United States Patent

[11] 3,561,361

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[73] Assignee United States of America as represented by the Secretary of the Army

[54] DETONATION SYSTEM FOR SHAPED CHARGES

4 Claims, 12 Drawing Figs.

[52] U.S. Cl. 102/24
[51] Int. Cl. F42b 1/02, F42b 3/08
[50] Field of Search 102/HC, 24, 27

[56] References Cited

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Primary Examiner—Verlin R. Pendegrass
Attorney—Edward J. Kelly

CLAIM: Claim 1. A shaped charge unit comprising a cylindrical block of solid explosive having a central axis and a cavity in its forward end symmetrical of said axis, a first annular booster coaxial of said axis and positioned about the perimeter of said block at the rearward end thereof, a second booster positioned on said axis over the rearward face of said block and in discrete relation with said first booster, means associated with said block and forming a circular chamber coaxial of said axis and rearwardly of the rear face of said block, there being first and second frustoconical channels from the perimeter of said chamber leading to said first and second boosters, respectively, the slant length of said first channel being less than the corresponding length of said second channel, explosive composition filling said chamber and channels, and a single initiator on said axis in central detonating relation with the explosive composition in said chamber.

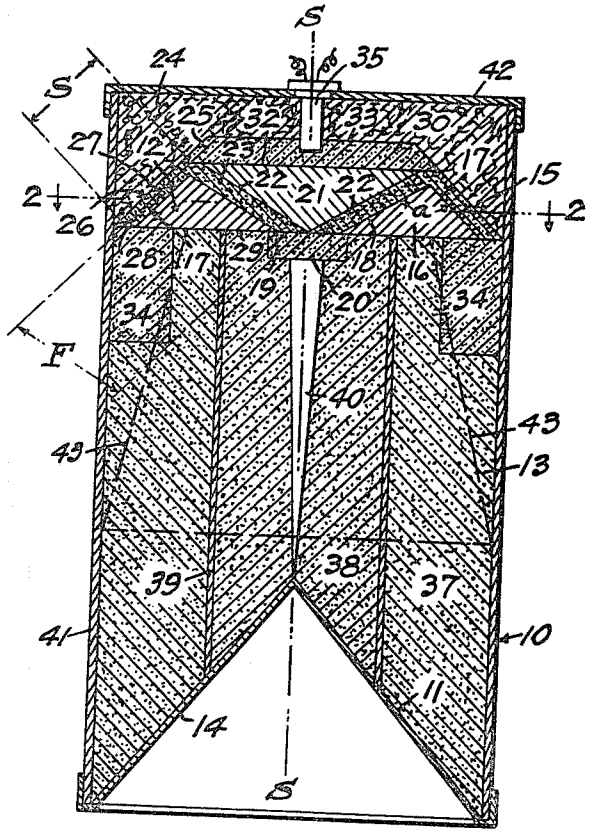

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Fig. 1.

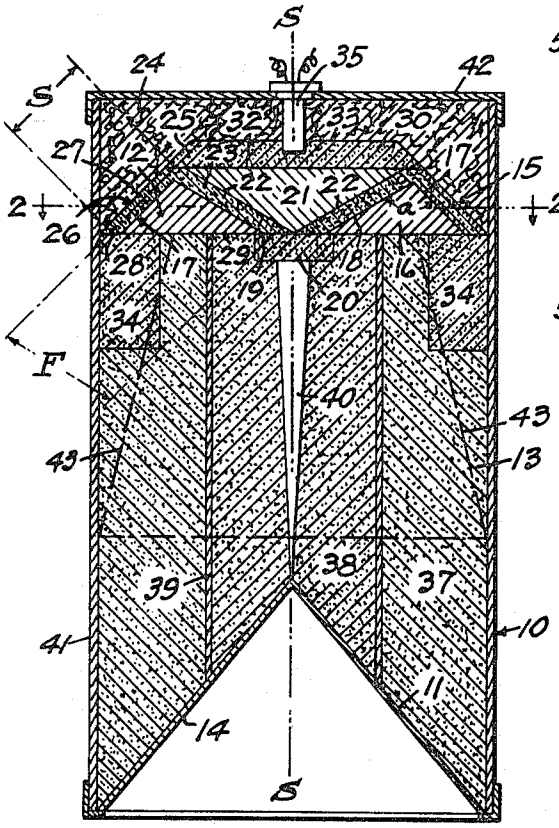

Fig. 3.

