thereof flowing down through the cutting shoe ducts or jets 25 to impinge directly upon the bottom of the hole. The other portion of the stream flowing through the ports or nozzles 30 tends to keep the annulus around the drill pipe filled as well as to wash the side of the hole to pick up chips and cuttings removed by the cutters 24. This stream impinges on the bottom of the well bore B and then flows radially inward from the outside of the hole to sweep the hole clean and carry cuttings and chips up through the central circular duct. Of course, with the annulus above the drill bit and the wall of the well bore sealed off by the casing 36 and sealing head 38 flow upward through the annulus is substantially prevented except to replace circulating fluid lost to porous formations and virtually all of the flow will go up through the central duct to carry not only the cuttings but also cores C broken off by the cam member 27. The cores C slide through the central duct and function as free pistons to travel to the surface and be delivered through the outlet conduit or hose 72 in the order in which they were cut so that the depth from which they were taken can readily be ascertained by the known depth to which the bit has penetrated and the velocity of the fluid. Because all of the circulation of the light fluid W is within the drill pipe itself, it is conducted through conduits of constant capacity so that velocity variations normally resulting from increased conductor area are avoided and hydraulic efficiency is greatly increased. Preferably, the central duct formed by the inner

drill pipe 22 is equal or substantially equal in cross-sectional area to that of the annular duct between the inner drill pipe and the outer drill pipe 23 for purposes of hydraulic efficiency.

With a light, low viscosity drilling fluid being used, friction loss in the drill bit and drill pipe is maintained at a minimum and high turbulence is achieved to effectively remove cuttings, resulting in higher drilling rates and increased cooling capacity with less pressure on formations. Since the well bore annulus is not used as a conduit for circulation of the light drilling fluid, I can use it to particular advantage by introducing a column of thixotropic mud M, slightly heavier than the circulating liquid extending from the surface to a level indicated by line L in FIG. 1 above the flow-dividing discharge port 32. This heavy thixotropic mud is delivered from a storage tank 80 through a pipe 81 by means of a pump 82 driven through motor 83 through a one-way check valve 84. As a means of controlling the delivery of the heavier, more viscous blow-out preventing fluid a Bourdon tube 85 opens into the casing. Electrical contacts 86 and 87 are bridged by a conductor 88 whenever the Bourdon tube is distorted by an increase or decrease in pressure within the casing above and below a predetermined range. When the contact is thus established, electrical current from a source thereof 89 is supplied to the motor 83 to pump more fluid into the annulus. Thus, when pressure within the annulus and, hence, the casing 36 decreases by virtue of increased capacity within the annulus caused by further penetration of the drill bit, more drilling fluid is added. By the same token, when pressure increases because of a sudden surge of gas being released from a pocket penetrated by the bit, electrical contact is made and heavy fluid is added to increase resistance against blow-out. In emergency instances, the circulating mud pumps may be used to pump heavy mud at a high rate into the hole annulus by way of the outlet duct 41 to "kill" the well. In such instances mud may also be pumped through the conduit 71. Also, if desired conduits 71 and 72 may be closed off completely to close in a well.

Thus, I am able to achieve the ultimate in drilling fluid efficiency by selecting two different fluids, each having characteristics desirable to perform given functions. The light, watery circulating fluid W may be pumped with minimum horsepower requirement and exerts less pressure on the formation; it provides superior turbulent scouring action at the hole bottom and hence removes cuttings effectively; it does not tend to entrain gas but will release it at the surface; and it permits rapid separation of cuttings at the surface. Tests have shown that water is the best circulating fluid insofar as drilling rate is concerned and is a very efficient coolant for the drill bit. This water may have salt added in solution to increase the weight somewhat in areas of high gas pressure; to assist in flocculation of colloidal cuttings at the surface; and to prevent hydration and swelling of any shales or clay it may contact in and adjacent to the hole as well as in porous formations invaded by the brine. Since, the light fluid is circulated in controlled conduits, greater fluid velocity can be achieved. Hence, the lifting capacity of even a clear water for carrying chips to the surface is adequate. Moreover, since the cuttings are within the drill pipe, the dropping thereof to the hole bottom does not create too serious a problem. If circulation is to be interrupted for any length of time, the drill pipe is first flushed clean. Another advantage resulting from the use of water as the circulating fluid is the rapidity with which even fine sand particles drop out at the surface. Obviously efficient removal of sand and cuttings increase the life of the pumps, pipe jets and orifices.

