June 30, 1970 S. J. JACOBS 3,517,615

EXPLOSIVE WAVE SHAPER

Filed July 14, 1961

FIG.1.

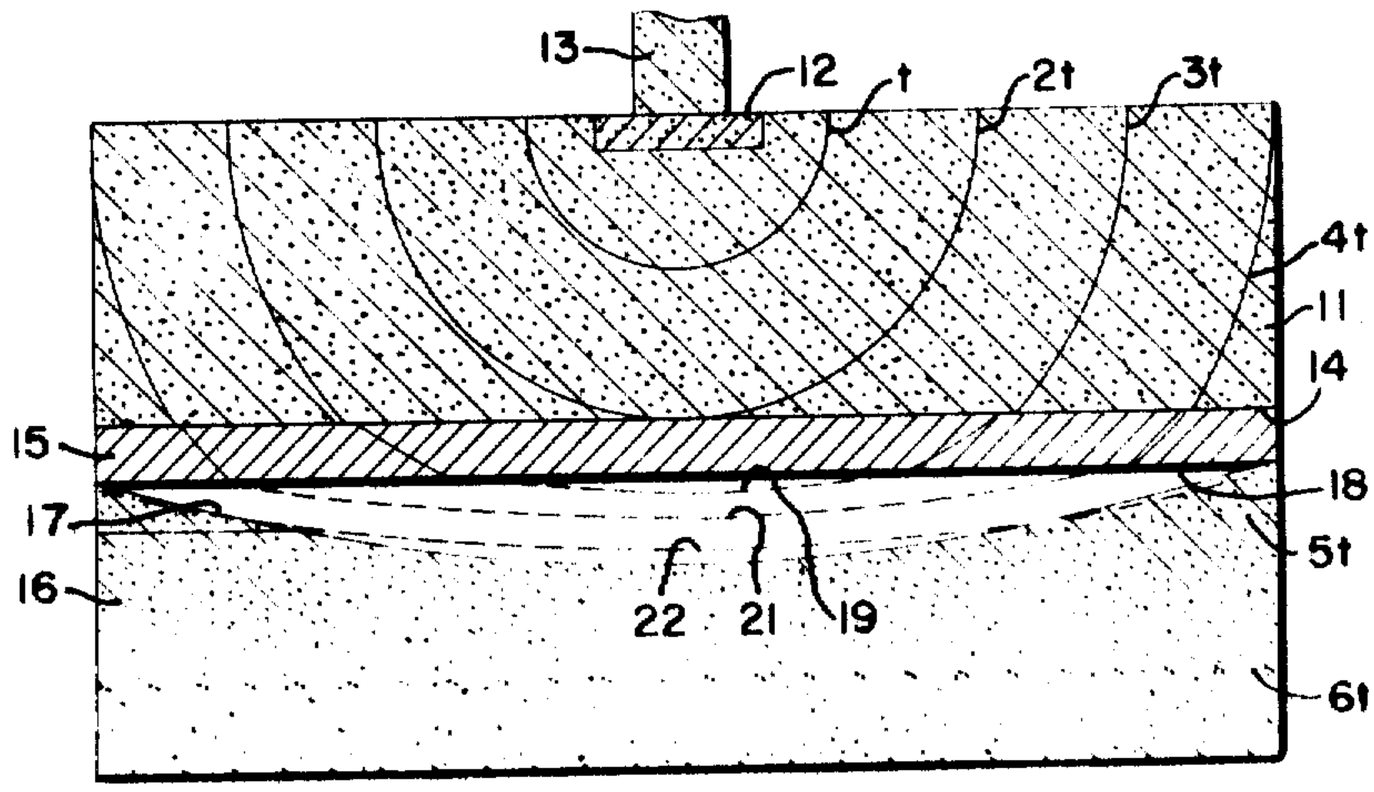


FIG.2.

