My invention relates to a method of drilling wells and more particularly to drilling wells through layers of heaving shale.

In undertaking development of areas for obtaining oil, great difficulty is encountered in certain regions of south Texas where heaving shale is encountered in the Oligocene formation. Drilling through heaving shale is encountered where it is of considerable depth, has baffled operators for years. Throughout the Gulf Coast fields, oil and gas are overlain by shales of considerable thickness. Some of these cave badly. In places, the caving and associated movements assume such magnitude and force as to be termed "heaving". Starting usually with a slight sloughing and caving, the trouble increases progressively until the rock movements attain force of great magnitude, such that they are impossible to control by any known method. Each heave grows more severe than the one preceding. At first, there is merely a tendency to stick the drill pipe in the hole and pack off circulation but, as the trouble becomes accentuated a single heave may close the hole or fill it for thousands of feet. When this occurs, drill pipe and casing are bent, twisted and broken. The junk left in the hole may never be found. In extreme cases, drill holes several thousand feet deep, enclosed nearly to the bottom, will be filled nearly to the surface with fragments of shale heaving from close to the bottom. Such forces, once active, cannot be controlled.

The formations which heave are composed of various kinds of shale interbedded with each other. Some have bentonitic characteristics which cause them to swell many times their initial volumes upon contact with water. Others merely disintegrate without swelling. This disintegration is caused primarily by hydration.

In my co-pending application, No. 40,746, filed September 16, 1935, I have disclosed that continuous circulation of drilling mud without stopping while adding sections to the drill string would promote the drilling through heaving shale. The cessation of circulation frequently will cause the loss of the hole either through the sticking of the drilling string or the developing of heaves before the objective can be reached. One of the primary requisites in drilling through heaving shale, therefore, is speed in the operations.

As pointed out, the heaving first starts with a slight sloughing and caving. If this is kept to a minimum, heaves of such magnitude as to destroy the hole can be prevented.

One of the methods of preventing heaving from developing so rapidly that heaves of large magnitude are reached is to employ chemical muds. With ordinary drilling muds composed of colloidal matter suspended in water, the walls of the hole act as a filter. The water from the mud penetrates the formation, depositing a filter cake of waxy material. The water, however, causes hydration of the shale, followed by disintegration and sloughing. Both the shale and the walling material are broken down progressively, thus exposing more shale to hydration. This process is self-stimulating and will develop heaving within a short time, usually a few days after the initial penetration of the shale. I employ sodium silicate drilling muds. Sodium silicate reacts with the shale to form insoluble, protective films on all exposed surfaces. The shale is thus protected against hydration and disintegration. Sufficient mud viscosity to carry out the cutting, coated with protective silicates, is obtained through the addition of sodium bentonite. Weighting materials may be used to furnish additional weight so that the hydrostatic pressure of the column of drilling fluid will tend to prevent the collapsing of the hole from the weight of the formations themselves.

One object of my invention is to provide a method of drilling oil wells through layers of heaving shale.

Other and further objects of my invention will appear from the following description.

In the accompanying drawings which form part of the instant specification and are to be read in conjunction therewith and in which like reference numerals are used to indicate like parts in the various views:

Figure 1 is a diagrammatic cross sectional view of an oil well known as "Moody No. 2-A", located near Seadrift, Calhoun County, Texas.

Figure 2 is a diagrammatic view of the rig in one stage of the drilling operations.

Figure 3 is a diagrammatic view of the rig in another stage of the operations.

Figure 5 is an enlarged detail view with parts in section of a bit head containing a collapsible drilling bit, expanded for drilling.

Figure 6 is a view with parts in section of the bit head and collapsible drilling bit with the blades in closed position for pulling out of the hole through the casing.

Figure 7 is a detail view partly in section of a quick acting joint.
Figure 8 is a sectional view taken on the line 8-8 of Figure 7.

Figure 9 is a sectional view of a valve joint with which continuous circulation is maintained.

My method can be best understood by describing it with reference to a particular well but it is to be understood that this is by way of example and not by way of limitation.

The well shown diagrammatically in cross section in Figure 1 is a completed well drilled by the use of my method within 150 feet of a well previously lost by heaving of the shales. The heaving shale was encountered at 6150 feet, in the Diocritus, Heterosteigna, and Margininlla formations of the Oligocene era which extended for 1600 feet.

The drilling was started with an ordinary rotary type of drilling and conventional methods and at 162 feet a 20 inch casing was set and cemented at 2. Drilling, still by conventional methods, continued to 1475 feet and a 16 inch casing 3 was set and cemented at 4. Drilling then continued, still by conventional methods, to about 6100 feet, within 50 feet of the beginning of the heaving shale. A casing 8, 11\% inches in diameter, was then set and cemented at 6, a thousand sacks of cement being used. Up until this point, the drilling presented no difficulties and any conventional method of rotary drilling can be employed.

Heaving of shale does not occur until after the heaving shale layer has been penetrated for some distance. The heaving shale has been penetrated for about 300 feet before departure from the conventional methods. This can always be gauged by watching the cuttings carefully and, when signs of caving are noticed it is unsafe to drill deeper and set the casing by conventional methods.

