July 31, 1956 I. J. McCULLOUGH 2,756,677

WELL PERFORATING DEVICE

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Fig. 2

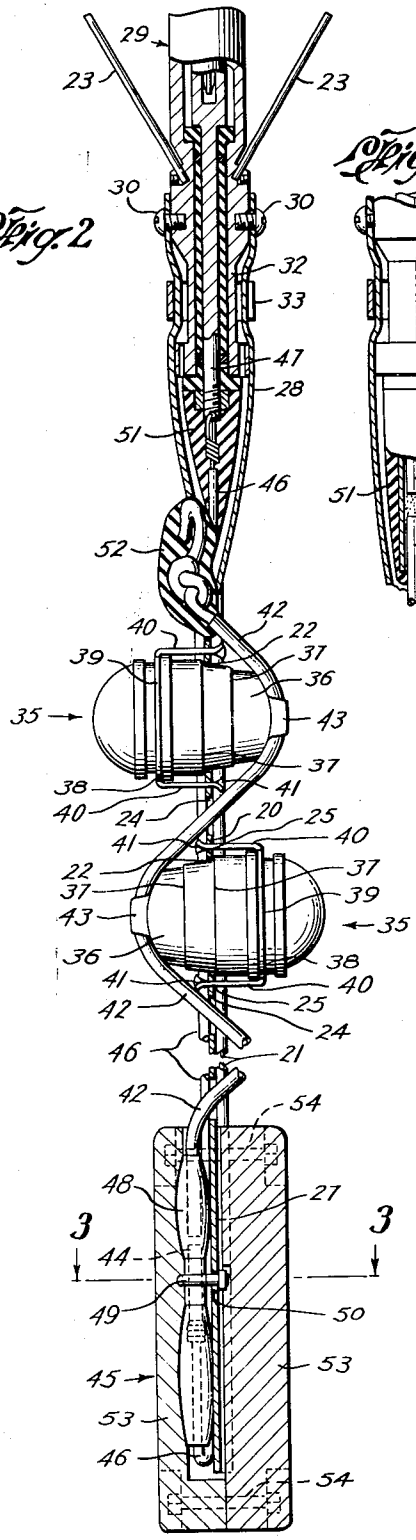


Fig. 15

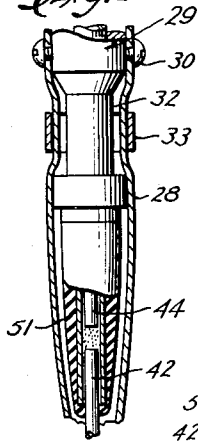
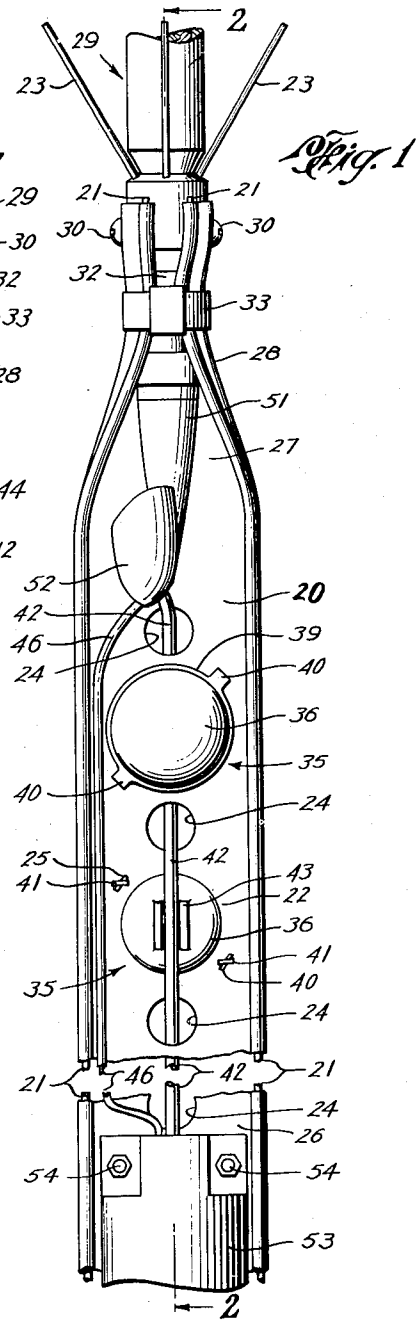


