BLASTING ACCESSORIES

DU PONT

DU PONT

BLASTING ACCESSORIES ASSURE MAXIMUM EFFICIENCY WITH EXPLOSIVES

A-1023* (June '20)

BLASTING ACCESSORIES

BLASTING CAPS, SAFETY FUSE, CAP CRIMPERS, ELECTRIC BLASTING CAPS, DELAY ELECTRIC BLASTING CAPS, BLASTING MACHINES, ELECTRIC SQUIBS, DELAY ELECTRIC IGNITERS, CONNECTING WIRE, LEADING WIRE, GALVANOMETERS, RHEOSTATS, CORDEAU, THAWING KETTLES, BLASTING MATS, TAMPING BAGS, ETC.

MANUFACTURED BY

E. I. DU PONT DE NEMOURS & COMPANY

(INCORPORATED)

WILMINGTON, DELAWARE

BLASTING ACCESSORIES

EXPLOSIVES themselves demand first consideration when blasting is to be done, but the fact must not be overlooked that they cannot be properly exploded and will not develop their full strength without certain materials and appliances especially designed for the purpose. In addition to those articles necessary to develop the energy of a charge of explosives, there are other devices which, although they may not be absolutely requisite, contribute to safety, certainty and economy in the use of explosives. These are called "Blasting Accessories."

The importance of using Blasting Accessories that are up to the highest standard in every respect cannot be overestimated. The very best grade costs but a trifle in comparison with the charge of explosives with which they are used. It is poor economy to attempt to detonate explosives with an inferior detonator, for this always results in a considerable waste of the explosives.

The Du Pont Company has learned by more than a hundred years of experience just what is required in the shape of Blasting Accessories, and jealously maintains its standard of highest quality.

VIEWS OF BLASTING CAP WORKS AT POMPTON LAKES, NEW JERSEY

DU PONT

Blasting Accessories

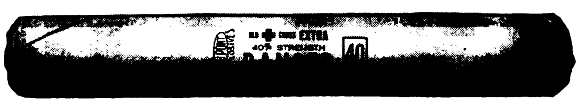
Classes of Explosives

There are two general classes of explosives—deflagrating and detonating.

Deflagrating Explosives.—This class of explosives includes all of those which are fired by sparks furnished by the spit (flying sparks) from an electric squib, safety fuse or a miners' squib. This class of explosives may also be fired by means of any of the detonators intended for high explosives. The principal deflagrating explosive is blasting powder.

DU PONT BLASTING POWDER GRAINS

Detonating Explosives.—This class of explosives includes all the dynamites, nitroglycerin, ammonia, gelatin and Arctic and Judson powders. They are not fired by sparks or flame, but require some powerful intermediate agent, such as an electric blasting cap, blasting cap or cordeau. These agents are called detonators.



A CARTRIDGE OF DYNAMITE

Deflagrating explosives, when loaded in large quantities, are frequently fired or exploded by charges of high explosives.

The Advantages of Strong Detonators

When high explosives are detonated, the stronger or sharper the initial shock the more effective is the detonation of the charge. It is a well-known fact that strong detonators will exert this effect more powerfully than will weaker ones. To obtain the full value of the explosive charge, it must be detonated completely. If the detonation is incomplete, a greater quantity of explosive is required to do the work, and large volumes of poisonous gases may be evolved—a matter of serious consequence when the work is underground. Instances are known where workmen have been killed by gases given off from partially detonated or burning explosives.

Complete detonation results in a minimum of flame, a point of first importance with those explosives intended for use in the presence of inflammable gas or coal dust. Electric blasting caps or other detonators too weak to detonate completely a charge of high explosives may generate sufficient heat to ignite it.

The effect of a detonator on a charge of high explosives in a bore hole is not infinitely powerful, but decreases with distance. It is, therefore, easy to understand the necessity for using detonators strong enough to ensure the effect of the detonator being felt throughout the charge. It might be understood from this that the detonator should be located in the center of the charge; this would be considered correct had not numerous tests shown that the greatest effect of the detonator is produced straight away from its loaded end and in a line with its long axis. For this reason it is advisable to have detonators pointed toward the main part of the charge or to use not less than two electric blasting caps in deep bore holes so that there is no danger of the diminishing force of the detonators failing to detonate completely the entire charge. This use of several detonators in a single large charge acts also as a safeguard against the danger of an occasional broken wire. The electric blasting caps should not be farther apart, in deep holes, than from twenty to twenty-five feet and for the lower strengths of insensitive explosives it is better to have them even closer to each other.

A point to be remembered in buying detonators is that the charge which they contain is weakened by moisture, and consequently, unless storage conditions are of the best, a fair margin of safety in strength should be allowed. Blasting caps, being open at one end, are more quickly weakened by dampness than are electric blasting caps.

Another strong argument for allowing a fair margin of safety in strength when buying detonators is the very small cost of the detonator in comparison with that of the charge of explosives with which they are used. It is difficult to understand why any one, in order to save a few cents on the price of a hundred detonators, would risk the misfire, partial detonation or imperfect work of the charge of explosives in a bore hole, which would result at best in the loss of several dollars and may cost thousands if the charge burns in a gaseous coal mine or if unexploded dynamite happens to cause a fatal accident.

The extended study and tests of explosives conducted during the past few years by the United States Bureau of Mines have clearly demonstrated the economy of using only strong detonators, and cautions against the use of weak detonators are numerous.

The Du Pont No. 6 Blasting Cap and Du Pont No. 6 Electric Blasting cap, recommended throughout this catalogue for detonating high explosives, comply with the specifications for strong detonators. The No. 8 Electric Blasting Cap and the No. 8 Blasting Cap have nearly double the strength of the No. 6.

Strong electric blasting caps and blasting caps should be used with all high explosives for the following reasons:

They insure complete detonation.
They increase the execution of the explosive.
They tend to counterbalance careless and improper usage.
They offset, to some extent, deterioration of explosives and detonators due to improper storage.
They reduce fumes from the explosives to a minimum.
They decrease the size and duration of flame.
They prevent the loss of the charge by burning.
Their effect carries further in long charges.
They reduce the chances of misfires.

Blasting by Electricity

Blasting by electricity is the most effective and economical system, and surpasses all others in safety and certainty as well as in results accomplished. Electric blasting makes it possible to fire several charges simultaneously. Great economy of explosives is effected by firing shots together, and it is often impossible to obtain satisfactory results otherwise.

Many kinds of blasting can be accomplished only by electric firing. Almost every kind of blasting that can be done by the cap and fuse method can now be done more safely, quickly and conveniently by electricity. With this method delayed explosions, or "hang fires," are hardly possible, and, as the blaster can always be a considerable distance away from the explosive when it detonates, the possibility of accident is reduced to a minimum.

No method of blasting in gaseous or dusty coal mines, other than the electrical one, deserves consideration because in all others the ignition in the open of some burning substance is necessary, even though a device be used whereby the safety fuse or squib can be ignited without exposing an open light or flame in a gaseous place.

It is believed by many authorities that disastrous explosions in coal mines have been caused by a blown-out shot occurring shortly after a number of other blasts have been fired. This cannot happen if the firing is done by electricity, when as many shots as desired are fired simultaneously. In submarine or other very wet work, no other system is feasible. In underground work, where ventilation is not good, burning safety fuse and miners' squibs increases the smoke and fumes very materially. It is not uncommon for the fire to break through the side of the fuse and ignite the charge of explosives before detonating the blasting cap, resulting in poor execution and increase in fumes. This cannot occur when the blasting is done by electricity.

Equipment Required

The equipment necessary for electric blasting is as follows:

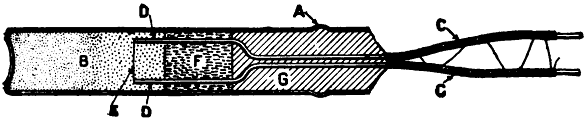
Electric Blasting Caps*	Connecting Wire
Leading Wire	Blasting Machine

The Galvanometer and Rheostat will also prove of much assistance and very often effect a saving of both time and money.

All of these accessories and their uses are fully described in the following pages.

Electric Blasting Caps

An electric blasting cap, as the name implies, is a special form of detonator fired or exploded by an electric current.



SECTIONAL VIEW OF ELECTRIC BLASTING CAP

The illustration above shows an electric blasting cap in section. A is a copper shell, having a corrugation thrown out from the inside, which holds the composition plug more firmly in place; B is a chamber containing the explosive charge; C, insulated copper wires entering the cap; D, the bare ends of the copper wires, projecting through the plug into the charge; E, a fine wire bridge soldered to and connecting the two ends of the copper

*For different classes of work the electric blasting caps are replaced by delay electric blasting caps, waterproof electric blasting caps, submarine electric blasting caps, delay electric igniters or electric squibs.

wires, which is heated by the electric current, thereby firing the explosive charge; F, the composition plug holding the electric blasting cap wires firmly in place; G, the filling material.

The strength of electric blasting caps is governed by the amount of the explosive charge contained, and is expressed by the numbers 6 and 8. The No. 8 Du Pont Electric Blasting Caps contain nearly twice the charge of the No. 6 and are almost twice as strong. Where large charges of explosives are used in one bore hole the use of a No. 8 Electric Blasting Cap will more than pay for itself in increased execution of the dynamite.

The following table describes fully the two sizes or strengths:

Grade	No. 6	No. 8
Color of Label	Red	Green
Length of Shell	$1\frac{9}{16}$"	2"
Calibre of Shell	.273"	.273"

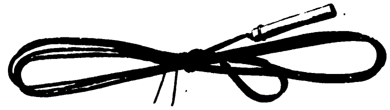
There is also a No. 7 Electric Blasting Cap that is intermediate between Nos. 6 and 8, but on account of one of these two strengths being adapted to all general work, the No. 7 strength is not recommended and is furnished only on special order.

The blasting cap wires, shown in the sectional view of the electric blasting cap, vary in length to suit different depths of bore holes and different classes of work. They must always be long enough to reach a few inches out of the bore hole, and should preferably be long enough to reach to the wires of the adjoining bore holes.

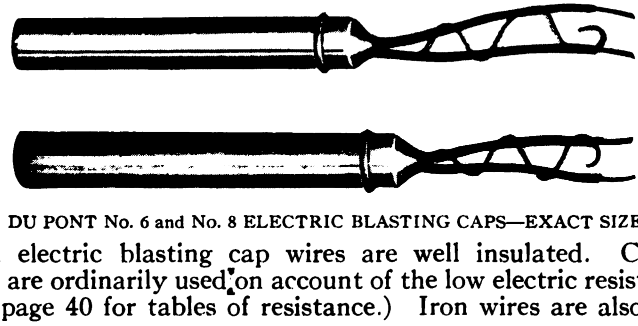
Stock lengths of wires are:

4 ft.	10 ft.	16 ft.
6 ft.	12 ft.	18 ft.
8 ft.	14 ft.	20 ft.

Special lengths not shown above will be supplied on special order.



A DU PONT ELECTRIC BLASTING CAP SHOWING WIRES



DU PONT No. 6 and No. 8 ELECTRIC BLASTING CAPS—EXACT SIZE

All electric blasting cap wires are well insulated. Copper wires are ordinarily used on account of the low electric resistance. (See page 40 for tables of resistance.) Iron wires are also used to some extent, especially in coal mining, but on account of the electric resistance of iron being about six times as great as that of copper, a blasting machine cannot fire as many electric detonators when iron wires are used as when copper wires are used. (See page 40 for table of resistance of iron wires.) The standard lengths of iron wires are 2, 4, 6 and 8 feet. Longer lengths will be supplied on special order, but they are not recommended. The iron wires are carefully insulated. For general work copper wires are far superior.

CARTON OF 50 ELECTRIC BLASTING CAPS

Electric blasting caps are packed in pasteboard cartons, which are inclosed in heavy wooden cases. The cartons contain either 25 or 50 electric blasting caps, depending on the length of the wires. Electric blasting caps with wires from 4 feet to 16 feet long are packed for domestic trade 500 to the case, while those with longer wires are packed 250 to the case.

The storage of electric blasting caps should always be given careful attention by the consumer. If they are permitted to remain for a long time in a very warm place, the waterproofing material in the insulation dries out to such an extent that the insulation may break when the wires are bent, and misfires result if an attempt is made to use them in wet work.

The explosive charge in the electric blasting caps is very easily affected by moisture, and if they are stored too long in a damp or wet place they may deteriorate. This charge is also very sensitive, and may be exploded by a moderately hard knock or jar. Electric blasting caps should, therefore, be handled carefully. Careful handling is also necessary on account of the delicate bridge wire (see sectional view of electric blasting caps), which may be broken by rough usage. When broken, the electric blasting cap is absolutely useless. The wires must not be bent sharply or forcibly separated at the point where they enter the copper cap, as this may break or loosen the filling material and permit water to enter and damage the explosive charge. These precautions are necessary with all classes of electric detonators.

Care must be taken when tamping the bore hole not to break either the electric blasting cap wires or the insulation on them, or to pull the electric blasting cap out of the primer.

Many misfires are due to carelessness in loading and tamping bore holes.

In each carton of electric blasting caps there is a paper tag called the "follow-up" tag. In case any trouble is experienced with the electric blasting caps, this tag should be preserved, as well as any unused electric blasting caps, and, in addition, the markings on the wooden cases in which the cartons were packed should be recorded.

SHIPPING CASE OF ELECTRIC BLASTING CAPS

Du Pont Electric Blasting Caps are so constructed as to be highly satisfactory for moist and wet work. They can be used under several feet of water if the time between loading and firing is not too great. They are not intended for use under great heads of water, or for submarine work.

Waterproof Electric Blasting Caps

Although electric blasting cap wires and copper shells are well insulated against water, they are not intended for extremely wet work, and if used in water, particularly under pressure, water may leak into the cap so that the explosive charge is destroyed or the electric current may "short circuit" through the water instead of passing through the bridge wire, which is of high resistance. For such work electric blasting caps with special insulation for wet work are used. These specially insulated electric blasting caps are called Du Pont Waterproof Electric Blasting Caps.

These are made in the same strengths, No. 6 and No. 8, with the same lengths of insulated copper wires as the electric blasting caps. Iron wires are not used. In order to give better waterproofing the copper shell is longer than for electric blasting caps so as to allow more space for filling material, shown at G (see sectional view of electric blasting cap on previous page). The copper wires have a special insulation which allows their use in water not over 30 feet deep. Where the depth of water is over 30 feet and where the primers are to remain in the water for a period longer than two days, the Submarine Electric Blasting Caps are strongly recommended because of their special water-resisting insulation.

Waterproof electric blasting caps must be placed within the charge of explosives just the same as Electric Blasting caps, with the important difference that safeguards must be taken to protect the primers from water. The waterproofing of primers and charges is discussed on page 61.

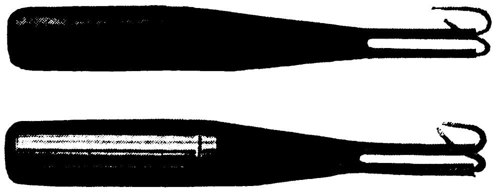
DU PONT WATERPROOF ELECTRIC BLASTING CAP

They must be handled in the same careful way as electric blasting caps. They are packed in cartons, and then in cases of the same size as are used for electric blasting caps. The weights of packages are slightly greater than those of electric blasting caps.

Submarine Electric Blasting Caps

For under-water work, where the greatest safeguards against water are necessary for safety and for developing the full strength of explosives, a special Submarine Electric Blasting Cap is used. It is made somewhat like the waterproof electric blasting

DU PONT WATERPROOF ELECTRIC BLASTING CAPS AND SUBMARINE ELECTRIC BLASTING CAPS ARE MADE TO STAND THE SEVEREST UNDER-WATER CONDITIONS



DU PONT SUBMARINE ELECTRIC BLASTING CAP AND SECTION OF SAME TO SHOW THE GUTTA-PERCHA COVERING

cap, with well-insulated wires and a long waterproof shell for the detonating charge. It is further waterproofed by having a heavy covering of gutta-percha over the shell and the lower or cap ends of the wires.

Submarine Electric Blasting Caps are made in the same strengths as Electric Blasting Caps Nos. 6 and 8.

To meet the requirements for under-water conditions, Submarine electric blasting caps are furnished (on special factory orders only) with gutta-percha insulated wires.

They are primed, connected and fired as are other electric blasting caps, and the necessary precautions are taken to guard against water entering the primed cartridge. (See page 61.)

Submarine electric blasting caps require the same careful storing and handling as do other electric detonators. They are packed in cartons as are electric blasting caps, but weigh slightly more.

Delay Electric Blasting Caps

In some kinds of blasting, particularly in tunnel and shaft work, it is necessary to blast each round of bore holes in sections or in rotation. It is generally a saving in time if this can be done in such a way as to obviate the necessity of returning to the working face after each section has been blasted to arrange for the next blast. When fuse and blasting caps are used to detonate the explosive, the sections of fuse for the different bore holes are cut in different lengths so that the charges will explode in the proper

First Delay (Size Reduced). Length of Shell, 1 Inch

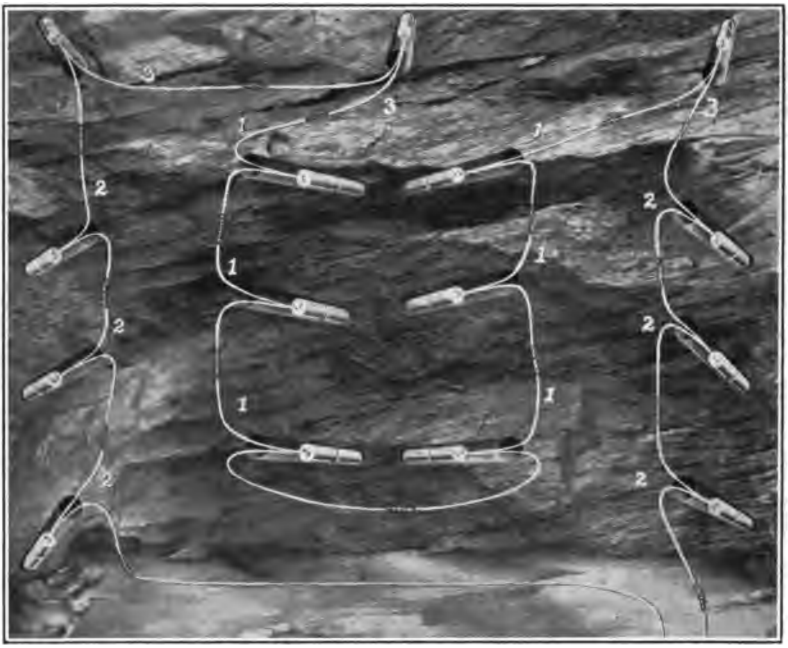
Second Delay (Size Reduced). Length of Shell, 1 ½ Inches

DELAY ELECTRIC BLASTING CAPS

sequence if the fuses are lighted at about the same time. There is practically no limit to the number of charges which can be exploded in sequence with fuse and blasting caps in this way, but electric firing is much more satisfactory for the many reasons of safety and effectiveness pointed out in the chapter on Electric Blasting. Under most conditions there is nothing to be gained by dividing the round of holes into more than three sections. This permits of cut, relief and rib shots.

The Du Pont Delay Electric Blasting Caps have been developed for such conditions so that these three classes of shots may be fired in rotation with a single set of wiring and with but one application of the electric current, and in such a way that there is no trouble from the first round of shots breaking the wires for the second and third rounds, as is the case when two or three sets of wires are used for a series of shots using only electric blasting caps.

There are two kinds of delay electric blasting caps—first delay and second delay. These are so constructed that there is a short lapse of time after the current is applied before the first delays explode, and a longer delay before the second delays



METHOD OF CONNECTING INSTANTANEOUS, FIRST DELAY AND SECOND DELAY ELECTRIC BLASTING CAPS explode. It should not be understood that all first delays explode simultaneously, but the variation in time is very little and all first delays explode before any of the second delays. There is also a little variation in the time of explosion of the second delays.

In practical work the delay electric blasting caps are used in connection with Du Pont Electric Blasting Caps. As the electric blasting caps explode immediately upon receiving the electric current, they are used in the holes that are to go first, such as cut holes, thereby relieving the burden on the second set of holes, such as relief shots, which are primed with first delays. The last set of holes, such as rib shots, are primed with second delays and explode after all of the others are out of the way. A better understanding of this loading may be obtained by a close study of the illustration of a method of connecting delay electric blasting caps as shown on opposite page.

Delay electric blasting caps are manufactured in Nos. 6 and 8 strengths, as are electric blasting caps. They are fitted with copper wires only. The lengths of the wires are the same as for electric blasting caps, and longer wires are furnished on special order. The wires on the first delays are white, and those on the second delays are blue, to distinguish them from one another and from electric blasting caps before and after loading. A third delay with red wires is furnished on special order.

Delay electric blasting cap wires are connected for blasting just as are electric blasting caps. They may be connected in the same series with any of the other Du Pont electric detonators or with Du Pont Delay Electric Igniters. Delay electric blasting caps are packed in cartons such as are used for electric blasting caps, but the packages weigh slightly more than packages of electric blasting caps.

Weights and Dimensions of Packages of Domestic Electric Blasting Cap Cases

Quantity Per Case	Quantity Per Carton	Length, Feet	Gross Lbs.	Tare Lbs.	Net Lbs.	Outside Dimensions Length	Width	Depth	Dimensions Cartons
500	50	4′	25	7½	17½	22″ x	9½″ x	9½″	8″ x 4″ x 4″
500	50	6′	31	7½	23½	22″ x	9½″ x	9½″	8″ x 4″ x 4″
500	50	8′	38	8½	29½	22″ x	11½″ x	9½″	10″ x 4″ x 4″
500	50	10′	44	8½	35½	22″ x	11½″ x	9½″	10″ x 4″ x 4″
500	50	12′	53	10	43	22″ x	15½″ x	9½″	14″ x 4″ x 4″
500	50	14′	59	10	49	22″ x	15½″ x	9½″	14″ x 4″ x 4″
500	50	16′	66	10¾	55¼	22″ x	17½″ x	9½″	16″ x 4″ x 4″
250	25	18′	44	10¾	33¼	22″ x	17½″ x	9½″	16″ x 4″ x 4″
250	25	20′	47	10¾	36¼	22″ x	17½″ x	9½″	16″ x 4″ x 4″

Delay Electric Igniters

A delay electric igniter is made up of a cylindrical copper tube, into one end of which the necessary wires, plug, etc., are inserted, and into the other end is crimped a piece of fuse 2 inches, 4 inches, 6 inches, 8 inches, 10 inches or 12 inches in length. The igniters are designated as first delay, second delay and so on to sixth delay, respectively, the delay being determined by the length of the fuse. They are made with insulated copper or iron wires of the same length as the Du Pont Electric Blasting Caps. Longer wires may be had on special factory orders, and also longer lengths of fuse in order to secure more delays or longer intervals of delay.