At the point of setting of casing 5, the problem was to drill through 1600 feet of heaving shale without losing the hole. In order to successfully accomplish this, the following objectives must be kept in mind:

1. Disintegration and swelling of the shale due to hydration by water from drilling muds must be minimized.

2. The drilling must proceed with despatch to prevent aggravation of caving or heaving. This necessitates:

   a. Use of mechanical equipment enabling new sections of drill string to be added rapidly.

   b. A circular drill string, with uniform diameter, even while adding sections to the drill string.

   c. A method of drilling in which it will not be necessary to pull the drill string to set a casing accomplished by the use of the casing itself as the drilling string and the use of a collapsible bit which can be withdrawn without disturbing the drilling string in order to convert the drilling string into a casing.

3. To prevent the action of gas blowing shale into the hole.

4. To prevent movement of shale caused by weight of overlying formations.

The action of gas blowing shale into the hole was prevented by the use of drill muds, the hydrostatic weight of which would hold back the gas, and the movement of shale caused by the weight of overlying formations was likewise minimized by the use of drilling muds and by keeping the pipe in the hole and converting it into a casing.

To prevent disintegration and swelling of the shale by preventing hydration thereof, sodium silicate drilling muds were employed. Sodium silicate reacts with rock forming materials such as calcium, magnesium and aluminum compounds to seal the pores of the rocks and thus render them water resisting. Its protective action is practically instantaneous. This quick chemical action permits rapid drilling without having to wait for the slow walling action of ordinary muds. Mud weights ranging from 8 to 15 pounds per gallon with viscosities held at 30 to 40 seconds as measured with the Marsh funnel viscometer—500 cc. in and 500 cc. out—were employed.

As pointed out above, the heaving does not immediately develop forces of large magnitude and in many cases it is possible to bail the hole sufficiently with ordinary muds to delay caving of such proportions as to lose the hole, if the drilling proceeds with sufficient rapidity. It is essential always to maintain a continuous circulation. This is done by means of a valve using which is shown in Figure 9 in which a valve 7 is adapted to close an opening in the side of the union or an opening across the bore of the union depending on whether the flow is downwardly through the union or upwardly through the union.

In order to insure rapidity of adding sections, a quick acting Joint is employed such as shown in Figures 7 and 8. A male portion 9 of the quick acting joint is secured to the casing 10 at the top of the section. The male portion is provided with lugs 11 which are adapted to fit the female portion 12 of the joint which is secured in any suitable manner to the bottom of a section of casing. The female portion is provided with grooves 13, aligned with the lugs 11. To make the joint, the grooves 13 are seated in the slots 14 and the male portion telescoped in the female portion of the joint. Hammer pins 14 are driven at right angles to the axis and lock the joint in telescoped position. The hammer pins taper so that, when they are driven the joint is drawn together. Safety pins 15 are fitted to prevent the hammer pins 14 from withdrawing. This joint has many advantages in making a quick connection. Stabbing may take place at an angle and it is not necessary to carefully start the thread as is the case with the usual connection so that connection work is speeded up considerably.

Figure 3 shows the assembly with drilling through the heaving shale ready to begin. The drill string is comprised of 8\% inch casing. The bottom of the casing terminates in a bit head 16 in which a Collins tool 17 and any suitable construction is adapted to be seated. The bit head and collapsible bit are shown in Figures 5 and 6. In Figure 5 the bit is shown in extended position in the bit head 16 with the cutting blades 18 extended. In Figure 6 the bit is shown in collapsed position ready to be pulled out of the hole. The depth of heaving shale is known from geophysical data and, in this case, it was 1600 feet. The casing 19 is assembled with usual casing joints for 1600 feet, at which point a back-off joint 20 is inserted. The back-off joints are known to the art and consist of a number of sections having means to permit easy unscrewing. This may be accomplished by making the threads of greater pitch so that, when the string is rotated in the opposite direction, it will unscrew at the back-off joint. The casing is extended out of the hole by the use of special semi-flush joints for drilling strings, and a valve joint 21 is inserted in the string. The top of the casing string is connected to a swivel 22 by a hammer joint 23. No Kelly is used. In drilling, a special drive arrangement for round drill pipe is used. This is known to the art. The drive consists...
principally of a drill pipe clamp in which four tong guides are set. The grip on the pipe is secured by driving wedges through slotted pins. In drilling, the clamps travel downward on two upward drive posts set at opposite points in the rotary table. The length of the drive is fixed and when this amount has been drilled, the rotation is stopped, and the wedges are driven out. The clamps, of course, are then lowered to the top of the drive posts and drilling continued and the operation repeated.

Figure 2 shows the assembly after the drilling has progressed through the heaving shale to the point where it is necessary to add a new section. While the drilling is proceeding, all mud is removed from the well. The section which contains silicates is pumped from the mud pit 24 through hose 25 which is controlled by valve 27 to the swivel connection, whence the mud passes downwardly through the pipe, and out of the casing through pipe 28 back into the mud pit. When the point of drilling is reached when it is necessary to add a new section of drilling string, it is turned in the Houck drill and the new section is screwed in the derrick and the lower end is connected by a quick acting joint. Valve 27 is then closed and the wedge pins 14 of the quick acting joint are removed. Connection is made between the new section of drilling string and the hole in the derrick, and circulation will be continued through the opening in the side of the union 21.