Fig. 1



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Fig. 10

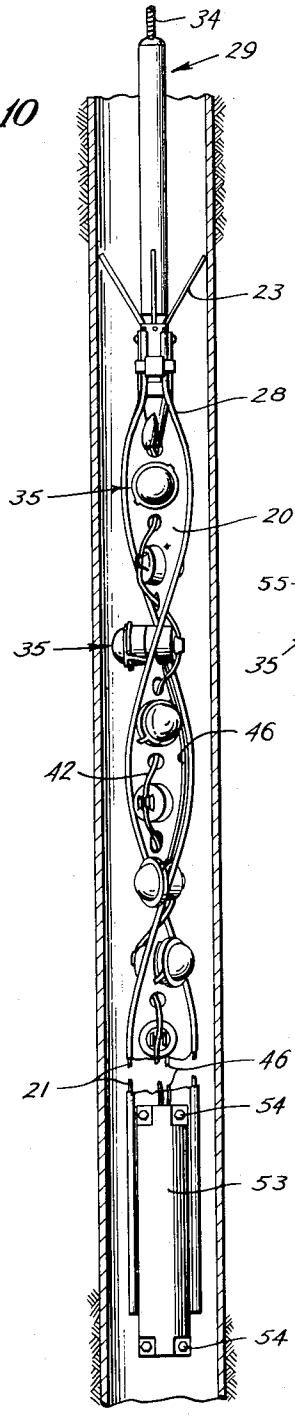
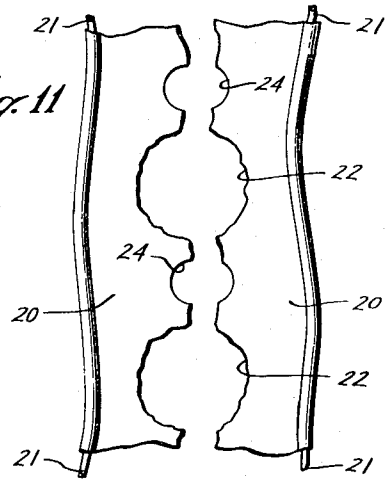


Fig. 11



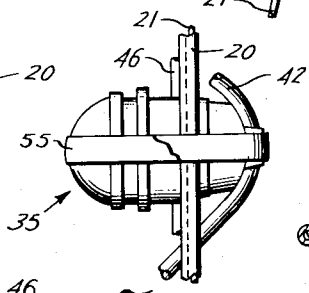


Fig. 16

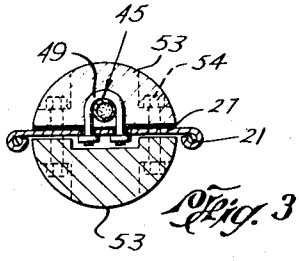


Fig. 3

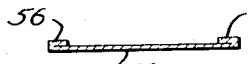


Fig. 12

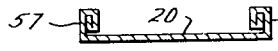


Fig. 13

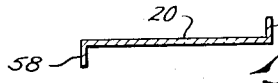


Fig. 14

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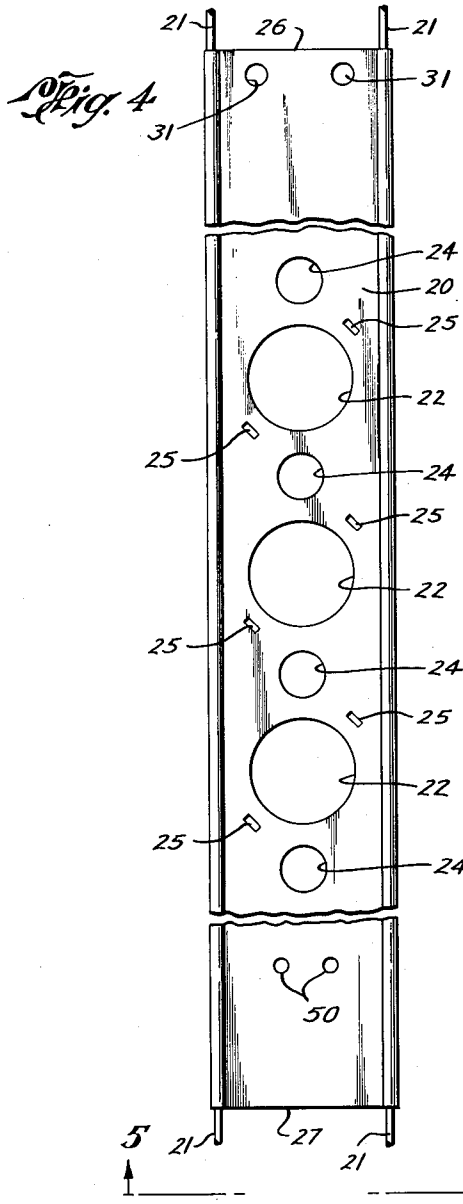


