March 17, 1953 J. A. ZUBLIN 2,631,820

APPARATUS FOR DRILLING CURVED BORES DEVIATING FROM EXISTING VERTICAL WELL BORES

Filed April 4, 1951 2 SHEETS--SHEET 1

Fig. 1.

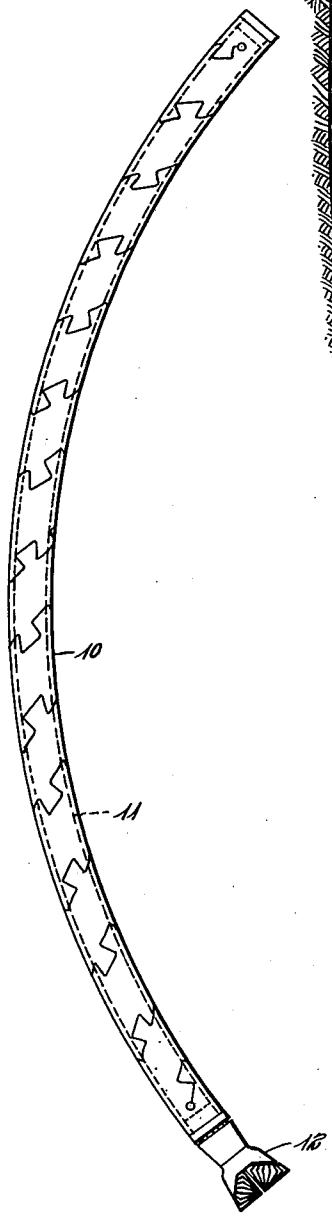
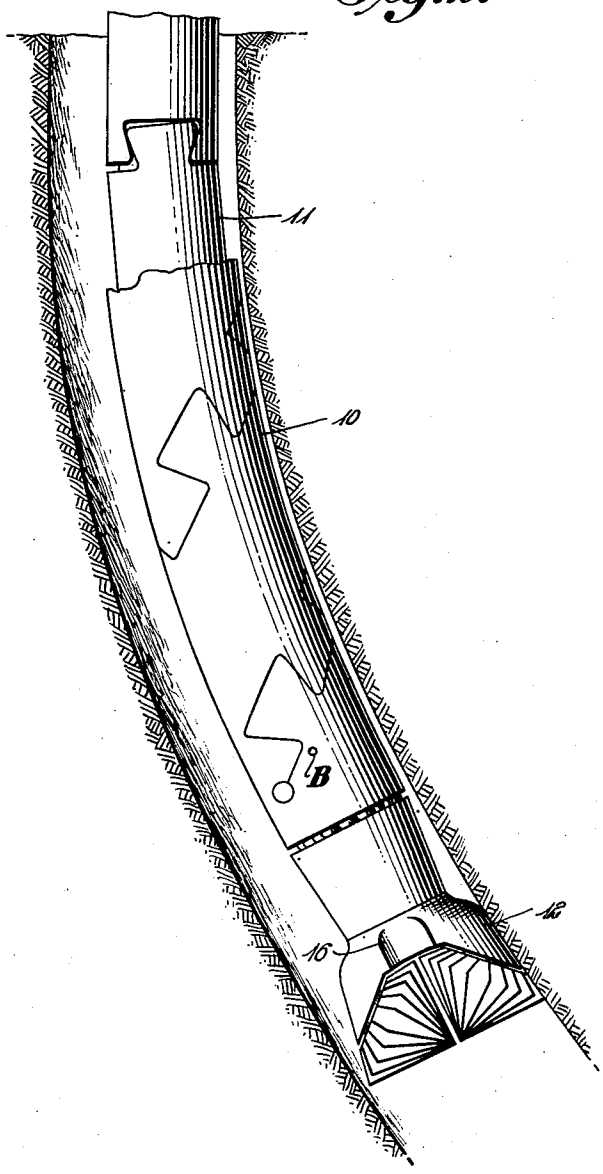


Fig. 2.



