

May 15, 1956

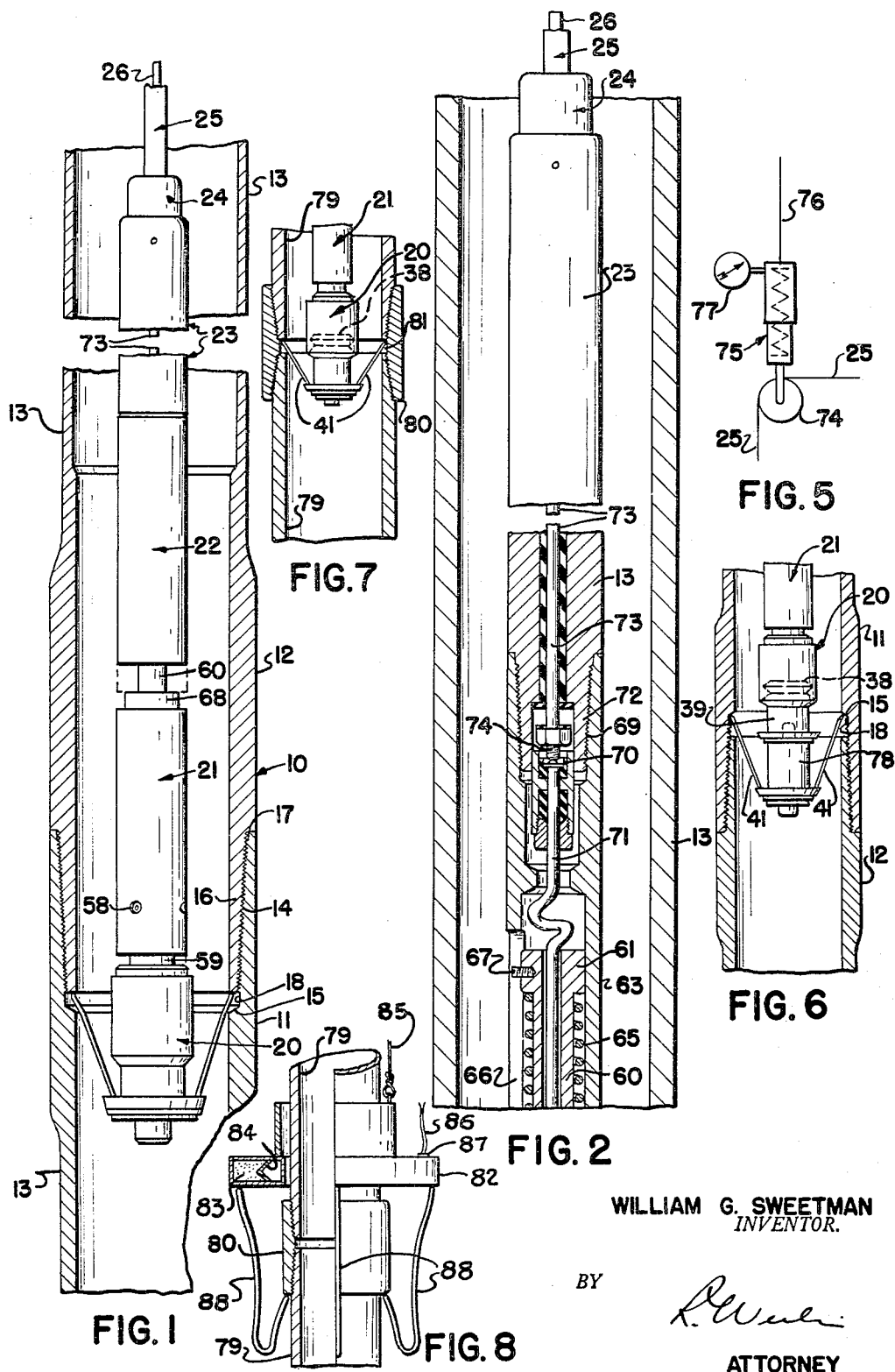
W. G. SWEETMAN

2,745,345

APPARATUS FOR RELEASING THREADED PIPE COUPLINGS

Filed Sept. 18, 1948

2 Sheets-Sheet 1



WILLIAM G. SWEETMAN
INVENTOR.