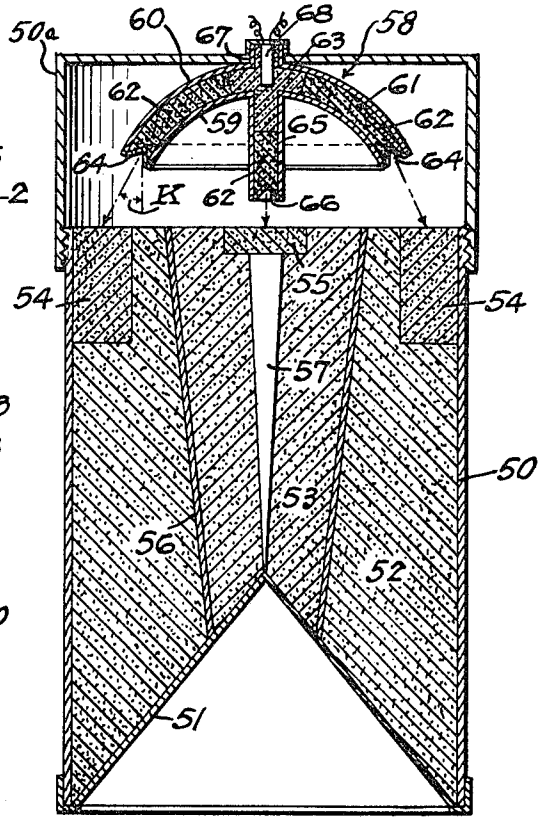

Fig. 2.

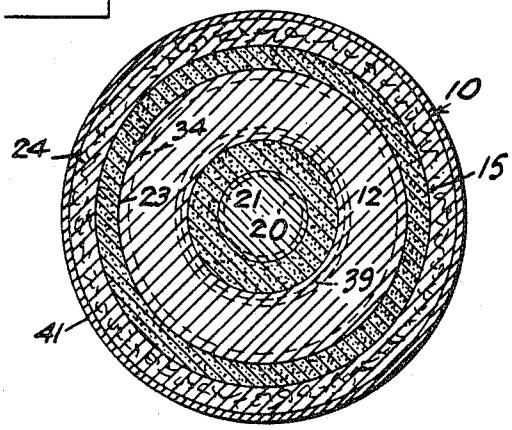

Fig. 4.

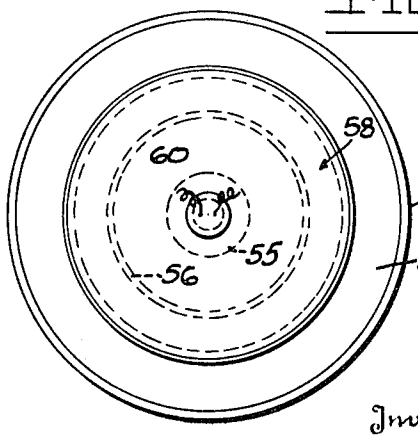

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Fig. 5.

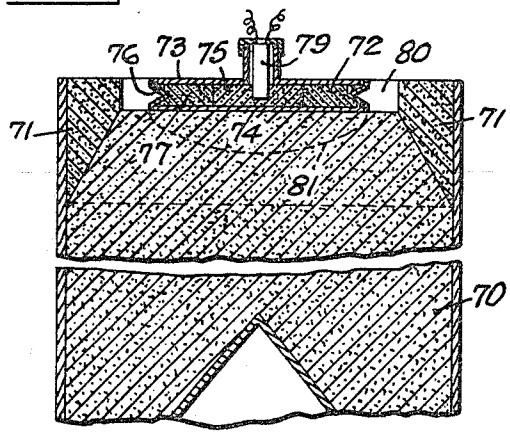

Fig. 8.

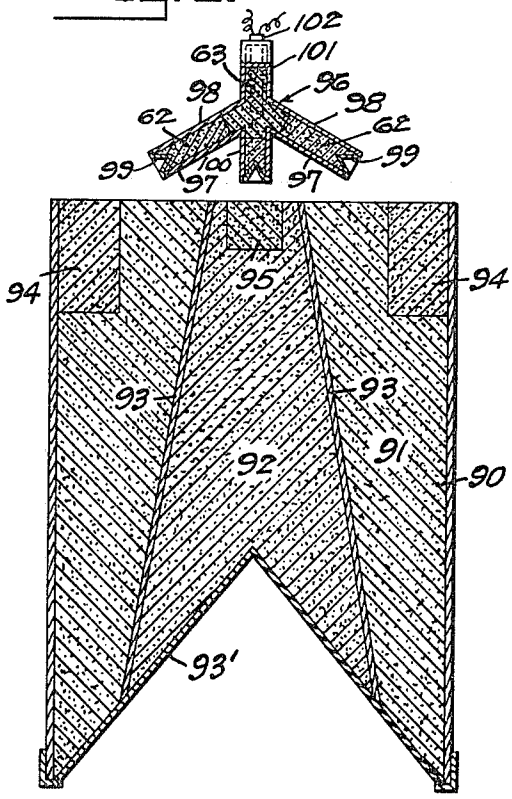

Fig. 6.