Fig. 4

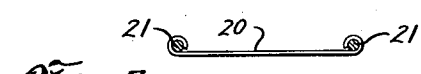


Fig. 5

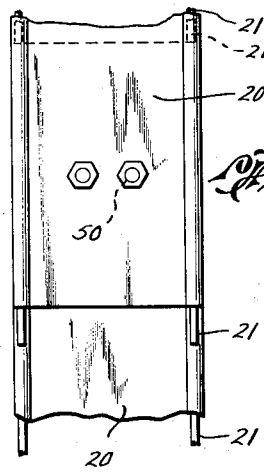


Fig. 6

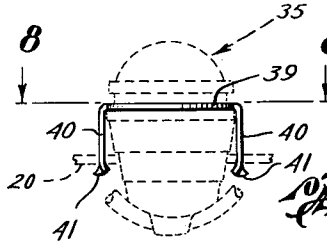


Fig. 7

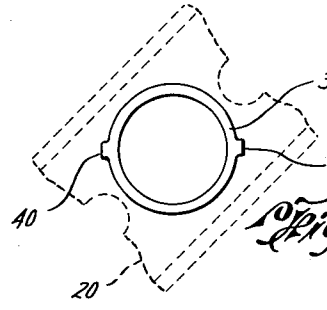


Fig. 8

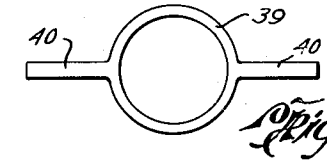


Fig. 9

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United States Patent Office

2,756,677

Patented July 31, 1956

2,756,677

WELL PERFORATING DEVICE

Ira J. McCullough, Los Angeles, Calif., assignor to McCullough Tool Company, Los Angeles, Calif., a corporation of Nevada

Application October 14, 1950, Serial No. 190,105

13 Claims. (Cl. 102—20)

This invention relates to devices employed in perforating the wall of a well bore and particularly to an improved form of carrier employed to support explosive perforating charges of the hollow or so-called "jet" type during the operations of lowering such charges into a well bore, and firing them after the carrier is in place, and which is thereafter retrievable from the well bore.

In the art of well perforating by means of explosive hollow charges, it is normally desirable to employ a multiplicity of perforating units, arranged generally longitudinally along a carrier, and which may be fired, ordinarily simultaneously, or substantially so, to provide a corresponding plurality of perforations along the opposite section of the wall of the well bore. Various types of carriers have heretofore been employed which fall into two general classes, namely, recoverable and expendible. The recoverable type is ordinarily constructed in the form of a cylindrical steel body, which may be solid or hollow, and which is provided with a plurality of sockets, receptacles, or barrels into which the perforating units may be inserted and protected against intrusion of well fluids by suitable sealing covers or caps. The several perforating units are ordinarily connected to a suitable detonating train which extends through the interior of the carrier body. Carriers of this general type have several disadvantages in that they are relatively expensive and complicated to construct, and although recoverable, normally suffer considerable battering and damage by the explosion of the charges, so that they may only be run a very few times before they must be discarded or require extensive re-machining or repair before re-use. Also, they are necessarily relatively rigid, heavy, and bulky and must be of considerable length to support the substantial number of charges commonly employed for a single run, have only relatively small clearance with respect to the wall of the well bore, and consequently cannot be used to carry large shaped charges in the well bore. As a result, they are subject to becoming stuck in the well bore, particularly where the latter is not straight or smooth, and often present difficulty in lowering and in the recovery after firing. Also, if such bodies should become broken in the well bore, a not uncommon occurrence, fishing these broken parts out of the well may be very difficult or even impossible because of their size and mass.

Expendible carriers are of various types and may be constructed of various metals, plastics, cement and the like, and may be made in solid or open-work structural form, all of which are designed to disintegrate or shatter under the explosive forces of the charges. Such carriers have the principal disadvantage that the pieces resulting from their disintegration remain in the well bore where they may plug the perforations made by the charges and may have to be washed or fished from the well bore to clear the latter properly. Thus, in the case of expendable carriers, it is highly desirable to provide constructions which will leave a minimum of so-called "junk" in the well bore after use.

Accordingly, the principal objects of this invention include the provision of an improved form of carrier for hollow-type explosive charges for insertion in a well bore, which will effectively support and position any desired number of such charges; which will leave a minimum amount of junk in the well bore; which is of exceptionally simple and cheap construction such that it may be expended in use; which, while expendable in the sense that it is not re-usable, is nevertheless recoverable from the well bore; which permits use of charges of maximum dimensions for a given well bore diameter; which furnishes a positive indication of the firing of the several charges; and which possesses a high degree of flexibility such that it may be readily lowered through, and removed from, well bores which are not perfectly straight and smooth.