BY

R. W. Sweetman

ATTORNEY

May 15, 1956

W. G. SWEETMAN

2,745,345

APPARATUS FOR RELEASING THREADED PIPE COUPLINGS

Filed Sept. 18, 1948

2 Sheets-Sheet 2

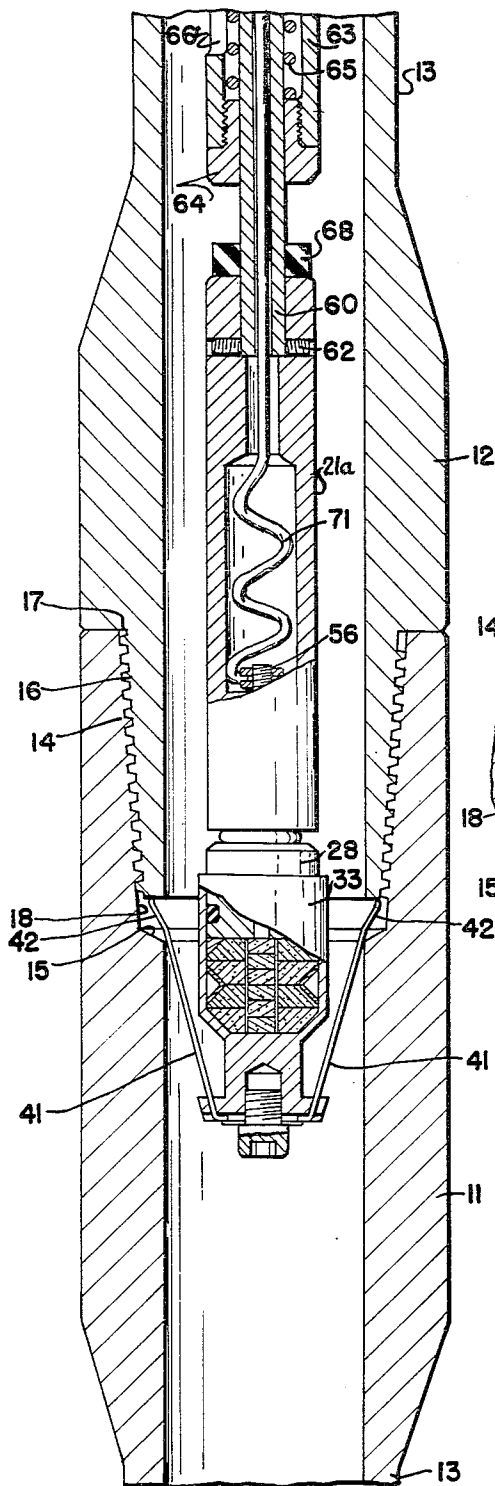


FIG. 2-A

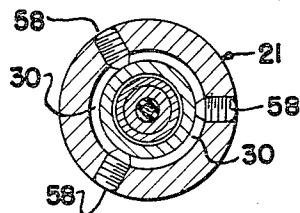


FIG. 4

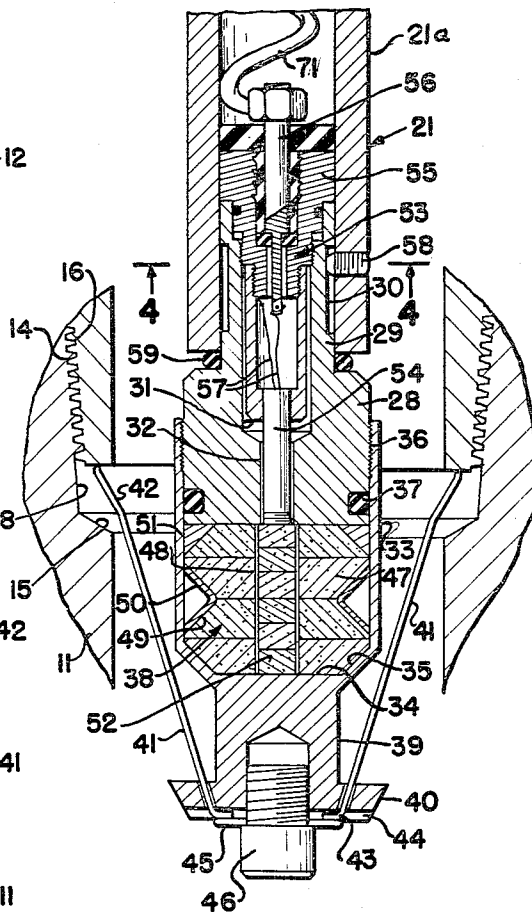


FIG. 3

WILLIAM G. SWEETMAN
INVENTOR.

