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CLEARING LAND OF STUMPS



Published by
The Institute of Makers of Explosives
103 Park Avenue, New York City

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INTRODUCTORY

THIS bulletin is published by The Institute of Makers of Explosives. The aim is to give the united conclusions and the sum of the experiences to date of nearly all makers of explosives and of farmers who have dealt successfully with the problem of stumps in fields, roads or any land to be cleaned up.

The material has been assembled so any phase of it will be available easily and quickly. Conflicts of opinion have been eliminated in favor of known facts and formulæ. The bulletin is offered as a manual or handbook for farmers, home and road builders, contractors, park makers and others who remove stumps from land, and as a textbook for students of agriculture.

Readers will find that the recommendations are impartial, and that the suggestions on that part of the work which can be done best with explosives are particularly complete.

To Clear or not to Clear

A "stump" may be defined as any kind of a growth that obstructs land, whether it is the butt of a cut tree, a tall snag, a living tree or a bunch of sprouts or brush. From the viewpoint of a farmer it is a stump if it obstructs the plowing and other tillage of the land.



The sort of wreckage practically perfect stump blasting should give. The pieces are shattered so they are easy to handle and so they burn well.

Before deciding to clear land, the owner should consider several features of the matter well. The reckless slaughtering of the timber has left in stumps many thousands of acres of land which is not fit for cultivation and that should go back into timber.

When Not to Clear Such land, of course, should not be cleared. On the other hand it is folly to permit brush land which has good soil to lie idle when a hundred years will not develop profitable timber on it.

Much land that is in woods now should be left so, for timber and for fuel. Every farm should have its timber tract, where the forest is conserved in a way to make it permanent. To cut young growth that will make good timber in a reasonable time is a mistake, no matter how good the soil is. Remember, too, the wind-break value of a piece of woods adjoining farm land, and consider the effect on land you now farm of taking away the protection afforded.

Do not clear land where the soil is too stony to be cultivated to advantage, or land that is exceptionally steep or incurably swampy. Do not clear when the profits would not justify the clearing. And do not clear when you can buy equally good improved land for less than the cost of clearing.

There is a certain sentimental satisfaction in clearing and cleaning up one's own place, connecting fields and improving it generally, even though such improving will not add greatly to the actual money income from the crops. This will have a bearing in some instances.

But hard-headed judgment should not be swayed too much by sentiment, for there are a good many thousands of acres that have been cleared and now are parts of farms, which it would be wise and profitable to plant to

forest again. Lay out your clearing carefully. Include no corners, gullies or steep places you will afterwards neglect. And make sure your field is rightly placed in relation to the rest of the farm.



A fertile looking field which could not possibly pay a net profit of more than half what it should so long as the stumps remain as they are. Two or three years' gain in crops, or less, would pay for the blasting out of the stumps.

About new clearing there may be some question, but about taking out stumps in good cultivated land there can be none. There are stumps in fields and along fences, roads, hedges and on home grounds. There are pastures that are pastures and not wheat fields or orchards because cultivation among the stumps is too inconvenient. There are old fruit trees and old shade trees that are diseased and a menace. All these should come out, and the quicker they come out the better.



Worth little even as pasture land, never rising in value, but potentially worth \$100 an acre as soon as it is cleared. This is the sort of valley floor that makes splendid fields of oats, corn, alfalfa and other hay.

The Profit and Loss Account of Stumps

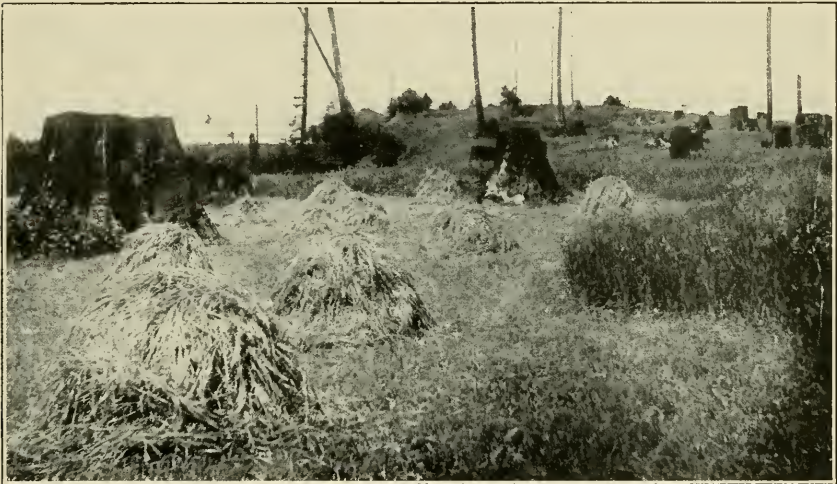
The man who is taking up the farming of cut-over land knows that he cannot do much until the stumps are removed. But lest he be tempted to permit some of them to remain in the cultivated fields, as many men on older farms are doing, it is well to point out some of the losses which stumps cause and some of the gain which their removal brings.

No farm is well ordered when its fields are foul, and no farmer commands the respect of his neighbors when stumps are crowding out his crops. The loss in self-respect probably is even more serious.

In farming stumpy fields a man does not have that sense of having done his best, which is half the battle for success.

Tool breakage is another source of loss caused by stumps. Plows and furrows are broken, mowing machines and binders are both broken and racked and in some cases the use of machinery is prevented. Heavy engine tools cannot be used at all where there are roots in the ground.

Greater speed and ease of cultivation is a prime reason for taking out stumps. The use of gang plows, wide harrows and other modern labor- and



When the stumps are as thick as the hay piles or the shocks of wheat or oats or corn there is something the matter with the farm system. They are boarders who never pay any hills.

time-saving equipment and methods is practical and economical only on land that is clean, both above and below the surface. And such use is becoming of more and more importance, as farm wages go higher and labor becomes scarcer.

The injury to horses often is much greater from a money standpoint. Spavins and sprains result from jerks against roots. Mares are caused to slink foals, young horses are made balky. The danger of injury to men is by no means absent. The kick of plow handles rupture many men, and every year sees its quota of broken arms and legs among farmers who try to plow, cultivate or mow among stumps.

Weed spread is a thing that must be charged up to stumps. They grow about the stumps, mature seed and pollute the whole farm.

Just as the presence of stumps tends to lower the value of land and to keep it down, clearing off the stumps will raise it and keep it on the increase. Once start to clearing away the stumps on your place and the neighbors and people who pass on the roads will take it for granted that the place is a paying proposition, worth developing. If you want to sell it, there is no surer way of adding a few hundred or a few thousand dollars to the selling price. To hold stump land for increase in value is a mistake. *Clear it up and force the increase.*

The actual gain in crops to be secured by the removal of stumps can be measured by the proportion of the total ground that they occupy. For instance, in many cases a stump takes up a square rod of ground. In measuring the value of the removal of stumps, the gain in crops and in speed and ease of working the ground should be compared, not with the total value of the crop, but with the net profit before stumps are removed. Thus, if a



This is the typical appearance of much land that is very fertile and which would pay handsomely if in alfalfa or fruit. (Near Linville Falls, N. C.)

25-bushel crop of wheat costs 20 bushels to grow, the addition of 5 bushels to the yield will increase the net profit 100 per cent. Two dozen stumps to the acre may occupy such a large part of the acre that their removal will double the net profit.

The clearing up of land can be made to mean something more than the financial profit it brings, for when properly handled it well can be made one of the links that hold the boys to the farm. Once a boy has helped to develop a property in a way that he enjoys he will remember that place as home as long as he lives. And boys will be enthusiastic over the clearing operations, with the necessary planning for new fields, the blasting and stump pulling, and the burning afterwards, if the work is managed along some of the newer lines which take out the drudgery.

The Essentials of Good Stump Removing

Before settling on a plan for removing stumps, it is well to have clearly before you just what is required.

The stumps must come out entirely, or at least deep enough so that roots never will catch plows or other implements. Stumps with roots must be disposed of as profitably as possible, used if possible, or burned cheaply. They often can be sold or used at home for firewood of some kind, or sold for extract



When all the trees of a woods-lot are cut down, the ground seldom is protected from animals and so treated as to grow a new piece of forest. But it should either be put in forest or cleaned up and farmed. The green stumps should be left stand a season, then should be blasted out with about four charges each. They are almost impossible to pull economically.

purposes. Failing this, they must be burned on the ground with as little damage to the soil as possible. In any case they must be broken into pieces small enough to handle by hand, unless derricks and power are to be used to handle them.

The total money expense of the clearing project must be within the capital available for the purpose, and the labor and time required must not exceed the supply. The condition in which the ground is left also is important. The holes should be shallow, and the less littering and tearing up of the surface there is, the better. The work usually should be finished in time for planting a crop in the spring, for the loss of a year's time costs money.

These are the things which should be included in the plans for clearing.

Nature of Stumps and Conditions Affecting Their Removal

There are about 500 different varieties of trees which make stumps in America, and it is not advisable to classify them all in this bulletin. What is of value is to review the nature of their roots.

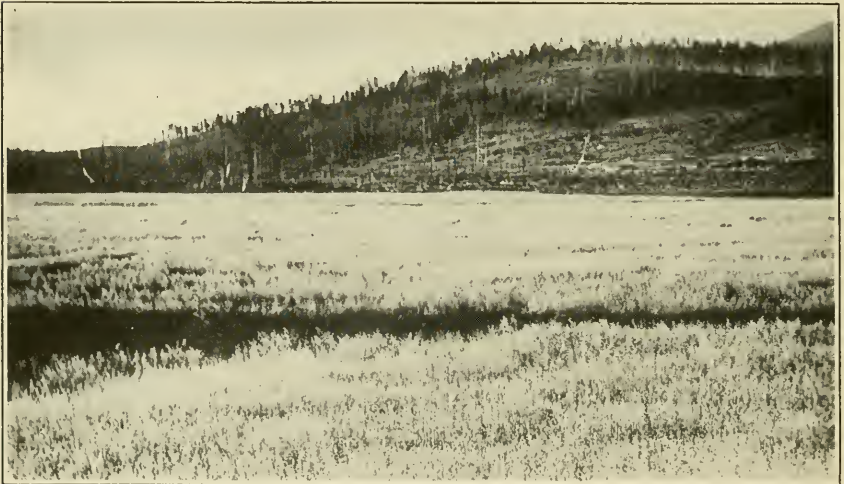
There are three general types of roots—lateral roots, semi-tap roots and tap roots. (See cuts, pages 24 to 26.) Some varieties of trees always grow in one way; other varieties grow in either of two ways, depending on soil conditions. The stumps of some trees rot fast, while others are very durable. Some roots die when the trees are cut; others throw up sprouts. The wood of some roots is tough and can be twisted a great deal without breaking; of other varieties it is brittle and will break off when bent or jerked.

Typical tap-root stumps are long-leaf southern pine, hickory and black gum. Some of these trees grow a root that is almost as big as the trunk, extending straight down into the ground. Others have slender roots. Sometimes these tap-roots send out lateral roots of some size, but in other cases the laterals are limited to hundreds of short, hair-like rootlets growing from the main tap-root. The tap-root itself sometimes splits at a point several feet underground into several smaller roots, all of them continuing to grow nearly straight down.

Root Growth

Typical lateral root stumps are elms, soft maples, locust, dogwood, elder, hemlock and some cypress. The roots of these trees grow in all directions from the trunk near the surface of the ground. Working the ground close about such stumps is next to impossible.

The largest class of stumps is the semi-tap-root class. Belonging to this class are white pine, poplar, chestnut, ash, walnut, red, black, pin and other oaks, persimmon and sassafras. Stumps of this class are harder to remove



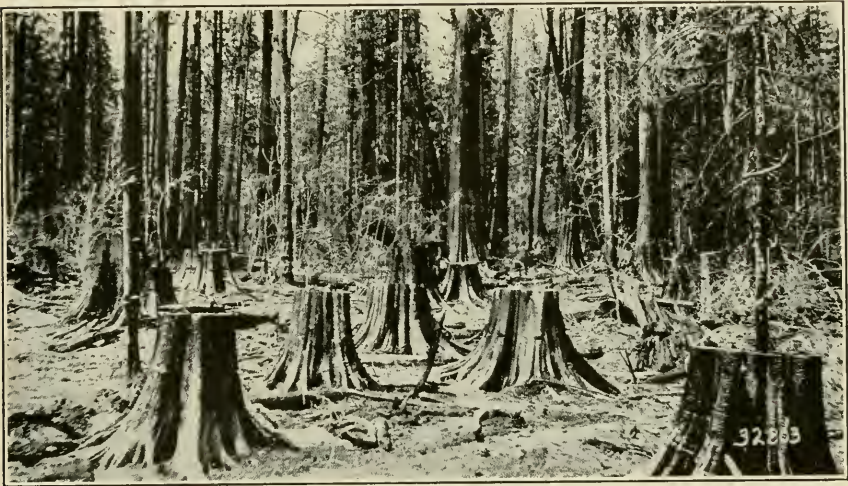
Wonderfully productive meadows, for timothy, alfalfa or other grass, can be made by cleaning up and draining stump flats. This land was a tangle of old logs and stumps a few months before the picture was taken. (Michigan Land & Lumber Company.)

than either of the other two types, because the roots generally are big and strong and grow in all directions, some along the surface, others almost straight down and still others between.

What may be classed as a fourth division is composed of the root clusters of sprouts and bushes of almost any sort of trees, whose growth has not yet taken the characteristic form. Brush of willow, elder, maple, chestnut, hickory, oak and witchhazel may be named. The roots are very firmly anchored in the ground for a distance of three or four feet in all directions.

The nature of the soil and the height of the water-table in it have much to do with determining the root growth. A hemlock tree, for instance, will send its roots down till they almost take on the nature of the semi-tap-root class in soil that is loose, free from stones and *dry*. The same tree would have few roots deeper in the ground than 6 inches where the soil is hard and the water-table near the surface. The root growth of other varieties of trees

is affected by water and soil in the same way. A tree that grows on a steep hillside probably will have heavier roots on the sides than on the downhill and uphill grades.



A glimpse of primeval forest and of primeval stumps, the like of which few farmers meet in the eastern part of the country any more. Such land is expensive to clear but it is exceptionally fertile in most cases.

Some stumps are durable and others will rot very fast. White pine, Norway pine, locust and cedar stumps will last fifty years without decaying enough to make much difference in the work of their removal. Chestnut, white oak and catalpa are nearly as durable. **Rotting** The other oaks, poplar, ash, hemlock, hickory and gum rot so fast that in a few years a team of horses can roll out stumps of considerable size.

