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ROCK DRILL FOR RECOVERING SAMPLES
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3,421,591

Fig. 1

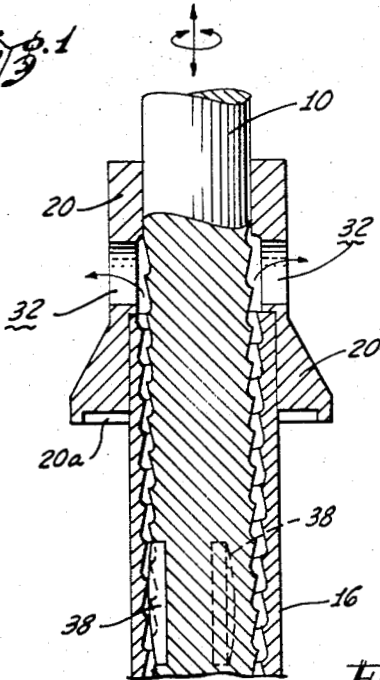


Fig. 4

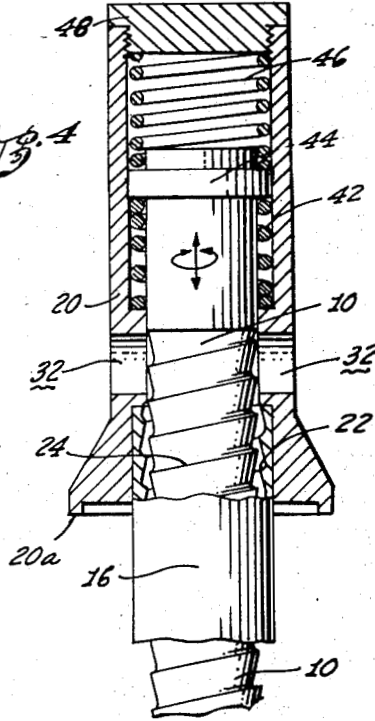


Fig. 5

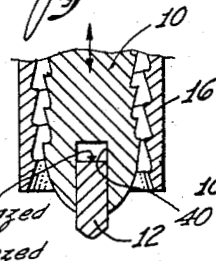


Fig. 3

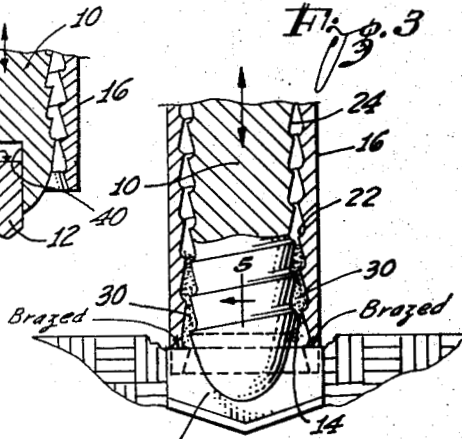


Fig. 2

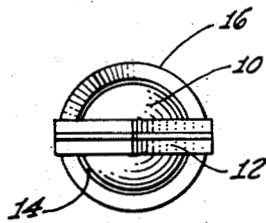
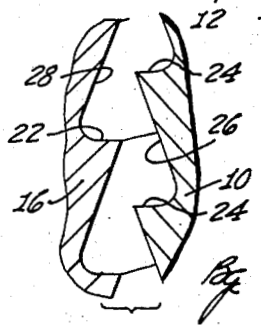


Fig. 6



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ROCK DRILL FOR RECOVERING SAMPLES

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9 Claims

Int. Cl. E21b 17/00; E21c 13/04; E21c 13/06

ABSTRACT OF THE DISCLOSURE

A rock drill is provided comprising a drill rod and surrounding sleeve. The drill rod exterior and surrounding sleeve interior are threaded so that the tips on the rod threads and the tips of the sleeve threads are staggered. The vibratory motion of the rod and sleeve serve to propel rock particles through the annular space between the rod and sleeve and upwardly by reason of the threaded surfaces of the respective rod and sleeve.

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 USC 2457).

