

# The use of Explosives on the Farm

by

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Published by the University of Minnesota, College of Agriculture, Extension Division, F. W. Peck, Director, and distributed in furtherance of the purposes of the cooperative agricultural extension work provided for in the Act of Congress of May 8, 1914.

**E**XPLOSIONS may be used to advantage for many purposes in agricultural work, among the most common being blasting of stumps, rocks, and moderate sized ditches. The object of this bulletin is to explain the methods of handling explosives with the greatest degree of safety and how to secure most efficient and most satisfactory results.

Explosives are dangerous when not properly handled, but comparatively safe when handled as they should be. Blasting caps are the most dangerous. They are very sensitive and will explode from heat or from an outside shock. Dynamite in itself is not so dangerous, but when it is carried with caps the combination must be respected, because the accidental explosion of the caps may also explode the dynamite. Caps should be kept out of the hands of children.

While it is necessary to have both dynamite and blasting caps in the field when blasting is done, they should never be carried in the same box.

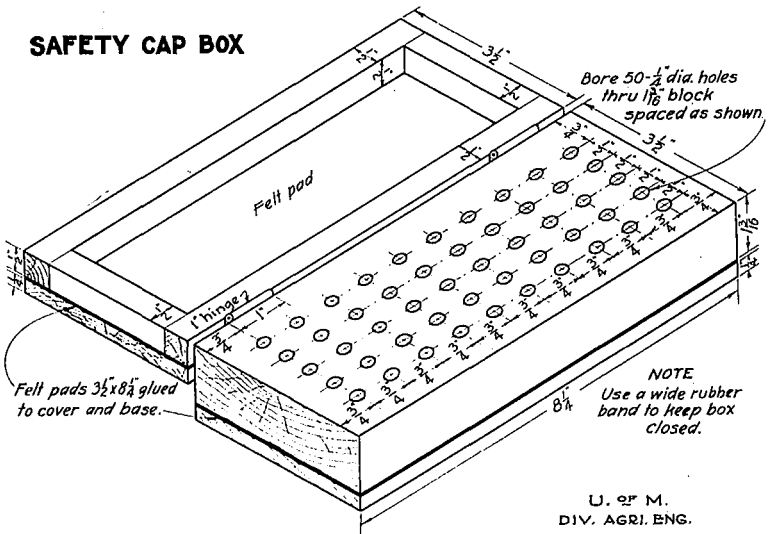


Fig. 1. The safety cap box provides a safe and convenient means for carrying blasting caps on the job.

## BLASTING MATERIALS

### Blasting Caps (Common)

The No. 6 blasting cap is the size commonly used for all agricultural blasting. For ordinary cap and fuse blasting, the common cap is used—copper shell 1 $\frac{5}{8}$  inches long and  $\frac{1}{4}$  inch in diameter with one end open. It is filled about half full with a very sensitive explosive material, while the upper end is left open for the fuse to be inserted. Blasting caps are very sensitive to friction or heat. The explosive material in the caps must not be disturbed.

A very convenient and comparatively safe means of carrying blasting caps in the field is the **safety cap box**, shown in Figure 1. This box is easily made from soft wood (preferably white pine). The diagram gives all the necessary dimensions. It is desirable to paint the box red.



Fig. 2. If the end of the fuse has been cut off squarely, it is easily inserted into the cap.

### Fuse

A good grade of safety fuse should be used. Fuse should not be allowed to get wet. In cold weather it must be handled carefully to avoid sharp kinks or breaks, as a result of which the train of powder in the center of the fuse may be broken and thus cause a hangfire. A hangfire is a condition which exists when a charge fails to explode within a reasonable time after the fuse has been lighted. Such charges may not explode for several hours after, and should not be approached until the following day. Fuse will burn at the rate of about 2 feet per minute, or somewhat slower.

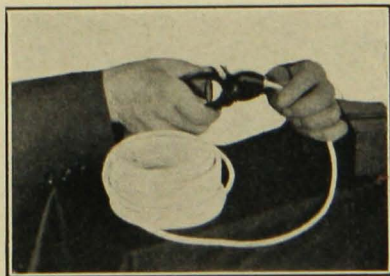


Fig. 3. The cap is carefully fastened to the fuse with a cap crimper which is made for this purpose and exactly fits the cap.

### Attaching Cap To Fuse

The end of the fuse should be cut off squarely before it is inserted into the open end of the cap. This is done with the fuse-cutter attachment to a cap crimper or with a knife. Make sure that the end of the fuse reaches the explosive material in the cap, but do not force or twist the fuse after it touches the bottom.

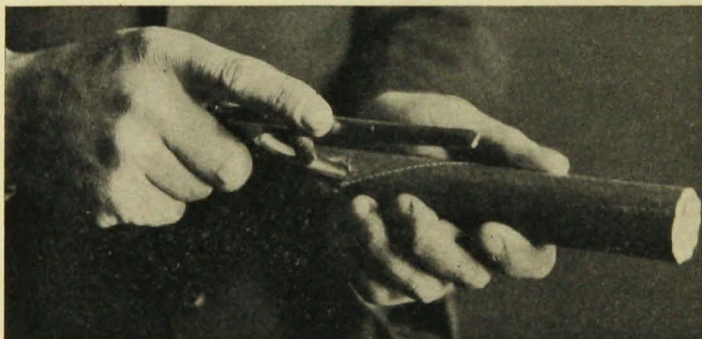


Fig. 4. The hole is made in the stick of dynamite so that the cap will be lengthwise of the stick.