It should be understood that during the first season, after any variety of tree is cut and the stump and roots die, the bark and soft outer layer of wood rots away, making the roots loose in their earth channels. It is the inner or mature wood which lasts.

Another characteristic of stumps which is of importance in clearing plans is their sprouting. None of the pine stumps will sprout when a tree is cut, but nearly all the hardwood stumps will do so. **Sprouting** Chestnut is a great sprouter. A stump that does not sprout is not getting any worse as time passes, but one that does sprout is likely to be harder to take out each succeeding season.

All kinds of stumps pull easier when the ground is wet than when dry. Explosives are more efficient in wet ground than in dry. Pulling machinery ordinarily is handicapped in very wet ground, because **Water** of the lack of firm footing.

The nature of the soil, whether light or heavy, has a considerable effect on the way stumps come out of the ground. Naturally a loose, fluffy sand will hold the roots less than heavy clay. Pulling them out



This clump of trees was blasted out (not cut down.) The stumps are torn out better than they might have been without the weight of the tops to pull them over.

of sand, therefore, is much easier than out of heavy soil. On the other hand, light soil will not confine the gases of explosives nearly as well as clay. In sand the greater ease of tearing the roots loose is more than offset by the lowered efficiency of the blast.

Kinds of Soil The foregoing principles should be of more actual service to land clearers than a description of the conditions in different sections. If your stumps are Southern long-leaf pine, you know they will not sprout, and are of the tap-root class. If they are white pine of Michigan or Maine, you know they are of the semi-tap-root class, that they will not sprout and that they



This picture shows what they look like when down. The roots are torn out better than they would have been without the tops to pull them over. Note how easily they can be sawed or chopped.



When stumps are lifted by frost as much as some of these, they often can be pulled economically. They should be split up afterwards with light charges of explosive placed in auger holes or between roots, under a mudcap.

probably will outlast you if you do not move them. In case of a locust stump in Oklahoma, you know that you have a lateral root stump to deal with, that will sprout and that will last as long as the white pine. These illustrations serve to point out how every reader can classify his own stumps as to facts about them that are important from the clearing standpoint.

Methods of Clearing Land of Stumps

A half-dozen methods of removing stumps are more or less well developed throughout the country. Everyone who clears land, whether it is only the removal of stumps from cultivated fields or the clearing up of logged-off areas, should study the different systems in order to decide which of them is best under any particular conditions. No one method is best all the time, and in nearly every case a combination of various means will be found most effective.

Lists of Methods

Digging out the stumps by hand.

Pulling the stumps. The pulling may be done with horses or machines. The pull may be direct, or may be doubled or tripled in force by means of blocks and cable or rope. If with machines, it may be with a traction engine hauling direct, a donkey engine hauling by means of a drum and cable, a capstan puller run by horse power or man power, or a tripod puller which lifts the stumps straight up. (See pages 15 to 21.)

Burning the stumps. The old-fashioned practice was to start a fire alongside a stump and keep it going till the stump was consumed. Charpit burning consists of keeping an intensely hot but small fire about the base of a stump under a covering of earth. Another method is to bore auger holes through the

stump or part way through, to form draft holes and flues. A favorite method in some sections is to burn out the roots with a gasoline torch to a depth below the plow line.

Finally, there is the use of explosives to blast out the stumps.

Combinations of methods very often are valuable, and are recommended at proper points.

Stump Disposal

The land clearer must remember the necessity of disposing of stumps after they are out of the ground. It is expensive and difficult to haul or burn whole stumps. Several hundreds of pounds of earth nearly always stick to the roots of big stumps taken out unbroken. For this reason wherever it is possible to do so the stumps should be broken into pieces small enough to be handled easily before the job is considered done. There is no comparing the cost of burning stumps, when they have to be piled by means of a derrick, with the cost when they can be handled by hand.

Choice of a Method

Whether to remove stumps when they are green or to let them decay a year or more is a problem to be decided by your plans and the uses to which you will put the land. Newly cut-over land is clean. It has few weeds and no sprouts. In one season it will not develop much of this growth, but in two or more seasons it will, and will be very much harder to clear than it would have been the first year.

The stumps are hard to take out while they are green. It costs much more to do the work then than a year or more later, after the bark and sap-wood has rotted from the roots.

But it costs money to miss crops, too, and if you are ready to put the ground to work at once, it is folly to wait for the stumps to rot. To wait from summer till the following spring is not a bad idea, for that loses little or no time, and starts the rotting process which makes removal easier and cheaper.

Speaking in general of pulling and blasting, pulling the stumps probably is better and cheaper when the stumps are very small, and blasting when they are large. Where a large number of big stumps are to be removed a combination of the two methods is advisable.

When stumps are small or numerous they can be pulled by a team of horses hitched direct, by a capstan puller, traction engine or donkey engine, with ease and speed. The pulled stumps can be handled by hand directly, and disposed of without trouble. The same is true to a lesser degree when larger stumps grow small and shallow roots, which require but little power to lift and move.

For stumps larger than 3 to 5 inches, explosives can be used alone effectively and economically, though there are important considerations which modify such a rule. One of them is that of soil. Explosives work more effectively in heavy, tight soil, such as moist clay, than in dry sand. Therefore, in dry, light soil it often is cheaper to pull all the stumps not too large to handle without breaking up, while in heavy soil it usually is cheaper to pull only very small stumps that will come out easily, and to use explosives, alone or in combination, for everything larger.

Old, well-decayed stumps too big to handle should be removed with explosives alone. Small green stumps may be blasted out clean, roots and all, but large green stumps nearly always require a combination of methods, as,



This picture shows how the roots of large green stumps can be broken up for handling by proper blasting of the stumps. There is little reason in clearing a piece of land twice of the same stumps—once to free them from their beds and again to dispose of them—by pulling—when the job can be completed with half the trouble and expense by blasting and hand piling.

for instance, blasting and team pulling, or pulling with a capstan puller. The cost of explosives often can be cut down by making use of such a combination of methods. A heavy team, or other means of pulling, will take out roots after the ground has been loosened with explosives.

Tap-root stumps larger than your arm should be blasted. Tap-root stumps cannot be pulled to advantage, though when very small they can be broken off by a side pull. Where land is swampy on the surface, and roots consequently lie shallow, a heavy team often can rip out stumps by direct pull, even up to fifteen inches in diameter.

Large stumps that are pulled may be broken up afterward with small charges of explosives placed in auger holes, but in general it may be stated that large stumps should be blasted first.

The folly of pulling out stumps that are big, and then spending as much money in getting rid of them as it costs to pull them, will be plain to any one. They can be disposed of at a fraction of the cost when they are well broken up.

A more detailed consideration of the pulling of stumps probably is desirable. Pullers are most successful in the loose jack pine land of the North and the similar pine land in the South, and in clearing hardwood cut-over land where nearly all the stumps are small. They are particularly serviceable where the stumps stand close together, measure 3 to 6 inches and have root systems which do not bring up much dirt. Under such conditions a stump puller is a good investment, especially where there is plenty of man and horse labor available at low cost.

But it does not pay to buy a machine for a small acreage of clearing—only where a considerable quantity of clearing is to be done. In vicinities where the soil is light and there are many stumps on newly cut-over land,

several farmers should co-operate in the purchase of a stump puller and should help one another to use it.

A stump puller works to least advantage under clay soil conditions. An-



Two large hardwood trees which stood close together and were blasted out at one shot, without cutting down. About eight charges were used. The cavity in the ground is small and the soil is free from tight roots.

other factor is the water in the ground. The ground must be fairly dry when the machine is used, even though the stumps require harder pulls then than when the ground is water-soaked. In mud, horses soon become mired deeply. Pulling of stumps must be done in the summer or fall. Of course, they cannot be pulled when the ground is frozen.

A capstan puller can be used on a moderately steep hill, though the cost of pulling the stumps from such ground will be greater than from level land. Whenever it is desired to use a stump puller, have explosive materials on hand to blow out or to split and loosen any stump larger than about 5 inches.

Donkey Engine A donkey engine outfit especially designed for stump pulling can be used effectively and with success. It makes an expensive outfit, however, and unless there are several hundred acres of clearing to do, consideration of it may be dropped. In the case of very large acreage, it is the logical form of capstan puller to use.

Traction Engine A traction engine, pulling stumps direct, is a very effective means of getting stumps out. In fact, when such an engine is available it is doubtful if the purchase of any other machine ought to be considered. Both traction and donkey engine pulling is subject to the same limitations as pulling by any other means, and should be confined to such work as they can do to advantage in comparison with explosives or other methods.

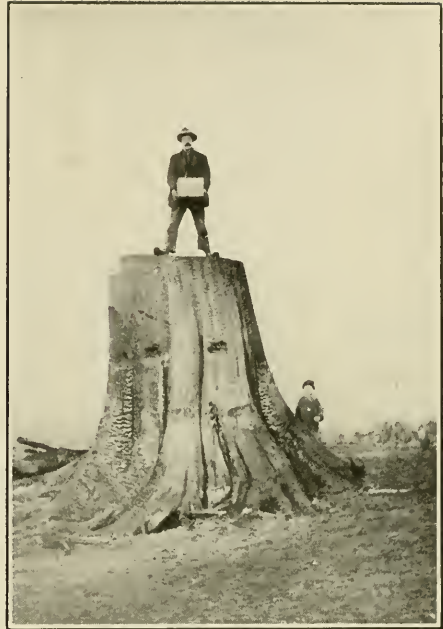
The detailed consideration of the blasting of stumps may be short and to the point. The use of explosives reduces the labor of land clearing greatly. One or two men with explosives can do the work of a large crew with pullers or fire.

When to Blast The stumps can be blasted out clean. Thousands and thousands of acres of stump land are cleared completely every year with explosives alone. While the use of some means of pulling in connection with explosives undoubtedly cuts down the cost on a large tract of clearing, the added ease and speed of the work of explosives alone is considered by many people to offset this economy. For small tracts or a few stumps it is foolish to provide pulling facilities. Do the work with explosives.

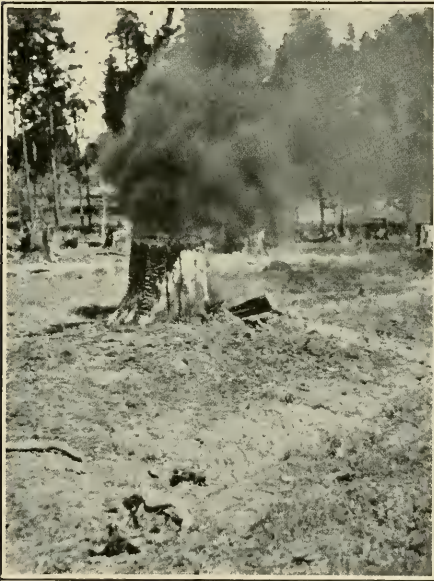
The blasting splits the stumps into pieces easy to handle, and to sell or burn. When it is not desired to blast stumps out clean, the charges can be kept down and the stumps split and the dirt loosened and thrown away from the roots. The blasting does the work in a short time.

The investment of money is kept down when explosives alone are used. There is no machinery or equipment left on your hands after the clearing is done. Yet the best use of stump pullers and of explosives is mainly distinct and different, and they should be considered, not in competition, but in combination. A good team and a supply of explosive material is a winning combination nearly every time, and explosives are bound to play an important part in nearly every land-clearing operation.

Digging out stumps is practicable under certain exceptional circumstances. If you cannot get explosives and if you have men who are doing nothing, they may be put to digging out stumps; but if wages have to be paid, such clearing is bound to cost four or five times as much as when the work is done by better methods.



Big stumps such as this can be blasted out electrically much easier and better than with charges fired with fuse.



This pine stump is burning freely, and likely will be consumed if it receives some attention. The roots were bared of dirt and the stump was split by a light charge of explosive. When stumps can be left to dry for a couple of months after such splitting, they will burn very well, though pine stumps can be burned immediately afterward with a little coaxing.

Burning by charpitting is a practicable and cheap method of getting rid of soft wood stumps of large size and in heavy or clay soil when the weather is dry for two months or more at a time. It is not successful in lighter soils. It is costly when labor must be hired for the purpose, and wastes time. This method of removing stumps is chiefly valuable for settlers of logged-off or cut-over land who must fight their way through with little or no money.

Burning by means of auger holes, and the use of oil, are freak methods not suitable for general use. They should not be attempted when the clearing operation is seriously intended to be economical. Burning with a torch of some kind is effective, but expensive.

Detailed Directions for Clearing Land of Stumps

Digging Out Stumps

If you dig right down after the roots, trenching to bare them, cutting them off with an axe first at the sides and then underneath, the stumps can be rolled out as though they were pulled. The cost is high.



Typical tap-root stumps, with the dirt washed away. To blast them out the charge must be located against the big root, four or five feet below the surface of the ground. Two charges to each root are better than one, though either loading will cut the root off successfully.

If possible to know beforehand that you must dig stumps out, do it before the trees are cut. Dig a trench about them, taking away the support, and cut the lateral roots, and then let the wind and water finish the job. The water in the trench will soften the subsoil. The best time of year to do it is in the spring, when the wind is strong and the ground is loose.

Trench about Trees

Burning Out Stumps

Charpitting is perhaps the best method of burning stumps. The fire is kept burning at the base of the stump till it burns entirely through, and till the top is consumed as it settles down and the roots are eaten out to a proper depth below the surface of the ground. The fire is confined by a covering of earth.

Charpitting

Charpitting is effective only when heavy grounds can be secured to cover the fire. Sand, loam or other light soil cannot be used for the purpose successfully.

The stumps should be reasonably dry, and the weather should be dry during the burning process, which takes two to six weeks. Light showers are not objectionable, but heavy, settled rains cause failure. Pine stumps burn best, because of the pitchy nature of the sap remaining. Any other soft wood can be burned this way. The successful burning out of hardwoods requires favorable conditions in all respects, and is rather doubtful in the hands of inexperienced operators.

Conditions

The procedure is as follows: Remove the bark from the base at least. On some stumps it is necessary to dig away a little dirt. The fire should be started low enough so that it will burn in under the stump at the spaces between the roots.

Gather some fuel wood—any kind that will make good coals, though mixed oak and a little pine likely will be best. **Directions** Cut this wood like stove wood—say about a foot long, and split fairly fine. Lay and stand the sticks round the stump till you have a layer at least 6 or 8 inches thick. You can pile wood and start the fire entirely round the stump, or only about a quarter of the way round as you prefer. Putting wood all round takes more wood and more time to prepare, but burns the stump out quicker and has more chance of success.