The present invention relates to an improved construction for rock drilling apparatus, particularly useful for lunar and planetary sampling, for example, and it relates more particularly to an improved rotary impact type of rock drill which is capable of recovering rock cuttings from the cutting zone and raising the cuttings to the surface for analysis or disposal.

In the construction of most rock drilling apparatus it is usually necessary to provide some means for removing the rock cuttings from the cutting zone at the bottom of the drilled hole. The removal of the rock cuttings is usually necessary so that the cuttings themselves may be analyzed, and also so that the drilling operation may be continued unimpeded.

In the past it has been conventionally known to employ some means, such as an inclined ramp, conveyor or rotating spring to remove rock cuttings from the cutting zone at the bottom of a drilled hole. Also, it has been previously proposed that rock cuttings be removed from the bottom of a drilled hole by introducing compressed air through the drilling apparatus itself. Compressed air would be introduced with sufficient pressure to blow the rock particles up between the drill rod and an outer stationary sleeve surrounding the rod, to an exit port at the surface.

However, the prior art systems and mechanisms, such as those enumerated above, have, for the most part, proven to be not only complicated and expensive, but additionally, have proven to be relatively inefficient in their operation.

The drill assembly of the present invention provides a simple and inexpensive means for removing rock cuttings from the cutting zone, and for raising the cuttings up, out and clear of the drilled hole. The useful end results for the rock drill assembly of the invention are achieved in accordance with the concepts of the invention included in the embodiments to be more fully described hereinafter, by the provision of sawtooth-shaped threads on the outer surface of a drill rod, and by the provision of similar juxtaposed threads on the inner surface of a coextensive stationary sleeve which surrounds and is coaxial with the drill rod.

In accordance with the concepts of one embodiment of the rock drill assembly of the invention, the drill rod, to be described more fully hereinafter, is rapidly driven in the axial direction in a reciprocal manner, and at the same time is rotated slowly. The rapid reciprocal and rotary

motion imparted to the drill rod is in accordance with known and usual rock drilling drive motion.

In accordance with the concepts of another embodiment of the rock drill assembly of the invention the drill rod is suspended freely, by opposing spring members, within a coextensive stationary sleeve which surrounds and is coaxial with the drill rod. In this embodiment of the invention the impact energy, and the rapid reciprocal and rotary drive motion, imparted to the drill bit is transmitted through collar and sleeve members to the bit while the rod is suspended freely to vibrate within the sleeve member, independently from all impacting or driving motion.

In both embodiments of the rock drill assembly of the invention illustrated in the drawings, the exterior surface of the drill rod and the inner surface of the sleeve which surrounds and is coaxial with the drill rod are provided with sawtooth threads so configured that the upper surfaces of the threads are essentially horizontal and normal to the vertical axis of the drill rod and sleeve, and the lower surfaces of the threads taper at a steep angle. The threads provided on the drill rod and on the sleeve have the same pitch.

In the embodiment of the invention wherein the drill rod and surrounding sleeve are driven by the same rapid reciprocal and rotary drive motion the threads on the drill rod and sleeve are positioned so that the tips of the rod threads and the tips of the sleeve threads are staggered. As the drill assembly is subjected to an axial vibratory motion, rock particles in the annular space between the rod and sleeve are propelled upward by the flat upper surfaces of the threads on the rod and sleeve and deflected radially by the slanting lower surfaces of the threads. In this manner rock particles progress up through the sleeve on a step-by-step basis and are discharged through an exit orifice provided in the upper portion of the rock drill.

An object of the present invention, therefore, is to provide an improved rock drill which is constructed so as effectively to remove rock cuttings from the rock cutting zone, and to elevate such cuttings clear of the drilled hole to the surface; this being achieved in a simple, inexpensive, and yet most efficient manner.