A cap crimper is the safest tool to use for fastening the cap to the fuse. Pliers, jack knives, and other make-shift tools are **unsafe** and unsatisfactory. The use of a crimper also reduces to a minimum the possibility of a hangfire. The importance of the use of cap crimpers for safe and effective blasting is emphasized by the following extract from a letter from the United States Department of Agriculture, Bureau of Public Roads.



Fig. 5. The cap is completely hidden in the stick of dynamite.

"The Bureau of Public Roads has felt for some time that it is imperative, both from the standpoint of safety and of effectiveness in the use of commercial and government explosives, to secure a greater use of cap crimpers. We feel that there is no other thing that will do more toward the prevention of hangfires and the accidents which so often accompany them than the proper priming of an explosive charge. There is no question but that the use of crimpers is one of the vitally important things in securing a properly primed charge."

### Making the Primer

The cap, with the fuse attached to it, is inserted into a stick of dynamite. A stick of dynamite prepared in this way is known as the **primer**. One handle of the cap crimper usually has a pointed end so it may be used to punch the hole in the dynamite for the cap, as in Figure 4. The cap is inserted in the side as shown in Figure 5. It should be as nearly as possible parallel with the stick of dynamite. Every precaution should be taken to keep the cap and fuse from pulling out while the primer is being pushed into the bore hole. It is usually well to tie it with a string, as shown in Figure 6.

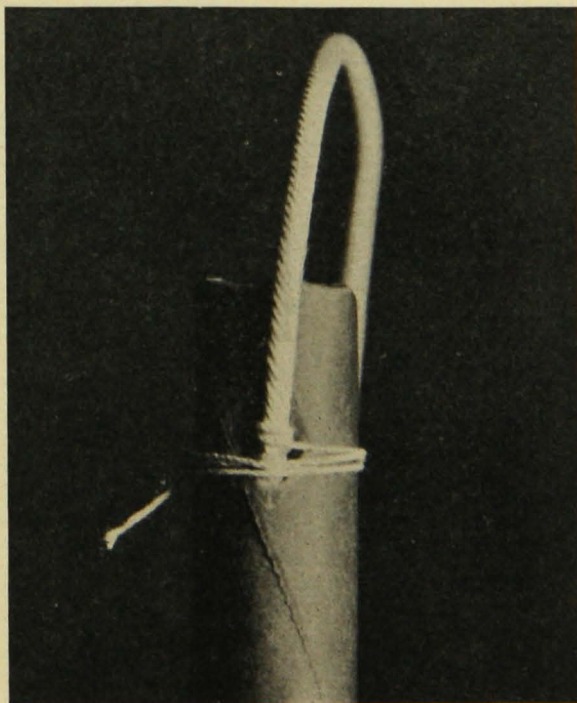


Fig. 6. Fastening the cap and fuse onto the stick of dynamite is one way to help prevent misfires.

### Electric Blasting Caps

Electric blasting caps must be used when the electric method of firing is desired. These caps are made in the same sizes as the common caps, and the No. 6 electric cap is used for all agricultural blasting. These caps contain the same amount of explosive material as the common caps, but have two wires fastened in them in place of the fuse. The wires vary in length, depending on the nature of the work for which the caps are to be used. These caps are just as dangerous as the common blasting caps, and should be handled with the same precautions. The primer with electric caps is made in exactly the same way as with the common caps. The electric caps are more advantageous, however, as the cap wires may be used to prevent the cap from slipping out. (Fig. 7.) This makes it unnecessary to use string.

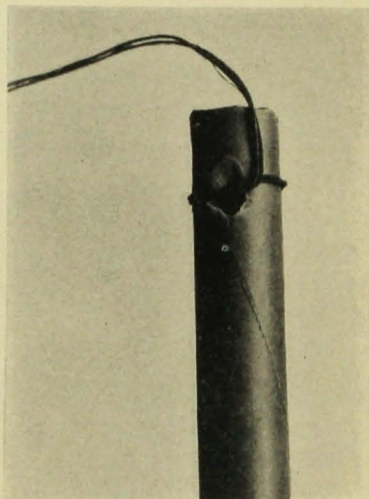
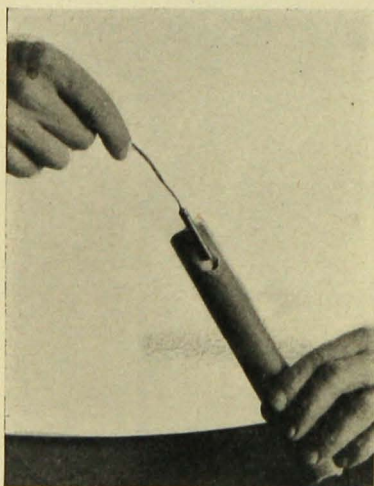


Fig. 7. Making the primer with the electric blasting cap.

