United States Patent

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[73] Assignee **Mobil Oil Corporation**

[54] **WELL TUBE SCRAPING TOOL**
9 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **166/153,** 15/104.06, 166/170
[51] **Int. Cl.** **F216 33/16,** F21b 37/02
[50] **Field of Search** 166/153–156, 170, 171; 15/104.5, 104.6; 138/89; 118/DIG. 10–13

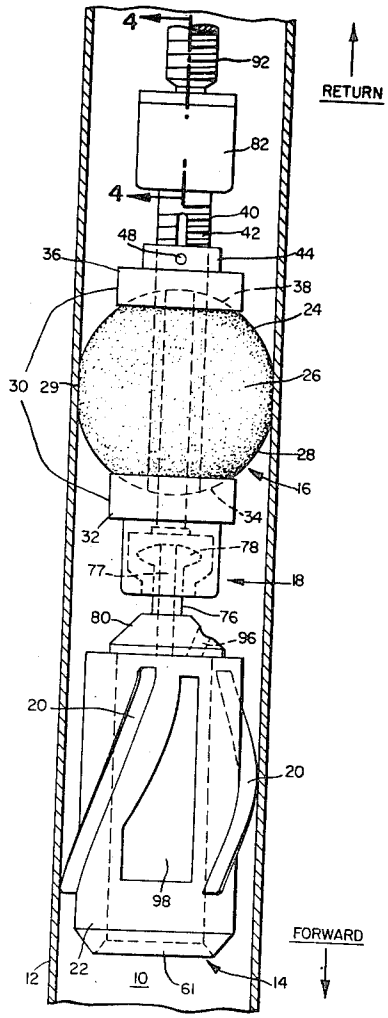
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ABSTRACT: A piston section of a TFL tool having an elastic substantially spherical sealing member is serially connected through a ball-and-socket flexible coupling to a scraper section having radially extending scraper blades. Clamping members located on opposite sides of the sealing member may be moved with respect to one another along the axis of the TFL tool to adjust the diameter of the sealing member by varying the axially compressive forces on the sealing member.