They are designed for firing charges of explosives in rotation, one after another. By using Du Pont Electric Blasting Caps in the cut holes or the first set of holes to be fired, first delays in the second set, second delays in the third set, and then following with the other delays in order.

When a delay electric igniter is used with dynamite it is necessary to cut off a quarter inch from the end of the fuse, crimp a No. 6 or No. 8 Blasting Cap to the fuse and insert it in a cartridge of dynamite as a primer. When used with blasting powder, it is not necessary to use a blasting cap, but the *end* of the fuse only should be in contact with the powder.

DELAY ELECTRIC IGNITER

They can be used with success in tunnel driving, shaft sinking, or any other work of this character when it is desirable to have the shots fired in rotation. They can be used in dry or moist work.

The use of delay electric igniters is strongly recommended for coal and other mining, especially where it is unsafe to fire more than one shot at a time. By their use it is possible to load as many as six shots, and with one set of connections and one application of the current, to have each shot fired singly. This applies to the use of both blasting powder and dynamite.

Where the copper shell is placed so that it is covered with tamping there is a minimum of fuse smoke allowed to escape.

Delay electric igniters require the same careful storage as other electric blasting accessories. They are packed in the same kind of cartons as electric blasting caps. The number packed in each carton depends on the length of the fuse.

Electric Squibs

Blasting powder is best ignited in the center of the charge. It is impossible to do this with certainty with miners' squibs or safety fuse. It can easily be done with Du Pont Electric Squibs.

When a charge of blasting powder in a long bore hole is ignited at one end, it is always possible for some of the coal or rock to move before the entire charge explodes, and thus relieve the confinement from the powder in the far end of the hole. This is most likely to happen when large charges are ignited at the end nearest the mouth of the bore hole. Then more or less of the powder at the back of the bore hole, where the burden is usually the heaviest, does very little execution, and a large flame and a great volume of smoke are projected into the working place.

Attempts to ignite the charge at the center are sometimes made by extending the fuse to that point; but this is seldom successful, owing to the fact that most fuse will spit fire from the sides and ignite the charge where the fuse enters it. Even the very best tape and gutta-percha fuse will do this occasionally. The expense attached to the use of the highest quality of fuse has caused this method of igniting charges of blasting powder in bore holes to be practically abandoned.

EXACT SIZE OF DU PONT ELECTRIC SQUIB

Miners' squibs, often used for igniting blasting powder charges in bore holes, are sometimes uncertain in their rate of burning, and may give but little time for the blaster to reach a place of safety after lighting them. This makes it necessary, when a number of shots are ready to be fired, for the blaster to return to the face several times, causing the loss of valuable time. The miners' squib also necessitates an opening in the tamping which may result in the flames from the blast blowing back into the open and igniting mine dust or gas. This opening makes gas-tight tamping impossible.

All of these disadvantages are overcome by the use of Du Pont Electric Squibs that give all the general advantages of electrical firing. These Electric Squibs are similar in general appearance to Du Pont Electric Blasting Caps, but have a heavy paper shell or cap instead of a copper one. The end of the shell is closed with a small cork, which should be taken out before using. The charge in this cap does not detonate as does that in electric blasting caps, but merely shoots out a small flame. When electric squibs are used, the charge of blasting powder can be ignited in the center, thus giving a little quicker and stronger action, and insuring the explosion of the entire charge before any of the surrounding material can fall and cut off a portion of it. The bore hole can be tamped solid, leaving no vent for a partial loss of the strength of the powder. When the entire charge is exploded at once, less smoke is given off by the blast. This, with the elimination of smoke from burning safety fuse, or miners' squibs, results in purer air, making it possible for both miners and draught animals to do more work. Aside from better blasting and greater safety, this one feature is of sufficient advantage to warrant the use of electric squibs.

Another advantage in using electric squibs is that when it is possible to fire more than one shot at a time all of the bore holes can be connected in series and fired at the same instant. This results in a very considerable saving of time, as well as powder, as shot firers can cover much more ground than when using fuse or miners' squibs.

CARTON OF ELECTRIC SQUIBS

It is much safer to blast with electric squibs than with fuse or miners' squibs, because shots are not fired until everyone, including the blaster, is a safe distance away, and because danger of hang fires is entirely obviated.

Advantages resulting from the use of electric squibs are:

Instantaneous firing.

Control of moment of firing.

Simultaneous firing of a number of shots.

Greater efficiency of blasting powder.

Saving of time.

Greater safety.

Elimination of fumes from safety fuse.

Decrease of smoke from blasting powder.

Electric squibs require the same good storage conditions as electric blasting caps. Although they cannot be exploded by shock or concussion as can electric blasting caps, they must be handled just as carefully, for their construction is necessarily delicate and they can be easily broken by rough handling.

They are manufactured with 4, 6, 8, 10 and 12 foot copper wires, and 4, 5, 6 and 8 foot iron wires. Those with iron wires are somewhat less expensive, but require a stronger electric current to explode them, because of the inferior conductivity of iron as compared with copper wire. They are also more easily affected by moisture. We do not recommend electric squibs with iron wires longer than 8 feet, nor do we carry them in stock.

ELECTRIC SQUIB WITH 6-FOOT WIRES

Electric squibs are packed 50 to the carton and 10 cartons to the case. Gross and net weights of cases are as follows:

Quantity	Length	Kind of Wire	Gross Weight	Net Weight	Outside Dimensions of Cases
500	4 ft.	Copper	23 lbs.	15½ lbs.	22" x 9½" x 9½"
500	6 ft.	Copper	29 lbs.	21½ lbs.	22" x 9½" x 9½"
500	8 ft.	Copper	36 lbs.	27½ lbs.	22" x 11½" x 9½"
500	4 ft.	Iron	25 lbs.	16½ lbs.	22" x 11½" x 9½"
500	5 ft.	Iron	27 lbs.	18½ lbs.	22" x 11½" x 9½"
500	6 ft.	Iron	32 lbs.	23½ lbs.	22" x 11½" x 9½"
500	8 ft.	Iron	39 lbs.	29 lbs.	22" x 15½" x 9½"

Cases of ½" material. For inside dimensions deduct one inch from each dimension.

The method of wiring electric squibs is exactly the same as for other electric detonators. This is described on pages 45 to 51.

Photographic Squibs

The use of electric squibs is highly successful for firing photographic flash powders. By their use any number of flashes may be fired at the same time. The action is positive. For this work the squibs may be fired by means of a blasting machine or an electric lighting circuit. Photographic electric squibs are made with 6-inch copper wires. They are connected up in exactly the same manner as Du Pont Electric Squibs and Electric Blasting Caps.

Connecting Wire

Connecting wire is insulated copper wire (No. 20 Brown & Sharpe gauge). It is put up in 1-pound and 2-pound spools. A 1-pound spool is 3 inches in diameter, 4 inches long and holds about 210 feet of wire. A 2-pound spool is 3 inches in diameter, 5½ inches long and holds about 420 feet of wire.

Connecting Wire
(1-lb. Spool)

Connecting wire is used to join the wires of the electric blasting caps together, when they are not long enough to reach between the adjoining bore holes. The ends of the connecting wire must be scraped bright before connections are made. The joints should not be permitted to lie in water or on wet ground. If this cannot be prevented, the joint should be covered with insulating tape.

No. 21 (Brown & Sharpe gauge) Insulated Copper Wire is also used for connecting wire, but is not recommended because it is considered too small for best results.

A 1-pound spool of No. 21 Connecting Wire holds about 260 feet and a 2-pound spool about 520 feet.

The resistance of No. 20 gauge Insulated Copper Connecting Wire is 10.14 ohms per thousand feet. The resistance of the No. 21 size is 12.78 ohms per thousand feet.

Leading Wire

The wire commonly used for connecting electric blasting caps, other electric detonators and electric squibs to the blasting machine is known as leading wire. It is insulated copper wire (No. 14 Brown & Sharpe gauge) and is furnished in coils of the following lengths and weights:

200 ft.	about 4 lbs.	300 ft.	about 5.8 lbs.
250 ft.	about 5 lbs.	500 ft.	about 9.6 lbs.

The leading wire should always be long enough to keep the blaster well out of the zone of danger.

Duplex leading wire is made by binding together two insulated copper wires with an outside insulation, thus giving a return circuit cable that may be handled the same as a single wire. It weighs approximately twice as much as the same length of single leading wire and can be had in coils of the same lengths.

Duplex wire is more satisfactory for use where the two end holes in a blast are not far apart, as in stump blasting and similar work. Single wire is generally preferred to the Duplex where the end holes are far apart, as in quarry and electric ditch blasting. Single leading wire is frequently used for connecting wire instead of the small gauge connecting wire, especially in large blasts.

ROLL OF LEADING WIRE

SINGLE LEADING WIRE SLIGHTLY REDUCED

DUPLEX LEADING WIRE (ACTUAL SIZE)

Special Leading Wire for Miners

For the use of miners and a few other blasters who fire but from one to three charges in a blast, and then under conditions where it is not necessary to be far from the blast, a special 18-gauge Duplex Leading Wire is furnished on special order in 100 and 150 foot lengths. This wire weighs 1.85 pounds per hundred feet. This leading wire is intended only for the work specified and is not intended for general blasting.

Leading Wire Reels

The leading wire reel is a valuable accessory in enabling the blaster to coil up his leading wire with a minimum of kinking of the wires. It keeps the two wires separate, avoiding the chance of accidental short circuits. The crank is built in the form of a handle for the easy carrying of the leading wire reel. Aside from the convenience, its use will save its price many times over in the course of a few years.

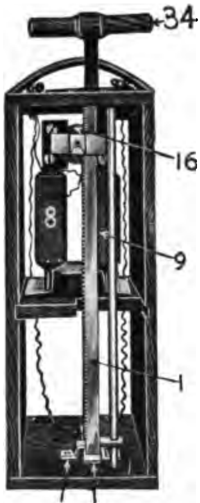
LEADING WIRE REEL

Blasting Machines

Blasting machines are used to generate the current for firing blasts by electricity.

Du Pont Blasting Machines, with the exception of the Pocket Blasting Machine, are small portable dynamos, in which the armature is rotated by the downward thrust of the rack bar, thereby converting muscular energy into electrical energy. They are not magnetos, although they are often erroneously so called.

A magneto has a permanent magnet for a field, whereas the dynamos in the Du Pont Blasting Machines have electro-magnets. They are wound somewhat differently from a dynamo built for delivering a continuous current for power or lighting purposes, in that the current in the Du Pont Blasting Machines is short circuited through the field magnets for the purpose of building up, intensifying and storing the current until the end of the rack bar stroke, when the whole accumulated current is sent out through the firing line.



PARTS OF DU PONT BLASTING MACHINE

The construction of the push-down Du Pont Blasting Machines is shown in the accompanying illustration. 1, Rack bar, showing teeth which engage the pinion on end of armature; 4, the contact spring, which, when struck by the bottom of the descending rack bar, breaks the contact between two small platinum bearings, one on the upper face of the contact spring and the other on the under side of the bridge 5, and in this way throws the entire current through the outside circuit; that is, leading wire, electric blasting caps and connecting wire; 8, 9, field magnets; 16, revolving armature; 34, rack bar handle.

They are rated according to the number of electric blasting caps that they can be depended upon to fire when connected in series. For convenience, the electric blasting cap with 30-foot copper wires is taken as the unit. There are six different sizes, all of which are two-post machines.

Du Pont Pocket Blasting Machine


Pocket Size

The Pocket Blasting Machine is a light-weight machine, having permanent field magnets, especially made for coal mining, where it is not often required to fire more than one charge at a time. It is also serviceable for small jobs, such as stump and boulder blasting. It has a capacity of three electric blasting caps. It weighs 4½ pounds. It is furnished with a removable handle, which prevents its being operated by any other person than the blaster.

Method of Operating

To operate the Du Pont Pocket Blasting Machine, first remove the carrying handle from the socket and insert the firing handle, taking care to see that it is properly engaged in the teeth below. Hold the machine firmly in one hand, with the other hand on the handle. When ready to fire give the handle a quick, hard turn in a clockwise direction. This generates the current and causes it to flow through the leading wires

METHOD OF OPERATING A DU PONT POCKET BLASTING MACHINE

Position of the hands preparatory to giving the handle the clockwise turn to generate the current.

Position of the hands after completion of generation of current.

No. 2 Blasting Machine

The No. 2 size is generally used in stump and boulder blasting, for springing bore holes on large work, and for mining where it is desired to fire more than five electric blasting caps at a time. It is strongly made, weighs 15 pounds, and has a capacity of ten electric blasting caps with copper wires, or seven electric blasting caps with iron wires.

Its use, in connection with a large blasting machine, will often save time and money, being more portable and less expensive than the size necessary for large blasts.

No. 3 Blasting Machine

The standard size for quarry and mine. Its capacity is thirty electric blasting caps with copper wires. Weight, 25 pounds. Due to its small size this blasting machine can be easily carried and operated with satisfactory results. It is recommended for all general blasting opera-

No. 2

No. 3

tions, where a larger blasting machine is not necessary, and even where a smaller one, except the pocket blasting machine, will do the work.

It is small enough to be carried easily, and yet is strong enough for any thing except the largest blasts.

This size has given satisfaction to users for many years and is the most popular of all blasting machines.

No. 4 Blasting Machine

A large machine for quarry, mine and excavating work. Capacity, fifty electric blasting caps with copper wires. Weight, 42 lbs.

This machine is a larger size of the same type as the popular No. 3 Blasting Machine. It can be depended upon for successfully firing as large blasts as are required on any except the very largest work.

No. 5 Blasting Machine

The No. 5 is a type of blasting machine embodying a number of mechanical and electrical improvements. It is very easily operated and built especially strong to withstand severe usage. It is particularly adapted for use in quarry and contracting work, where it is desirable to fire a large number of electric detonators at one time. It has a capacity of 100 electric blasting caps with copper wires. It weighs 53 pounds.

No. 4

No. 5

It is the best blasting machine of its capacity ever produced.

No. 6 Blasting Machine

The No. 6 Blasting Machine, while operated like the others, is of a different type, embodying many refinements of design, giving a machine of great power and lighter weight. It has a capacity of 150 copper wire electric blasting caps, and is, by far, the most powerful blasting machine made. It weighs only 37 pounds.

All Du Pont Blasting Machines are securely boxed for shipment. The shipping boxes make excellent containers for storing and protecting blasting machines when they are not in use.

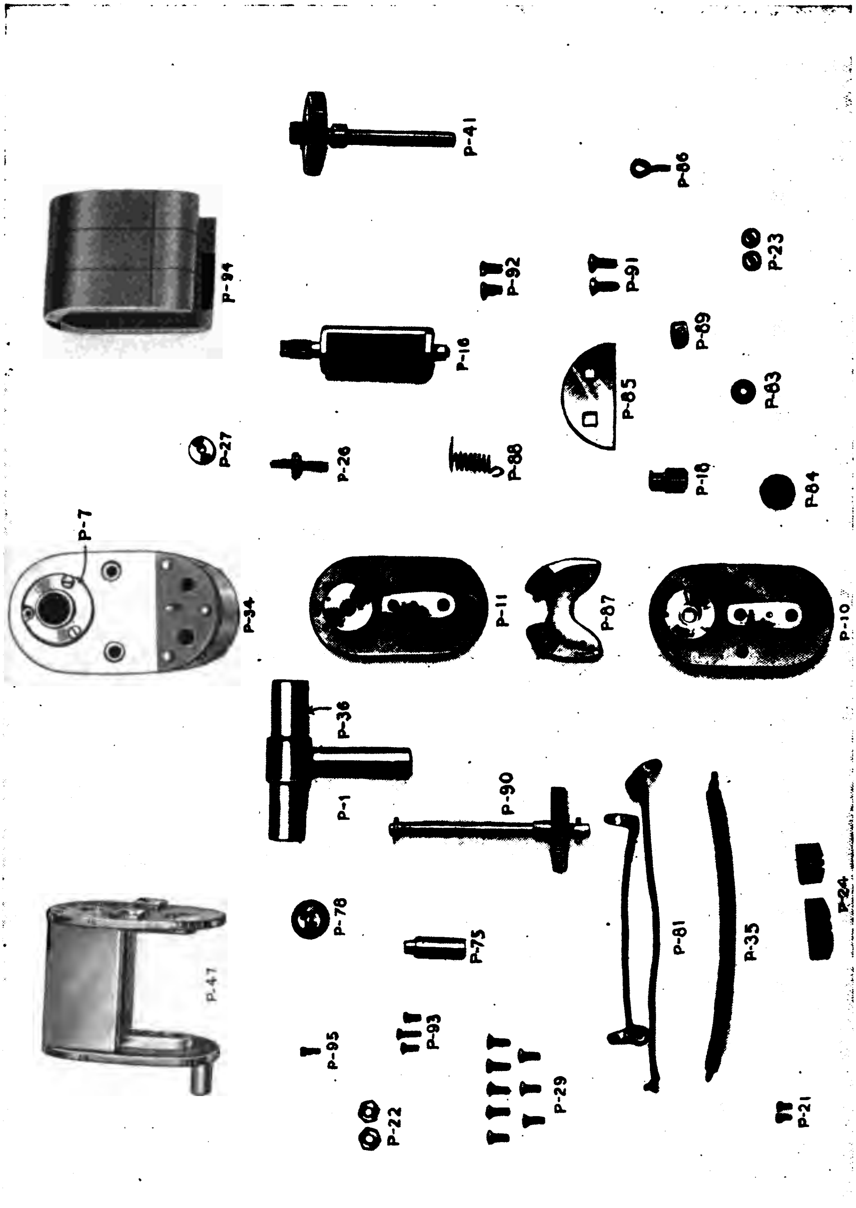
No. 6

Table Showing Capacities and Uses of Du Pont Blasting Machines

Size of Machine	Capacity, Number of 30-foot Electric Blasting Caps, Copper Wires	Used For
Pocket	1 to 3	Mining, stumping and boulder blasting.
No. 2	1 to 10	Springing bore holes, all classes of small blasts.
No. 3	1 to 30	General work and mining.
No. 4	1 to 50	Large quarry and contracting work.
No. 5	1 to 100	All classes of large blasts.
No. 6	1 to 150	All classes of large blasts.

Operating a Du Pont Push-Down Blasting Machine

To operate the push-down blasting machine (Nos. 2, 3, 4, 5, 6), set it squarely on a solid, level place, connect up the wiring as described on pages 45 and 48, lift up the rack bar by the handle to its full extent, and with one quick, hard stroke push it down to the bottom of the box with a *solid thud* using both hands. Try



PARTS OF DU PONT POCKET BLASTING MACHINE to knock the bottom out of the machine. As the rack bar approaches the bottom, it becomes more difficult to operate, because of the "building up" of the current; but the speed of the thrust should not be diminished, because the finish of the operation is more important than the start. Do not be afraid of pushing the rack bar down too hard. The machine is built to stand it, and this is the only way to use it successfully.

OPERATING A DU PONT BLASTING MACHINE

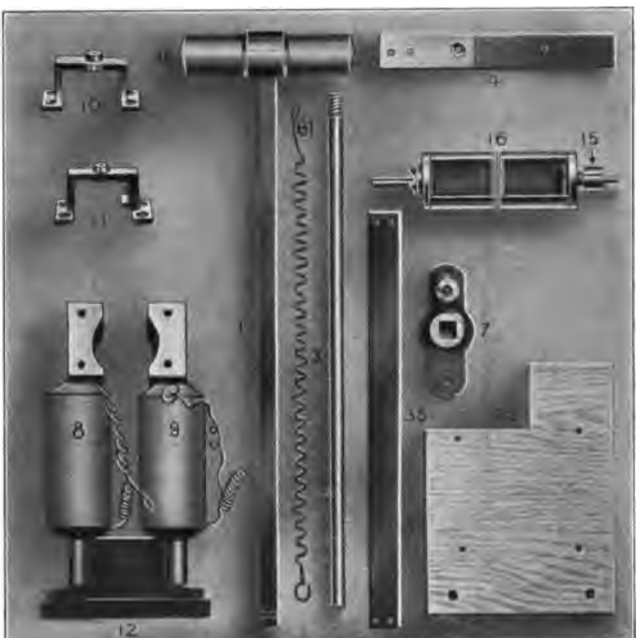
Blasting Machine Parts

The parts of these blasting machines are all standard, and when worn out or broken can be replaced at a small cost. When ordering, give the style and number of the blasting machine in which they are used, as well as the number of the part as shown in illustration on the following pages. Do not return a blasting machine to us to be repaired without first securing proper shipping directions from our nearest branch office.

List of Parts of Du Pont Pocket Blasting Machines

P- 1. Winding Key.
P- 7. Guide Plate for Winding Key. (Should be ordered together with P-34 Brass Case only.)
*P-10. Commutator Bearing. (Should be ordered in pairs with P-87 Gear Shield.)
*P-11. Gear Bearing.
P-16. Armature, complete with Heads and Commutator.
P-18. Armature Pinion.
P-21. Brass Screws (2) for Brushes.
P-22. Hexagon Nuts (2).
P-23. Brush Screw Insulators.
P-24. Brush Insulators.
P-26. Binding Post.
P-27. Thumb Nut for Binding Post.
P-29. Iron Screws (8) for Bearings $\frac{3}{8}'' \times \frac{6}{32}''$.
P-34. Brass Case, complete with P-7 Guide Plate for Winding Key.
P-35. Brass Chain, with Rubber Cover.
P-36. Wooden Handle.
P-41. Ratchet Gear with Clutch, Ball Bearings, Pinion and Shaft.
P-47. Two Pole Pieces with Ends.
P-75. Half Gear Stop.
P-78. Brass Cap for Key-Hole.
P-81. Connecting Wire with Contacts.
P-83. Binding Post Insulators.
P-84. Leather Washer.
P-85. Fibre on Top Plate.
P-86. Hook for Chain.
*P-87. Gear Shield. (Should be ordered together with P-10 Commutator Bearing and P-11 Gear Bearing.)
P-88. Release Spring on Half Gear.
P-89. Brass Collars with Set Screw.
P-90. Half Gear, Shaft, Contact Spring and Copper Bur.
P-91. Screws (Oval Head) 2 for top of case.
P-92. Screws (Flat Head) 2 for bottom of case.
P-93. Brass Screws (Oval Head) for Guide Plate.
P-94. Magnets (3) Esterline.
P-95. Screws (1) for Pinion.