INVENTOR

John A. Zublin

BY Burns, Doane & Benedict

ATTORNEYS

March 17, 1953 J. A. ZUBLIN 2,631,820

APPARATUS FOR DRILLING CURVED BORES DEVIATING FROM EXISTING VERTICAL WELL BORES

Filed April 4, 1951 2 SHEETS—SHEET 2

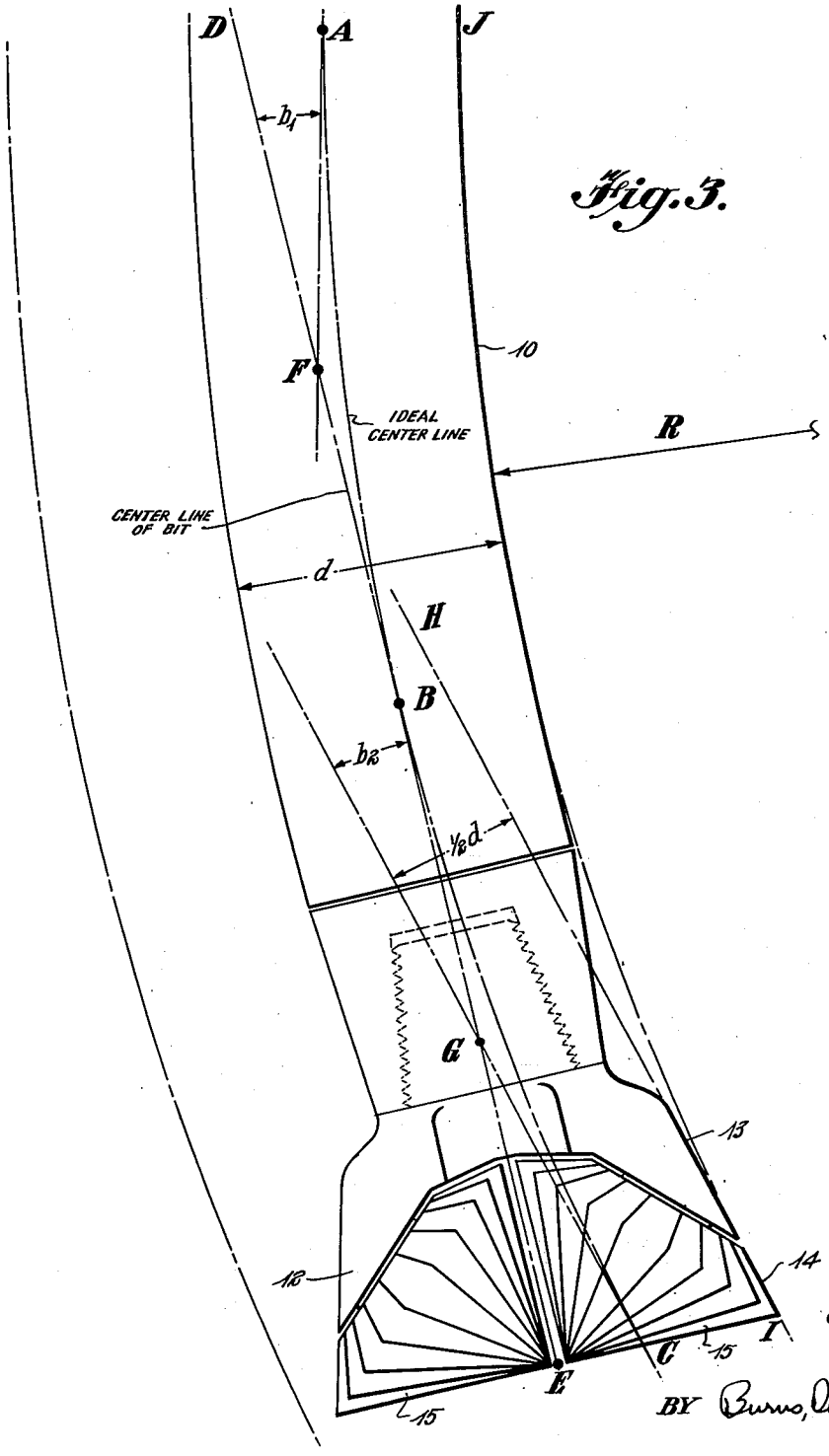


Fig. 3.