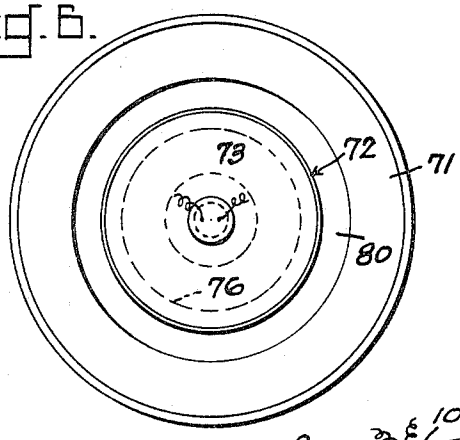

Fig. 7.

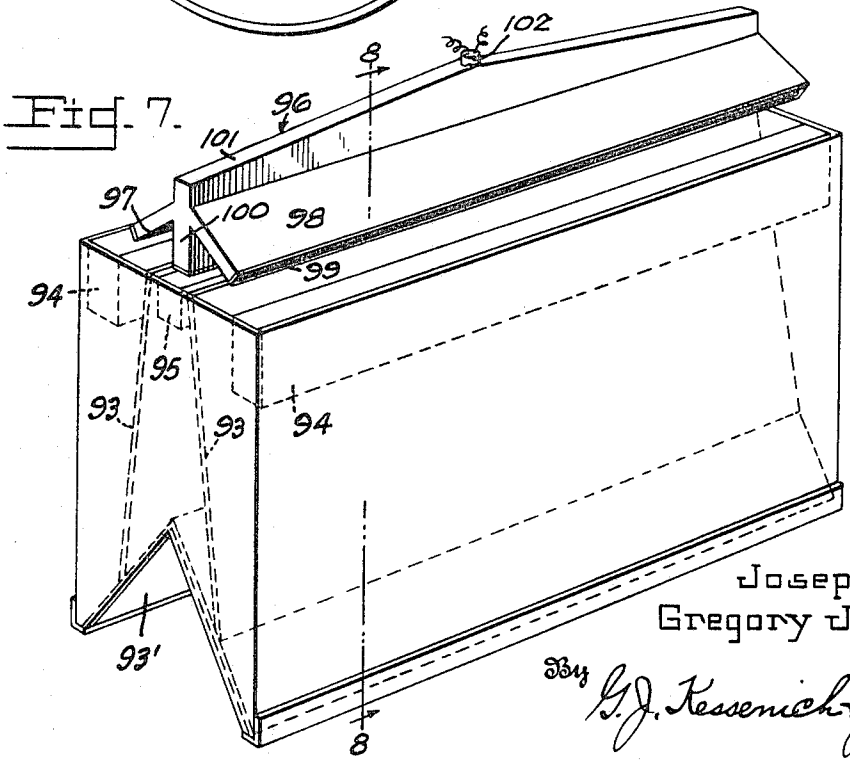

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Fig. 9.

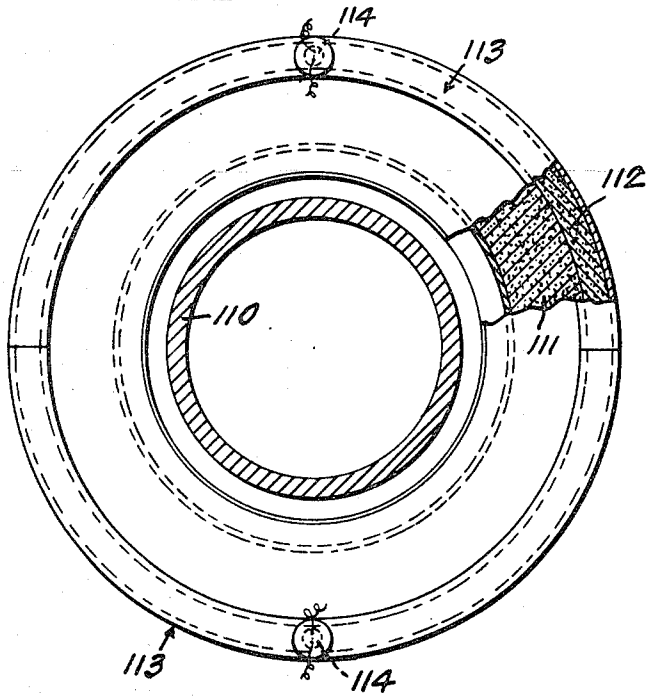


Fig. 10.