*Parts P-10 Commutator Bearing, P-11 Gear Bearing and P-87 Gear Shield should all three be ordered together so that they may be properly drilled and fitted up.



PARTS OF DU PONT Nos. 2, 3 AND 4 BLASTING MACHINES

Parts of Blasting Machines Nos. 2, 3, 4

(*Specify Number of Blasting Machine See Page 30*)

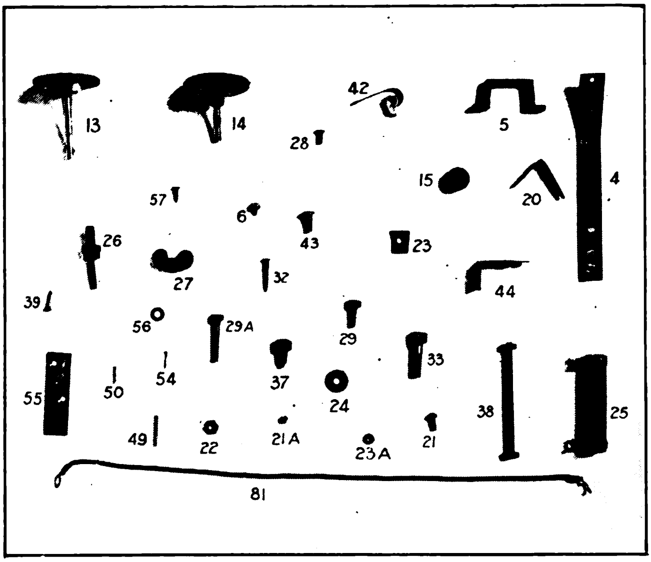
1.	Rack Bar.
2.	Guide Yoke.
3.	Guide Rod.
4.	Contact Spring.
5.	Bridge.
6.	Contact Screw.
7.	Guide Plate.
8 and 9.	Fields, a pair.
8.	Field.
9 and 12.	Field and Base Block.
10 and 11.	Bearings, a pair.
12.	Base Block.
13 and 14.	Armature Heads and Shaft, a pair.
15.	Commutator.
16.	Armature.
17.	Clutch.
18.	Armature Pinion.
19.	Pinion Spring.
20.	Brush.
21.	Brush Screws.
22.	Brass Nut.
23 and 24.	Insulators.
26.	Binding Post.
27.	Wing Nut.
28.	Armature Screws.
29.	Bearing Screw.
30.	Iron Screw for Base Block.
31.	Copper Rivet.
32.	Iron Screw.
33.	Iron Screw with Nut to Bolt No. 12 to No. 45.
34.	Mahogany Case.
35.	Leather Strap.
36.	Wood Handle.
45.	Shelf.
81.	Connecting Wire.

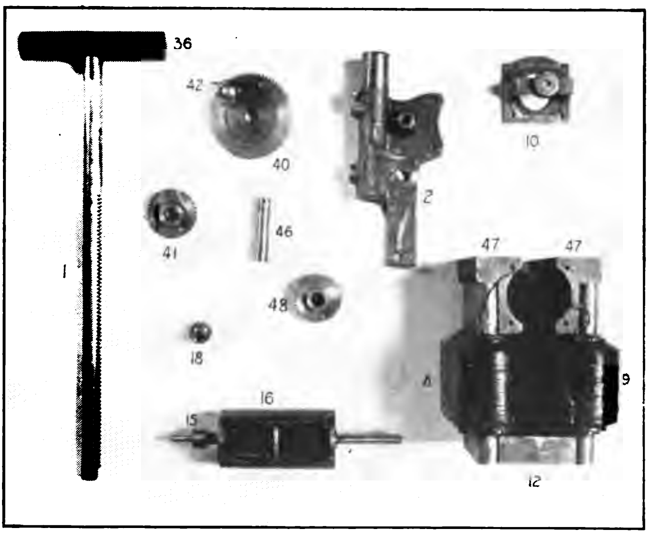
On No. 2 machine parts No. 9 (Field) and No. 13 (Base Block) are cast together and cannot be sold separately.

Parts of Blasting Machine No. 5

(*Specify Number of Blasting Machine See Page 32.*)

1.	Rack Bar.
2.	Rack Guide and Rear Bearing.
4.	Contact Spring.
5.	Bridge.
6.	Contact Screw.
8 and 9.	Fields.
10.	Front Bearing.
12.	Base Block.
13.	Armature Rear Head and Shaft.
14.	Armature Front Head and Shaft.
15.	Commutator.
16.	Armature Complete with Commutator.
18.	Armature Pinion.
20.	Brush.
21 and 21a.	Brush Screw.
22.	Brass Nut.
23 and 23a.	Brush Insulators.
24.	Resistance Coil Insulator.
25.	Resistance Unit.
26.	Binding Post.
27.	Wing Nut.
28.	Armature Screw.
29 and 29a.	Rear Bearing Bolts.
33.	Iron Supporting Screw.
34.	Mahogany Case.
35.	Leather Strap.
36.	Wood Handle.
37.	Rack Bar Stop Screw.
38.	Bolt with Nuts for Resistance Unit.
39.	Brass Screw for Resistance Unit Brackets.
40.	Large Gear.
41.	Ratchet Gear.
42.	Pawl and Spring.
43.	Pawl Pin.
44.	Resistance Unit Bracket.
46.	Large Shaft.
47.	Pole Pieces.
48.	Intermediate Pinion.
49.	Pin for Intermediate Pinion or Ratchet Gear.
50.	Pin for Pinion.
54.	Pin for Pawl Spring.
55.	Contact Plate.
56.	Brass Washers.
57.	Screw for Contact Plate.
81.	Connecting Wire.





PARTS OF DU PONT No. 5 BLASTING MACHINE

PARTS OF DU PONT No. 6 BLASTING MACHINE

List of Parts of Du Pont No. 6 Blasting Machine

- 1. Rack Bar.
- 2. Rack Bar Guide.
- 4. Contact Spring.
- 5. Top Plate.
- 6. Rack Bar Guide Yoke.
- 8 and 9. Fields.
- 10. Large Gear Bearings.
- 12. Base Shelf.
- 13. Generator Front Bearings and Shield.
- 14. Generator Rear Bearings.
- 20. Brush.
- 21. Brush Holder.
- 21a Brush Spring.
- 22. Corners.
- 25. Screws for Large Gear Bearings.
- 26. Binding Post (Regular Standard).
- 27. Wing Nut (Regular Standard).
- 28. Screws for Rack Guide.
- 33. Screws for Generator.
- 35. Brass Handle.
- 36. Handle for Rack Bar.
- 37. Rack Bar Stop Screw.
- 38. Rack Bar Insulator.
- 39. Screws for Shelf (brass).
- 40. Pinion.
- 40a Pinion Pin.
- 41. Ratchet Gear and Pin.
- 42. Large Gear, including Pawl, Spring and Shaft.
- 55. Contact Plate.
- 56. Oil Cups.
- 80. Armature, including Commutator.
- 81. Connecting Wire.
- 82. Motor, complete.
- Mahogany Case.

Care of Blasting Machines

Du Pont Blasting Machines are strongly made, and will stand with little deterioration the treatment to which it is necessary to subject them. Their mechanism, though designed as simply as possible, is more or less complicated and delicate, and they must be treated with at least some consideration. There can be no possible excuse for throwing a blasting machine about, or permitting it to remain exposed to wet weather or lying in the mud. When a blasting machine is treated in this way its life will be short and its usefulness limited.

Remember that good care will prolong the usefulness of the blasting machine, will reduce the necessity for repairs and will help to maintain its efficiency. The bearings and gearings should be lightly oiled occasionally, but on the commutator, which is the small copper-covered wheel on the end of the armature shaft, *never use oil.* If the commutator becomes badly discolored or dirty and needs cleaning, hold a piece of fine sandpaper, No. 00, against it while rotating it slowly. Never use emery. See that the two slots cut in the copper part of the commutator are clean, and with no particle of metal or anything else in them which might cause a short circuit. Keep the copper brushes (see 16, page 24) clean, and see that they bear firmly on the commutator. Keep the circuit-breaking contacts clean and bright.

When a blasting machine is not in use, store it in a dry and comparatively cool place—not in a leaky tool box or on top of a boiler.

Every blasting machine is tested thoroughly before leaving the works. If a new one does not give satisfactory results when received, it may not have been operated properly or may have been injured by rough handling during transportation.

Every blasting machine should be tested occasionally with a Du Pont Rheostat.

Galvanometer

The galvanometer is a small instrument used to determine whether a blasting circuit is closed or open; that is, whether the circuit is in the proper condition for the blast, or, because of defective wires or poor connections, will fail to transmit the electric current. The Du Pont Galvanometer can be used also to measure the amount of resistance, thus indicating the existence of leaks or short circuits. It is of value in testing not only blasting circuits, but also individual electric detonators.

The instrument is a magnetic device in which an electric current from a small chloride of silver dry cell moves a pointer across a scale. There are two binding posts conveniently located for connections. When a passageway (circuit) is offered, so that the electric current can pass from one binding post to the other, the current from the battery cell flows through this circuit, traversing the galvanometer coil on the way, causing the pointer to be deflected. The cell and needle are contained in a case made of metal and hard rubber, which is in turn contained in a leather carrying case. The galvanometer is small and flat and may be carried comfortably in the pocket, or, when in use, slung from the shoulder by the strap.

The battery cell is one selected after a long series of experiments. While of long life and of great constancy, it is very weak. The current which is sent through an electric detonator when making a test with the assembled instrument is less than one-tenth of the strength required to explode it. The length of time a battery cell will last depends, of course, upon how frequently it is used and how long the current is allowed to flow in making each test. When properly used, one cell is sufficient for several thousand tests. The simple form of connection enables the user to easily replace the exhausted cell with a new one. The cell is very small and light and can be sent by mail.

As the construction of the galvanometer and the methods for using it are quite simple, the instrument is adapted to the requirements of the practical blaster as distinguished from the trained electrician, whose finer instruments and methods would be at a disadvantage under the conditions prevailing on the ordinary electric blasting job. The galvanometer gives as accurate electrical tests as are ordinarily needed in blasting work.

DU PONT GALVANOMETER WITH CARRYING CASE AND STRAP

We recommend the Du Pont Galvanometer to our customers because it is a convenience and a time-saver and because the exactness of operation which it makes possible secures better execution from explosives, lessens the risk of blast failures, and minimizes the danger of accidents.

Care of Galvanometer

Although the galvanometer is simple in design, and as substantially made as possible for such an instrument, some of the parts are necessarily of delicate construction. It should, therefore, be handled carefully and kept perfectly dry.

The galvanometer should be tested before being used by placing a short piece of copper wire momentarily across its two binding posts. The wire having almost no resistance, the needle should be deflected to its widest limit. If it does not move or go across the scale, the battery cell is exhausted or weakened and must be replaced by a fresh one.

To renew the battery cell, carefully take out the screws in the face of the metal case, using a good screwdriver of the right size. The exhausted cell is then easily lifted out, and the connecting wires transferred to the fresh cell. The only precaution necessary is to be sure the + and — poles are connected to the corresponding wires. The connectors at the ends of the cell wires are marked + and — , and so no difficulty should be experienced.

Method of Operating

Testing a Circuit.—To test a circuit it is necessary only to touch the ends of the two leading wires to its two binding posts, after all connections are ready for the blast. If the circuit is perfect the needle will move along the scale. If the needle does not move there is a break in the circuit. If the needle does not move as far as it should there is a place of high resistance, such as a bad joint.

The galvanometer can be used for testing circuits only when the electric blasting caps are connected in series. (See pages 45-46.) In a parallel circuit, each electric blasting cap must be tested separately. A parallel series circuit must be separated into individual series and each series tested by itself.

Locating a Break.—To locate a break make sure that the ends of the leading wires to be attached are separated and not touching anything (see page 38). Secure a piece of connecting wire, N, to one end connection, D, of the circuit. This wire must be long enough to reach from the joint D to joint C. Now touch the free end of the wire N to the contact post L of the galvanometer, and either direct or through the second piece of

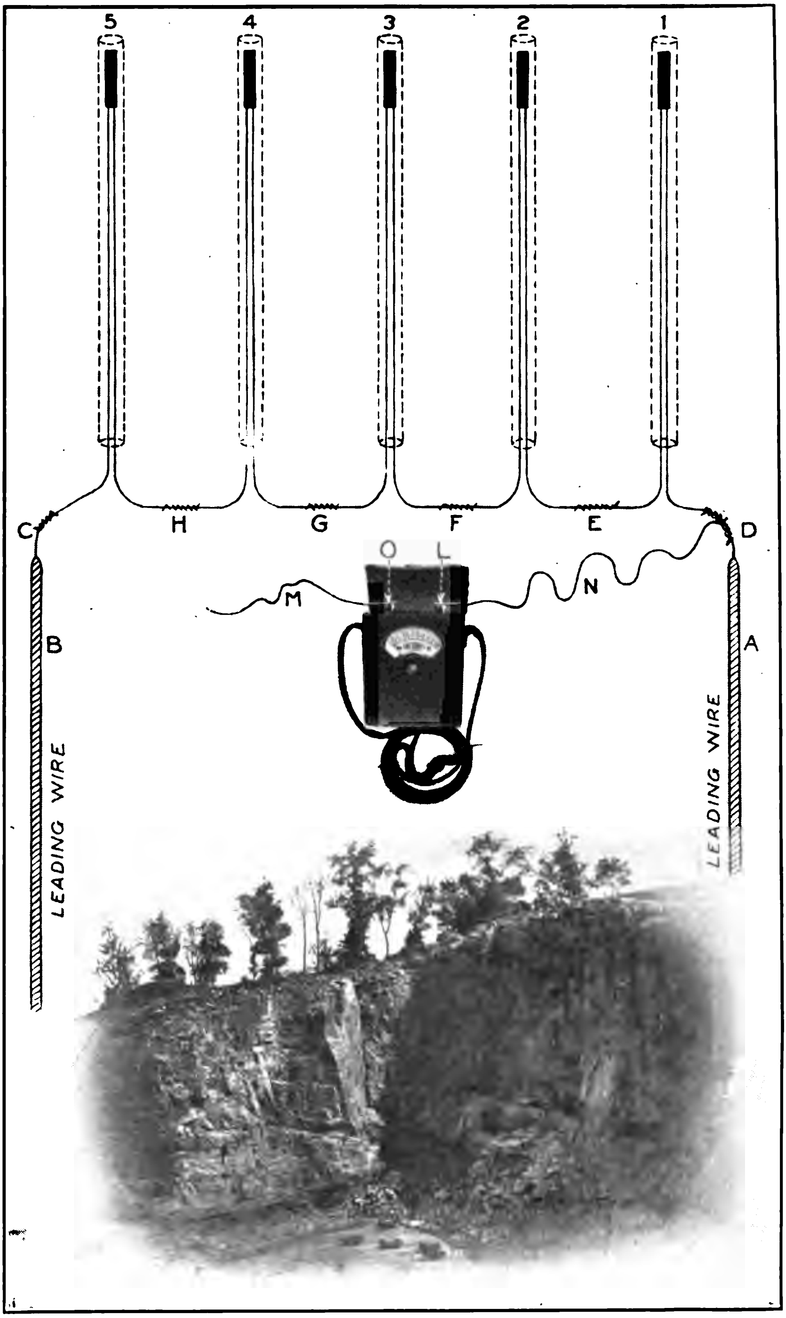


DIAGRAM SHOWING METHOD OF LOCATING A BREAK WITH A DU PONT GALVANOMETER leading wire M, touch the other contact post of the galvanometer to the joint C. If the galvanometer now shows circuit while it did not when the test was made from the other end of the leading wires, the break is in the leading wires and they must be repaired. If it does not show circuit, find the break in the electric blasting cap or connecting wire by holding the end of wire N to contact post L and touching the other contact post (or the short piece of wire M touching the contact post on the galvanometer) to each of the bare joints E, F, G, and H in succession. As long as you are "inside" the break, these contacts will cause the needle to be deflected. As soon as you get beyond the break or point of high resistance, you get either a very slight deflection or none at all. In this way the trouble can be quickly traced to the break or bad joint. For instance, if a wire in bore hole No. 3 is broken, you get a deflection when M is touched to F, but none on touching G; this shows that the break is between F and G. The break can then be easily repaired if above the tamping.

If below the tamping and there are two electric detonators in the hole, the broken one can be left out of the wiring and the hole fired by the good one.

If there is but one electric blasting cap in the hole and its wires are broken off below the tamping, the hole must be handled as a misfired shot.

Testing Single Electric Blasting Caps.—Single electric blasting caps can be tested, both before and after putting them in the bore hole, simply by touching the ends of the electric blasting cap wires to the two contact posts.

It is an excellent practice to test all electric blasting caps after finishing the loading, but before tamping the hole, as well as while tamping if the tamping is several feet deep.

Resistance Table

The following table gives the resistance of Du Pont electrical firing devices.

These include Electric Blasting Caps, Electric Squibs, Delay Electric Blasting Caps and Delay Electric Igniters, with both copper and iron wires, and Waterproof and Submarine Electric Blasting Caps, with copper wires. Note that the Submarine and Waterproof Electric Blasting Cap wires are No. 22 gauge up to 18 ft. lengths, inclusive. In lengths of 20 ft. and over, the wires are No. 20 gauge.

Copper wires, which are enameled, have the same resistance as plain copper wires but have much better insulation.

Table of Resistance in Ohms of Electrical Firing Devices

Length of Wires of Electric Firing Devices in feet	Regular Copper Wire Electric Blasting Caps and Duplex Copper Wire Electric Blasting Caps	Submarine and Waterproof Electric Blasting Caps with Enameled Copper Wires	"Panama" Electric Blasting Caps Copper Wire Only	Delay Electric Blasting Caps, Delay Electric Igniters and Electric Squibs with Copper Wires	Electric Blasting Caps with Iron Wire	Electric Squibs and Delay Electric Igniters with Iron Wire
4	1.255	1.255		0.935	2.093	1.857
5					2.261	2.000
6	1.343	1.343		1.000	2.448	2.261
8	1.439	1.439		1.068	3.000	2.529
10	1.500	1.500		1.143	3.280	3.000
12	1.608	1.608		1.206	3.690	
14	1.679	1.679		1.272		
16	1.727	1.727		1.325		
18	1.803	1.803		1.400		
20	1.857	1.479	1.479	1.459		
22	1.913	1.521	1.521	1.521		
24	1.970	1.564	1.564	1.586		
26	2.030	1.631	1.631	1.655		
28	2.093	1.679	1.679	1.727		
30	2.158	1.727	1.727	1.777		

Table of Resistance of Copper Leading and Connecting Wire in Ohms per 1000 feet

No. 8 Brown & Sharpe Gauge	.6271	Ohms	Usual size for power and lighting circuits.
No. 10 " " " "	.9972	"	
No. 12 " " " "	1.586	"	
No. 14 " " " "	2.521	"	Standard gauge for leading wire.
No. 16 " " " "	4.009	"	Sometimes used for short leading wire.
No. 18 " " " "	6.374	"	
No. 20 " " " "	10.14	"	Connecting wire.
No. 21 " " " "	12.78	"	
No. 22 " " " "	16.12	"	Standard size for copper wire Electric Firing Devices.

Each foot of electric blasting cap wire doubled (2 wires) has a resistance of .032 ohms. The bridge of each electric blasting cap has a resistance of 1.10 ohms. The bridge of the electric squibs, delay electric blasting cap and delay electric igniter has a resistance of .859 ohms. The resistance of the iron wire of the size used for Du Pont Iron Wire Electric Firing Devices is about 101.0 ohms per 1000 feet.

Determining Resistance of Blasting Circuit

Connected in Series

To determine the resistance of any blasting circuit where the electric firing devices are connected in series, multiply the resistance of one firing device by the number in the circuit. Add to this the resistance of the leading wire and the connecting wire, and the result will be the total resistance of the circuit.

For example, if in a given blast 50 electric blasting caps with copper lead wires 20 feet long are used, also 100 feet of No. 20 Connecting Wire and 500 feet of No. 14 Single Leading Wire (or 250 feet of Duplex Wire), the total resistance would be found in the following manner.

One Electric Blasting Cap with 20 ft. copper wire has resistance of 1.857 ohms. 50 of said caps have resistance of	92.85 Ohms
1000 feet of No. 20 Connecting Wire has resistance of 10.14 ohms. 100 feet has resistance of	1.014 "
1000 feet of No. 14 Gauge Leading Wire has resistance of 2.521 ohms. 500 feet has resistance of	1.26 "
The total resistance of the entire circuit would be	95.12 Ohms

When exceptionally long lengths of leading or connecting wire are used in blasting circuits, the resistance should be computed and added to that of the electric detonators to guard against overloading the blasting machine.

Caution

The question is often asked whether it is absolutely safe to pass even the weak testing current of this galvanometer through a single electric detonator. The only answer we can give is that *we have tested many millions with the Du Pont Galvanometer without a single accident.* There is nothing in the handling of explosives, or electric blasting caps, that can be said to be entirely safe.

Those who question the safety of testing with a galvanometer in the manner outlined above can insure greater safety, when testing a single electric blasting cap, by placing it in a short piece of iron pipe, or similar receptacle, so that its accidental detonation would do no harm. In locating breaks in a circuit where the electric detonators are in the bore holes, the tests can be made from a safe distance, through a pair of leading wires. The latter procedure involves, of course, a trip to the loaded bore hole every time the connections are changed for a new test.

