April 17, 1956 R. E. SNYDER 2,742,265

IMPACT DRILL

Original Filed June 5, 1946

Fig. 1.

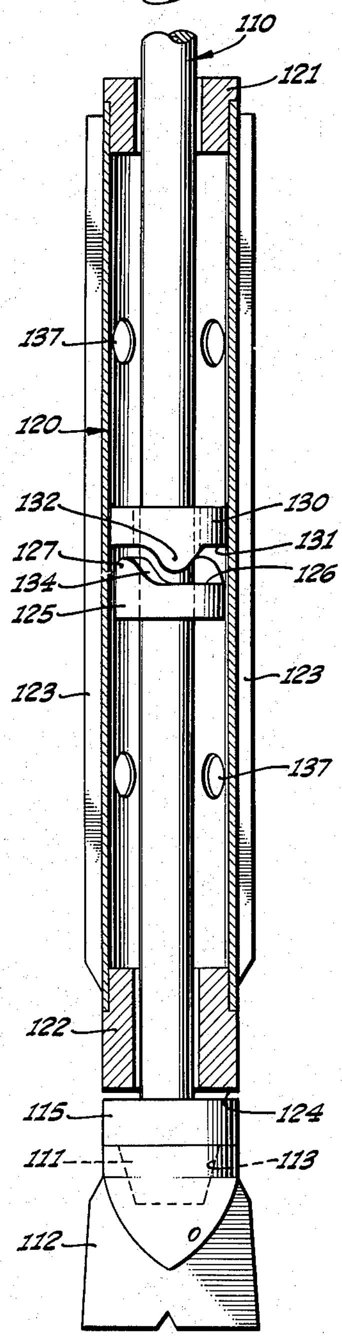
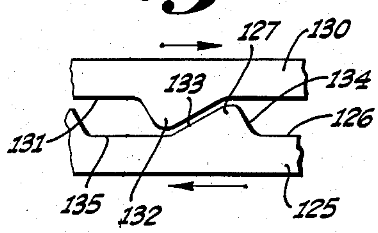


Fig. 2.



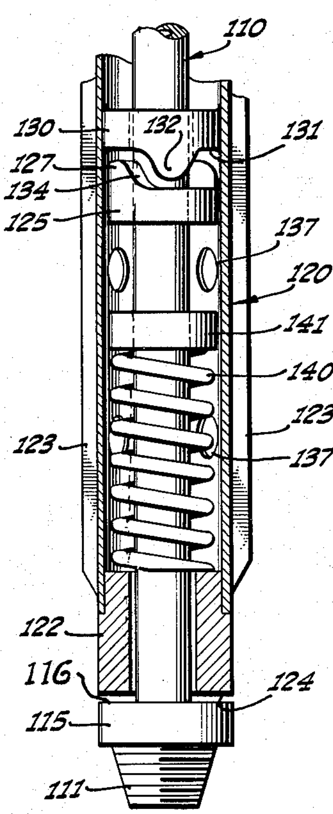
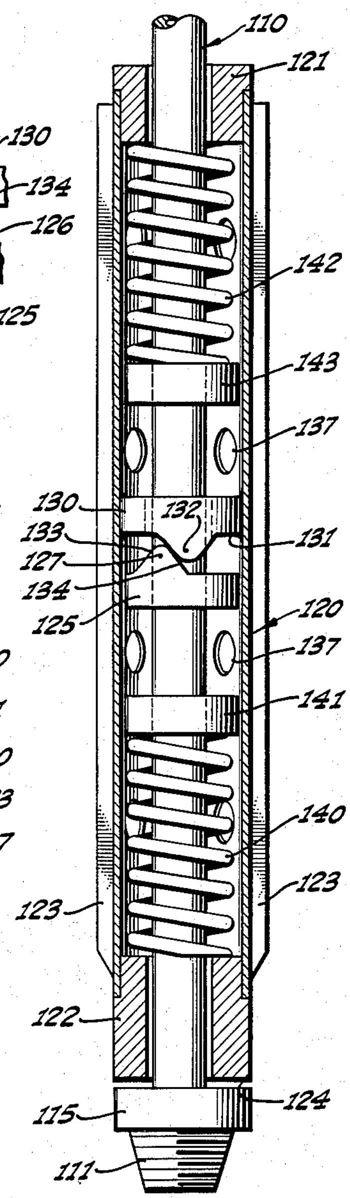


Fig. 3.