After the wood is in place it must be covered with a little straw, fern or other material of the kind, and then with a thin layer of dirt. The dirt layer should not be more than 3 or 4 inches thick. It must be of clay or very heavy soil. The dirt should be piled against the stump up to about 18 inches high, but no higher.

Start the fire at each quarter of the space round the stump. That is, if the wood runs only a quarter way round, start one fire; if all the way round, start 4 fires. Leave the holes where the fire is started open only for a little while, and then cover them up.

The fire must be kept covered all the time and never be allowed to burn into an open blaze. It is really smouldering and coaling of the wood. When the fire blazes much of the fuel supplied is burned up and the heat is lost instead of forced to eat its way into the stump. The object is to confine the heat. When this is properly done the fire becomes intensely hot round the stump.

As the stump burns through and the fire goes deeper, the dirt cover may break through. Such places must be covered with more dirt. If the fire burns higher up the stump than where the dirt is piled in the first place, put it out up there instead of trying to pile the dirt higher.

As soon as the stump is burned through, the top will settle down and continue to burn. Keep the fire covered over the ends of roots that burn off, so it will eat its way deep into the ground. If it breaks out to the air it will not burn far. While the stumps are burning they must be watched and visited several times a day.

The cost of charpitting in the manner described is high when the actual time of the operator must be accounted for at regular rates of wages.

Another good method of burning that really is charpitting of a modified form, is to saw the stumps off close to the ground, block up the top part, and to start a fire between the two sawed faces. The faces should be as close together as possible while allowing the fire to be started and to burn. **Idaho Charpitting** Bank up the outside with dirt, as directed in preceding paragraphs, and keep the fire covered till the stump, roots and all, is consumed. Use stones to hold the two parts of the stump apart. It is best to do the sawing in the winter and raise the top part then, leaving it to dry out several months. The burning is done best in the summer.

Burning with a torch is simply a matter of digging away the ground from the roots, and applying the intensely hot flame at a point below the plow line. Torch burning is expensive business when time and fuel costs are counted up. The best kind of a torch to use is one with a fan or bellows. The kind of fuel used by the torch is not important, except that some fuels burn better than others. Gasoline perhaps is best.

Torch Burning A modification of charpitting sometimes is advisable in the case of pasturing the land for several years. The stumps are split and their roots uncovered with small charges of explosives. When they are thoroly dry, wood is piled between and over the split tops of the stumps and the whole thing is set on fire. With a little attention to keeping the burning ends of the roots covered with ashes and dirt toward the last, stumps may be consumed entirely by this method. It is not nearly so much trouble as charpitting, because the fire burns fiercely in the dry, shattered tops, and needs no attention other than the first piling of the fuel till it is time to look after the burning out of roots.

Pulling Out Stumps

Four forms of pulling are worth considering. These are by horses direct, with hand pullers and capstan pullers, and with donkey engines and traction engines.

Four Forms of Pulling A good heavy team of steady horses will take out most of the stumps which should be pulled whole, and almost any roots left by proper use of explosives where blasting and pulling are used in combination. You will need a couple of good log chains and a regular outfit of singletrees and spreaders. To increase the strength of the direct pull, you can use a frame made of 6 by 6 pine pieces in the shape of the letter A. Make it 6 feet high. Attach a short piece of chain round the tip of the A, to run down to the roots over the top of the stump, or else run the main chain from the horses over the top of this frame before attaching to the stump. Such a haul will upset a stump much easier than a direct hitch.

If you have to pull without the frame, aim to pass the chain over the top of the stump and hitch to a root on the other side, the farther out the better. Another good hitch and haul is the twist. Hitch to a root and drive so that the chain tends to wrap round the stump.

When saplings are to be removed do not cut them first, but hitch the chain to them as far up as you can reach. While the team is hauling on them, a man should cut the roots on the opposite side with an axe.

A few days of stump pulling is enough at one time. Rest the horses and men at some other work. The clearing of land by this method is heavy and tiresome, and can easily become disheartening if kept up too long.

A capstan puller consists of a frame, a drum on bearings, a pole to hitch horses to, and a wire cable fastened to the drum. Some of them have gearing which reduces the speed of the drum and increases its pulling power. These work very slowly.

The pullers have to be anchored to solid stumps near the place where they are set up. The limiting factor in the use of pullers is this anchor or anchors. When you pull, you do not always know whether the stump out at the end of the cable or the one behind the machine will come. To set the machine takes time, and you should be careful to make the anchorage as secure as possible.

If your puller comes without a pole, you can get one in the woods near home. Cut a 6-inch tree—ash, white oak, hickory or the like—and use a 20-foot length. Better attach an old wagon tongue to this where the horses are to be hitched, to keep the pole from hitting the horses when stumps give way suddenly. Some operators also attach a second pole in front of the horses, to lead them in the circle, saving continued driving.

It is better to wind up the cable on an empty drum; the cable wears much less in this way. For that reason use only enough cable to cover the drum—not two layers on it. The length of the cable will govern the area you can clear with one set of the machines. This usually will be about an acre.

Three men can clear an average acre of cut-over land of small stumps in one day. Three men will handle a small outfit. Handling the cable is heavy work, and you want no boys on the job. The hooks for catching the roots that come with the machines usually are poorly designed. You can have a better one made by welding together two old steel plowshares in a manner that your blacksmith will understand if you show him the original hook. For best results a hook should weigh about 50 pounds, though to be so light it must contain only good steel.

Pullers are not suited for taking out occasional stumps in cultivated fields, but only to clearing cut-over land where stumps stand close together. The machine should be brought on the job only after the necessary blasting has been done. Then the small stumps and whatever roots are left by the blasting can be taken out at the same time. A supply of explosives should be kept on hand for blasting out the anchor stumps after the machine has done all the work it can.

A tripod puller is effective, but cumbersome to handle and expensive to operate. It is not recommended.

A donkey engine for stump pulling should have about the same power as for logging operations, and should be constructed about the same. There should be two drums, one for the pulling cable and the other for the return line, the return drum geared faster than on a logging donkey.

About 350 feet of pulling cable can be used. Inch or inch and a quarter cable usually will be best. The return line would be half or five-eighths inch. With 350 feet of main cable, 10 acres can be cleared at one setting. It speeds up operations to use a cluster cable with three or four hooks. Several small stumps can be pulled at once with this.

A donkey engine outfit requires five or six men to operate it. With it stumps of any size can be pulled. When they are too big to handle directly

it is best to break them up with explosives before attempting to burn or otherwise dispose of them. Very large stumps should be loosened and split before they are pulled.

Little needs to be said about using a traction engine. You will need heavy chains and heavy hooks. The chain should be nothing less than five-eighths inch. A short piece of inch or larger wire cable is better. Fifty feet or so is enough. The hook should be of steel, with one point, and should weigh 50 to 100 pounds. The entire hitching apparatus should be strong enough to stand jerking on with the weight and power of the engine.

Traction Engine Pulling

The cost of operating pulling machines and of clearing land with them varies so much that no figures are safe to depend on. It depends on the kind of soil, the kind of stumps and especially on the skill with which the machines are operated. When everything is at the very best, land can be cleared economically with donkey engines and traction engines in combination with explosives. When conditions are not favorable the cost of these methods is very high.

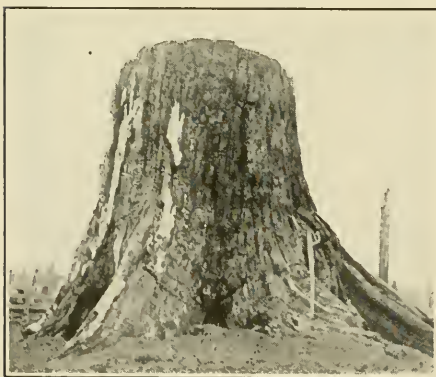
For any kind of stump pulling you will need shovels, hoes, axes and bars. The probing rod also is useful for locating roots.

The directions for removing stumps with explosives are given in full detail, and in order to do the matter justice they are placed in a separate chapter.

Blasting Out Stumps

Blasting Out Stumps

A proper charge of explosives placed under a stump will tear the roots loose, lift the whole stump out, and break it into pieces. The whole operation is simple, safe, short and easy. Any sort of stump, of any size, in any soil, any weather, can be blasted out successfully, and the blasting is a practical and efficient method whether there is one stump to be removed from the middle of a cultivated field or a lawn, or thousands of acres of the heaviest logged-off land clearing to be done.



It is folly to attempt to blast out many big stumps, such as this one, without an electric blasting machine. Such a stump should have six to eight charges properly located about it. These numerous charges will contain less total explosive than one charge large enough to remove the stump. The hole they make is much smaller.

The best time of the year to blast out stumps is a matter of compromise between conflicting requirements. On the one hand explosives work most effectively in moist clay and wet sand soils. On the other hand, it is bad from a tillage standpoint to blast heavy ground when wet. (See page 38 for further discussion.)

With all the facts before you, the selection of time is a matter for your own judgment. If cost did not need to be considered, summer or fall would

Time of Year

be ideal. Blasting out stumps from frozen ground can be done with satisfaction. In fact, the stumps are broken up better then than at any other time, though the work is harder on account of the difficulty of making holes.

Success, and especially economy, in stump blasting, is a matter of common sense and judgment plus some knowledge of the stumps and of explosives. Close attention to apparently small matters insures good work. The things that the blaster must consider are the location for the charges, the proper size of holes, the amount of explosives required, the length of fuse, depth of hole, tamping and the like.

Loading Charges of Explosive

To blast out a stump the explosives must be placed in a hole underneath it. Make the hole first. Then prepare the charge of explosives as directed on pages 34 to 38. Pack the explosives in the hole, tamp and fire.



In blasting out big green stumps, the holes for the three to eight charges should be made as nearly as possible under the main anchor roots. The man on the right is smoothing out a hole, getting it ready for the charge; the one on the left is shoving a stick home with the tamping rod.

Load stumps by no rule, but with regard to their root systems and to the nature of the soil. The aim is to tear the roots out of their anchorage in the ground, or to break them off below tillage depth. To do this you must place the charge or charges of explosives as close to their burden as possible—hitch them as short as possible to the load. The load or burden is not the weight of the stump so much as its grip on the ground. You must get good confinement of the gases. If there is a weak wall on one side of an explosion and a fairly solid or firm wall on the other, the weak wall will give way, and very little breakage or movement will be made in the other.

Depth for Charges

The charge of explosives should be located just deep enough to secure this confinement and to be under the load to be lifted, but not any deeper. If

charges are too deep there is great waste of energy in uselessly lifting earth. This is costly. Charges that are placed too shallow will blow off the tops of stumps or split them, leaving roots tight in the ground.



The charges are placed and the wires connected, the stock has been chased away and the helpers warned back—now the blaster is ready to shove the handle of his machine down and to fire the explosive.

This may be the center, but it is by no means always so. If the stumps have grown on a hillside, the roots may be heavier cut sideways than uphill or downhill. Very often a tree on the level has heavier roots on one side than on the other. Usually it is of advantage to blast a big stump with more than one charge, placing one charge under each of the large roots and one under the center of the stump. A charge under a root should be at a point where the weight of the stump will be balanced by the pull of the ground at the other end. This point usually will be a foot or two out from the edge of the body of the stump.

In the foregoing suggestions, no mention has been made of the three main types of root growth—tap-root, semi-tap root and lateral root; but with the principles of blasting in mind, it is easy to see that a properly placed charge under a lateral root stump will be very shallow. If such a stump is to be taken out with several charges instead of only one, all but one of the charges will have to be located well out from the stumps proper, under main roots.

Semi-tap root stumps require deeper placing of charges than lateral root stumps. When such stumps are taken out with more than one charge, the points for the explosive are closer in, under the main roots where they dip a couple of feet below the surface.

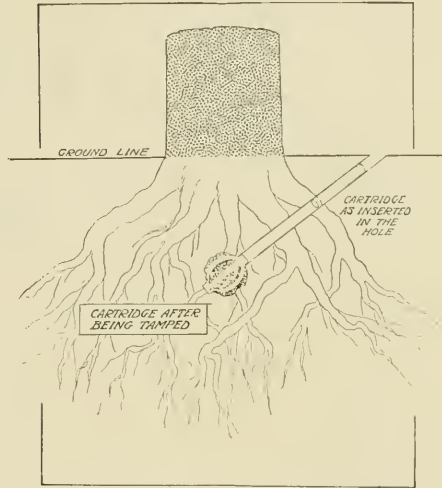
The underground nature of each stump should be determined before placing charge or even making holes. You can do this partly by observing the roots that rise above the surface, but mostly by probing down among the roots with

Since clay and other heavy soils hold the gases much better than sand, and wet ground holds them better than dry ground, a much thicker covering of dry sand is required over a charge to confine the gases properly than of wet clay. Charges, therefore, must be placed deeper in sand. Usually the charges should be placed right next to the wood of the roots in clay soil, and in sand with 6 to 30 inches of ground between the charge and the roots (tap roots excepted—see next page). Large stumps, and old stumps, require shallower placing of charges in proportion to diameter than small stumps and green stumps. Long-rooted stumps require deeper placing than short-rooted ones.

With the foregoing points in mind, it will be seen that the charges should be placed directly under that part of the stump that will give the greatest resistance.

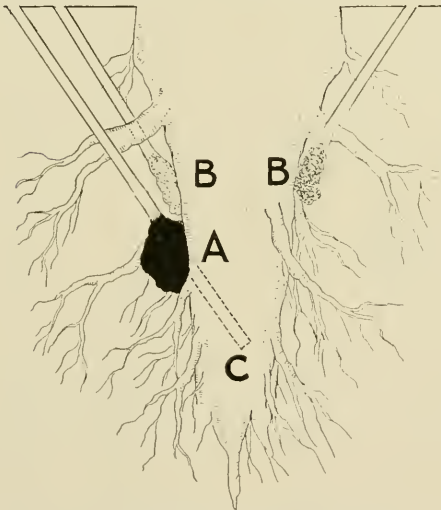
the quarter-inch steel needle known as a probing rod. Every blaster should have one of these rods and should make use of it at each stump.

There are two ways of blasting out true tap-root stumps. One is to bore a hole in the wood of the tap-root itself, and the other is to place the charges right alongside the root and against it, like mudcap charges are placed in stone blasting. In placing the charge in the wood, make a hole in the ground down to a point a couple of feet below the surface of the ground. Then bore a hole in the wood with a wood auger. This hole should go two-thirds or three-fourths of the way through the root. Fill the hole in the wood with explosives, fire, and the resulting blast will cut off the root.



How cartridges of powder swell and fill the hole when they are split and pressed with tamping stick.