### Electric and Cap and Fuse Methods of Blasting Compared

A blasting machine, as shown in Figure 8, is used to furnish the current when the electric method of blasting is used. These machines are made in different sizes, each size handling a definite number of caps at one time. The most practical size for farm blasting operations is one having a capacity of 10 caps. For special work, one with a capacity of 30 caps may be better. Other means of firing may be used, as dry cells, wet batteries, or magnetoës. These, however, are unreliable and unsafe and consequently their use is not recommended. The blasting caps are connected in series as shown in Figure 9, and a duplex or double lead wire of at least 150 or 200 feet connects the caps

with the blasting machine. If the wires which are attached to the caps are not long enough to reach from one to the other, connecting wire may be used to complete the circuit. No. 20 insulated copper wire is used for this purpose. This may be purchased from explosive manufacturers under the name "connecting wire." The lead wire should be long enough that the operator may be in a safe position when the blast is fired. The lead wire should be disconnected from the blasting machine after each blast.

Any number of charges may be detonated at the same instant with the electric method. This can not be done with the cap and fuse method. The electric method is also safer, as the blaster has the time of fire under absolute control. He knows exactly when the charge is to explode. If for any reason it does not explode when the blasting machine is operated, the wires should be disconnected and the source of trouble may be located without danger.

The cap and fuse method on the other hand is cheaper where there is no advantage in firing several charges simultaneously.

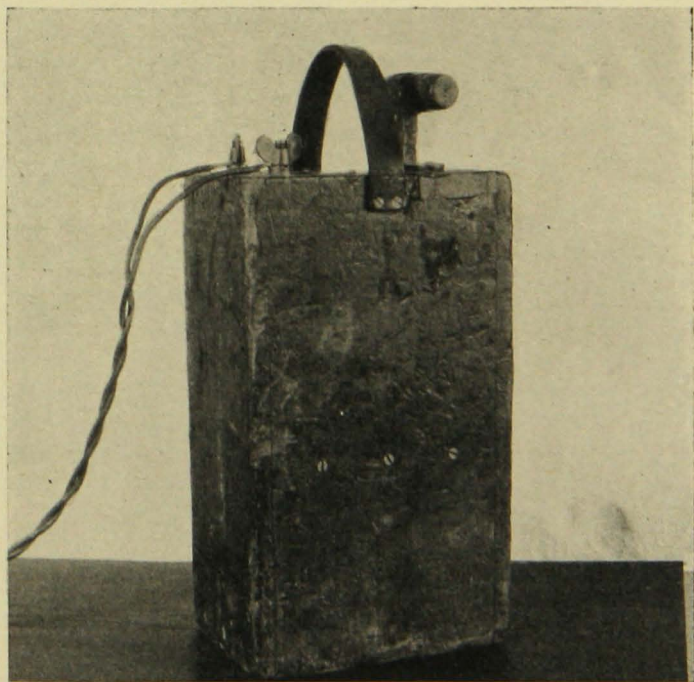


Fig. 8. A blasting machine furnishes a safe and simple means of furnishing the current to set off electric blasting caps.

### Kinds of Explosives

Many kinds and grades of explosives are available for agricultural blasting. The particular grade which should be used will depend largely on the nature of the work to be done, and will vary from 20 per cent to 60 per cent dynamite. During recent years war-salvaged explosives have been used with very satisfactory results. These are practically equivalent stick for stick to 40 per cent dynamite. The grades best suited for the different uses are discussed in the following paragraphs.

### STUMP BLASTING

#### Blast When the Ground Is Wet

In order to secure the most possible benefit from a charge of explosives, it must be confined as nearly air-tight as possible. This condition is much more easily and better obtained in wet than in dry soil. Early spring, therefore, is the best time of the year to blast stumps from the standpoint of soil moisture, and the work at that time fits in well with the regular farm operations. Sometimes there is sufficient moisture to do good work in the fall.

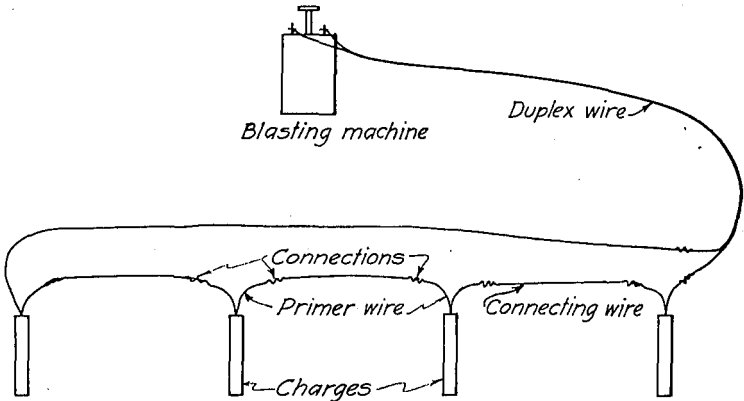


Fig. 9. Electric blasting caps are connected in series. If the cap wires are too short, connecting wire may be used.

#### Use the Right Kind of Tools

The use of good tools is very important, as they make it possible to get completely under the stumps and to place the charge where it will be the most effective. This can not always be done with a small makeshift auger, or when using a buggy axle as a bar. The cost of explosive material and time wasted with poor tools is much more than the cost of several sets of good tools, such as are shown in Figure 10.



A good soil auger is important. This should be not less than  $1\frac{1}{2}$  inches in diameter and may be 2 inches or even larger. It should have a shank so as to make a total length of at least 4 feet.

