United States Patent [19]

Perkins

[11] **3,834,472**

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[54] **JARRING ACCELERATOR**

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[52] **U.S. Cl.** **175/321,** 175/296, 267/125

[51] **Int. Cl.** **E21b 17/00**

[58] **Field of Search** 267/125, 137; 166/178; 175/296, 306, 321

[56] **References Cited**

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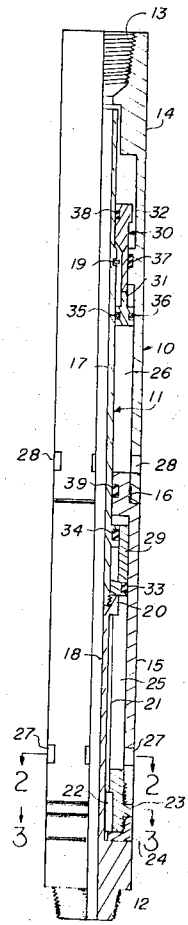
Primary Examiner—David H. Brown

Attorney, Agent, or Firm—Torres & Berryhill

[57] **ABSTRACT**

Accelerator apparatus for use with a jar in a drill string comprising: a cylindrical housing; a tubular mandrel disposed within the housing for axial movement between a fully retracted position and a fully extended position relative thereto; connection threads on the housing and mandrel for connecting the apparatus in a drill string above a jar; at least one annular chamber formed between the housing and mandrel; ports providing fluid communication between the chamber and a substantially constant pressure fluid source, and an annular surface carried on the mandrel within the annular chamber for transmitting forces from fluid within the chamber to the mandrel, tending to force the mandrel toward its retracted position. At least one other annular surface may be carried on a sleeve member mounted in the chamber independently of the mandrel but engagable by a portion of the mandrel on a predetermined amount of movement from its fully retracted position toward the fully extending position to cumulatively assist the first annular surface in transmitting forces from the fluid to the mandrel.