In placing the charge of explosives against the wood, get it at least 4 feet deep. If you can command an electric blasting machine for firing, divide the charge in two and place the two parts on opposite sides. These charges may be placed only $3\frac{1}{2}$ feet deep, though you should not hesitate to place the charges at a greater depth when blasting large tap-root stumps, particularly if the ground is of a light nature.



How to place charges for blasting out tap-rooted stump. Three methods are shown. "A" shows how to do it with one charge, using cap and fuse and not boring into the wood. "B" shows how to place two charges when electric blasting machine is available. "C" shows by dotted lines position of auger hole in wood where one charge could be placed to cut off the root and throw out the stump. Any one of the three methods will do the work.

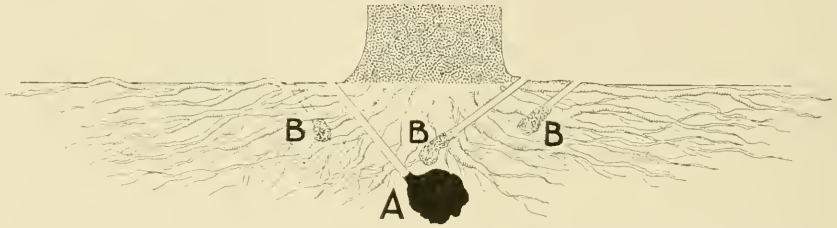
In all sorts of stump blasting the holes for the charges can be dug with narrow-bladed shovels, spades or crowbars, or bored with dirt augers. (See page 32.) In stony land augers cannot be used, or can be used only for parts of

Making Holes

the holes. All things considered, it is hard to beat the bar and sledge combination for making holes for charges of no more than two or three sticks, or for starting holes for larger charges.

The bored hole is better than the dug one because it can be tamped tighter. After much dirt once is taken out, it will not be tamped back in again as solid as it was before. Holes for inch-and-a-quarter sticks of explosives should

be made with inch-and-a-half augers or bars. In blasting exceptionally large stumps, use 2-inch or 3-inch augers. The holes usually can be started between roots and in depressions, but do not sacrifice good placing of charges for ease in making holes.

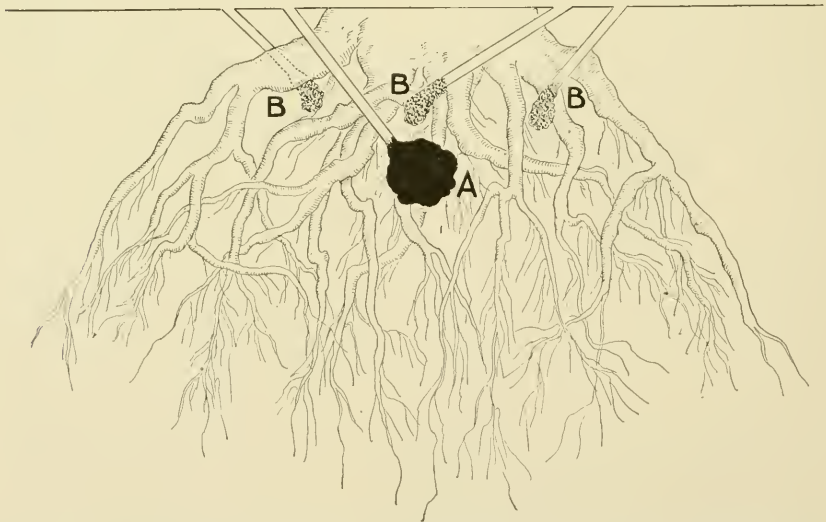


How to place charges under lateral rooted stump. "A" shows how to place charge when the cap and fuse are used and one charge is relied upon to remove the stump. "B" shows how to place three small charges under main roots when stump is to be removed with several charges fired by electric blasting machine. Use either method "A" or "B"—never both.

In water-saturated ground of a heavy nature, in case you have difficulty in getting the charge properly centered or placed (when no electric blasting machine is available for firing), you can make use of what is known as propagated detonation. Divide the big charge into several small ones in different holes bored from two, three or four sides of the stump, but all ending close together down under at the right point. If these charges are tamped solid and they are not more than a foot apart they all will explode at once when one of them is fired with a cap and fuse in the usual way.

In making holes for blasting out tap-root stumps, start the bar or auger straight down along the root from the surface. When you have reached the required depth, wriggle the bar sideways to make the hole wide at the bottom.

Wherever the number of stumps runs into many thousands, it will pay to get a machine to bore the holes. Such a machine will bore all the holes needed

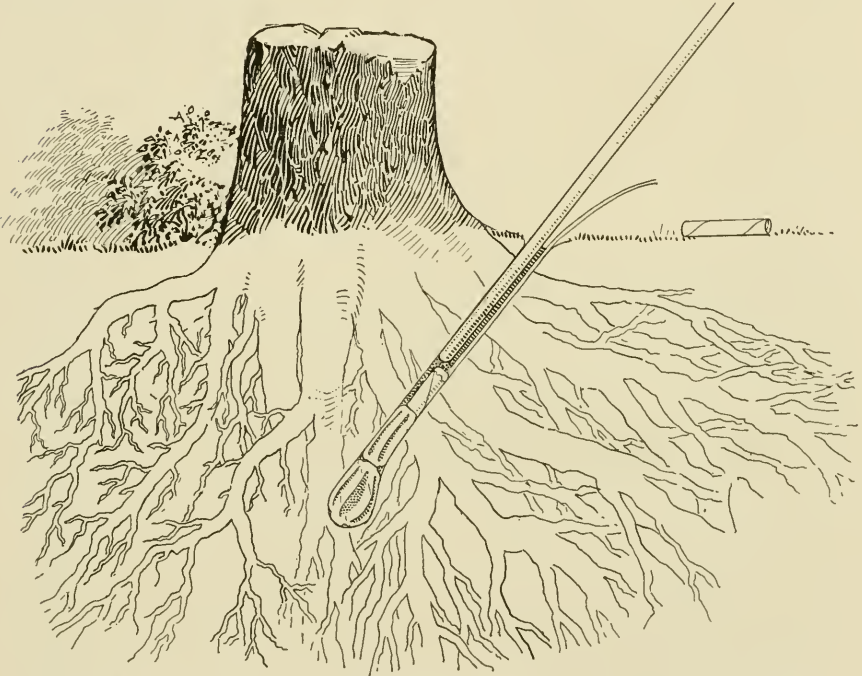


How to place the charges under semi-tap-rooted stumps. "A" shows proper position where one charge and cap and fuse are used. "B" shows proper positions of several small charges when electric blasting machine is used. Use either one or the other method illustrated—never both.

under the stumps at the rate of 500 or 600 a day, and at very much lower cost than the same work can be done by hand. The machine bores almost as fast in wood as in earth, and is particularly serviceable when roots have to be penetrated in order to get the charges to the right spots.

Power Boring

Machines can be bought complete in small sizes suited to land-clearing purposes, or can be bought in parts and assembled on home-made frames. Electric machines are most convenient. Steam and compressed air machines are next best. Flexible shaft machines and direct-g geared machines are least satisfactory. The flexible shafts break. The steam outfits freeze up and are troubled with burst pipes. All the outfits except steam ones can be run by gasoline engines.



To show sticks of explosives expanded, as permitted by splitting of stick wrappings, in big hole.

An electric boring outfit consists of a small gasoline engine—say about 5 horse power—on a wagon belted or geared to a 3 kilowatt dynamo, and that equipped with two drill heads and 200 feet of electric cable. A supply of 1½-inch augers completes the outfit. Such an outfit costs about \$500. You can use any gas engine. The dynamo will cost somewhat less than \$250, and the drills about \$80 each.

It takes five men to run this outfit—two men on each drill and one man to drive and to handle the cables. This man should lift the cables carefully over stumps and prevent them from kinking and getting caught. The steam and compressed air and the direct drive machines will not be described, because improvements continually are coming out. Watch the farm papers for advertisements, or write to any maker of explosives for names of manufacturers of these machines, if you are interested in them.

Study the methods of handling explosives as outlined on pages 34 to 40 and 58 to 61, to which every reader is referred at this point, before trying to load charges. A few special hints will be given here.

Charges of explosives usually should be as near as may be in a round bulk—not strung out for 2 or 3 feet in a long hole. To get them so the hole must be enlarged at the bottom by scraping or springing. Slit the paper wrappings of the sticks and press the sticks in the hole with the tamping stick till they swell to fit the hole tight and shorten to 2 to 4 inches in length. (See pages 24 to 26.) But do not do this if the hole is very wet.

When you have many stumps to blast out, it often is a good practice to make holes in the forenoon and then to load and shoot after dinner. Load and fire all the holes you have prepared when you go to the field, after which you can proceed to make more holes. *Always fire the charges soon after they are loaded.* To do this prevents missing charges, and avoids chance explosions due to meddling, and the like. If the holes are wet, firing immediately is required to avoid weakening of the explosive by water.

If you prepare your charges in the field, you can cut a supply of pieces of fuse before you go out. Make the pieces of varying lengths and crimp caps on them to prevent the powder shaking out of the ends. Take the roll along with you to provide for holes requiring longer fuse. Don't attempt to use pieces of fuse less than 15 inches long. They are dangerous.

Use plenty of water when tamping the holes, and tamp well. See that the ground is packed solid, not only where you made the hole, but all around the stump. Often there are holes dug by skunks, groundhogs, gophers, squirrels, rats or mice under stumps. Keep the charge of explosives away from these cavities—better fill them up.



Some such appearance is necessary in stump blasting, but the less of it there is the better. The ideal blast is just strong enough, and is so located, that it rolls the roots free of their beds and splits them apart, but does not throw them an unnecessary foot. Loud reports and much dirt high in the air show careless loading and useless expense.

In lighting many fuses a gasoline or oil torch is useful. But there isn't anything much better than to stick the burning end of a freshly scratched match right against the powder in the end of the fuse. (See page 58.) Remember that the outside cover of the fuse does not burn, but the spark runs down the center as a drop of water might run down a tube. Do not leave the fuse till it spits sparks regularly.

None of your charges are likely to misfire if you load carefully, and if you have taken proper care of your explosive materials before loading. But if misfires do occur with fuse, do not investigate them for several hours, at least. (See page 63 for discussion of misfires.)

Of course, in electric firing you can

investigate a misfire immediately after the wires have been disconnected at the blasting machine.

Amount of Explosives Required to Blast Out Stumps

A proper charge of explosives for a stump blast has a dead, muffled report. It lifts out and splits the stump. Loud report and the throwing of the pieces far shows that too much explosives have been used. When stumps merely are split and tight roots are left, not enough explosives have been used (or it may be placed too shallow). If the explosion is muffled and does not throw pieces far, but digs too big a hole, the charge is too heavy and too deeply placed.

It is impossible to lay down exact rules for the amounts of explosives to use. This bulletin will include figures of amounts that have been used to blast out some stumps, but these figures must be regarded as correct only under identical conditions of soil, kind and age and size of stump, amount of water in soil, kind and grade of explosives, and amount of confinement in the hole. Experience must be the teacher in this matter.

A green stump requires a great deal more explosive than one that has stood a few years. More explosives are required in stony land than in smooth land to blast out stumps. The harder and heavier the soil is, the less explosives are required, and the looser and lighter it is the more explosives are required. Dry soil requires more explosives than moist soil.



As these roots lie, they show the result of an almost ideal blast. There is little hole in the ground; the stump is well broken up; the roots are cleaned of dirt; and no roots have been thrown very far.

When you want to blast a stump entirely out, it is better to load too heavily than too lightly, for roots left tight in the ground after the top of a stump is blasted off are hard to get out. If you are not familiar with stump blasting, start with the small stumps and load them as you think they should be after considering the various points explained in foregoing pages, and in view of the following figures.

Ordinarily it takes one pound of explosives for each foot in diameter of stump, when the stump is such as a white pine in clay soil cut 10 years or longer. Green stumps of any kind require more than this—usually about half again as much; sometimes twice as much. A rule for the enormous stumps

of the Pacific Coast is to square the diameter of the stump, measured in feet, and use this figure as the number of $1\frac{1}{4}$ by 8 inch sticks of explosives required. This rule usually over-estimates the amount required for stumps larger than 3 feet in diameter.



Examples of the incomplete job resulting from trying to blast out very big stumps having wide-spreading roots, with one charge to each one. Unless the charge is excessively heavy, which means that it is expensive in explosives and in loading, it can not be placed deep enough to remove the whole stump. Even if it is deep enough and heavy enough to be successful it is objectionable on account of the big crater made. Each big stump should have several charges.