BY

A. W. Sweetman

ATTORNEY

1

2,745,345

APPARATUS FOR RELEASING THREADED PIPE COUPLINGS

William G. Sweetman, Houston, Tex.

Application September 18, 1943, Serial No. 49,990

4 Claims. (Cl. 102—21.3)

This invention relates to an apparatus including a device for releasing the threaded connection between sections of a pipe string which have become stuck in a well in order to permit unscrewing of a portion of the pipe string so that it may be retrieved from the well.

In the rotary drilling of wells, drilling strings are conventionally employed which are made up of sections of pipe connected together by heavy screw couplings, commonly called "tool joints." Such tool joints conventionally comprise an internally threaded box member and an externally threaded pin member adapted to be screwed tightly into the box member when the joints are made up. Such drilling strings frequently become stuck tightly in a well, whereupon it becomes highly desirable to retrieve a maximum amount of the pipe above the point at which the string is stuck. Unscrewing of the string from the top of the well is generally unsatisfactory because there is no way of assuring that the lowermost joint above the point at which the pipe is stuck will be the one which will unscrew to thereby permit maximum recovery. Also because of the tightness with which the joints are normally made up, or become set up during use, the unscrewing torque required will often lead to twisting-off of the string, which will result in excessive losses and damage to the pipe.

Various methods have heretofore been employed to sever the pipe string at the desired point. These methods include the use of mechanical cutting tools, explosive and the like. Mechanical cutting is expensive and time consuming, while shooting with explosives has heretofore been generally ineffective and undesirable particularly because of the consequent damage to the pipe and to the surrounding well bore. Other methods have attempted to use limited quantities of explosives to jar the coupling while an unscrewing torque is applied to the pipe string but have proven generally ineffective because of the difficulty of effectively localizing the force of the explosive which may result in tightening rather than loosening the joint, and may cause excessive damage to the pipe.

One of the objects of this invention is to provide a device for releasing a pipe joint whereby such operation may be performed in a simple and effective manner and with simple instrumentalities.

Another object of this invention is the provision of a novel apparatus for employing explosives to effect release of pipe sections in a well.

An important object is to provide an apparatus employing explosives which effectively concentrates the force of the explosive preferentially on the female member of a tool joint to effect uniform radial expansion of the same relative to the male member to thereby effectively loosen the threaded connection therebetween.

Another important object is the provision of a novel apparatus for effecting the release of a pipe coupling.

Other and more specific objects and advantages of this invention will become apparent from the following detailed description when read in conjunction with the accompanying drawings which illustrate one useful embodiment in accordance with this invention.

In the drawings:

Fig. 1 illustrates a pipe releasing device in accordance with this invention in position in a well pipe for effecting release thereof;

2

Figs. 2 and 2a, together is an enlarged longitudinal sectional view of the device shown in Fig. 1;

Fig. 3 is an enlarged fragmentary view in longitudinal section of the explosive member of the device;

Fig. 4 is a cross-section along line 4—4 of Fig. 3;

Fig. 5 illustrates the suspension of the device from a conventional weight indicator;

Fig. 6 is a view similar to Fig. 1 showing another embodiment of this invention;

Fig. 7 is a view showing the application of the invention to a casing or tubing; and

Fig. 8 is a general view, somewhat diagrammatic in form, showing another embodiment of this invention.

Generally stated and in accordance with an illustrative embodiment of this invention, the apparatus provides means for producing adjacent the joint and impinging against one of the joint sections but in a direction away from the other joint section, an annular gaseous jet of sufficient intensity to loosen the joint, and this jet is axially confined. While releasing of the joint may be accomplished by directing the jet generally in the zone of the joint, better results are obtained by directing the jet against one of the joint sections. The jet may be directed inside against the female of the joint to expand it; however the jet may be also directed against the outside of a male section to compress it. In each case, the purpose is to release the joint so it can be disconnected.

The device for releasing the joint can be exceedingly simple; thus it may comprise a carrier shaped to extend circumferentially of the joint when placed adjacent thereto, and this carrier may be provided with a detonatable chemical charge shaped annularly to direct an annular axially confined jet against the joint, and preferably against one of the joint sections as heretofore noted. The carrier may be shaped to be placed interiorly of and adjacent the joint, particularly where the expansion is to be of the female section; the carrier may however be shaped to pass over the pipe joint where the male section is to be contracted. Suitable means may be provided for locating the carrier adjacent a joint in order to act thereon.