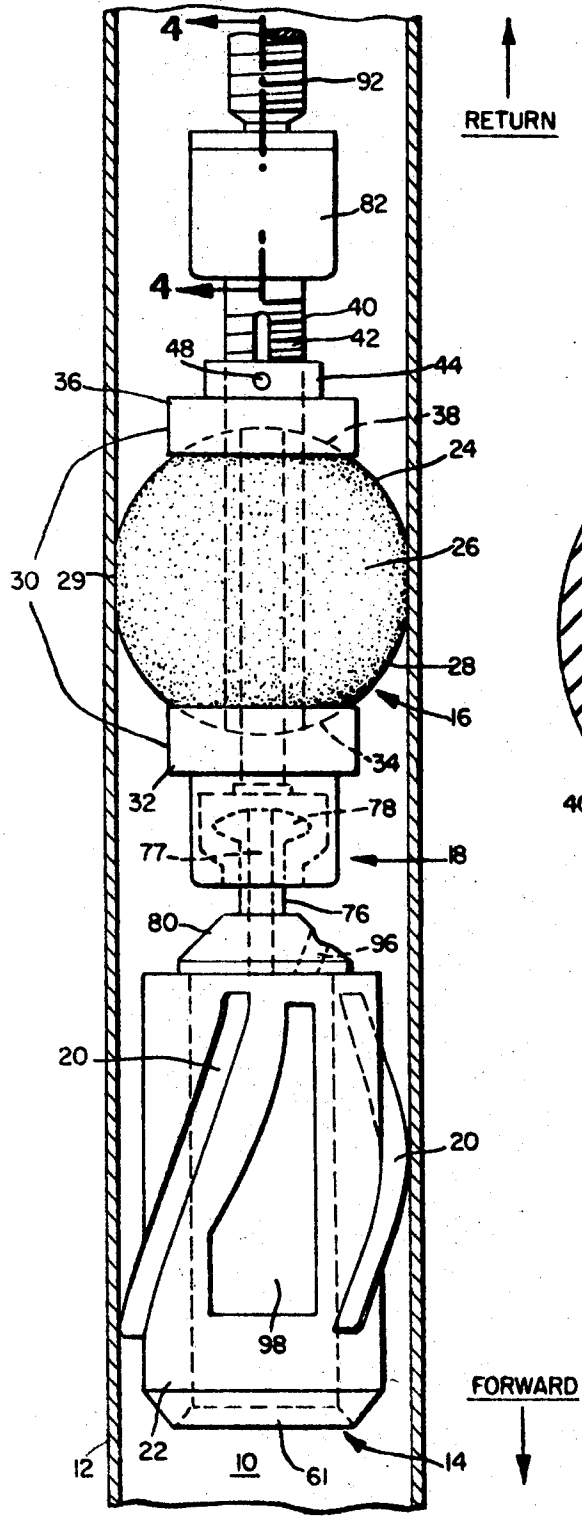

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Fig. 1

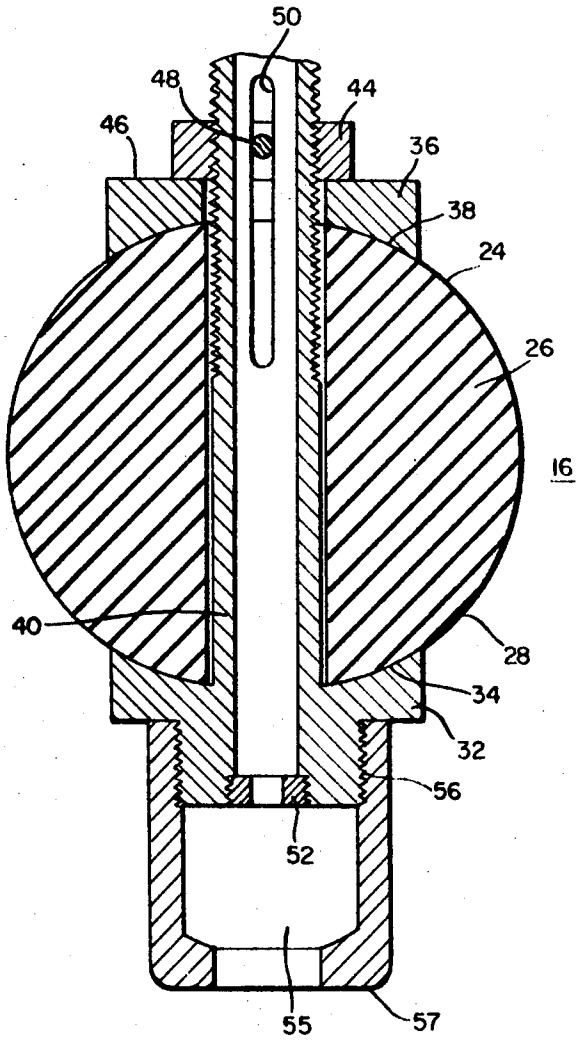

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Fig. 2

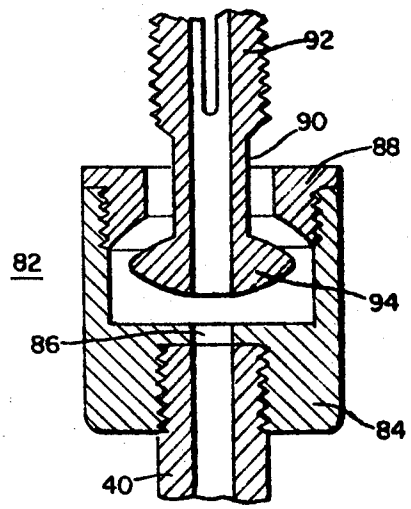


Fig. 4

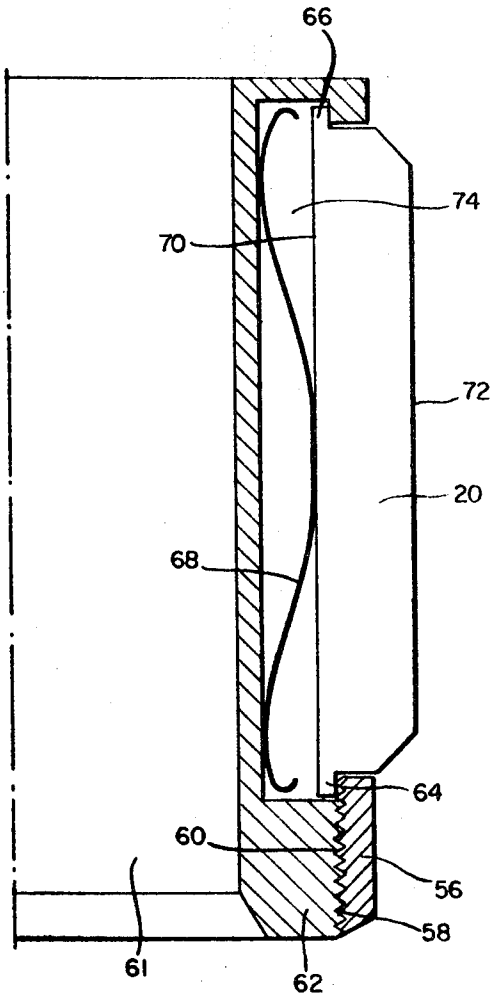


Fig. 3

WELL TUBE SCRAPING TOOL

BACKGROUND OF THE INVENTION

This invention relates to a tool for scraping deposits from the walls of well tubing.

Oftentimes, crude oil obtained from fluid mineral deposits will include long chain paraffin hydrocarbons. As this crude oil passes through tubing associated with any well which taps these fluid mineral deposits, the paraffin hydrocarbons within the crude oil will tend to solidify and plate out on the tubing of the well production string. This deposition of the paraffin hydrocarbons may ultimately close the production string when a sufficient amount of the paraffin hydrocarbons have solidified on the walls with the result that oil and/or gas production from the well will cease.

In certain instances, water injection is utilized for production assistance with wells leading to fluid mineral deposits. When water injection is utilized, tubing in the form of an injection string extends to selected depths in the well. If the temperature of the water passing through the injection string is sufficiently low, various sulfates and carbonates in the water can produce an effect very similar to that produced by the previously described paraffin. More particularly, the sulfates and carbonates once solidified by the low temperatures will tend to close the injection string.

In order to remove the accumulation of solidified paraffin, sulfates and carbonates, it has been a conventional practice in the oil and gas industry to utilize tools which may be pumped through the tubing associated with the wells which are generally known as TFL or "through flowline" tools. Generally, these TFL tools are in the form of a string comprising one or more locomotor sections in the form of a piston which is driven by the pressure applied by fluid introduced into the tubing. Such tools usually include a scraper section, and coupling means serially connecting one or more piston units and at least one scraper unit. The prior art structure of these conventional tools have significant limitations.