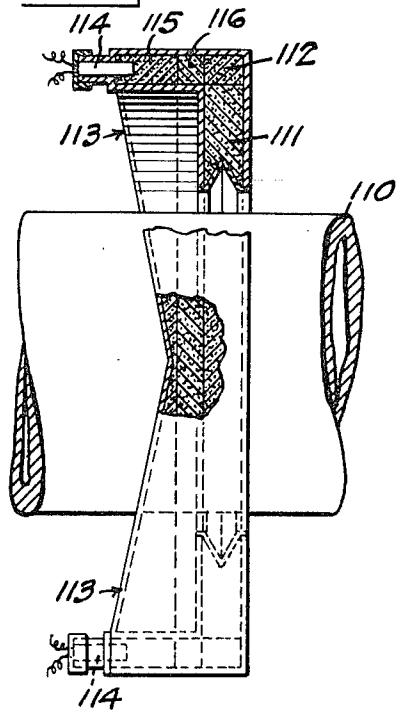


Fig. 11.

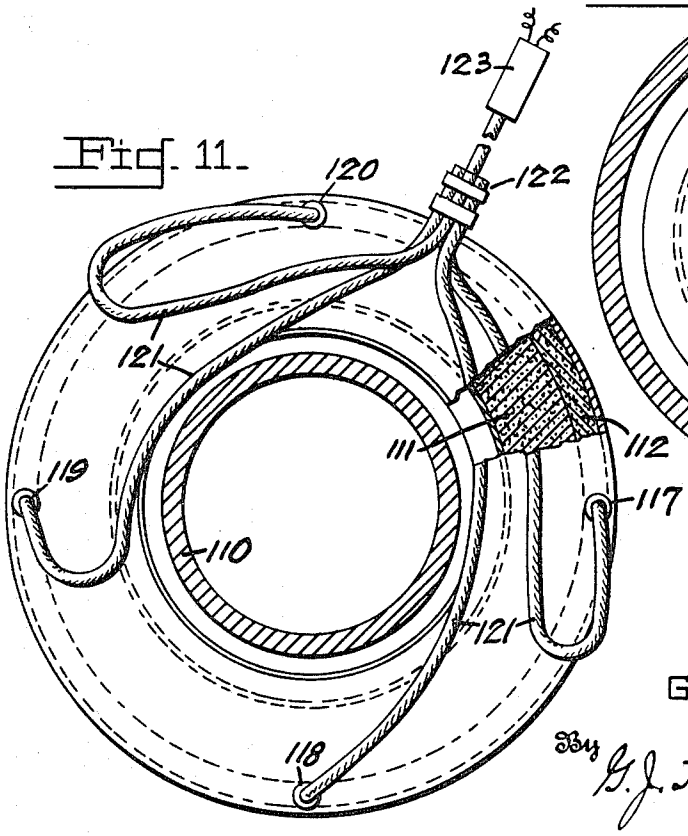
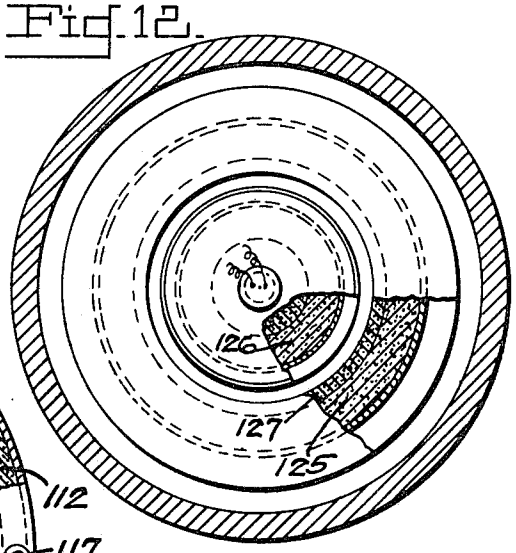


Fig. 12.



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DETONATION SYSTEM FOR SHAPED CHARGES

This invention relates to the art of detonating shaped charges.

One of the principal objects of our invention is to provide a system for detonating shaped charges which will very considerably increase the effectiveness of a charge of this type independently of the external configuration thereof.

Another important object of our invention is to provide a system for detonating shaped charges which will be effective to cause certain zones, or volumes, of explosives included in charges, having certain external geometric configurations of simple form, to have an additive effect to the total explosive effect that may be obtained from charges having these external configurations through detonation systems available to the art prior to our invention; thus, at once utilizing these otherwise ineffective volumes to produce useful energy and obviating the reason for eliminating such zones, or volumes, from the charge and resulting comparative complex external configurations characterizing present shaped charges.

Still another object of our invention is to provide a detonation system adapted to initiate detonation of a shaped charge in selected separate zones thereof in such manner as to achieve more efficient collapse of the cavity liner, if the charge is so provided and in all cases more effective action of the jet formed, upon detonation of the charge.

Another object of our invention is to provide a system for detonating and controlling the detonation waves in a shaped charge so as to effect more efficient liner collapse and/or jet action upon detonation of the charge.