Referring to the drawings, Fig. 1 shows the device in position in a conventional tool joint, indicated generally by the numeral 10, preparatory to effecting release thereof. Tool joint 10 consists of a tubular box 11 and a tubular pin 12. Box 11 and pin 12 are connected to adjacent sections of a pipe string 13. Box 11 has a tapered internally threaded portion 14 and is provided with an internal shoulder 15 spaced somewhat below the lower end of threaded portion 14. Pin 12 has a correspondingly tapered threaded portion 16 insertible into box 11 and engageable with the threads therein. Pin 12 is provided with an outwardly extending shoulder 17 at the upper end of threaded portion 16 which is adapted to engage the upper end of box 11 when the joint is made up. The length of portion 16 of the pin is conventionally made somewhat less than the depth of threaded portion 14 of the box so that when the joint members are fully made up, the inner end of pin 12 will be spaced above shoulder 15 providing an annular recess 18 in the joint between shoulder 15 and the inner end of pin 12. As noted, such tool joints are entirely conventional and are normally of standardized dimensions throughout, the wall thickness of the pin and box members being generally much thicker than the walls of the pipe sections which are connected together thereby.

The releasing device in accordance with this invention is shown generally in Fig. 1 and in detail in the other figures. The device consists generally of a firing head 20 having a shock absorber 21, a member 22, which will be referred to as a "joint locator" which is telescopically connected to shock absorber 21, a weighting member or

"sinker bar" 23 connected to joint locator member 22, and a cable connection 24 connected to the upper end of sinker bar 23 and having, in turn, connected thereto a lowering cable 25 through which is threaded an electrical current conducting cable 26.

Referring now to Figs. 2, 2a and 3, firing head 20 comprises a cylindrical body 28 having an upwardly extending boss 29 provided in its exterior surface with a plurality of longitudinal grooves 30. Box 29 and body 28 are provided with an axial bore 31 which is reduced in diameter in its lower end as at 32. Body 28 is adapted to be inserted into the upper end of a tubular sleeve 33 which is closed at its lower end by an end wall 34 having upwardly and outwardly tapering inner corners 35. A threaded connection, indicated at 36, is provided between the upper end of sleeve 33 and the exterior of body 28 to provide a tight connection therebetween and a compressible packing ring, such as a conventional O-ring 37, is suitably arranged below threaded connection 36 between the adjacent surfaces of body 28 and sleeve 33 to provide a fluid-tight seal therebetween. With the described arrangement, end wall 34 will be spaced from the lower end of body 28 to provide a chamber adapted to contain a charge of suitable detonating explosive, indicated generally by the numeral 38. The lower end of sleeve 33 is provided with a downwardly extending boss 39 provided at its lower end with a laterally extending flange 40. A plurality of spring fingers 41 are mounted in circumferentially spaced relation in flange 40 and extend upwardly and radially outwardly therefrom into compressive engagement with the inner wall of joint 10. The upper ends 42 of fingers 41 are preferably first bent slightly outwardly and their uppermost tips are then bent inwardly slightly so that as the fingers are compressed inwardly in passing downwardly over the inner walls of pipe 13 and joint 10, ends 41 will pass over any protuberances or pits which may be present along these walls but when drawn upwardly will snap into any substantial recesses, such as recess 18, and engage the upper wall thereof, such as is formed by the lower end of portion 16 of the tool joint pin. The lower ends of fingers 41 extend through suitable perforations in flange 40 and are bent inwardly at 43 to seat in radial grooves 44 provided in the lower face of flange 40. A washer 45 is clamped against the bent ends 43 of the fingers by means of a stud 46 which is screwed into the lower end of boss 39, to thereby firmly fasten the fingers to flange 40.