18 Claims, 7 Drawing Figures



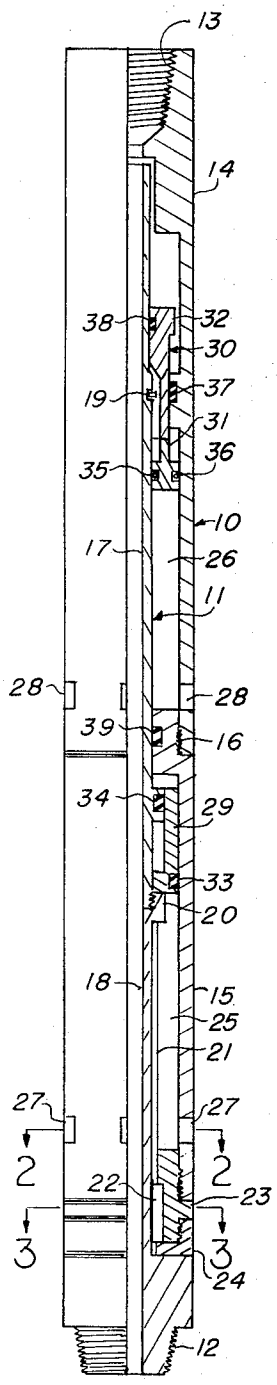


FIG. 1

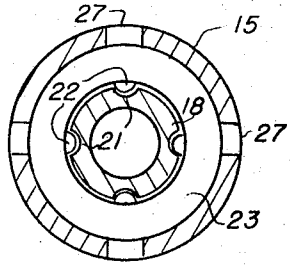


FIG. 2

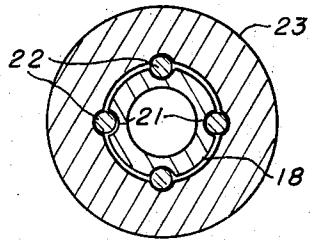


FIG. 3

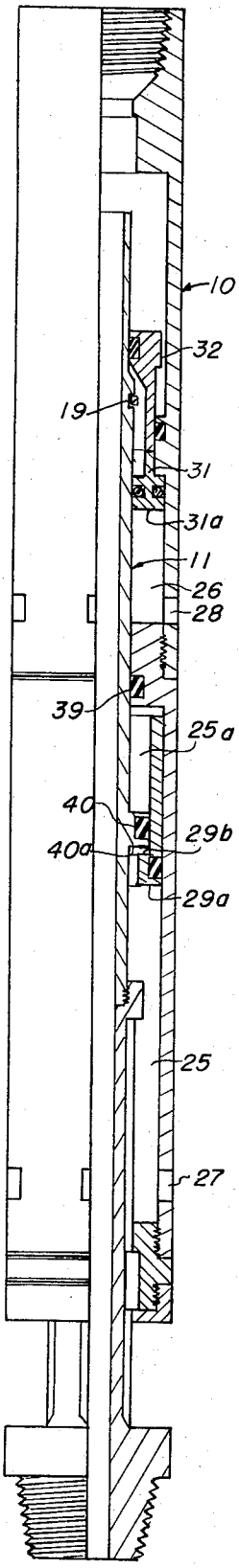

10
32
19
31
31a
11
26
28
39
25a
40
29b
40a
29a
25
27

FIG. 4

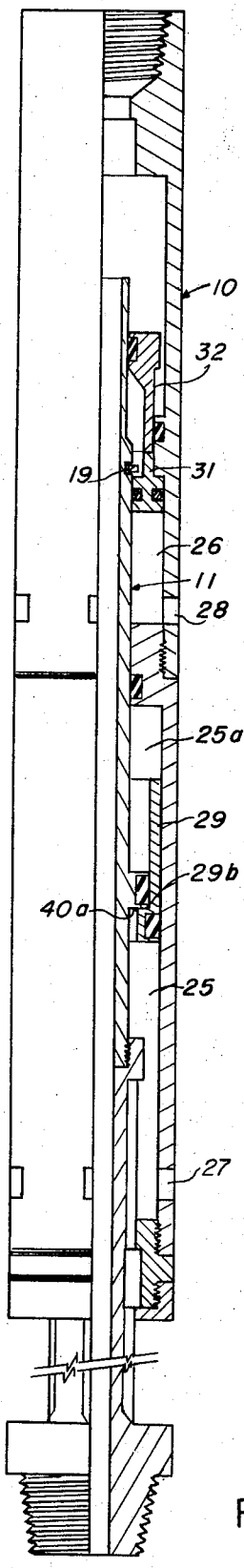

10
32
19
31
26
11
28
25a
29
29b
40a
25
27

FIG. 5

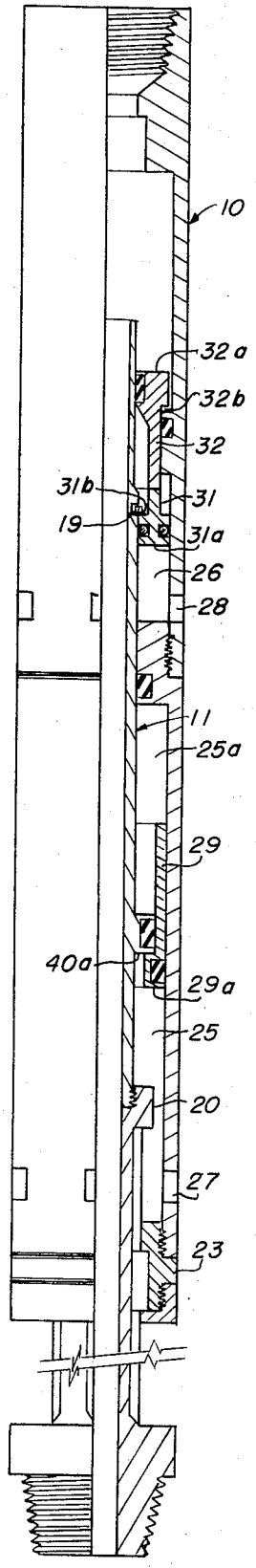

10
32a
32b
32
31b
31
19
31a
26
28
11
25a
29
40a
29a
25
20
27
23

FIG. 6

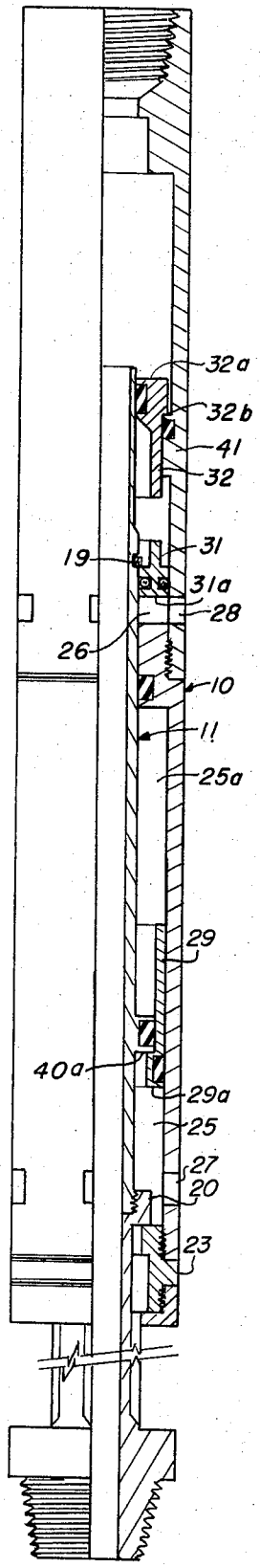

32a
32b
41
32
31
19
31a
28
26
10
11
25a
29
40a
29a
25
27
20
23

FIG. 7

JARRING ACCELERATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to oil and/or gas well apparatus designed to impart high impact blows to well tools or other objects lodged in the well bore for the purpose of removing them. In particular, the invention concerns apparatus for use with conventional jar devices so as to supplement or increase the effectiveness of force normally imparted by the jar.

2. Brief Description of the Prior Art

In the drilling and production of oil and gas wells, tools or other objects occasionally become stuck in the well bore. It is then necessary to perform a fishing operation to remove the lodged item. A line of tools referred to as "jars" has been developed to aid in such recovery. Usually the string of tools for removing such an item comprises, from the bottom upwardly: a spear or overshot, a bumper jar, a mechanical or hydraulic jarring mechanism, drill collars and the supporting pipe string.

Usually, the first step in removal is to engage the lodge item with either the spear or overshot. After this is accomplished, tension is placed on the lodged item through the pipe string. The pull or tension on the pipe string causes the string to be elongated. The jarring mechanism is usually designed to allow tension to be placed on the string until a certain amount of tension is reached. At this time the jarring mechanism is released and allows the elongated pipe to contract rapidly for a short distance, at which time it is suddenly stopped by the jar mechanism. The sudden halting of contraction by the jar imparts a high intensity blow against the lodged item and, it is hoped, causes the item to be unlodged for removal. The additional mass of the drill collars helps intensify the blow.

One of the problems associated with conventional jars is their inability to impart a sufficient blow in shallow or crooked well holes. A shallow hole does not allow for sufficient pipe stretch to obtain the necessary jarring blow. The pipe string in a crooked hole, or one drilled at an angle to the vertical, may also be prevented from full stretching and may absorb some of the jarring effect due to friction between the pipe string and the wellbore. Thus, the effectiveness of conventional jarring tools may be substantially reduced in a shallow or crooked wellbore. Furthermore, even in straight holes and those with sufficient depth to fully stretch the pipe, the conventional jarring device may not deliver enough force to dislodge the stuck "fish".