One limitation has been the restriction of the tools to use in well tubing having bends with a radius of curvature of approximately 5 feet or greater. The piston sections of the tools are in part responsible for this limitation, due to the axial length of the tube encountering or sealing surface. Inability of pistons to pass through bends of lesser curvature is also due to the inelastic nature of at least a portion of the encountering or sealing surface. Inability of the prior art tools as a whole to make these turns has also been due to rather inflexible coupling utilized between the piston section and the scraper section and the elongation of the scraper section.

Another limitation of the prior art tools arises out of their substantial cost. As mentioned previously, these tools include a plurality of sections which form a tool string. Each of the sections of the prior art tools has been expensive in itself, making the cost of the entire tool string, including each of these expensive sections a significant item when considering production costs for wells.

A further limitation of the prior art tools has been the necessity to utilize a separate set of tools for each tubing size. Thus, it becomes necessary to have a plurality of tool strings in order to properly service a plurality of wells having various tubing sizes. Since, as mentioned previously, the cost of a single tool string is a rather important item to be considered in the production costs, it will be readily appreciated that the necessity for a plurality of tool strings may become a very critical factor in production.

A still further limitation is related to the necessity to replace the various sections of a tool string due to wear. In this connection, it will be appreciated that a tight seal between a piston section and the tubing is necessary if the tool string is to be pumped through the tubing on the basis of fluid pressure applied at one end of the piston section. Accordingly, if the piston sections become worn at the sealing surfaces so as to permit excessive slippage of fluid around each piston, the piston section will fail as a means of locomotion for the tool

string. This will necessitate the replacement of the particular worn piston section in the tool string with the consequent expense.