Charge 38 comprises a body of a suitable detonating chemical 47 which is molded or pressed into a generally disk shape having an axial orifice 48 therethrough. The outer peripheral face of the charge is hollowed at 49. The hollow may be V-shaped or arcuate and is lined with a correspondingly shaped liner 50 which may be constructed of thin copper, steel, or other suitable metal. For convenience chemical 47 may be formed of symmetrical half-disks having suitably shaped peripheries, so that when two of them are placed side-by-side, in the arrangement illustrated, they will together form the charge 47 having the required peripheral hollow shape. The outer diameters of the charge and liner 50 are dimensioned so that their outer edges will be flush with the inner wall of sleeve 33 and will fit snugly thereagainst when the firing head is assembled. When necessary or desirable additional half-disks of the explosive may be placed, as illustrated, on opposite sides of the main charge to supplement the mass and, therefore, the power of the charge. Corners 35 serve as fillers for the tapered outer edge of the lower half-disk, while a suitably shaped filler ring 51, constructed of metal or rigid plastic material, will be arranged, as illustrated, about the edge of the upper half-disk of the explosive.

Orifice 48 is filled with a charge of a suitable booster explosive 52, preferably in the form of a pile of short cylindrical pellets. A fuze element, indicated generally by the numeral 53, comprises a cylindrical electrical

detonating cap 54, installed in the end of a tubular bushing 55 which is adapted to be screwed into the upper end of boss 29. A current-carrying electrode 56 extends through the bore of bushing 55 and is suitably insulated therefrom. The inner end of electrode 56 is connected to one of the wire leads 57 of the detonating cap, the other lead being suitably grounded by being connected to the bushing which is, in turn, in electrical contact with the other metallic parts of the device.

10 Boss 29 carrying the fuze element extends into the lower end of the bore of a sleeve 21a and is connected thereto by means of set-screws 58 which extend radially through the wall of sleeve 21a into grooves 30. With this arrangement sleeve 21a is connected to firing head 20 so as to prevent relative rotation therebetween while permitting a limited degree of relative longitudinal movement as determined by the length of grooves 30. A resilient bumper ring 59, constructed of rubber or like resilient material, is placed about boss 29 between the upper edge of body 28 and the lower end of sleeve 21a. Extending from the upper end of the bore of sleeve 21a is an elongated axially bored stem 60, having an enlarged head 61 at its upper end. The lower end of stem 60 is held in place in the bore of sleeve 21a by means of radial set-screws 62 extending through the wall of sleeve 21a into engagement with the end of the stem.

Stem 60 is slidably inserted in the bore of a tubular cylinder 63, the lower end of which is closed by a tubular bushing 64 surrounding stem 60. A coil spring 65 is mounted in cylinder 63 surrounding stem 60 and is held in compression between head 61 and bushing 64. Stem 60, cylinder 63 and coil spring 65 together generally comprise the joint locator element 22, previously referred to. An elongated slot 66 is cut through the wall of cylinder 63 and forms a guide for a stud 67 extending laterally from the upper end of stem 60 between the side wall of slot 65, whereby relative longitudinal movement between stem 60 and cylinder 63 may occur while relative rotational movement is prevented. A relatively massive bumper ring 68, constructed of resilient rubber or other rubber-like materials surrounds stem 60 and is disposed between the upper end of sleeve 21a and the adjacent lower end of cylinder 63. Sleeve 21a and bumper rings 59 and 68 constitute the shock absorber element 21. The upper end of cylinder 63 is provided with a screw socket 69 in the base of which is seated an electrical contact 70 from which a conductor wire 71 leads downwardly through the bore of stem 60 into the bore of sleeve 21a where it is connected to the upper end of electrode 56. Socket 69 is adapted to receive a tubular threaded pin 72 carried by the lower end of sinker bar 23, which is axially bored to receive a conductor wire 73 which is connected at its lower end to an electrical contact 74 mounted in the bore of pin 72 and adapted to make electrical connection with contact 70 when pin 72 is screwed tightly into socket 69. It will be understood that the upper end of conductor wire 73 is connected to a similar electrical contact (not shown) which will be engaged by an electrical contact carried by cable connection 24 and connected to conductor cable 26 when cable connection 24 is connected to the upper end of the sinker bar in the conventional manner. Lowering cable 25 with its enclosed conductor cable 26 extend to the surface and pass over a pulley 74 (Fig. 5) which is resiliently supported by a conventional weight indicator, indicated schematically at 75, which is, in turn, suspended by a line 76 from the usual derrick (not shown). Weight indicator 75 may be of any of the conventional electrical or mechanical forms adapted to register or record, as on the dial 77, small changes in the weight of the string of tools supported by pulley 74. It will be understood that cable 25 passes to a reeling drum (not shown) of conventional design employed to raise and lower the well end of cable 25, while conductor cable 26 is connected to a suitable source of electric current for supplying firing current to the device.

