

[54] **EXPLOSIVE INITIATOR DEVICE**

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[51] Int. Cl. **F42c 19/08; F42d 1/04**

[58] Field of Search **102/22-24, 102/DIG. 2**

[56] **References Cited**
UNITED STATES PATENTS

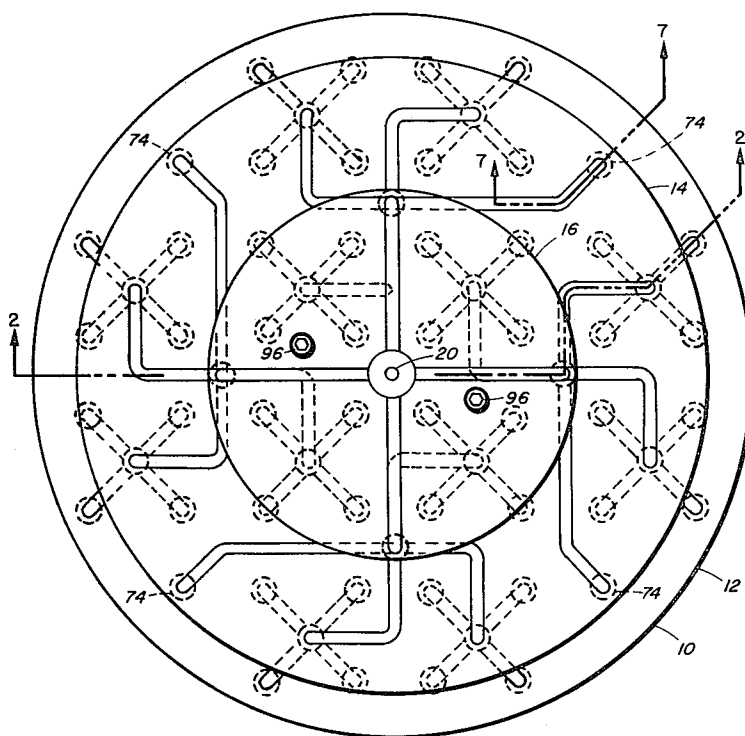
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[57] **ABSTRACT**

A device for simultaneously transferring a single explosive detonation from an initial detonation point to a plurality of detonation points. The device comprises four circular plates arranged in a stacked configuration with each plate including an arrangement of intersecting slots in which lengths of heat resistant mild detonating cord are positioned terminating in explosive booster ends. The explosive booster end of each detonating cord is positioned superjacent to the point of intersection of an arrangement of slots in a subjacent plate. In a preferred embodiment, the uppermost plate has four explosive terminations, the plate subjacent thereto sixteen, the next subjacent plate fifty-two with the lowermost plate having fifty-two explosive charges.