Fig. 4.



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IMPACT DRILL

Robert E. Snyder, Pasadena, Calif.

Original application June 5, 1946, Serial No. 674,526. Divided and this application September 13, 1954, Serial No. 455,494

10 Claims. (Cl. 255—3)

My invention relates generally to earth boring apparatus, and more particularly to such apparatus of a rotary type wherein an impact is periodically delivered to the drill bit while it is being rotated. This application is a division of my co-pending application Serial No. 271,013, now abandoned, which is a continuation of my application Serial No. 674,526, filed June 5, 1946, now abandoned.

In my co-pending application Serial Number 527,179, filed March 20, 1944, now Patent No. 2,425,012, issued August 5, 1947, I have disclosed a novel drill having a hammer thereon adapted to deliver impacts to the bit when the latter is rotated. While the device shown and described in that application is very satisfactory, and represents a distinct advance in the art, I have now developed certain improvements which both improve the operation of the drill, and also permit a different type of impact to be delivered to the bit.

In my said co-pending application, I have disclosed a drill wherein the relative rotation of two cam members lifts one of those cam members and then allows it to drop upon the other. Under certain conditions, it has been found that the impact of one cam member upon the other materially increases the wear of the parts. Furthermore, when a cam member having a single lift portion is used, the impact of the other cam member is not uniform around the surface of the first cam member, and consequently a bending stress may be developed on the shank to which the first cam member is attached.

In addition, I have found that by increasing the weight of the reciprocable or hammer portion of the drill, and by counter-balancing a portion of this weight so that the lifting cams do only the same amount of work in each case, I am able to increase the momentum of the hammer and thereby provide an impact having a different quality and result without increasing the work required to rotate the cam. Furthermore, by providing a resilient mount for the hammer, I am able to establish a condition of mechanical resonance in the hammer system so that the efficiency of the drill is greatly increased.

It is therefore an object of my invention to provide a rotary impact drill having a resilient portion in which resonance may be established to aid in the effectiveness of the impact upon the bit.

It is another object of my invention to provide a drill in which the impact may be caused, to a greater or lesser degree, by the momentum of the impact member, as distinguished from its weight.

A further object of my invention is to provide an improved impact receiving member on the drill, with a corresponding impact face on the hammer so that the cams operating the hammer mechanism are subject to less wear.

It is still another object of my invention to provide a drill having hammer and anvil portions so located that

the impact delivered by the hammer is more uniformly distributed over the anvil surface to minimize bending stresses on the shank.

These and other objects and advantages of my invention will become apparent from the following description of various forms thereof, and from the drawings illustrating those forms, in which:

Fig. 1 is a side elevational view, partially in section, of a simple drill employing my improved cam means;

Fig. 2 is an elevational view of the periphery of the cam members as they would appear if flattened into a plane;

Fig. 3 is a side elevational view, partially in section, showing the application of the improved cam means shown in Fig. 1 to a drill having a "bumper" spring thereon; and

Fig. 4 is a side elevational view, partially in section, of a drill similar to that shown in Fig. 3 but having, in addition, a resilient supporting spring mounted therein.

As seen in Fig. 1, I provide a simple rotary impact drill, such as that shown and described in my aforesaid co-pending application, with a pair of cam members which act solely to lift the hammer or impact member and then drop it so that a separate face thereof impacts against an anvil member attached to the bit. In this form, a shank **110** is provided with a suitable connecting means (not shown) at its upper end for connection to the lower end of the customary drill string used in drilling wells. At its lower end, the shank **110** is provided with a second connection which may advantageously be a "pin" **111** of the usual pin and box connection known in the art. A bit **112**, having a box connection **113**, is adapted to be attached to the lower end of the shank **110** in the customary manner and rotated thereby. Immediately above the pin **111** I rigidly attach an anvil member **115** to the shank **110**, the upper surface **116** of the anvil member being perpendicular to the axis of the shank so that, as hereinafter described, bending stresses of the shank are minimized.

