Sept. 8, 1959 A. A. MATHEWSON, JR., ET AL 2,903,240

SONIC EARTH BORING DRILL

Filed Nov. 1, 1957

Fig. 1

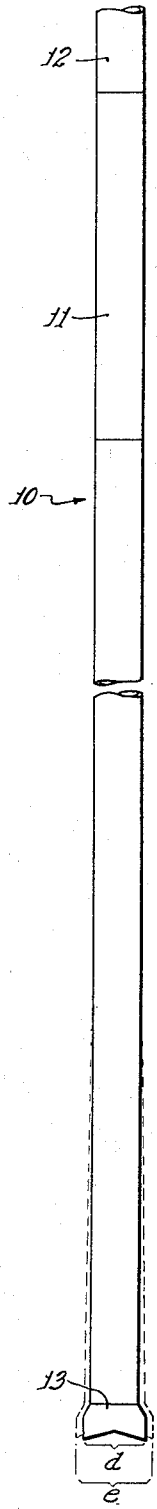


Fig. 2

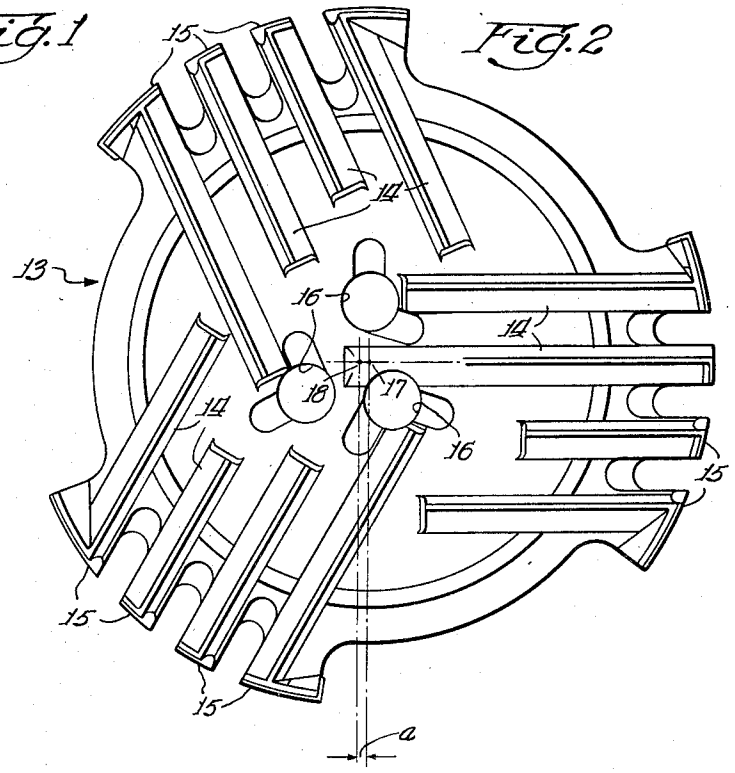


Fig. 3

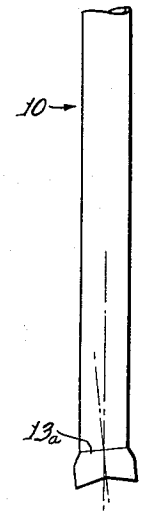


Fig. 4

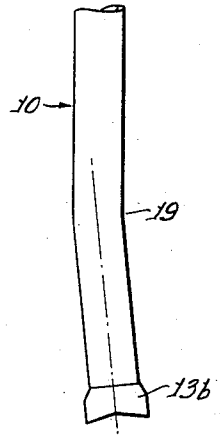
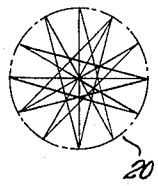


Fig. 5



Inventors:
Arthur A. Mathewson
and Charles S. Penfield
By: Frank C. Parker
Atty.

United States Patent Office

2,903,240

Patented Sept. 8, 1959

2,903,240

SONIC EARTH BORING DRILL

Arthur A. Mathewson, Jr., La Canada, and Charles S. Penfield, Camarillo, Calif., assignors to Borg-Warner Corporation, Chicago, Ill., a corporation of Illinois

Application November 1, 1957, Serial No. 694,017

8 Claims. (Cl. 255—4)

The present invention relates generally to earth boring devices and is particularly concerned with that class of earth boring drills comprising a vibratory elastic bar formed with a drill bit on the leading end thereof, which bar is adapted to vibrate longitudinally at a predetermined resonant vibration frequency, while the bit is in drilling engagement with the earth formation at the end of the bore, in order to fracture the formation adjacent to the bit.