INVENTOR
John A. Zublin

BY Burns, Doane & Benedict
ATTORNEYS

Patented Mar. 17, 1953 2,631,820

UNITED STATES PATENT OFFICE

2,631,820

APPARATUS FOR DRILLING CURVED BORES DEVIATING FROM EXISTING VERTICAL WELL BORES

John A. Zublin, Los Angeles, Calif.

Application April 4, 1951, Serial No. 219,266

4 Claims. (Cl. 255—1.6)

1

The present invention relates to a novel apparatus for drilling lateral bores deviating from existing vertical well bores, having especial utility in secondary recovery of oil and gas from producing sand.

The art of drilling lateral bores deviating from existing vertical well bores is now rather well developed and is the subject matter of several prior United States patents issued to me, exemplary of which are U. S. Patents 2,336,338, 2,344,277 and 2,382,933. The present invention is addressed to specific improvements in apparatus for accomplishing accurate control over the direction and curvature of a deviating bore. By following the techniques of my prior patents, curved bores have been drilled from vertical oil well bores at depths ranging from 3,000 to 7,000 feet. By the employment of the record of an oil well obtained by the electric well logging thereof, it is possible to locate the oil-bearing sands and the thickness of oil-bearing strata within very close limits. It is essential to the successful secondary production of oil through the medium of deviating bores that they be initiated and extended into the oil-bearing strata at the proper elevation so that the horizontal extension of the deviating bore will penetrate the most prolific portion of the oil-producing zone. It has now become possible to survey the orientation and the inclination of a completed deviating curved bore through the use of newly developed surveying tools which give a series of readings at selected intervals and allow the accurate tracing on a chart of the course of the curved deviating bore.

With the apparatus of my prior patents I have had a considerable success but have found it difficult to accurately control the curvature of a deviating bore and to insure its extension and termination within the desired portion of the oil-bearing strata. It is highly desirable to avoid mishaps in the drilling of deviating bores and to insure that any horizontal extension thereof will lie at the proper level and not miss the zone of greatest oil recovery. It will be appreciated that in instances where a smaller radius of curvature of the bore is brought about than that contemplated or intended, any horizontal extension of the curved bore will extend upwardly and often terminate well above the desired level, whereas if a larger radius of curvature is drilled than contemplated, any horizontal extension of the curved bore may well lie below the desired level for greatest oil recovery.

I have now ascertained that inaccuracies occasioned due to variations in curvature of a bore drill are due in part to the employment of standard rotary rock bits of conventional design because of the relation of the bit body and the cutting teeth at the cutting face of the bit. Since the drilling of a deviating bore is effected, pursuant to the teachings of my prior patents, in part by the energy imparted by the normally curved flexible resilient drill guide, the bit body in encountering changing formations of alternate hardness and softness influences the course of the bit. I have found that it is possible to so design the bit and correlate it to the operating elements of the apparatus for drilling the deviating bore as to minimize the tendency of the bit to be deflected from the desired course. It is thus a primary purpose and object of the present invention to provide an improved apparatus for effecting the drilling of curved deviating bores of a desired radius with a minimum of deviation from that predetermined desired radius.

2

I have ascertained that the drilling of a curved bore of a desired radius is largely a function of adjusting a forward axial drilling pressure and then radial side pressure so that the resultant force of the two component forces is a tangent to the desired curvature, and in developing the apparatus of the present invention I have taken advantage of this factor. It will be appreciated that in ordinary vertical drilling outside radial forces exerted on a drill bit are compensated for and absorbed by the heavy assembly including the rigid drill columns, whereas radial forces striking a bit carried by a resilient guide in a curved bore must be absorbed by limited spring pressure of the flexible, curved resilient drill guide.

Pursuant to the present invention I have developed a drilling apparatus assembly including a bit that is effective to maintain its course even though radial forces tend to deviate it from that course.

It will be appreciated that in all apparatus for drilling deviating curved bores from vertical well bores through the technique of employing a normally curved flexible resilient drill guide such as described in my prior patents hereinabove identified, there is of necessity always present a rigid portion of apparatus embodying the bit body and usually a short section above it. Therefore, it becomes a more specific purpose and object of the present invention to provide apparatus for drilling a curved bore of predetermined radius with a flexible resilient curved drill guide which apparatus, however, embodies a rigid lower portion which cannot partake of the curvature induced by the resilient nature of the curved drill guide.