In the past few years, accelerator apparatus has been developed for solving some of the problems associated with conventional jars. These devices are connected in the drill string above a conventional jar and the drill collars located just above the jar. The accelerator accumulates tensile energy on the upstroke of the jar rather than distributing the tensile energy through the full length of the pipe string. When the jar trips, the sudden release of energy accumulated in the accelerator causes the drill collars to accelerate upward at an increased speed. When the jar reaches its maximum free travel, a much increased impact blow is delivered directly to the fish and independently of the drill string. In addition such accelerator devices serve to isolate the jarring impact so that it is not transmitted to equipment at the surface. Such accelerator devices may be seen in the following U.S. Patents: U.S. Pat. Nos. 2,295,352; 3,472,326; 3,570,612; and 3,606,297.

Although the accelerator devices of the prior art are effective, they are not without some problems. For example, one of such devices, which is filled with an inert gas, has the problem of maintaining the gas under high and intense pressure, requiring very expensive seals. All of the accelerators of the prior art known to the applicant function by compressing fluids or springs within a chamber of the device during the upstroke of the jar. When the jar is tripped the compressed fluids or springs cause the drill collar mass to be accelerated. However, as the fluids or springs expand, during the free travel of the jarring tool, the force accelerating the mass is reduced, reducing the effectiveness of the accelerator device as the jar hammer approaches the jar anvil for impact.

SUMMARY OF THE INVENTION

The present invention pertains to accelerator apparatus for use with a jar in a drill string and is designed to overcome some of the problems associated with prior accelerator devices. The apparatus may comprise: a cylindrical housing; a tubular mandrel disposed within the housing for axial movement between a fully retracted position and a fully extended position; connecting threads on the housing and mandrel for connecting the apparatus in a drill string; at least one annular chamber formed between the housing and mandrel; ports providing fluid communication between the annular chamber and a substantially constant pressure fluid source and at least one annular surface within the chamber for transmitting forces from fluid within the chamber to the mandrel tending to force the mandrel toward the retracted position.

Since these annular surfaces are subjected to the pressure within the chamber, which is the same as pressure of the constant pressure fluid source (e.g., the hydrostatic head of the drilling fluid within the well), the force exerted against the mandrel through any one of these annular surfaces is constant throughout the travel of the mandrel. When the jar is tripped, a constant accelerating force is applied to the mandrel and the drilling collars connected therebelow. Thus the apparatus of the present invention may utilize the hydrostatic head in the wellbore, or any other constant pressure fluid source, to maintain a constant accelerating force during the free travel of the jar with which it is used. Unlike the accelerators of the prior art, the present accelerator does not have declining pressures or forces.

It is therefore an object of the present invention to provide an accelerating device which maintains a constant accelerating force throughout the entire free travel of the jar. Another object of the present invention is to provide an accelerating device which is capable of a great deal of flexibility due to a plurality of annular surfaces which may be utilized therein. In other words, additional annular surfaces may be brought into play, to cumulatively assist the first annular surface, merely by extending the mandrel by additional predetermined axial movements. Furthermore, the apparatus of the present invention is simple to manufacture, operate and maintain. No expensive high pressure seals are required. Other objects and advantages of the inven-

tion will be apparent from the description which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following description, reference will be made to the accompanying drawings in which:

FIG. **1** is a quarter-sectional elevation view of an accelerator device for use with a well jar, according to a preferred embodiment of the invention;

FIG. **2**, taken along line **2—2** of FIG. **1**, is a horizontal cross-sectional view of the accelerator device;

FIG. **3**, taken along line **3—3** of FIG. **1**, is another horizontal cross-sectional view of the accelerator device;

FIG. **4** is a quarter-sectional elevation view of the accelerator device of FIGS. **1–3**, shown in a first extended position;

FIG. **5** is a quarter-sectional elevation view of the accelerator device of FIG. **4**, shown in a second or more extended position;

FIG. **6** is a quarter-sectional elevation view of the accelerator device of FIGS. **4** and **5**, shown in a third or still more extended position; and