The non-circulating mud M is preferably somewhat heavier than the circulating fluid W to balance the static head of the circulating fluid, taking into account the suspended cuttings, velocity, friction loss and the elevation of platform 45. This heavier mud aids in preventing gas

blowout and hole cave-in. The non-circulating mud M is normally a thixotropic, colloidal clay suspension to provide efficient lubrication of the drill pipe and, hence, reduce rotary horsepower. Also it forms an effective coating or filter cake to seal off porous formations; it protects the hole when the pipe is removed; it prevents water, gas or oil from invading the annulus from porous formations above the bit 3.

A particular advantage of my apparatus is its adaptability to drilling with air or other gas as the circulating medium, as particularly shown in FIG. 5. In that embodiment gas, preferably air, or engine exhaust gas is delivered from a suitable source such as an air compressor 91 with air being delivered through a flexible hose 71a into the inlet duct 71 to flow downward through the pipe string through the annular conduit to the bottom of the well bore. Alternatively gas from another well or otherwise available source may be delivered through conduit 71b to serve as the circulating fluid. There, as in the case of a liquid circulating fluid, the stream is divided and a portion thereof flows directly through the drill bit to ducts 25 while another portion is directed through the flow dividing discharge nozzles 30a, which are normally directed upward, into the annulus around the drill pipe. In this embodiment, the discharge nozzles 30a not only serve to sweep out the well bore for more efficient cutting but also to prevent difficulty caused by introduction of either water or gas from pockets by the well bit.

Normally, the valve 90 in the outlet duct 41 opening from the annulus is closed and gas flowing outward through the flow dividing nozzles 32 maintains the annulus at sufficient pressure to direct virtually all of the flow up through the central duct to remove cuttings and cores C as well as to maintain the bit cool. However, when a water sand 92 is penetrated by the bit, water droplets will normally seep through the well bore wall and moisten chips and cuttings which mixture is rolled and pressed by the drill bit 26 to form a hard, compact cement layer on the wall of the well bore B. This compaction is not unlike a water bound macadam structure which grows until fluid flow in the annulus is substantially blocked and the drill pipe often frozen against removal. However, with my apparatus should such moistening occur, the cuttings are within the inner drill pipe 8 and thereby protected against pressure rolling. Nevertheless, the first sign of wet chips will prompt the opening of valve 90 by the operator to permit gas to flow out of the annulus and hence produce an upward flow from the nozzles 30a. The amount of this upward flow can be controlled directly by degree of the opening of the valve 90 so that all of the water seeping from the water stand will be carried harmlessly up through the annulus away from the chips so that the well bore itself and cuttings arising therefrom can be maintained dry for continued drilling. This, of course cannot be done with conventional drilling equipment.

By the same token should a gas pocket 93 be penetrated by the drill bit, gas will, while the gas sand is being cut, flow up through the drill pipe to increase removal of the chips and cuttings and, more important, to be contained therein and thus reduce explosion and fire hazard appreciably. After the bit 3 has penetrated through the gas pocket, and substantially all the gas flows into the annulus B the greatest danger normally results from the presence of the gas-air mixture with cuttings being agitated by the steel drill pipe. Obviously, sparks generated by impact of cuttings and steel, due to such agitation, may cause a substantial explosion and fire hazard. However, with my apparatus, the valve 90 may again be opened to direct flow of air upward through the annulus and remove the gas away from the spark producing cuttings and out of the hole. In the event the gas released from the subterranean pocket into the annulus is of a pressure and volume of sufficient magnitude, it may in fact, be turned to advantage. In that situation, the air compressor may be turned off and

the inlet conduit 71 closed off to close off the annular duct within the drill pipe. Simultaneously, the release valve 90 is closed so that the only channel for escape of the gas is up through the central duct to function itself as the circulating fluid. Since there is now no air to mix with the gas there is no danger of an explosion resulting from sparks. Thus my system of checks and controls renders the use of air or gas as a circulating medium highly practical.

While I have described and shown a preferred embodiment of my invention, it is apparent that many modifications and changes can be made therein without departing from the spirit and scope of my invention which is intended to be defined by the claims following.