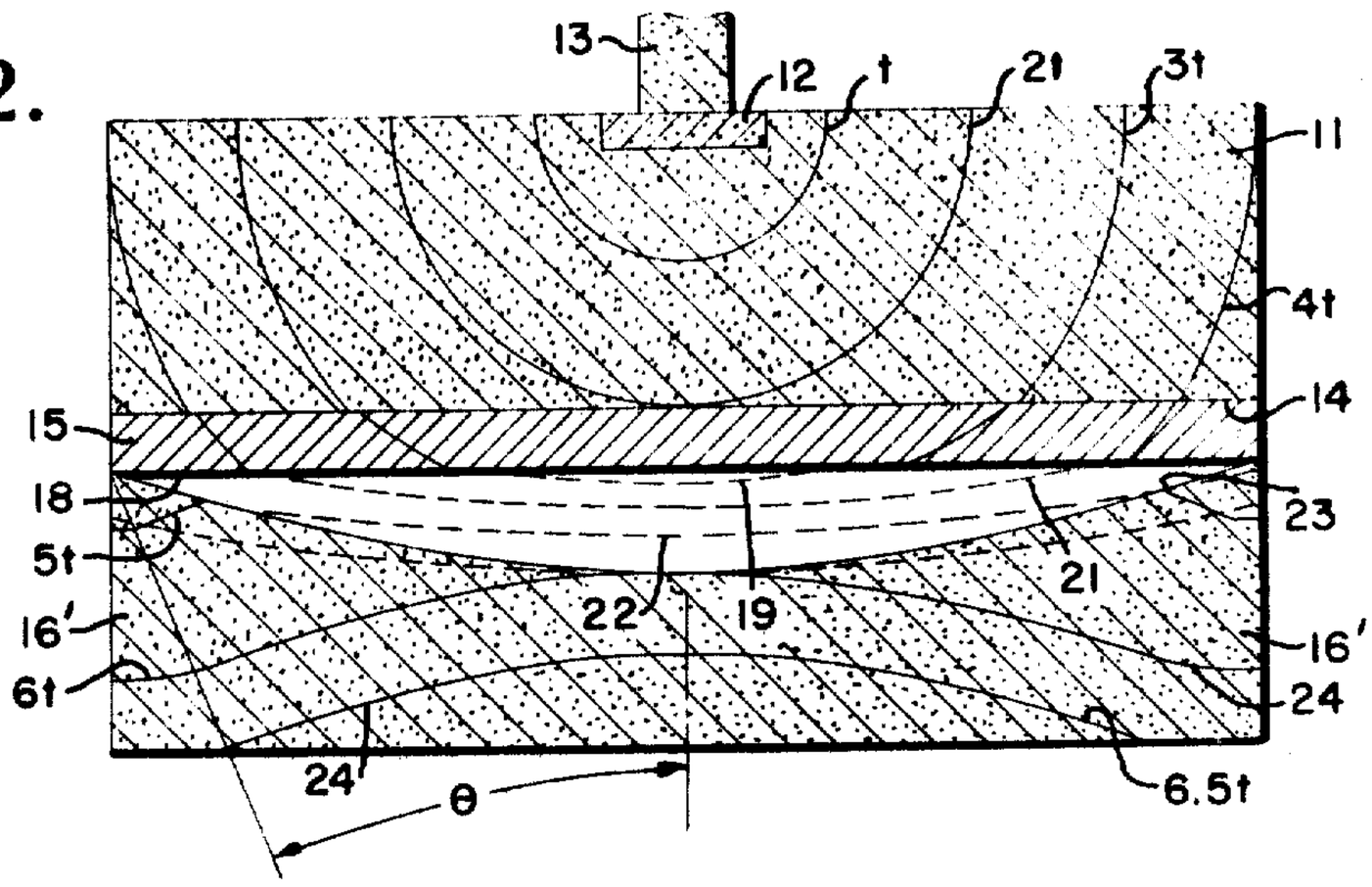
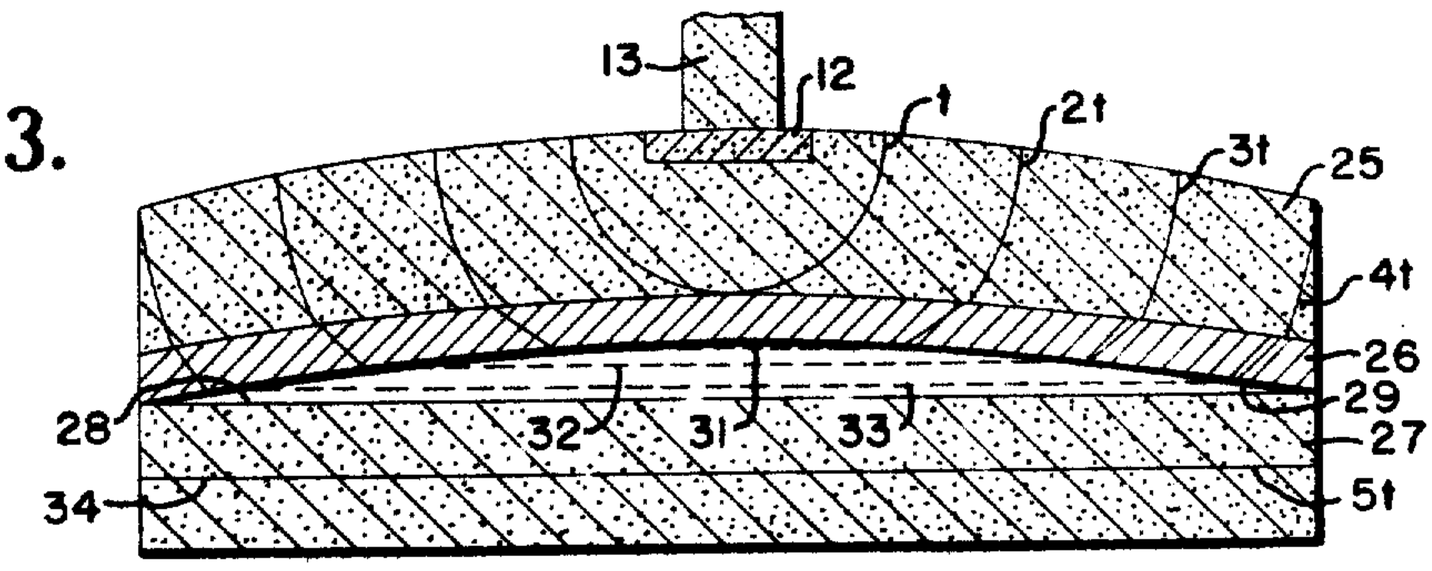