The stated objects as well as others will be apparent from the following description when considered with the accompanying drawings in which like reference characters refer to like elements throughout the several views, and wherein:

FIG. 1 is a vertical sectional view through a lined shaped charge showing one form of detonation system in accordance with our invention;

FIG. 2 is a transverse sectional view taken upon line 2–2 of FIG. 1;

FIG. 3 is a vertical sectional view through a lined shaped charge showing another form of detonation system according to our invention;

FIG. 4 is a plan view of the charge and detonation system shown in FIG. 3;

FIG. 5 is a vertical sectional view through a lined shaped charge showing still another form of detonation system within the purview of our invention;

FIG. 6 is a plan view of the charge shown in FIG. 5;

FIG. 7 is a perspective view of a lined linear shaped charge provided with a detonation system in accordance with the teachings of our invention;

FIG. 8 is a vertical sectional view taken upon the line 8–8 of FIG. 7;

FIG. 9 is a front elevation partially in section of an annual, or arcuate, linear shaped charge in circumscribing position relative to a target and provided with a detonation system pursuant to our invention;

FIG. 10 is a side elevation partially in section of the charge shown in FIG. 9;

FIG. 11 is a view similar to FIG. 9 showing a modified form of detonation system; and

FIG. 12 is a front elevation partially in section of an annual, or arcuate, linear shaped charge in relative circumscribed position with respect to a target in combination with a detonation system according to our invention.

Referring now to the drawings there is shown in FIG. 1 a lined shaped charge 10 symmetrical about, or having a cross section symmetrical about, the line of symmetry S–S, which extends through, or contains the centers of the cavity 11 and base 12. The cavity 11 may be of any symmetric shape suitable to effect desired direction of the force resulting from detonation of the explosive body 13 of the charge, all in a manner now well known in the art, and the cavity may be lined with a liner 14 fitting the cavity. The liner may be made of any appropriate metallic or nonmetallic material and of a thickness which will best serve the particular purpose at hand.

The detonation system of our invention as shown in FIG. 1 comprises a detonator generally indicated at 15 and is formed of an annular base element 16 having outer surfaces 17 and inner surfaces 18 arranged in relative converging relation in an axial direction away from the charge. The base element 16 is arranged symmetrically about the line of symmetry S–S and provides, in the form here illustrated, a circular opening 19 symmetrical about line S–S, which provides a means of communicating detonation to the booster 20 for explosive body 13, as hereinafter more clearly shown. Within the space defined by the inner surfaces 18 of the base element there is suitably arranged an inverted generally conically shaped intermediate element or member 21 with the axis thereof generally coinciding with the line of symmetry S–S and the slant surfaces 22 thereof spaced from and cooperating with inner surfaces 18 of base element 16 to define a first detonator cavity 23 terminating in or just above the opening 19. A cap element 24 formed with an interiorly disposed truncated generally conical recess 25 is arranged to receive the base and intermediate elements as shown in FIG. 1. As shown, the adjacent slant wall portion 26 of the cap which defines the corresponding portion of recess 25 is spaced from the outer surfaces 17 of base element 16 and cooperate therewith to form a second detonator cavity 27 which terminates in an annular opening 28 in the base plane 29 of the base element in concentric relation to the opening 19 and which functions to communicate detonation to the booster 34. A third cavity or fuse powder well 30 is formed between the surface 32 of intermediate element 21 and surface 33 of the cap element 24. The fuse powder well 30 communicates with the first and second detonator cavities as indicated in FIG. 1.

An initiator 35 for igniting fuse powder charged into the fuse powder well or cavity 30 may be inserted through a suitable opening arranged through the cap element along the line S–S for the purpose and may be affixed in operative position through a frictional fit in the opening or by any other conventional securing means adaptable to the purpose.

In use the first and second detonator cavities will be charged with explosive adapted to be detonated by the particular fuse powder with which the well or cavity 30 is charged, and in turn adapted to detonate the boosters 20 and 34 which will thereupon detonate the explosive body 13.

The detonator 15 as illustrated in FIGS. 1 and 2 is particularly adapted to the detonation of shaped charges having an external cylindrical or generally similar configuration and may with slight obvious modification be adapted to use for detonating linear charges.

The slant length of the first detonator cavity 23 as measured from the intersection of this cavity with fuse powder well 30 to the opening 19 as indicated at F in FIG. 1 is illustrated as being greater than the slant length of the second detonator cavity 27 as measured from the intersection of this cavity with the fuse powder well 30 to the annular opening 28 and indicated at S. The reason for this exists in the fact that by virtue of our construction the fuse powder in the fuse powder well 30 can be made to detonate the explosive in the first and second detonator cavities substantially simultaneous, and that in the case where explosive body 13 is constituted of a single explosive compound or mixture and is generally formed to have the external shape shown in FIG. 1 it is desirable to detonate the body 13 through booster 34 slightly earlier than the body is detonated through booster 20 for reasons hereinafter stated. In making the slant length of cavity 27 slightly less than the slant length of cavity 23 the differential order of detonation desired is achieved.