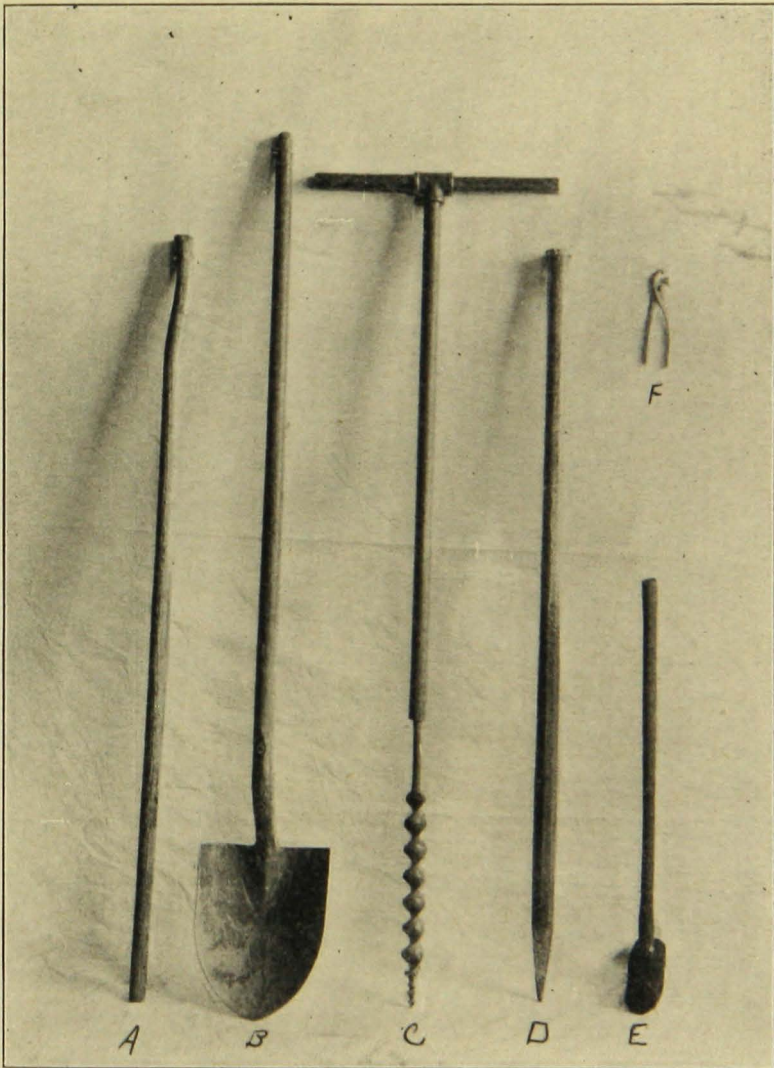


Fig. 10. Basting tools. (From Special Bul. No. 60.)

The driving iron is made of octagon tool steel and is  $1\frac{1}{2}$  inches in diameter. It is about 4 feet long and has a pencil point on one end. A sledge weighing 8 or 10 pounds is used to drive the iron into the ground. Ordinarily the bar is very easily pulled out by striking it on the side a few times with the sledge after it has been driven in. This

bar makes a very good combination with a  $1\frac{1}{2}$  inch soil auger, as they may be used interchangeably in the same hole.

A wooden tamping stick should always be used to tamp the charge. This should be 4 or 5 feet long and small enough in diameter to slip freely into a  $1\frac{1}{2}$ -inch bore hole. A shovel handle makes a very good tamping stick. A round-point shovel or spade, a pair of cap crimpers, and perhaps a crowbar, complete the necessary equipment.

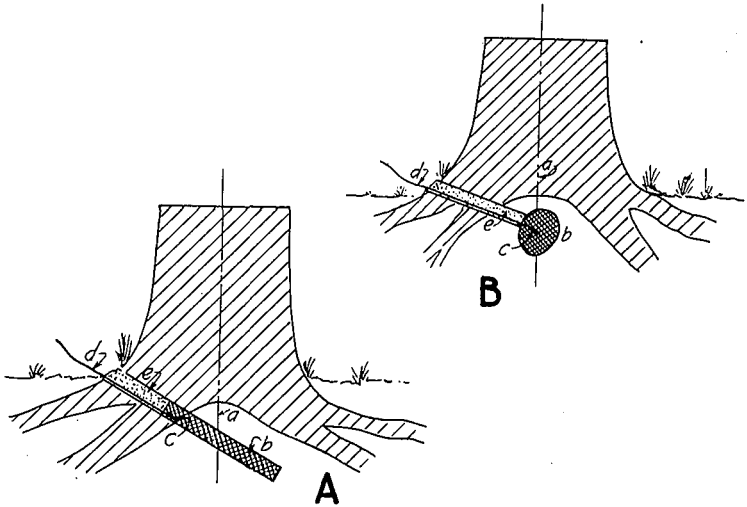


Fig. 11. Place the charge under the center of resistance.

- |                        |                     |
|------------------------|---------------------|
| a—Center of the stump. | d—Fuse.             |
| b—Explosive material.  | e—Tamping material. |
| c—Blasting cap.        |                     |

### Location and Depth of Hole

The location and depth of the hole are very important, as explosives can give best results only when properly placed. To avoid wasting explosive energy and doing a poor job of blasting, the user must keep in mind that the force of an explosion is the same in all directions and that the explosive charge must be placed directly under the load which is to be lifted.