Reciprocably mounted on shank **110** is a cylindrical hammer member **120** having an inwardly extending collar **121** at its upper end, and a similar inwardly extending collar **122** at its lower end. As shown, the internal diameter of the cylindrical hammer **120** is somewhat larger than the diameter of the shank **110** and the shoulders **121** and **122** act as bearing and centering members to hold the hammer concentric with the shank while permitting axial and rotational movement of the hammer.

On the outer surface of the hammer **120**, I prefer to fasten a plurality of generally vertical blades or vanes **123** which extend into the drilling fluid or mud surrounding the drill. When the shank **110** is rotated, hammer **120** tends to rotate with it but is retarded by the action of the vanes **123** on the mud surrounding them, and the hammer therefore rotates with respect to the shank. The blades **123** may take different shapes and be positioned in different directions along the surface of the hammer **120**, but to simplify the disclosure herein, I have shown these blades as being simple vertical members which extend along the outside surface of the hammer.

To provide an impact surface for the hammer **120** which will cooperate with the anvil surface **116**, lower collar **122** has its lower surface **124** formed perpendicular to the axis of the hammer body **120**; and the outer diameter of this collar is made approximately equal to the outer diameter of the anvil member **115**. In this way, full advantage is taken of the size of the anvil **115**, and since the impact faces **116** and **124** are parallel to each other and perpendicular to the axis of the shank **110**, there are no forces tending to bend or twist the shank because of non-uniformity of the distribution of impact around the anvil **115**.

A cam member **125** is formed as a collar rigidly attached to shank **110**, and having a slight clearance from hammer **120** so as to be free to move independently of the latter. The upper surface **126** of cam member **125** forms the actual cam surface, and is provided with one or more lobes **127**, while a similar cam member **130**, having a lower cam surface **131** with an equal number of lobes **132**, is firmly connected to hammer **120** and spaced from shank **110**. On one side of lobe **127**, the cam surface **126** is provided with a rise **133**, while on the other side there is a fall **134**; and between the fall and the rise there is a low dwell **135**, as shown in Fig. 5. Cam member **130** is preferably shaped similarly to cam member **125** just described, and the relative rotation of the cams in the direction shown by the arrows will cause cam **130** to be lifted and then immediately dropped, remaining in this lowered position until such time as lobe **132** again approaches lobe **127**.

In order that the lobe of one cam will not impact against the low dwell of the other cam when hammer **120** is dropped, the cams are mounted so that their operating surfaces are separated a slight amount when impact surface **124** of hammer **120** bears against impact surface **116** of anvil **115**. This condition is shown in Fig. 2, where it will be seen that the cam surfaces **126** and **131** touch each other only when the rise of lobe **132** bears against the rise of lobe **127**. It has been found that after lobes **127** and **132** have passed each other, there is a continued rotational movement of hammer **120** and cam **130**, with respect to shank **110** and cam **125**, so that even if the two cam members were allowed to impact together, lobe **132** would be laterally displaced a considerable amount from lobe **127** at the time of impact. Consequently, it is possible to form the cam members **125** and **130** so that the cam falls **134** are not vertical but instead are inclined at an angle to provide greater strength and better wearing qualities of the lobes. As will later be seen, should the lobe of one cam actually impact against the fall of the opposite cam, no harm would be done since such impact would merely tend to increase the speed of rotation or movement of cam **130** with respect to cam **125**.

It is thus seen that cam members **125** and **130** act as lift cams only and are in contact with each other only while cam **130** is being raised with respect to cam member **125**. At all other times, these members are separated, and the weight of the hammer member **120** is carried by the impact faces **116** and **124**.