More specifically, the improved carrier in accordance with one embodiment of this invention comprises a narrow elongated strip of flat material, which may be relatively soft and pliable metal, such as ordinary aluminum, brass, copper, zinc, or steel sheet, having a width such as to be readily insertible in the bore of a well. The side margins of the strip may be re-inforced in any suitable manner, as by bending the edges at right angles to the plane of the strip to form short flanges; by rolling or crimping the edges to form beads thereon; or by rolling or crimping the edges around steel wires extending longitudinally along the side edges. Intermediate the edges of the strip and preferably along the center portion thereof, a plurality of longitudinally spaced holes or openings is provided for mounting individual perforating units which may be held in place by any suitable fastening means, such as wire, clips, tape or the like. The upper end of the strip carrier is adapted for attachment to a lowering cable and a firing head for firing a detonating train which is strung along the carrier and connected to the several charges. Weighting means of any suitable form may be attached to the carrier to assist in lowering the device through a well bore. The reinforcement of the edges of the strip carrier provides additional tensile strength without substantially reducing the flexibility of the strip, and forms flexible members which will bend or spread under transverse forces produced by detonation of the charges without shearing, so that the entire strip carrier remains sufficiently intact to be withdrawn from the well after the charges are fired. In order to further reduce the resistance to the shearing forces produced by the charges and to cause the strip to preferentially split or part longitudinally intermediate the side edges, the metal strip may be additionally weakened longitudinally along its center portion in any suitable manner, as by removal of some of the metal intermediate the charge-supporting openings.

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

In the drawings:

Fig. 1 is a front elevational view of one form of the carrier structure in accordance with this invention showing the structure fully assembled with the perforating charges preparatory to insertion in a well bore;

Fig. 2 is a longitudinal sectional view generally along line 2—2 of Fig. 1;

Fig. 3 is a cross-sectional view along line 3—3 of Fig. 2;

Fig. 4 is an elevational view of a strip carrier blank;

Fig. 5 is an end view looking upwardly toward the lower end of the carrier blank along line 5—5 of Fig. 4;

Fig. 6 is a fragmentary view showing an arrangement for connecting together two carrier sections;

Fig. 7 is a plan view of a metal clip shown positioned to hold a perforating unit in place on the carrier;

Fig. 8 is a front elevation of the metal clip looking along line 8—8 of Fig. 7;

Fig. 9 is an elevational view of the clip blank;

Fig. 10 is a view of the assembled carrier positioned in a well casing and showing the carrier twisted about its longitudinal axis to alter the angular orientation of the perforating charge;

Fig. 11 is a fragmentary view of the carrier which is illustrative of the condition of the carrier after firing of the perforating units;

Figs. 12, 13 and 14, are cross-sectional views of various modified shapes in which the carrier may be constructed;

Fig. 15 is a fragmentary view, partly in section, showing an alternative arrangement for firing the perforating charges mounted on the carrier; and

Fig. 16 illustrates another means by which the perforating units may be fastened in place on the carrier.

Referring first to Fig. 4, the carrier in accordance with one embodiment of this invention comprises a narrow elongated strip 20 constructed of a relatively pliable sheet metal, such as ordinary sheet brass, copper, zinc, aluminum, or steel, of any suitable or standard thickness, such as one-sixteenth inch (0.0625). The width of the strip will be made somewhat less than the diameter of the well bore into which it is to be inserted. By "well bore," it will be understood that reference is had to either the usual pipe or casing employed to line a well bore or the uncased bore itself. The length of strip 20 may be any suitable or desired length, a convenient length for most purposes being about 12 feet. The side margins of the strip are suitably reinforced by continuous pieces of strong steel wire 21, such as piano wire, which are fastened to the strip by rolling or crimping the edges of the strip about the lengths of wire. The reinforcement thus provided for the edges of the metal strip serves to increase the tensile strength of the carrier and to resist transverse shearing or parting stresses which may be developed in the strip. Wire of about 0.072 to 0.125 inch in diameter, employed with aluminum strip about one-sixteenth inch thick provides a construction which is found to be adequate in most cases.

A plurality of relatively large diameter circular holes 22, are drilled or punched in strip 20 generally along its center line and preferably on uniform center spacing, the spacing between holes 22 being such as to provide the desired number of openings per foot of strip, for example, four holes per foot on three-inch centers. Smaller holes 24 may be drilled or punched in the center portions of strip 20 intermediate adjacent pairs of the larger holes 22 to thereby remove additional metal from the strip along its center, one purpose being to additionally weaken the strip generally along its center line for purposes to be described hereinafter. These smaller holes 24 also provide means for threading or winding explosive detonating cord therethrough in forming detonating connections to the several perforating units, as will be described hereinafter. Narrow slots 25—25, punched in the strip, are provided on opposite sides of each of the openings 22 for receiving the ends of the means employed for fastening the explosive charges in place in the strip, as will be subsequently described.