The bore hole should be made so that the center of the charge will be under the center of resistance. In order to have the charge placed properly, therefore, it is usually necessary to make the hole a short distance past the center of the stump as shown in Figure 11A. If the stump requires a large charge, and a small auger or driving iron is used to make the hole, it is advisable to enlarge the bottom of the bore hole by means of a small charge of dynamite, known as a "springer" charge (Fig. 11b). This consists of 1 or 2 inches of a stick of dynamite with cap and fuse inserted. This small charge is placed at the bottom of the hole and fired without tamping.

The depth of the hole will vary with the size of the stump. It should be deep enough to throw out all the roots, but not deeper than is necessary to do this because a deep hole requires much more explosive than a shallow one. A large stump will require a deeper hole than a small one.

### Amount of Explosives to Use

The size of the load will vary considerably with conditions. It is quite natural that a large stump will require more force to take it out than a small one. Many other factors, however, help to determine the size of the charge. Some of these are the age of the stump, the kind of stump, and the amount of moisture in the soil. When all other conditions are equal, a green stump will require more explosive than a dead one and much more material will be required in a dry soil than in a wet soil.

It is impossible to state definitely the size of charge necessary for different kinds of stumps under different conditions. It is always well to make several trial shots. This will make it possible to estimate quite closely the proper load. The following table gives approximate information which may be used as a preliminary guide in making test shots.

Number of Sticks of 40 Per Cent Dynamite Required to Blast Various Sizes and Kinds of Stumps Under Different Conditions.

Diameter (In.)	Maximum Sticks	Minimum Sticks
8	2	1
12	4	2
18	7	3
24	10	5
30	15	7
40	25	10

### Placing the Charge

Great care must be exercised in placing the charge in the bore hole. Remember that a compact charge will give much better results than one in which the material has not been packed tightly and which has considerable air space around it. To make it possible to pack the explosive material tightly, the sticks should be slit with a knife at least once, as shown in Figure 12. As each stick is placed into the hole it is packed in tightly with the tamping stick. The last stick of the charge is the **primer** which is shown in Figure 6. If this stick is to be slit, that should be done before the cap is inserted. Since the primer charge has the cap in it, it is handled more carefully and not packed so hard with the tamping stick.

### Tamping

Tamping is very important. If the hole is not tamped, the force of the explosion will be practically wasted regardless of other precau-

tions which may have been taken in placing the charge. Moist dirt makes very effective tamping material and is usually quite easily obtained. The object of thoro tamping is to confine the explosive material as compactly and as nearly air-tight as possible so that the gases which are formed by the explosion can not escape, but do useful work.

### Firing the Charge

The length of fuse to be used depends largely on the depth of the bore hole. It should be long enough that the blaster may get well out of the way before the charge goes off, and it should not be so short that the hole can not be tamped with dirt completely to the top. The end of the fuse is slit with a knife or a cap crimper as shown in Figure 13. The slit is made half way through the diameter of the fuse and the loose ends are then pulled open with the thumbs so as to expose the powder. A very satisfactory way to light the fuse is to stick the head of a match into the powder just as it begins to flare, immediately after it has been struck. When the fuse begins to spit, the powder train has started to burn.

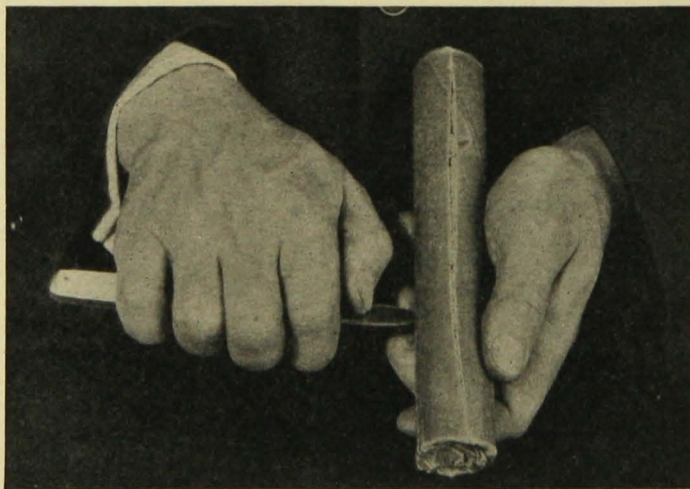


Fig. 12. Slitting the explosive with a knife makes it possible to mash the stick in the bottom of the bore hole and thus pack it very compactly.

### Handling Misfires

If for any reason the charge does not explode within a reasonable time after the fuse has been lighted, it is a hangfire. This condition may be due to several causes which are usually the results of careless handling of the fuse or carelessly making the primer or placing the charge.

Hangfires may usually be avoided by being careful not to put any sharp kinks in the fuse, especially in cold weather. Use a good grade of fuse and do not allow it to become wet. Be sure that the end of the fuse touches the explosive material in the cap. Always use a cap crimper to fasten the cap onto the fuse. Prepare the "primer" very carefully and make sure that the cap and fuse will not pull out of the stick of explosive.