Perhaps the most well-known sonic drill of the general type to which the present invention relates is disclosed in the patent to A. G. Bodine, Jr. 2,554,005, which patent discloses a longitudinally vibratory elastic bar, having a drilling bit at the leading end thereof, and including motive means at the bottom of the suspending drill string for inducing longitudinal vibration to said bar at substantially the resonant vibration frequency thereof in order to reciprocate the bit at the leading end of the bar while the bit is disposed in drilling engagement with the formation at the end of an earth bore.

The present invention comprises an improvement over the basic drilling system and apparatus disclosed in said Bodine patent and the principal object of the present invention is to provide a sonic drill including such an elastic vibratory bar and including means for inducing lateral vibration to the leading end of the elastic bar which enables the drill to form a bore in the earth's formation having a slightly greater diameter than the diameter of the drilling bit itself.

As will be readily understood, when an earth boring drill of the vibratory type is used for some period of time, the drilling bit naturally becomes somewhat dulled after a certain amount of use depending upon the type and hardness of the formation being penetrated and, as a result, the drill does not form a bore with as large a diameter as is the case with a new and unworn bit. Consequently, as drilling progresses after a new bit has been mounted on the leading end of the drill rod, the bore formed thereby gradually becomes smaller in diameter as the drilling progresses and the bit becomes progressively duller. Subsequently, when it becomes necessary to withdraw the drill string and change bits, the new bit inserted into the bore becomes stuck in the bore before reaching the bottom and thereby makes it necessary to ream out the bore hole to enable the bit to penetrate to the bottom of the hole. With the elastic vibratory bar and bit constructed in accordance with the teachings of the present invention, whereby the bore formed by the drill is somewhat larger in diameter than the diameter of the bit, the costly and time consuming reaming operation is unnecessary and the overall drilling operation is thereby faster.

A more detailed object of the present invention is to provide a sonic drill having a vibratory elastic bar and including a drilling bit disposed at the leading end of the bar, with the centerline of the bit misaligned slightly with respect to the centerline of the bar, whereby lateral vibrations of the bit are induced when the bit is in drilling engagement with the earth formation so that the bore formed in the formation is of a greater diameter than the diameter of the bit. In the present disclosure a bit with its centerline disposed parallel to the centerline of the drill rod but spaced slightly therefrom is disclosed, as well as two other embodiments, both of which comprise a bit having its centerline disposed at a slight angle to the centerline of the drill rod. In one of said last-mentioned two different embodiments, the bit itself is skewed with respect to the drill rod and in the other, the drill rod is bent slightly at the lower end adjacent the bit. These three embodiments have been disclosed by way of illustration and not with any intent to limit the scope of the present invention.

Additional objects and advantages of the present invent will become apparent from the following detailed description, when read in conjunction with the appended drawing, wherein:

Fig. 1 is a schematic illustration of a vibratory elastic bar having a drilling bit disposed at the lower end thereof and with its centerline slightly misaligned with respect to the centerline of the bar;

Fig. 2 is a detail bottom plan view of a drilling bit of the general type suitable for use in a drilling system as contemplated by the present invention and with the centerline of the drill bit disposed parallel to but in spaced relationship with the centerline of the drill rod.

Fig. 3 discloses schematically a second embodiment of the invention wherein the drilling bit is skewed or angularly disposed with respect to the drill rod;

Fig. 4 discloses schematically a third embodiment of the invention wherein the drill rod is bent slightly in order to misalign the bit with respect to the drill rod and;

Fig. 5 is a diagram illustrating schematically the path of movement of any point on any of the drilling bits disclosed herein during operation of the drill.