Amount of Explosives Used to Blast Stumps

The following table is taken from records of blasting in Minnesota, Pennsylvania, Oregon, Kentucky, Michigan and Florida. The stumps were blown out effectively and successfully, and the figures should serve as a reliable guide.

| Diameter Stump Inches | Kind Stump | Kind Soil | Sticks $1\frac{1}{4}$ inch Dynamite or Powder |
|--------------------------|---------------|--------------|--------------------------------------------------|
| 10 | Pine, dead | Clay | 1 |
| 12 | Pine, dead | Sand | $1\frac{1}{2}$ |
| 12 | Pine, dead | Loam | 1 |
| 12 | Pine, dead | Clay | 1 |
| 14 | Pine, dead | Clay | 2 |
| 15 | Pine, green | Loam | 4 |
| 16 | Pine, dead | Clay | $1\frac{1}{2}$ |
| 18 | Pine, dead | Sand | 3 |
| 18 | Pine, dead | Loam | 2 |
| 18 | Pine, dead | Clay | $1\frac{1}{2}$ |
| 20 | Pine, dead | Sand | 7 |
| 20 | Pine, dead | Clay | 4 |
| 24 | Pine, dead | Loam | 5 |
| 24 | Pine, green | Sand | 10 |
| 24 | Pine, dead | Sand | $5\frac{1}{2}$ |
| 24 | Pine, dead | Loam | $4\frac{1}{2}$ |
| 24 | Pine, dead | Clay | 4 |
| 36 | Pine, dead | Sand | 10 |
| 36 | Pine, dead | Loam | $8\frac{1}{2}$ |
| 36 | Pine, dead | Clay | $7\frac{1}{2}$ |
| 40 | Pine, dead | Clay | 7 |
| 48 | Pine, dead | Sand | 13 |
| 48 | Pine, dead | Loam | 10 |

| Diameter Stump Inches | Kind Stump | Kind Soil | Sticks $1\frac{1}{4}$ inch Dynamite or Powder |
|--------------------------|--------------------|--------------|--------------------------------------------------|
| 48 | Pine, dead | Clay | 9 |
| 60 | Pine, dead | Clay | 15 |
| 8 | Oak, dead | Sand | $1\frac{1}{2}$ |
| 12 | Oak, dead | Sand | 2 |
| 12 | Oak, dead | Loam | $1\frac{1}{2}$ |
| 15 | Oak, dead | Loam | $1\frac{1}{2}$ |
| 16 | Oak, dead | Clay | $1\frac{1}{2}$ |
| 16 | Oak, green | Clay | 3 |
| 18 | Oak, dead | Loam | 3 |
| 20 | Oak, dead | Loam | $3\frac{1}{2}$ |
| 24 | Oak, dead | Clay | 3 |
| 26 | Oak, dead | Clay | 2 |
| 27 | Oak, dead | Sand | 5 |
| 27 | Oak, dead | Loam | $4\frac{1}{2}$ |
| 30 | Oak, dead | Clay | $4\frac{1}{2}$ |
| 30 | Oak, dead | Sand | 6 |
| 34 | Oak, dead | Clay | $4\frac{1}{2}$ |
| 38 | Oak, dead | Clay | $5\frac{1}{2}$ |
| 30 | Fir, dead | Loam | 10 |
| 36 | Fir, dead | Clay | 12 |
| 40 | Fir, green | Loam | 20 |
| 48 | Fir, dead | Loam | 26 |
| 72 | Fir, dead | Clay | 36 |
| 60 | Spruce, green | Sand | 32 |
| 15 | Hemlock, dead | Sand | 2 |
| 10 | Walnut, dead | Loam | 1 |
| 15 | Gum, green | Clay | $3\frac{1}{2}$ |
| 24 | Gum, dead | Sand | 4 |
| 16 | Black gum, green | Sand | $5\frac{1}{2}$ |
| 16 | Sugar maple, green | Sand | $5\frac{1}{2}$ |
| 20 | Snag, dead | Sand | $4\frac{1}{2}$ |
| 6 | Tap-root pine | Sand | $\frac{1}{2}$ |
| 8 | Tap-root pine | Sand | $\frac{3}{4}$ |
| 10 | Tap-root pine | Sand | 1 |
| 12 | Tap-root pine | Sand | $1\frac{1}{2}$ |
| 15 | Tap-root pine | Sand | 2 |
| 18 | Tap-root pine | Sand | $2\frac{1}{2}$ |
| 6 | Tap-root pine | Sand | 1 |
| 8 | Tap-root pine | Sand | $1\frac{1}{2}$ |
| 12 | Tap-root pine | Sand | 3 |
| 15 | Tap-root pine | Sand | 4 |
| 18 | Tap-root pine | Sand | 5 |

} Charge
in
wood
} Charge
against
wood

Proper blasts throw out little dirt. They pull the roots out of the ground, and permit most of what little dirt they do lift to fall back in the hole. In consequence good blasting leaves small holes.

An excellent plan for any blaster is to carry a notebook and a yardstick and keep track of the blasts he makes. Make note of the size, kind, age of stump, kind of soil, amount of water, kind and amount of explosives used, and the result of the blast, in each case.

The figures here given will serve as a guide for the first shots. As the work proceeds, base your loading on your own experience.

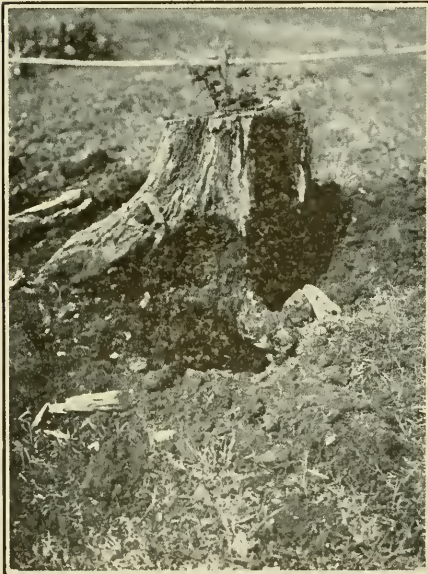


Here two charges, fired together electrically, were correctly proportioned and placed except that one was located too shallow and too far in toward the center. It should have been out under this remaining root, shown in the picture, which then would not have required pulling with horses or another blast.

Kind of Explosives to Use

The kinds and grades of explosives best to use for blasting out stumps are few, and vary with the nature of the soil.

In a heavy soil an explosive which cracks, lifts and heaves is more desirable than one which shatters. In other words, a slow-acting explosive is the one to use. This means dynamite or powder of 20% strength or less; and further, in dry work or where the charges can be fired quickly after loading, it means ammonia explosives. If the charges must be exposed for some time to water, nitroglycerin powder or dynamite had better be used.



The single charge under this stump was placed too deep and too much to one side. It exhausted most of its energy in the ground far below the roots, and then what was left escaped between the roots, blowing the dirt away but not having enough power to carry the roots with it.

In dry, light soils, such as dry sand, it is necessary to use an explosive that exerts its full force before the gases can give way, as in mudcapping rock. For that reason 50% ammonia or nitroglycerin powder or dynamite is the explosive to use in dry sand and similar soils, or 60% will do. Intermediate grades of soil usually can be depended on to hold the gases enough to permit the use of the slower 20% explosives.

The above does not mean that

these grades of explosives are demanded for removing stumps. The fact is that stumps can be blasted out with almost any explosives manufactured; but the work can be done more economically and cheaply if the grades recommended above are used.



Four charges fired together tore this stump loose from its moorings and moved it six feet down the hill, but did not break it up. Another charge should have been located close under the center. It can be broken up easily now, however, by loading one stick charge down in the center of the hollow top. THIS STUMP IS A WHITE PINE, CUT 75 YEARS AGO.

The 20% explosives, especially the ammonia, leave the ground in better condition. A violent and quick-acting explosive tears out large holes in heavy ground, and packs the earth about the edges.

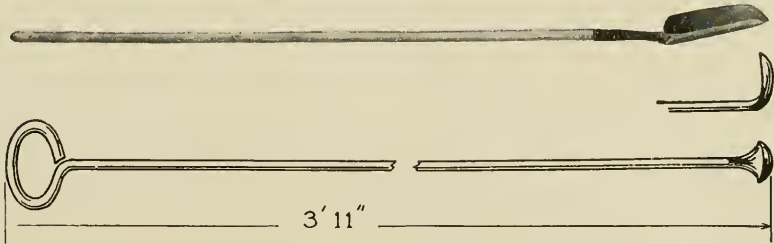
Time Required for and Cost of Blasting Stumps

A day's work for one man is 30 to 60 average stumps blasted out. If three men can work as a crew, two making holes and one loading and firing, the number of stumps per man will be much increased.

The cost of blasting stumps is a variable quantity. Those which blast out the cheapest are well-rotted oak or walnut, in moist clay soil. Probably the stumps which cost most to blast are green white pine or oak in dry sand. The skill and good judgment of the blaster also has much to do with the cost.

Tools

The tools you will need for blasting stumps are all common ones. The pictures show better what they are like than words can tell. You can use grubbing hoes, axes, crowbars for driving and for hand use, soil augers, long-shanked wood augers, wood tamping sticks, cap crimpers, water buckets, pocket





This stump came out as a result of a charge that was placed too deep and a little to one side of the proper position, and is not broken up for handling. It can be broken very easily as it lays, by locating a one stick mudcap charge between the two large roots seen in the picture. Had the original charge been a foot nearer the surface, the stump would have been broken in several pieces and all thrown out.

This bulletin recommends electric firing for stump blasting strongly whenever there is enough blasting to be done to justify the purchase of a blasting

knives, steel probing rods, adzes, long-handled shovels, spade shovels, spoon shovels, scrapers, spoon bars, sledges and possibly other tools.

An old wood auger does not make a good soil auger, though it can be used in a pinch. For boring in ground an auger should have a leading point 2 or 3 inches long. Both wood and soil augers should have cutting bits that can be filed sharp a good many times without destroying them. Most blasting tools are supplied by all makers of explosives, and by hardware dealers. Some of them can be made at home, by your blacksmith.

The spoon shovel and spoon bars are for tunneling and enlarging bore holes. Make them by turning up and trimming the edges of long-handled shovels. The probing rod is a piece of quarter-inch steel 6 feet long, with one end sharpened to a point. It had better have a handle turned over, or made into a ring. No long description of any of these tools will be given here, because farmers are familiar with them.



A very old white pine stump blown out with three charges fired together electrically. The stump is well torn loose and cleaned, but another charge should have been placed at a point close to the wood under the center, to split the stump for easy handling.

machine. (See page 63.) One to fire up to 10 charges can be obtained at a moderate cost. If skillfully handled its use will save its cost for each 500 pounds of explosive fired. Electric firing makes possible work in stump blasting that is superior to the work produced by any fuse firing when conditions are difficult. The several small explosions help one another.



The blaster located his charges under this stump too far toward one side. The result is that the roots of the other side are left sticking in the ground and require another blast.

General Hints

To blast out standing trees, use about twenty per cent. more explosives than you would for the stumps. It is better to blast big trees with several charges, firing them electrically.

When big green stumps are blasted out with one charge placed under the



The result of an attempt to blast out a very large green stump with one charge. The explosives were located deep under the center, but they could not reach out far enough to tear loose the many firmly anchored roots. Such stumps should be blasted with three or more charges all fired together electrically.

center, some of the roots often break off high up, so that they interfere with plows. They are better blasted with several charges placed round the edges. If you are using a stump puller, split and loosen all the big stumps with explosives before pulling them.

It is more expensive to remove severely burned stumps than those with the tops intact. In blasting decayed stumps and those with no tops, fill the center cavity with ground and tamp it tight. Then place the charges in the usual way.

In blasting old rotten stumps that have sound roots, you often find the center underneath has rotted out, or become so that it is only a mass of punk. This material will not hold the gases of the explosives. To blast such stumps, better use an electric blasting machine, and several charges, or if fuse must be used, place the charges under the roots, or deep under the center, filling the hollow center with wet clay or loam.

Old logs and snags frequently are too big to haul or handle and to burn on clearings. Do not waste time cutting them in two, but smash them up with charges of about half a stick of explosives placed in an auger hole. If no auger is handy, put a heavier charge in a notch chopped in the log and cover with 6 inches of mud.

Fat pine tap-root stumps often may be shattered by charges of explosives placed in the top-roots, and the stumps left to dry. After a few weeks these stumps will burn like oil pots.

Many farmers can clear their land with very little loss of time from regular work by going about it in a systematic campaign. In an hour or two each evening a good many stumps can be blasted out and the work will be a pleasure. Only one man is needed. By making sure that the charges are rightly placed and proportioned to the stump, the roots all will be broken up so one man can handle them.

Headache Avoid working in the fumes and smoke of blasts, which
Prevention will cause headache. Also keep the explosives from touching
 the skin of your hands, by wearing gloves.



When the charge is placed too shallow in the blasting of a stump that is newly cut or that has not rotted much, the top is ripped off, leaving many tight roots sticking high enough to catch a plow.

In removing saplings of sassafras and persimmon and stumps with long, tough roots that may sprout if permitted to break off in the ground, it often is of advantage to explode half stick charges a couple of feet under the trunks. This will not take out the trees, but will loosen the ground so that when they are pulled over in the usual way the roots all will come away.

Be careful not to miss charges that are placed, when you are lighting fuse or connecting wires. Get them all as you pass the stumps they are under. Unfired charges are liable to weakening and damage, and are sources of danger.



This is what the stump field should look like after the roots have been blown out. If the land is to be farmed, the next plowing should see every root removed.

Stumps make good fireplace wood and kindling wood. You likely can sell fireplace wood in nearby towns by doing a little advertising or inquiring of people you know. Pine stumps have won a place in the hearts of all American farmers as kindling wood.

Stump Disposal On nearly every farm and at nearly every home it pays to keep a large supply of pine roots for kindling. Don't destroy stumps when your wood-house is empty.

At many points roots can be sold as fuel for engines. In many parts of the South stumps can be sold for turpentine extraction. Everyone should make an effort to sell or to use his stumps rather than to destroy them. They represent real fuel value, and a little effort usually will get it out. The home kindling pile can be made big enough to last for years. The roots are ready-cut kindling of the best grade. As fireplace wood they are superior to top growth, because of mineral elements in the sap. They make as good fuel for lime kilns as any other wood. The price for home use near large cities often is upward of \$8 to \$12 a cord. For turpentine extraction the roots are worth at least \$3.50 a cord. Farmers themselves can afford to pay at least \$1.50 a cord, with the cost of hauling added, rather than to burn the stumps.

But when stumps cannot be sold or used they must be burned on the ground. Where they have been pulled out, without breaking up with explosives, and are large, the pulling engine or horses must be used to pile them, with the help of a derrick or gin-pole. An engine and a winch, using a cable, is a very good outfit for this purpose. A derrick may be a tripod with legs up to 40 to 45 feet long, or it may be a swinging boom derrick, with mast up to



Wood is a very expensive commodity in many parts of this country to-day. It never will get cheaper. Utilization of all parts of the trees that are cut down in land clearing is the thing to do whenever it is possible.

30 feet high and boom 25 feet long. Let the mast lean a little toward the pile of stumps, so the boom will swing round itself with its load. Another good machine is the Conrath portable piler, much used in Wisconsin. It requires 10 pieces of timber or poles, of which the largest, the two skids and the boom, are 20 to 22 feet long. A gin-pole may be any height that is convenient. An old dead tree makes a good one. Let it burn with the

stumps piled about it. With 150 feet of half-inch cable and a pair of double blocks the piling can be done with horses.

A better way to handle stumps than with a derrick is to use small charges of explosives to break them up after they are pulled. When stumps are well blasted the problem of disposal is simple.

Start numerous small fires and pile the roots on as they burn down. The fires can be kept going till all the roots are burned up, by putting on new roots and by shoving in butts. Have a wagon or sled and keep hauling and unloading all the time. Drive about the clearing on regular routes, each time making larger circles and throwing off a few roots as you pass by each fire. One man can clean up more acreage in this way in an equal time than several men working to pile the stumps in high piles with a derrick, except in cases where



The ideal size and kind of pile for burning stumps and roots. These piles can be built by hand, in unloading the stumps from a low wagon or sled. The fires can be started and more roots fed to keep them going.

the stumps are large and unbroken, or are left in very large pieces. What saves expense is piling by hand.

When you clear land by blasting, postpone all burning of brush, logs, etc., till after the stumps are blasted. Then have a grand burning of everything at once. But do not burn the surface—don't let the fire run over the ground. Keep it strictly to the boundaries of the piles. There is a whole lot of fertilizer in the layer of leaves, moss, twigs and other vegetable matter that every piece of cut-over or logged-off land has on the surface. It is foolishness to destroy this. Plow it down. It is worth a good many dollars on every acre.