3 Claims, 12 Drawing Figures


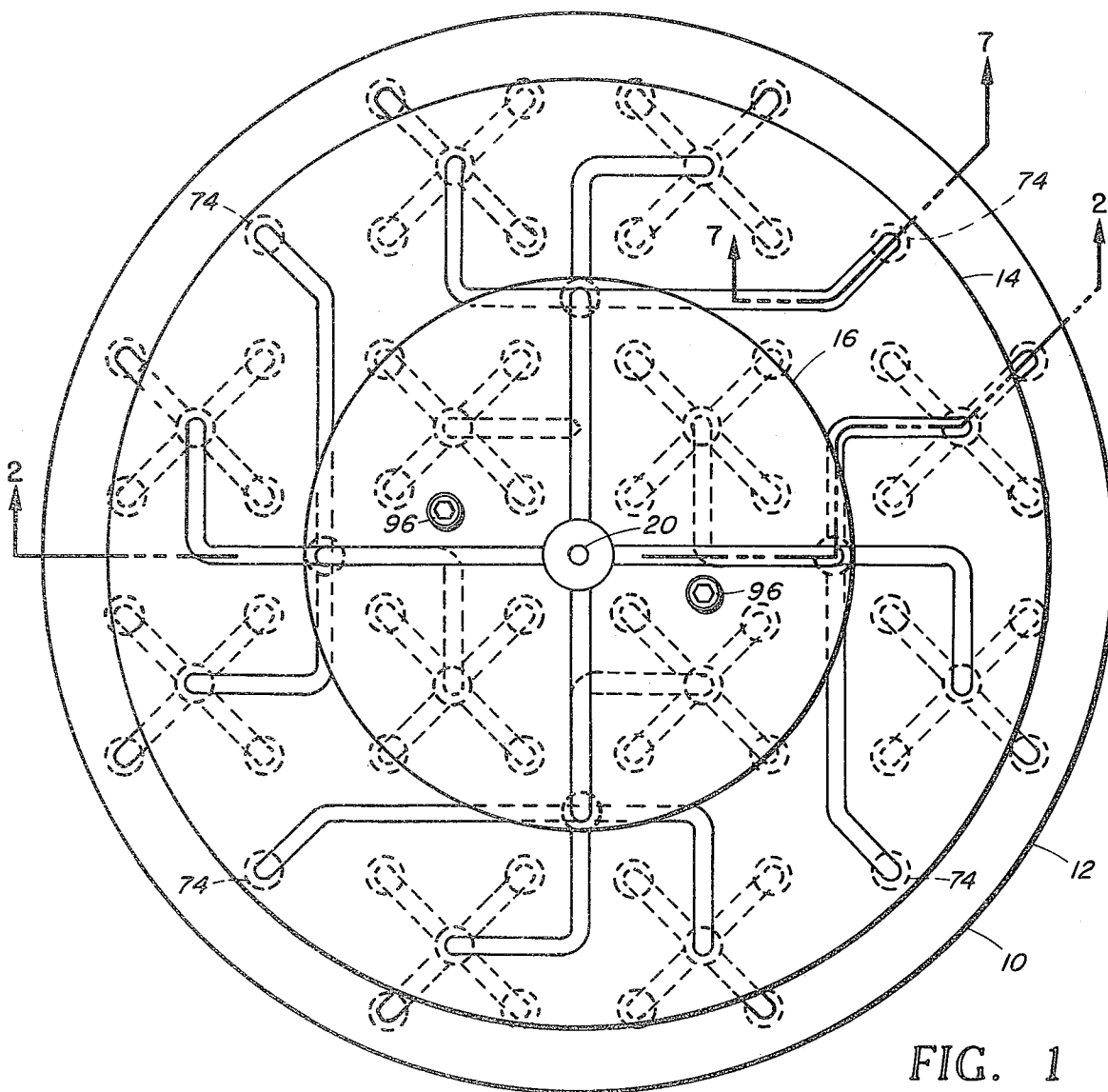


FIG. 1

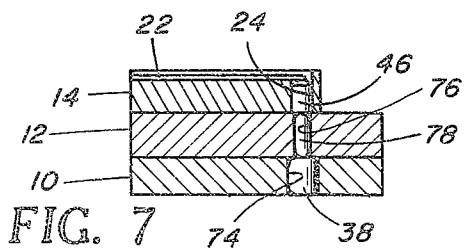


FIG. 7

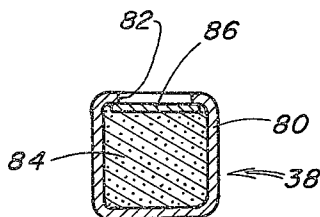


FIG. 8

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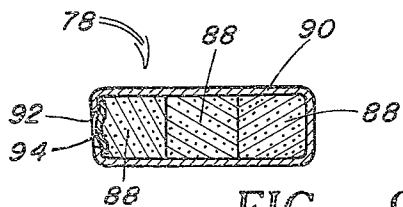


FIG. 9

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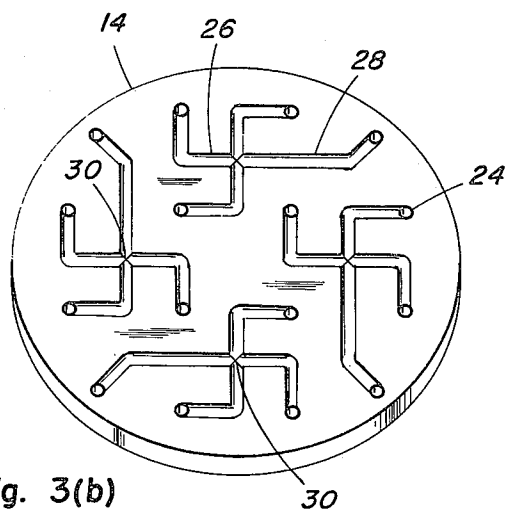


Fig. 3(b)