In case of a hangfire, the charge should be left alone until the following day. It may explode at any time for several hours after the fuse has been lighted. When a hangfire fails to explode it becomes a misfire. In attempting to remove a misfire it is necessary to proceed with extreme care as long as the live blasting cap still exists in the charge. Sometimes it is possible to bore underneath the stump from another side and get down to the original charge. Then place another primer stick next to the old charge and set it off in that way. This method however is not usually recommended because it is possible that the original cap may be thrown away and not exploded and thus still be a source of danger.

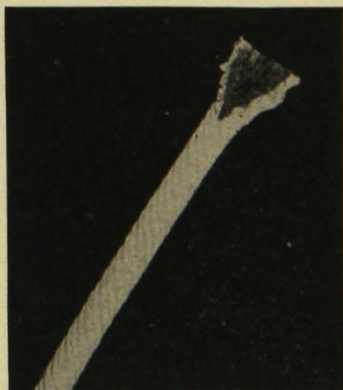


Fig. 13. The fuse is easily lighted when the end is slit so as to expose the train of powder.

As a rule a better way to proceed is to follow the original bore hole and remove the dirt as carefully as possible. This will probably be a very slow process because an auger would be used very carefully, if at all. Remove enough dirt with a wooden stick and with the hands to make it possible to get out the old blasting cap. Then place another primer stick next to the old charge, tamp the bore hole in the usual way, and fire the charge.

### Electric Method of Blasting Stumps

With large stumps which have a hollow center and large lateral roots, it is sometimes advantageous to place several charges under the same

stump and to fire them all at the same time. The electric method of firing must be used to accomplish this. When a number of charges are exploded simultaneously, one blast will help the other and the combined effect will be much greater than the effect of the same amount of explosive material in a single charge.

Electric caps are more expensive than common caps, but with some stumps enough explosive can be saved by distributing the charge to more than make up for the extra cost, to say nothing of the greater safety. Figure 14 illustrates the method of locating charges under a stump loaded electrically. Each charge is placed directly under one or a group of strong roots. The process of placing the charge is exactly the same as that for the cap and fuse method, except that an electric cap is used in each charge to make the primer. Each electric cap has two wires and they are connected in series, as shown in Figure 14.

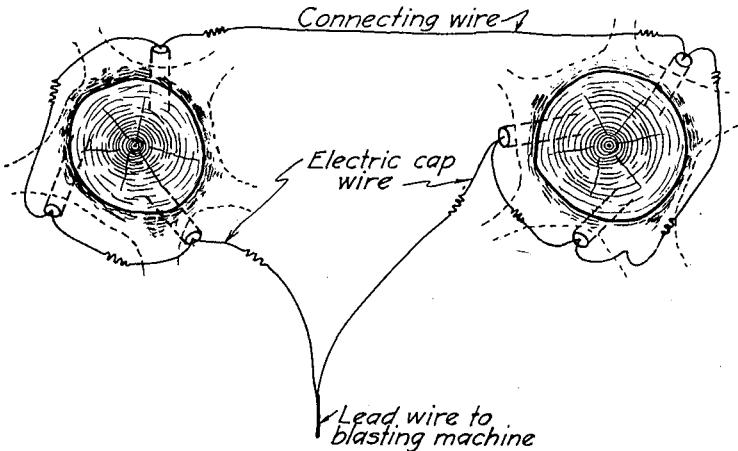


Fig. 14. The electric method of blasting makes it possible to distribute charges under the stump.

## ROCK BLASTING

### Mud-Capping

Explosives may be used in several ways for blasting rocks. One method is commonly known as "mud-capping." The object of this method is to break the rock. It consists in placing the explosive on the surface of the rock in a compact heap and then covering it with 10 or 12 inches of stiff mud. To obtain best results it is important that this covering of mud be large and wet. Mud is cheaper than explosives, and a small covering of comparatively dry dirt will waste considerable explosive force. The mud should be free from stones, sod, leaves, twigs, and other foreign material. If the stone which is to be broken tends to be flat rather than round, the charge should be placed on a flat

side rather than at one end. Sometimes it is possible to find a natural crevice or depression which makes an ideal location for the charge.

If more than two or three sticks of explosives are used in one load, it is usually best to pour the powder out of the paper wrapper. This makes it possible to get all the powder in a small compact heap, with a minimum of air space, which can not be done when the sticks themselves are placed on the rock. The heap of explosive should be covered with one or more of the wrappers that were around the sticks to keep out moisture. The cap with fuse attached or the electric cap is put into the powder before the mud is put over it.

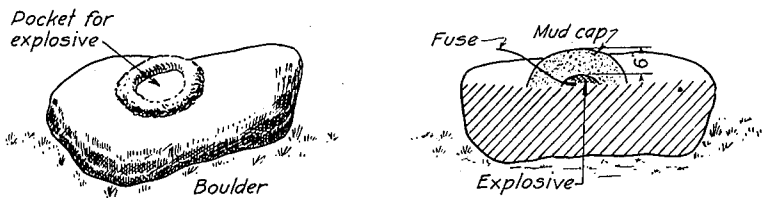


Fig. 15. To make a good mud-cap, use a thick covering of stiff mud to cover the charge.