Having described my invention I claim:

1. A drill pipe string comprising:

a series of dual-passage metallic pipe stands each including an inner pipe and an outer pipe attached to said inner pipe in coaxial spaced relation,

each of said inner pipes containing an inner passage with said inner passages of successive stands being in communication with one another at their adjacent ends,

said two pipes of each stand forming radially therebetween an outer passage isolated from the inner passage of the corresponding stand with said outer passages of successive stands being in communication with one another at their adjacent ends,

each of said outer pipes having integral threaded end portions directly threadably interengagable with the end portions of the outer pipes of successive stands to form a joint between said outer pipes and to secure successive stands together,

each of said inner pipes having integral end portions constructed so that adjacent end portions of the inner pipes of successive stands will fit telescopically one within the other to form therebetween fluid-passing joints having generally-cylindrical axially-extending telescopically interfitting opposed surfaces,

said adjacent inner pipe end portions, in the fully made-up condition of said outer pipe joints being free of axially interengageable stop surfaces which will prevent a limited range of relative axial movement between said adjacent inner pipe end portions occasioned by thermal and/or tensile differential expansion and/or contraction effects on the metal of said pipes,

one of said opposed surfaces having therein a circumferential groove; a deformable seal ring in said groove and slidably engageable with the other of said surfaces to form a seal preventing fluid leakage between said inner and outer passages,

means adjacent both ends of said inner pipe of each stand centering said ends in the outer pipe of said stand, and

means attaching said inner pipe of said stand in fixed axial position relative to the outer pipe of said stand at a single location along the length of the pipes of said stand.

2. A drill pipe string as recited in claim 1 wherein: the minimum cross-sectional area of the series of inner passages is about the same as the minimum cross-sectional area of a series of outer passages.

3. A drill pipe string comprising:

a series of dual-passage pipe stands, each including an inner pipe and an outer pipe attached to said inner pipe in coaxial spaced relation,

each of said inner pipes containing an inner passage with said inner passages of successive stands being in communication with one another at their adjacent ends,

said two pipes of each stand forming radially therebetween an outer passage isolated from the inner passage of the corresponding stand with said outer pas-

sages of successive stands being in communication with one another at their adjacent ends,
 each of said outer pipes having end portions threaded-ly interengageable with the end portions of the outer pipes of successive stands to form a joint between said outer pipes and to secure successive stands together,
 each of said inner pipes having end portions constructed so that adjacent end portions of the inner pipes of successive stands will fit telescopically one within the other to form therebetween fluid-passing joints having generally cylindrical axially-extending telescopically interfitting opposed surfaces,
 said adjacent inner pipe end portions, in the fully made-up condition of said outer pipe joints being free of axially interengageable stop surfaces which will prevent a limited range of relative axial movement between said adjacent inner pipe end portions occasioned by differential thermal and/or tensile expansion and/or contraction effects on said pipes,
 one of said opposed surfaces having therein a deformable seal ring slidably engageable with the other of said surfaces to form a seal preventing fluid leakage between said inner and outer passages, said outer pipes having cylindrical inner surfaces,
 means adjacent both ends of said inner pipe of each stand and fixed thereto centering said ends in the outer pipe of said stand by engagement with said cylindrical inner surfaces, said inner and outer pipes being free of mutually wedging surfaces which would impede relative expansion or contraction of said pipes, and
 means attaching said inner pipe of said stand in fixed axial position relative to the outer pipe of said stand at a single location along the length of the pipes of said stand.
 4. A drill pipe string comprising:
 a series of dual-passage pipe stands each including an outer pipe and an inner pipe,
 each of said inner pipes forming an inner passage with said inner passages of successive stands being in communication with one another at their adjacent ends,
 said two pipes of each stand forming radially therebetween an outer passage isolated from the inner passage of the corresponding stand with said outer passages of successive stands being in communication with one another at their adjacent ends,
 each of said outer pipes having end portions fixedly interengageable with the end portions of the outer pipes of successive stands to form a joint between said outer pipes and to secure successive stands together,
 each of said inner pipes having end portions constructed so that adjacent end portions of the inner pipes of successive stands will fit telescopically one within the other to form therebetween fluid-passing joints having axially-extending telescopically interfitting opposed surfaces,
 said adjacent inner pipe end portions, in the fully made-up condition of said outer pipe joints being free of axially interengageable stop surfaces which will prevent a limited range of relative axial movement in either direction between said adjacent inner pipe end portions,
 cylindrical surfaces on one of said pipes,
 means fixed on the other of said pipes and spaced along the length of each stand locating the axes of the inner and outer pipe of said stand in fixed relation by engagement with said cylindrical surfaces, said inner and outer pipes being free of mutually wedging surfaces which would impede relative expansion or contraction of said pipes, and
 means connecting said inner pipe of said stand to the outer pipe of said stand at a single location along