While we have illustrated F as being greater than S in FIG. 1 we can, where it is desirable to do so because of the explosive body 13 being constituted of explosive components having different detonation velocities, make F equal to S, or make F less than s by simply varying the angle *a* of relative convergence of the surfaces 17—18 of base element 16 together with the sur-

faces cooperating therewith to define the detonator cavities 23 and 27.

While the detonator cavities are shown to be relatively converging at an obtuse angle, angle *a* may be an acute angle where it is desirable to make both openings 19 and 28 annular openings extending in the same general direction from fuse powder well 30 at small angular difference.

To make opening 19 annular instead of circular in shape it is only necessary to position the apex of intermediate member or element 21 further along line S–S toward the cavity of the charge, it being recognized that for ease of construction that member 21 may be truncated when it is desired to provide an opening 19 annular in shape of any appreciable radius.

We may also considerably vary the size and shape of cavities 23 and 27 by simply varying the shape of surfaces 17-18-etc. which cooperate to define the cavities and for some purposes we may make the surface of base element disclosed in plane 29 either concave or convex for certain controls of the detonation process.

We may also alter the size of the intercommunication openings between cavities 23-27-30 by varying the method of intersecting these cavities in any of a number of methods which will be apparent to those skilled in this art.

The explosive body 13 may, if desired, be constituted of a component 37 and a component 38 of detonable explosives having different detonation velocities in which event the slant lengths F and S of cavities 23 and 27 would be varied accordingly. We have shown a barrier 39 made of paper, plastic, glass, suitable metal, or similar material, separating the charge components 37, 38 and for influencing the shape of the detonation wave fronts formed by the components upon detonation thereof. For the same purpose we have provided the component 38 with a conically shaped core 40 made of material similar to the material used for the barrier 39.

The charge may be encased in a suitable container 41 provided with a closure 42.

For the purpose of illustrating one advantage inherent in the operation of our detonation system it may be assumed that explosive body 13 is composed of a single component of detonable explosive compound or mixture. Such a component detonated by the conventional axial detonation system is ineffective as to that volume of the explosive indicated as lying in the space externally of the dotted lines 43, due to the relative late detonation thereof, and for this reason accounts for the odd shapes given to these regions of conventional shaped charges. By proper selection of S in our detonation system it is possible to detonate this volume of the explosive body through booster 34 in point of time sufficiently prior to detonation of the explosive body in its axial region at its base by means of booster 20 that the detonation waves therefrom will be additive to the detonation waves emanating from the principal part of the explosive body and will, therefore, enhance the collapsing effect on the liner 14 as well as the action of the jet resulting from detonation. The advantages in this system are quite apparent and need not be enumerated.

The same result may be achieved with body 13 being formed with components 37—38 of explosives having different detonation velocities and varying the lengths F–S accordingly so as to differentially detonate the components in point of time to effect desired timed relation impact of the forces resulting from detonation of the two components upon the liner 14. Either component 37 or 38 may be the fastest detonating explosive and the same result achieved by adjusting lengths F–S. The barrier 39 and core 40 assist the detonation process by exercising a governing influence upon the inherently characteristic lateral expansion of the detonation waves formed upon detonation of the components.

In the claims, the term "effective length" means the distance as illustrated at F and S, FIG. 1, that is, the length of the shortest path along which the detonation wave must pass between chamber or cavity 30 and the respective booster charges 20 and 34.

The detonation system disclosed in FIGS. 3 and 4 accomplishes the same result as the system shown in FIGS. 1 and 2, but employs a different type of detonator, one which utilizes the shaped charge principle. In these views a shaped charge of cylindrical or similar external configuration is indicated at 50 and has a liner for the cavity of any desired shape as indicated at 51. The explosive body of the charge may, but does not necessarily have to be, comprised of components 52 and 53 having the same or different detonation velocities and detonation thereof may be initiated by boosters 54 and 55, respectively. The booster 54 may be annular in plan form and the booster 55 may be circular in plan form, both as in the case of boosters 20 and 34 of FIG. 1. For the same reason as the barrier and core are provided in the charge of FIG. 1 the charge components 52 and 53 of this form may likewise be separated by a barrier 56 of similar material to barrier 39 and the component 53 may have an axial core 57 similar to core 40. In this case, however, barrier 56 is of inverted truncated conical form to direct the detonation waves from the two components 52 and 53 upon liner 51 in a slightly different form to accentuate the effect of the waves upon different parts of the liner.

