July 8, 1958 R. L. KLOTZ 2,842,056

EXPLOSIVE CHARGE

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Fig. 1.

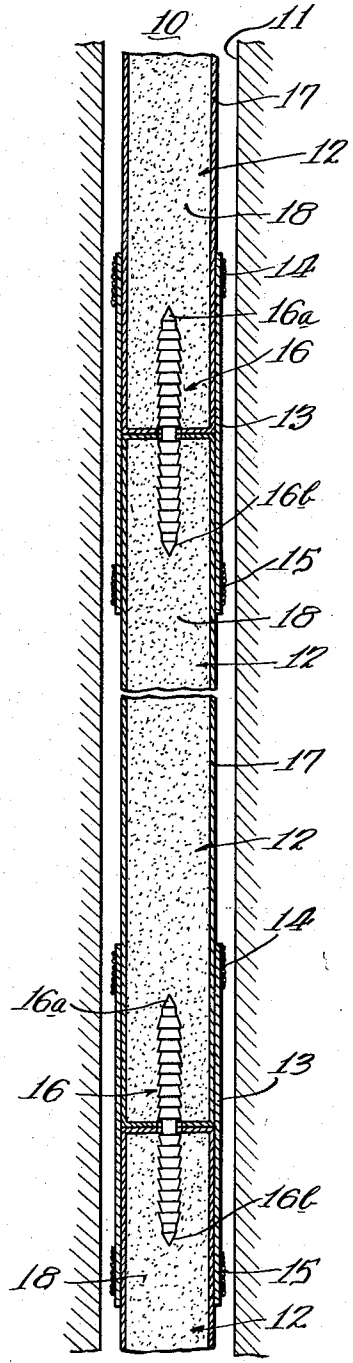


Fig. 2.

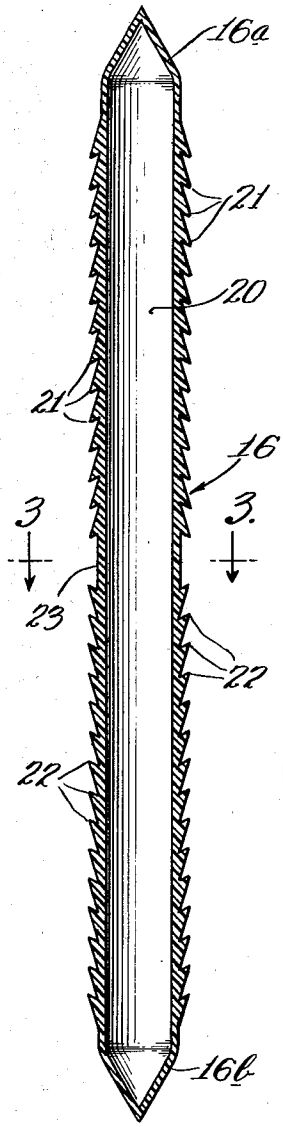
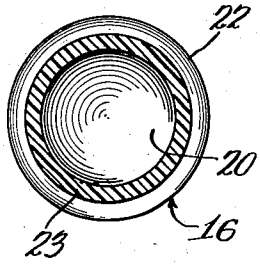


Fig. 3.



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Fig. 4.

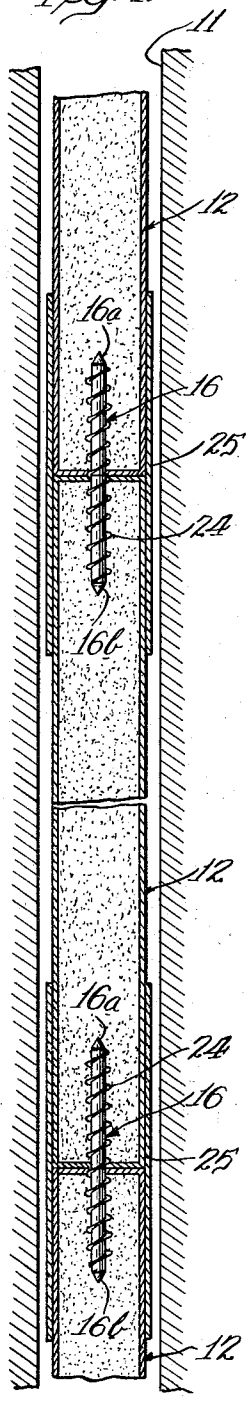


Fig. 5.