the length of the pipes of said stand to support said inner pipe within said outer pipe.
 5. A drill pipe string comprising:
 a series of dual-passage pipe stands each including an inner pipe and an outer pipe,
 each of said inner pipes forming an inner passage with said inner passages of successive stands being in communication with one another at their adjacent ends,
 said two pipes of each stand forming radially therebetween an outer passage isolated from the inner passage of the corresponding stand with said outer passages of successive stands being in communication with one another at their adjacent ends,
 means for fixedly securing the end portions of the outer pipes of successive stands together to form a rigid joint between said outer pipes,
 each of said inner pipes having end portions constructed so that adjacent end portions of the inner pipes of successive stands will fit telescopically one within the other to form therebetween fluid-passing joints having axially-extending telescopically interfitting opposed surfaces,
 said adjacent inner pipe end portions, in the fully made-up condition of said outer pipe joints being free of axially interengageable stop surfaces which will prevent a limited range of relative axial movement between said adjacent inner pipe end portions in either direction,
 cylindrical inner surfaces on said outer pipe,
 means spaced along the length of said inner pipe of each stand and fixed thereon locating it within the outer pipe of said stand relative to the axis thereof by engagement with said surfaces, said inner and outer pipes being free of mutually wedging surfaces which would impede relative expansion or contraction of said pipes, and
 means connecting said inner pipe of said stand to the outer pipe of said stand along a limited portion of the length of the pipes of said stand to support said inner pipe longitudinally in said outer pipe.
 6. The drill pipe string defined by claim 5 including:
 means forming a fluid-tight seal between said adjacent inner pipe and portions throughout said limited range of relative axial movement.
 7. A drill pipe string comprising:
 a series of dual-passage pipe stands each including an inner pipe and an outer pipe,
 each of said inner pipes forming an inner passage with said inner passages of successive stands being in communication with one another at their adjacent ends,
 said two pipes of each stand forming radially therebetween an outer passage isolated from the inner passage of the corresponding stand with said outer passages of successive stands being in communication with one another at their adjacent ends,
 means threadedly connecting the end portions of the outer pipes of successive stands to form a joint between said outer pipes and to secure successive stands together,
 each of said inner pipes having end portions which, in the fully made-up condition of said outer pipe joints, are free of axially interengageable stop surfaces which will prevent a limited range of relative axial movement in either direction between said adjacent inner pipe end portions,
 means forming a fluid-tight joint between said adjacent inner pipe end portions throughout said limited range of relative axial movement,
 cylindrical surfaces on one of said pipes,
 axially spaced means fixed on the other of said pipes positioning said inner pipe of each stand with the ends thereof centered within the outer pipe of said stand by engagement with said cylindrical surfaces,

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said inner and outer pipes being free of mutually wedging surfaces which would impede relative expansion or contraction of said pipes, and means connecting said inner pipe of said stand relative to the outer pipe of said stand along a limited portion of the length of said stand to support and retain said inner pipe within said outer pipe.

8. Well drilling apparatus including:
 a drill pipe string, an annular core cutting bit, a core breaker, and fluid circulating means,
 said drill pipe string comprising:
 a series of dual-passage pipe stands each including an inner pipe and an outer pipe,
 each of said inner pipes forming an inner passage with said inner passages of successive stands being in communication with one another at their adjacent ends,
 said two pipes of each stand forming radially therebetween an outer passage isolated from the inner passage of the corresponding stand with said outer passages of successive stands being in communication with one another at their adjacent ends,
 means threadedly interengaging the end portions of the outer pipes of successive stands to form a joint between said outer pipes and to secure successive stands together,
 each of said inner pipes having end portions constructed so that adjacent end portions of the inner pipes of successive stands will fit telescopically one within the other to form therebetween fluid-passing joints,
 said adjacent inner pipe end portions, in the fully made-up condition of said outer pipe joints being free of axially interengageable stop surfaces which will prevent a limited range of relative axial movement between said adjacent inner pipe end portions in either direction,
 means positioning said inner pipe of each stand with respect to the axis of the outer pipe of said stand, and
 means connecting said inner pipe of said stand to the outer pipe of said stand along a limited portion of the length of said stand to support said inner pipe within said outer pipe,
 the lower end of said inner pipe of each stand being tapered inwardly and upwardly to minimize the area of radial blocking surfaces that might impede upward movement of objects in said inner passage,
 said annular drill bit being secured on the lower end of said drill pipe string with the opening therein in communication with said inner passage,
 said core breaker being secured in said inner passage above said drill bit to be engaged by cores cut by said drill bit,
 means for delivering a drilling fluid into said outer passage near the surface of the earth, and
 means for restricting flow of said drilling fluid upward in the annulus around said drill pipe string.