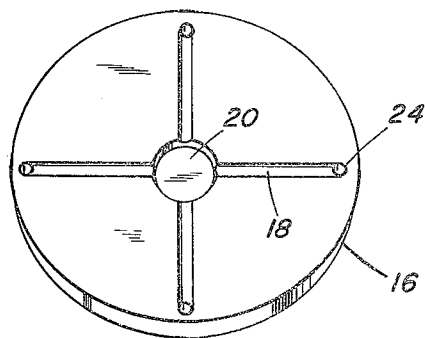


Fig. 3(a)

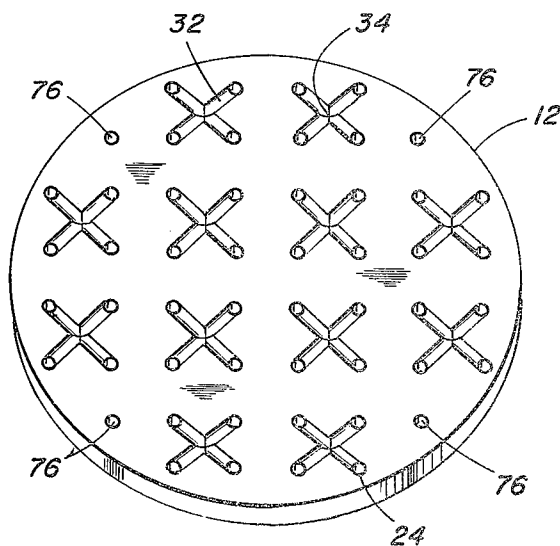


Fig. 3(c)

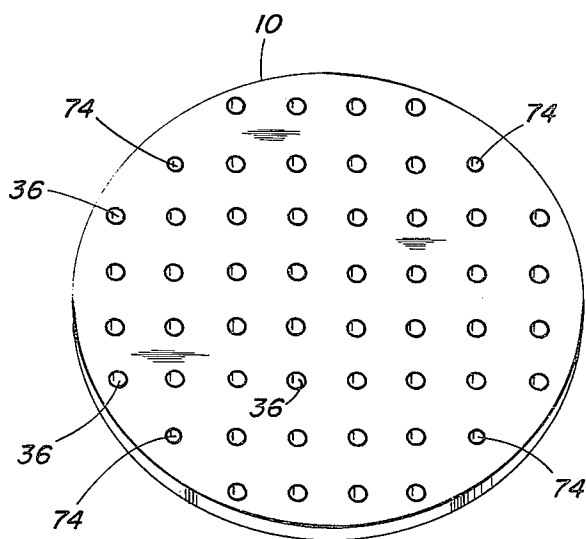


Fig. 3(d)