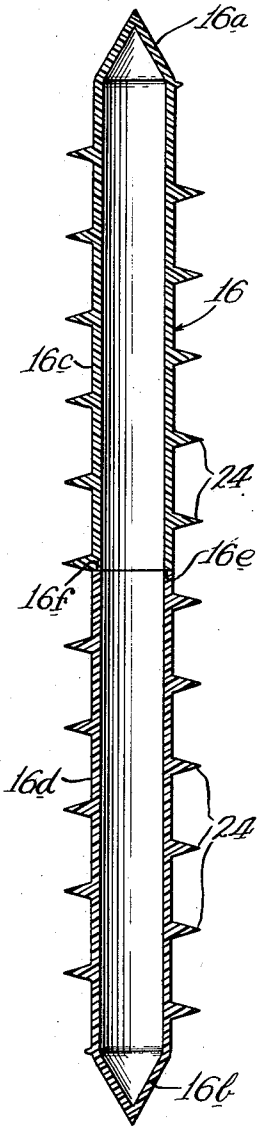
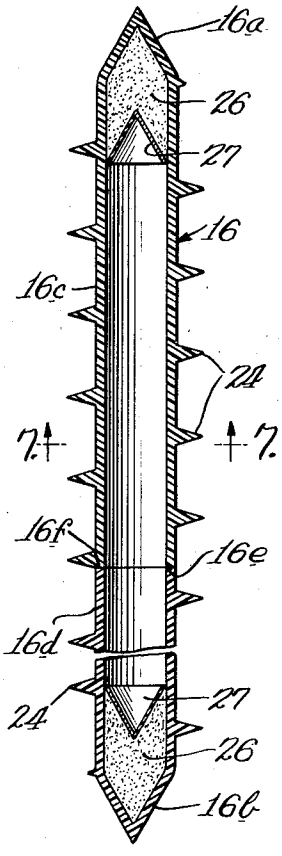


Fig. 6.



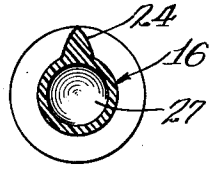


Fig. 7.

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EXPLOSIVE CHARGE

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Application May 4, 1954, Serial No. 427,457

11 Claims. (Cl. 102—24)

The present invention relates to explosive charges and more particularly to improved facilities for securing a plurality of explosive cartridges together in end-to-end relationship to form an elongated explosive column, and for insuring complete detonation of the entire column of explosive cartridges.

One method of insuring complete detonation of a long column of explosives of the type commonly used in seismic survey operations, mining, quarrying, and similar operations, is described and claimed in copending application Serial No. 746,578, filed May 7, 1947, by Robert L. Klotz, Jr., and assigned to the same assignee as the present invention, which application matured into Patent No. 2,683,414 on July 13, 1954. The above identified application discloses an arrangement wherein a plurality of cartridges, at least some of which have jet forming cavities in one end, are aligned in end-to-end relationship to form an explosive column of the desired length. When the column is detonated, the jet forming cavity in the end of each cartridge of the column which is so equipped produces an explosive jet effect which is directed into the next adjacent cartridge, thereby to strengthen and revitalize the detonating wave traveling along the column. The present invention relates to improved facilities for instrumenting the arrangement disclosed in the identified Klotz application in a simple and economical manner and for securing the explosive cartridges together to form the desired elongated columnar charge.

It is an object of the present invention to provide improved facilities for insuring complete detonation of all of the cartridges in an elongated columnar charge.

It is another object of the invention to provide improved facilities for connecting and securing together two explosive charges which are so formed and arranged that a jet forming cavity is formed in one of the cartridges which acts to produce an explosive jet upon detonation of the one cartridge which is directed into the other cartridge.

It is a further object of the invention to provide an improved connecting pin for interconnecting two explosive cartridges in an elongated explosive charge and for producing an explosive jet at one end of one of the cartridges which is directed into the other of the cartridges upon detonation of the one cartridge.

According to still another object of the invention, the present improved pin is effective to produce the desired explosive jet regardless of which of the two cartridges which the pin connects is detonated first.