FIG. **7** is a quarter-sectional elevation view of the accelerator device of FIGS. **4–6**, shown in a fourth or fully extended position.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring first to FIGS. **1–3**, the accelerator device of the present invention comprises a cylindrical housing **10** and a tubular mandrel **11** disposed therein for limited axial relative thereto. The housing and mandrel may be provided with threaded pin and box connections **12** and **13**, respectively, for connection in a drill or handling string. Normally a fishing tool (not shown) would be connected to the lower end of the string and a conventional jar (not shown) would be connected above the fishing tool. A plurality of drill collars (not shown) would be connected between the jar and the accelerating device. The remainder of the string would comprise a plurality of pipe joints extending from the accelerating device to the surface of the well (not shown) allowing tension to be placed on the jar and the accelerating device by pulling upwardly on the string.

The housing in the preferred embodiment shown may comprise an upper section **14** in which the threaded box **13** is provided and a lower section **15** threadedly connected at **16.** The mandrel **11** in the preferred embodiment may comprise an upper section **17** threadedly connected to a lower section **18.** The upper section **17** of the mandrel may be provided with an annular stop ring or shoulder **19**, the purpose of which will be more fully understood hereafter. The lower section **18** of the mandrel may also be provided with an annular stop shoulder **20**, the purpose of which will be explained hereafter.

The lower section **18** of the mandrel may also be provided with longitudinal spline grooves **21** adapted to slidingly receive corresponding spline pins **22** carried by the housing **10.** The spline pins **22** may be mounted in longitudinal semicircular grooves provided therefore in a spline mounting **23** which may be threadedly connected to the lower end of lower housing section **15.** A retainer ring **24** may be threadedly connected to the adaptor to allow assembly and replacement of spline pins **22.** The cooperating female and male spline elements **21** and **22** allow axial movement of the mandrel **11** relative to the housing **10** but prevent relative rotation therebetween. Thus, the accelerator device may be extended and retracted while still providing a means by which torque can be transmitted from the handling string thereabove to the fish or any other tool therebelow.

One or more annular chambers **25** and **26** are formed between the housing **10** and mandrel **11.** In the exemplary embodiment, these chambers **25, 26** are in fluid communication with the exterior of the housing **10** by means of fluid ports **27** and **28.** In other embodiments, the ports could be in the walls of mandrel section **18,** providing communication with the tubing string to which the accelerator device would be connected. In either case the ports **27** and **28** would provide fluid communication with a substantially constant pressure fluid source.

A first sleeve member **29** is slidingly disposed in one of the annular chambers **25.** A sleeve assembly **30,** comprising second and third sleeve members **31** and **32,** may be slidingly disposed within the upper chamber **26.** Annular seal members **33, 34, 35, 36, 37** and **38** are provided between the sleeves and the housing **10** or the mandrel **11** which the respective sleeve engages. An annular seal **39** is also provided between the housing **10** and mandrel **11** to isolate the respective chambers **25** and **26.**

Referring also now to FIG. **4**, the operation of the accelerator device will be more fully described. In the fully retracted position of FIG. **1** and the first, or slightly extended, position of FIG. **4** and upward force is exerted against the mandrel **11** through a downwardly facing annular surface **40***a* on an annular shoulder **40** affixed to mandrel **11.** The force applied to the mandrel **11** at any position of travel between the fully retracted position and the first extended position shown in FIG. **4** is equal to the pressure within chamber **25** times the area of annular surface **40***a*. The pressure in chamber **25** is, of course, equal to the hydrostatic head of the drilling fluid or mud in the wellbore surrounding the exterior of housing **10.** Thus, the upwardly directed force on mandrel **11** is constant for a predetermined amount of relative axial movement between housing **10** and mandrel **11** caused by applying an upwardly directed force at the surface of the well through the pipe string. This movement is slightly greater than the free travel of the jarring device with which the accelerator is used. Should the tension placed on the string be sufficient to trip the jar at this time, the drill collars below the accelerator device would be accelerated upwardly by a constant force throughout the free travel of the jar, the force being equal to the hydrostatic head surrounding the accelerator device times the annular area **40***a*. Up to this point none of the annular surfaces of sleeve members **29, 31** and **32** have any effect on the mandrel. This is due to the fact that the sleeve members **29** and **31** are not yet in a position to transmit forces through their annular surfaces **29***a* and **31***a*, respectively, to the mandrel. In the positions of FIGS. **1** and **4** these forces are transmitted to the housing **10** and have no effect on the mandrel **11.**