Substantially blank portions 26 and 27 are left at the upper and lower ends, respectively, of the strip.

Referring now to Figs. 1 and 2, it will be seen that the upper blank portion 26 may be rolled or otherwise suitably bent symmetrically about its longitudinal center line to form a generally tubular neck 28 for reception of the lower end of a generally conventional firing head, designated generally by the numeral 29. The latter is adapted to be inserted in neck 28 and is provided with an annular groove 32 into which the adjacent portion of neck 28 may be compressed by encircling the latter with a metal locking band 33, as shown, which may be of any suitable or conventional form adapted to firmly fasten neck 28 to the firing head, to thereby attach the carrier to the firing head and the lowering line. A pair of screws 30—30 extend through a pair of holes 31—31 in opposite sides of neck 28 and screw into the inserted portion of the firing head to prevent relative rotation between the carrier and the firing head. Firing head 29 is connected to the usual lowering cable 34 (Fig. 10) by which the carrier may be lowered into and withdrawn from a well bore and the firing head may be provided with radially arranged upwardly and outwardly extending wire fingers 23 which may be employed in the conventional manner for positioning the carrier in the well bore.

The carrier is adapted to support explosive perforating units, designated generally by the numerals 35, which are generally tubular in form and preferably of generally frusto-conical external shape. Perforating units of this type are described in detail in the U. S. application of William G. Sweetman, Serial No. 163,146, filed May 20, 1950, but the specific details of such perforating units do not form a part of this invention, and only the external shape of outer casings 36 is illustrated herein for the purpose of showing the manner in which such units may be mounted or supported on the carrier of this invention. It should be understood, however, that such casings contain hollowed explosive charges which are designed, upon detonation, to discharge a high velocity narrow gaseous jet generally along the longitudinal axis of the charge unit which performs the desired perforation of the wall of the well bore.

As shown particularly in Figs. 1 and 2, one of the units 35 is inserted into each of the openings 22 and positioned co-axially therein, the taper of the exterior of the casing 36 serving to limit the extent to which the unit extends through the opening in accordance with the diameter of the opening 22. Ordinarily the casings 36 are provided with series of external annular shoulders 37—37 increasing in diameter toward the larger end of the casing. These shoulders may also serve as abutments to engage the margin of opening 22. The smaller the diameters of holes 22, the greater will be the distance which the discharge end of the perforating unit will project from the side of the carrier. As the perforating units are normally made to standardized dimensions, the diameter of openings 22 may be selected in relation thereto to provide the desired degree of lateral projection of the units relative to the face of the carrier. Perforating units of the type illustrated will ordinarily be provided with an external annular shoulder 38 adjacent its discharge end. This may be employed for fastening the unit in place on the carrier by means of metal clips of the form shown particularly in Figs. 7, 8 and 9. These clips comprise a circular band 39 adapted to slip over the discharge end of the perforating unit and seat against shoulder 38. A pair of flat metal wings 40 extend from opposite sides of band 39 and are adapted to be bent rearwardly to extend along the sides of the perforating unit and project through slots 25—25 to the opposite face of strip 20. The projecting ends of wings 40 are then twisted, as at 41, in any suitable manner to lock them to the slots, the degree of twist being such as to draw the unit rearwardly in opening 22 to thereby hold it tightly in place in the slot either by wedging action of the tapered surface of casing 36 in opening 22 or by compression of shoulder 37 against the adjacent margin of the opening.

Alternate ones of the perforating units 35 may be inserted from opposite directions through openings 22, as illustrated particularly in Figs. 1 and 2, the resulting perforations being 180° apart in the wall of the well bore. It will be understood that all of the perforating units may be faced in the same direction, if desired, or in any other desired arrangement. Fig. 10 illustrates

another manner in which the perforating units may be oriented, at different angles, about the longitudinal axis of the carrier. This is done by merely twisting the carrier in any suitable manner about its longitudinal axis. By virtue of the flexible construction of the carrier this may be very easily accomplished and will ordinarily be done by first mounting the units in the manner illustrated in Fig. 1 and then applying the desired degree of twist to the carrier.