FIG.3.



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EXPLOSIVE WAVE SHAPER

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U.S. Cl. 102—22 7 Claims

This invention relates to the explosives art and more patricularly to a booster device for changing the wave front of a detonation wave to a planar or other desired configuration to obtain a desired explosive pattern or effect.

In devices heretofore devised for configuring the shape of the detonation wave in an explosive charge it has been the usual practice to employ a booster charge referred to as an explosive lens or wave shaping generator consisting of two explosives one of high detonation velocity and the other of low detonation velocity. The two charges are usually configured with axial symmetry, for example in a plane wave generator to create a plane wave from a point initiation by a detonator, the low velocity explosive may be in the shape of a cone. The high velocity explosive also shaped conically is placed outside the low velocity explosive as an annulus of constant thickness. A detonator nad booster charge may be located at the apex of the cone. For a suitably chosen apex angle in the cone of low velocity explosive the detonation of a detonator at the apex of the low velocity explosive causes detonation to travel in the two explosives in such a way that a plane detonation wave appears at the base of the low velocity cone.

In accordance with the present invention the acceptor explosive is detonated by a flying plate of uniform thickness interposed between the donor and acceptor explosives in such manner that the plate is suddenly moved from an initial position in proximate spaced relation or in contact with the donor explosive, as the case may be, into a predetermined contact relation with the acceptor explosive as the donor explosive is detonated, the plate being driven into contact with the acceptor explosive with sufficient force to cause detonation thereof by shock resulting from impact by the plate. By proper configuration of the working surface of the acceptor or donor explosive and the degree of separation therebetween, the diverging wave from the point of initiation within the donor explosive is reshaped to a plane wave or other wave of predetermined character by the delaying action of the relatively low velocity of the transfer or flying plate across the cavity, as will be more clearly apparent as the description proceeds.

The device of the present invention possesses all of the advantages of the prior art devices of this character and in addition thereto is less bulky by reason of a decreased ratio of height to diameter of the charges and the space therebetween and the additional advantage of a more closely controlled and more easily reproduced configuration of the detonation wave within the acceptor explosive.