Should the force required for extending the mandrel **11** to the position of FIG. **4** not be great enough to trip the jar, additional tension would be placed on the drill

string. After only slight movement from the position of FIG. 4, the annular surface 40*a* would engage an opposing annular surface 29*b* on the first sleeve member 29 causing the sleeve 29 to be moved therewith, as shown in FIG. 5. At this point the annular surface 29*a* would cumulatively assist the annular surface 40*a* in transmitting forces from the fluid within chamber 25 to the mandrel 11. The force exerted through the two annular surfaces 40*a* and 29*a* would be equal to the cross sectional area of chamber 25 times the pressure therein. The pressure in the isolated portion 25*a* of chamber 25 would be negligible. Thus, the force necessary for moving the mandrel to a further extended position would be substantially increased. If, at the end of this stage of travel a sufficient force is applied to trip the jar therebelow, the mandrel 11 would be retracted, applying a constant accelerating force to the drill collars therebelow throughout the entire free travel of the jar. Note that the sleeve member 31 still resides in its initial position, having no effect upon the force applied to the mandrel 11.

Upon slightly further extension of the mandrel 11, snap ring 19 comes into contact with an opposing annular surface 31*b* on the second sleeve member 31 causing the sleeve member 31 to be moved downwardly within chamber 26, as shown in FIG. 6. At this point a force is transmitted through annular surface 31*a* to the mandrel 11, cumulatively assisting the forces transmitted through annular surfaces 40*a* and 29*a* in chamber 25. However, a portion of this force is cancelled or negated by an opposing force transmitted through the annular surface 32*a* is in fluid communication with the interior of housing 10 and mandrel 11 and the drill string thereabove. Thus, the pressure of fluids within the drill string acting on annular surface 32*a*, partially offsets the force acting through annular surface 31*a*.

If, at the end of movement of the third stage, the jar is tripped, a constant force, equal to the cross sectional areas of chambers 25 and 26 times the hydrostatic pressure within the wellbore less the hydrostatic pressure within the wellstring times the annular surface area 32*a*, will be applied to the drill collars throughout the free travel of the jar device.

Should additional force be required to trip the jar device, the mandrel would be moved to a fully extended position, as shown in FIG. 7. After only slight movement from the position of FIG. 6, an annular surface 32*b* of upper sleeve member 32 engages annular shoulder 41 on housing 10. This prevents further downward travel of sleeve 32 and allows separation of sleeve 31 therefrom. Once sleeve 31 and 32 have been separated, the opposing or cancelling force transmitted through annular area 32*a* is removed. Therefore, the entire force applied through annular surface 31*a* is transmitted to the mandrel 11. At this point, the force transmitted to the mandrel is equal to the cross-sectional areas of chambers 25 and 26 multiplied by the pressure therein (the hydrostatic head within the wellbore). If the jar device has not been tripped prior to this stage it can be tripped by placing additional tension on the drill string and the jar through the accelerator device since shoulder 20 has come to rest against spline pin mount 23. When the jar is tripped, drill collars will be accelerated upwardly with a constant force throughout the entire free travel of the jar.

The exemplary embodiment has been described for operation utilizing the hydrostatic head since this is the simplest and most logical application. It should be understood that the pressure in the wellbore could be increased, by various means, above the hydrostatic head, if so desired. Furthermore, as previously stated, the ports 28 and 29 could be placed in the mandrel, providing fluid communication with the tubing string. In any of these cases, the chambers would be communicating with a substantially constant pressure fluid source.