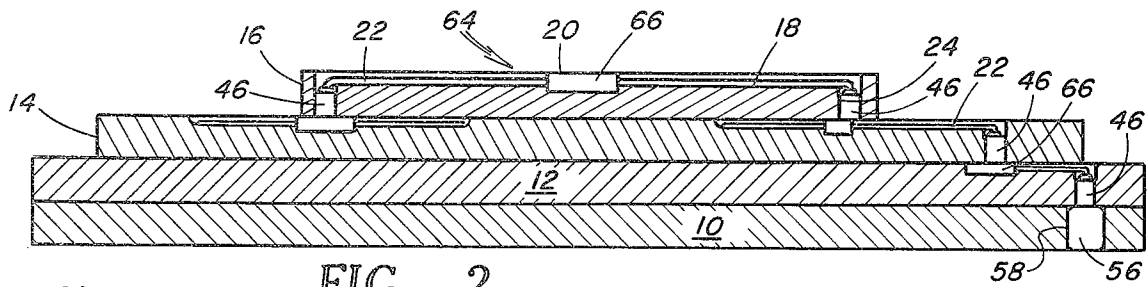


FIG. 2

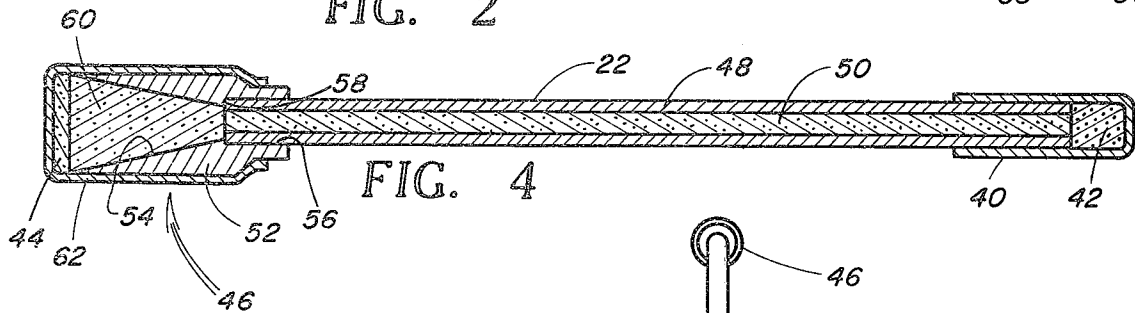


FIG. 4

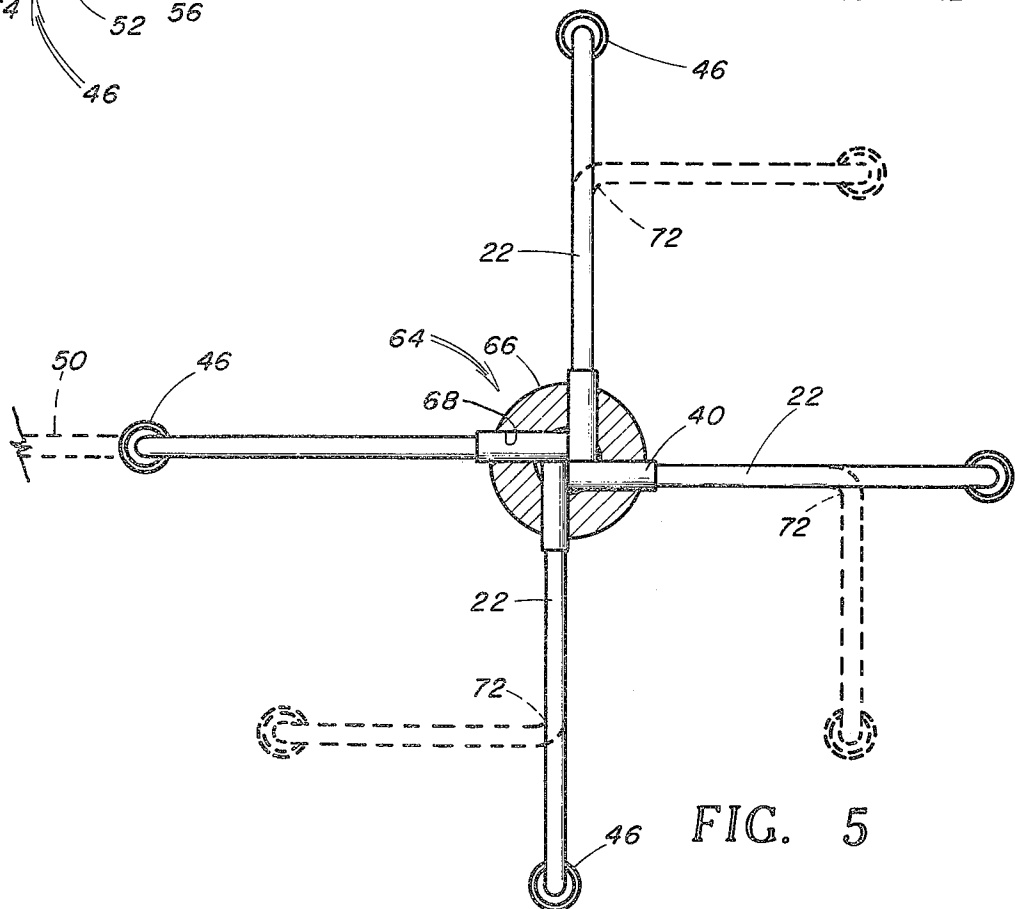


FIG. 5

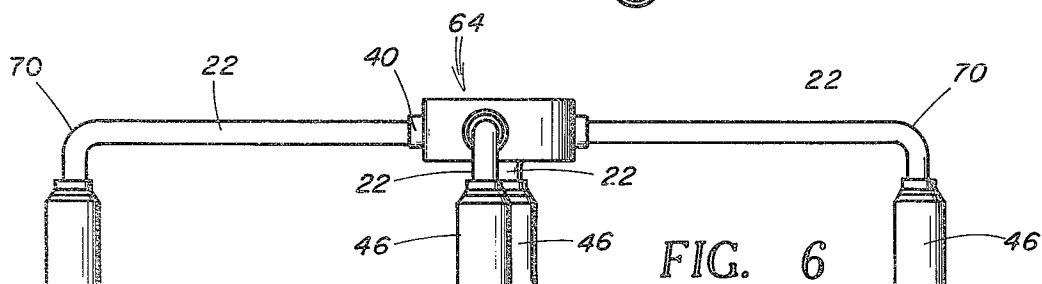


FIG. 6

EXPLOSIVE INITIATOR DEVICE

BACKGROUND OF THE INVENTION

This invention relates generally to explosive initiators and more particularly to a multipoint simultaneous explosive initiating device.

In many diverse applications it is desirable to employ an explosive charge in which the generated detonation front arrives simultaneously at a plurality of predetermined points on a particular geometric surface. It has been found practical, for example, to emboss a metal surface by means of a detonation front which is made to arrive simultaneously at a plurality of points on the surface of the metal. Further, by placing the surface at which the plurality of simultaneous explosive initiations occur in abutting relationship with the surface of a block of homogeneous explosive material a plane explosive detonation wave may be generated within the block of explosive. The use of such a device is important in basic scientific investigations of explosive phenomena such, for example, as the exceedingly high pressures of short duration created upon the simultaneous ignition of a plurality of points on a particular surface. Recently, a need has arisen in applications such as those mentioned hereinbefore, for such a simultaneous detonation system to be operable in high temperature environments.

In the past, detonation systems have been devised in various forms. One such system utilizes a large number of electric initiators. Another comprises apparatus in which the detonation wave is transmitted between charges by flying plates or fragments. In addition, systems utilizing stacked configurations such as multiple layers of flexible sheet explosive material separated and supported by an inert elastomer and systems having a plurality of layers of a tap-sensitive high explosive with each explosive layer being separated from the adjacent layer by a barrier plate provided with an array of detonation-transmitting channels have been used with some degree of success.