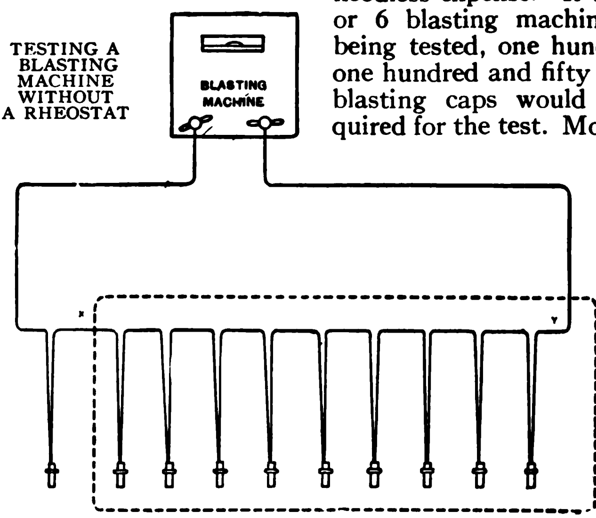
Rheostat

The Du Pont Rheostat is a simple little instrument used for testing the efficiency of blasting machines in an economical and positive manner.

Dimensions, ¾" x 1¾" x 4 11/16"
Weight, 5 oz.

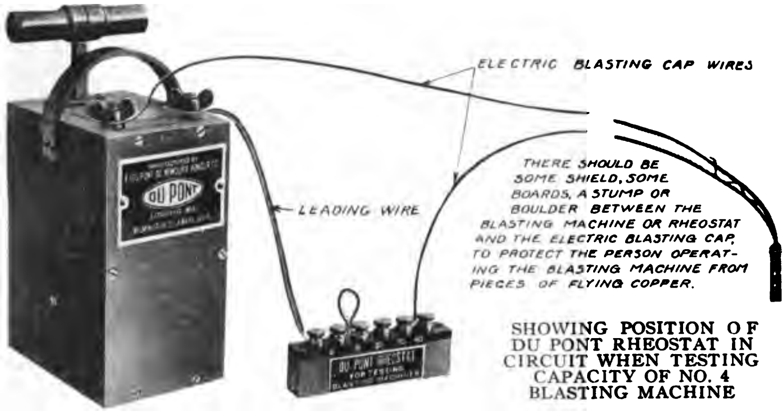
One way to test, for example, a No. 2 blasting machine, which has a capacity of ten electric blasting caps, is to connect ten electric blasting caps in series and then to the blasting machine and operate the machine. If all the electric blasting caps fired, the machine would be working up to its rated capacity; if the electric blasting caps did not fire, the machine would not be up to standard. The results obtained would be absolutely accurate. The objection to this method is that it consumes so many electric blasting caps, thus causing needless expense. If a No. 5 or 6 blasting machine were being tested, one hundred or one hundred and fifty electric blasting caps would be required for the test. Moreover, the firing of so many electric blasting caps in the open would be dangerous.

TESTING A BLASTING MACHINE WITHOUT A RHEOSTAT



To obviate this expense, the Du Pont Rheostat is substituted for all but one of the electric blasting caps, as is indicated in the following diagram.

When such a series connection is made and the blasting ma-



SHOWING POSITION OF DU PONT RHEOSTAT IN CIRCUIT WHEN TESTING CAPACITY OF NO. 4 BLASTING MACHINE

chine operated, the single electric blasting cap either fires or does not fire, and indicates whether or not the blasting machine is up to capacity.

The internal construction of the Rheostat is shown diagrammatically on page 44. It is an arrangement of coils of high resistance wire of a certain length, with the binding posts 1 and 6 attached to its ends, and the binding posts 2, 3, 4 and 5 attached to it at intermediate points. The entire length of the resistance wire in the Rheostat has a resistance sufficient to represent a test of one hundred 30-foot electric blasting caps, with the leading wire, connecting wire and all connections in the blasting circuit.

It will be noted that the binding posts, 1, 2, 3, 4, 5 and 6 are not attached to the resistance wire at equal distances. The purpose of this is to afford different resistances between different binding posts, each representing a test of a certain number of electric blasting caps. If wires X and Y are attached to binding posts 1 and 2, the test represents a test of five electric blasting caps; if to posts 2 and 3, of ten electric blasting caps; to posts 3 and 4, of twenty electric blasting caps; or to posts 4 and 5, of twenty-five electric blasting caps. But the wires X and Y need not be attached to adjoining posts. If, for instance, they are attached to posts 1 and 4, the test represents the sum of the intervening numbers, five, ten and twenty, or a total of thirty-five electric blasting caps.

As shown by the numbers stamped upon the hard rubber between the binding posts, a large number of tests, representing from five up to one hundred electric blasting caps, can be easily made.

The resistances in the Rheostat are based upon 30-foot electric blasting caps and the required surplus resistance. If the electric blasting caps in use are of shorter lengths, it will be possible to fire a greater number than this test will indicate, even, in some cases, up to twice the number. On the other hand, there may be circumstances which will cut down the number that can be fired below what the Rheostat test will indicate. Chief among these is leakage of electric current in some part of the blasting circuit, either from bare joints or wire touching damp ground, or other conductors, or from fluids of great penetrating qualities coming in contact with the insulation of the wires for too long a time before firing. Of these fluids, the worst are the strong saline liquids, even though they be in small amounts, and bore-hole washings in certain kinds of rock. If the electric blasting caps differ greatly in sensitiveness to the firing current, this will also cut down the number that can be depended upon to fire simultaneously.

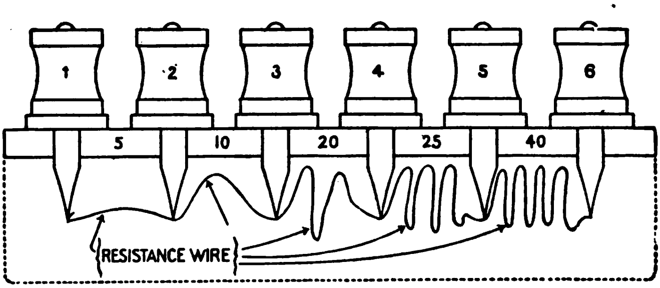


DIAGRAM OF CONSTRUCTION OF A RHEOSTAT

When testing blasting machines having capacities of more than one hundred detonators, two Rheostats are used in series.

Should it be necessary to test a blasting machine for ninety detonators, the resistance of ten, between posts 2 and 3, must be blocked out. This is done by connecting these posts by means of a piece of heavy copper wire or a coin. In this way the resistance between any two posts can be subtracted from the total resistance or the resistance between any two posts outside of the two that are blocked out.

Be sure to use only one electric detonator or electric squib in testing a blasting machine with a Rheostat.

Table of Resistances of Rheostat in Ohms

The resistances furnished between the different posts of the Rheostat are as follows:

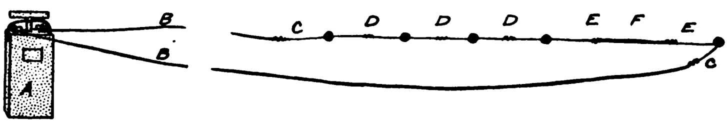
Between 1 and 2	16 ohms	Between 1 and 5	192 ohms
Between 2 and 3	32 ohms	Between 1 and 6	320 ohms
Between 3 and 4	64 ohms	Between 2 and 4	96 ohms
Between 4 and 5	80 ohms	Between 2 and 5	176 ohms
Between 5 and 6	128 ohms	Between 2 and 6	304 ohms
Between 1 and 3	48 ohms	Between 3 and 5	144 ohms
Between 1 and 4	112 ohms	Between 3 and 6	272 ohms

Between 4 and 6........208 ohms

Wiring for Electric Blasts

When firing by electricity, whether using any of the electric detonators, or electric squibs or delay electric igniters, the holes may be connected in one of three ways,—in series, in parallel, or in parallel series.

Series Connections.—When using a blasting machine all blasting circuits must be in series. The series connection is made by connecting one wire from each hole to one wire in the next hole and so on to the end, when only the two end wires are left free. These are connected to the ends of the leading wire. All of this is shown in the accompanying cut.



SERIES CONNECTION FOR ELECTRICAL FIRING

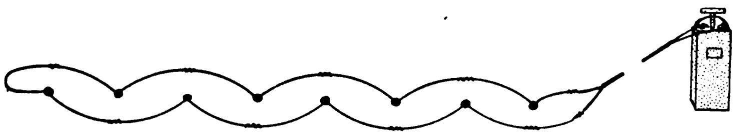
A. Blasting machine. B. The two strands of single leading wire.
C. Connections between leading wire and electric blasting cap wires.
D. Connections between electric blasting cap wires.
E. Connections between electric blasting cap wires and a short piece of connecting wire F, used to connect electric blasting cap wires that are too short to reach from hole to hole. This may be left out when long electric blasting cap wires are used, or it may be used between all holes in some cases.

This method of wiring can also be used when a power or lighting circuit is used for firing the blast. A power current of 1½ amperes is required for each series and a sufficient voltage to overcome the resistance of the circuit, as is shown by the resistance tables on page 40.

When duplex wire is used a piece of connecting wire, A, is required to connect the extreme end to the leading wire as is shown. This has a single objection in that it introduces an additional connection which, if improperly made, will increase the resistance.

SHOWING USE OF DUPLEX LEADING WIRE

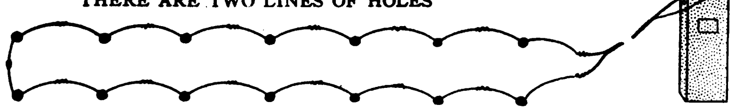
Some blasters prefer a slightly different method of making connections which obviates the use of connecting wire in connection with duplex leading wire. It takes one less connection, but is somewhat more expensive on account of requiring longer electric blasting cap wires and demands the closest attention in order to get a good circuit.



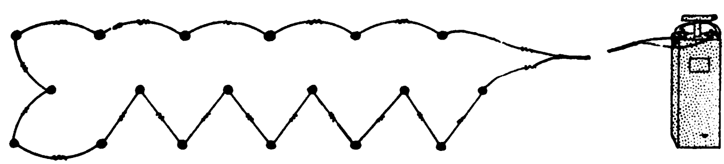
ANOTHER METHOD OF CONNECTING DUPLEX LEADING WIRE

An excellent method of making a series connection where two lines of holes are used is shown in the following sketch. This is of especial advantage when using two lines of holes with delay electric blasting caps or delay electric igniters and in blasting wide ditches. Either single or duplex leading wire may be used.

SHOWING HOW TO MAKE A SERIES CONNECTION WHEN THERE ARE TWO LINES OF HOLES

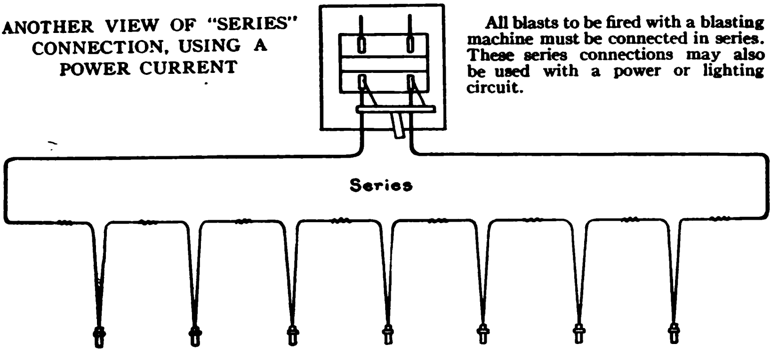


How three lines of holes for the use of delay electric blasting caps or delay electric igniters or for very wide ditch blasts may be connected in series is shown in the following diagram. Either single or duplex leading wire may be used.



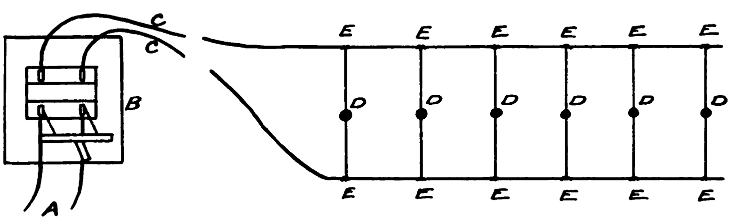
SHOWING METHOD OF CONNECTING THREE LINES OF HOLES

ANOTHER VIEW OF "SERIES" CONNECTION, USING A POWER CURRENT



All blasts to be fired with a blasting machine must be connected in series. These series connections may also be used with a power or lighting circuit.

Parallel Connections.—When power or lighting circuits are used for firing, the circuit may be connected in parallel. This type of circuit differs materially from the series circuit, and is shown graphically in the accompanying cut. For such a circuit, the firing current must have 1½ amperes for each detonator or squib, but the voltage of the current can be less than when the connections of the same number of detonators are in series.



SHOWING PARALLEL METHOD OF CONNECTING UP WHEN POWER OR LIGHTING CIRCUITS ARE USED

A. Power or lighting circuit.

B. Blasting switch for closing circuit.

C. Leading wires of sufficient length to keep the switch B a safe distance from the blast and to reach past the last hole.to be fired.

D. Bore holes with electric detonators.

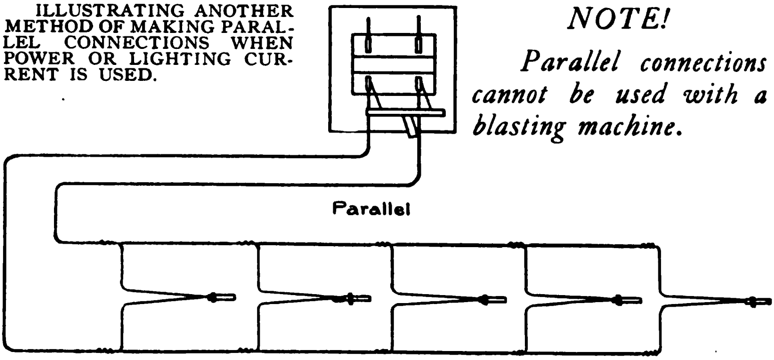
E. Connections between the detonator wires from holes D to the leading wire C.

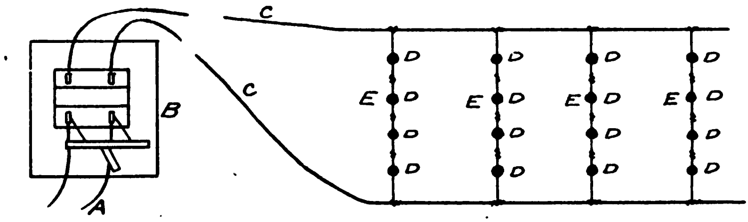
Parallel Series Connections.—A circuit connected in parallel series is a number of series circuits, two or more, connected in parallel as is shown in the accompanying diagram. This type of circuit can be used only with a power or lighting current. Such a circuit requires 1½ amperes for each series, shown as E, but the voltage required is less than the amount required to overcome the resistance in the series having the greatest resistance. The determination of this point is a slightly complicated mathematical problem for the blaster, and it is best to allow a large margin of safety in the way of too much voltage.

ILLUSTRATING ANOTHER METHOD OF MAKING PARALLEL CONNECTIONS WHEN POWER OR LIGHTING CURRENT IS USED.

NOTE!

Parallel connections cannot be used with a blasting machine.



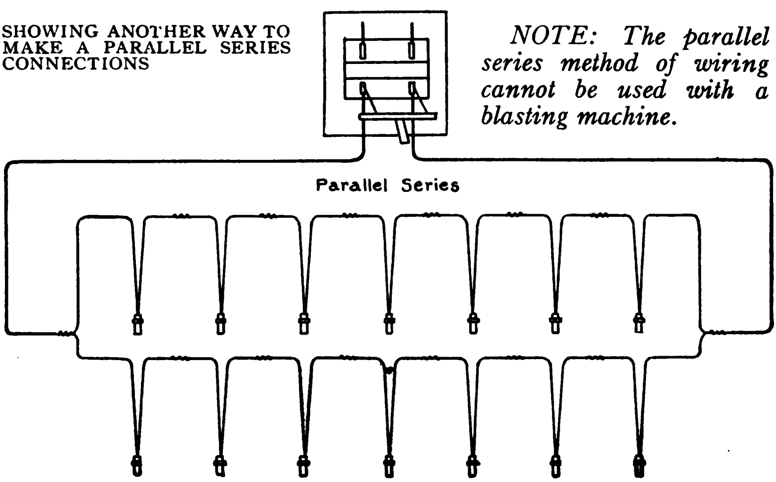


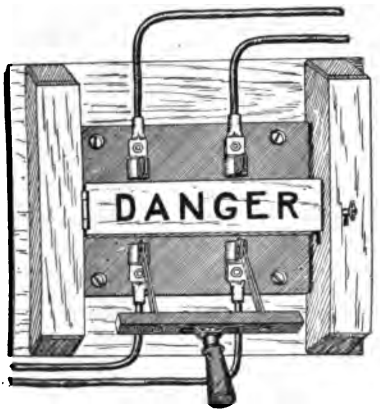
SHOWING PARALLEL SERIES CONNECTION HAVING TWO OR MORE CIRCUITS

A. Wires of power or lighting circuit. B. Blasting switch for closing circuit.
C. Leading wires of sufficient length to keep the switch B at a safe distance from the blast and to reach past the last hole.
D. Bore holes with electric detonators. E. Individual series of holes D.

SHOWING ANOTHER WAY TO MAKE A PARALLEL SERIES CONNECTIONS

NOTE: The parallel series method of wiring cannot be used with a blasting machine.





SAFETY FIRING SWITCH FOR POWER CIRCUITS

Safety Firing Switch

The illustration shows a very simple and effective way to prevent the premature closing of a circuit used to supply current for electrical detonation of explosives. With the key in the hands of the shot-firer he is the only one able to close the circuit until he is prepared to "set off" the shots.

Making and Protecting Wire Connections

The wiring or connecting of an electric blast must be well and correctly done to insure success. The work of wiring may be divided into three parts: connecting the detonator or squib wires together either directly or by means of connecting wire; connecting the proper detonator wires to the leading wire; and connecting the leading wire to the blasting machine.

Connecting Detonator Wires.—Connections between detonator wires or between detonator wires and connecting wires must all be well made. First scrape the bare ends of the wires with a knife blade, and then join them with a long twist (generally known as "Western Union Twist") such as is shown in the accompanying sketch. Such a twist should be tightly made to

SHOWING "WESTERN UNION" METHOD OF JOINING WIRES

CORRECTLY TWISTED WIRES COVERED WITH TAPING

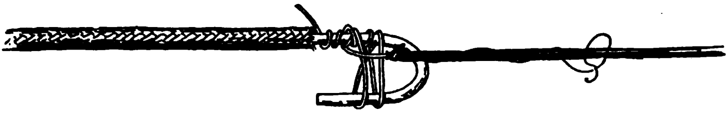
keep the resistance in the joint down to a minimum. If there is no bare end to the connecting wire, skin off about two inches of the insulation. A later paragraph will give detailed information about protecting these bare joints.

Never, under any circumstances, loop wires together as is shown as the wrong way.

Twenty-four holes with two electric blasting caps in eacn hole—48 electric blasting caps in all—connected in series. The blast should be fired with a No. 4 or a No. 5 Du Pont Blasting Machine, or with a power or lighting circuit of 110 volts and 1½ amperes.

LOOPED WIRES—THE WRONG WAY

Connecting Detonator Wire to Leading Wire.—In making connections between detonator wires and leading wires the same precautions must be observed with regard to cleaning the ends of the wires. Wrap the detonator or connecting wires tightly around the end of the leading wire about one inch from the end.



AN EXCELLENT METHOD OF CONNECTING AN ELECTRIC BLASTING CAP WIRE TO A LEADING WIRE

Then bend the end of leading wire back sharply and take a turn or two of the detonator wire around the loop. This last loop is simply to make a stronger connection to withstand any accidental pull on the leading wire that might tear the connection loose.

Connecting the Leading Wire to Blasting Machine.—The connection of the leading wire to the blasting machine is made by loosening the wing nuts on the two binding posts, inserting the ends of leading wire into the small holes in the binding posts and tightening the wing nuts down on the wires.

Protecting Bare Joints.—The naked joints in the wires of a blasting circuit must always be protected against short circuiting, especially through water. This is done in several ways. When connections lie on moist ground they may be held up by supporting them on stones, blocks or sticks so that only the insulated parts of the wires touch the ground and supports; or the joints may be insulated with tape. While not generally needed where the joints can be held off the ground, the taping of joints is strongly recommended where the joints are covered by tamping, where they cannot be held out of the water on props, and where blasting must be done in a rainstorm. It is very desirable to tape the joints of leading wire.

Blasting with Cap and Fuse

Blasting Caps

Blasting caps are the detonators used for firing high explosives when electric blasting is not practiced. They must always be used with safety fuse, and are in no way interchangeable with electric blasting caps. Using blasting caps and fuse, it is not possible to fire a number of blasts simultaneously. Such blasting must be done with electric blasting caps or other electric firing agents.

METAL BOX CONTAINING 100 No. 6 DU PONT BLASTING CAPS.

Blasting caps are small drawn copper cylinders, closed at one end and loaded with a small charge of a very sensitive and violent explosive that is exploded by the spit of sparks from safety fuse.

Dimensions of Du Pont Blasting Caps

	No. 6	No. 8
Outside Color of Box	Red	Green
Length of Copper Shell	1½″	2 11/32″
Outside Diameter of Copper Shell	.234″	.24″

NOTE.—The *inside* diameter of both the No. 6 and the No. 8 Du Pont Blasting Cap is .2205″

Du Pont Blasting Caps are manufactured in the No. 6 and No. 8 sizes and are exactly the same strength as the corresponding designations of Electric Blasting Caps.

A No. 7 Blasting Cap is intermediate in strength between Nos. 6 and 8, but as one of these two numbers is adaptable to all general classes of blasting, the No. 7 strength is not recommended and is furnished only on special factory order.

All blasting caps are packed in tin boxes, each containing 100. Ten boxes are in turn packed in cartons and the cartons, with sawdust, in wooden shipping cases.

No. 6 DU PONT BLASTING CAP

No. 8 DU PONT BLASTING CAP

Packages of Du Pont Blasting Caps for Domestic Shipment

Gross Weight of Packages
No. 6 Blasting Caps

No. of Case	Quantity per Case	In Oblong Boxes	In Round Boxes
0	500	5½ pounds	6 pounds
1	1,000	10½ "	11½ "
2	2,000	18½ "	17 "
3	3,000	29 "	30 "
5	5,000	40½ "	43 "

No. 8 Blasting Caps

No. of Case	Quantity per Case	In Oblong Boxes	In Round Boxes
0	500	11 pounds	11 pounds
1	1,000	15½ "	16 "
2	2,000	24 "	24 "
3	3,000	44 "	45 "
5	5,000	62 "	65½ "

It will be seen that with the exception of case No. 0 the number of the case indicates the number of thousands of blasting caps in the case. As no cases contain 4,000 caps, there is no No. 4 case.