The detonating train for the units comprises a continuous length of flexible detonating cord 42, such as the well-known "Prima Cord," which extends along the length of the carrier and is trained successively over the rear ends of the several perforating units in the manner as illustrated, for example, in Figs. 1 and 2, the cord passing alternately to opposite sides of the carrier through openings 24. The rear ends of the casings 36 may be provided with notches 43 to receive and retain the detonating cord in proper detonating position over the ends of the units. In the arrangement illustrated particularly in Figs. 1 and 2, the detonating cord is fired from its lower end by means of a conventional electrically fired blasting cap 44 which is positioned adjacent the lower end of the detonating cord, to form a connection, designated generally by the numeral 45. Electric current for firing the blasting cap is supplied thereto by means of a conventional electrical lead 46 which is strung along the face of the carrier and connects to an electrode 47 which extends through the center of firing head 29, electrode 47 forming part of a conventional electrical conductor (not shown) which is threaded in the usual manner through lowering cable 34 and extends therewith to the surface where conventional electrical initiating equipment (not shown) is located. Connection 45 formed between blasting cap 44 and the adjacent end of detonating cord 42 is enclosed within a suitable waterproof insulating jacket 48 which may form a part of the connection, and this connection may be suitably clamped to one side of portion 27 of the carrier, as by means of a U-bolt 49 which extends through openings 50—50 provided in portion 27. The connection between the upper end of lead 46 and electrode 47 is also wrapped and enclosed in a suitable water-proof insulating covering 51 which may be shaped to be enclosed within the lower end of neck 28 of the carrier, in a manner as illustrated in Figs. 1 and 2. The upper free end of detonating cord 42 is also enclosed in a water-proof wrapping 52 to protect it against intrusion of fluids which may be present in the well bore. It will be understood that detonating cord 42 will also be encased within a suitable water-proof, insulating covering such as rubber, or the like.

Fig. 15 illustrates a modified firing arrangement by which detonating cord 42 may be fired from its upper end, rather than from its lower end. Either firing arrangement may be employed successsfully with the carrier construction herein described for firing the complete train of perforating units.

While either the top or bottom firing arrangement may be used successfully, it will generally be found to be preferable to use the arrangement for firing the units upwardly from the bottom of the string. This firing arrangement has the additional advantages that by firing the charges from the bottom, if the carrier should, through some untoward circumstance, part at the location of any particular charge, only the portion below this point, and from which the charges had been fired, would drop into the well bore, while the portion above the point of separation, containing the remaining charges, whether fired or unfired, would be recoverable. The bottom firing arrangement, therefore, affords an additional important measure of safety and assurance with respect to protection of the well and the perforating device. This firing arrangement may be applied with similar advantage to other and more conventional types of perforating devices in which a series of charges are mounted for sequential firing.

Since the weight of the carrier including the perforating units mounted therein is relatively small, it may be found desirable in many cases to add weight to the carrier in order to assure rapid and uninterrupted descent of the carrier through the well bore, particularly where there is fluid present in the well bore, as is most often the case. Such additional weight may be applied in various ways. One convenient arrangement is illustrated and consists of a pair of lead bars 53—53 of generally semi-cylindrical form, which may be mounted on opposite sides of portion 27 of the carrier and connected together by means of bolts 54 which pass transversely through the bars and portion 27. One of the bars may be hollowed out to accommodate connection 45 and serves also to protect this connection from striking projections which might be present along the well bore.

In operation, the carrier having the perforating units mounted therein and connected to firing head and lowering line in the manner illustrated, for example, in Figs. 1 and 2, is lowered to the desired point in the well. Firing current will be supplied from the surface to blasting cap 44 which will explode and set off detonating cord 42 which will, in turn, detonate each of the charges in succession. The intervals between the firing of the successive perforating units will, of course, be extremely small so that for all practical purposes, their detonations occur substantially simultaneously. Explosion of perforating charges will completely disintegrate the perforating units. It is a characteristic of well designed hollow perforating charges, that a portion of the forces of the explosion will discharge from the hollowed end in the form of narrow gaseous jets along the longitudinal axis of the charge. However, substantial radial forces will also be developed and these will, of course, act upon the edges of openings 22 surrounding the perforating units. By making the carrier of relatively thin sheet metal, as described above, these forces tend to tear strip 20 apart, preferentially along its longitudinal center where the strip has been weakened by the removal of the metal to form openings 22 and additionally by the removal of intermediate portions of the metal in forming holes 24. This results in what I have termed a "can-opener" effect, in that the carrier strip is split longitudinally, the reinforced edges and the relatively wider adjacent metal sections acting to effectively resist transverse shearing stresses so that the edge portions remain substantially intact and unbroken, although subjected to some degree of bending. Fig. 11 illustrates the general appearance of a portion of the carrier after explosion of the charges. Upper and lower portions 26 and 27 which have not been substantially weakened also remain intact and remain connected to firing head 29 through the unbroken edge portions of the carrier, with the result that, after the charges have been fired, the entire carrier, together with the wires 21 will be withdrawn from the well bore, along with the firing head and cable. Thus a very minimum of "junk" will be left in the well bore.

