This invention relates to well perforating assemblies and particularly to firing means therefor.

In completing wells drilled by the rotary method it has long been the practice to perforate casing set in the well adjacent the producing formation for the purpose of providing ingress to the well from said formation. Similarly in wells drilled by said rotary method but in which casing has not been set, it is frequently customary to perforate the formations by firing thereinto for the purpose of initiating or increasing fluid production.

A known method of perforating through casing as aforesaid was to lower into the well gun bodies consisting of more or less solid blocks of steel provided with barrels having explosive and bullets therein and fire the bullets. More recently, as witness United States Letters Patent No. 2,493,256 to Muskat et al., dated January 10, 1950, and entitled “Apparatus for Perforating Well Casings and Well Walls,” a method has been developed for perforating in wells through the use of shaped charges, such method being adaptable to either perforating through casing or perforating directly into the open formation.

The shaped charge apparatus is fired generally by the use of a detonating fuse which is fired electrically by a detonator assembly and in turn initiates the explosion of the shaped charges substantially simultaneously, said detonating fuse passing from detonator assembly throughout the shaped charge apparatus in juxtaposition to each charged charge assembly taken on the line 2-2 of Fig. 1a.

In its general aspect the invention comprises a carrier 10 supporting shaped charges 12 fired by a detonating fuse 14, the carrier being connected to a firing head 16 in which is provided a booster 18 abutting the detonating fuse 14 and a detonator charge 20 held closely adjacent the booster. The booster and detonator charges are held in place within a closed, sealed chamber, and a barrier member 21 is interposed between said chamber and the carrier-firing head connection, thus isolating the detonator from the carrier. This general combination results in more positive detonating fuse firing and improved sealing, and in the event of misfire, unexploded shaped charges are not dropped into the well.

Referring now more specifically to the embodiment of the invention shown in the drawings, it will be seen that a shaped charge assembly is suspended in the usual manner by a cable 22 affixed to a rope socket assembly 24. The rope basket assembly 24 is threaded to a contact sub 26, the sub and socket assembly being provided with the usual means including an insulated passageway 28 to permit the conductor 30 which passes through the cable 22 from the surface to extend into the recess 32 in the contact sub 26. The collar 34, a part of the firing head 16, is carried by the shoulder 36 of the sub 26 and in turn threadedly receives the threaded end 38 of the barrier member 21, said barrier member being provided with the collar locators 40.

It will be seen, therefore, that a firing chamber 42 is defined within the firing head 16 by the contact sub 26 and the barrier member 21, the upper portion of the firing chamber including recess 32 in the contact sub 26 and the lower part of the chamber being defined by the threaded end 38 of the barrier member 21.

Barrier member 21 is bored to provide a passageway 44 through which extends the detonating fuse 14 into the chamber 42, so that such detonating fuse and the extending end of the detonator 20 may be operably associated in manner which will be described hereinafter.

The passageway 44 extends through the reduced portion 46 of the barrier member 21, and to this reduced portion 46 is affixed the connector 23, as by screws 48, the connector supporting the shaped charge carrier 10 which consists of a series of ringed supporting members 50 interconnected by copper pins 52, the uppermost ring supporting member being affixed to the connector 23 by a copper pin 54.

Shaped charges 12 are retained within the ringed supporting members 50 and are secured with respect thereto by set screws 56. It is seen that the detonating fuse 14 passes from the passageway 44 over the rearward end of each shaped charge 12, being held in juxtaposition with respect to said rearward ends by straps 58 which are themselves secured to the shaped charges 12 by screws 59. A lower seal 62 is provided for the detonating fuse which is secured as by wire 64 to the lowermost supporting member 50. As indicated in Fig. 1b varying numbers of shaped charges may be accommodated to the structure by merely varying the number of supporting members 50.

Referring now to the means within the firing chamber 42, Fig. 2 shows that within the recess 32 are provided packing rings 66 and 68 and a flanged pin 70. Connected to this pin is the conductor 30. Threaded into the counterbore 72 of the contact sub 26 is a detonator holder 74 which detonator holder is provided with a bore 76 receiving an insulating bushing 78 abutting a necked portion 80 of said bore. Receives within said bushing is the detonator charge 20 which detonator charge extends into the counterbored recess 82 in the end of the detonator holder 74 and which contacts a com-
pression spring 84 which abuts the flange of the flanged pin 70.