CARTON OF BLASTING CAPS

All cases are well made of sound lumber. Cases for export trade are tin lined to give the blasting cap additional protection. They weigh slightly more than those for domestic shipments.

Blasting caps should be stored in a dry place. When conveying them to the work where they are to be used no moisture whatever should be permitted to get into the charge which they contain, as this charge is very quickly affected by dampness, and will absorb moisture and deteriorate. Storage in damp places, such as open sheds or tool boxes in mines, is likely to affect the charge in blasting caps, and may weaken them to such an extent that they will not properly detonate high explosives.

The methods of attaching the blasting cap to the fuse, and of priming high explosive cartridges with the blasting cap and fuse, are described in other portions of this catalogue.

Du Pont Blasting Caps are manufactured with the same care and undergo the same rigid inspections as do all other Du Pont products. When properly used, they can be depended on to do the work for which they are intended.

CASE OF BLASTING CAPS

In each box of blasting caps there is a small card known as the "follow-up" card or inspector's ticket. In case trouble is experienced with the blasting caps this ticket, with any unused blasting caps, should be preserved in order to facilitate investigation.

Safety Fuse

Safety fuse is the medium of bringing sparks to fire blasting caps or to ignite a charge of blasting powder. It is made up of a thin train of powder tightly compressed in, and more or less waterproofed by inner and outer wrappings or coverings.

The different kinds of safety fuse made may be divided into four classes, according to the kinds of blasting for which they are intended. These classes are:

Dry work. Damp work. Wet work. Under water.

The classification of brands of fuse sold by the Du Pont Company according to this standard is:

Dry	Damp	Wet	Under Water
Hemp (white)*	Single Tape†*	Double Tape†*	Triple Tape†*
Hemp (black) †	Sylvanite‡	White Monarch‡	Black Monarch‡
Cotton*	Beaver*	Comet†	Eclipse†
Planet†	Charter Oak*	Shield†	Pacific†
	Blue Label†		American Eagle†
			Clover*
			Crescent*
			Reliable Gutta Percha*
			Stag*
			Bear‡
			Acme‡
			Victor†

*Is sold east of Montana, Wyoming, Colorado and New Mexico, or in the Eastern States.
†Is sold in and west of Montana, Idaho, Utah and Arizona or the Western States.
‡Is sold in the States of Wyoming, Colorado and New Mexico, or the Middle Western States.

Safety Fuse Packages

Safety fuse is manufactured in lengths of 50 feet, which lengths are made into rolls. Two rolls are fitted, one inside the other, and neatly wrapped in paper. The double rolls are packed in wooden cases. Export orders are shipped in tin cans or tin-lined boxes. The sizes of packages are given in the following tables:

Ensign-Bickford Company's Fuse Package

Size	Contents	Approximate Weights			Outside Dimensions	
		Hemp and Cotton	Triple Tape	Others*	Hemp and Cotton	Others*
0	500 ft.	6 lbs.	10 lbs.	10 lbs.	7¼"x 7½"x14¾"	7" x 7¾"x15"
1	1,000 ft.	13 lbs.	20 lbs.	20 lbs.	6¾"x11¼"x13"	7¼"x13¾"x14¾"
2	2,000 ft.	25 lbs.	45 lbs.	40 lbs.	13½"x13¾"x15"	13½"x13¾"x15"
3	3,000 ft.	40 lbs.	70 lbs.	60 lbs.	13½"x13¾"x15"	14½"x15" x20½"
4	4,000 ft.	50 lbs.	85 lbs.	80 lbs.	14½"x15" x20½"	14½"x20½"x20½"
5	5,000 ft.	65 lbs.	110 lbs.	100 lbs.	14½"x20½"x20½"	14½"x20½"x24"
6	6,000 ft.	75 lbs.	130 lbs.	115 lbs.	10½"x20" x27"	14½"x20¼"x27½"

* Others are Single Tape, Double Tape, Planet, Beaver, Charter Oak, Clover, Anchor, Crescent, Reliable and Stag.

For export shipments, fuse may be packed in water-tight cans, containing 500 feet each, and snugly packed in iron-strapped wooden cases, or in tin-lined wooden cases if preferred.

The packing and the weights of other fuse named in this book, but not included in the tables, are approximately the same as for similar classes of fuse on which detailed information is given.

It should be remembered that in all classes of blasting where water is encountered the loading should be done and the shots fired as soon as possible. While the brands listed for use under water will burn through water when first loaded, they will not withstand wetting for a long time, especially when under pressure of several feet of water.

Hemp Fuse and Cotton Fuse are too small in diameter to properly fit the standard blasting cap, and should be used only for exploding blasting powder charges where a blasting cap is unnecessary, unless a dynamite primer is used.

Burning Speed of Fuse

Safety fuse sold in the Eastern States burns, in the open, at the rate of about thirty-two seconds per foot, except Charter Oak and Clover brands, which have a burning speed, in the open, of about 40 seconds per foot; that sold in the Middle Western and Western States burns at the rate of between 36 and 39 seconds per foot. This burning speed is subject to a variation of 10 per cent either way. Fuse burns faster when tightly tamped. The length of fuse used in a blast must always be long enough for the blaster to retire to a safe distance.

Each fuse wrapper is stamped with a serial number, which, with the markings on the packing case, should be preserved in case trouble is experienced with the fuse, for identification and to facilitate investigation.

Dimensions of Cases Containing Fuse for Export

Case No. 0 (All Brands)	8¼″ x 15″ x 8¼″
" " 1 " "	8¼″ x 15″ x 16¼″
" " 2 " "	16¼″ x 15″ x 15¼″
" " 3 " "	23¼″ x 15″ x 15¼″
" " 4 " "	30″ x 15″ x 15¼″
" " 5 " "	37¼″ x 15″ x 15¼″
" " 6 " "	30¼″ x 15″ x 22½″

Approximate Weights and Dimensions of Cases of Fuse Made by Coast Manufacturing and Supply Company

Bear Brand

Package	Gross Weight	Tare	Net Weight	Outside Dimensions
1,000 ft. case	23 lbs.	7 lbs.	16 lbs.	14½" x 15½" x 8¼"
2,000 ft. case	44 lbs.	11 lbs.	33 lbs.	26" x 15½" x 8¼"
3,000 ft. case	62 lbs.	14 lbs.	48 lbs.	37" x 15½" x 8¼"
6,000 ft. case	115 lbs.	23 lbs.	92 lbs.	37" x 15½" x 15½"

American Eagle and Blue Label

Package	Gross Weight	Tare	Net Weight	Outside Dimensions
1,000 ft. case	23 lbs.	7 lbs.	16 lbs.	14½" x 15½" x 8¼"
2,000 ft. case	41 lbs.	11 lbs.	30 lbs.	26" x 15½" x 8¼"
3,000 ft. case	55½ lbs.	14 lbs.	41½ lbs.	37" x 15½" x 8¼"
6,000 ft. case	107½ lbs.	23 lbs.	84½ lbs.	37" x 15½" x 15½"

Victor Brand

Package	Gross Weight	Tare	Net Weight	Outside Dimensions
1,000 ft. case	23 lbs.	7 lbs.	16 lbs.	14½" x 15½" x 8¼"
2,000 ft. case	41 lbs.	11 lbs.	30 lbs.	26" x 15½" x 8¼"
3,000 ft. case	58 lbs.	14 lbs.	44 lbs.	37" x 15½" x 8¼"
6,000 ft. case	111 lbs.	23 lbs.	88 lbs.	37" x 15½" x 15½"

Pacific Brand

Package	Gross Weight	Tare	Net Weight	Outside Dimensions
1,000 ft. case	23 lbs.	7 lbs.	16 lbs.	14½" x 15½" x 8¼"
2,000 ft. case	41 lbs.	11 lbs.	30 lbs.	26" x 15½" x 8¼"
3,000 ft. case	58 lbs.	14 lbs.	44 lbs.	37" x 15½" x 8¼"
6,000 ft. case	114 lbs.	23 lbs.	91 lbs.	37" x 15½" x 15½"

Comet Brand

Package	Gross Weight	Tare	Net Weight	Outside Dimensions
1,000 ft. case	23 lbs.	7 lbs.	16 lbs.	14½" x 15½" x 8¼"
2,000 ft. case	41 lbs.	11 lbs.	30 lbs.	26" x 15½" x 8¼"
3,000 ft. case	59½ lbs.	14 lbs.	45½ lbs.	37" x 15½" x 8¼"
6,000 ft. case	115 lbs.	23 lbs.	92 lbs.	37" x 15½" x 15½"

Eclipse Brand

1,000 ft. case	23 lbs.	7 lbs.	16 lbs.	14½" x 15½" x 8¼"
2,000 ft. case	44 lbs.	11 lbs.	33 lbs.	26" x 15½" x 8¼"
3,000 ft. case	62½ lbs.	14 lbs.	48½ lbs.	37" x 15½" x 8¼"
6,000 ft. case	116 lbs.	23 lbs.	93 lbs.	37" x 15½" x 15½"

Single Taped

1,000 ft. case	23 lbs.	7 lbs.	16 lbs.	14½" x 15½" x 8¼"
2,000 ft. case	41 lbs.	11 lbs.	30 lbs.	26" x 15½" x 8¼"
3,000 ft. case	56½ lbs.	14 lbs.	42½ lbs.	37" x 15½" x 8¼"
6,000 ft. case	.108 lbs.	23 lbs.	85 lbs.	37" x 15½" x 15½"

Double Taped

1,000 ft. case	23 lbs.	7 lbs.	16 lbs.	14½" x 15½" x 8¼"
2,000 ft. case	41 lbs.	11 lbs.	30 lbs.	26" x 15½" x 8¼"
3,000 ft. case	59 lbs.	14 lbs.	45 lbs.	37" x 15½" x 8¼"
6,000 ft. case	114 lbs.	23 lbs.	91 lbs.	37" x 15½" x 15½"

Triple Taped

1,000 ft. case	23 lbs.	7 lbs.	16 lbs.	14½" x 15½" x 8¼"
2,000 ft. case	44 lbs.	11 lbs.	33 lbs.	26" x 15½" x 8¼"
3,000 ft. case	60½ lbs.	14 lbs.	46½ lbs.	37" x 15½" x 8¼"
6,000 ft. case	116 lbs.	23 lbs.	93 lbs.	37" x 15½" x 15½"

Hemp (Black)*

10,000 ft. case	114 lbs.	23 lbs.	91 lbs.	14½" x 15½" x 37"

*Packed only in full cases of 10,000 feet each.

Storage and Handling of Fuse

Safety fuse cannot be kept in good condition unless stored in a *cool*, *dry* place. If stored in a hot place, the heat is likely to melt the waterproofing material, causing it to penetrate to the powder core or making the fuse too soft; or the heat may dry out the fuse so that it will break when unrolled. If stored in a damp place, the powder in the fuse soon absorbs moisture and fails to burn properly.

When handling safety fuse, do not twist or "kink" it. Always cut off at least two inches of the end of the coil and insert the fresh cut end of the fuse in the blasting cap, because the powder in the end becomes damp and ineffective very quickly. It is also likely to spill out of the cut end after the fuse has been handled a little. In either case a misfire might occur.

DOUBLE ROLL OF SAFETY FUSE WITH PAPER WRAPPING REMOVED

Always cut the end of the safety fuse which is to be inserted in the blasting cap squarely across and not diagonally, as the point made by a diagonal cut may be bent forward when the safety fuse is pushed into the blasting cap, and in this way prevent the spark from shooting into the blasting cap charge.

Always press the end of the safety fuse gently against the charge in the blasting cap before crimping the blasting cap. All safety fuse, except Cotton and Hemp, is made to fit as snugly as possible into the blasting cap in order to prevent water or moisture from entering. If the safety fuse is found at any time to be a little too large to enter the blasting cap, do not attempt to cut off any of the tape or yarn, but squeeze or roll the end between the thumb and finger until it is small enough.

It occasionally happens that when subjected to summer heat the waterproofing of some kinds of fuse will absorb the white material put on the outside, causing it to appear black or of a dingy yellow color. This unfavorable appearance does not necessarily indicate that the fuse is damaged. It is probably perfectly good, but it should be tested, and this will readily determine its condition.

If fuse is stored too long, it may be dry and hard, or the powder may be impaired by age. Gutta-percha fuse is most likely to deteriorate from age because the gutta-percha becomes oxidized by contact with air.

In tape fuse, places may be found where the diameter is slightly enlarged for about an inch in length. This is caused by the overlapping of the ends of the tape where two pieces are sewed together. It does not indicate any defect in the fuse.

Cap Crimpers

When using blasting caps and safety fuse, it is essential that the blasting caps be securely fastened or crimped to the fuse. If the joining is not firm, there is danger that the fuse will be pulled out when the primed cartridges are loaded and the bore holes tamped. An imperfect joining makes the waterproofing of the cap difficult. The most satisfactory crimp can be made by using a cap crimper,—an instrument designed for the purpose.

No. 1
DU PONT
CAP
CRIMPER

The Du Pont Cap Crimpers make a flat sleeve crimp which holds the cap securely on the fuse and makes waterproofing possible with but a small amount of waterproofing material.

Du Pont Cap Crimpers are made in two types, No. 1 and No. 2.

No. 1 Cap Crimper is made of blued steel. It is 5½ inches long and is made with the sleeve type of crimping jaws, having one handle pointed for use as a punch in priming dynamite cartridges.

No. 2 Cap Crimper is made of steel, nickel plated. It is 7 inches long. In addition to the crimper, it is provided with a most effective fuse cutting device, so designed as to prevent accidental cutting of blasting caps. One handle is pointed for use as a punch and the other has a screwdriver point.

NO. 2
DU PONT
CAP
CRIMPER

Both of these crimpers are so made that they cannot squeeze the copper shell far enough into the fuse to interfere with the burning of the powder train and cause misfires. They are well made of good material and, if used only for the purposes intended, will give good service for a long time.

BLASTING CAP CRIMPED TO FUSE

Du Pont Cap Sealing Compound

Du Pont Cap Sealing Compound is a material for sealing water-tight the space between the shell of a blasting cap and the fuse which is inserted into the blasting cap.

However well the cap may be fastened to the fuse by the crimper, it is almost impossible to make a joint that will prevent water from leaking in and spoiling the cap. The cap is especially liable to damage from water when "countered" fuse is used, because the uneven surface of such fuse formed by the spirally wound cords leaves small air spaces between the fuse and the shell through which water may leak down into the cap. Therefore, whenever the cap is to come in contact with water, it should be made waterproof by sealing with Du Pont Cap Sealing Compound.

DU PONT CAP SEALING COMPOUND

After the blasting cap is crimped on the fuse, the cap with two or three inches of the fuse is dipped for a few seconds into the cap sealing compound and hung up to dry. It is not necessary to soak the cap in the compound. By the time the compound has dried for about thirty minutes, a water-tight joint is formed which will resist almost any amount of water commonly encountered in blasting with cap and fuse. The cap should be used soon after it is dry, as the Cap Sealing Compound becomes brittle after a few days and is liable to crack and admit water.

Du Pont Cap Sealing Compound is put up in half-pint, pint, quart and gallon cans.

CAP SEALING COMPOUND APPLIED TO CRIMP

Making Primers

A high explosive cartridge containing an electric blasting cap or other detonator is called a primer.

Primers must be properly made to insure the complete detonation of the explosive; to keep the detonator from pulling out of the explosive; to guard against moisture; to permit easy and safe loading of bore holes; to keep the safety fuse, when blasting caps and safety fuses are used, from pulling out of the blasting cap.

Priming a Cartridge with Blasting Cap and Safety Fuse

In making a primer with blasting cap and fuse, cut off a sufficient length of fuse to reach from the charge of explosives loaded in the bore hole to three or four inches above the collar or top of the bore hole. In all classes of blasting, the length of the fuse must be governed by the time required for the blaster to reach a safe place after lighting the fuse.

After removing the cover of the blasting cap box, allow a single blasting cap to slide gently into the hand. Never try to pick a blasting cap out of the box with a wire, knife blade, stick, or other hard substance. See that no foreign matter, such as dirt or grit, is in the open end of the blasting cap; if there is any, shake it out gently. If the end of the fuse is flattened, roll it between the thumb and finger to round it out again and slip the blasting cap gently over the end of the fuse so that the fuse reaches down to the explosive charge in the blasting cap.

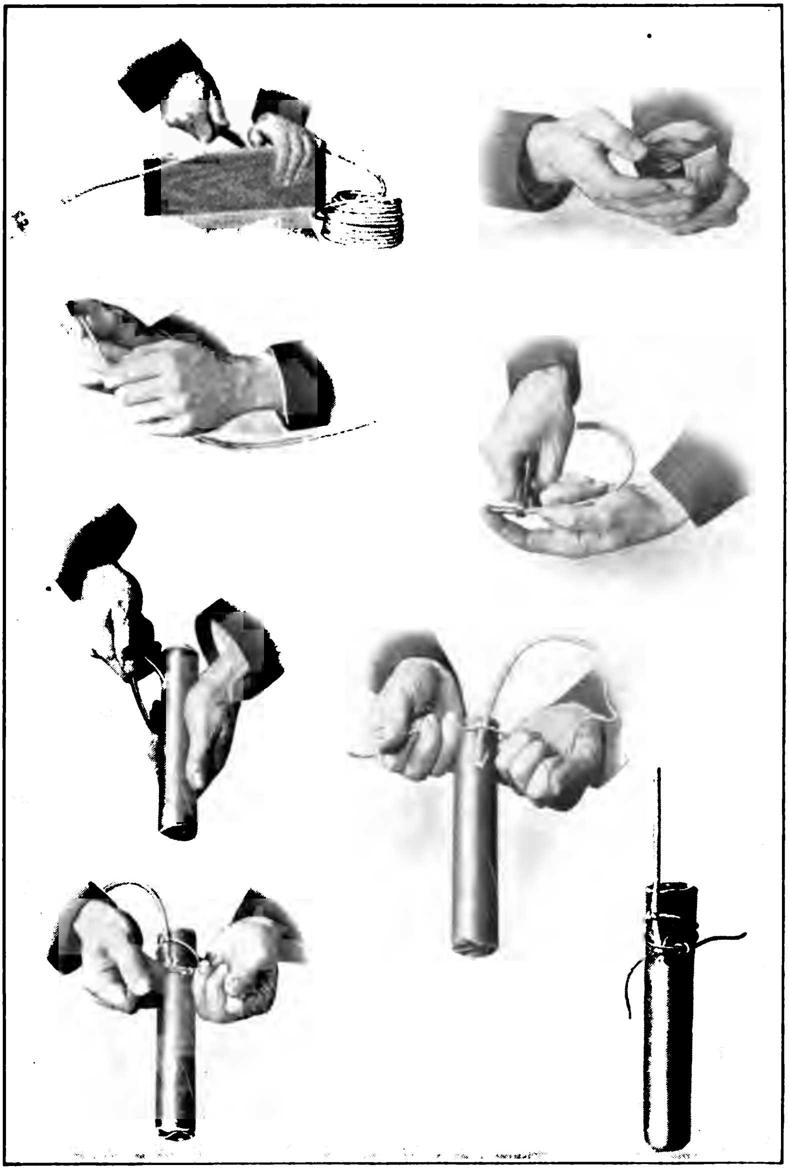
Do not twist the fuse into the blasting cap, and do not use violence or force when handling the blasting caps or when making primers.

When the blasting cap is placed on the fuse, fasten it securely in place with a Du Pont Cap Crimper. The crimp must be made close to the open end of the blasting cap as shown on page 62. To make the crimp further down would in all probability cause a premature explosion and seriously injure the blaster.

When the primer is to be used under water, the union between the blasting cap and the fuse should be protected against moisture by a coating of Du Pont Cap Sealing Compound or other suitable material.

Priming in the Side of Cartridges.—To prime a cartridge in the side the blasting cap and fuse are handled as has just been described. The hole is begun about an inch or an inch and a half from one end of the cartridge, and should point in and toward the other end, so that when the blasting cap is inserted it will be as nearly parallel as possible to the sides of the cartridge. *It should never be punched straight through the cartridge,* as such a hole would not place the blasting cap in the proper position for detonating the explosive. A blasting cap placed in such a hole would be easily displaced or injured in loading. The correct location and angle of such a hole are indicated page on 62. The hole should be deep enough to receive the entire copper shell of the blasting cap.

The blasting cap with fuse attached is slipped into the hole and securely fastened by means of a cord tied around both the fuse and cartridge, as is illustrated on page 62.

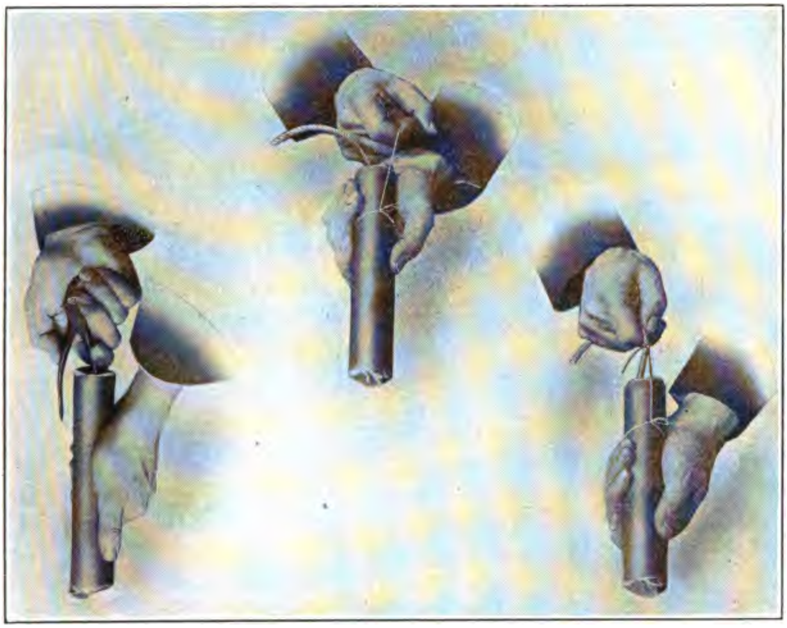


MAKING UP A PRIMER WITH A BLASTING CAP AND SAFETY FUSE

This method of priming in the side has the advantage of leaving more space for placing the tamping stick on the primer, but it cannot be used in such small holes as can the end primers on account of the fuse lying alongside the cartridge and thereby increasing the total diameter. This method does not place the blasting cap in quite so good a position as priming in the end.