When you burn a clearing, first get in touch with the fire warden of the district if there is any forested land at all near your place. Use every precaution to prevent the fire from getting out of your clearing and beyond your control.

You will hear—once in a long while—some man say that blasting out stumps hurts the soil. When you do, tell him he is mistaken. Proper blasting is beneficial to the soil. It is so beneficial that on thousands of farms subsoil blasting is regarded as a standard practice. In many orchard sections no one thinks of planting fruit or shade trees without first preparing the ground for them by blasting. There is a bulletin published on that subject which you should have if you are interested.

It is proper to add here, however, that when the ground is wet a blast does not produce the same effect in it as when it is dry. Subsoil blasting must be done when the ground is dry enough to crumble. Blasting a heavy soil

Blasting Benefits Soil



A good method of piling certain kinds of green roots. Piles even as large as this will prove to be more expensive than smaller piles in nearly every instance, and this method is justified only when stumps that do not burn well, such as green cypress, pine and fir, have to be burned quickly.

that is in a plastic condition will make it more compact instead of loosening it. It is possible to do damage to a spot in a cultivated field by making a hole there—by digging out a stump, pulling a stump or blasting out a stump—and failing to fill it up level with the surrounding surface.

This bulletin states, correctly, that explosives take stumps out most efficiently when the ground is moist. While this is true, if you want to secure subsoiling benefit to the land at the same time you blast out stumps,

you must do the work when the ground is at least reasonably dry. By blasting the stumps when the soil is not wet you sacrifice some of the efficiency of the explosives in the stump removing, and gain in fertility.

Don't allow the second growth to start at all. Pasture the land with what stock you have. To get goats especially for the purpose is practicable on large tracts, but the small tract had better be pastured by the cattle or hogs or sheep that the farm already has. Goat clearing is advisable only where time is plenty and money for development is scarce. Cut brush to the ground when it is in full leaf. Do the grubbing at intervals through the summer, as time permits. Remember that the grubbing must be deep to kill the roots—a foot down at least.

Clearing Sprouts



In this operation four men and five horses are used to pile the stumps. The gin-pole is a modification of the swinging boom derrick. The operation is rather expensive owing to its comparative inefficiency compared to hand-handling of the stumps when they are well broken.

After the stumps and sprouts are off the land, there still is some work to do before it is ready for crops. New land is fertile, but it usually needs lime.

The unevenness and stump holes should be filled after the plowing is done. A small horse scraper is a valuable implement for this, but anything made like a King split-log road drag will do the work. Make a complete job of the leveling. Scrape the bumps into the hollows, and make the surface as even as possible, so that no water will stand in pools. This leveling should be done carefully in old cultivated fields as well as in new ground.

To take full advantage of the big supply of plant food available in the soil of newly cleared land, you must plant crops that will bring in money. This may be a grain such as corn, but is more likely to be hay, cotton or fruit.

Crops for New Ground

Strawberries are pre-eminently a new land crop. They never do as well on old land. If you have marketing facilities for them, put your new ground in strawberries for two or three years.

Potatoes are another paying crop on new land. Corn bears fairly well, but not much better than on old land. Other quick-bearing fruits, such as gooseberries, currants, raspberries and dewberries, do very well. Vegetables like tomatoes, sweet corn, water-melons, beets and squash, succeed very well. Oats is a very bad crop to plant because of the weeds it invariably helps to spring up.

The hay crops are excellent, and in some of them there is a great deal of profit. Alfalfa is the best of them all. If you are planning to plant alfalfa, wait two years after clearing and plowing, meanwhile giving the land a heavy application of lime and cultivating it in some of the other crops named. All the clovers are good. Some people like to sow clover and timothy mixed.

On high land sow red clover and timothy; on low land alsike, timothy and red top grass. Soy beans, Canada field peas, field beans, cowpeas, mammoth clover and sweet clover, cotton and tobacco, all will yield enormous crops on new ground.

If you have cleared in the summer, harrow and disc at once, and sow rye, to be plowed down the next spring if you are going to cultivate the land, or to be mowed if you sow grass seed. The clover should be sowed on the surface of the ground just as the snow leaves in the spring. If you do not get a good stand from the first seeding, do not be satisfied with the poor one, but tear it up and seed over again. You cannot afford to let new ground loaf. There is money in making it work.



A type of "gin-pole" used to pile stumps for burning. Often piling by hand in small piles is much cheaper.

Preparing Charges of Explosives for Firing

A charge of explosives for the purposes of these directions is considered to be all the explosives needed for a single hole with cap and fuse or electric blasting cap properly inserted in the stick of dynamite or powder (see pages 44 to 45) and tamped in the hole, ready to fire. The preparation of charges is practically the same for all sorts of farm blasting. The slight variations advisable to suit different kinds of work are not enough to call for separate treatment, since the principles are all the same.

All who use and buy explosives should read the next chapter, beginning on page 51, on the nature and actions of explosives. It is only the man who understands all the facts mentioned there who will be able to load and blast with greatest ease, speed and results.

Scope of This Chapter

It is important for everyone who blasts to understand why he does things, as well as how to do them. For that reason the following discussion of the preparation of charges is made full and complete, with due attention to all the important factors involved. Details of any particular part of the operation can be found quickly by referring to the heading desired, as given in the index.

Readers who may not desire a full discussion are referred to the following brief outline of the process.

Be careful that explosives, cap and fuse are in perfect condition. Cut a length of fuse sufficient for the hole to be loaded, making the cut clean, without dragging ends, at a slight slant of, say, 30 to 45 degrees from right angle.

Pick a cap from the little tin cap box, carefully, with your fingers, and slide it gently on the end of the fuse. With a proper cap crimper fasten the cap securely to the fuse, making the crimp close to the open end of cap. Avoid twisting or punching the end of fuse against the bottom of cap as well as drawing it away from the bottom. For wet work waterproof the joint of cap and fuse with tallow, soap or other material. Do not use thin grease or oil.

Next punch a hole at a long slant in the side of the stick to be primed. Better use a wooden punch for the purpose. The handle of the cap crimper may be used.

Insert the cap in the hole made as described, tie the fuse in place, and, for wet work, waterproof all openings in the stick. You then are ready to load.

Provide space enough in the hole at the proper point to hold the required amount of explosives in a bulk that is not too long. Be sure before you start to press in the sticks to the bottom of the hole (see page 26) that there is enough clearance to permit their easy and certain entrance. Tamp fully and firmly up to the top of the hole.

The charge is now ready to fire, which may be done by pressing the burning or flaring head of a freshly scratched match against the powder in the split end of the fuse.

Carrying Explosives and Supplies

The place to keep the explosives is in the magazine or storage place, and not with you in the field. Carry with you in warm weather only enough for the job or the day, or in cold weather only as much as can be kept warm and in condition for firing until you are through loading. Keep explosives separate from caps.

Protection of Explosives

A good way to carry the caps, fuse and small tools is in a basket. Put a piece of blanket in the bottom, to keep

out dampness when the basket is on the ground. Some blasters use an explosives box for the purpose, putting a wood handle or double wire bale on it. The tight wood box probably is a little better than the basket because it affords somewhat more complete protection to the contents.

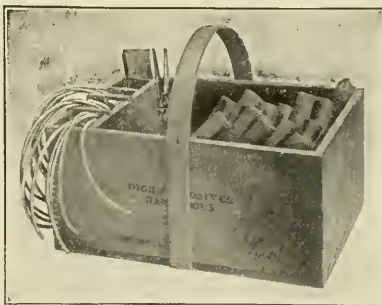
Whatever the method of carrying the explosives, it should be well protected. This consists in keeping the hot sun off it, keeping rain and fog off it, keeping it away from dampness of the ground, and keeping it safe from meddlesome people and animals.

Many blasters prepare charges before going to the field, but it is better practice to carry along the tools and materials, and to put them together or make the primers on the spot after all the holes are made in the ground or rock, and when everything is ready for the firing except to put the explosive in place.

These remarks are given as reminders. Full discussion of proper handling and storing of explosives can be found on pages 66 to 68 respectively.

Tools and Materials Required

The first step in preparation of charges is to assemble the following: as many sticks of explosive (or parts of stick, if charges are to be less than full sticks) as there are holes to be primed; an equal number of caps; a sufficient quantity of fuse; some string; a wood punch with an end the size of a cap for about 3 inches; a pair of cap crimpers; a pocket knife. If the holes are very damp or full of water you also will need some tallow or other waterproofing material. In certain cases a sharp hatchet or axe and a block of wood will be worth having. The purpose and use of these items will be made clear later.



A handy box for carrying supplies to field.

Putting Caps and Fuse Together (Making Primers)

Fuse is described as to sizes and properties on page 65 and caps on pages 64 to 65. Readers who are not familiar with them should turn to those pages at this point. Unroll the fuse and cut off a length that will be enough, since fuse burns about 2 feet in a minute (there are variations—see page 66).

Three feet will give you $1\frac{1}{2}$ minutes or a sufficient time to get beyond danger under ordinary conditions. The fuse, of course, must be long enough to reach out of the mouth of the hole when the charge is in place. Measure the depth of the hole before you cut the fuse.

The Fuse Warm cold fuse before attempting to bend it. It may be taken into any warm room for the purpose but should be subjected to no heat greater than 110 degrees. If for any reason you have doubts about the condition of your fuse, cut off a foot or more and try it without any cap or explosive. If it will burn properly it is all right.

Be sure to get fresh ends both for the match and to put into the cap. If fuse has been cut for some time into lengths, it is well to cut off short pieces from the old ends in order to bring fresh powder right to the tips.

Cut the fuse off at a very slight angle or bevel—say 30 to 45 degrees, as shown in the diagram. This slant is for the purpose of giving a little space between the actual end of the powder and the explosive material in the bottom of the cap, to enable the spark to spit into material

Cutting the Fuse

The only way to regulate the space is to cut the fuse as directed and let the long tip rest gently against the bottom of the cap. The spark has a better chance to ignite the explosive material in the cap when it spits from the end of the fuse than when it merely burns up to the end without any space to spit into.

The end of the fuse where cut off should be clean and free from dragging ends and threads. If it is not cut off clean, part of the covering may double over the end of the fuse in the cap and keep the spark away from the explosive, causing a misfire. Be careful to keep both ends of fuse off damp ground and out of puddles of water.

If the fuse has been mashed, or is too thick to go into the cap easily, do not peel off any of the covering. Reduce the diameter by squeezing it with the cap crimpers or by rolling it on a smooth surface under a knife blade or other smooth implement. Sometimes you can reduce it by rolling it between the thumb and finger.

The very best way to cut fuse is on a block of wood with a sharp knife. The blade can be pressed right through the fuse and will make a clean cut. Another good tool is a sharp axe, to be used on a block of wood. The method of cutting is of small importance, just so the actual cut is made smooth and even enough. If you do use other tools, have a knife with you to trim up ends that are not true. Be careful to avoid twisting, pinching or otherwise knocking the freshly cut end of the fuse about, for you may shake out the powder back far enough to cause a misfire. The powder should come out flush with end.

To get one cap out of the tin box in which they came, tilt the box up on edge till some of the caps slide forward, and then pick the cap up with your fingers. Don't attempt, on penalty of losing a hand, to take a cap out of a box by running a nail or a little stick or the fuse into it in the box. Be careful you do not drop a cap to the ground or floor.

Turn the cap upside down, to make sure there is no dirt in it, and gently slide it on the fuse till the end of the fuse just touches the bottom of the cap. Do not ram, press or twist the end against the bottom.

Hold the fuse with capped end up, to keep the cap from sliding off, and crimp the cap fast. This you do with the special plier-like tool called a cap crimper.



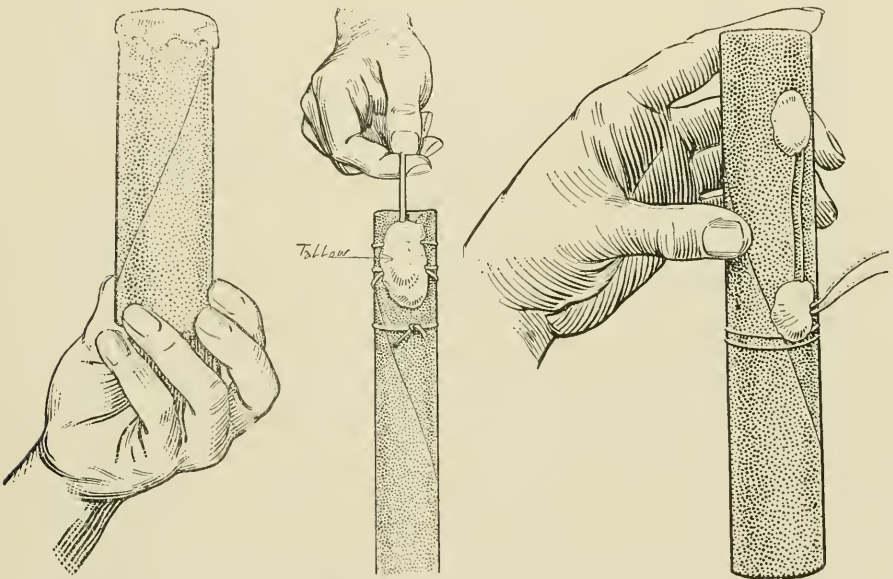
"Crimp" or fasten caps to fuse with a regular crimping tool. This tool does the job far better than it can be done in any other way.

The "crimp" is made by pinching the open end of the cap tight to the fuse. It should be made within the last quarter inch of the open end of the cap. Never make it toward the closed end because you might disturb the explosive material in the bottom of the cap and cause it to explode.

Cap crimpers are supplied by

all makers of explosives. Order one or more when you buy your explosive. It is well to have an extra one about to use in case you lose one on extensive jobs.

This fastening of the fuse to the cap is one of the points in blasting where a great deal of abuse occurs. Blasters think they can take a chance with danger or with misfires, and attempt to crimp the caps some other way. Except in extreme emergency don't try to crimp a cap with anything except a regular crimping tool; but there are times when one may not have a crimper nor be in a position to wait till one can be purchased. There is a way out of this difficulty—which is to secure a makeshift crimp with something else than a crimper. It is possible to use a pair of pliers, or a small pair of pincers, and accomplish something that may hold the cap on the fuse. The best makeshift crimp is to take a fold of the cap up at one side of the mouth with a pair of close fitting, square-nosed pliers. Be careful while doing this that you do not grind the end of fuse against the bottom of cap, or pull the end back from the bottom. If the fuse should pull away from the bottom of cap a quarter inch, a misfire likely would result.