When the shank **110** is rotated slowly, the frictional drag of the vanes **123** through the mud will be insufficient to overcome the friction existing between the impact surfaces **116** and **124**, and between the cam rise portions **133** of the cam surfaces **126** and **131**; consequently there will be no rotation of the hammer **120** with respect to the shank. However, as the speed of rotation of shank **110** is increased, the frictional drag on the vanes **123** will be increased until at some critical speed, hammer **120** will start to rotate with respect to the shank and will be raised as cams **125** and **130** move past each other. As lobe **132** passes lobe **127**, hammer **120** will start to fall, though continuing to rotate, and face **124** will impact against face **116** of the anvil **115**. Since these two faces are perpendicular to the axis of shank **110**, there will be no force tending to bend the shank, and its life will thereby be increased. In addition, since the full impact is taken by the surfaces **116** and **124**, and none by the cam members **125** and **130**, the wear on these cam members will be materially reduced and their life will likewise be increased. To prevent any fluid or mud within the hammer member **120** from slowing or preventing the movement of the hammer member, I provide holes **137** in the latter so that fluid may readily move through the walls of the hammer as the latter is reciprocated.

As the speed of rotation of shank **110** is increased, hammer **120** will be reciprocated at an increasing rate. It is conceivable that under certain conditions, however, shank **110** would be rotated at such a speed that hammer **120** would not have an opportunity to impact against anvil **115** before the cam members **125** and **130** started to raise the hammer again. Even before this point has been reached, the acceleration imparted to the hammer **120** by the cam members **125** and **130** will be such that cam member **130** will continue its upward movement even after lobes **127** and **132** have passed each other. This is not an efficient method of operation, nor is the method first mentioned where the hammer does not have an opportunity to impact against the anvil **115**. These difficulties will be particularly noticeable when the hammer member **120** is quite light, and consequently, I prefer to make the simple drill shown in Fig. 1 of medium weight.

Where it is desirable or necessary to use a light weight hammer, I prefer to construct my drill in accordance with the form illustrated in Fig. 3. As shown therein, the drill is similar to the form just described with the addition of a spring **140** and a collar **14**. Spring **140** increases the impact of the hammer **120** on the anvil **115** over that which would be provided by the weight of the hammer alone and extends between the latter and a projection on the shank **110**. This projection may be the cam member **125**, but I have generally found it preferable to install an outwardly projecting collar **141** attached to the shank and spaced from the walls of hammer **120**. The spring **140** may then bear against the lower surface of collar **141** and the upper surface of bearing collar **122** to urge the hammer **120** downwardly at all times. As cam members **125** and **130** rotate with respect to each other, hammer **120** is raised and spring **140** is compressed so that potential energy is stored in them. When lobes **127** and **132** of the cam members **125** and **130** have passed each other, the hammer **120** moves downwardly under the urging of gravity and the spring **140** so that a considerable impact is delivered to anvil **115**.

If it is felt undesirable to have the cam members **125** and **130** lift hammer **120** against the urging of spring **140** at all times, the length of the spring may be shortened so that it bears against the collar **141** and the bearing collar **122** only when lobe **132** moves about lobe **127**. In this way, spring **140** acts as a bumper spring to prevent the excessive upward movement of hammer **120** which results in the inefficient method of operation previously mentioned. Consequently, a light-weight hammer may be used at rotational speeds of the shank **110** which would otherwise cause the hammer to "float" without impacting against the anvil **115**.

Under other conditions, it is often desirable to provide a hammer in which the momentum of its impact is greater than that delivered by either of the forms shown in Fig. 1 or 3. When this is to be done, I provide a counterbalanced hammer wherein a portion of the weight of the hammer is supported by resilient means. Such a drill is shown in Fig. 4. This form is substantially identical to the form of drill shown in Fig. 3, with the addition of a helical supporting spring **142** and collar **143**. Collar **143** is rigidly attached to shank **110**, and is spaced from hammer **120** so that the latter may move without bearing against or touching the collar. Spring **142** surrounds shank **110** and extends between collar **143** and upper bearing collar **121** and has a relatively low spring rate so that the upwardly directed force exerted by the spring on the upper bearing collar remains substantially constant throughout the range of movement of hammer **120**.

With such an arrangement as that just described, it is seen that the upward force which the cam members **125** and **130** must exert to raise the body **120** is only the "unsupported" weight of the body, neglecting the effect of spring **140** if present and any acceleration imparted to the body. Thus, if the body **120** weighs 500 pounds and the spring **142** exerts an upward force of 400 pounds, the cams **125** and **130** need exert an upward force of only 100 pounds in order to raise the body **120**. As a comparison, if the body **120** weighed only 100 pounds and had no spring support, the cams **125** and **130** would likewise have to exert an upward force of 100 pounds in order to raise the body **120**; and if the spring supported body and the unsupported body are each raised the same distance, the same amount of work will be done by the cams in each case, and hence equal amounts of work will be returned to them when the bodies are allowed to fall. However, because of the difference of the mass of the two bodies, the momentums will be different, and the impacts delivered to the bits will be different.