One of the objects of this invention is to provide a new and improved explosive wave shaper employing a uniformly thick plate between the donor and acceptor charges for shaping the detonation wave to a predetermined configuration by impact of the acceptor charge therewith.

Another object is a system for shaping an explosive wave by impact with a shock transfer plate of uniform thickness immediately following deformation of the plate to a predetermined configuration in response to a spherical detonation wave applied thereto by the donor charge as the donor charge is detonated.

Still another object is the provision of a new and improved explosive wave shaper which is compact and includes a flying shock transfer plate of uniform thickness for detonation of the acceptor charge according to a predetermined pattern.

These and many other objects will become more readily apparent from the following description taken in connection with the accompanying drawing wherein:

FIG. 1 is a diagrammatic view of the wave shaping system of the present invention suitable for producing a plane wave detonation;

FIG. 2 is a diagrammatic view of the system of the present invention according to an alternative form thereof for producing a detonation wave having a convergent wave front; and

FIG. 3 is a diagrammatic view of the system of the present invention according to an alternative form thereof.

Referring now to the drawing for a more complete understanding of the invention on which like numerals of reference are employed to designate like parts throughout the several views and more particularly to FIG. 1 thereof, there is shown thereon a high explosive donor, booster, or primer charge **11** having a conventional initiator **12** such as tetryl embedded therein. A detonator **13** is affixed to the initiator **12** and connected in a conventional manner to a suitable source of voltage (not shown) for initiation. It will be understood, of course, that the entire assembly may be encased in a suitable container or the like, as is the general practice. For simplicity, however, only the booster itself is shown.

The booster is provided with a flat working surface **14** in initial abutting relation with a flat metal plate **15** of uniform thickness substantially as shown. Abutting the plate **15** on the opposite side thereof and along a peripheral portion is an acceptor or working explosive **16** having a generally spherical cavity **17** formed therein for engagement by the metal plate when the metal plate has been deformed by an explosive wave received from the donor into substantial matching relation therewith. In this embodiment of the invention the boundary of cavity **17** is precisely configured such that the impact of the plate **15** therewith initiates a detonation wave within the acceptor explosive **16** at the peripheral portion of the acceptor and thence progressively toward the center of the cavity as the plate is deformed into contact therewith and strikes the acceptor with sufficient force to detonate the same thereby to produce a planar detonation wave. The pressure wave within the donor **11** set up by the initiator **12** is shown diagrammatically on FIG. 1 by the curved lines t, $2t$, $3t$, $4t$ at equal intervals of time t. At time $2t$ the spherical detonation wave within the donor has impinged on the central portion of the plate **15**. As the wave continues to expand it spreads outwardly toward the outer edge of plate **15** and causes the center of the plate to be deformed toward the acceptor **16**, the surface **18** of the plate being deformed to the position indicated in dashed outline at **19** when the wave within the donor explosive has progressed to the line $3t$. The plate **15** is additionally deformed such that the surface **18** thereof is in the position indicated by dashed outline **21** at time $4t$ and at a time subsequent thereto the surface **18** is deformed to a position as indicated by dashed outline **22** and strikes the generally spherical surface of cavity **17** of the acceptor with sufficient force to initiate detonation of the acceptor along an annular portion near the periphery thereof and spreading rapidly toward the center portion of the cavity as the flying plate is additionally deformed into

contact therewith in such manner that a plane wave is transmitted by the acceptor explosive.

On FIG. 2 is shown a system for producing a convergent wave from the acceptor explosive **16** in response to impingement of plate **15** on the acceptor explosive at a cavity **23** formed therein. The cavity **23** is generally similar to cavity **17** of the system of FIG. 1 and like cavity **17** is of general spherical configuruation. The cavity **23** differs from cavity **17**, however, in conforming to a portion of a sphere of less radious than the cavity of FIG. 1. It will be noted that, as in FIG. 1, the upper portion of the acceptor as viewed in the figure engages plate **15** along a peripheral portion thereof and the central portion of the cavity, therefore, is spaced initially at a greater distance from surface **18** of the plate than is the case of cavity **17** of FIG. 1.