However, almost all of these prior art systems possess certain distinct disadvantages. Inherent in each of them is the use of highly sensitive explosive materials. As a consequence, it is not uncommon to have a premature initiation of a few of the points on the surface due to the extreme sensitivity of the explosive employed. The multiple electric detonator systems involve both costly and bulky apparatus while the moving metal detonator systems must be especially designed for each detonation wave configuration desired. Moreover, none of these systems give any degree of structural integrity when used in circumstances requiring a high degree of strength and rigidity such, for example, as when the initiator is desired to physically separate two compartments in a vehicle, such as a torpedo. Finally, none of the aforementioned devices have been designed to be used with "heat resistant explosives" which expression, for the instant purposes defines those explosives having a melting point above 300° C and a vacuum thermal stability such that they decompose at a rate less than 2.0 cc/gm/hr at 260° C.

The primary reason for the inability of the prior art devices to use heat resistant explosives is that the shock intensity of the detonation front developed by the heat resistant explosive is substantially smaller than the shock intensity of the detonation front developed by conventional explosives. For this reason it has been im-

practical until recently to employ a heat resistant explosive in a multipoint simultaneous detonation system.

Accordingly, one object of this invention is to provide a new and improved explosive device in which a detonation that originates at a single point therein arrives simultaneously at a plurality of points on a surface.

Another object of the invention is the provision of a new and improved detonation initiating and wave shaping device having substantial strength characteristics.

Still another object of the present invention is to provide a new and improved explosive detonation device utilizable with heat resistant explosives.

A further object of the instant invention is to provide a new and improved detonation wave shaping system which may utilize mild detonating cord to transmit a detonation front from a single detonation point in one plane simultaneously to a plurality of detonation points in another plane.

Briefly, in accordance with one embodiment of this invention, these and other objects are attained by providing a stacked array of a plurality of plates wherein the path of detonation transfer from a centrally located position in the uppermost plate is converted into an increasing number of detonations effected by configurations of detonating cords of geometric symmetry and of equal lengths in each successive plate, finally terminating in a series of points of simultaneous explosive initiations in the lowermost plate.

