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STEPPED TERMINATION FOR SONIC CASING DRIVE

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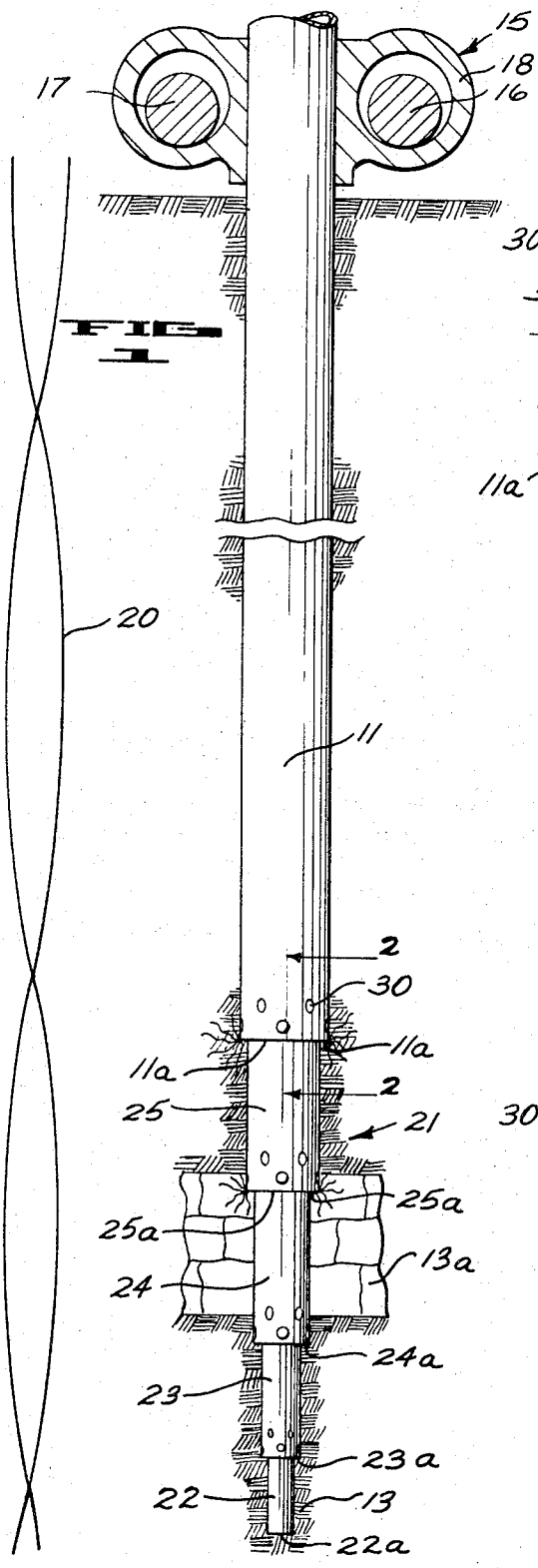