Thus, the accelerator device of the present invention offers a means by which a constant accelerating force may be applied to the drill collars of a fishing string throughout the entire free travel of the jar. It is not limited by a decreasing pressure in its annular chambers, since the pressure is equal to the substantially constant pressure fluid source with which it is in communication. Furthermore, the accelerator device of the present invention is provided with a plurality of annular surfaces for cumulatively assisting each other in transmitting forces from the constant pressure fluid source to the mandrel upon predetermined axial movement of the tubular mandrel from a fully retracted position toward a fully extending position. In other words, the effective area and resultant force applied to the mandrel may be varied dependent upon the axial position of the mandrel relative to the housing. Such a device is much more efficient and flexible than the accelerator devices of the prior art.

Although the preferred embodiment of the invention described herein has been described as having two annular chambers and three sleeve members, it should be understood that the invention is not so limited. Any number of chambers and sleeves can be provided depending upon the forces and flexibility desired. Various other changes in the size, shape, and materials of the assembly, as well as in the details of construction, may be made without departing from the spirit of the invention. In fact many variations of the invention will be obvious to those skilled in the art and the scope of the invention is intended to be limited only by the claims which follow.

I claim:

1. Accelerator apparatus for use with a jar in a drill string comprising:

a. a cylindrical housing;

b. a tubular mandrel disposed within said housing for axial movement between a fully retracted position and a fully extended position relative thereto;

c. connection means on said housing and mandrel for connecting said apparatus in said drill string above said jar;

d. annular chamber means formed between said housing and said mandrel;

e. port means providing fluid communication between said chamber means and a substantially constant pressure fluid source; and

f. annular surface means within said chamber means for transmitting forces from fluid within said chamber means to said mandrel tending to force said mandrel toward said retracted position, the effective area of said annular surface means being variable depending on the axial position of said mandrel relative to said housing.

2. Accelerator apparatus as set forth in claim 1 in which said annular surface means comprises a plurality of annular surfaces cumulatively assisting each other in transmitting forces from said fluid to said mandrel upon predetermined axial movement of said tubular mandrel

from said fully retracted position toward said fully extended position.

3. Accelerator apparatus as set forth in claim 2 in which each of said predetermined axial movements is greater than the free travel of said jar.

4. Accelerator apparatus as set forth in claim 2 in which said annular surface means comprises a first annular surface affixed to said mandrel and a second annular surface carried on sleeve means, said sleeve means being mounted in said chamber means independently of said mandrel and engagable by a portion of said mandrel on a predetermined amount of movement from said fully retracted position toward said fully extended position to increase the effective area of said annular surface means for transmitting said forces to said mandrel.

5. Accelerator apparatus as set forth in claim 4 comprising first seal means between said sleeve means and said housing and second seal means between said sleeve means and said mandrel, providing sliding sealing engagement between said sleeve means and said housing and said mandrel, respectively.

6. Accelerator apparatus as set forth in claim 5 in which said sleeve means comprises a tubular skirt portion connected to an enlarged head portion by an annular shoulder, said annular shoulder being engagable by said portion of said mandrel on said predetermined amount of movement.

7. Accelerator apparatus as set forth in claim 6 in which said head portion comprises said second annular surface, the end of said skirt portion being isolated from the pressure communicated to said chamber means through said port means.

8. Accelerator apparatus as set forth in claim 4 in which said annular surface means comprises a third annular surface carried on second sleeve means, said second sleeve means being mounted in said chamber means independently of said mandrel and engagable by another portion of said mandrel on a further predetermined amount of movement toward said fully extended position to further increase the effective area of said annular surface means for transmitting said forces to said mandrel.

9. Accelerator apparatus as set forth in claim 8 comprising seal means between said second sleeve means and said housing and between said second sleeve means and said mandrel, providing sliding sealing engagement between said second sleeve means and said housing and said mandrel, respectively.