In addition to permitting the body **120** to develop a greater momentum for a given amount of work done by the cam members **125** and **130**, the spring **142** permits of another feature which will be found to be of considerable advantage in drilling. It is well known that in a system having a spring which supports a weight, there is a certain natural frequency with which the system will vibrate if moved from its rest point. This frequency will have a value which is dependent upon the stiffness of the spring and the weight or mass of the body supported by it, and this natural frequency of vibration will hereinafter be spoken of as the frequency of free vibration. The energy required to establish and maintain oscillation in such a system will be at a minimum when the frequency of a disturbing force or the impressed frequency is equal to the natural frequency (the condition of resonance).

Turning now to the drill, it will be seen that the spring **142** and the body **120** combine to form a system such as that described above which will have a natural frequency determined by the stiffness of the spring **142** and the weight of the body **120**. If the cams **125** and **130** are caused to rotate with respect to each other so that the body **120** is raised and lowered at a rate equal to the natural frequency of the system, a minimum amount of work is required to rotate the cams; or expressed differently, if a constant amount of work is done in causing the rotation, the amplitude or height of the movement will be greater and hence a greater impact will be delivered to the bit **112**. It is thus possible to provide a reciprocating system which will have the frequency imparted by the rotation of the cams **125** and **130** equal to the natural frequency, and thus a drill of maximum efficiency will be secured. However, instead of selecting a drill to operate a particular frequency of the cams **125** and **130**, it is generally found desirable to vary the impressed frequency until it equals the natural frequency of the spring suspension.

In the case where spring **140** is employed and bears against the collar **122** urging it downwardly at all times, it will be apparent that the characteristics of the spring **140** must take this into account in determining the net upward force which must be exerted by the cams **125** and **130**. In addition, the resonant frequency of the entire system, including the body **120** and the springs **140** and **142** should be taken into account to derive the full benefit of the structure.

From the foregoing description, it will be seen that the drills herein disclosed will deliver an impact to the bit which is different from that imparted by an "upsprung" body, both because of the difference in momentum and because of the mechanical resonance set up in the resilient system. The impact of the resilient system, whether of a single or double spring form, may often be used to secure superior results when drilling through earth formations where the non-resilient system does not achieve its maximum effectiveness.

Furthermore, it will be seen that by using the lift cam and anvil arrangement herein disclosed, wear of the cam

surfaces will be considerably reduced and the forces tending to bend the shank will be minimized.

I have thus disclosed an improved form of impact drill possessing advantages not had by previous drills. It is obvious that modifications may be made in the construction of such drills, and I do not wish to be limited to the particular form or arrangement of parts herein described and shown, except as limited by my claims.

I claim:

1. An impact drill which includes: a shank adapted to have a drill bit attached thereto; a hammer rotatably and reciprocably mounted on said shank; an anvil rigidly attached to said shank and adapted to be impacted by said hammer; vane means attached to the outer surface of said hammer and adapted to retard the rotation of said hammer with respect to said shank when the latter is rotated; cam means between said shank and said hammer adapted to raise and then drop said hammer as the latter is rotated with respect to said shank, said cam means receiving no impact and being separated except when said hammer is being raised; and spring means connected between said shank and said hammer and supporting a substantial portion of the weight of said hammer to form therewith a resilient system wherein said hammer, when not reciprocating, has materially less than its total weight supported by said anvil.

2. An impact drill which includes: a shank; a hammer rotatably and reciprocably mounted on said shank; resilient weight supporting means connected between said hammer and said shank supporting a substantial portion of the weight of said hammer, and forming, with said hammer, a resilient system wherein said hammer, when not reciprocating, is urged downwardly by resultant force materially less than that caused by its weight; an anvil rigidly attached to said shank and adapted to be impacted by said hammer; means adapted to retard the rotation of said hammer with respect to said shank as the latter is rotated; and cam means connected to said hammer and said shank adapted to lift said hammer and then drop it upon said anvil as said hammer is rotated with respect to said shank.