Another limitation of the prior art tools is related to the sealing surface of the piston section(s). In some instances, the piston section comprises tungsten inserts which are attached to a vulcanized rubber sleeve and serve as an encountering surface on the tubing of the well. After extensive use of the piston sections, tungsten inserts come loose from the rubber sleeve, and if this happens, the tungsten inserts can become wedged between the tool and the tubing, thereby jamming the tool string in the tubing. When the sealing surface comprises rubber rings, sand may accumulate between the rings and the tubing which will result in a wedging action which may also jam the tool string.

Finally, the prior art tool strings have been relatively heavy. Consequently, a good deal of pressure is required to raise the tool string out of the tubing of a well, pressure which is not always available. Furthermore, a considerable braking capability must be provided to overcome the inertia of these heavy tool strings upon the return of those tool strings to their storage location. It will be appreciated by those skilled in the art that the energy to be dissipated may be very considerable when the tool string approached the storage facility at a high velocity.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide a tube-cleaning tool which may be utilized with well tubing having bends of relatively small radii of curvature.

It is also an object of this invention to provide a tool of reduced cost.

It is another object of this invention to provide a tool which may be utilized with a plurality of tubing diameters.

It is yet another object of this invention to provide a tool which may be adjusted to compensate for wear of the tool.

It is a further object of this invention to provide a tool which is not prone to jamming within the well tubing.

And it is a still further object of this invention to provide a tool which has a reduced weight and therefore, reduced inertia.

In accordance with these objects, the tool may comprise a piston section having an elastic tube-encountering surface which is substantially arcuate along the axis of the tool. The diameter of such a piston may be adjusted by closing or releasing clamping means at opposite ends of the piston in order to accommodate various tubing sizes and compensate for wear.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention and further advantages thereof will become apparent from the following description and the drawings, in which:

FIG. 1 is a side elevation of a portion of a TFL tool string including a scraper section and one of a plurality of locomotor or piston sections;

FIG. 2 is a vertical section of the piston section of the tool;

FIG. 3 is a partial vertical section which includes one blade of the scraper section; and

FIG. 4 is a vertical section of the flexible coupling of the tool.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, there is disclosed a portion of a TFL tool string **10** within a well tubing **12** having a scraper unit or section **14** serially connected to a piston unit or section **16** by a flexible coupling **18**. During the scraping operation of the well tubing **12**, spring-loaded scraper blades **20** which extend helically along and around the scraper body **22** will encounter and scrape away paraffin or scales on the tubing **12** as the tool string **10** is driven in the forward direction by fluid pressure from the rear.

This fluid pressure from the rear, acting upon the rearward cross section of the piston section **16**, including a hemispherical portion **24** of a spherical sealing member **26**, will provide sufficient locomotive force to move the entire tool string **10** in the forward direction for scraping paraffin on scales from the tubing **12**. Similarly, fluid pressure in the return direction acting upon the forward cross section of the piston section **16**, including a hemispherical portion **28** of the spherical sealing member **26**, will provide a return locomotive force for the tool string **10** after the paraffin or scales have been scraped from the walls of the tubing **12**. As will now be made clear, it is the rather short axial length of the tubing encountering surface **29** which is characteristic of the arcuate or spherical sealing member **26** which is particularly important in achieving certain of the objects of this invention. In addition, the elastic nature of the encountering surface **29** as provided by the spherical sealing member **26** and means for applying axially compressive forces on the sealing member **26** as provided by axially mutually movable clamping means **30**, permit other objects of this invention to be achieved.

By utilizing Hycar as a material for the sealing member **26**, sufficient elasticity will be provided to permit the adjustability of the encountering surface through a diameter ranging from 1.7 to 2.0 inches for 2 1/16 and 2 3/8 inch tubing or 2.0 to 2.5 inches for 2 3/8 and 2 7/8 inch tubing. Hycar is a trade name for various types of synthetic rubber sold by the B. F. Goodrich Chemical Company. The preferred rubber is a Hycar Nitrile rubber which is a copolymer of butadiene and acrylonitriles. This rubber has a superior resistance to oil, salt water and solvents. Other elastic materials may be utilized, as long as they are resistant to oil and salt water.