It will be noted from Fig. 11 that the edges of holes 22 present a battered appearance, while the edges of holes 24, although torn apart, remain relatively smooth. The battered appearance of the holes in which the charges were originally mounted provides a very valuable indication that the perforating unit has, in fact, been detonated. When a string of perforating charges is lowered in a well and fired, it is, of course, highly important that all of the charges should fire. With more conventional types of carriers heretofore employed, particularly expendible carriers, there was no practical way of determining whether or not all of the charges had fired, since the carriers remained in the well bore. With carriers constructed in accordance with the present invention, the carrier is not only recoverable, but is substantially

intact except for the longitudinal split therein. Thus, merely by visual inspection of the carrier, after it is withdrawn from the well, a quick determination of the firing efficiency can be made.

Carriers in accordance with this invention have the additional advantage that, by virtue of their narrow, flat construction, they occupy a minimum amount of space in a well bore and thereby permit utilization of charges of maximum dimensions within the limits of the well bore diameter. Their longitudinal and lateral flexibility permits them to be lowered in crooked well bores and through partially collapsed casing or tight places.

As noted, these carriers may be made in any desired length or made up of sections connected end to end to obtain a length sufficient to support any desired number of perforating units. Fig. 6 illustrates one simple type of connection between carrier sections in which the ends of two sections are simply over-lapped slightly and bolted together.

Fig. 16 illustrates another arrangement for fastening the perforating units in place on the carrier without using the previously described metal clips. In this modification, a unit is inserted in its supporting opening 22 and several turns of ordinary electrical tape 55 may be wrapped circularly about the carrier and the ends of the unit in the manner illustrated to tie the two firmly together and retain the perforating unit in the desired position. It will be understood that various other conventional fastening arrangements may also be employed for this purpose.

Figs. 12, 13 and 14 illustrate in cross-section other suitable shapes for carriers constructed in accordance with this invention. In Fig. 12, the edges of strip 20 are merely turned inwardly and crimped to form reinforcing beads 56. In Fig. 13, the edges are shown double-crimped, as at 57. In Fig. 14, the edges are turned oppositely at right angles to strip 20 to form oppositely extending edge flanges 58. It will be obvious that numerous other arrangements may be successfully employed for effectively reinforcing the side edges of strip 20.

Generally speaking, the thickness of sheet 20 should be the minimum commensurate with the strength required to provide firm support for the perforating units. It should also be sufficiently rigid so as not to buckle or pile up when being lowered into the well bore while, at the same time, it should be sufficiently flexible to follow a crooked or inclined or irregular bore. As noted, about one-sixteenth inch aluminum sheet is adequate for most purposes, although sheets somewhat thicker or thinner may be successfully employed. Such sheets will have sufficient tensile strength to support whatever loads may be required in the ordinary case and, of course, reinforcement of the edges provides such additional tensile strength, as may be required. Various other metals, such as copper, brass, zinc, soft iron, mild steel, and the like, having the desired physical characteristics and form, may be employed in the construction of the carriers in accordance with this invention. Also, various non-metallic sheet materials, such as semi-hard rubber or plastic compositions, and even suitably stiffened canvas or other fabrics may be employed for construction of carriers in accordance with this invention.

By reason of the relatively simple construction of the carriers herein described, it will be obvious that they may be constructed so that they may be discarded after use with small economic cost. The firing head and weighting members which are also recoverable can be re-used repeatedly.

It will be understood that various changes and alterations may be made in the details of this invention within the scope of the appended claims but without departing from the spirit of this invention.

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

1. A well perforating device, comprising, an elongated continuous strip of relatively thin sheet metal shaped to be longitudinally inserted in a well bore, a plurality of longitudinally spaced openings in the medial portion of said strip intermediate the opposite side edges thereof whereby to provide longitudinally continuous marginal sections extending laterally from said openings to the side edges of said strip, an explosive perforating unit of the hollow charge type fixedly mounted in each of said openings transversely to the plane of said strip, means for connecting the upper end of said strip to a lowering means, and a detonating train extending longitudinally of said strip in detonating contact with each of said perforating units.

2. A well perforating device, comprising, an elongated continuous strip of relatively thin sheet metal shaped to be longitudinally inserted in a well bore, a plurality of longitudinally spaced openings in the medial portion of said strip intermediate the side edges thereof whereby to provide longitudinally continuous marginal sections extending laterally from said openings to the side edges of said strip, continuous reinforcing elements extending longitudinally along said marginal sections, an explosive perforating unit of the hollow charge type fixedly mounted in each of said openings transversely to the plane of said strip, means for connecting the upper end of said strip to a lowering means, and a detonating train extending longitudinally of said strip in detonating contact with each of said perforating units.