Such a primer is waterproofed by covering the joint between the fuse and paper shell with a waterproofing material.

Priming in the Ends of Cartridges.—There are two good methods of priming cartridges in the end.



PRIMING IN END OF CARTRIDGE

(*a*) With the handle of the cap crimper or a wooden awl, punch a hole straight into the end of the cartridge to a sufficient depth to receive all of the copper shell of the blasting cap and fasten it there by means of a cord tied first around the cartridge and then around the fuse, as is shown above. This is an easily made and highly satisfactory primer.

To waterproof such a primer, close the hole where the fuse enters the cartridge with suitable sealing materials.

(*b*) The other method is to unfold the paper from the end of the cartridge and punch a hole directly into the center of the exposed dynamite, close the loose part of the paper shell around the fuse, and tie it tightly. The process of waterproofing is the same as stated in the preceding paragraph.

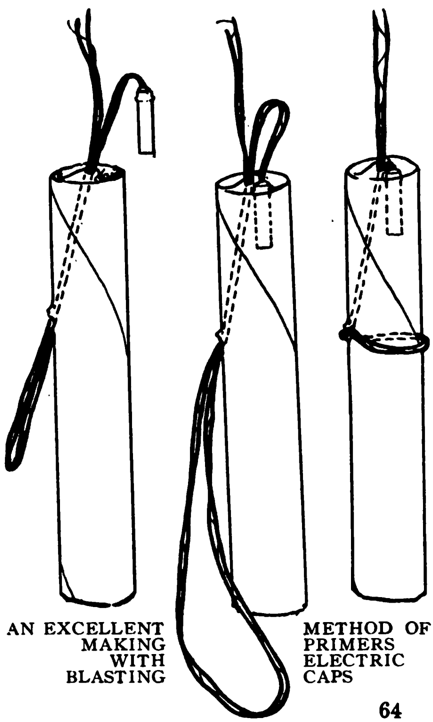
Priming in the end has the advantage of placing the blasting cap or other detonator in the best possible position for detonating the explosives used; but it sometimes has the disadvantage, especially when the bore holes are small, of bending the fuse too sharply and causing it to be scraped or torn, and also of not leaving sufficient room to place the tamping stick on the primer to slip the latter into place in the bore hole.

There are a number of other methods of making primers, but the three methods described are the only ones that have proved to be safe and reliable.

Fuse should never be laced through cartridges of high explosives, as the powder inside of the fuse may burn through the covering or "side spit" and ignite the dynamite before the cap explodes. This materially reduces the force of the blast.

Priming with Electric Blasting Caps

Primers can be made with electric blasting caps or other electric detonators by any of the methods described for the use of blasting cap and fuse. The waterproofing is done in exactly the same way.



AN EXCELLENT METHOD OF MAKING PRIMERS WITH ELECTRIC BLASTING CAPS

Many blasters, however, prefer to use a slightly quicker method, which has been found entirely satisfactory. Punch a hole from the center of the end of the cartridge in a slanting direction so that it will come out at the side two or three inches from the end, insert the end of the doubled over wires of the electric blasting cap, loop these around the cartridge, and punch another hole in the top a little to one side of the first and straight down. Insert the capsule in this last hole as far as possible and take up the slack on the wires. You then have a primer in which the wires do not cross each other at any point and the capsule is lying nearly along the center line of the cartridge, a primer which hangs vertically, so that it is possible to load it in the bore hole without its lodging against the sides.

The wires of electric blasting caps should never be fastened around high explosive cartridges by half-hitching them, as a strong pull might either break the wires or cut the insulation.

Priming with Other Du Pont Electric Detonators

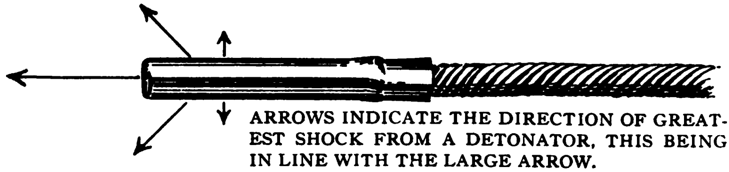
Primers with other electric detonators, such as delay electric blasting caps, submarine electric blasting caps and waterproof electric blasting caps, are made exactly as are primers with electric blasting caps, with the single difference that deeper holes in the explosive cartridge are required to receive the detonators.

Priming with Du Pont Delay Electric Igniters

When delay electric igniters are used to detonate high explosives a blasting cap is crimped on the end of the fuse, and the priming then done as with blasting cap and safety fuse.

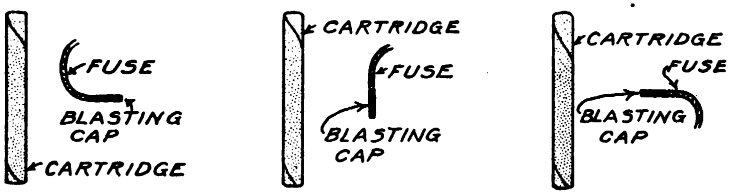
Operation of Detonators

The force of all explosives is exerted equally in all directions, but blasting caps, electric blasting caps and all other Du Pont detonators have copper shells so constructed that the shock from the explosion is greater from the closed end than from the sides. This is the end away from the fuse or wires. This closed end is frequently referred to as the "business end". It should not be understood that all of the shock from an exploding detonator goes out from the end, for such is not the case. There is shock in all directions, but the greatest shock is from the end. This is indicated by the arrow in the following sketch.



ARROWS INDICATE THE DIRECTION OF GREATEST SHOCK FROM A DETONATOR, THIS BEING IN LINE WITH THE LARGE ARROW.

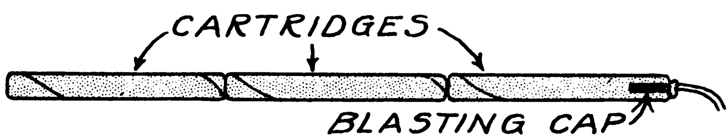
The purpose of detonators is to give off shock and heat to charges of high explosives to cause detonation. The greater the shock, the stronger the detonation and the better the work that is done by the explosive. For this reason it is desirable to have the detonators point directly toward the explosive charge. A better understanding of this may be had by referring to the accompanying figures. A shows a detonator pointing directly away from a cartridge of high explosives. Using an insensitive dynamite, the explosion of the blasting cap would not detonate the explosive. B-shows a blasting cap the same distance from a cartridge of high explosives, but pointing parallel to the cartridge. Using the same insensitive dynamite, if this cap caused any detonation at all, it would be incomplete and weak.



C shows the same insensitive dynamite and the blasting cap the same distance away as before, but pointing directly toward the dynamite. In this position the detonation of the dynamite should be complete.

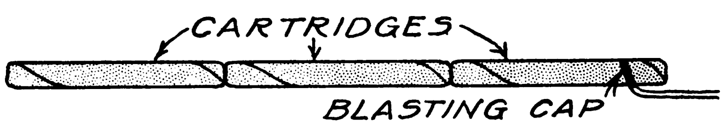
These positions of blasting cap and dynamite are purely demonstration examples, and should never be attempted in actual work. However, they illustrate just how a blasting cap or other detonator should point.

A detonator should point, as nearly as possible, directly toward the main portion of the charge of explosives.



SHOWING HOW BLASTING CAP SHOULD POINT WHEN BORE HOLE IS LOADED WITH SEVERAL CARTRIDGES

Were the single blasting cap pointed diagonally across the cartridge primer, as shown below, the shock to, and effect on, the cartridges in the other end of the bore hole would be much less.



PLACING BLASTING CAP DIAGONALLY LESSENS EFFECTIVENESS OF DETONATOR

Additional Blasting Accessories

Thawing Kettles

Many high explosives containing nitroglycerin chill or freeze and become insensitive in cold weather. When frozen, dynamite is difficult to detonate or it may burn instead of explode. Burning dynamite gives off fumes so poisonous that men have been killed by them. Dynamite when chilled or frozen cannot develop its full strength in a blast. Some provision, therefore, must be made for thawing it and for *keeping it thawed* until it is loaded into the bore hole.

On work where these explosives are used in large quantities, thawing houses are necessary; but even then the thawing kettle should be employed to take the explosives from the thawing house to the place where they are to be used, to prevent them from becoming chilled or frozen again.

DU PONT THAWING KETTLE

If not more than two or three hundred pounds of explosives are used at one time, three or four large thawing kettles are all that are necessary, as they will thoroughly thaw that quantity of frozen dynamite in a few hours.

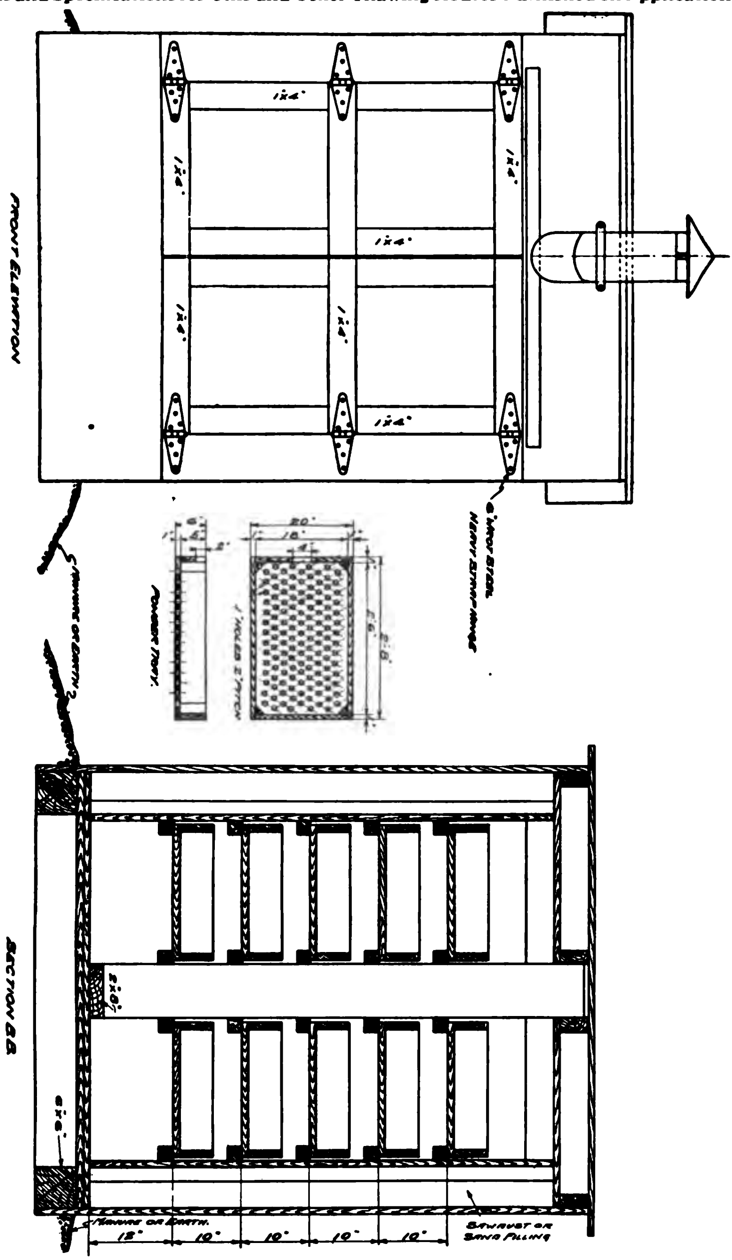
Du Pont Thawing Kettles are all made in one piece with a water-tight compartment for the explosives, which is surrounded by the receptacle for the hot water used to furnish the heat for thawing. This hot water must not come in contact with the dynamite.

While Du Pont Thawing Kettles will retain their heat and keep the explosive thawed for a considerable time, depending, of course, on the nature of the weather, this effective period can be increased to about five times as long if the warm kettle is kept in a barrel or box with dry hay surrounding it. This hay can be held in place by a cylinder of wire screen, so that the thawing kettle can easily be removed and replaced. If the barrel be mounted on two wheels with a tongue attachment, the dynamite can be readily drawn from point to point about the outside work without being exposed to the cold air until it is to be loaded in the bore hole. The explosive may also be kept thawed by wrapping old blankets or sacks around the warm kettle.

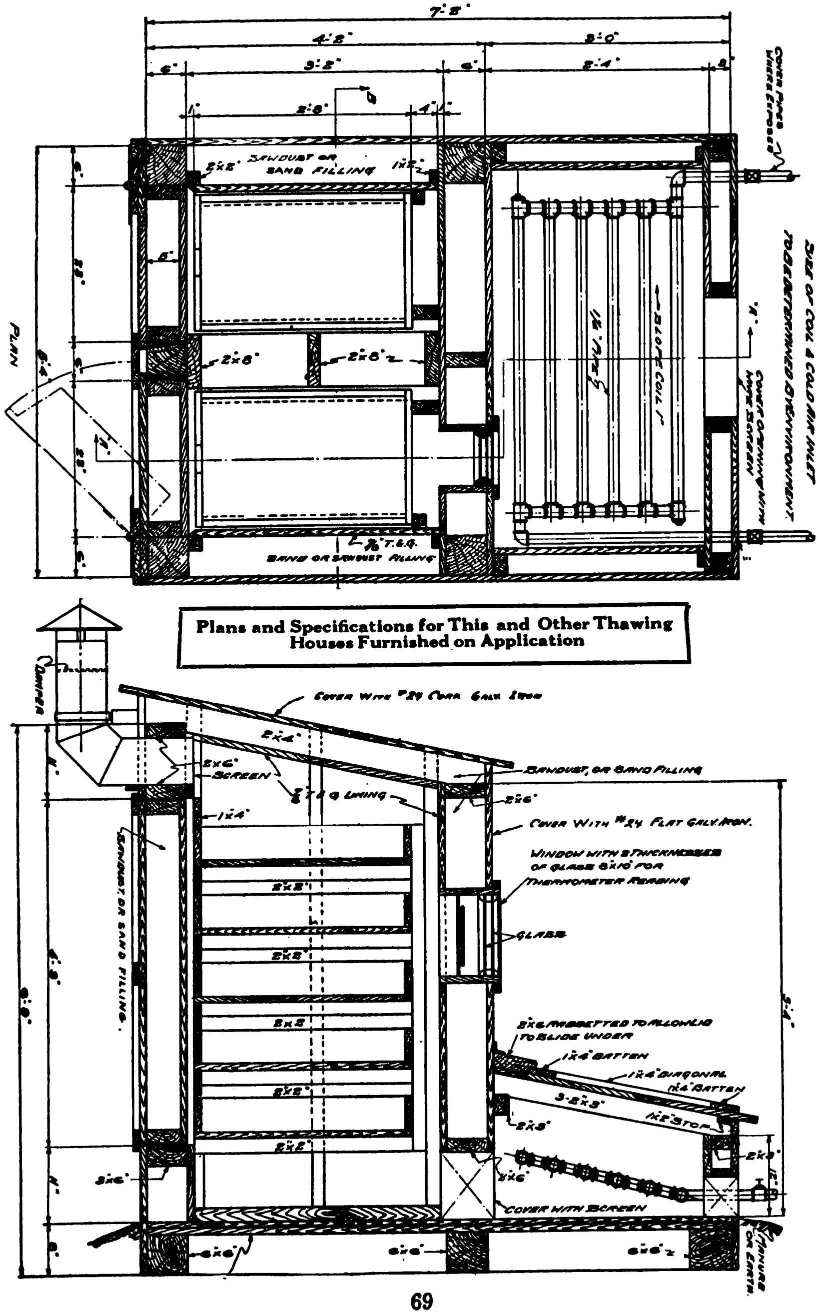
Under no circumstances must the water be heated in thawing kettles, even though the explosives be first removed, because nitroglycerin exudes readily from warm dynamite, and enough of it is likely to be found in the bottom of the explosives compartment of a thawing kettle that has been in use for some time to cause a serious accident if the thawing kettle should be placed

Dynamite Thawing House Heated by Hot Water

Plans and Specifications for This and Other Thawing Houses Furnished on Application



Dynamite Thawing House Heated by Hot Water



Plans and Specifications for This and Other Thawing Houses Furnished on Application

over a fire. It is necessary to heat the water in something else before filling the water jacket. *The hot water must always be tested before filling the dynamite compartment. If it is hot enough to burn the hand, do not put the explosives into the thawing kettle.* Never fill the water jacket unless the explosives compartment is empty. See that the explosives compartment is perfectly dry before it is filled.

Thawing kettles should be kept clean at all times. Should any of the explosive compounds leak out, the explosives compartment should be thoroughly cleaned with a solution of sal soda.

The use of thawing kettles can, to a large extent, be done away with by using low-freezing explosives such as Red Cross Extra Dynamite and Red Cross Gelatin. Arctic Powder does not freeze and never requires thawing.

Capacities and Dimensions of Thawing Kettles

	Capacity	Weight Empty	Weight of Water	Total Weight Filled	Outside Dimensions
Du Pont No. 1.	30 lbs.	12½ lbs.	40 lbs.	82½ lbs.	14" x 14½"
Du Pont No. 2.	60 lbs.	17½ lbs.	77½ lbs.	155 lbs.	17½" x 21"

TAMPING BAG
(Empty)

TAMPING BAG
(Full)

Tamping Bags

Tamping bags made of heavy paper are used in many places as containers for sand, clay or loam used for tamping. They save time and trouble when loading bore holes, particularly those pointing upward.

Tamping bags are a great convenience to miners, and their use often saves many times their cost in economy of explosives.

They are also employed as containers for blasting powder when the miner or blaster desires to make up the charge in cartridge form, as is generally the custom when it is used in mines, in open work that is damp, and in holes pointing upward.

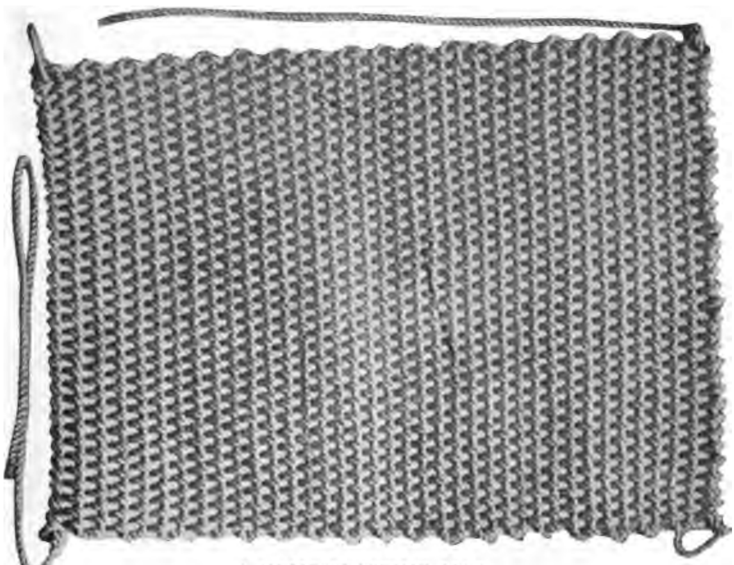
Tamping bags are made approximately two inches longer than shown in the table below in order to provide for folding at the end when filled.

Tamping bags are put up in bundles of 500 each, and packed ten bundles to the bale. They are manufactured in the following sizes:

Size No.	Size	No. in Bale	Shipping Weight per Bale
A	1" x 8"	5,000	28 lbs.
B	1¼" x 8"	5,000	31 lbs.
C	1¼" x 10"	5,000	37½ lbs.
D	1¼" x 12"	5,000	45 lbs.
E	1½" x 8"	5,000	36 lbs.
F	1½" x 10"	5,000	44 lbs.
G	1½" x 12"	5,000	48 lbs.
H	1½" x 16"	5,000	62 lbs.
J	2" x 18"	5,000	86 lbs.

Blasting Mats

Blasting mats are closely woven mats of hemp or wire rope. They are used over blasts or between blasts and property to catch or hold material flying from the blasts. Hemp rope is generally used and is considered the best, although steel wire rope has been tried with success. The mats are made of 1 inch, 1¼ inch or 1½ inch rope, according to the demands of the customer. They are not carried in stock, but are woven on order and are made in any size required. If the blasting mats are to cover light charges of explosives, they may be spread directly over the bore holes; but



A HEMP BLASTING MAT

if heavier charges are used, railroad ties or logs should be put down first and the mats on top of them. Sometimes the mats are propped on lightly supported uprights several feet above the blast, so that when the blast is fired the flying rock is stopped by the under side of the mat.

These arrangements are very effective in preventing the rock from being thrown into the air and should always be adopted when blasting is done near thoroughfares or buildings. Boards and logs alone are not sufficient.

Cordeau

Cordeau, or detonating fuse, is a small lead tube, about the same diameter as triple tape fuse, filled with a yellow explosive compound which has a velocity of detonation of about 17,000 feet (more than 3 miles) per second. In other words, a piece of cordeau 17,000 feet long, if detonated at one end, will explode throughout its entire length in about one second. It is now used principally in deep well-drill blast holes and similar large blasts.

In spite of the great velocity and strength of the detonation of cordeau, it is very insensitive and cannot be exploded by hammering, pinching or burning. It is, therefore, safe to handle and load. It is exploded in actual use by means of blasting caps, electric blasting caps or by detonating dynamite

The extreme violence of the explosion of cordeau is sufficient to detonate high explosives lying alongside it in a bore hole.

Cordeau is furnished either with the plain lead covering or with the lead covering surrounded with a second covering of cotton

Plain

Countered

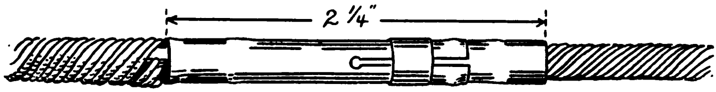
SPOOLS OF CORDEAU

cord, the first being called plain and the second countered. Countered cordeau is more resistant to abrasion of tamping materials.

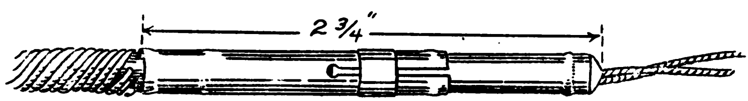
Cordeau is shipped on spools containing from 100 feet to 500 feet each, not necessarily all of one length, the exact length of each piece being specified on the spool head. The first number shown represents the length in feet of the cordeau which would be first removed from the spool, the next number the second length, and the other number, if any, the third length.