Further and more specific objects of the invention will become apparent as the description proceeds, which will be given with reference to the accompanying drawings wherein:

Figure 1 is a side elevation of the apparatus conforming to the present invention;

Figure 2 is an enlarged detail view particularly illustrating the lower end of the resilient drill guide and the drill bit body, and

Figure 3 is a schematic drawing illustrating the manner in which the conical surface of the drill bit body is developed.

Referring more particularly to Figure 1, it is desired to point out that the primary elements of the apparatus disclosed in this figure are the outer normally curved flexible resilient metallic drill bit guide 10 which is preferably constructed pursuant to the disclosure and teachings of my United States Patent 2,515,365, issued July 18, 1950, the inner drill bit drive member 11 which is preferably constructed pursuant to the teachings and disclosure of my United States Patent 2,515,366, issued July 18, 1950, and the drill bit 12 secured to and rotatable by the drill bit drive member 11 which, it will be understood, is rotatably mounted on the interior of the normally curved resilient drill guide 10. Details of the assembly form no part of the present invention but are disclosed, for example, in my applications Serial Nos. 189,591, filed October 11, 1950, now Patent No. 2,585,207, and 64,524, filed December 10, 1948.

Referring to Figure 2, the point indicated at B designates the point at which resiliency of the flexible drill guide 10 and the inner drive member 11 in assembled position cease to have flexibility and that portion of the apparatus below the point B including the lower portion of the inner drill bit drive member 11 and the drill bit 12 are rigid and rotate about a straight line axis.

It will be appreciated that the normally curved resilient flexible drill guide 10 has a predetermined curvature when assuming its normal unstressed curved configuration. By way of example, it has been found practical to use a normally curved flexible resilient drill bit guide of about 16 feet in length with a radius of curvature such that the center of the guide in unstressed configuration will lie about three feet distant from a line intersecting the opposite ends of the drill bit guide.

I have additionally found that the rigid portion at the lower end of the assembly, including the lower end portion of the drill bit drive member 11 and the bit 12, should not be substantially greater than twice the diameter of the cutting face of the bit, and this rigid portion of the assembly should usually lie within the limits of from one and one-half times the diameter of the cutting face of the bit and two times the diameter of the cutting face of the bit.

Referring to Figure 3, the curvature of the flexible resilient drill guide is schematically indicated as R and it will thus be appreciated that the ideal center line will be that curved line which lies at the center of the normally curved flexible drill bit guide 10, namely, the curved line A—C of Figure 3 which, it will be observed, passes through point B, i. e., the point below which the apparatus is rigid. The line D—E is tangent to the curved ideal center line A—C at the point B and represents the straight line axis about which the bit 12 must turn. In the development of the bit the distance A—B along the curved line A—C and extending in a flexible resilient portion of the apparatus is equal in length to the line B—C along the line A—C extending through the rigid portion of the apparatus. A straight line drawn tangent to the curved line A—C at point A will intersect line D—E at point F, whereas a line drawn tangent to line A—C at point C will intersect the line D—E at point G, yielding the equal angles *b1* and *b2*. The line H—I drawn parallel to the line G—C at a distance therefrom equal to one-half the diameter of the flexible drill guide 10 will be found to be tangent to the curved line J—I at point I. The line J—I represents the curvature of smallest radius defining the curved resilient drill guide 10.

Now I have found that if the outer conical wall 13 of the drill bit body and the extremities of the teeth 14 of the rotating cutters 15 of the bit 12 are so formed that upon rotation of the bit 12 about the straight line axis B—E the outer surface of the bit and teeth will be defined by the line H—I tangent to the curved line of smallest radius defining the flexible resilient drill guide, the bit will at all times tend to assume a position that will cut a curved bore on the radius R. I have also found that a bit developed in the manner above described with the outer conical surface of the bit body tapered inwardly toward the axis of rotation of the bit along a line tangent to that curve of smallest radius defining the flexible resilient drill guide at the point of contact of the cutting face of the bit with such curved surface will at all times tend to hug the wall of the curved bore of smallest radius and minimize any tendency of the apparatus to deviate from the predetermined desired curvature. There will, of course, always be a slight vibration of the bit which will occasion the drilling of a bore of slightly greater diameter than the diameter of the cutting face of the bit.