More particularly, the length of the surface **29** which encounters the tubing **12**, is short, substantially less than the diameter of the sealing member **26**, so as to permit the piston unit **16** to pass through bends in the tubing **12** having a rather small radius of curvature; i.e., 3 feet. Furthermore, this arcuate or spherical nature of the sealing member **26** will, upon the application of axially varying compressive forces exerted by the clamping means **30**, permit the diameter of the encountering surface **29** to be enlarged or reduced. Thus, the piston section **16** may be utilized in conjunction with tubing **12** having bends of differing radii of curvature and may also be adjusted to accommodate for wear along the tubing encountering surface **29**. Furthermore, by eliminating metallic inserts in the sealing member **26** and avoiding the use of rubber rings, the jamming potential of the piston section is substantially reduced or eliminated.

Referring now to FIG. **2** in explanation of the means for adjusting the outside diameter of the piston section **16**, it will be seen that the clamping means **30** comprises a forward clamp **32**, including a concave rearward face **34** which substantially conforms with the forward hemispherical portion **28** and a similar clamping member **36** having a forward concave surface **38** which substantially conforms with the rearward hemispherical portion **24**. The clamping means **30** further comprises a hollow shaft **40** which is integral with the clamping member **32** and extends axially through the sealing member **26**. In order to achieve the application of axially varying compressive forces on the sealing member **26** by the clamping member **34** and the clamping member **36**, the hollow shaft **40** is threaded over a portion **42** to permit a threaded engagement with a nut **44** at the rearward face **46** of the clamping member **36**. As the nut **44** is advanced along the threaded portion **42** toward the clamping member **32**, the nut **44** will bear upon the rearward face **46** of the clamping member **36** to apply an increased axially compressive force on the spherical sealing member **26** thereby increasing the outside diameter thereof at the encountering surface **29**. As the nut **44** is backed off on the threaded portion **42** away from the clamping member **32**, decreased compressive forces will be applied to the spherical sealing member **26**, thereby contracting the outside diameter at the encountering surface **29**. In order to maintain a particular outside diameter for the spherical sealing member **26** and thus the piston section **16**, a pin **48** is inserted through a hole in the nut **44** and extends into one or both of the diametrically opposing slots **50** which extend axially along the hollow shaft **40** so as to be substantially coextensive with the threaded portion **42**. At the forward end and central portion of the hollow shaft **40**, there is provided a removable choke **52** which permits control of the bypass fluid through the axially extending bypass passageways of the tool **10**, including the hollow shaft **40**. At the forward end and outer portion of the hollow shaft **40**, there is provided a socket member **54** of the flexible coupling **18** which threadably engages the hollow shaft **40** at a threaded portion **56**.

As will now be appreciated, the diameter of the spherical sealing member **26** and thus the piston section **16** is adjustable to permit the use of the tool string **10** with various sizes of well tubing. In order to permit the use of the scraper section **14** with various sizes of well tubing **12**, the scraper blades **20** are spring loaded and means are provided to permit the removal and interchange of springs to control the outside diameter of the scraper section **20** as shown in FIG. **3**. More particularly, the scraper body **22** having a central bypass passageway **61**, includes a cap **56** having internal threads **58** which engage thread **60** of a sleeve **62**. By removing the cap **56**, the forward shoulder **64** of each scraper blade **20** will be exposed permitting the forward end of the scraper blade **20** to be raised and moved forwardly, thereby exposing a rear shoulder **66** and permitting each scraper blade **20** to be removed. A leaf spring **68** is contained within a helical slot **74** and bears upon an inner surface **70** of the scraper blade **20**, thereby controlling the position of an outer scraping surface **72** and the diameter of the scraper section **14**. Since the leaf spring **68** may be removed, it is possible to utilize different sizes of leaf springs to achieve varying and adjustable radial protrusion of the scraper blades **20** out of the slots **74** in the scraper body **22**. Consequently, the diameter of the scraper section **14** may be made to correspond with the diameter of the piston section **16** so as to correspond with a particular well tubing size. Furthermore, the rather short axial length of the scraper section **14** in conjunction with the spring loaded blades permits the scraper section **14** to pass through tubing bends of relatively small radii of curvature.