Cordeau Accessories

Several accessories are needed when using cordeau. When it is exploded by means of a blasting cap and safety fuse, a "Union" is used to hold the blasting cap firmly in place; when an electric blasting cap is used a "Special Union" is used as shown in sketch below.

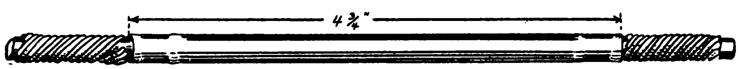


UNION FOR ATTACHING A BLASTING CAP TO CORDEAU

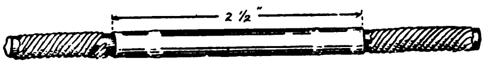


SPECIAL UNION FOR ATTACHING ELECTRIC BLASTING CAP TO CORDEAU

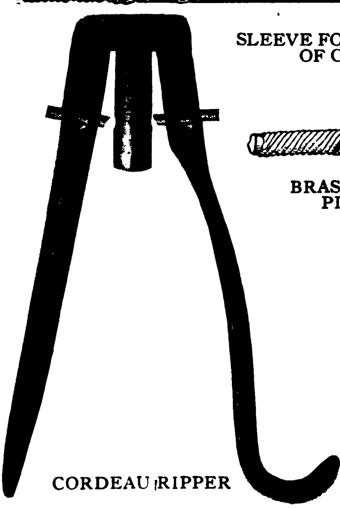
For splicing two lengths of cordeau together a brass coupling is used. A longer sleeve for making a stronger splice is shown in the following sketch:



SLEEVE FOR FASTENING TWO PIECES OF CORDEAU TOGETHER



BRASS COUPLING FOR FASTENING TWO PIECES OF CORDEAU TOGETHER

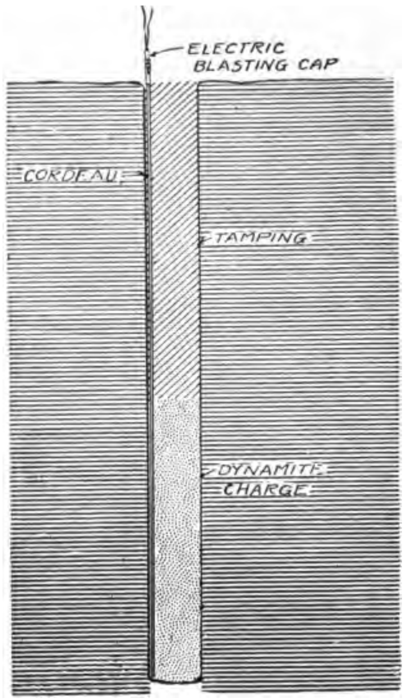


CORDEAU RIPPER

The Cordeau Ripper is a special tool for ripping or splitting the cordeau covering at the end when making connections to a surface main line for a branch or bore hole line as described in the paragraph at the bottom of the next page.

Loading a Hole with Cordeau

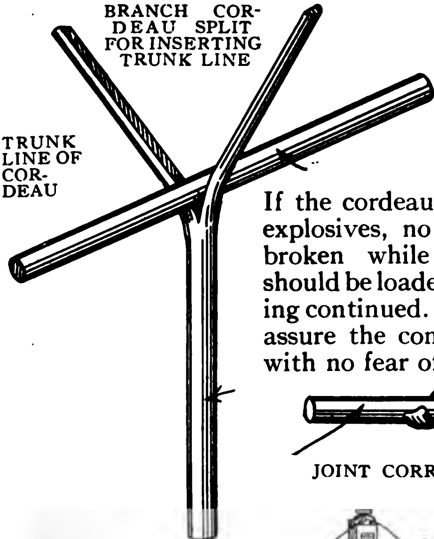
The end of the cordeau is tied to or laced through a dynamite cartridge and it is allowed to run off the spool until the cartridge reaches bottom and the cordeau extends full length of the hole. The rest of the charge is loaded in the usual manner. If there is water in the hole, the end of the cordeau should be sealed by hammering the lead together. When the hole is tamped, the cordeau is cut allowing six inches to extend above the collar of the hole. An electric blasting cap is attached to the end of cordeau at each hole by means of a brass union made for the purpose. Then the electric blasting caps are connected up and fired in the usual manner. The use of an electric blasting cap at each hole is cheaper and surer than using a surface cordeau connection. The surface line does no work other than carry detonation.



SHOWING LOCATION OF CORDEAU, REACHING TO BOTTOM OF BORE HOLE.

Method of Making Surface Connection

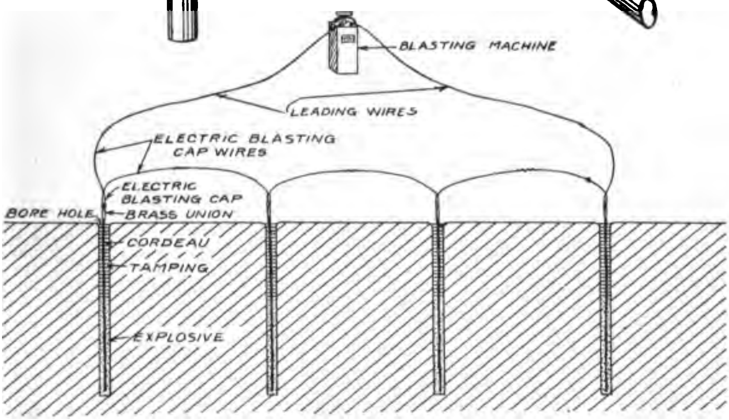
The end of cordeau extending from the hole is split in half for about 3 inches in length and separated. A special tool called a ripper or slitter is used for this. A main or trunk line is laid along the top of holes on the surface so that the main line lies in the crotch formed by the split ends. These ends are twisted tightly around the main line, one to the right, the other to the left. A blasting cap or electric blasting cap is connected to the end of the main line and fired, detonating the whole blast. As many as 76 holes 86 feet deep have been fired with one blasting cap. Great care should be used to see that connections are tight and that the angle between the main line and branch line is a right angle. The explosive in the tube will not stand water and, in rainy weather, extreme care is necessary if surface connections are used.



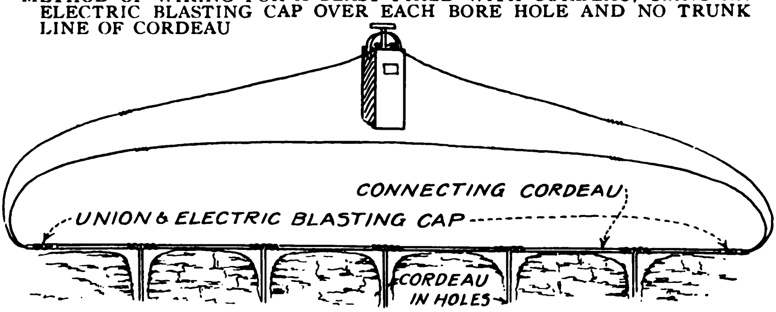
The load of dynamite in well drill holes may be broken as many times as desired and still require only one line of cordeau.

If the cordeau is broken while loading the explosives, no harm is done, but if it is broken while tamping, some dynamite should be loaded at that point and the tamping continued. The dynamite so loaded will assure the continuation of the detonation with no fear of a misfire.

JOINT CORRECTLY MADE



METHOD OF WIRING FOR A BLAST FIRED WITH CORDEAU, USING AN ELECTRIC BLASTING CAP OVER EACH BORE HOLE AND NO TRUNK LINE OF CORDEAU



SHOWING TRUNK LINE OF CORDEAU AND LOCATION OF ELECTRIC BLASTING CAP

Elementary Electrical Principles Applicable to Detonation of Explosives

1. In Fig. 1 is shown an ordinary dry cell battery, with its two binding posts or connectors (A-B). These are called, respectively, the positive and negative poles.

If the poles are connected with a piece of wire (C) an electric current will flow through it, in the direction indicated by the arrows, and will continue to flow until the chemicals are exhausted.

2. Such a wire affording a path for the current from the positive to the negative pole of a battery is called a circuit. The current flows only when the circuit is complete, and a single break in the continuity of the wire stops the flow of current throughout the entire circuit.

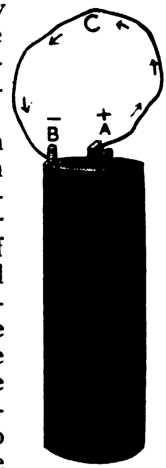


FIG. 1

The wire comprising the circuit can be much longer than shown in Fig 1.—even many miles in length—and still the current will follow it throughout its entire length, as long as some shorter or easier path between the two poles is not offered. If the wire is covered with some insulating material like silk, rubber or cotton, so as to prevent the current from escaping from it and following some shorter or easier course, then the wire may be wound many times around other objects, or make any number of bends and twists, and still the current will follow it from one pole of the battery to the other, with almost as much ease as it did the short piece of wire in Fig. 1.

3. Now, how do we know that a current is flowing through the wire in the manner described? We know it *by its effects*, and a few of these effects, which are of great importance in understanding blasting by electricity, will answer for the present consideration.

a. First, if part of the ordinary thick copper wire used in Fig. 1 be replaced by a very fine piece of wire (G, Fig. 2), the fine wire being preferably of iron, platinum or German silver, then the difficulty which the current has in passing through this small piece of wire, or, as electricians say, "overcoming its resistance", will transform part of the current into heat. The fine wire will become red hot, and even melt if the current is strong. This is the principle made use of in firing electric blasting caps. Another familiar application is the incandescent electric light, where a fine carbon or tungsten wire is forced to carry a large amount of current, and becomes so intensely white hot (incandescent) that it gives out light.

FIG. 2

b. Second, if wire insulated with cotton or silk* be wound many times around a bar of ordinary soft iron (Fig. 3), the ends of the wire being connected with a battery so that the current will flow through it, the iron bar will become powerfully magnetic. As soon as the circuit is interrupted† at any point, whether by removing one or both wires from the battery, or breaking or cutting the wire anywhere throughout its length, nearly all the magnetism‡ immediately departs from the iron. As soon as the circuit is closed, the magnetism returns, even though the opening and closing of the circuit is performed many times a second and the point of interruption is in a far distant part of the circuit. If another piece of iron for the magnet to attract is balanced by a spring over the magnet, every time the circuit is closed it will be drawn toward the magnet, and when the circuit is opened the spring will draw it away. Such a piece of iron provided for the magnet to act upon is called an armature. The telegraph sounder (Fig. 4) works on this principle, the armature in its up and down movements causing a lever to strike resonant metal pegs, which give out the familiar clicks, by the sound of which the operator reads the message. Many other electrical instruments also work on this same principle.


FIG. 3

c. Third, that an electric current is flowing through the wire (Fig. 1) can be shown by crossing part of the wire over a compass as

*Non-conductors are those substances which do not carry the electric current. Conductors are those substances which carry it readily; poor conductors are those which carry it, but with difficulty. Strictly speaking, there are no perfect non-conductors, and no perfect conductors; but the terms are in common use and are convenient and unobjectionable if it is borne in mind that they are relative. Metals are the best conductors; silver heads the list, followed in turn by copper, zinc, iron, platinum, lead, mercury, etc. Among the best non-conductors are glass, rubber, sulphur, silk, cotton, paraffin, tar, resinous materials, oils, etc. Water is a representative of poor conductors, but its conductivity is greatly increased when various salts, such as those likely to be derived from rocks in drilling, are dissolved in it. Acids also increase the conductivity of water.

†Interrupting or breaking a circuit at any point is referred to by electricians as "opening" the circuit; re-establishing it, so that the current can pass, as "closing" the circuit.

‡Soft iron readily loses nearly all its magnetism as soon as the current stops, and the softer the iron the more readily it becomes demagnetized, although it never loses all of it. Hard steel, on the contrary, retains a great deal of magnetism once it has been magnetized, and on this principle depends a permanent magnet. The magnetism left in an electromagnet after the current has ceased is called "residual magnetism."

FIG. 4

in Fig. 5. Ordinarily, of course, the needle of the compass will point north and south, and the wire above it should run in the same direction. But as soon as the connection with the battery is established the needle will be deflected, so that it will stand at right angles to the wire, or, in other words, point east and west. If the end of the wire that is connected with the positive pole of the battery be transferred to the negative pole, and *vice versa* (that is, if the "poles be changed") the *needle will reverse its direction*, so that the end which pointed east before will now point west.

4. The needle will also reverse its direction if the wire C, Fig. 5, be moved from its position above the needle to one below it, as shown by the dotted line. In other words, the direction of the electric current affects the direction in which the magnetic needle is deflected, deflecting it one way when passing above the needle and in the opposite way when passing below it. This fact enables us to very greatly intensify the action of the current upon the magnetic needle, by putting a coil of insulated wire about the compass, as shown in Fig. 6. With such an arrangement, all the strands of wire above the needle are carrying the current in one direction and all those below in the opposite direction. They all, therefore, tend to deflect the needle in the same manner, and the effect is very greatly magnified; so much so, that an instrument constructed on this principle indicates the passage of currents that are too feeble to be detected by any other means. Such an instrument is called a galvanometer.

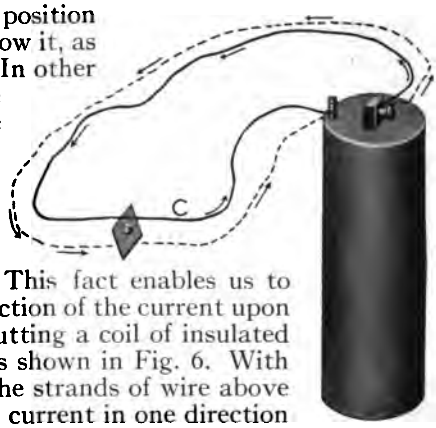


FIG. 5

5. *Practical Magnets.*—The electromagnet is much more powderful when, instead of the wires being wound on a straight bar as in Fig. 3, the bar is bent U shape, as shown in A and B, Fig. 7, for in this position both ends can be made to act at once upon the same piece of iron, and they can attract it with double, or more than double, force. It is also found

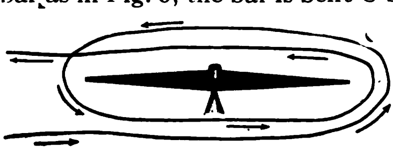


FIG. 6

that the wire in the middle of the electromagnet does not have as much of an effect as that near the ends, and for this reason the wire is not generally wound on the middle part, but only on the ends, as shown in B, Fig. 7. Again, it is ordinarily advantageous, from the manufacturing standpoint, to make the iron core of a magnet in sections, afterwards fastening them together, as shown in C, Fig. 7. The sections H-I can then be wound with the wire, just as thread is wound on a spool, securing great efficiency as well as ease in manufacture (D, Fig. 7).

Such electromagnets, when of large size and actuated by powerful currents, are of tremendous power, and will lift masses of iron weighing tons.

6. If a piece of soft iron, *i. e.*, an armature (paragraph 3-b, page 77), be placed between the poles of a conveniently shaped

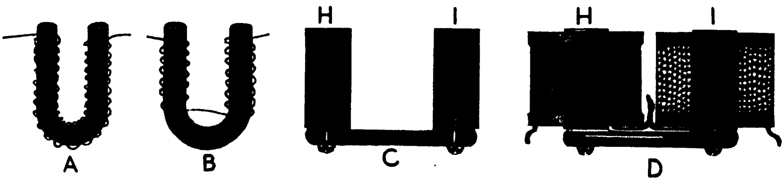


FIG. 7

magnet, as shown in Fig. 8, the piece of soft iron is also caused to become magnetic. North polarity is induced in the end near, or in contact with, the south pole, and *vice versa*. If the position of the armature is reversed, so that the end A is nearest the south, and B nearest the north pole of the magnet, then the armature reverses its polarity, so as always to present its south end to the north end of the controlling ("field") magnet. This it does, even though the reversal of ends is very rapid, such as would result from fixing a shaft into the armature at J, and rotating it rapidly in the direction shown by the arrows.

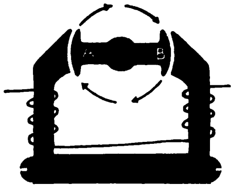


FIG. 8

We have seen (paragraph 3-b, page 77) that passing an electric current through wire wound upon a soft iron bar is capable of causing it to become magnetic. The reverse of this proposition, namely, the induction of an electric current in the wire about an iron bar by causing the bar to become magnetic, is also true with certain limitations. Take such a bar wound with wire (A, Fig. 9) and connect the ends of the wire with a galvanometer (the construction of which is explained in paragraph 4, page 78), so that we will know whenever a current passes. Now cause the end of the bar to approach the live electromagnet B, Fig. 9. All the time it is approaching B, the galvanometer shows that an electric current is passing. When the movement is stopped, the current stops.

If the movement be reversed, that is, if the wire-wound bar be moved away from the magnet, the galvanometer will again show that a current is passing, but ***in the opposite direction.***

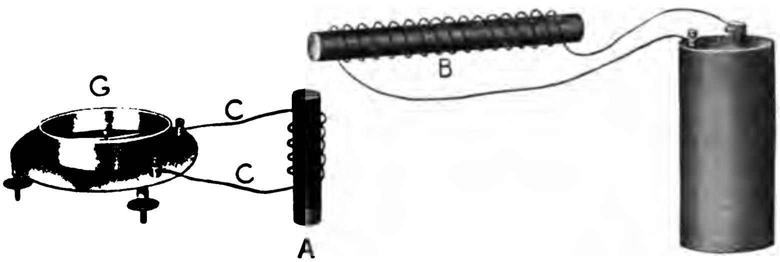


FIG. 9

The reason the current is set up (induced) in the wire around the iron bar is that the iron bar is caused to become magnetic as it approaches the live magnet (paragraph 6, page 79), and loses this induced magnetism as it is withdrawn; and there is a natural law that *any change in the magnetic condition of an iron core will induce an electric current in wire around it.*

It may be argued that the result is not an electric current, but a series of electric pulsations. That is perfectly true; but if the pulsations are sufficiently frequent, through rapid rotation of the armature shaft, they produce similar enough effects to the steady flow of a battery current to be available for most purposes.

But the currents induced in the armature do more than pulsate. If the ends of the armature wire are connected with a galvanometer, and the armature slowly revolved so that the movements of the needle can be watched, the needle will be found to swing first to the east, then to the west, then east, then west again, changing direction with each half revolution of the armature. If the end of the galvanometer needle should be equipped with a pen, so that it could make a mark on a paper tape moved steadily beneath it by clockwork, the tracing that would be obtained by this experiment would look like Fig. 10.

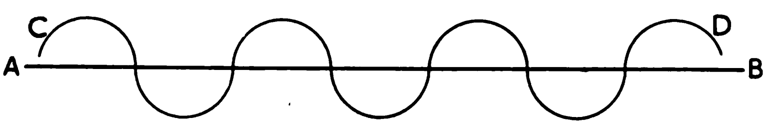


FIG. 10

In this illustration, Fig. 10, the straight line A B is the mark the pen would make if the paper were moved forward with the needle at rest and pointing to zero, or north. The wavy line C D is the mark made by the needle when such a current, continually reversing its direction, is sent through the apparatus. Such a current is called an *alternating current.*

But it is evident from what has already been said (paragraph 4, page 78) that such an alternating current would not do to energize the field magnet. In order to maintain the constant polarity of the field magnet, the current supplying it with energy must be in one direction, like the battery current. This is called a *direct current.* The alternating current induced in the armature is, therefore, rectified or changed into a direct current by means of the *commutator* (Fig. 11).

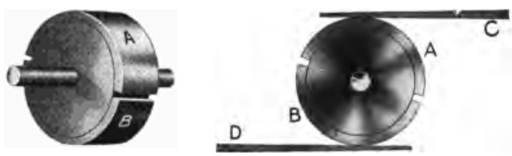


FIG. 11

The commutator in the blasting machine consists of a cylinder of hard fiber or rubber, covered with copper, and mounted on the same shaft which drives the armature. The copper is cut lengthwise into two sections (A and B, Fig. 11). These are firmly attached to the surface of the hard fiber very close together, but not touching; that is, they are insulated from each other by the fiber which carries them. One end of the armature wire is connected with section A, the other with section B.

The current is taken off of the commutator for use by copper brushes, C and D (Fig. 11). Now, as the commutator revolves with the shaft, while the brushes remain stationary, the section A is in contact with brush C for half a revolution, then with brush D for the other half. The same thing happens to section B. Therefore, the effect of the commutator is to change the alternating armature current into a *direct current,* and the tracing which the recording galvanometer will make on the tape, when it receives the current from the dynamo equipped with the commutator, is shown in Fig. 12.

The alternating current would fire electric blasting caps as well as the direct current; but if it were not converted into a direct current as it is, we would either have to energize the field magnet with a battery or use a permanent magnet. With the present arrangement, we simply lead the rectified current from the armature through the wire on the field magnet, which is thus energized

Fig. 12

by the current from its own armature. At the start, the very slight residual magnetism which is retained by the field magnet (see note††, paragraph 3-b, page 77) is sufficient to set up a feeble current in the armature. This in turn makes the field magnet stronger, and the stronger field magnet develops a stronger current in the armature. Thus the machine "builds up," as it is called, until after a few revolutions it is working at its full power. You can notice this when you push down the rack bar of a blasting machine. The first part of the stroke is easy, but after the armature has made a few revolutions it pushes quite hard, because the magnet has become strong and pulls back on the armature, tending to resist our efforts to turn it.

The dynamo just described, which is used in most American blasting machines, is one of the simplest and earliest forms of dynamo. Those used for generating powerful currents for electric lighting and power are more complicated, and more efficient electrically than those made on this simple design; that is, if the blasting machine dynamo were constructed on modern principles it would take less power for the same output of current or give greater output with the same amount of power, whichever way one chooses to look at it. But, for the purposes to which a blasting machine is put, considerations of simplicity outweigh this kind of efficiency. Blasters would rather exert a little more muscle in operating the blasting machine than pay for the increased cost of repairs to a more modern dynamo, not to mention the increased initial cost. Indeed, it is doubtful if a more satisfactory blasting machine could be reasonably asked for than the ordinary push-down blasting machine just as it is now made. Certainly no other piece of electrical machinery would stand the misuse to which many of these blasting machines are subjected in practice, and still continue to do good work, day after day and year after year, as many of them do in spite of it all.