BRIEF DESCRIPTION OF THE DRAWING

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a plan view of the explosive detonation device of the present invention illustrating the various paths along which the detonation front travels;

FIG. 2 is a cross-sectional view of the device taken along line 2—2 of FIG. 1;

FIGS. 3(a) to 3(d) are perspective views of the individual plates which comprise the device;

FIG. 4 is a sectional view of a typical detonating cord and the apparatus associated therewith used to transmit the detonation wave through the device;

FIG. 5 is a plan view of a typical assembly of detonating cords with a modification thereof shown in phantom;

FIG. 6 is a side view of the assembly of FIG. 5;

FIG. 7 is a partial cross-sectional view of the device taken along line 7—7 of FIG. 1;

FIG. 8 is a sectional view of an explosive charge of the present invention; and

FIG. 9 is a sectional view of an explosive lead of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings wherein like reference characters designate identical or corresponding parts throughout the several views, and more particularly to FIGS. 1 and 2 thereof, the explosive initiator of the present invention is shown as including a series of thin circular plates 10, 12, 14 and 16 which are stacked superjacenty in a concentric and contacting fashion.

The plates are preferably made of a suitable inert metallic material, such for example, as aluminum. They also may be made of wood if dimensional tolerances can be achieved. The uppermost plate 16 has the smallest diameter of the plates with plate 14 being next in size. Plates 10 and 12 are of equal diameter with plate 10 being the lowermost plate.

Referring now to FIG. 3(a), plate 16 is shown as having four radial slots 18 formed therein emanating from the center of the plate at right angles to each other forming an effective intersection point 20. Each of slots 18 is so formed as to be receivable of a length of heat resistant mild detonating cord 22, as best seen in FIG. 2, and which will be described in greater detail hereinafter. The terminal end 24 of each slot 18 extends through the plate 16 as best shown in FIG. 2.

Plate 14, as shown in FIG. 3(b), has four arrangements of slots 26 formed therein with each arrangement in the shape of a cross having four arms intersecting at 30 with the ends of three of these arms bent at right angles. The fourth leg of each arrangement is elongated, as at 28, for purposes which will be made more apparent hereinafter. The slots 26 in plate 14, similarly to the slots 18 of plate 16 are adapted to receive mild detonating cord described hereinafter. As in the slots 18 of plate 16, the terminal points 24 of the slots 26 extend through the plate 14.

Referring back to FIG. 1, it will be noted that the geometry of plates 16 and 14 is such that when plate 16 is placed in position over plate 14 the terminal ends 24 of the slots in plate 16 are positioned directly above the four intersection points 30 of slots 26 in plate 14. This strategic positioning of the plates is essential to the proper functioning of the device as will be more fully explained hereinafter.

As shown in FIG. 3(c), plate 12 has twelve cross-shaped slot configurations 32 each having points of intersection formed therein. The slots 32 are substantially identical to the slots of plate 16 except reduced in length. When placed in position beneath plate 14 the intersection points 34 of each slot arrangement 32 in plate 12 are directly subjacent to the terminal points 24 of the slots 26 of plate 14.

As shown in FIG. 3(d), plate 10 comprises a plurality of equally spaced cylindrical cavities 36 which extend through the plate 10 and which houses individual explosive charges 38. The spacing of the cavities 36 is determined by the positions of the terminal points 24 of slots 32 in plate 12, that is, the cavities 36 are positioned such that when plate 10 is in position beneath plate 12 each of cavities 36 lies directly beneath a terminal end 24 in plate 12.

A typical length of heat resistant mild detonating cord 22 is illustrated in FIG. 4 as having one end connected to a cup-shaped cap 40 containing a heat resistant explosive 42 and its other end connected to a base charge 44 of a heat resistant explosive by an end coupler 46. This cord structure is described in applicant's copending application Ser. No. 475,035, filed July 26, 1965. It includes a mild detonating cord which comprises a cylindrical metallic sheath 48, preferably made of a lead alloy, having an inner diameter of approximately 0.025 inches and is filled with a heat resistant explosive 50. Examples of heat resistant explosives are DIPAM (dipicramid), HNS (hexanitrostilbene), NONA (nonanitroterphenyl), and the like.

Since a heat resistant mild detonating cord has a lower intensity detonation front than a conventional mild detonating cord, when the detonation front from a small diameter heat resistant mild detonating cord travels into a substantially larger diameter base charge of a heat resistant explosive degradation of that wave front occurs and the base charge does not detonate.