10. Accelerator apparatus as set forth in claim 8 in which said second sleeve means comprises first and second sleeve members having mutually engagable tubular skirt portions connected to enlarged head portions, said third annular surface being carried on said first sleeve member head portion, the head portion of said second sleeve member comprising a forth annular surface in fluid communication with the interior of said mandrel and transmitting forces from fluid within said mandrel tending to cancel a portion of the force transmitted to said mandrel by said third annular surface.

11. Accelerator apparatus as set forth in claim 10 in which said second sleeve member is provided with shoulder means engagable with said housing on still a further predetermined amount of movement toward said fully extended position to separate said first and second sleeve members to still further increase the effective area of said annular surface means for transmitting said forces to said mandrel.

12. Accelerator apparatus for use with a jar in a drill string comprising:

a. a cylindrical housing;

b. a tubular mandrel disposed with said housing for axial movement between a fully retracted position and a fully extended position relative thereto;

c. connection means on said housing and mandrel for connecting said apparatus in a drill string above said jar;

d. an annular chamber formed between said housing and said mandrel;

e. port means in said housing providing fluid communication between said chamber and a substantially constant pressure fluid source;

f. a first annular surface carried by said mandrel within said chamber for transmitting forces from fluid within said chamber to said mandrel in a direction tending to move said mandrel toward said retracted position; and

g. a sleeve member mounted in said chamber for sliding sealing engagement therewith and having a second annular surface thereon, said sleeve member being adapted for engagement with a portion of said mandrel, upon predetermined axial movement toward said fully extended position, to cumulatively assist said first mentioned annular surface in transmitting forces from said fluid within said chamber to said mandrel.

13. Accelerator apparatus as set forth in claim 12 in which said predetermined axial movement is greater than the free travel of said jar.

14. Accelerator apparatus as set forth in claim 12 comprising male and female spline members carried by said housing and mandrel, permitting relative axial movement but preventing relative rotation therebetween.

15. Accelerator apparatus for use with a jar in a drill string comprising:

a. a cylindrical housing;

b. a tubular mandrel disposed within said housing for axial movement between a fully retracted position and a fully extended position relative thereto;

c. connection means on said housing and mandrel for connecting said apparatus in a drill string above said jar;

d. a first chamber formed between said housing and said mandrel;

e. first port means in said housing providing fluid communication between said chamber and a substantially constant pressure fluid source;

f. an annular surface carried by said mandrel within said first chamber for transmitting forces from fluid within said first chamber to said mandrel in a direction tending to move said mandrel toward said retracted position;

g. a second annular chamber formed between said housing and said mandrel and axially spaced from said first chamber;

h. second port means providing fluid communication between said second chamber and said substantially constant pressure fluid source; and

i. surface means within said second chamber for transmitting forces from fluid within said second chamber to said mandrel cumulatively assisting the

forces transmitted through said mandrel annular surface.

16. Accelerator apparatus as set forth in claim **15** in which said surface means comprises a sleeve member in sliding and sealing engagement with said second chamber and having an annular surface thereon exposed to the pressure within said second chamber, said sleeve member being engagable by a portion of said mandrel on a predetermined amount of movement toward said fully extended position to effect said transmission of forces to said mandrel through said sleeve member annular surface.

17. Accelerator apparatus as set forth in claim **16** comprising another sleeve member in sliding and sealing engagement with the exterior of said mandrel and the interior of said housing and having an annular surface thereon exposed to the pressure within the interior of said mandrel, said another sleeve member being engageable with said first mentioned sleeve member to cancel at least part of the forces transmitted through said first mentioned sleeve member annular surface to said mandrel.

18. Accelerator apparatus as set forth in claim **17** in which said another sleeve member is engageable with a portion of said housing on predetermined axial movement of said mandrel toward said fully extended position separating said another sleeve member from said first mentioned sleeve member and rendering said another sleeve member ineffective for said cancellation of forces.

* * * * *