Let us now dissect an ordinary blasting machine, as a review, and see how these electrical principles apply. Fig. 13 shows a two-post blasting machine. Note the field magnets 8 and 9 with their winding of coarse wire. In the figure the armature 16 can be seen with its winding of finer wire.

Note the brushes 20, bearing on the commutator just as already described, and see where the ends of the armature wire are soldered, each to its respective commutator section. On the other side is the rack and pinion ratchet movement, by which the downward thrust of the rack bar I imparts rotary movement to the armature. This is so simple that anyone can see at a glance how it works, and it need not be dealt with here.

There is one part of the blasting machine, simple, but of great importance, which has not yet been taken up, and that is the "shunt," sometimes called the "circuit breaker." This is the brass contrivance 4 placed in the bottom of the box. It is really nothing but a brass spring which makes contact with the bridge 5, when in its normal position, the parts which come in contact being covered with platinum, so that they will remain bright and make a good electrical connection.

The function of this shunt is as follows: The spring 4, called the contact spring, is connected by means of a piece of heavy copper wire to one of the binding posts, 26, representing one pole of the dynamo; the bridge is connected with the other binding post, representing the other pole of the dynamo. When the contact spring is up in contact with the bridge a short, easy circuit, called a shunt circuit, of practically no resistance, is offered for the electric current to pass from one pole to the other—in the language of the electrician, the dynamo is "short circuited". While the rack bar is being pushed down, the blasting machine is building up the current generated passing across the shunt, so that by the time the rack bar is near the bottom of the stroke the dynamo is working at its maximum. When the rack bar strikes the contact spring, however, separating it from the bridge, the short circuit is broken, and the current of the dynamo has now no other way to pass from one pole to the other except by flowing out through the electric blasting cap circuit, and it does this just at the instant when it is at its maximum strength. The fine bridge wire in each blasting cap heats up instantly, causing all the caps to explode at the same time.

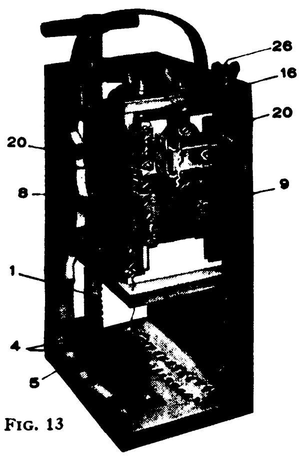


FIG. 13

Were it not for the shunt, operating as just described, current from the dynamo would begin to flow through the electric blasting caps as soon as one started to push down the rack bar. It would be a very weak current at first, gradually increasing with the building up of the blasting machine. Such a current is not well adapted to fire a number of electric blasting caps simultaneously, because it is impossible to make all of exactly the same degree of sensitiveness, and with the gradually increasing current, the more sensitive electric blasting caps would fire first, breaking the circuit and causing the less sensitive ones to miss. By employing the shunt, on the other hand, no current is sent out from the blasting machine until there is ample power to fire even the least sensitive.

Effective Use of Electric Blasting Apparatus

Almost anyone can use electric blasting accessories and obtain good results, merely by following general instructions. However, the knowledge of the principles underlying their action, which will have been gained by reading the previous chapter, will be a great aid in obtaining their highest possible efficiency. Again, when the man who understands the principles encounters difficulties, he knows how to overcome them, while the man who does not understand has to be helped out of his troubles.

Care of Blasting Machine

One who knows the internal construction of the blasting machine, and has learned from examination and study what a nice piece of mechanism it really is, will generally take good care of it. Keeping it, when not in use, in a clean, dry place is the first thing you can do to help the blasting machine help you. Down in a wet tunnel or mine is *not* a good place to store such an instrument, and if it must be used in such places, as is often the case, and it cannot be taken to the surface between times (which is sometimes the case), a water-tight closet or box should be built for it, in as good a location as can be found. Remember that the case is only wood, and, if saturated with water, may swell and put the internal parts out of adjustment. Occasionally rubbing a *little* oil—preferably thick cylinder oil—into the grain of the wood will help it to resist the water. The best way to apply the oil is by rubbing the box with a greasy rag.

When you use the blasting machine, try to find a clean, level place to stand it on, such as a dry plank, so that the bottom will not be all wet when you put it away after using.

After the principles of its operation are thoroughly understood, the efficiency of the blasting machine may be kept up to the maximum by occasional inspection and care of the internal parts, although they are so constructed as to seldom require much care.

The first thing to be considered in caring for the dynamo and working parts is occasional oiling. Much judgment should be used here, for too much oil is worse than none at all. The only parts that need oil are the bearings of the armature shaft and of the armature pinion. The other iron parts that can be reached, particularly the faces of the armature (not the wire), should be wiped off with a greasy rag to prevent them from rusting. *No oil should be used on, or allowed to come in contact with, the brushes and commutator, nor with the contact spring and its contact points.*

For this reason, the amount of oil used in any part of the blasting machine should be small; if too much is used, the oil will afterwards flow over into places where it is not wanted. This is especially the case when the rack bar is oiled. Too much oil here will inevitably flow down upon the contact spring and its contact points, and cause a poor electrical connection with the bridge. In fact, a poor electrical connection at this point is one of the most common causes of the poor work and erratic behavior of the blasting machine. Wiping off the rack bar and guide rod with a greasy rag will give them all the lubrication they require.

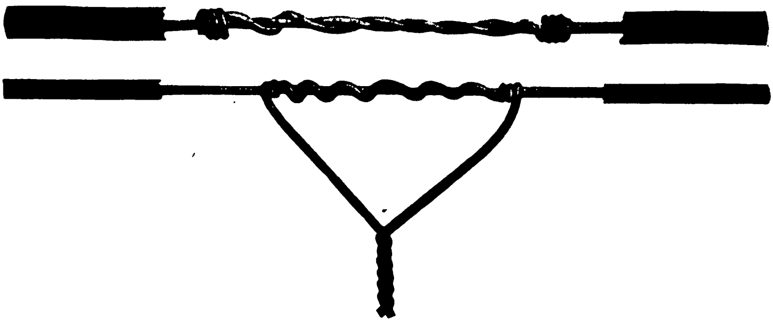
The friction incident to ordinary usage will generally be sufficient to keep the surfaces bright where the brushes bear upon the commutator, *unless* some misguided person has oiled them. In that case, the oil should be removed as well as possible by thorough cleaning with a rag saturated with gasoline. If the brushes seem to be too rapidly wearing into the commutator, so that they absolutely demand some kind of lubricant, use a little graphite taken from a soft lead pencil. After removing the oil by the use of gasoline, be sure that all the gasoline and its vapor are out of the box before closing it up; if confined, the vapor may afterwards ignite and blow the box apart.

All contact points on the contact spring, bridge, and elsewhere may be cleaned occasionally with fine sandpaper. However, sandpaper should be used in or about a blasting machine only with the greatest care. Dust or fine particles from the sandpaper must not be allowed to get into the working parts of the machine, as they will cause these parts to wear out rapidly. Care must also be taken, especially when cleaning the platinum contact points, not to rub too vigorously. A gentle rubbing is sufficient to remove any dirt or oxide and brighten the parts, whereas a few vigorous rubbings will grind off the platinum points themselves. If the platinum is ground away so that only brass remains, the working of the machine will be impaired, for the brass quickly becomes oxidized by the hot flash given off when the circuit is broken, and thereafter fails to make a good contact.

Making Joints

The joints connecting the various electric blasting caps, leading wires and connecting wires that are to comprise the circuit often do not receive as much attention as they should. It is true that mere contact between perfectly clean wires is sufficient to permit the passage of the current, but it is almost impossible to get them perfectly clean, and the joint should, therefore, be made in such a manner as to press together a considerable amount of the wire, after it has been cleaned as thoroughly as possible. This preliminary cleaning or scraping should never be neglected. There is sure to be tar or grease present from the waterproofing material used, as well as oxides, dirt and some kind of foreign material that has adhered to the wire.

There are many methods of making joints, some of them good and some bad. The one generally recommended is made as shown in the following illustration:



Another good way, if one has pliers to finish up the joint, is that shown in the lower cut. This is made in the same way as the joint in the previous figure, except that the ends, which are left long for that purpose, are twisted together.

It is much easier to connect together wires of the same size than wires of different sizes, such as leading and electric blasting cap wires. For this purpose, a joint like that shown on page 50 is good—the spring of the thick wire keeping up a tension on the small wire, and causing it to make a good contact. It is difficult to make a nice joint under such circumstances, but it can be made good electrically if the wires are first thoroughly cleaned.

Joints in the leading wire, when they must be made, should be made with special care. Those in the connecting and electric blasting cap wires, as a rule, have to do service only for a few minutes or hours; but those in the leading wire will be there while the leading wire lasts, and if poorly made will give trouble long after their location is forgotten. The above illustrations show how such joints should be made. The method is just the same as that recommended for the electric blasting cap wires, except that these joints should be about 2 or 3 inches in length. *It pays* to have joints in the leading wire *soldered.* Some of the most peculiar and erratic troubles are due to defective joints in the leading wire, which worked satisfactorily for a number of shots, but afterwards became bad through corrosion having formed between the contact surfaces. The electrical condition of such a joint is liable to change on the slightest movement of the wire, to be good one minute and bad the next, and for that reason to cause a trouble difficult to locate.

Of course, wherever a joint has been made, the wire will be bare of insulation, and the question is often asked whether, in such cases, it is always necessary to use insulating tape for covering the bare places. Where these joints are in the leading wire, and especially where they are in electric blasting cap or connecting wire which is to be inside of the bore hole and covered with tamping, they should be taped. If the joints are not to go underground, it is not absolutely necessary to tape them; it will be sufficient if they are elevated and kept off the ground, or from touching anything, by placing blocks of wood under the wire near the joint. Joints in the leading wire can be treated in this way also, thus avoiding the necessity of taping them; but it is a nuisance to have to go all over the line blocking up bare places before a blast, when the whole trouble could be avoided by a few turns of insulating tape. In fact, a well made, soldered and taped joint puts the leading wire in almost as good condition as when new, while a few questionable joints are sure at some time to be a source of annoyance, delay and danger.

It is best not to have any more joints in the circuit than are absolutely necessary. Joints are especially objectionable when they have to be lowered into the bore hole because the electric blasting cap wires are too short. These wires should be long enough to prevent the necessity of making this kind of joints. It is even better to have them long enough to connect directly with the wire of the electric blasting cap in the adjoining bore hole, thus avoiding the use of connecting wire as well as saving time. When connecting wire is required, *old electric blasting cap wire* that is full of joints and bruises from having already been through a blast *should not be used.* Use new connecting wire. The use of old, damaged electric blasting cap or connecting wire is the worst kind of false economy. No experienced contractor needs to be told how expensive it is to have a long period of delay after the men have been ordered away from the work, while the blaster pokes around, looking for the "reason why the shot did not go," all men, horses and machinery idle meanwhile.

Preparing Primers

Preparing the primer is really one of the most important steps in all blasting operations. And yet, how frequently we find this work entrusted to one of the least skilled among the workmen. It ought to be done in the safest suitable place that can be found, and it should also be done in the manner which is calculated to secure the best results. Yet both of these considerations are frequently violated, and the priming is done in the thawing house or magazine where an accidental explosion would be certain to cause widespread disaster, and is also done in a manner just the opposite to that recommended by the manufacturers of explosives and blasting accessories. These methods have been given in detail in other parts of this book.

In spite of the recommendations of the manufacturers, however, it is very seldom one finds a blaster making primers in the right way, the reason generally given being that "it is too much trouble to hunt up strings and tie them". Of all operations where results justify a little extra trouble, none can exceed in importance the making of the primer, for upon this depends the success of the entire blast. Of course, it takes a little longer to make primers in the proper way than it does by the half-hitch method, but the extra time is well spent, and it should be borne in mind that it is the time of *one man*, while the time spent in "hunting trouble" is the *combined time of all the men, horses and machinery*. There never yet was a cheap misfire.

The primer especially must be well thawed, and in the best possible condition. If the bore holes are wet, it is well to seal up the place where the detonator has been inserted in the cartridge by means of soap, tar or some other waterproofing material, since, if the explosive immediately surrounding the detonator is impaired in any way, it is likely to cause a failure or inferior work of the entire blast.

Firing Shots Promptly

Once the loading has commenced, a blast should be loaded and fired as quickly as possible. Many things may happen to detract from the efficiency of a charge after it is loaded, and the chances increase with every minute that elapses between loading and firing. The dynamite may freeze if the rock or ground is cold enough. Water may work its way into the explosive charge or into the electric blasting caps. The insulation on the wires may be affected by moisture, so that the leakage of current will cause one or more charges to miss.

Operating the Blasting Machine

The blasting machine should always be operated with as much force as the operator can exert. Try especially to finish the last part of the stroke with your full power, for when the rack bar nears the end of the stroke it will push quite hard, tending to check the movement, and yet the end of the stroke is the most important of all. It takes a man with considerable strength and with some skill to get the full force out of a large blasting machine.

It is, of course, obvious that no more current is required to fire strong electric blasting caps than weak ones. Those with very long wires, however, do require more current, for the small copper wire which is used has some resistance. An electric blasting cap with 26-foot wires would take about twice as strong a current to fire it as it would if the current could be delivered close to the electric blasting cap instead of having to go through the 26-foot wires.

Testing Blasting Machines and Electric Blasting Caps to Avoid Misfire

Many careful blasters have long wished for some means to guard against misfires by which the blasting machine and the individual electric blasting caps could be tested, before attempting to use them. If they could always be used just as they come from the factory, without being subjected to the unfavorable conditions they so often meet with in transportation and storage, it is probable that there would be little need for testing because every manufacturer carefully tests his goods before sending them out. The Du Pont Company tests its detonators twice. Electric blasting caps are liable to damage during transportation and storage, and particularly so if they are stored in a damp place.

The Du Pont Rheostat should be used in testing blasting machines. For testing electric blasting caps and the blasting circuit, the Du Pont Galvanometer is recommended.

A test with almost any kind of testing instrument would be sufficient to reveal the most common defect, the presence of a broken bridge in an electric blasting cap. All instruments, however, will not indicate those electric blasting caps which are defective through a short circuit, such as those in which the electric blasting cap wires are not insulated from each other within the electric blasting cap, or have accidentally come into contact after having been manufactured. In such cases, the electric blasting caps would fail to fire, of course, because the current would follow the short circuit and not go through the bridge. To identify electric blasting caps defective from this cause, it is necessary to have some form of instrument which will show fairly accurately the electrical resistance.

When testing electric blasting caps, they should always be placed in such a position that if one of them should happen to explode accidentally no one will be injured. Placing them around the corner of a stone wall or behind a stump or stone is an easy and safe way, or, if there are but a few of them, they can be buried under a foot of dry sand. If there are many, so that the total amount of fulminate is considerable, the particles of sand themselves would become projectiles capable of injuring anyone near by.

Of course, there are occasions, as for instance, when there has been a misfire and it is necessary to locate the trouble, when some risk must be taken, even to making use of the galvanometer in testing electric blasting caps that are loaded in bore holes with explosives, and often in locations where the firing of the charge during the test would be disastrous to the tester. But under such conditions, the very remote danger of the test replaces the much greater danger which always exists whenever a blast misfires and the blaster is hunting about for the reason.

Under such circumstances, there is no doubt that a great saving in the total amount of risk results from locating the trouble with accuracy and celerity, even though there be a remote risk in the test itself. The current from a Du Pont Galvanometer has never been known to explode an electric blasting cap. The chances of firing an electric blasting cap while testing are thousands of times greater when an ordinary series magneto telephone bell or other unsuitable instrument is used. Several persons have been badly injured in this way because they not only made use of an improper testing instrument, but also neglected to place the electric blasting cap in a safe location. It is remarkable what extensive damage the flying particles of copper from one of these electric blasting caps are capable of doing.

The current from a magneto bell is too weak to fire an electric blasting cap by heating its bridge, but it is of sufficient intensity to jump across small gaps, such as would result if an electric blasting cap had a broken bridge, and the broken ends were very close to each other. When the current jumps across such a gap, a spark is produced which is often sufficient to ignite the explosive mixture. Another way in which an electric blasting cap might become sensitive to the current from a magneto bell is by the formation of corrosion between the ends of a break, such as where, through the entrance of moisture, the copper wire had corroded off the bridge at one of the soldered joints. Should the electric blasting cap subsequently dry out, it may show a resistance several hundred times greater than normal, and would be very likely to fire from the current from a magneto bell, while there would be very little likelihood of its firing from the weak current from a suitable testing battery like that in the Du Pont Galvanometer.

What lulls the suspicion of a blaster who tests with a magneto (and the matter is mentioned here because there are many who do) is the fact that he is often able to test a great many electric blasting caps with it before one of them explodes in the testing process. But some day one that is defective in the manner above described is encountered—and then, too frequently, it means a maimed hand, blindness or worse. For this reason, the use of any kind of testing current, except that from a weak battery used in connection with a galvanometer, or Wheatstone bridge, is most earnestly condemned, and further, the electric blasting caps should be placed in some location where they will do no harm if one should explode. When the test of a loaded bore hole must be made, and it is impracticable to attach the leading wires and test from a safe distance, the test should be undertaken with the full recognition that it is a risk, even though a remote one when a suitable instrument is used, and no one but the tester himself should be exposed to the risk.

General Precautions to be Observed with Regard to Explosives

DON'T forget the nature of explosives, but remember that with proper care they can be handled with comparative safety.

DON'T smoke while you are handling explosives, and DON'T handle explosives near an open light.

DON'T shoot into explosives with a rifle or pistol, either in or out of a magazine.

DON'T leave explosives in a field or any place where animals can get at them. Cattle like the taste of soda and saltpeter in explosives, but the other ingredients would probably make them sick or kill them.

DON'T handle or store explosives in or near a residence.

DON'T leave explosives in a wet or damp place. They should be kept in a suitable, dry place, under lock and key, and where children or irresponsible persons cannot get at them.

DON'T explode a charge to chamber a bore hole and then immediately reload it, as the bore hole will be hot, and the second charge may explode prematurely.

DON'T do tamping with iron or steel bars or tools. Use only a wooden tamping stick with no metal parts.

DON'T *force* a primer into a bore hole.

DON'T explode a charge before everyone is well beyond the danger zone and protected from flying debris. Protect your supply of explosives also from danger from this source.

DON'T hurry in seeking an explanation for the failure of a charge to explode.

DON'T drill, bore or pick out a charge which has failed to explode. Drill and charge another bore hole at least two feet from the missed one.

DON'T use two kinds of explosives in the same bore hole, except where one is used as a primer to detonate the other, as where dynamite is used to detonate Du Pont Low Powder. The quicker explosive may open cracks in the rock and allow the slower to blow out through these cracks, doing little or no work.

DON'T use blasting powder, permissible explosives or high explosives in the same bore hole in coal mines.

DON'T use frozen or chilled explosives. Dynamite, other than Red Cross, often freezes at a temperature between 45° F. and 50° F.

DON'T use any arrangement for thawing dynamite other than one of those recommended by the Du Pont Company.

DON'T thaw dynamite on heated stoves, rocks, bricks or metal, or in an oven, and don't thaw dynamite in front of, near or over a steam boiler or fire of any kind.

DON'T take dynamite into or near a blacksmith shop or near a forge on open work.

DON'T put dynamite on shelves or anything else directly over steam or hot-water pipes or other heated metal surface.

DON'T cut or break a dynamite cartridge while it is frozen, and don't rub a cartridge of dynamite in the hands to complete thawing.

DON'T heat a thawing house with pipes containing steam under pressure.

DON'T place a hot-water thawer over a fire, and never put dynamite into hot water or allow it to come in contact with steam.

DON'T allow thawed dynamite to remain exposed to low temperature, but use as soon as possible.

DON'T allow priming (the placing of a blasting cap, or electric blasting cap in dynamite) to be done in a thawing house.

DON'T prime a dynamite cartridge or charge or connect bore holes for electric firing during the immediate approach or progress of a thunderstorm.

DON'T carry blasting caps or electric blasting caps in your pocket.

DON'T tap or otherwise investigate a blasting cap or electric blasting cap.

DON'T attempt to take blasting caps from the box by inserting a wire, nail or other sharp instrument.

DON'T try to withdraw the wires from an electric blasting cap.

DON'T fasten a blasting cap to the safety fuse with the teeth or by flattening it with a knife; use a cap crimper.

DON'T keep electric blasting caps, blasting machines or blasting caps in a damp place.

DON'T attempt to use electric blasting caps with the regular insulation in very wet work. For this purpose secure Du Pont Waterproof or Gutta-percha Covered Electric Blasting Caps.

DON'T worry along with old, broken leading wire or connecting wire. A new supply won't cost much and will pay for itself many times over.

DON'T handle safety fuse carelessly in cold weather, for when cold it is stiff and breaks easily.

DON'T store or transport blasting caps or electric blasting caps with high explosives.

DON'T store safety fuse in a hot place, as this may dry it out so that uncoiling will break it.

DON'T lace safety fuse through dynamite cartridges. This practice is frequently responsible for the burning of the charge.

DON'T operate blasting machines half-heartedly. They are built to be operated with full force. They must be kept clean and dry.

DON'T cut the safety fuse short to save time. It is a dangerous economy.

DON'T expect a cheap article to give as good results as a high-grade one.

DON'T expect explosives to do good work if you try to explode them with a detonator weaker than a No. 6 (red label).

DON'T leave detonators exposed to the direct rays of the sun.

DON'T leave detonators where the rays of the sun will strike them after passing through glass.

DON'T have matches about you while handling explosives.

DON'T store explosives so that the cartridges stand on end.

DON'T open cases of explosives in a magazine.

DON'T open cases of explosives with a nail puller, pick or chisel.

DON'T prime both ends of a cartridge of explosive when making primers of half cartridges, with a blasting cap or electric blasting cap, before cutting it in two. Cut the cartridge in half and prime each piece separately.

DON'T use a needle of iron or steel when firing by means of miners' squibs. Use one of copper or brass.

DON'T keep blasting caps or electric blasting caps in the same box or container with other explosives in the field. Keep them separate.

DON'T use electric blasting caps of different manufacture in the same blast.

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For Handling, Storing, Delivering and Shipping EXPLOSIVES

THE Du Pont Company will furnish, upon request, a set of rules printed on cloth for posting in magazines. Provision is made for the signature of the official in charge of the mine or other work requiring explosives.

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ESTABLISHED, 1802