The operation of the system of FIG. 2 differs from that of FIG. 1 by reason of the fact that the plate **15** is required to be additionally deformed in response to the detonation wave received from the donor before the central portion of the surface of the acceptor explosive defining cavity **23** is engaged thereby.

As clearly shown in FIG. 2 the detonation wave **24** set up wtihin the acceptor **16** has progressed through the acceptor to the solid line designated **6***t* which corresponds generally to the time of impingement of the central portion of plate **15** with the central portion of cavity **23**. At time **6.5***t* the pressure wave **24** is of spherical configuration and converging upon a point outside the boundaries of acceptor explosive **16'**, the angle of convergence of the wave upon this point being designated by the symbol ϕ.

On FIG. 3 is shown an alternative form of the invention for producing a wave of planar characteristic from the explosive acceptor. According to this embodiment of the invention the explosive donor designated by numeral **25** is preferably of uniform thickness and configured generally spherically on opposite sides thereof. A metal plate **26** of uniform thickness is formed into a spherical configuration, the outer spherical surface of which is formed to a portion of a sphere having the same radius as the internal spherical surface of the donor **25** to provide a close fitting contact therebetween throughout the respective contacting surfaces.

Explosive acceptor **27** is provided with a flat surface **28** abutting the outer peripheral portion of metal plate **26** substantially as shown. The detonating wave from initiator **12** first impinges plate **26** at a central portion thereof at time *t*. The lower surface **29** of plate **26** is deformed to the position shown in dashed outline and designated **31** at time **2***t*. This lower surface is flat, expanded and moved downward to the position indicated at **32** at time **3***t* and at position **33** at time **4***t*.

Just after time **4***t* the entire lower surface of the plate is deformed to a planar surface and strikes the flat surface of acceptor explosive **27** simultaneously throughout the entire surface thereof with a force sufficient to detonate the acceptor and set up a planar explosive wave **34** therein as shown at time **5***t*.

Whereas the invention has been described with particular reference to the formation of a detonating wave of planar character and converging character respectively, it is not so limited as it will be apparent to others, after understanding the invention, that by substitution of part of the acceptor by an inert solid suitably shaped and situated so that it will be impacted by the metal plate upon initiation of the donor charge, a shock wave may be caused by such impact to pass through the inert solid and enter the acceptor explosive with sufficient velocity to initiate a detonation wave, it being merely necessary to so shape the parts that the detonation wave in the acceptor is of desired configuration when initiated by the shock. Furthermore, if desired, the plate may be composed of any material other than metal suitable for the purpose and having sufficiently high density for satisfactory operation such, for example, as a plastic or ceramic. The plate may also be composed of two different materials of a suitable density and laminated together in any well known manner. In addition, the donor explosive may be initiated at a line therein in lieu of a point and the parts including the deformable inertial element forming the wave shaper may be of general cylindrical configuration with the axis thereof parallel to the line of initiation. It is also contemplated that in the case where the detonation of the donor originates at a point, the wave shaper including the deformable inertial element may be of annular configuration symmetrically disposed about and encircling the point in such a maner as to form a wave front of cylindrical symmetry.

Obviously many modifications and variations of the present invention are possible in the 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.

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

1. An explosive wave shaper comprising a donor high explosive, an acceptor explosive spaced from the donor explosive in close proximity thereto, and a substantially flat inert metal plate of uniform thickness disposed contiguous to and coextensive with the working surface of said donor explosive and between the acceptor explosive and the donor explosive and initially supported thereby, at least one of said donor and acceptor explosives having a shallow symmetrical cavity of spherical configuration coextensive with the working surface thereof formed therein opposite said plate whereby the plate is deformed during travel thereof across said cavity sufficiently to effect a planar detonation wave through the acceptor explosive in response to sudden impact of the plate therewith as the donor explosive is initiated.

2. A wave shaper according to claim **1** including means disposed within the donor explosive for initiating it at a point disposed in predetermined spaced relation from said cavity.