Further objects and advantages of the present invention will become apparent as the following description proceed, and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of the present invention, reference may be had to the accompanying drawings in which:

Fig. 1 is a view of an elongated charge formed of a plurality of cartridges interconnected by connecting means characterized by the features of the present invention and arranged in end-to-end relationship within a shot hole;

Fig. 2 is a side sectional view illustrating one of the present improved pins for interconnecting adjacent pairs of the cartridges embodied in the explosive charge shown in Fig. 1;

Fig. 3 is a sectional view taken along the line 3—3 in Fig. 2;

Fig. 4 illustrates a modified embodiment of the invention;

Fig. 5 is a sectional view taken along the line 5—5 in Fig. 4;

Fig. 6 is a partial sectional view illustrating a further embodiment of the invention; and

Fig. 7 is a sectional view taken along the line 7—7 in Fig. 6.

Referring now to the drawings and more particularly to Fig. 1 thereof, there is illustrated an elongated explosive charge or column **10** comprising a plurality of explosive cartridges **12** which are arranged in end-to-end relationship in a shot hole **11** in the manner conventionally employed in quarry mining operations and seismic shooting operations. In accordance with the present invention, each adjacent pair of cartridges is connected and secured together by means of a hollow pin **16** the ends of which are inserted into the explosive material of the two connected cartridges **12**. This pin is provided with end wall parts which define a jet forming cavity in the explosive material of one of the connected cartridges which acts to produce an explosive jet upon detonation of the one cartridge which forms in and is transmitted through the hollow pin into the explosive material of the other connected cartridge. If desired, the cartridges may also be further secured together by the conventional arrangement known as "taping" or "lathing," in which one or more laths, such as the laths **13**, are bridged across the junction points between each pair of adjacent charges **12** and are taped to these cartridges as indicated at **14** and **15** to produce a rigid or semi-rigid elongated charge. Alternatively, the sleeve type of cartridge connection illustrated in Fig. 4 may be used in addition to the connecting pins **16**, if deemed desirable. However, when the present improved connecting pins **16** are employed to interconnect the cartridges **12**, the sleeve couplings or "taping" or "lathing" arrangements are not ordinarily required for reasons which will be apparent from the following explanation. However, if such conventional connecting arrangements are used in combination with the present improved connecting pins, an extremely sturdy explosive column capable of withstanding the most severe conditions of loading may be easily and quickly assembled.

It is well known that the detonation or propagation wave traversing a column of explosive material tends to become less intense the further the detonating wave travels from the point of initiation. This tendency increases as the diameter of the explosive column decreases. It also increases as the pressure, such as the fluid tamping pressure used in the shot hole increases, and as the sensitivity of the explosive material used is decreased. As a consequence, only a portion of the explosive material provided in a long column of low sensitivity explosive material may be exploded in response to detonation of the column at one end thereof. Moreover, when the column is sectionalized, as by stacking a number of cartridges in the manner described above, any foreign matter such as dirt, water, etc., which may inadvertently get between the ends of any pair of abutting cartridges, in

many cases has the effect of attenuating the detonating wave as it travels from one cartridge to the abutting cartridge to the point where the abutting cartridge is not detonated. Any such undetonated explosive material used in a given charge is not only a waste of material, but, in addition, constitutes an explosives hazard which remains after the blasting or shooting operation is completed. The problem as thus outlined is solved in a simple and economical manner by employing the present improved pins **16** to interconnect and bridge the cartridges **12** in the manner more fully explained below.

As shown in Fig. 1 of the drawings, each of the cartridges **12** comprises a suitable container **17** of generally cylindrical configuration, within which is contained the explosive material **18** of the cartridge. In accordance with conventional practice, the containers **17** are made of a non-metallic packaging material, such as heavy cardboard, which is capable of being perforated by the pointed ends of the hollow connecting pins **16**. For the purpose of producing the desired jet forming cavity in the explosive material into which either end of the pin **16** is inserted, this pin is provided with thin end wall parts forming the pointed ends **16***a* and **16***b*. These end wall parts also act as liners for the jet forming cavities which they form in the explosive material of the cartridges **12** into which they are inserted. If required by the character of the container material, the holes through which the ends of the pins are inserted into the cartridges may be prepunched on the job by using a pointed brass or bronze punch for the purpose. The two pin ends are connected by a hollow body portion **20** of uniform diameter, in which an explosive jet may form and through which the explosive jet may be transmitted from the explosive material of one connected cartridge **12** into the explosive material of the other connected cartridge **12**. The pin **16** is formed of relatively rigid material such as molded plastic, metal, glass, ceramic, or the like, and the end portions **16***a* and **16***b* of the pin are illustrated in the drawing as having a substantially conical shape although, as will become evident from the following explanation, these end portions may have other configurations, if desired.