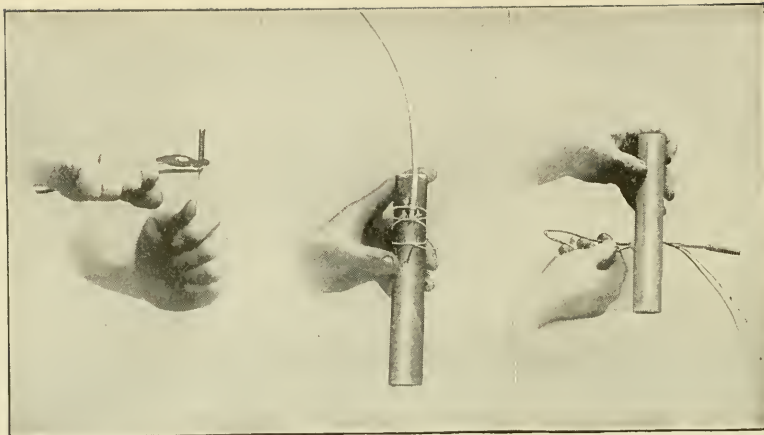
Waterproofed (tallowed) sticks ready for loading in wet holes.

When the charge is to be placed in a dry hole, waterproofing is not needed, but in a wet hole the connections between fuse and cap must be made water-tight with tallow or soap. Do not use grease, because it may unite with the tar in the composition of the fuse cover and soften it, when the powder train will be ruined. Water in the cap will surely make it worthless.

Waterproofing

Inserting Caps in Explosive

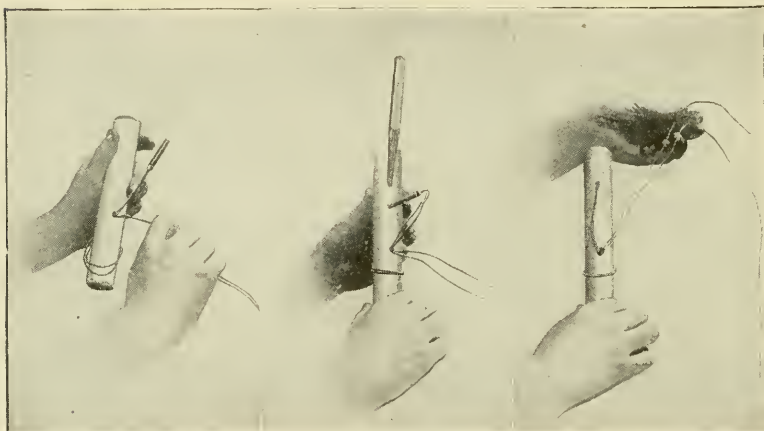
The best location for a cap in a stick of explosive for farm blasting is in a hole in the side, about an inch and a half from one end. The best position for the cap at this point is at a slant that takes it in from the side toward the center, but as near longways, or parallel with the sides of the stick, as possible.



Crimping cap with the cap crimper.

Fuse tied firmly to stick with string.

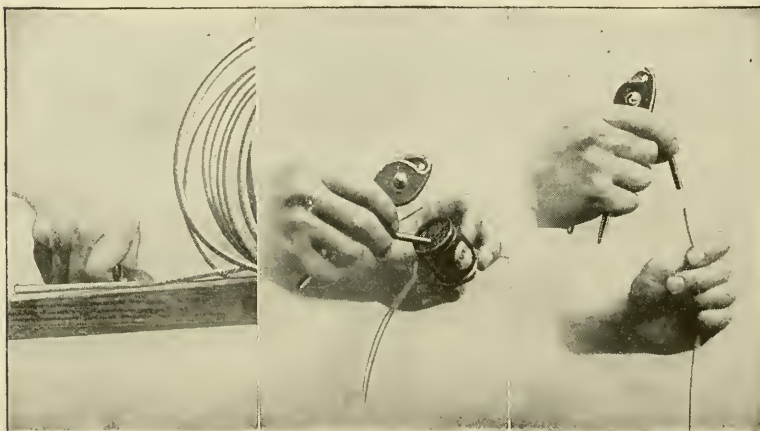
Electric Blasting—Pass the doubled fuze wires through a hole in stick of powder.



Loop the doubled end of fuze wires over end of stick.

Pull loop tight, bend wires at cap, punch slanting hole in stick high up and round to side a little.

Insert cap in slanting hole to bend of wires, take up slack in wires. (Waterproof holes if ground is wet.)



In cutting fuse from roll use sharp knife.

Taking one cap carefully from box.

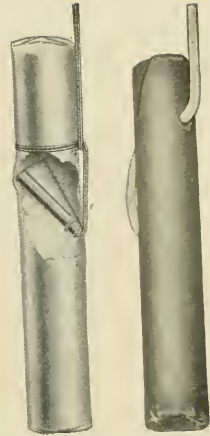
Inserting fresh end of fuze in cap.

Position of Cap in Stick

In other words, when making the hole for the cap in the explosive, make it with as long a slant down toward the other end of the stick as possible. There are reasons for this connected with superior or inferior detonation.

Another style of priming much used is to set the cap in a hole made in the end of the stick of explosive, and then to tie the paper about the fuse or wires. This is good so long as it is not damaged, but experience shows that the tamping stick often bends the fuse over sharply when the primed stick is pressed into the hole and sometimes even interferes with the cap itself. With side priming there is a cushion of the soft explosive between the end of the stick and cap. End priming always is good provided sufficient care is taken in loading to prevent disturbing or displacing the fuse or cap with tamping rod.

When all the explosive is removed from its stick wrappings, the cap must be inserted in the loose explosive. This should be done by making a hole, as in a stick. But it seldom pays to take all the explosive out of stick wrappings. Nearly always you can leave a half stick of explosive intact for the cap.



Bad priming.



A good crimp.

To make the hole for the cap use the handle of the cap crimper or a wooden punch just a little larger than the cap. The hole should be large enough to let the cap in without much pressing, but should leave no air space about the cap. The depth of the hole also is important. It should be just enough so that the entire cap can be buried in the explosive, but not any deeper. If it is deeper, the cap may be forced on down to the bottom, which will leave some of the fuse in contact with the explosive (may cause burning instead of exploding of powder), or the cap may be seated just inside the wrapping, leaving an air space at the inside end or bottom of the hole, which may lower the effectiveness of the explosive.

Making Hole in Explosive

When the cap is seated in its hole in the side of the stick, the fuse will extend up along the stick past the near end. It must be tied in this position, so securely that the fuse and the cap will not be pulled back in handling or by rubbing against the side of the hole when the stick is pressed down. The best way to secure it is to wrap a strong string several times below the point where the cap is inserted, then give two or three wraps about the fuse, and pull tight and tie; or take two loops about the fuse and then several wraps about the stick.

Fastening Fuse to Explosive



Cutting stick in two—roll it under knife blade

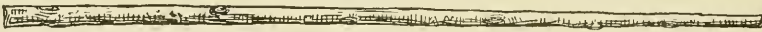
When the foregoing directions have been complied with you have a stick of explosive primed with a cap and fuse. It is ready to put in the hole in the rock or ground.

Loading Charges in Holes

You will need a tamping stick. This must be of wood, and had better be about the size of a stick of explosive, which usually will be $1\frac{1}{4}$ inches in diameter, except in case of blockhole blasting of boulders, when a smaller stick sometimes is needed to go in small drill holes. Never use a metal rod for tamping. Make sure that the hole is ready. It must be big enough to allow sticks of explosive to slide down easily (except in the case of small holes drilled in rock, when the explosive all must be taken out of the stick wrappings and crumbled and pressed into the hole).

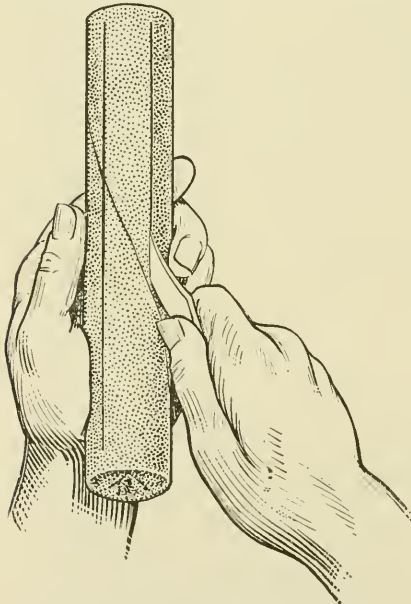
Tamping rod Loose stones, sharp stones and roots that obstruct the hole should be removed with a bar or spoon scraper. This work must be completed before starting to load. If obstructions fall into the hole, after some of the explosive is in place, don't try to remove it by force. Make another hole at a safe distance from the first, put in another charge and fire it.

Measure the hole with your tamping stick and judge if there is space for the required charge at the right point. Nearly always a charge of explosives



The tamping rod should be of wood.

should be as much on a pile as possible. If one or 2 sticks are all the explosive required, it usually will not hurt to put them end to end. But if 3 or more sticks are required, to put them end to end makes the charge too long, and places the force of the blast elsewhere than where it should be.



Slitting the paper wrapping of stick to let it swell to fill dry hole.

When your judgment tells you that the charge should be in a more or less round bulk, enlarge the hole at the point where the charge should be made. Sometimes this can be done by scraping it out at the bottom with a toe-bar or spoon-bar. Again, if much enlarging is required, it is well to use a small amount of explosive to secure it. This is called springing. To do this prime about a quarter of a stick as usual, and push it to the bottom of the hole. Use no tamping. After it is fired wait till the hole cools, and you will find a cavity large enough for your full charge.

It is better to avoid springing holes if you can, on account of the fact that the cavity often is enlarged too much, and the surrounding earth is loosened so much as to injure confinement. (See page 55 on detonation). A great deal can be done by scraping the small auger hole out to 2 or 3 inches in diameter at the bottom and then causing the

sticks to enlarge and fill the hole solidly. To accomplish this enlargement of sticks, slit their wrappings 3 or 4 places lengthwise, from end to end. Then press them home with the tamping stick. They will expand and shorten. Four to 6 sticks in this way can be got into the full length of two.

Still another way is to take the explosive entirely out of the stick wrappings, and with the help of a tin or paper tube, such, for instance, as calendars are mailed in, funnel it down to the bottom of the hole. But neither this method nor slitting the sticks is wise in wet holes. It is true that nitroglycerin powders will stand considerable water, but the safe rule in wet blasting is to leave the sticks intact. Ammonia powders or dynamites will not stand wetting inside the paper of the sticks without damage. (Never under any circumstances cut, break, unwrap or punch holes in explosive that is frozen. You invite an explosion in your hands when you do).

When there is more than one stick in the charge, place the primed stick on top of the others—put it in the hole last or next to last—when using the cap-and-fuse method of firing.

Be sure that all parts of the charge are in firm contact. It will not do to have air spaces, or dirt, or wrinkled paper between the sticks. While all the powder likely would go off under these conditions, it will not do as much work as it should.

The sticks of explosive may fit tightly in the holes. In that case do not ram or pound them, but press firmly against them, one at a time, with the tamping stick. Press the explosive into tight contact with the sides all round, at the bottom of the hole.

Tamping

Tamping is a necessity. The charge should be tightly confined. It is only in springing holes and sometimes in digging post holes that no tamping is advisable, and in ditching that the quantity needed is less.

Tamping

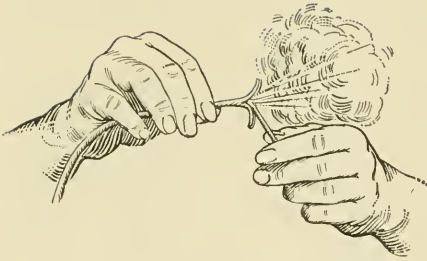
When the explosive is in place at the bottom of the hole, start the tamping by rolling in some loose ground. Keep the tamping stick working up and down to seat this ground against the explosive, though make no effort to get it tight till there is a few inches or so over the explosive. An exception to this rule is in the case of blockhole blasting of boulders and ledges, when damp clay tamping should be packed solid all the way down to the explosives. The rule for the least contents of tamping that will do good work is that it should be 6 or 7 times as deep as the hole measures in diameter.

If the tamping is less than this, the best results will not be secured, hence deep holes often are necessary for the sake of confinement of charge as well as to contain the amount of powder used.

Hold the fuse to one side with one hand while the tamping stick is worked with the other hand. Rake the dirt to the mouth of the hole and be careful to get in the hole only earth—not clods, sticks, grass, etc. Be very careful not to damage the cover of the fuse with the tamping stick.

Fill the hole to the top with tamping, and make it tight. The best material for tamping is moist clay. Tamping material always is better when made *wet* enough to ball. In fact, there isn't much better tamping than water itself in the hole, when it can be made to cover the charges deeply enough. Use the heaviest earth within reach, and if it is dry, better carry some water for wetting it.

Firing



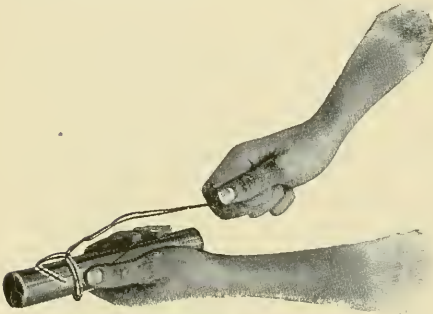
Stick the burning head of a match against the powder to light fuse surely.

Preparing Charges for Electric Firing (Making Primers)

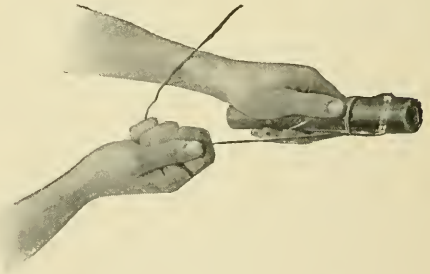
Up to this point in the directions for preparing charges the text has spoken only of caps and fuse. When the firing is to be done with an electric blasting machine instead of fuse, you must use electric blasting caps.

These come from the makers with the wires already fastened in them. (See pages 64 and 65.) They are ready to be inserted in the stick of explosive without any preparation such as ordinary caps and fuse require.

Make a slanting hole in the stick of explosive just as is described on pages 44 to 46. Into this insert the electric blasting cap, letting its wires project just as the fuse does when fuse is used. Then tie the wires to the stick with a string as fuse is tied, to prevent the cap from being pulled partly or entirely out of the hole.