Other objects and advantages of the invention will become apparent from a consideration of the accompanying drawings, in which:

FIGURE 1 is a side sectional elevation of an impact type rock drill constructed in accordance with the concepts of one of the embodiments of the invention;

FIGURE 2 is a cross-sectional view of the lower end of the drill assembly of FIGURE 1 taken substantially along the line 2—2 of FIGURE 1;

FIGURE 3 is a fragmentary side sectional view showing the lower portion of an alternate embodiment of an impact type rock drill constructed in accordance with the concepts of the invention;

FIGURE 4 is a fragmentary side sectional view showing the upper portion of the alternate embodiment of the impact type rock drill shown in FIGURE 3;

FIGURE 5 is a cross-sectional view of the lower end of the rock drill shown in FIGURE 3 taken substantially along the line 5—5 of FIGURE 3;

FIGURE 6 is an enlarged section of the drill rod, and the sleeve coaxial therewith, showing the thread configurations on the rod and sleeve.

Referring to the drawings it is seen that the rotary impact rock drill assembly of the invention includes an elongated drill rod 10. In the embodiment shown in FIGURES 1 and 2 the drill rod 10 is driven by an external drive means, not shown, which imparts rapid reciprocal linear motion to the drill rod and, at the same time, imparts a relatively slow rotational movement to the rod.

In the embodiment shown in FIGURES 1 and 2, the drill rod 10 is surrounded by a stationary sleeve 16 which

is coextensive and coaxial with the rod. As shown in FIGURE 1, the lower extremity of the sleeve 16 extends into a drill bit 12. The upper portion of the drill bit 12 extends into, and is retained by the rod 10. The hardened steel bit 12 is mounted on the lower extremity of both the drill rod 10 and sleeve 16 by brazing or by other suitable means.

In the embodiment of the invention shown in FIGURE 1 the housing 20 is solidly attached to the drill rod 10 and sleeve 16 by brazing or by other suitable means. Key members 38 appropriately spaced at intervals of 120°, for example, within the drill rod 10 provide further rigid support for the drill assembly. In the embodiment of the invention shown in FIGURES 3, 4 and 5 the housing 20 is solidly attached to the sleeve 16 by brazing or by other suitable means but the drill rod 10 is suspended freely within the sleeve 16 and housing 20, and is therefore not attached to the housing 20 as is the drill rod 10 of the embodiment of the invention shown in FIGURE 1. As shown in FIGURES 1 and 4 the lower portion of the housing 20 may be provided with an outwardly tapered configuration so as to define a flange 20a.

The cutting zone of the rock drill assembly is at the bottom of the drilled hole and as the moving parts of the drill are rapidly driven in a reciprocal manner in an axial direction, and at the same time rotated slowly, the impact of the bit 12 on the rock at the cutting zone loosens and pulverizes the rock. The action of the rock drill causes rock fragments, or cuttings, to be produced at the cutting zone.

As best seen in FIGURES 2 and 3 the bit 12, rod 10 and sleeve 16 are so configured that an annular transport chamber 14 exists between the rod 10 and sleeve 16. As the drill assembly is moved reciprocally, and simultaneously rotated, rock fragments or cuttings at the bottom of the drilled hole are caused to move into the annular transport chamber 14 between the rod 10 and the sleeve 16. The lower faces of the rod 10 and the sleeve 16, as best seen in FIGURE 2, are contoured so as to guide the rock fragments or cuttings 30, seen in FIGURE 3, into the annular transport chamber 14.

In accordance with the concepts of the present invention, projection means are formed on the inner surface of the sleeve 16. These projection means extend along the entire length of the sleeve. The projection means may be, for example, in the form of threads 22, as illustrated, having a sawtooth configuration so as to provide a series of essentially horizontal "shelves" around the inner peripheral surface of the sleeve 16 extending from one end of the sleeve to the other.

Similarly, projection means are formed on the outer surface of the drill rod 10 in juxtaposition with the projection means 22. The projection means provided on the outer surface of the drill rod 10 may take the form of threads 24, as illustrated, having a sawtooth configuration so as to provide a series of essentially horizontal "shelves" around the outer surface of the drill rod 10.

Referring to FIGURE 6 which shows an enlarged section of the projection means, or threads, provided on the rod 10 and sleeve 16 it is seen that both the threads 22 and 24 have upper surfaces which are essentially horizontal, and therefore normal to the vertical axis of the rod 10 and sleeve 16, and have lower surfaces, 28 and 26 respectively, which taper at a steep angle. The threads 22 and 24, as best shown in FIGURE 6, are provided with the same pitch and are so positioned that the end tips of the threads 22 are staggered in relation to the tips of the threads 24.