So that the tool string may pass through bends in the tubing **12** of fairly small radii of curvature, there is provided a flexible coupling between the various units of the tool string. Each such coupling unit provides for a universal-joint action and each provides an operation similar to couplings of the ball-and-socket type. As shown in FIGS. **1** and **2**, a socket element **54** of the flexible coupling **18** has a fluid bypass passageway **55**. One end of the socket **54** has a collar **57** having an arcuate interior and the other end has threads **56** engaging the hollow shaft **40**. Before the socket **54** is secured in place, the ball element **76** of the flexible coupling is dropped into place. This element has a shank **77** with an axial opening therethrough forming bypass passageway and an enlarged head **78** with opposed arcuate surfaces. The forward arcuate surface permits angular movement between the arcuate interior of the collar **57** and the ball element **76** as the tool moves in the return direction while the renewal arcuate surface permits angular movement of the ball element **76** as the tool moves in the forward direction. The flexible coupling **82** as shown in FIG. **4** is essentially the same as the coupling **18** with several slight differences. A socket member **84** has an enlarged, threaded, counterbore into which extends another threaded end of the hollow shaft **40**. In order to retain a ball element **90** having a slotted shank **92** and an enlarged head **94**, the inner cylindrical surface of the socket **84** is threaded to receive a bushing **88** having a rearward surface which is provided with a curvature complementary to that of the curvature of the enlarged head **94**. While other types of flexible coupling means may be utilized, those shown are preferred for ease of manufacture, servicing, and cost. Where couplings of other types are utilized, they must be of the type for transmitting substantial axial forces first in one direction and then the other.

As described in the foregoing, there are means provided along the axis of the tool string **10** to permit bypass fluid to flow down to the scraper section **14**. Upon reaching the scraper section **14**, this bypass fluid flows out around the scraper blades **20** after passing through a bypass port **96** in the cap **80** and bypass openings **98** in the sleeve **62** of the scraper body **22**. The purpose of permitting axial transmission of bypass fluid as well as the specific functions of the bypass port **96** and the bypass openings **98** may best be understood from the following description of the scraping operation.

During the scraping operation, the tool **10** is moved in the forward direction by a locomotive fluid acting upon the rearward hemispherical portion **24** of the spherical sealing member **26**. When the tool string **10** includes other piston sections **16**, the locomotive fluid will also act upon similar hemispherical portions **24** of the respective piston sections to provide additional locomotive force for the tool **10**. Since a perfect seal between the piston **16** and tubing **12** is not obtained, a certain amount of slippage fluid will pass around the hemispherical sealing member **26** and other such sealing members. The amount of slippage fluid may be controlled and thus the locomotive force on the tool string **10** may be controlled by adjusting the outside diameter of the sealing member **26** with the clamping means **30**. Of course, as mentioned previously, the same clamping means **30** may adjust the diameter of the sealing member **26** to compensate for wear as well as accommodate various tubing sizes.

A certain amount of locomotive fluid will pass through the hollow axial bypass passageways of the tool string **10** in order to facilitate the scraping at the scraper blades **20**. After the bypass fluid reaches the flexible coupling **18** and passes through the hollow shank **77** to the scraper section **14**, the bypass fluid flows outwardly to the scraper blades **20**. A portion of the fluid flows through the bypass port **96** at the rearward end of the scraper unit **14** to flow out and around the scraper blades **20**. Another portion of the bypass fluid flows out through the bypass openings **98** to the scraper blades. All of the bypass fluid flowing through the bypass port **96** and the bypass openings **98** serves to keep the scraper blades clean while also forcing the scraped paraffin or scales ahead of the scraper unit **14** as the tool **10** passes through the tubing **12**. It will be understood that the amount of bypass fluid passing through the bypass port **96** and the bypass openings **98** as well as the magnitude of the locomotive force applied to the piston section **16** is in large part controlled by the fluid-resistance presented by the axial bypass passageways of the tool string **10**. This resistance may be controlled by the bypass choke **52** of the hollow shaft **40**. By removing the bypass choke **52** having a particular inside diameter and substituting another bypass choke **52** having a different inside diameter, the overall resistance along the hollow axial length of the tool string **10** may be varied.