The end coupler 46 includes an elongate metallic housing 52 having a frusto-conical recess 54 axially formed in one portion thereof and a communicating axial cylindrical bore 56 formed in the other portion thereof, defining an annular shoulder 58 therebetween. The end coupler 46 provides for amplification of the detonation front generated by ignition of the heat resistant mild detonating cord 18 to a magnitude sufficient to initiate the base charge 44. Cord 22 is inserted into the axial bore 56 until the end thereof abuts the annular shoulder 58. A suitable adhesive (not shown), such as epoxy resin or other potting composition, may be employed to bond the end of the cord within the end coupler 46. The frusto-conical recess 54 is filled with a booster charge 60 of HNS (Grade 1) explosive. HNS (Grade 1) is a super-fine grade of hexanitrostilbene prepared by the method disclosed in U.S. Pat. No. 3,505,413 issued on Apr. 7, 1970 to Kathryn G. Shipp. It has been found that if it is attempted to utilize other explosives for the booster charge rather than the HNS (Grade 1) type booster charge, the shock wave deteriorates rather than amplifies and hence does not detonate the base charge 24. The explosives contained in the end coupler 46 are held therein by a cylindrical cap member 62 opened at one end thereof which is crimped over metallic housing 52 so as to be fixed in place.

Turning now to FIGS. 5 and 6, an assembly 64 of four lengths of mild detonating cord 22 is shown as composed of four individual lengths of cord arranged as the arms of a cross with their abutting ends connected to explosive-filled caps 40. A ring-shaped manifold 66 is provided having suitable apertures 68 to accommodate the caps 40 and thereby retains the assembly 64 in the desired configuration. The cords may be shaped in any desired manner, such, for example, as by turning the opposite ends having end coupler 46 downward as at 70 as depicted in FIG. 6.

As shown in FIG. 2, the cord assembly 64 is disposed in the slots 18 in top plate 16. As hereinbefore set forth, the slots are turned in a downward direction at the ends 24 thereof to accommodate the end couplers 46 at the ends of each cord 22. The slot ends 24 communicate with the underside of plate 16 forming a through-bore to allow the tip of the end couplers to be flush with the lower face of plate 16. It is to be noted that the intersection point 20 is widened in the central portion of the plate 16 to accommodate the ring manifold 66.

The ability of the mild detonating cord to be bent in right angles as, for example, at 72 (FIG. 5) enables the mild detonating cord assemblies to be suitably placed within the slots 26 in plate 14. The general configuration of the detonating cord assembly, as depicted in phantom lines in FIG. 5, is similar to the configuration employed for plate 16, i.e., the cap 40 at the ends of the individual cords are held in abutting relationship by a ring-shaped manifold 66 with the cords extending outwardly at right angles to the two immediate adjacent cords. As shown by phantom lines, three of the cords are merely twisted in a right angle bend while the fourth cord is suitably extended to form the appropri-

ate configuration for plate 14. As hereinbefore stated, the terminal points 24 of the slots 26 communicate with the lower surface of plate 14 thereby permitting the end surface of end coupler 46 to be flush with the lower surface as best seen in FIG. 2.

It is to be noted that there are four charge cavities 74 in plate 10 as shown in FIG. 3(d) which upon assembly of the device will not lie beneath any terminal point 24 of slots 32 in plate 12. The four explosive charges 38 housed in these four cavities are necessary to maintain the uniform nature of the detonation wave created upon the simultaneous ignition of the explosive charges 38 as will be discussed hereinafter in the operation of the invention. In plate 12 directly above the four cavities 74 of plate 10, as shown in FIGS. 3(c) and 7, are four cylindrical explosive lead cavities 76 which house cylindrical explosive leads 78. Suprajacent the explosive lead cavities 76, positioned in plate 12, is an end coupler 46 which is connected to the end of a length of mild detonating cord 22 which itself comprises the elongated leg 28 of the detonating cord assemblies 64 of plate 14.

As shown in FIG. 8, explosive charge 38 is composed of a substantially cube-shaped metallic cup 80 having an opening 82 on one end thereof and being filled with an RDX (cyclotrimethylenetrinitramine) composition explosive 84 containing approximately 98% RDX and 2% calcium stearate pressed at 10,000 psi. The opening 82 is closed by a thin metallic closure disc 86.