The detonator indicated in its entirety at 58 is comprised of a pair of generally concentric spherical members 59—60 separated to form a space or cavity 61 in which a detonable explosive 62 may be charged in the outer zone of the space 61 and a suitable fuse powder 63 charged in the inner zone of the space. The outer end portion of the explosive may be shaped to form an annular cavity of suitable configuration, such as any of the shapes employed in shaped charges and this cavity may be lined with a liner 64 complemental in shape to the cavity, which can be made of any appropriate material, and which serves as a closure for the outer end of space 61. As clearly shown the detonator assembly 58 also includes an axially disposed depending detonator 65 provided with a lined shaped end portion 66. A cap member 50*a* locates the detonator assembly 58 in fixed relation to the booster charges 54 and 55. Detonator 65 may be made to depend below the lower edges of the spherical members 59—60, as viewed in FIG. 3, so as to facilitate obtaining a greater ratio of fuse powder 63 to detonating explosive 62 than is provided in space 61 whereby detonation of the depending detonator 65 may be differentially timed relative to the spherical detonator.

The uppermost spherical member 60 is provided with an upstanding axially disposed tubular protrusion 67 adapted to receive and be utilized to affix in position a suitable initiator 68.

By shaping the detonable explosive of the detonator as indicated at 64 and 66 the force effect of detonation will be directed along the lines as indicated by the arrows in FIG. 3 and by virtue of the concentrated effect of these forces will be effective through a substantial air or similar gaseous medium to impinge upon the boosters 54—55 within the relative narrow transverse zones thereof.

Although we have shown the liner 64 and complemental cavity to be annular in form we also contemplate forms comprised of any desired arcuate portion of the annulus shown. We also contemplate any variations in angle K shown in FIG. 3, negative or positive, to correspondingly vary the line of action of the spherical detonator, which may be conveniently accomplished by making members 59—60 either greater or lesser segmental portions of the spheres containing them.

As previously mentioned we may vary the ratio of fuse powder 63 to detonable explosive 62 in both the spherical detonator and depending detonator to control the timing of detonation of these two detonator components of detonator 58 as desired.

The system shown in FIGS. 5 and 6 is generally similar to the system shown in FIGS. 3 and 4. In this system a shaped charge 70 is provided with an annular booster 71 which may be detonated by an annular detonator 72. Detonator 72 is shown as being comprised of a pair of spaced circular members or plates 73 and 74 providing a space or cavity 75 closed at the outer end by a liner-closure 76 of suitable shaped form

and made of any appropriate material. Detonable explosive 77 is charged in an annual outer portion of space 75 and a fuse powder is charged in the space inwardly of the explosive 77. The fuse powder may be ignited by an initiator 79 mounted in the same manner as initiator 68. The detonator may detonate booster 71 through the air gap 80 and if desired the explosive body of charge 70 may be constituted of two components separated by a barrier and/or provided with a core as in FIGS. 1 or 3. We also contemplate using a concave or convex insert indicated at 81 to influence wave front formation of the detonation wave if desired.

By shaping the members 73—74 rectangularly instead of circularly the detonator 72 may readily be adapted for use with a linear shaped charge. In this case the booster 71 instead of being annular would be comprised of two parallel sections symmetrically disposed about the longitudinal line of symmetry of the linear charge and the liner 76 could be omitted from the ends of the detonator.

A detonator system is shown in FIGS. 7 and 8 which is especially suitable for use with linear charges. The system is quite similar to the system shown in FIGS. 3 and 4. A charge 90 is shown comprised of an explosive body constituted of two components 91 and 92 separated by upwardly converging barrier walls 93 slightly different in form than the barriers shown in FIGS. 1 and 3 to have a slightly different action on the detonation waves impinging upon the linear liner 93' Longitudinal side and central boosters 94, 94 and 95 are provided although the central booster 95 may be omitted if desired.

A detonator generally indicated at 96 is comprised of a pair angularly shaped spaced parallel members 97 and 98 joined at the outer ends thereof by closure liners 99 of suitably shaped configuration to correspondingly shape the detonable explosive charged into the space or cavity between the members 97—98. A central longitudinal extending depending shaped detonator component indicated at 100 is provided as shown. To effect substantially instantaneous detonation of the explosive 62 charged in the space between the angular members 97—98 the protuberance 101 is extended to substantially a central point longitudinally of the charge as shown and an initiator 102 may be affixed in a manner similar to the method used in affixing the initiators 68 and 79 to the respective cooperating detonators.

As in the form of FIGS. 3 and 4 the ratio of fuse powder 63 to explosive 62 in the two detonator components of the detonator of FIG. 7 may be varied to obtain differentially timed detonation of the two components.

It is contemplated that detonators 96 may be employed in abutting relation, if required by the length of the linear charge, and that in such cases the outer end portions the liners 99 and the liner for the depending detonator component may be given a slight angular bend so as to ensure overlapping of the detonation forces upon the boosters at the abutting ends of the detonators. When detonators 96 are used in abutting relation under the conditions stated action of initiators 102 would be initiated simultaneously.