3. An impact drill which includes: a shank adapted to have a drill bit attached thereto; a hammer rotatably and reciprocably mounted on said shank and having a flat impact face thereon; an anvil rigidly attached to said shank and adapted to be impacted by said hammer, said anvil having a flat impact face adapted to cooperate with the impact face of said hammer; means counterbalancing a substantial portion of the weight of said hammer and thereby reducing the portion of said weight supported by said anvil; means adapted to retard the rotation of said hammer with respect to said shank when the latter is rotated; and cam means adapted to raise and then drop said hammer as the latter is rotated with respect to said shank, the quality of impact caused thereby being determined by the momentum of the reciprocating members.

4. An impact drill which includes: a shank adapted to have a drill bit attached thereto; a hammer reciprocably mounted on said shank; resilient means connected between said hammer and said shank to support a substantial portion of the weight of said hammer and form, with said hammer, a resilient system; vane means attached to the outer surface of said hammer and extending outwardly therefrom to engage a fluid surrounding said hammer and to retard the rotation of said hammer with respect to said shank; cam means between said shank and said hammer adapted to reciprocate the latter when said shank is rotated with respect to said hammer, the work done by said cam means in raising said hammer being proportional to the net downward force exerted by said body; and means attached to said shank for receiving an impact from said hammer when the latter is reciprocated, the quality of said impact being determined by the momentum of the elements of said resilient system.

5. An impact drill which includes: a rotatable shank adapted to have a drill bit attached thereto; a hammer rotatably and reciprocably mounted on said shank and having a flat impact face thereon; an anvil rigidly attached to said shank and adapted to be impacted by said hammer, said anvil having a flat impact face adapted to cooperate with the impact face of said hammer; shoulders attached to said hammer and to said shank; spring means extending between said shoulders and supporting a portion of the weight of said hammer, said hammer and said spring means forming a resilient system; a cam member attached to said shank; a cam member attached to said hammer for movement therewith, said cam members cooperating to reciprocate said hammer when the latter is rotated with respect to said shank, the work done by said cam members in raising said hammer being proportional to the net downward force exerted by said hammer; and means adapted to cause rotation of said body with respect to said shank when the latter is rotated, whereby said hammer is reciprocated and caused to impact against said anvil, and said resilient system may be operated at its resonant frequency when said shank is rotated at normal drilling speeds, to aid in the causing of said impact.

6. A drill of the character described which includes: a shank adapted to have a drill bit attached thereto; a lower cam member attached to said shank; an upper cam member rotatably and reciprocably mounted on said shank, said upper and lower cam members cooperating to raise said upper cam member and allow it to fall when rotated with respect to said lower cam member; a body attached to said upper cam member and surrounding said shank, operable to impact against a member connected to said bit; spring means supporting a substantial portion of the weight of said body and forming therewith a resiliently mounted system; and means adapted to retard rotation of said body with respect to said shank when the latter is revolved, whereby said body is caused to oscillate at the resonant frequency of said resiliently mounted system when said shank is rotated at normal drilling speeds, thereby delivering impacts to said bit.

7. An impact drill which includes: a shank adapted to have a drill bit attached thereto; a hammer reciprocably mounted on said shank; resilient supporting means connected between said hammer and said shank to support a substantial portion of the weight of said hammer and forming a resonant oscillatory system including said body and said resilient means; an anvil rigidly attached to said shank, having an annular impact surface perpendicular to the axis of said shank, said hammer having a similar impact surface adapted to cooperate with said anvil impact surface to support a portion of the weight of said hammer and convert a downward movement of said hammer into an impact delivered to said anvil; vane means attached to the outer surface of said hammer and adapted to retard the rotation thereof with respect to said shank as the latter is rotated; cam means rigidly connected to said shank for rotation therewith; and a cooperating cam means rigidly connected to said hammer for movement therewith, said cam means having a lobe with a rise on one side thereof, a fall on the other side, and a low dwell between said rise and fall, said cooperating cam means being so positioned with respect to said cam means that said cooperating cam means is lifted by said rise, but does not travel to said low dwell, whereby said hammer is lifted and then dropped to impact against said anvil when said hammer is retarded in rotation with respect to said shank, and a condition of resonance may be established in said oscillatory system when said shank is rotated at normal drilling speeds.