FIG. 1

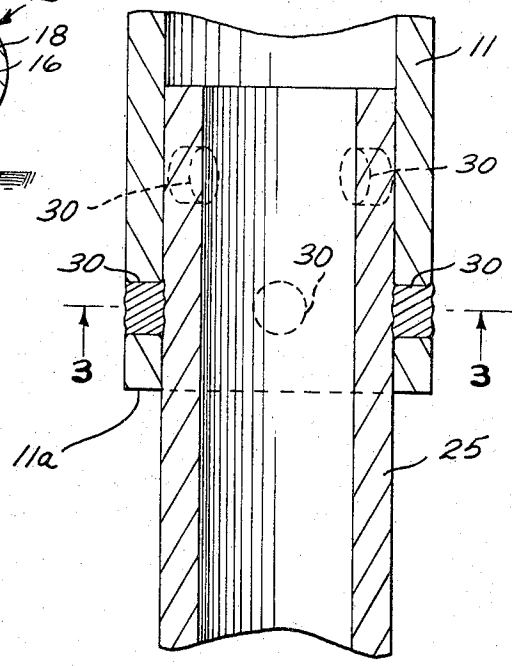


FIG. 2

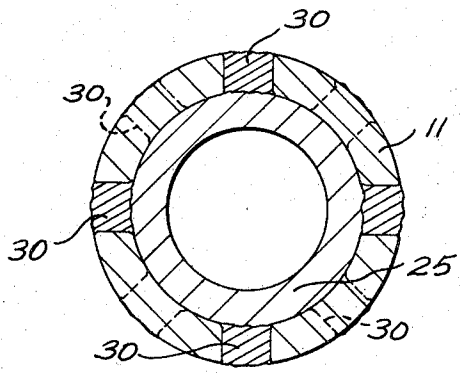


FIG. 3

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STEPPED TERMINATION FOR SONIC CASING DRIVE

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ABSTRACT OF THE DISCLOSURE

A penetration point has a plurality of increasingly wider diametered steps, such steps being spaced substantially from each other. Each such step forms a drive shoulder extending substantially perpendicularly from the longitudinal axis of the penetration point and cooperates in the driving of the point through an earthen formation, with each shoulder operating to make a pilot hole for the next succeeding shoulder.

This invention relates to a tapering stepped termination for a sonic casing drive, and more particularly to such a device for facilitating the driving of a casing through earthen formations.

Casing members can be efficiently driven through earthen formations by applying acoustical energy thereto as described, for example, in my Patent No. 2,975,846. In driving at great depths, it is often difficult to obtain a straight, non-deviated hole. Further, where hard earthen formations are encountered, penetration oftentimes becomes quite difficult. The device of this invention provides means for overcoming the aforementioned difficulties by providing a unique tapering stepped penetration tool member which is attached to the driving end of the casing. This tool member not only greatly eases the penetration of earthen formations but also facilitates the driving of a straight hole.

The device of this invention comprises a penetration point having a plurality of drive members of different diameters. Such drive members are arranged in a generally tapered configuration with the smallest diametered member at the tip of the penetration point, with successively larger diametered members following in the order of their sizes. The penetration point thus formed has a plurality of increasingly wider diametered steps, with the end of each driving member forming a shoulder extending substantially perpendicularly from the longitudinal axis of the penetration point. The shoulders thus all cooperate in the driving operation with each driving member making a pilot hole for the next succeeding member.

It is therefore an object of this invention to provide means for facilitating the sonic driving of casing members.

It is a further object of this invention to facilitate the sonic driving of a straight non-deviated hole.

It is still another object of this invention to ease the penetration of a sonically driven casing member.

It is still another object of this invention to provide means for averaging the effective impedance of a sonic drive system to facilitate the maintenance of the resonant vibration thereof.

Other objects of this invention will become apparent from the following description taken in connection with the accompanying drawings, of which—

FIG. 1 is an elevation view of a preferred embodiment of the device of the invention,

FIG. 2 is a cross sectional view taken along the plane indicated by 2—2 in FIG. 1, and

FIG. 3 is a cross sectional view taken along the plane indicated by 3—3 in FIG. 2.

To facilitate the comprehension of the problem involved and the techniques utilized in the device of the invention to overcome same, it is helpful to analogize the acoustically vibrating circuit used to an equivalent electrical circuit. This type of analogy is well known to those skilled in the art and is described, for example, in chapter 2 of Sonics by Hueter and Bolt, published in 1955 by John Wiley and Sons. In such an analogy, force F is equated with electrical voltage E; velocity of vibration u is equated with electrical current i; mechanical compliance C_m, is equated with electrical capactance C_m; mass M is equated with electrical inductance L; mechanical resistance (friction) R_m is equated with electrical resistance R; and mechanical impedance Z_m is equated with electrical impedance Z_e. Thus, it can be shown that if a member is elastically vibrated by means of an acoustical sine-soidal force, $F_0 \sin \omega t$, ω being equal to 2π times the frequency of vibration, that

$$Z_m = R_m + j\left(\omega M - \frac{1}{\omega C_m}\right) = \frac{F_0 \sin \omega t}{u} \quad (1)$$

Where ωM is equal to $1/\omega C_m$, a resonant condition exits, and the effective mechanical impedance Z_m is equal to the mechanical resistance R_m, reactive impedance components ωM and $1/\omega C_m$ cancelling each other out. Under such a resonant condition, velocity of vibration u is at a maximum, effective power factor is unity, and energy is most efficiently delivered to a load to which the resonant system may be coupled. The device of this invention is helpful in maintaining such an efficient resonant condition throughout the driving operation by lessening the variations in overall impedance presented to the vibrating system.