FIGS. 9 and 10 disclose a form of our detonation system especially adapted for external use against a target having an external circular or arcuate configuration. For convenience of illustration we have shown a tubular target 110 to be attacked externally by an annular or arcuate shaped charge 111 provided with a lined shaped cavity of any symmetric form, but for purposes of illustration shown to be of triangular cross section.

Where conditions will not permit the employment of detonators of the type indicated at 113 in FIG. 10 the charge 111 may be detonated through the booster 112, which is detonable at spaced angular points, such as the points 117, 118, 119, 120, more or less, by means of primacord or similar detonable fuse elements 121 of equal length and detonable from a single station 122 through an initiator 123, all as shown in FIG. 11.

The system of detonation disclosed in FIG. 12 employs a detonator very similar to the detonator 72 shown in FIG. 5 with an annular or arcuate lined shaped charge 125 adapted to be circumscribed by and attack the interior of a target having a circular or arcuate interior configuration. The detonator 126 is identified by the same reference characters identifying like elements of detonator 72 and functions to initiate detonation of charge 125 through the booster 127 in the same manner that detonator 72 functions to initiate detonation of charge 70 through booster 71.

The charge 111 is provided with a booster 112 which may be simultaneously detonated throughout its arcuate extent by one or more detonators 113 suitably affixed in any appropriate manner to charge 111 in the relation shown in FIG. 10. Each detonator 113 is provided with an initiator 114 located at substantially a central point of the detonator so as to initiate burning of the fuse powder 115 which in turn is so arranged as shown as to cause simultaneous detonation of the detonable fuse explosive 116 throughout its length all in a manner similar to the manner in which the detonator 96 functions. In the example shown two detonators 114 are illustrated, any number of these detonators may be employed with provision being made for simultaneous energization of the initiators 114. A single detonator 113 may be employed if conditions will permit the formation thereof in a funnel shaped form with the apex of the funnel lying on the longitudinal axis of the target as shown in FIG. 10 and the initiator 114 at the apex of the funnel.

In certain special applications we contemplate use of detonators of the type shown in our prior U.S. Pat. Nos. 2,232,690, 2,359,301 and 2,426,997 in detonation systems of the type herein disclosed where it is desired to initiate detonation of the explosive in an annual zone.

We claim:

1. A shaped charge unit comprising a cylindrical block of solid explosive having a central axis and a cavity in its forward end symmetrical of said axis, a first annular booster coaxial of said axis and positioned about the perimeter of said block at the rearward end thereof, a second booster positioned on said axis over the rearward face of said block and in discrete relation with said first booster, means associated with said block and forming a circular chamber coaxial of said axis and rearwardly of the rear face of said block, there being first and second frustoconical channels from the perimeter of said chamber leading to said first and second boosters, respectively, the slant length of said first channel being less than the corresponding length of said second channel, explosive composition filling said chamber and channels, and a single initiator on said axis in central detonating relation with the explosive composition in said chamber.

2. In a shaped charge unit, a body of solid explosive having a central longitudinal axis, and a cavity in its forward end symmetrical of said axis, a first annular booster charge in detonating relation with the rear end of said body about the periphery thereof and coaxial of said axis, a second booster charge in detonating relation with the rear end of said body and positioned on said axis in centralized spaced relation with respect to said first booster charge, detonator means associated with said body and operable to initiate said first and second booster charges sequentially in the order mentioned, said detonator means comprising means forming discrete annular shaped channels from a common apex to said first and second charges, explosive filling said channels, a single initiator positioned on said axis, and fuse material associating said initiator and explosive at said apex throughout the circumference thereof, the effective lengths of said channels being different one from the other.

3. A shaped charge unit as recited in claim 2, the effective length of the channel leading to said second booster being greater than the corresponding length of the channel leading to said first booster.

4. In a shaped charge, a substantially cylindrical body of explosive having a longitudinal axis of symmetry and a lined cavity in its forward end symmetrical of said axis, an explosive train for detonating said body, the elements of said explosive

train juxtaposed in sequential detonating relationship, said explosive train comprising a first booster charge in detonating relation with said body at the rearward end thereof and in radially spaced coaxial position about said axis, a second booster charge in detonating relation with said body at the rearward end thereof and positioned on said axis in spaced relation with said first booster charge, a first detonating charge extending into detonating relation with said first booster charge, a second detonating charge extending into detonating relation with said second booster charge, a fuse charge in detonating relation with said first and second detonating charges, and a primer extending within said fuse charge, said first detonating charge housed within a pair of concentric surfaces symmetrical about said axis, said surfaces defining between them a continuous forwardly and outwardly directed chamber opening toward said first booster charge, said second detonating charge housed within a tubular passageway extending from said chamber and opening toward said second booster charge, said first and second detonating charges shaped to direct initiating jets upon said booster charges.