In forming the column **10** of explosive cartridges **12**, one end of each pin **16** is driven or pushed by hand or other suitable means, if necessary, into one end of a cartridge **12**, leaving approximately half of the pin and one pointed end exposed. The exposed half of the pin **16** is then pushed into the next adjacent cartridge in the column as shown in Fig. 1 of the drawings. This operation is repeated until a complete column **10** is formed containing the desired number of cartridges. In this connection, it should be noted that the pins **16** may be first inserted either into the top of each cartridge and the next succeeding cartridge dropped thereon or, alternatively, the pin may be inserted into the bottom of a cartridge and the cartridge and pin may be dropped onto the next lower cartridge. In order to insure that the pin **16** will positively engage the explosive material within the containers **17** of the interconnected cartridges and to prevent inadvertent withdrawal of the pin, the sides of the pin are oppositely toothed or serrated as indicated at **21** and **22**. At the center of the pin, the serrations are omitted to provide an annular recess **23** of somewhat reduced diameter for receiving the edges of the perforated cartridge container end walls through which the pin extends.

Although the end walls **16***a* and **16***b* of the pin **16** are illustrated as having a cone-shaped configuration, other similar shaped end wall configurations symmetrical about the axis of the pin **16** and capable of producing the desired jet forming cavities in the explosive material into which the pin is inserted may be employed if desired. The conical end wall configuration is preferred, however, since the pointed ends of the conical structures facilitate insertion of the ends of the pin into the explosive cartridges. In any case and as stated above, the purpose of providing the shaped end walls **16***a* and **16***b* to define jet forming cavities in the explosive material into which the pin is inserted, is to permit the well known "Munroe Effect," i. e., directionalized explosive effect, to be obtained.

Specifically, each alternate jet forming cavity thus produced in the explosive charge **10** acts to redistribute and concentrate the explosive energy of the portion of the explosive material nearest the cavity into an explosive jet. Thus, if the charge **10** is initially detonated at the top of the charge, as by means of an electrically energized detonating cap located at the top of the charge **10**, the cavities produced by the pin end walls **16***a*, as shown in Fig. 1 of the drawings, are effective to produce the desired explosive jets. In this case, the intervening jet forming cavities produced by the pin ends **16***b* in the explosive column perform no useful function. On the other hand, if the charge **10** is initially detonated at the bottom of the charge, the cavities formed by the pin end walls **16***b* are effective to produce the desired explosive jets and the cavities formed by the pin end walls **16***a* are not effective. In other words only the cavity produced in the explosive column by the end of each pin **16** which is nearest the point of initial detonation of the column is effective to produce the desired explosive jet effect. However, by using identical end wall structures at both ends of the pin **16**, the desired jet effect is obtained in use, regardless of which end of each pin is inserted into a given cartridge in the column. Thus the pin is completely reversible.

Referring again to Fig. 2 of the drawings, as an explosive jet is formed at the upper end, for example, of the pin **16** within the stand-off chamber defined by the cylindrical pin body portion **20**, it is transmitted through this chamber, disintegrates the end walls **16***b* and detonates the explosive material in which the end walls **16***b* are disposed. Since the chamber within the pin **16** is completely enclosed, no mud, tamping fluid or other foreign substance can enter this chamber to interfere with transmission of the explosive jet from one of the two cartridges which the pin connects to the other cartridge. As a consequence, any fluid or mud filled space which may exist between the connected cartridges or any misalignment of the cartridges in the shot hole cannot interfere with the transfer of detonation from one of the two connected cartridges to the other. Thus by using the present improved pins, all that is required to obtain complete detonation of all of the cartridges in a long columnar charge is that the ends of the pins be firmly imbedded in the explosive material of the cartridges which they respectively connect. Moreover, by employing the jet forming connecting pins **16** to interconnect the cartridges **12** in a column **10**, the overall detonating time of the column is substantially decreased. Thus, the detonating jet is formed at the active end of each pin **16** and is transmitted through the stand-off chamber of the hollow pin well into the explosive material of the cartridge into which the non-active end of the pin projects, thereby to initiate detonation of this material, well before all of the explosive material of the cartridge into which the active end of the pin projects is all detonated. The result is a speeding up of the detonation of the entire explosive column **10**.