It is also a feature of the invention to provide axially extending flutes 16 in the outer surface of the drill bit body to permit passage of drilling fluid and facilitate longitudinal movement of the apparatus in the bore.

Having thus described my invention, what I claim is:

1. Apparatus for drilling a curved bore deviating from an existing vertical well bore, comprising a normally nonrotating curved flexible resilient tubular metal drill guide, an inner rotatable flexible tubular metal drive member having a short nonflexible terminal end portion, said inner rotatable member being mounted for rotation within said normally nonrotating drill guide, a nonflexible drill bit body rigidly secured to said nonflexible terminal end portion of said drive member to rotate therewith, the outer wall of said drill bit body tapering upwardly and inwardly toward the axis of rotation thereof along a line that is tangent, to a projection of that curve of smallest radius defining said curved drill guide, at a point in the projection of said curve of smallest radius disposed at a distance from the flexible portion of said drill guide approximately equal to the over-all length of said nonresilient terminal portion of said drive member and said drill bit body and cutting elements carried by said bit body lying substantially in said tangential line.

2. Apparatus for drilling a curved bore deviating from an existing vertical well bore, comprising a normally nonrotating curved flexible resilient tubular metal drill guide, an inner rotatable flexible tubular metal drive member having a short nonflexible terminal end portion, said

inner rotatable member being mounted for rotation within said normally nonrotating drill guide, a nonflexible drill bit body rigidly secured to said nonflexible terminal end portion of said drive member to rotate therewith, the outer wall of said drill bit body tapering upwardly and inwardly toward the axis of rotation thereof along a line that is tangent, to a projection of the smaller curve defining said curved drill guide, at a point in the projection of said curve disposed at a distance from the flexible portion of said drill guide approximately equal to the over-all length of said nonresilient terminal portion of said drive member and said drill bit body, rotary cutters carried by said drill bit body, the outer teeth of which terminate in cutting edges lying substantially in said tangential line.

3. Apparatus for drilling a curved bore deviating from an existing vertical well bore, comprising a normally nonrotating curved flexible resilient tubular metal drill guide, an inner rotatable flexible tubular metal drive member having a short nonflexible terminal end portion, said inner rotatable member being mounted for rotation within said normally nonrotating drill guide, a nonflexible drill bit body rigidly secured to said nonflexible terminal end portion of said drive member to rotate therewith, the outer wall of said drill bit body tapering upwardly and inwardly toward the axis of rotation thereof along a line that is tangent, to a projection of that curve of smallest radius defining said curved drill guide, at a point in the projection of said curve of smallest radius disposed at a distance from the flexible portion of said drill guide approximately equal to the over-all length of said nonresilient terminal portion of said drive member and said drill bit body, said drill bit body having at least one vertically extending flute cut out of its tapered outer wall to facilitate movement of the bit through drilling fluid in the bore and cutting elements carried by said bit body lying substantially in said tangential line.

4. Apparatus for drilling a curved bore deviating from an existing vertical well bore, comprising a normally nonrotating curved flexible resilient tubular metal drill guide, an inner rotatable flexible tubular metal drive member having a short nonflexible terminal end portion, said inner rotatable member being mounted for rotation within said normally nonrotating drill guide, a nonflexible drill bit body rigidly secured to said nonflexible terminal end portion of said drive member to rotate therewith, the outer wall of said drill bit body tapering upwardly and inwardly toward the axis of rotation thereof along a line that is tangent, to a projection of the smaller curve defining said curved drill guide, at a point in the projection of said curve disposed at a distance from the flexible portion of said drill guide approximately equal to the over-all length of said nonresilient terminal portion of said drive member and said drill bit body, rotary cutters carried by said drill bit body, the outer teeth of which terminate in cutting edges lying substantially in said tangential line, said drill bit body having at least one vertically extending flute cut out of its tapered outer wall to facilitate movement of the bit through drilling fluid in the bore.

JOHN A. ZUBLIN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,336,338	Zublin	Dec. 7, 1943