At the lowermost portion of the firing chamber 42 is provided a sealing member 86 threaded by an extension 87 into the counterbore 85 of the threaded end 38 of the barrier member 21. Said sealing member is bored to provide for the detonating fuse 14 a substantial continuation of the passageway 44 and connected to said detonating fuse is the booster 18, said booster comprising a thin frangible casing 98 such as aluminum, crimped over the explosive of the detonating fuse 14 and including explosive of higher sensitivity and relatively less density in intimate contact with the detonating fuse explosive. The detonating fuse is provided with a rubber insulating sleeve 92 which overlaps the casing 90 of the booster.

To provide a seal for the firing chamber 42 between booster casing and sealing member 86, a series of resilient gaskets 94 are provided, retained in place by a sealing ring 96. Sealing compression is afforded for said gaskets in addition to support for the booster 18 by a fluid seal gland 98 threaded into the counterbore portion of the sealing member 86. An opening is provided in the cap 100 of the fluid seal gland 98 to expose the booster 18 to the effect of the blast of the detonator charge 20. It will be seen that an O ring 102 is provided as a seal between the sealing member 86 and the contact sub 26 to complete the seal for the firing chamber 42. By the aforesaid apparatus therefor, positive firing through insuring intimate contact between detonator charge and booster or detonating fuse is afforded as is a safe fluid seal. And loss of unfrayed charges in the well through misfiring is prevented, the barrier member 21 interposing between connector 23 and firing chamber 42.

In addition to the seal furnished by the O ring 102, access to the interior of the chamber 42 is denied to well fluids by virtue of the gaskets 94, and indeed fluid pressure merely improves the seal at this point. The fluid seal gland 98 in compressing the aforesaid gaskets guarantees the seal against well fluids even in the absence of substantial well fluid pressure and through its cap 100 prevents a forcing of the booster 18 from its proper position. In complementary fashion the compression spring 84 at all times urges the detonator charge 20 towards intimate firing contact in relation to the booster in addition to providing an electrical conduit between said detonator charge and said booster.

Various modifications and changes from the aforedescribed preferred embodiment of the present invention may occur to those skilled in the art without departure from the essence of the invention, and it is intended to cover herein all such modifications and changes as come within the true scope and spirit of the appended claims.

1. In a well perforating assembly firing head the combination of: an upper firing head element; a lower firing head element removably secured to said upper firing head element, said elements defining a closed firing chamber, to which access is had upon separation of said elements, said lower element having a passageway extending therethrough from the exterior to said firing chamber; a detonating fuse booster supporting member in said firing chamber, said member being removable secured to said lower element and having a bore therethrough forming a continuation of said passageway; sealing means between said member and one of said elements preventing ingress of well fluids to said firing chamber; a detonating fuse booster in the bore of said supporting member; means sealing and rigidly securing said booster in said bore including packing within said bore about said booster and means compressing said packing between said booster and the wall of said bore comprising a gland threaded into said bore from the inner end thereof, said gland having a flange overlapping the inner end of said booster and restraining said booster against movement into said chamber, said sealing means being exposed to pressure of well fluids on the outside thereof; a detonating fuse having an end sealed to the outer end of said booster and extending through said passageway for firing detonating charges supported outside of said firing head; a detonator holder in said firing chamber, said detonator holder being removable secured to said upper element and having a bore therethrough; a detonator charge positioned in the bore of said holder with the lower end of said detonator charge being supported closely adjacent to the inner end of said booster, said detonator being slidable in the bore of said holder away from said booster; resilient means urging said detonator towards said booster; and means for firing said detonator.

2. In a well perforating assembly firing head the combination of: an upper firing head element; a lower firing head element removably secured to said upper firing head element, said elements defining a closed firing chamber to which access is had upon separation of said elements, said lower element having a passageway extending therethrough from the exterior to said firing chamber; a detonating fuse booster in the bore of said supporting member; means sealing and rigidly securing said booster in said bore including packing within said bore about said booster and means compressing said packing between said booster and the wall of said bore comprising a gland threaded into said bore from the inner end thereof, said gland having a flange overlapping the inner end of said booster and restraining said booster against movement into said chamber, said sealing means being exposed to pressure of well fluids on the outside thereof; a detonating fuse having an end sealed to the outer end of said booster and extending through said passageway for firing detonating charges supported outside of said firing head; a detonator charge within said chamber, said detonator charge being resiliently urged to a closely adjacent position with respect to said detonating fuse end; and means for firing said detonator.

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