Explosive 47 and booster 52 may be made of one or more of many well known chemical substances of the type generally designated as "detonating" explosives which, upon detonation, decompose very rapidly to generally gaseous decomposition products which are capable of attaining extremely high velocities, particularly when suitably controlled and directed in accordance with the method and apparatus of this invention. Numerous chemicals of this character are available for use in accordance with this invention including such materials as pentaerythritol tetranitrate (PETN), Tetryl, Pentolite (50% PETN and 50% TNT), trinitrotoluene (TNT), Amatol, Cyclonite, Tetrytol (60% Tetryl and 40% TNT), and many others well known to those familiar with such detonating chemicals. The explosive chemicals will ordinarily be used, as previously noted, in the compressed and molded form.

The above described device is operated in the following manner: The device, assembled as illustrated in the drawings, will be suspended from lowering cable 25 and lowered thereby through pipe 13. Ordinarily, the lowermost point at which the pipe is free will have been previously determined by means which are well known in the industry and the depth thereof from the top of the well measured. The releasing device will be lowered to approximately the indicated point, spring fingers 41 being compressed as the tool passes downwardly through the pipe and connecting tool joints. When the device has reached its lowermost point of travel, the cable will be carefully drawn upwardly at the top of the well until the upper ends of fingers 41 come in contact with the recesses 18 in the first of the tool joints above the point of maximum descent. Ends 42 of the fingers will expand into the recess and engage the lower end of pin 12 in that joint, thereby effectively lodging the device in the joint at that point and resisting further upward movement of the cable. The length and point of attachment of fingers 41 to firing head 20 will be dimensioned with respect to the relative elevation of charge 38, so that when the upper ends of the fingers have engaged the end of the tool joint pin, the hollowed face of the charge will be opposite the wall of box 11 a short distance below the end of pin 12. This is very important because it is essential that the major portion of the force of the charge should be preferentially concentrated on the wall of box 11. When the device has thus lodged in the tool joint, the upward strain on the cable will compress coil spring 65 by drawing cylinder 63 upwardly relative to stem 60 above bumper ring 68, as indicated by the solid lines in Figs. 1 and 2a. This compression of coil spring 65 will be transmitted through weight indicator 75 to dial 77, appearing as an increase in weight thereon, and will thereby immediately apprise the operator at the surface that fingers 41 have engaged the tool joint. The contraction of the coil spring acts to take the tensile load off of fingers 41 due to the upward pull on the cable, while at the same time providing the warning indication to the operator that the fingers have lodged, otherwise, and particularly when operating at depths of several thousand feet, the drag of the heavy cable and attached tools would completely mask the pull resulting from the lodgment of the relatively weak fingers in the joint recess and the fingers might be pulled out of the recess without the operator becoming aware of this occurrence. The weight indicator recording or registering device will normally be so calibrated with respect to the strength of coil spring 65, that each inch of contraction of the latter will indicate a predetermined weight increase on the weight indicator. Also coil spring 65 will be selected of a suitable strength with respect to that of fingers 41, so that the coil spring will contract two or three inches or more, for example, before fingers 41 will collapse under the tension applied to the cable. Thus, as soon as the operator observes a change in weight indication corresponding to a contraction of say two inches in coil spring 65, he will know that fingers 41 have lodged in the selected joint and will immediately stop further upward pull

on the cable. During descent of the tool the frictional drag of fingers 41 on the pipe wall will allow cylinder 63 to move downwardly into contact with bumper ring 68, as indicated by the broken lines in Figs. 1 and 2a, and the weight of sinker bar 23 and cylinder 63 will thus be imposed on the lower members of the device, thereby overcoming the resistance of the fingers and acting to push the device downwardly, as previously noted.