Just as in electrical circuitry, maximum acoustical energy can be transferred from one circuit element to another where a good impedance match exists, i.e., where the two elements have like impedances. This fact becomes particularly significant in the apparatus of the instant invention where energy transfer from the penetrating stepped driving member to the earthen formation is necessary to cause the disintegration of such formation in effecting the driving operation. By observation of Equation 1 it can be seen that the impedance Z_m is high where the force F_0 is high, and velocity of vibration u is relatively low. Thus, in view of the high impedance characteristics of most earthen formations, it is desirable that the driving shoulders exhibit high impedance characteristics, i.e., high force conditions exist thereat.

Also of significance in the instant invention is the attainment of high acoustical Q in the driven member to markedly increase the efficiency of the vibration thereof and to provide a maximum amount of cyclic energy for the driving operation. As for the equivalent electrical circuit, the Q of an acoustically vibrating circuit is defined as the sharpness of resonance thereof and is indicative of the ratio of the energy stored in each vibration cycle to

the energy used in each cycle. Q is mathematically equated to the ratio between ωM and ωR_m. Thus, the effective Q of the acoustically vibrating circuit can be maximized to make for highly efficient high amplitude vibration by minimizing the effective friction in the vibrating circuit, and/or maximizing the effective mass in such circuit. The device of this invention operates to minimize such friction to make for a higher Q.

In considering Equation 1 it should be kept in mind that this equation represents the total effective resistance, mass, and compliance in the acoustically vibrating circuit, and that these parameters are generally distributed throughout the system rather than being lumped in any one component or portion thereof.

Referring now to the figures, a preferred embodiment of the device of the invention is shown. Casing member **11** is driven into earthen formation **13** by means of sonic energy applied thereto from orbiting mass oscillator **15**. Oscillator **15** may be of the type described in my co-pending application 454,335, filed May 10, 1965. Oscillator **15** includes a pair of oppositely oriented rotor members **16** and **17** retained for rotation in raceways formed in housing **18**. Rotors **16** and **17** may be pneumatically driven in opposite directions, and are phased with respect to each other to produce high amplitude vibration at sonic frequencies along axes parallel to the longitudinal axis of casing **11**. The phasal relationship between rotors **16** and **17** is such that all lateral vibrational components are cancelled out.

Housing **18** is tightly clamped to the outer wall of casing **11** so that the longitudinal vibration generated by the oscillator is transferred to the casing. The frequency of rotation of rotors **16** and **17** is made such as to set up longitudinal resonant vibration of casing **11** whereby standing waves **20** appear therealong. Orbiting mass oscillator **15** tends to compensate for small changes in the impedance of the vibrating system to maintain the resonant vibration thereof with such variations.

Attached to the driving end of casing **11** is stepped penetration point **21**, which comprises concentric drive members **22–25**. Drive members **22–25** may be in the form of cylindrical pipe sections having increasingly larger diameters as we proceed from the tip of the point to the top end thereof, the point thus having an overall tapered configuration. Each drive member **22–25** has a respective driving shoulder portion **22***a*–**25***a*. The end portion **11***a* of casing **11** also forms a driving shoulder. Drive members **22–25** are telescopically fitted into each other, with member **25** being so fitted into casing **11**. The members are then plug welded together as indicated in FIGS. 2 and 3, by means of welding joints **30**.

It is to be noted that the shoulder portions **22***a*–**25***a* and **11***a* run substantially perpendicularly from the longitudinal axis of casing **11** and thus provide sharp driving surfaces. It is also to be noted that driving member **22** is solid rather than being hollow in configuration as are the other driving members.