8. An impact drill which includes: a shank adapted to be rotated; an anvil rigidly attached to said shank, having an impact surface perpendicular to the axis of said shank; a cylindrical hammer rotatably and reciprocably mounted on said shank, having an annular impact

surface perpendicular to the axis of said shank and cooperating with said anvil impact surface to support said hammer and to convert a downward movement of said hammer into an impact delivered to said anvil; shoulders attached to said hammer and to said shank; spring means mounted between said shoulders and supporting at least a substantial portion of the weight of said hammer and forming with the latter a system capable of resonant oscillation wherein said hammer is reciprocated; a plurality of vanes attached to the outer surface of said hammer and extending along the length thereof to engage a fluid surrounding said hammer, whereby the frictional resistance of said fluid to the passage of said vanes therethrough causes a retarding of said vanes and said hammer with respect to said shank as the latter is rotated; a cam means rigidly connected to said shank for rotation therewith; and a cooperating cam means rigidly connected to said hammer for movement therewith, said cam means having a lobe with a rise on one side thereof, a fall on the other side, and a low dwell between said rise and fall, said cooperating cam means being so positioned with respect to said cam means that said cooperating cam means is lifted by said rise of said cam means but does not travel to said low dwell, whereby said hammer is lifted and then dropped to impact against said anvil as said hammer is retarded in rotation with respect to said shank, said spring and hammer system being so proportioned that said hammer is oscillated at the resonant frequency of said system to impact against said anvil when said shank is rotated at a normal drilling speed.

9. An impact drill which includes: a rotatable shank adapted to have a drill bit attached thereto; a tubular hammer rotatably and reciprocably mounted on said shank but spaced therefrom; a shoulder extending outwardly from said shank within said hammer but spaced from the latter; a shoulder extending outwardly from said hammer, surrounding said shank but spaced therefrom; a helical spring having a relatively low spring rate, extending between said shoulders and supporting a substantial portion of the weight of said hammer, said spring and said hammer forming a resonant system; an anvil rigidly attached to said shank and adapted to be impacted by said hammer, said anvil having a flat impact face adapted to cooperate with a similar impact face of said hammer; cam means between said shank and said hammer adapted to raise and then drop said hammer as the latter is rotated with respect to said shank, the operative members of said cam means receiving no impact and being separated except when said hammer is being raised; and vane means attached to the outer surface of said hammer and adapted to retard the rotations thereof with respect to said shank as the latter is rotated, whereby said hammer is rotated with respect to said shank and said cam members reciprocate said hammer to cause the latter to impact against said anvil at the resonant frequency of said resonant system when said shank is rotated at normal drilling speeds.

10. An impact drill which includes: a shank adapted to have a drill bit attached thereto; an anvil rigidly attached to said shank, having an annular impact surface perpendicular to the axis of said shank; a cylindrical hammer rotatably and reciprocably mounted on said shank, having an annular impact surface perpendicular to the axis of said shank and cooperating with said anvil impact surface to support a portion of the weight of said hammer and convert a downward movement of said hammer into an impact delivered to said anvil; means attached to said hammer adapted to retard the rotation thereof with respect to said shank as the latter is rotated; resilient means between said hammer and said shank supporting a substantial portion of the weight of said hammer to form a resonant system including said hammer and said resilient means; cam means rigidly connected to said shank for rotation therewith; and a cooperating cam means rigidly connected to said hammer

for movement therewith, said cam means having a lobe with a rise on one side thereof, a fall on the other side, and a low dwell between said rise and fall, said cooperating cam means being so positioned with respect to said cam means that said cooperating cam means is lifted by said rise of said cam means, but does not travel to said low dwell, whereby said hammer is lifted and then dropped to impact against said anvil as said hammer is retarded in rotation with respect to said shank, and the frequency of said impact may be caused to coincide with the natural frequency of said resilient system to establish a condition of resonant reciprocation.

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