If the charge is large enough and if the mud-capping has been properly done, the force of the explosion will break the rock. To do this work most satisfactorily and efficiently a quick-acting explosive is necessary. Fifty or 60 per cent dynamite is much better than 20 or 30 per cent. The stone to be broken should always be entirely exposed. When part or all of the stone is buried, either of two methods may be used: (1) A narrow trench may be dug around the stone down to the bottom of it, as shown on page 1. This will give it room to expand when the charge is exploded, and consequently will make it much easier to break; or (2) a charge of explosive may be placed under the rock to throw it out of the ground preparatory to mud-capping.

### Underdrilling

This process is known as the "underdrilling" method of blasting. It consists in making a hole in the ground underneath the rock with an auger or a driving iron. The charge is placed much as it would be under a stump. (See Fig. 16.) A low-grade explosive, 20 or 30 per cent, is suitable for this purpose. The charge usually is so located that there is a quantity of dirt between it and the under side of the rock. This acts as a cushion to break the force of the explosion, and consequently rocks blasted by this method are thrown out of the ground if a large enough charge is used, but are seldom broken.

### Undermining

The "undermining" method of blasting rocks is illustrated in Figure 17. The object of placing the charge as shown is to break the rock with the same charge that is used to throw it out. It is practically the same thing as putting a mud-cap underneath. Because it is desired to break the rock when using this method, it is well to use a quick-acting explosive of from 40 to 60 per cent. In this method special attention must be paid to getting the charge close against the lower side of the rock with no dirt or other foreign material between the two. To make this possible, it is sometimes necessary to dig down on one side slightly below the level of the bottom of the rock. Thus one can actually make a small cavity underneath in which to place the charge "E" as shown in Figure 17. The explosive should be placed as nearly as possible under the center of the rock. If it is partly or entirely buried, something about its size and shape may be learned by probing around it with a bar.

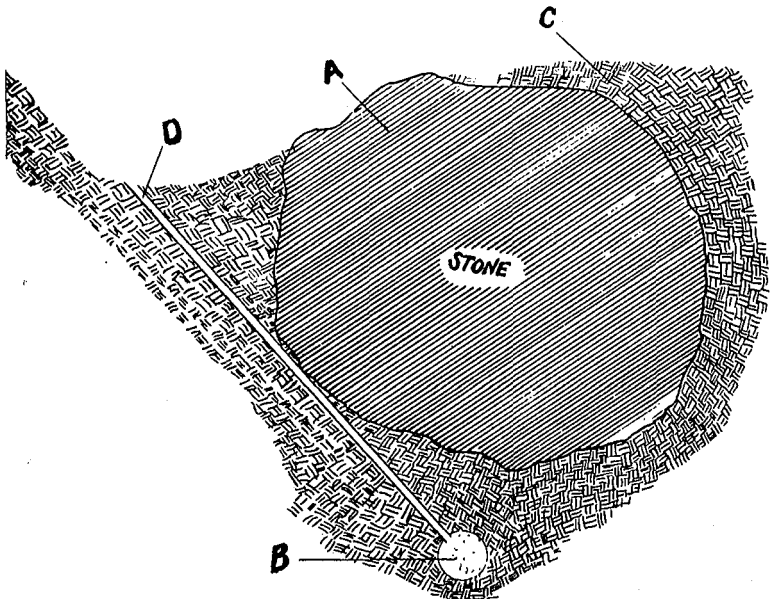


Fig. 16. Underdrilling to place explosive under the stone.

- a—Stone.
- b—Pocket large enough for necessary explosives.
- c—Soil.
- d—Hole made with driving iron or dirt auger.

When stones are almost or entirely buried, it is usually more economical to use the undermining method than to use a combination of the other two. Some additional labor is required to place the charge, but this is usually more than paid for in the saving made in explosive



costs. The advantage of the undermining method can be better appreciated when one considers that the two operations of breaking and throwing out of the ground are completed with the one blast.

If only a small portion of the stone is beneath the surface of the ground, it may be more economical to dig a narrow trench around it before "mud-capping," as shown on page 1.

### DITCH BLASTING

Under some conditions, explosives may be used to advantage in the construction of moderate sized ditches, more particularly for temporary use or emergency relief, while under other conditions it is more economical and the job is better and more permanent if other methods are used.

Good results are obtained in blasting small ditches where the soil is moist. Whether it is more economical in first cost to blast or to use other means will depend largely on the amount of moisture in the soil and also upon the conditions for digging or scraping. A satisfactory ditch through a peat swamp which is littered with stumps, logs, and other rubbish, can often be made with explosives where digging would be very expensive or perhaps impossible. On the other hand, on dry upland soils, especially of a sandy character, it is usually not economical to use explosives.