In the operation of the rock drill assembly the hardened steel bit 12 of the drill assembly is pressed firmly against the rock or other materials to be broken, cut, pulverized and lifted by the drill. As the drill assembly is driven by an external drive means, not shown, a rapid reciprocal linear motion, and a relatively slow rotary motion, is imparted to the drill assembly. The rapid reciprocal linear

motion imparted to the drill assembly causes the drill bit 12 to exert a high instantaneous pressure against the rock face or other surface to be drilled causing particles of that surface to be sloughed off and pulverized by the drill. The reaction of the drill on the hard surface of the rock or other material to be cut causes a reinforced vibratory motion to be imparted to the drill assembly.

Rock particles are guided into the annular transport chamber 14 between the rod 10 and sleeve 16 by the contoured lower faces of the rod 10 and sleeve 16, as best seen in FIGURE 2. As the drill assembly is being subjected to axial vibratory motion the rock particles 30 in the annular transport chamber 14 are being propelled upward by the flat upper surfaces of the threads 22 and 24 and deflected radially by the tapered lower surfaces 28 and 26 of the threads 22 and 24 respectively. In this manner the broken, cut and pulverized particles 30 are transported step by step upwardly until these particles reach the discharge port 32 provided in the housing 20 of the drill assembly.

A constructed embodiment of the drill assembly shown in FIGURES 1 and 2 has been found to operate with a high degree of efficiency in providing a flow of cuttings from the cutting zone, through the annular transport chamber 14 and through the discharge ports 32 for disposal where the cuttings are discharged and collected for analysis. Moreover, the assembly is extremely simple in its construction, and involves no extraneous parts or components, and merely requires the suitable configuration of the drill rod 10 and sleeve 16, as described above.

The embodiment of the drill assembly shown in FIGURES 3-5 is generally similar to the embodiment shown in FIGURE 1, and like components of the two embodiments have been indicated by the same numbers. The embodiment of the drill assembly shown in FIGURES 3-5, however, includes a drill rod 10 which is suspended freely within a housing 20 and sleeve 16 by opposing spring members 42 and 46. The lower spring 42 is mounted within the housing 20 immediately above discharge ports 32 provided in the housing. The lower end of the spring 42, as seen in FIGURE 4, bears against the housing 20, and its upper end bears against the under side of a flange 44 provided on the upper end of the drill rod 10. The upper portion of the housing 20 as seen in FIGURE 4 is closed by a cap member 48. The upper portion of the housing 20 and the cap member 48 may be provided with screw thread engaging structure, for example, as shown in FIGURE 4, so that the cap member 48 may be removed from the housing 20 for facilitating the removal, repair, replacement and/or maintenance of any of the structural members within the drill assembly of the invention.

As shown in FIGURES 3 and 5, the lower portion of the drill rod 10 is provided with a slot 40. The slot 40 is made of appropriate size so that the drill rod 10 is free to vibrate with rapid reciprocal motion above the drill bit 12 without becoming bound to the drill bit and without interfering with the cutting operation of the drill bit. However, as best seen in FIGURES 3 and 5, the bit 12 is solidly attached to the sleeve 16 by brazing or by other suitable means. Similarly the sleeve 16 is solidly attached to the housing 20 by brazing or by other suitable means.

The drill assembly of the invention as shown in FIGURES 3-5 is driven by an external drive means not shown in the drawings. The external drive means imparts a rapid reciprocal linear motion, and a relatively slow rotary motion to the drill assembly. Since the drill rod 10 is provided with a slot 40 for engaging the drill bit 12 the drill rod 10 will be driven by the same rotary motion as that imparted to the drill assembly by the external drive means, not shown in the drawings. However, since the drill rod 10 is suspended freely within the housing 20 and sleeve 16 the drill rod vibrates with reciprocal linear motion which is independent of the reciprocal

linear motion imparted to the housing 20, sleeve 16 and drill bit 12 by the external drive means not shown in the drawings. The reciprocal linear motion of the drill rod 10 within the drill assembly is guided by the spring members 42 and 46, the housing 20, key members 38, shown in FIGURE 1, appropriately spaced at intervals of 120°, for example, within the drill rod 10, and the side walls of the slot 40 within the drill rod 10 which fits over the drill bit 12.