With the device now in position, firing current will be transmitted through conductor cable 26 to set off the charge. When the charge is detonated the gases generated thereby will be caused to converge by reason of the shape of hollow 49 and liner 50 into an annular radially directed jet or blast which will cut through the wall of sleeve 33 and strike a corresponding annular area on the inner wall of box 11. The force of the concentrated explosive blast will be uniformly distributed in a narrow annular band about the inner wall of box 12 and will uniformly expand it radially outwardly and effectively loosen the engagement of the box threads from the threads on pin 12. The explosion will ordinarily destroy most of the firing head 20 but bumper rings 59 and 68 will act to absorb the recoil of the device and effectively protect sleeve 21a and the upper elements of the device from damage. These parts will all be withdrawn from the well, after which, by applying suitable unscrewing torque to the pipe string at the top of the well, the entire string above the joint in which the explosion is set off can be unscrewed and withdrawn from the well. It will be found that lower pin 12 will be entirely undamaged and can be re-used. Tests made on subsequently recovered boxes in which the releasing device has been employed, show that these too are virtually undamaged except for a slight increase in their internal diameters.

By suitably varying the angles of hollow 49 and liner 50, the degree of concentration of the explosive force, and, therefore, of the pressure exerted against the box, may be varied as desired. An angle of about 90° will be found to be generally satisfactory for most cases but may be varied from about 80° to 100° the angle in each case being generally symmetrical about a central horizontal plane through the charge. With an angle of 90° the major part of the explosive force will be concentrated in a horizontal plane. As the angle is enlarged, the explosive force will diverge correspondingly and strike a somewhat wider annular area of the box with a consequent reduction in the pressure per unit of area. Reduction in the size of the angle will correspondingly converge the explosive force on a narrower annular area with consequent increase in pressure per unit of area. It will be understood, however, that the quantity of explosive and the size of the angle of the hollow will be adjusted in each case to produce a force below that which would result in cutting or bulging the metal of the box. By employing supplemental half-disks arranged on opposite sides of the main charge, in the manner illustrated in the drawings, that is, with their peripheries tapering toward the horizontal axis of the main charge, the explosive force of their detonation will serve to further confine and concentrate the force of the main charge generally along its horizontal axis. Such supplemental charges will ordinarily be used when relatively heavy pressures are desired.

Body 10 will ordinarily be made of steel or aluminum while sleeve 33 will ordinarily be constructed of aluminum or other relatively easily shatterable metal but may be made of any suitable rigid plastic material adapted to withstand the hydrostatic pressures when the device is used inside a pipe which is filled with fluid.

Fig. 6 illustrates a modification applicable to joints in which the positions of box 11 and pin 12 are reversed relative to the arrangement shown in Fig. 1. To provide for properly locating firing head 20 in relation to the box an adapter 78 carrying fingers 41 is screwed to the lower end of boss 39 and is made of suitable length relative to the dimensions of the joint so that when the

ends of the fingers lodge in recess 18 or against shoulder 15, charge 38 will be opposite the wall of box 11 and properly spaced axially relative to the end of pin 12. The method of operation including location of the selected joint will be the same as previously described.

Fig. 7 illustrates a modification of this invention as applied to casing or tubing in which the sections of pipe are joined by a double-ended female screw coupling. In this embodiment sections of pipe 79 are shown connected together by a conventional female screw coupling 80. In such connections the ends of the pipe sections normally do not meet even when fully made up, so that there will usually be provided an annular recess, as at 81, in which fingers 41 may engage, as in the previously described embodiments. In this modification the length of fingers 41 will be adjusted so that when they are engaged in recess 81, the horizontal axis of the hollow in charge 38 will be aligned with the portion of coupling 80 which is exposed thereto through recess 81. When the charge, so positioned, is fired, the axially confined annular jet will strike the exposed inner face of coupling 80 through recess 81 and expand the coupling to thereby loosen the joint.

Fig. 8 illustrates another embodiment by which a joint may be loosened by compressing the male member from the exterior thereof. This embodiment is shown applied to a tubing or casing joint such as that illustrated in Fig. 7. In this embodiment an annular carrier 82 is employed which is adapted to slide downwardly over pipe 79 and coupling 80. Carrier 82 has mounted therein a ring-shaped explosive charge 83 the inner periphery of which is hollowed and provided with a correspondingly hollowed liner 84, as illustrated. A lowering cable 85 is employed to lower the carrier down the outside of the pipe and an electrical conductor cable 86 is connected to a fuze 87, of generally conventional form, which is inserted into detonating relation to charge 83. Carrier 82 is provided with a plurality of depending spring fingers 88, the lower ends of which are bent upwardly and inwardly generally as shown. With this arrangement, the carrier may be lowered along the pipe, fingers 88 serving to center the carrier about the pipe so that it will pass freely over any couplings above that which is to be loosened. When the proper point is reached and an upward pull taken on cable 85, the ends of fingers 88 will lodge against the lower edge of the coupling next above the point of maximum descent. This will space the charge just above the upper edge of the coupling, as illustrated, so that the jet therefrom will strike the adjacent portion of the male end of the pipe section and compress or contract it sufficiently to loosen it in the joint.