Each drive member **22–25** makes a pilot hole for the succeedingly larger diametered drive member, and this tends to guide the driving in a straight line. Shoulder portions **23***a*–**25***a* and **11***a* produce lateral force vectors in the earthen material **13**, this tending to implode such earthen material, thereby greatly facilitating the driving action. Further, by utilizing a plurality of driving shoulders distributed longitudinally over the penetration point **21**, the overall impedance encountered by the driving point is averaged out through the driving operation. Thus, for example as shown in FIG. 1, shoulder portion **25***a* may be driving through a rock formation **13***a* while the remaining shoulder portions are driving through sand. Under such conditions, the very high impedance loads being experienced by shoulder portion **25***a* are averaged out by the lower impedance load being experienced by the other driving portions, so that the overall impedance is much lower than if the entire driving operation were to be involved in driving through the rock formation **13***a* at any one time as would be the case in the driving members utilized in the devices of the prior art. This impedance averaging tends to eliminate wide impedance variations in the vibrating system and thus facilitates the maintenance of resonant operation which, as already indicated, makes for most efficient operation.

Impedanc averaging can be optimized by making penetration point **21** such that the distance between shoulders **11***a* and **22***a* are less than a wavelength long at the vibrating frequency. This assures that all of the impedances are experienced by the tool in phase. In a typical operating embodiment of the device of the invention, excellent results have been achieved with a vibration frequency of 200–800 cycles per second with the casing **11** having an outside diameter of 9 inches, and the distances between shoulders **11***a* and **25***a* and shoulders **25***a* and **24***a* of 16 inches each, the distance between shoulder **24***a* and shoulder **23***a* being 12 inches, and the distance between shoulders **23***a* and **22***a* being 8 inches.

The device of this invention thus provides simple yet highly effective means for improving the efficiency of a sonic casing drive. The device of this invention enhances the driving operation by making for easier and straighter penetration. In addition, it facilitates the maintenance of a highly efficient resonant condition in the vibrating system, by minimizing impedance variations during the driving operation.

While the device of this invention has been described and illustrated in detail, it is to be clearly understood that this is intended by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of this invention being limited only by the terms of the following claims.

I claim:

1. A device for driving a casing into an earthen formation comprising

a sonic vibrational source attached to said casing for applying sonic energy thereto to cause longitudinal vibration thereof, and

a stepped penetration point attached to said casing at the driving end thereof for facilitating the penetration of said casing into said earthen formation,

said penetration point comprising a plurality of driving shoulders forming progressively wider diametered steps from the tip of said point to the casing attached end thereof, said shoulders being spaced substantially from each other, the distance between the uppermost and lowermost of said shoulders being less than one wave length of said sonic energy in said device,

whereby said driving shoulders facilitate the penetration of said formation and average out the effective impedance presented to said vibrating system.

2. The device as recited in claim **1** wherein said driving shoulders each comprise the end of a cylindrical member and run substantially perpendicularly from the longitudinal axis of the casing to provide sharp driving surfaces.

3. The device as recited in claim **2** wherein said cylindrical members are telescopically fitted together.

4. A device for driving a casing into an earthen formation comprising:

a sonic vibrational source attached to said casing for applying sonic energy thereto to cause longitudinal vibration thereof, and

a stepped penetration point attached to said casing at the driving end thereof for facilitating the penetration of said casing into said earthen formation,

said penetration point comprising a plurality of drive members having different diameters joined together in telescopic relationship, the drive member having the largest diameter being telescopically fitted into

said casing and attached thereto, the ends of each of said members into which a succeeding member is telescopically fitted forming sharp shoulders running substantially perpendicularly to the longitudinal axis of said casing, said shoulders forming progressively greater diametered steps running from the tip of said penetrating point to the casing attached end thereof, the drive member at the tip of said penetrating point being solid and the remaining drive members being hollow in configuration,

whereby said shoulders facilitate the penetration of said formation and average out the effective impedance presented to said vibrating system.

5. The device as recited in claim 4 wherein said drive members are joined together by plug welds.

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