It has been found that if vibrations of the drill rod 10 are dampened out to rapidly due, for example, to the structure of the material at the cutting zone, that the efficiency of the drill assembly to transport the cuttings to the surface may be somewhat impaired. However, by suspending the drill rod 10 freely within the housing 20 and sleeve 16 by opposing spring members 42 and 46, as shown in FIGURES 3-5, axial vibration of the drill rod may be established to any desired degree by an appropriate selection of the spring members 42 and 46. Thus the embodiment of the drill assembly of the invention as shown in FIGURES 3-5 provides for efficient transportation of cuttings from the cutting zone to the discharge ports 32 of the drill assembly for all conditions of material at the cutting zone.

It will be appreciated, of course, that while particular embodiments of the invention have been shown and described, modifications may be made. It is intended in the following claims to cover all such modifications as fall within the permissible range of equivalents in accordance with the scope and spirit of the invention.

What is claimed is:

1. A rock drill assembly including:
 - a vertical sleeve;
 - first projection means comprising a plurality of substantially horizontal upward facing surfaces formed on the inner surface of said sleeve and extending axially along at least a portion of the length thereof;
 - a drill rod vertically mounted within said sleeve and rigidly attached thereto;
 - second projection means comprising a plurality of substantially horizontal upward facing surfaces formed on the outer surface of said drill rod in juxtaposition with said first projection means and extending axially along at least a portion of the length of said rod; and
 - a bit mounted on the lower end of said sleeve for drilling rock at a cutting zone and producing rock cuttings when applied to the cutting zone, said bit being configured to feed such cuttings into the space between said rod and said sleeve when said bit is driven in a reciprocal axial motion;
 - said first and said second projection means elevating said cuttings in a step-by-step manner from one level to another within said rock drill assembly until said cuttings are discharged from said rock drill assembly.
2. The assembly defined in claim 1 in which said first and second projection means are in the form of threads having a sawtooth section.
3. The assembly defined in claim 2 wherein said threads have upper surfaces which are essentially horizontal and normal to the vertical axis of said sleeve and said rod and have lower surfaces which taper at a relatively steep angle.

4. The assembly defined in claim 2 wherein the end tips of said first projection means are staggered in relation to the end tips of said second projection means.

5. The assembly defined in claim 1 and which includes a housing surrounding said drill rod and said sleeve at a position displaced from said bit, said housing defining an exit port for said cuttings.

6. The assembly defined in claim 1 in which said bit is attached to said sleeve and to said drill rod.

7. The assembly defined in claim 1 including means for driving said assembly so that a reciprocal linear movement and a rotational movement are imparted to said assembly.

8. A rock drill assembly including:

- a vertical sleeve;
- first projection means comprising a plurality of substantially horizontal upward facing surfaces formed on the inner surface of said sleeve and extending axially along at least a portion of the length thereof;
- a drill rod vertically mounted within said sleeve and suspended freely therein by means including opposed springs;
- second projection means comprising a plurality of substantially horizontal upward facing surfaces formed on the outer surface of said drill rod in juxtaposition with said first projection means and extending axially along at least a portion of the length of said rod; and a bit mounted on the lower end of said sleeve for drilling rock at a cutting zone and producing rock cuttings when applied to the cutting zone, said bit being configured to feed such cuttings into the space between said rod and said sleeve when said bit is driven in a reciprocal axial motion;
- said first and said second projection means elevating said cuttings in a step by step manner from one level to another within said rock drill assembly until said cuttings are discharged from said rock drill assembly.

9. The assembly defined in claim 8 including means for driving said assembly so that a reciprocal linear movement and a rotational movement are imparted to said assembly.

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