In the modified embodiment of the invention illustrated in Figs. 4 and 5 of the drawings, the cartridges **12**, in addition to being interconnected by the present improved pins **16**, are also sleeve connected by means of sleeves **25**. As indicated above, the sleeve type of cartridge coupling is very well known to those skilled in the art. In most applications, the sleeve coupling can be omitted when the present improved pins **16** are used to interconnect the cartridges **12**. The connecting and jet producing pins **16** are identical with the pins illustrated in Figs. 1 and 2 of the drawings, except that long sharp

spiral threads **24** are provided externally of each pin along the cylindrical wall thereof to permit threading of the pin ends into the adjacent ends of two explosive cartridges **12** arranged in end-to-end relationship. The illustrated threaded pin arrangement is particularly well adapted for use in conjunction with explosive cartridges made up of the firmer types of explosives, such as those used in seismic survey operations. If desired, the top and bottom end walls of each explosive cartridge container may be provided with inwardly extending wells or chambers, which are formed integrally with the containers and walls and are internally threaded to receive the external threads **24** of the pins **16**, and thereby to facilitate interconnection of the cartridges. Such an arrangement will completely obviate any necessity for pre-punching the container end walls in order to start insertion of the ends of the pins into the cartridges **12**.

In Fig. 5 of the drawings there is also illustrated one method of fabricating the pins, regardless of whether the serrated structure shown in Figs. 1 and 2 or the externally threaded structure illustrated in Figs. 4 and 5 is employed. The method of fabrication there shown is particularly applicable to formation of the pins **16** from any moldable material such as plastic. As shown, the pins are molded into two halves **16***c* and **16***d*, following which the flat ends **16***e* and **16***f* thereof are brought into meeting engagement and welded together. This type of construction permits well known insert molding techniques to be employed in forming the pin halves **16***c* and **16***d*. In this connection, it will be understood that if the pins are formed of metal, the cylindrical barrel portion of each pin may be formed of one piece and the conical end parts **16***a* and **16***b* may be separately formed. In such case, the conical end parts **16***a* and **16***b* may be welded to the ends of the one piece metal pin to complete the structure.

In accordance with another important feature of the present invention, each of the pins **16** may be provided with a high sensitivity booster charge of explosive material internally thereof at each end thereof, in the manner illustrated in Fig. 6 of the drawings. Provision of the high sensitivity booster charges at the respective ends of the pins may be desirable to insure the production of the explosive jets through the pins in cases where the pins are used to interconnect explosive cartridges **12** containing explosive material having very low sensitivity. More specifically, each booster charge comprises a body of high sensitivity explosive material **26** which is held in position at the end of the pin **16** by means of a cone-shaped liner **27**. Each liner has an outer circumference such that it forms a press fit with the internal wall of the pin **16** when inserted thereinto. Each liner **27** thus defines a conical jet forming cavity in the booster charge which it holds in position at one end of the pin **16**, which is directed toward the opposite end of the pin. Thus, the cavities formed in the booster charges **26** by the liners **27** face each other through the hollow pin **16**.

As an alternative to the structure just described, the conical jet forming liners **27** may form a part of an elongated thin walled tube having an external diameter which closely approximates the internal bore diameter of the pin **16**, and having a length such that it leaves chambers at the ends thereof within the ends of the pin **16** which are of adequate size to receive the high sensitivity explosive charges **26**. If the tube structure is used, the pin halves **16***c* and **16***d* may be provided with interengaging shoulder portions at their ends **16***e* and **16***f* which are equipped with matching threads to permit the pin halves **16***c* and **16***d* to be screwed together after the pins are loaded with the high sensitivity charges **26** and the thin walled tube embodying the conical liners **27** at the ends thereof is inserted into the pin halves.

As will be understood, the cartridge connecting function of the pin structure illustrated in Fig. 6 of the drawings is accomplished in the exact manner explained above with reference to the two embodiments of the invention illustrated in Figs. 1 to 4, inclusive, and 7. Incident to use of the booster charge loaded pins **16** shown in Fig. 6 to interconnect two explosive cartridges **12** containing low sensitivity explosive material, the high sensitivity booster charges **26** are, of course, embedded in the explosive material located at the adjacent ends of the two connected cartridges. Accordingly, if the explosive column comprising the two connected cartridges is detonated at a point nearest the end **16***a* of the booster charge loaded pin, the booster charge located at this end of the pin is detonated incident to detonation of the explosive material in the cartridge in which this end of the pin is embedded, to produce a very high velocity explosive jet which is transmitted through the hollow pin to detonate the high sensitivity booster charge **26** located at the opposite end of the pin. Detonation of the latter booster charge has the effect of instantly detonating the low sensitivity explosive material of the cartridge in which the end **16***b* of the pin is embedded. Thus the Fig. 6 embodiment of the invention positively insures full and complete detonation of all cartridges in a long columnar charge regardless of the degree of sensitivity of the explosives contained within the cartridges.