When the scraping operation is completed, the tool string **10** may be returned to a suitable storage facility, such as that disclosed in U.S. Pat. No. 3,396,789 and assigned to the assignee of this invention, by the force of fluid in the return direction acting upon the cross section of the piston **16** including the forward hemispherical portion **28** of the spherical sealing member **26**. The return fluid will be applied to the piston section **16** after passing along the scraper blades **20** on the outside of the scraper body **22** as well as through the bypass port **96**. Any return locomotive fluid acting upon the subsequent piston sections is for the most part slippage fluid passing between the tubing **12** and the spherical sealing member **26**. Due to the lightweight of the piston section **16** and the scraper section **14**, braking problems at the storage facility are minimized.

Although a single piston section **16** has been shown and the use of additional piston sections suggested, it will be appreciated that a plurality of piston sections may be required where the force of the locomotive fluid, both forward and return, will cause sufficient slippage past a single-piston section to reduce the locomotive force on the tool string **10**. By using a plurality of piston sections, the overall slippage past the combination of all of the piston sections is substantially reduced, providing a greater locomotive force on the tool string **10**.

Since it may be desirable to add or remove various piston sections to the tool string **10**, the flexible coupling **82** is constructed so as to permit the ball **90** to be removed from the socket **84**. This is accomplished by unscrewing the bushing **88** from the first socket member **84** to expose the ball **90**. A similar construction is utilized at the flexible coupling **18** wherein the socket member **54** may be unscrewed from the hollow shaft **40** to permit the socket member **54** as well as the ball **76** to be separated from the piston section **16**. This separation may become necessary when the spherical sealing member **26** of the piston section **16** becomes sufficiently worn that the wear cannot be compensated for by adjusting the clamping means **30**.

In summary, it is to be noted that the scraper section **14** is relatively short and thus does not restrict the passage of the tool **10** through tubing bends having a 3-foot radius or less. Furthermore, the ball-type piston provides arcuate surfaces about which the piston **16** may rotate and the flexible couplings which terminate the piston **16** add an additional flexibility to the tool **10**. It will be remembered that the blades themselves are spring loaded and hence will to some degree conform to the tubing **12** which further aids the tool in passage through curved tubing.

Although a single embodiment of the invention has been specifically illustrated and described herein, it is to be understood that modifications may be made in the tool within the spirit and scope of the invention, as defined in the appended claims.

1. A piston section of a tool string adapted to be pumped through a well tubing for scraping deposits from the inner wall of the tubing comprising:
   - a substantially spherical elastic sealing member having an adjustable outside diameter;
   - a coupling means for coupling said piston section to at least one other section of the tool string;
   - a fluid bypass passageway extending through said elastic sealing member, said bypass means including means to adjust flow therethrough; and
   - an adjusting means including first and second clamping means located on opposite sides of said sealing member along the axis of the tool string and a hollow shaft extending therebetween, said first and second clamping members being mutually movable along the axis of the tool string to adjust the outside diameter of said sealing member by increasing or decreasing the axial compressive forces on said sealing member, said clamping means further comprises a nut and said hollow shaft includes external threads for engaging said nut, said first clamping means being rigidly affixed to said shaft and said second clamping means being movable along said shaft between said nut and said sealing member.

2. The combination of claim 1 including:
   - a scraper section and a flexible coupling means located between said piston section and said scraper section wherein said scraper section includes spring-loaded helical scraper blades extending axially along said scraper section, and said scraper section having at least one opening for bypass fluid communication between said hollow shaft and said scraper blades.

3. The combination of claim 2 wherein said flexible coupling means is of the ball-and-socket type.

4. A tool adapted to be pumped through tubing or the like comprising:
   - a piston section having:
     - a support member;
     - a substantially spherical sealing member mounted on the support member, said sealing member being elastic;
     - a pair of adjustment means on said support means, each of said means in engagement with said sealing member

on a diametrically opposed side from the other of said means, each of said adjustment means being mounted for relative movement with respect to the other along the axis of the tool to thereby adjust the diameter of said sealing member;

a tool section; and

means for flexibly connecting said piston section to said tool section.

5. The tool of claim 4 wherein:

said flexible connecting means is of the ball-and-socket type.

6. The tool of claim 4 including:

a fluid bypass through said piston section.

7. The tool of claim 6 including:

means for adjusting the flow through said fluid bypass through said piston section.

8. The tool of claim 7 wherein said tool section comprises:

a scraper means having outwardly biased, helical scraper blades.

9. The tool of claim 8 wherein:

said scraper section has at least one opening communicating said fluid bypass through said piston section with said scraper blades.