9. The well drilling apparatus defined by claim 8 including:

a source of pressurized gas,
 said drilling fluid delivering means connecting said source to said outer passage,
 means sealing off the annulus between the drill pipe string and the earth at the surface thereof,
 a conduit extending through said sealing means to the exterior thereof, and
 means for controlling the flow capacity of said conduit.

10. The well drilling apparatus defined by claim 8 wherein said flow restricting means comprises a column of fluid heavier than said drilling fluid in said annulus, and including:

a flow conductor for delivering said heavier fluid to said annulus,

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means for sealing off said annulus above said flow conductor,
 a valve device in said flow conductor,
 fluid pressure-responsive means for opening and closing said valve device in response respectively to fall and rise of a controlled pressure, and
 duct means connecting said annulus to said fluid-pressure-responsive means.

11. The well drilling apparatus defined by claim 8 wherein:

said core breaker severs from a sub-surface formation cores cut by said drill bit into lengths to be carried to the earth's surface by drilling fluid rising in said inner passage.

12. Well drilling apparatus including:

a drill pipe string, rotary drive means, an annular core cutting bit, and a core breaker,
 said drill pipe string comprising:
 a series of dual-passage pipe stands each including an inner pipe supported within an outer pipe,
 each of said inner pipes forming an inner passage with said inner passages of successive stands being in communication with one another at their adjacent ends,
 said two pipes of each stand forming radially therebetween an outer passage isolated from the inner passage of the corresponding stand with said outer passages of successive stands being in communication with one another at their adjacent ends,

means threadedly interengaging the end portions of the outer pipes of successive stands to form a joint between said outer pipes and to secure successive stands together,
 each of said inner pipes having end portions constructed so that adjacent end portions of the inner pipes of successive stands will fit telescopically one within the other to form therebetween fluid-passing joints,
 said adjacent inner pipe end portions, in the fully made-up condition of said outer pipe joints being free of axially interengageable stop surfaces which will prevent a limited range of relative axial movement in either direction between said adjacent inner pipe end portions,

means positioning said inner pipe of each stand with respect to the axis of the outer pipe of said stand, and
 means connecting said inner pipe of said stand to the outer pipe of said stand along a limited portion of the length of said stand to support said inner pipe within said outer pipe,

said rotary drive means comprising:
 an inner tubular member supported within an outer tubular member,
 means threadedly securing said outer tubular member to the outer pipe of one of said stands,
 each of said inner tubular member and said inner pipes having end portions constructed so that adjacent end portions of the inner pipe of a stand and said inner tubular member will fit telescopically one within the other to form therebetween fluid-passing joints,

said adjacent end portions of said inner tubular member and said inner pipe in the fully made-up condition of an outer pipe on said outer tubular member being free of axially interengageable stop surfaces which will prevent a limited range of relative axial movement in either direction between said adjacent end portions,

means connecting said inner tubular member to said outer tubular member at a single location along the length thereof to support said inner tubular member within said outer tubular member,

a support housing,
 elevator means for raising and lowering said support housing,

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rotary and thrust bearing means in said housing rotatably mounting and supporting said outer tubular member,

means for rotatably driving said outer tubular member,

means for delivering a drilling fluid into said outer tubular member, and

means for restricting flow of said drilling fluid upward in the annulus around said drill pipe string,

said annular drill bit being secured on the lower end of said drill pipe string with the opening therein in communication with said inner passage,

said core breaker being secured in said inner passage above said drill bit to be engaged by cores cut by said drill bit.