Valve 30 is then opened and mud will be pumped through hose 29 moving valve 1 upwardly on its seat, and circulation will be continued through the opening in the side of the union 21, Valve 27 is then closed and the wedge pins 14 of the quick acting joint are removed. Connection is made between the new section of drilling string and the hole in the derrick, and circulation will be continued through the opening in the side of the union 21. When the hole is reamed, valve 1 will close the opening and the plug 29 is replaced to prevent the pipe from accidentally stopping the flow or becoming unseated. Drilling is continued until the heaving shale has been penetrated. This is shown diagrammatically in Figure 4. A fishing tool is then inserted for drawing the wire line collapsible bit from the hole. The fishing tool is inserted through a stuffing box, circulation being maintained continuously. The bit is withdrawn from the hole and the drilling string is then cemented since it is to act as a casing. It will be observed that the drilling string is not withdrawn from the hole for the setting of casing but that casing is set simultaneously while the drilling proceeds, the drilling pipe itself being cased. It will be observed by reference to Figure 4 that a number of valve unions 21 and a number of quick acting joints 22 will be in the hole. The valve unions involve a restricted cross sectional opening and the valve unions and quick acting joints are expensive. It will be undesirable to leave these in the hole as permanent parts of the casing of the well.

After the drill casing has been cemented, the entire string is rotated in the opposite direction and the drill string will unscrew at the back-off joint since this is designed for this purpose. Since the back-off joint is above the bottom of the casing at least a distance equal to the thickness of the heaving shale, it will be observed that the entire region of heaving shale is protected by a casing. All of the valve unions and quick acting joints will be recovered by the use of the back-off joint. A casing having the customary joints and terminating in a back-off joint connection and being of full cross sectional area is then rerun. The back-off joint permits easy connection to be made at the bottom of the hole since the threads are of greater pitch. At this stage of the drilling, we have a casing clear through the heaving shale, securely cemented in place and from this point conventional drilling methods may be again employed and the oil sands are reached. The 8% inch casing 18 which has been cemented at 23 had a depth of about 6021 feet. The drilling proceeded in the conventional manner and a 5% inch casing 24 was run to a depth of 9003 feet and cemented. The casing 19 through the heaving shale formations supports the heaving shale and prevents it from caving. The sloughing which inevitably occurs when drilling through heaving shale is not of such magnitude as to enable serious heaves to occur. The shale packs around the casing and becomes static and the danger of loss of the hole is thus averted.

From the foregoing description, it is believed that my method of drilling will be clear to those skilled in the art. It will be observed that I have accomplished the objects of my invention. By my method, heaving shale formations can be penetrated where drilling has repeatedly been attempted unsuccessfully. It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and is within the scope of my claims. It is further obvious that various changes may be made in details within the scope of my claims without departing from the spirit of my invention. It is, therefore, to be understood that my invention is not to be limited to the specific details shown and described. Having thus described my invention, what I claim is:

1. A method of drilling oil and gas wells into the earth through a subterranean formation of caving nature, including the steps of drilling in a conventional manner until a region in the vicinity of the caving formation is reached, withdrawing the drilling string, setting a casing in the hole thus formed, continuing the drilling through the casing while maintaining continuous circulation of a drilling mud containing a silicate, adding sections of drilling pipe to the drilling string as drilling proceeds, while maintaining continuous circulation of said drilling mud until the caving formation has been penetrated, converting the drilling pipe into a well casing without removing the same from the drill hole and then continuing the drilling until the desired objective is reached.

2. An assembly for drilling through heaving shale comprising in combination the following assembly: a bit head adapted to receive a removable bit, a plurality of sections of drill pipe coupled to each other, an easily uncoupled joint, further sections of drill pipe coupled to said first sections of drill pipe by said easily detachable joint and coupled to each other by conventional joints, a union having an opening in the side thereof and provided with a valve adapted to close the bore of said union or said opening in the side thereof, said union coupling a further section of drill pipe to the remainder of the assembly, said last named section of drill pipe being provided with a quick acting coupling means, a swivel coupled to the assembly through said quick acting coupling means, means for pumping oil well mud into said swivel for passage down the drilling assembly, means for pumping oil well mud through said
valve union for passage down said drilling assembly, said easily uncoupled joint being positioned above the bit head a distance approximately equal to the thickness of the heaving shale to be penetrated.

3. A method of drilling oil and gas wells into the earth through a subterranean formation of caving nature, including the steps of drilling in a conventional manner until a region in the vicinity of the caving formation is reached, withdrawing the drilling string, setting a casing in the hole thus formed, continuing the drilling through the casing while maintaining continuous circulation of a drilling mud, adding sections of drilling pipe to the drilling string as drilling proceeds, while maintaining continuous circulation of said drilling mud until the caving formation has been penetrated, converting the drilling pipe into a well casing without removing the same from the drill hole and then continuing the drilling until the desired objective is reached.

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