With reference now to the drawing, and with particular reference to Figs. 1 and 2 thereof which disclose the first embodiment of the present invention, the invention constitutes a sonic drill comprising an elastic elongated longitudinally vibratory hollow drill rod or bar designated generally by reference numeral **10** which is adapted to be supported by a drill string suspended from a conventional derrick located at the earth's surface above a bore adapted to be drilled by the drill comprising the subject matter of this invention. Inasmuch as the supporting drill string and derrick may be identical with the similar apparatus of the system disclosed in the afore-mentioned Bodine Patent No. 2,554,005, it is not deemed essential that this apparatus be disclosed herein for a thorough understanding of the present invention, and it will suffice to say that the massive elastic drill rod or bar **10** includes a vibration generating mechanism designated generally by reference numeral **11** which may be actuated by a turbine mechanism disposed within that portion of the drill rod **10** designated by reference numeral **12**.

It will be understood that the elastic bar **10** may constitute a plurality of subs (unnumbered and not separately referred to herein) which may be connected together by suitable joints. Further, the elastic bar **10**, when in drilling engagement with earth formation at the bottom of an earth bore will be vibrated at the substantial resonant vibration frequency of the bar so that the bar elongates with each vibration wave by a magnitude of the order of up to one-half inch.

The drill rod or elastic bar **10** is provided with a drill bit **13** which may be of the type shown in detail in Fig. 2 and which comprises a plurality of face cutters **14** and gauge cutters **15**. The particular configuration of the face and gauge cutters **14** and **15** is not essential to the present invention as it is contemplated that there are many other

similar bit configurations which would function satisfactorily and which could replace the bit shown in detail in Fig. 2 and represented by reference numeral **13**. The bit **13** also includes a plurality of passages **16** through which mud fluid, which is pumped down or through the interior of the drill string, passes in order to wash the drilling fragments loosened at the bottom of the bore hole by means of the vibratory drill bit **13**.

In the bit **13** shown in detail in Fig. 2, the point **17** represents the centerline of the bit whereas the point **18** represents the centerline of the elastic bar **10**. The points **17** and **18** are thus spaced apart by an amount designated by reference character *a* and the bit is eccentric to the drill rod by said amount. The face cutters **14** of the bit lie generally in a plane and form what may be termed the leading bit face, and the plane of this face is substantially normal to the centerline of the bit which passes through point **17**. Thus, the bit centerline which passes through point **17** and the eccentric rod centerline which passes through point **18** are parallel to each other and spaced apart by the distance represented by reference character *a*.

When the drill shown in Fig. 1 is in operation, the drilling oscillator causes the elastic bar **10** to vibrate longitudinally at substantially its resonant vibration frequency. Due to the fact that the drilling bit **13** is misaligned with respect to the centerline of the bar **10**, when the bit strikes the formation with each longitudinal vibration, a lateral component is induced which causes the bit to vibrate laterally as indicated by the dotted lines designated by reference character *e*. This lateral vibration of the bit **13** is not in a single plane, but rather, is more of a reciprocable or vibratory motion and a gyratory motion combined. Fig. 5 shows schematically the general path of movement of any point on the bit **13** due to the lateral vibration of the bit. It will be understood that the lateral vibrations imparted to the bit **13** are not necessarily regular by reason of the fact that they result from the unbalanced bit striking the earth formation. The earth formation continuously varies as the bore progresses into the earth and the effect on the bit is constantly changing.

The gyratory motion of the drill bit **13** is quite similar to the motion of the end of a rod which is rigidly clamped in a vise, when the free end of the rod is plucked like a harp string. Such a rod does not vibrate in a plane, but instead, it gyrates, generally reciprocating within a closed curve which may or may not be a circle as designated by reference numeral **20** in Fig. 5. Actually, the closed curve within which the drill bit **13** vibrates or gyrates is probably a somewhat irregular curve due to the constantly changing forces to which the drill is subjected during operation thereof.

The above analogy to the operation of a rigidly held rod is given herein merely to illustrate a motion similar to that followed by the drilling bit **13**, it being understood that the lateral vibration of the drilling bit **13**, when the bit is in drilling engagement with the earth bore, is gyratory in some fashion and could possibly be as shown in Fig. 5. Due to the gyratory action of the drilling bit **13**, the diameter of which is represented by reference character *d*, the bit will drill an earth bore having a diameter represented by reference character *e* and which diameter will normally exceed the diameter of the bit **13**.