13. Well drilling apparatus including:

a drill pipe string, rotary drive means, an annular core cutting bit, and a core breaker,

said drill pipe string comprising:

a series of dual-passage pipe stands each including an inner pipe supported within an outer pipe,

each of said inner pipes forming an inner passage with said inner passages of successive stands being in communication with one another at their adjacent ends,

said two pipes of each stand forming radially therebetween an outer passage isolated from the inner passage of the corresponding stand with said outer passages of successive stands being in communication with one another at their adjacent ends,

means threadedly interengaging the end portions of the outer pipes of successive stands to form a joint between said outer pipes and to secure successive stands together,

said rotary drive means comprising:

an inner tubular member supported within an outer tubular member,

means threadedly securing said outer tubular member to the outer pipe of one of said stands,

said inner tubular member and said inner pipes having end portions constructed so that adjacent end portions of the inner pipe of a stand and said inner tubular member will fit telescopically one within the other to form therebetween fluid-passing joints,

said adjacent end portions of said inner tubular member and said inner pipe in the fully made-up condition of an outer pipe on said outer tubular member axially interengageable stop surfaces which will prevent a limited range of relative axial movement in either direction between said adjacent end portions,

means connecting said inner tubular member to said outer tubular member along a limited portion of the length thereof to support said inner tubular member within said outer tubular member,

a support housing,

elevator means for raising and lowering said support housing,

rotary and thrust bearing means in said housing rotatably mounting and supporting said outer tubular member,

means for delivering a drilling fluid into said outer tubular member, and

means for restricting flow of said drilling fluid upward in the annulus around said drill pipe string,

said annular drill bit being secured on the lower end of said drill pipe string with the opening therein in communication with said inner passage,

said core breaker being secured in said inner passage above said drill bit to be engaged by cores cut by said drill bit.

14. A drill pipe string comprising:

a series of pipe stands, each including an outer pipe and a smaller inner pipe within said outer pipe,

each of said inner pipes containing an inner passage with said inner passages of successive stands being

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in communication with one another at their adjacent ends,

said inner and outer pipes of each stand forming radially therebetween an outer passage isolated from the inner passage of the corresponding stand with said outer passages of successive stands being in communication with one another at their adjacent ends,

one of said inner and outer pipes of each stand having end portions fixedly interengageable with the end portions of the corresponding pipes of successive stands to form a joint between said corresponding pipes and to secure successive stands together,

the other of said inner and outer pipes of each stand having end portions constructed so that adjacent end portions of said other pipes of successive stands will fit telescopically one within the other to form therebetween fluid-passing joints having generally-cylindrical axially-extending telescopically interfitting opposed surfaces,

said adjacent other pipe end portions, in the fully made-up condition of said corresponding pipes of successive stands being free of axially interengageable stop surfaces which will prevent a limited range of relative axial movement between said adjacent other pipe end portions,

means forming a seal between said opposed surfaces to prevent fluid leakage between said inner and outer passages throughout said limited range of relative axial movement,

cylindrical surfaces on one of said pipes,

means fixed on the other of said pipes positioning the inner and outer pipes of each stand radially relative to each other by engagement with said cylindrical surfaces, said inner and outer pipes being free of mutually wedging surfaces which would impede relative expansion or contraction of said pipes, and

means supporting said other pipe of said stand axially relative to said one pipe of said stand at a single location along the length of the pipes of said stand.

15. A drill pipe stand comprising:

an outer pipe and a smaller diameter inner pipe within said outer pipe,

said inner pipe forming an inner flow passage,

said inner and outer pipes forming radially therebetween an outer flow passage isolated from said inner passage,

said outer pipe having end portions adapted for threaded interengagement with the end portions of the outer pipes of successive stands to form a joint between said outer pipes and to secure successive stands together,

said inner pipe having end portions formed to engage telescopically with the adjacent end portions of inner pipes of successive stands,

said inner pipe end portions being located relative to said outer pipe end portions so that in the fully made-up condition of said outer pipe joints the inner pipe end portions are free of axially interengageable stop surfaces which would prevent a limited range of relative axial movement between said adjacent inner pipe end portions,

means on at least one of said inner pipe end portions adapted to form a seal preventing fluid leakage between said inner and outer passages throughout said limited range of relative axial movement,

cylindrical surfaces on one of said pipes,

means fixed on the other of said pipes, positioning said inner and outer pipe means radially relative to each other by engagement with said cylindrical surfaces, said inner and outer pipes being free of mutually wedging surfaces which would impede relative expansion or contraction of said pipes, and

means supporting said inner pipe axially relative to said outer pipe at a single location along the length of said pipes.

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16. The drill pipe stand defined by claim 15 wherein: the minimum cross-sectional area of said inner flow passage is about the same as the minimum cross-sectional area of said outer flow passage.

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