3. A well perforating device, comprising, an elongated continuous strip of relatively thin material shaped to be longitudinally inserted in a well bore, a plurality of longitudinally spaced openings in the medial portion of said strip intermediate the opposite side edges thereof whereby to provide longitudinally continuous marginal sections extending laterally from said openings to the opposite side edges of said strip, an explosive perforating unit of the hollow charge type fixedly mounted in each of said openings transversely to the plane of said strip, means for connecting the upper end of said strip to a lowering means, and a detonating train extending longitudinally of said strip in detonating contact with each of said perforating units.

4. A well perforating device, comprising, an elongated continuous strip of relatively thin sheet material shaped to be longitudinally inserted in a well bore, a plurality of longitudinally spaced openings in the medial portion of said strip intermediate the side edges thereof whereby to provide longitudinally continuous marginal sections extending laterally from said openings to the opposite side edges of said strip, an explosive perforating unit of the hollow charge type fixedly mounted in each of said openings transversely to the plane of said strip, means for connecting the upper end of said strip to a lowering means, a detonating element extending longitudinally of said strip in detonating contact with each of said perforating units and initiating means connected to the lower end portion of the detonating element whereby to fire said units sequentially upwardly from the lowermost one of said units.

5. A well perforating device, comprising, an elongated continuous strip of relatively thin flat sheet material shaped for insertion longitudinally in a well bore, a plurality of longitudinally spaced openings through the medial portion of said strip and spaced from the opposite side edges thereof whereby to provide longitudinally continuous marginal sections of said strip extending laterally from said openings to the side edges of said strip, reinforcing elements disposed longitudinally along the side edges of both marginal sections, said marginal sections thereby having such structural strength that their resistance to lateral shear is greater than the resistance of said medial portion to longitudinal splitting, whereby the strip may be preferentially split longitudinally by the explosion of explosive units mounted in said openings, explosive perforating units of the hollow charge type mounted in one or more of said openings in fixed position transversely

to the plane of said strip, and a detonating train extending longitudinally of said strip in detonating contact with each of said perforating units.

6. A well perforating device according to claim 5 wherein said material is sheet metal approximately one-sixteenth inch thick, each of said reinforcing elements comprising a side marginal portion of said strip which has been bent inwardly upon itself.

7. A well perforating device according to claim 5 wherein said strip carrying said units is twisted about its longitudinal axis to angularly orient said charges relative to each other about said axis.

8. A well perforating device, comprising, an elongated continuous strip of relatively thin sheet metal adapted to be longitudinally inserted in a well bore, a plurality of longitudinally spaced openings in the medial portion of said strip intermediate the side edges thereof whereby to provide longitudinally continuous marginal sections extending laterally from said openings to said side edges, continuous reinforcing elements extending longitudinally along said marginal sections, explosive perforating units of the hollow charge type fixedly mounted in at least some of said openings transversely to the plane of said strip, means for connecting the upper end of said strip to a lowering means, and a detonating train extending longitudinally of said strip in detonating contact with each of said perforating units.

9. A well perforating device, comprising, an elongated continuous strip of relatively thin sheet metal shaped to be longitudinally inserted in a well bore, a plurality of longitudinally spaced openings in the medial portion of said strip intermediate the opposite side edges thereof to provide longitudinally continuous marginal sections extending laterally from said openings to said side edges, continuous reinforcing elements extending longitudinally along said marginal sections, an explosive perforating unit of the hollow charge type fixedly mounted in each of said openings transversely to the plane of the strip, strength-relief means other than said openings in said medial portion of the strip intermediate said units, means for connecting the upper end of said strip to a lowering means,

and a detonating train extending longitudinally of said strip in detonating contact with each of said perforating units.

10. A well perforating device according to claim 9 wherein each of said reinforcing elements comprises said side marginal section bent inwardly upon itself.

11. A well perforating device according to claim 9 wherein said strength-relief means comprise non-charge-supporting openings.

12. A well perforating device according to claim 11 wherein said reinforcing elements comprise metal reinforcing wires secured to the marginal sections of said strip.

13. A well perforating device, comprising, an elongated strip of relatively thin sheet metal adapted to be longitudinally inserted in a well bore, continuous reinforcing elements disposed longitudinally along the side margins of the strip, a plurality of longitudinally spaced explosive perforating units of the hollow charge type fixedly mounted in the medial portion of said strip and extending transversely through the strip, said strip being twisted about its longitudinal axis to angularly orient said charges relative to each other about said axis, and a detonating train on the strip in detonating contact with the several explosive units.

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