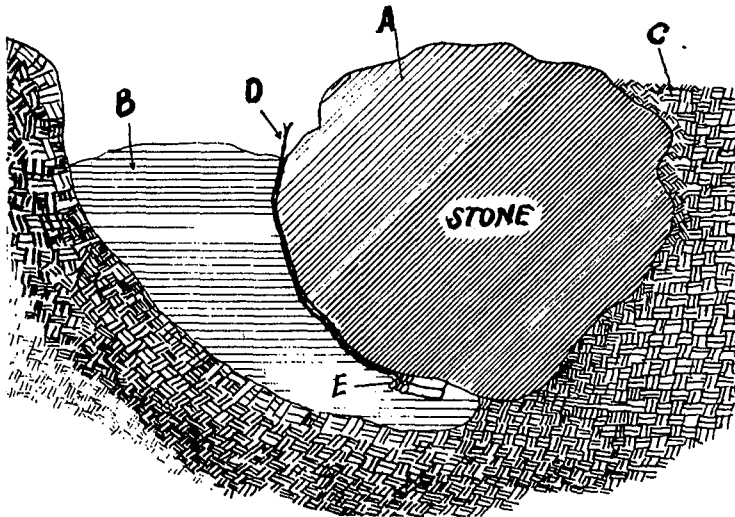


Fig. 17. Undermining in order to both break the stone and throw it out.

- a—Stone.
- b—Soil shoveled in after charge has been placed.
- c—Soil.
- d—Fuse.
- e—Charge.

A ditch made with explosives is a series of holes blasted in the ground. To obtain a ditch with smooth sides, the charges must be placed close enough together that the edge of the hole made by one will extend beyond the edge of the hole made by its neighbor; and all the charges must be fired at the same instant. This can be done only when using either the electric method of blasting or the "propagated" method.

### Electric Method

The electric method is perhaps the most practical because it can be used wherever the propagated method can be used, and in many places where it can not be used. Again, with the electric method one can use almost any kind of explosive, altho a quick-acting explosive is desirable for ditching, while the propagated method can be executed only with the use of 50 or 60 per cent straight nitroglycerine dynamite.

Figure 18 illustrates the method of placing the charges when using the electric method. A primer made with an electric cap, as described under "stump blasting," is placed in each hole.

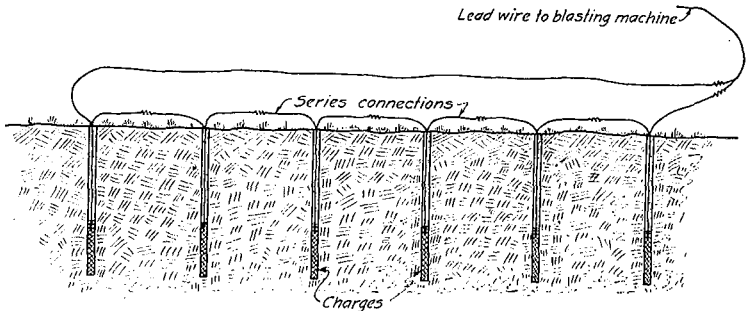


Fig. 18. The charges should be placed in a straight line. All charges are connected in series and connected to a lead wire which goes to the blasting machine.

The size and depth of the charges and the space between charges will vary with the size of the ditch desired and also with soil and moisture conditions. No definite rules can be set down. All existing conditions must be taken into consideration in each case, then several test shots should be made to determine experimentally the best combination. The following general principles may be used as a preliminary guide.

The size of the charge will depend on the depth of the proposed ditch and the condition of the soil. The ditch will ordinarily be about six inches deeper than the lower end of the charge. The distance between charges in the row will depend largely on the depth and to some extent on the size of the charges. This distance may be at

least equal to the depth and under some conditions even greater. A blasted ditch usually will be about twice as wide across the top as the depth.

### Propagated Method

There are several very definite restrictions on the use of this method: (1) only 50 or 60 per cent straight nitroglycerine dynamite should be used, (2) the soil must be very wet, (3) the charges must not be placed more than 24 inches apart, and (4) the temperature should not be too cold.

In using this method, a blasting cap is not placed in each charge, but in one charge in the center of the series. When this charge is exploded, the force is sufficient to detonate the next charge, provided it is not more than 24 inches away. This process continues to the end of the series of charges.

It can readily be seen that a very sensitive explosive is necessary. Ordinary 50 or 60 per cent ammonia dynamites are not sensitive enough. It is absolutely necessary to use 50 or 60 per cent straight nitroglycerine dynamite.

The distance through which the force of one explosion will be sufficient to detonate the next, will vary with conditions. Under no conditions can it be greater than 24 inches, and it is usually less. In a soil which is somewhat dry, the distance between charges would have to be less, as the shock is very readily transmitted through moisture. Other factors affecting this distance are temperature and the presence of obstructions in the ground, as wood or stones. These interfere with the transmission of the force from one charge to the other.

In attempting to use this method of blasting, several trial shots should first be made. Start with a comparatively short space between the charges and gradually increase this until the distance is found at which propagation will not take place. Then place the charges somewhat closer together than this maximum distance to insure good results. The average distance for good results is between 15 and 20 inches.

For the same sized ditch, the size of each charge will be somewhat smaller than it would be when using the electric method. This is because they are usually much closer together in the propagated method.

### Electric and Propagated Methods Compared

As stated previously, the conditions under which the propagated method may be used are definitely limited. If conditions are such that either method may be used, then the selection of a method will depend largely on the difference in the price of the two dynamites used. The straight nitroglycerine dynamite is always more expensive than the

ordinary dynamite, which may be used with electric caps. On the other hand, the cost of electric caps, which will perhaps range from 30 to 40 cents per rod, is saved when using the propagated method.

The electric method is always more reliable because the operator is always reasonably sure of all of the charges exploding. The element of risk and uncertainty is much greater when using the propagated method.