It has been found that when a 10⅝" bit is resonated longitudinally at 100 cycles per second, an eccentricity of 1/16" to ⅛" seems to be quite effective. With such a bit operating under these conditions the bit does not wear down on the high side, as would be expected if the bit were merely rotating, but rather, wears off substantially evenly all the way around, thereby indicating the random contact of all sides of the bit due to the gyratory motion caused by the lateral vibration. Further, it has been found if an eccentricity of 3/16" is used, the lateral forces are so violent that the hard facing is destroyed very rapidly even though quite uniformly around the bit and not only on the high side.

By causing the bit **13** to gyrate as it vibrates longitudinally, the earth bore drilled by the bit does not have the effect of confining the drill rod. Since the drill rod is not confined, as is the case when the bit **13** is disposed symmetrically with respect to the centerline of the drill rod or bar **10**, it is capable of vibrating laterally in response to the inducement to so vibrate which occurs when the eccentric bit **13** vibrates against the earth formation.

In Fig. 3, the drill bit **13***a* is disposed with its centerline at an acute angle to the centerline of the drill rod **10** and the action of the drill bit **13***a* is substantially like the action of the drill bit **13**.

Fig. 4 shows a second modification wherein the drill rod is bent, as indicated at **19** so that the drill bit **13***b* is disposed with its centerline at a slight angle to the centerline of the drill rod **10**. With this arrangement of the drill rod and bit, the action is likewise similar to that of the drilling system shown in Fig. 1.

Although the structural embodiments of the present invention have been illustrated rather simply and in schematic form only, it will be understood and it is contemplated that the present invention provides a sonic drill including a vibratory elastic drill rod or bar having a bit disposed at the leading end thereof which is asymmetrical with respect to the bar or, in other words, is misaligned slightly with respect to the bar to thereby induce the bit to vibrate laterally upon resonant longitudinal vibration of the bar when in drilling engagement with the earth formation at the end of the bore.

It is contemplated that changes and modifications may be made in the present invention without departing from the spirit or scope thereof.

What is claimed is:

1. In a sonic earth bore drilling system, the combination of a sonic drill including a vibratory elastic bar adapted to vibrate longitudinally at a predetermined resonant vibration frequency and having an earth bore drilling bit at the leading end thereof, said drilling bit being misaligned with respect to the centerline of said elastic bar for thereby inducing said bit to vibrate laterally upon resonant longitudinal vibration of the bar, while the bit is in drilling engagement with the earth formation at the end of the earth bore, whereby the bit is effective to drill the bore in the earth of a slightly greater diameter than the diameter of the bit.

2. The combination in accordance with claim 1, wherein the centerline of said bit is disposed substantially parallel to but spaced from the centerline of said bar.

3. The combination in accordance with claim 1, wherein the centerline of said bit is disposed at an acute angle to the centerline of said bar.

4. The combination in accordance with claim 1 wherein the leading end of said bar is bent slightly such that the bit centerline is angularly disposed with respect to said bar.

5. In a sonic earth bore drilling system, the combination of a sonic drill including a vibratory elastic bar adapted to vibrate longitudinally at a predetermined resonant vibration frequency and having an earth bore drilling bit at the leading end thereof, said drilling bit comprising a plurality of spaced cutting elements, certain of which generally define a leading bit face, the centerline of said bit extending through the substantial center of said bit and extending substantially normal to said leading bit face, and said bit centerline being misaligned with respect to the centerline of said elastic bar for thereby inducing said bit to vibrate laterally upon resonant longitudinal vibration of the bar while it is in drilling engagement with the earth formation at the end of the earth bore, whereby the bit is effective to drill the bore in the earth of a slightly greater diameter than the diameter of the bit.

6. The combination in accordance with claim 5, wherein the centerline of the bit is disposed substantially parallel to but spaced from the centerline of the bar.

7. The combination in accordance with claim 5 wherein the centerline of the bit is disposed at an acute angle to the centerline of the bar.

8. The combination in accordance with claim 1 wherein the leading end of the bar is bent slightly such that the bit centerline is angularly disposed with respect to said bar.

References Cited in the file of this patent

UNITED STATES PATENTS

443,072	Chapman	Dec. 16, 1890
2,164,348	Ross	July 4, 1939
2,554,005	Bodine	May 22, 1951
2,730,103	Mackta	Jan. 10, 1956