3. A wave shaper for shaping a detonation wave in an explosive to a predetermined configuration comprising a donor explosive charge having a shallow cavity of spherical configuration in and coextensive with the shock transmitting face thereof, an inert metal plate of uniform thickness coextensive with and disposed within said cavity in close fitting engagement therewith, an acceptor explosive having a planar receiving surface abutting said plate at an outer peripheral portion thereof, said plate being initially supported by said donor explosive charge and said acceptor explosive, means disposed within said donor explosive opposite the central portion of said cavity for initiating the donor explosive at a predetermined point whereby the plate is deformed in response to the initiation of said donor explosive in a manner to strike the planar surface of the acceptor explosive simultaneously throughout the planar surface thereby to produce an explosive wave of planar configuration in the acceptor explosive when the acceptor explosive is detonated by impact of the metal plate.

4. A system for shaping a detonation wave in an explosive to a converging configuration comprising a donor explosive charge having a planar surface through which a shock wave is transmitted as the donor explosive is initiated, means disposed within said donor explosive for initiating it at a predetermined point opposite the central portion of said surface, a flat metal plate of uniform thickness coextensive with and abutting said surface and deformable arcuately by the explosive force of the donor explosive as the donor explosive is initiated, an acceptor charge having a shallow cavity of spherical configuration formed in one face thereof and disposed with the cavity portion opposite said plate and in substantial abutting relation therewith, said cavity being coextensive with said plate and so configured that the plate strikes the acceptor

charge first at an outer annular portion thereof, said plate being supported by said donor explosive and acceptor charges the annular portion of the acceptor charge struck by the plate being of rapidly increasing area until the plate is deformed into contact with the central portion of the cavity, whereby the time interval between the impact of the plate with the first named annular portion of the acceptor charge and the contact of the plate with the central portion of said cavity provides a detonation wave within the acceptor explosive of converging character as the acceptor explosive is detonated by impact of the metal plate therewith.

5. A system for shaping a detonation wave in an explosive to a planar configuration comprising a donor explosive charge having a planar surface through which a shock wave is transmitted as the donor explosive is initiated, means disposed within said donor explosive for initiating it at a predetermined point opposite the central portion of said surface, a flat metal plate of uniform thickness coextensive with and abutting said surface and deformable arcuately by the explosive force of the donor explosive as the donor explosive is initiated, an acceptor charge having a shallow cavity of spherical configuration formed in one face thereof and disposed with the cavity portion opposite said plate and in substantial abutting relation therewith in a manner to support the plate against said donor explosive, said cavity being coextensive with and so configured that the plate strikes the acceptor charge first at an outer annular portion thereof of rapidly increasing area until the plate is deformed into contact with the central portion of the cavity, whereby the time interval between the impact of the plate with the first named annular portion of the acceptor charge and the contact of the plate with the central portion of said cavity provides a detonation wave within the acceptor explosive of planar character as the acceptor explosive is detonated by impact of the metal plate therewith.

6. The method of producing a plan detonation wave front from a high explosive charge arranged for detonation by impact of a metal plate therewith which comprises interposing a flat uniformly thick metal plate between a high explosive primer charge and a high explosive working charge in such manner that the plate is coextensive and initially in contact with a flat working surface on the primer charge throughout the entire surface and in contact initially with the working charge solely at a peripheral portion of the opposite surface of the plate, said working charge having a shallow depression of spherical configuration coextensive therewith and formed therein within said peripheral portion and disposed opposite said plate to form an air chamber therebetween, and initiating the primer charge at a predetermined point therein whereby the detonating wave front caused by the initiation of said primer explosive first impinges the surface of a central portion of said plate and moves progressively toward the periphery thereof thereby to deform the plate into matching relation with the cavity within the working explosive in such manner that the deformed plate strikes the entire surface of the cavity with a force sufficient to detonate the working explosive and set up a detonation wave therein having a planar wave front.

7. The method of detonating a high explosive working charge to produce a detonation wave therefrom a predetermined configuration in response to the impact of a substantially flat inert solid plate of uniform thickness therewith which comprises forming a symmetrical depression of spherical configuration in a coextensive with a working surface of the high explosive charge configured to be struck by said plate first along the outer peripheral portion thereof and thence progressively toward the central portion thereof in a manner to set up said detonation wave within the charge, placing a high explosive primer charge against the opposite side of said plate in a manner to support the plate against said working charge, and firing the primer explosive charge at a point within the primer charge spaced at a predetermined distance from said plate.

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U.S. Cl. X.R.

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