The explosive lead 78, as shown in FIG. 9, is substantially cylindrical and preferably includes three equal increments of HNS explosive 88 compressed at approximately 16,000 psi. The explosive is contained in an aluminum cylindrical cup 90 having an opening 92 at one end thereof wherein an aluminum closure disc 94 is positioned serving to close opening 92.

In assembly, the slots in plates 12, 14 and 16 are first filled with a suitable adhesive, such for example, as General Electric RTV 112 silicone rubber adhesive and the mild detonating cord assemblies subsequently positioned therein. The plates are fastened together by conventional means, such as bolts 96 (FIG. 1), which also serve to align the plates in the desired relative orientations with respect to each other.

In the operation of the device a fundamental law is relied upon which makes possible the successful operation thereof; i.e., a homogeneous explosive mass normally detonates at uniform velocity in all directions. Therefore, an explosive initiation occurring at the "effective intersection point" of the explosive cord assembly will create separate detonation waves in each length of cord which will travel outward at equal velocities and reach the end couplers 46 at the same instant. It may thus be seen that all of the paths between the initial point of initiation at the intersection point 20 of slots in plate 16 and each explosive charge 38 in plate 10 must be of equal length. This requirement, therefore, determines the configuration of the elongate leg 28 of the cord arrangements 64 and slot arrangements 26 of plate 14, i.e., the length of the path from the slot intersection point 30 of plate 14 through the elongated leg 28 to and through the explosive lead 78 and terminating at an explosive charge 38 is equal to the length of the path from the point of the slot intersection 30 through a "normal" leg of slot arrangement 26 to the intersection point 34 of slots 32 in plate 12, through a leg of one cross-shaped slot arrangement 32, and termi-

nating at an explosive charge 38. An arrangement is thus provided in which the explosive path between the intersection point 20 on plate 16 and each terminating explosive charge 38 in plate 10 is equal to that between that point and every other terminii and therefore the arrival of the detonation at all explosive charges, will be simultaneous.

A typical detonation transfer from an end coupler 46, for example, in plate 16 to a detonating cord in plate 14 occurs when the mild detonating cord is ignited, thereby creating a detonation front which travels through the cord and is amplified by end coupler 46 to a sufficient magnitude to effect the initiation of base charge 44 therein. Upon the initiation of base charge 44 the cup member 62 bursts and the expanding hot gases and fragments resulting therefrom penetrate the four caps 40 located directly therebeneath and initiate the explosive 42 contained therein thereby causing detonation fronts to be set up in the detonating cords in plate 14. A similar sequence is undergone in the case of an end coupler 46 at the end of an elongated leg 28 igniting an explosive lead 78 and also when the explosive charges 38 are ignited by the end couplers 46 or leads 78.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described herein.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. An explosive initiating device comprising:

a plurality of contacting, superjacent stacked plate members;

a plurality of arrangements of commonly joined mutually perpendicular mild detonating cords positioned within slots in said members, said arrangements disposed in progressively increasing numbers on all but the lowermost one of said superjacent plate members,

each of said detonating cords having a first explosive charge and a base charge connected to opposite ends thereof,

each of said first explosive charges being disposed at a juncture of each said arrangements formed by said commonly joined detonating cords and each of said base charges being disposed in a through bore formed in all but said lowermost one of said plate members,

each of said junctures of each of said detonating cord arrangements on all but the uppermost and lowermost ones of said plate members being located subjacent of the respective ones of said base charges of a superjacent one of said plate members; and

a plurality of second explosive charges disposed on equidistantly spaced through bores formed in said lowermost plate member, the majority of said through bores in said lowermost plate being positioned immediately subjacent of the base charges of a superjacent one of said plate members;

wherein the overall length of the respective paths from a point of initiation on the uppermost one of said plate members to each of said second explosive charges is equal, thereby affording a simultaneous initiation of said second explosive charges in said lowermost plate member in response to the ini-

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tiation of the intersecting mild detonating cord of said uppermost plate member.

2. A device as recited in claim 1 wherein said base charge and said first and second explosive charges comprise heat resistant explosive materials.

3. A device as recited in claim 2 wherein said base charge is connected to the end of said detonating cord by an end coupler comprising:
an elongated housing;

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said housing having a frusto-conical recess formed in one end thereof;

said housing having an axial bore formed in the other end thereof and intersecting said frusto-conical recess; and

said frusto-conical recess being filled with hexanitrostilbene (Grade 1) explosive.

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