It will be understood that various changes and alterations may be made in the details of the apparatus embodiments herein described within the scope of the appended claims but without departing from the spirit of this invention. While this invention is particularly designed for the release of a joint between sections of a pipe string in a well, it is useful for other applications.

What I claim and desire to secure by Letters Patent is:

1. Apparatus for releasing the threaded joint between the members of a male-female threaded coupling connecting pipe sections in a well, comprising, a carrier insertible in the bore of said coupling and movable longitudinally therein on a lowering cable, a continuous annular high explosive charge mounted on said carrier concentric with said coupling, said charge being composed of a pair of superposed flat rings of detonatable explosive having registering axial bores and complementary inwardly sloping peripheral edges to define between them a continuous annular hollow in the outer periphery of said charge, said hollow being triangular in cross-section and having an included angle of from about 80° to 100°, a body of booster explosive disposed in said axial bores, a liner conforming in shape to and seated in said hollow, a circumferentially extending wall closing said hollow at its base, radially extending resilient spacer

elements mounted on said carrier and engageable with the inner end of the male member of said coupling in response to upward movement by said cable to thereby selectively position said charge within the female member of said coupling and axially spaced from said inner end of said male member, a resilient connection means interposed between said carrier and said cable extendible by upward pull on said cable following engagement of said spacer means with said inner end of said male member, and detonating means on said carrier positioned on the longitudinal axis of said charge.

2. An apparatus according to claim 1 wherein said resilient connection means comprises a pair of telescopically connected tubular members, and a coil spring arranged in compression between said tubular members.

3. An apparatus for releasing the threaded joint between the members of a male-female threaded coupling connecting pipe sections in a well, comprising, a cylindrical body insertible in the bore of the coupling, a closed cylindrical chamber in said body, a continuous annular high explosive charge enclosed within said chamber, said charge comprising a pair of superposed flat rings of detonatable explosive having registering axial bores and having complementary inwardly sloping peripheral edges to define between them a peripheral hollow of triangular cross-section having an included angle of from about 80° to 100°, a body of booster explosive disposed in said axial bores, the base of the triangular hollow being substantially flush with the inner face of the wall of said chamber, a thin metallic liner conforming in shape to and seated within said hollow, means for positioning said body in the coupling with said hollow directed toward the female member thereof and axially spaced from the male member thereof, and detonating means on said body positioned in detonating relation to said charge on its longitudinal axis.

4. Apparatus for releasing the threaded joint between the members of a male-female threaded coupling connecting pipe sections in a well, comprising, a carrier insertible in the bore of said coupling, a continuous annular high explosive charge mounted on said carrier concentric with said coupling, means on said carrier for selectively positioning said charge within the female member of said coupling and axially spaced from the male member of the coupling, said charge being composed of a pair of superposed flat rings of detonatable explosive having registering axial bores and complementary inwardly sloping peripheral edges to define between them a continuous annular hollow in the outer periphery of said charge, a body of booster explosive disposed in said axial bores, a liner conforming in shape to and seated in said hollow, said hollow and liner being triangular in cross-section with an included angle of from about 80° to 100°, a circumferentially extending wall closing said hollow at its base, and detonating means mounted in said carrier and positioned to detonate said charge on its longitudinal axis.

References Cited in the file of this patent

UNITED STATES PATENTS

1,560,815	Hill	Nov. 10, 1925
1,582,184	Mims	Apr. 27, 1926
1,641,483	Greene	Sept. 6, 1927
2,305,261	Kinley	Dec. 15, 1942
2,344,297	Greene	Mar. 14, 1944
2,399,211	Davis	Apr. 30, 1946
2,407,093	Mohaupt	Sept. 3, 1946
2,407,991	McCullough	Sept. 24, 1946
2,415,814	Davis	Feb. 18, 1947
2,420,201	Seavey	May 6, 1947
2,494,256	Muskat et al.	Jan. 10, 1950
2,506,836	Kaltenberger	May 9, 1950
2,587,244	Sweetman	Feb. 26, 1952
2,684,030	Muskat et al.	July 20, 1954