It will be apparent to those skilled in the art that the present invention is not limited to the particular constructions shown, but that changes and modifications may be made without departing from the spirit and scope of the present invention. It is aimed in the appended claims to cover all such changes and modifications.

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

1. An explosive charge comprising a plurality of explosive cartridges each containing explosive material and arranged in end-to-end relationship to form a column of cartridges, detonating means for detonating said charge located at some point in said column, and at least one hollow pin inserted into the explosive material at the end of one of said cartridges remote from said detonating means and into the explosive material in the adjacent end of the next cartridge in said column to connect the two cartridges together, one end of said pin including structure shaped to define a jet forming cavity in the explosive material in one of the two connected cartridges for producing an explosive jet which is directed away from said detonation point from one of the two connected cartridges into the other of the two connected cartridges.

2. A hollow pin for securing together two adjacent explosive cartridges in a column of explosive cartridges, comprising end walls disposed at at least one end of said pin for defining a cone-shaped jet forming cavity in the explosive material of the cartridge into which said end walls are inserted, and a hollow body portion defining a stand-off chamber in which the explosive jet may form and through which the explosive jet is transmitted to the explosive material of the cartridge into which the other end of the pin is inserted, said hollow body portion being provided with external projections engageable with portions of the two adjacent cartridges to assist in securing said pin to the two cartridges.

3. An explosive charge comprising a pair of explosive cartridges each containing explosive material and arranged in end-to-end relationship, and securing means for securing said cartridges together in end to end relationship, said securing means including a structural element defining a jet forming cavity extending into the explosive material in one of said cartridges for producing an explosive jet upon detonation of the one cartridges which is directed into the other cartridge and said securing means also including a structural element extending into the explosive material in the other of said

cartridges and defining another jet forming cavity directed toward said one cartridge.

4. The explosive charge defined by claim 1 wherein said pin is provided with external projections engageable with the explosive material in each of the connected cartridges to assist in securing the pin to the two cartridges.

5. The explosive charge defined by claim 1 wherein the cavity defined by said pin is cone-shaped.

6. The structure defined by claim 3 wherein said securing means includes opposite ends respectively extending into said cartridges and wherein said securing means is provided with an explosive charge at one end together with means defining a jet forming cavity holding said explosive charge in position and facing the opposite end of the securing means.

7. The structure defined by claim 3 wherein said securing means includes opposite ends respectively extending into said cartridges and wherein said securing means is provided with explosive charges at its respective ends and with means defining jet forming cavities adjacent the explosive charges, which cavities face toward each other through the securing means.

8. The structure defined by claim 1 wherein said pin is provided with an explosive charge at one end together with means defining a jet forming cavity holding said explosive charge in position and facing the opposite end of the pin.

9. The structure defined by claim 1 wherein said pin is provided with explosive charges at its respective ends and wherein the explosive charges are retained within the pin by means defining jet forming cavities facing toward each other through the pin.

10. A hollow pin for securing together two adjacent cartridges in a column of explosive cartridges, said pin comprising a closed end portion at one end of said pin

shaped to define a jet forming cavity, structure closing the other end of said pin, a hollow body portion formed integrally with said structure and said end portion and defining a stand-off chamber, an explosive charge at one end of said pin, and means for holding said explosive charge in position at said one end of the pin and for defining a jet forming cavity facing the opposite end of the pin.

11. A hollow pin for securing together two adjacent cartridges in a column of explosive cartridges, said pin comprising a closed end portion at one end of said pin shaped to define a jet forming cavity, structure closing the other end of said pin, a hollow body portion formed integrally with said structure and said end portion and defining a hollow stand-off chamber, explosive charges at the respective ends of the pin, and means for holding the explosive charges within the pin and for defining jet forming cavities facing toward each other through the pin.

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