Bad method of fastening wires.
It is better to tie them.



Bad position of cap in stick, and of cap wires.

It is a little difficult to tie the wires tight enough with a string to prevent slipping. Another way to fasten them securely is to pass the wires through the stick. To do it punch a hole straight through the stick of explosive about the middle. Double the wires about 6 inches back of the cap and pass the doubled end through this hole. Then loop the doubled ends from the other side back round the lower end of the stick. Take up the slack in the wires and you will have a sure fastening. The cap can be inserted in the stick at another point, in a slanting hole, just as described previously.

In fixing wires of electric blasting caps to sticks, avoid crossing them and avoid bending them sharply or in any manner that will break their insulating. If the insulating is broken it likely will cause a short circuit, which will result in a misfire. *Never take a half hitch about the stick with the wires.* Do not pull at the wires and the cap, because to do so may break the fine bridge wire that causes the cap to explode when the current goes through.

Load these primed sticks the same as is directed for fuse primed charges. Be careful to avoid rupturing the insulating on the wires with small stones in the hole or with the tamping rod.

The finishing of the tamping leaves two wires projecting from each hole. They must be connected with the blasting machine or other source of current with connecting wire and leading wire, in the manner described fully on pages 60 to 63. Further discussion is not needed at this point.

Some General Suggestions

In priming sticks of explosive with fuse and blasting cap, you must be careful to avoid permitting the fuse to touch the explosive. High explosives will burn like gasoline or coal-oil. They are very easily set on fire by sparks spitting from fuse. When they are burning the explosion will be very much weaker than it otherwise would be, and will give off noxious gases.

A very frequent cause of misfires is the bending, kinking and crooking of fuse. This is especially frequent when the cap is inserted in the center of the end of the stick of explosive and then carelessly forced over against the side of the hole by the tamping stick and tamping material. Keep the fuse straight, and never under any circumstances lace it through the stick of explosive. That is a sure cause of trouble.

If it becomes necessary to remove a cap from a primed stick of explosive, do it gently and carefully, and unless the cap and fuse are immediately to be inserted in another stick, destroy them both by lifting a shovelful of earth and putting the cap under the ground in the hole, after which light the fuse and go away.

It is better not to lift or carry the primed stick of explosive by the fuse or wires when it can be helped. When a practice of carrying primed sticks by the fuse is made, misfires and poor explosions will be caused, not every time, but often enough to make it wiser not to do so. The cap often is pulled back in spite of the tie string.

Where explosives that are subject to water damage are used in work that is wet, matters can be helped by making the sticks waterproof with tallow, paraffine or other suitable material. It is practicable to stop all the seams on the sticks, load and fire without delay, even with explosives that would be put out of business if the water got at the actual material instead of only at the wrappings of the sticks. Pay particular attention to waxing or tallowing the place where the cap and wires go into the stick.

When doing wet blasting, use every care to keep the outer end of the fuse from dropping into the water or from resting on damp ground. The inner wrappings of fuse and the powder train itself take up water like a blotter. On a very foggy day it is well to keep fuse in a closed box. Mist and rain of course, will damage it.

Explosives and Blasting Supplies

The catalogs of manufacturers are not intended to give all the fundamental facts about and the differences between the various explosives. To do so would take too much space. They give the trade names and the measurements and weights of sticks and boxes, demanded by purchasers, and are prepared on the supposition that blasters and buyers of explosives know what they need. This bulletin includes explanations of the names under which blasting explosives are made and marketed, outlines their properties, and makes clear the work and conditions for which each grade is intended and suited.

Explosives

There are scores of different kinds of explosives made and used for blasting purposes, and many dozens of different names used for them. The most familiar name of any explosive in America is dynamite. Another familiar term is powder. Other names are farm powder, quarry
Names powder, contractor's powder, coal powder, stumping powder, Judson powder, gelatin, blasting gelatin, R. R. P., giant powder, blasting powder and dozens of others.

Nearly every one of the explosives designated by these names are made in several strengths, and in qualities to suit varying conditions. For this reason figures and other marks are attached to the names to distinguish the grades. In addition to this some of the names are used to designate not only one certain explosive but several widely different ones. This is particularly true of the names dynamite and powder. The selection of names in the preceding paragraph is made for illustrative purposes, and is not to be taken in any sense as a recommendation of those explosives for any purpose. The recommendations are given in detail on other pages.

All blasting explosives are not made from the same ingredients, and they differ a great deal in many other ways than in quality, as quality is generally understood. You can buy cornmeal that is good, bad or indifferent, but when
Differences you buy explosives you will find there are few which can be classed as of poor quality. Nearly every standard kind and grade is of excellent quality for some particular purpose and condition. And practically every one can be classed as of poor quality for conditions and purposes to which it is not suited.

Nor is the difference one of size of stick or grain, as the case may be, though this is one element. The main differences are ones of strength, quickness or speed of gases, sensitiveness, resistance to cold and to water, density, fumes and cost. Some explosives are suitable for wet work, and others only for dry work; some are adapted to blasting hard, tough rock, others to blasting ground only; some freeze when chilled a little; others can be exposed freely without freezing. And it should be noted that many of the better explosives of to-day have been developed during recent years and are comparatively new. The explosive to buy for any particular work is the best one on the market for all the conditions involved.

Black blasting powder has been known and used for several hundred years, and it is practically the same to-day as it has been for a long time. It is composed of saltpeter or nitrate of soda, sulphur and charcoal. It does not vary in strength, and varies little in other
Explosive properties.
Ingredients

The dynamites and high explosive powders have little or no relation to black blasting powder. They depend for their explosive force on other explosive chemicals the best known of

which are nitroglycerin and ammonium nitrate. It is not necessary in this brief description to name additional explosive elements.

The first dynamite was made in Europe by mixing nitroglycerin with a light spongy earth, and packing the mixture in paper tubes as sticks of dynamite and powder are packed to-day. Nitroglycerin itself is a wonderfully efficient explosive when it can be controlled, but it is so dangerous and unstable that it must be mixed and treated to make it safe enough to handle.

As other explosive chemicals become better understood, it has been found of advantage to substitute materials that are explosive for the light earth used to absorb the nitroglycerin. And more than that, the nitroglycerin itself has been displaced to varying degrees in some of the powders and dynamites by ammonium nitrate and other materials. Few blasting explosives contain no nitroglycerin at all, but many contain only 4 or 5 per cent. of it. Each of these combinations of materials, or formula, has its own peculiarities in addition to variation in strength, all of which information it is well for a buyer and blaster to understand.

The explosives marketed as "straight dynamites" and "straight powders" are made from nitroglycerin. Those made from an ammonium nitrate base are called by many manufacturers "extra" dynamites and powders. Gelatin dynamites and blasting gelatin are nitroglycerin explosives in which the nitroglycerin has been combined with gun cotton. The various special mine, quarry, stumping, farm and other miscellaneous dynamites and high explosive powders on the market are not so named that their ingredients can be determined without a statement from their makers.

The power of an explosive and its violence are two different qualities. The power, or direct strength, is due to the volume of the gases. If a pound of a certain explosive gives, for instance, 1,000 cubic feet of gas when completely detonated or fired, while a pound of another explosive gives 500 cubic feet and a pound of a third gives 2,000, the lifting power of each explosive will be in direct proportion to its gas volume.

But the violence of the gases depend, not on their volume, but on their speed. If they are comparatively slow in forming and in forcing their way out of their confinement they will break out large cracks and escape through them, pushing the material aside. If they are very fast or quick, they will grind and pulverize everything they come in contact with, and throw out the whole side of the confining material, but will not crack it so far.

The matter can be made clear by comparing a push with a blow of a hammer. Both may have equal power, but the effects on a block of wood, for instance, at the point where they are applied are very different. The push will move the object almost without marking it. The blow may move it, but it is sure to leave a mark of greater or less depth, depending on the nature of the hammer and its speed. A still better comparison, perhaps, is that between the blow of a sledge and of light hammer. It is possible to hit a blow of as much power or weight with one as with the other, but the material at the point where the blow lands with the light hammer will be badly dented, or maybe broken. The reason is that the light hammer moves with much greater speed.

In quarries blasters make use of these facts in order to get the rock broken out in pieces of the size preferred. When they want large pieces they use an explosive with sufficient power to break the rock, but, comparatively speaking with a slow speed of gases; when they want small pieces and much shattering, they use an explosive of the same or greater power but with swift and violent gas action.

For each result and for each material a certain power is required and a certain quickness of the gases is best. By way of illustration, take soil blasting for tillage purposes. There is no object in violently grinding the earth at one spot while surrounding earth that might be reached is left untouched. A proper explosive for this purpose is one that will have enough pulverizing action, that will lift and shake up the soil, and that extends its effects for long distances. For an example of the other extreme, take mud-capping rocks. For this work the explosive cannot be too violent in action. The gases, backed up by the rapidly yielding wall of air behind them, must strike the rock a crushing blow in the minimum of time.

Nitroglycerin and ammonia powders and dynamites, for all practical purposes, are of equal strengths when of equal markings. The strength is indicated accurately by percentage figures.

Nitroglycerin explosives are uniformly quicker and more violent in action than ammonium nitrate explosives, and the more nitroglycerin there is in the explosive the quicker it is. The ammonia explosives are not as quick, in any strength, as the corresponding nitroglycerin explosives. Therefore a 50% nitroglycerin powder is more violent than a 50% ammonia powder, and a 20% ammonia powder is much less violent than a 50% grade.

When the object is to shatter and reduce to fine fragments the material to be blasted, the proper explosive is a quick one, while when the object is to lift and shake up the material the best explosive is a slow one. (See table on page 55, also detailed recommendations on pages 22 and 25.) But there are other factors that must be considered.

Nitroglycerin explosives resist water better than ammonia explosives, but if the cartridge wrappings are not broken or opened, ammonia dynamite or powder can be loaded in wet holes with entire satisfaction. The firing should not be delayed any longer after loading than necessary, and it is wise to plan the work so that it may be done at the longest within a half hour after loading. Storage in a damp place will weaken explosives, especially ammonia explosives.

Gelatin explosives resist water very well, and may be loaded in wet holes, or under water, with assurance that they will explode with their full power. Blasting gelatin is entirely water-resisting.

Explosives will freeze, and when in this condition are dangerous, and cannot be fired properly, if at all, with a cap of any kind. They *must* be thawed and they must be handled very carefully if they are to be used. On no account attempt to cut the wrappings, to break a stick, or to handle the frozen explosive in the ordinary way. (See pages 56 to 58 for directions for thawing.)

Regular nitroglycerin explosives are quickest to freeze. Others, known as "Low Freezing," will stand much lower temperatures without showing trouble in this respect.

Freezing Ammonium nitrate explosives also will freeze, but not quite so quickly as nitroglycerin explosives. They too are made on both regular and low freezing formulas. The low freezing ammonia will stand more cold than the low freezing nitroglycerin.

The regular explosives will freeze at temperatures of 45 to 50 degrees. The low freezing explosives will not freeze and become solid till the thermometer gets down to at least 25 degrees, and in practice many of them can be used right out in the open without any trouble when the temperature is down to zero and below. The length of time the powder is exposed to the cold has much to do with its freezing.

The safety point for both low-freezing explosives and regular explosives is not a matter of rule, but of watching the explosive. When high explosive

powder or dynamite is frozen, the sticks will be hard, and when it is partly frozen they usually will have a mottled appearance on outside of the paper wrappings. The hardness may only be in spots. When not frozen, the sticks should be a little soft all over. No explosives should be handled much, cut, punched, rubbed, broken or loaded when they are frozen. They cannot be exploded satisfactorily and such acts are dangerous.

In cold weather always use the low freezing grade of explosives, for the regular grades may freeze in the holes before they can be fired. It is a good plan to use the stronger caps, say No. 8 (see page 64) in cold weather. When a charge of explosive is chilled but not frozen it can be fired satisfactorily by a heavier impulse (blow and heat) than ordinary, such as a fresh No. 8 cap gives. The low freezing explosives do not differ in action from the regular explosives, and are just as efficient.

The gases of explosives naturally are more or less objectionable when breathed. Some of them are poisonous, others are merely disagreeable. When explosives are used out in the open the gases are taken up by the air so quickly that none of them give any serious trouble, though they do cause headaches. It is only in tunnels and deep shafts where the air is confined that the matter of fumes is important, not on farms.

Special explosives have been developed for tunnel and mine work, but they are not important in agricultural work. The only fact about fumes worth knowing in farm blasting is that nitroglycerin explosives either in the form of their gases or when absorbed through the skin will cause headache somewhat quicker than ammonia explosives. The so-called fumeless explosives always cost more than any ordinary dynamites and powders and are not suited to farm work. Farmers will do well to buy grades of explosives suited for their special purpose.

Other Properties

Dynamites and most high explosive powders are light-colored materials that look like fine, sticky sawdust, and they always are packed in "sticks" made with cylinders of tough paper. These sticks vary in diameter and length. The standard is $1\frac{1}{4}$ inches in diameter and 8 inches long. This is the size carried in stock by dealers and in the magazines of the makers. You can get special sizes of sticks if you need a considerable quantity, varying from $\frac{7}{8}$ of an inch in diameter to 4 inches. Sizes other than the standard $1\frac{1}{4}$ by 8 inch may cost more per pound than the standard owing to higher packing cost.

Appearance of Explosives

Dynamites and high explosive powders are packed in wooden boxes containing 25 pounds or 50 pounds, as you prefer. A 50-pound box of 20% ammonia powder or dynamite will contain about 105, $1\frac{1}{4}$ by 8 inch sticks. If of 20% nitroglycerin, it will contain about 98 sticks. If of gelatin dynamite, or blasting gelatin, it will contain about 88 sticks.

A word should be said here about the cost of explosives. No quotations can be given because the prices vary in different parts of the country and from time to time. The ammonia products usually are cheapest. The cost of course follows the percentage strength, the low percentages cheaper and the high percentages dearer. Gelatin explosives cost about the same as straight nitroglycerin explosives. The special explosives for use in mines, tunnels, quarries, railroad construction work, etc., often cost more than the explosives recommended here for farm work.

In buying explosives look first to getting the one that is best suited to the work to be done, and aside from that the cheapest one. There

would be no object in using a straight nitroglycerin or a gelatin explosive when one of the ammonia farm powders would do the work, for the former explosive cost much more than the latter.

To avoid "explosive misfits" it is well to consider carefully the nature of the material to be blasted, the conditions of weather, water, etc., and the results wanted. The kind of explosives to use depends on these factors. Keeping in mind the facts mentioned in preceding paragraphs, the reader will see that there is a type of explosive made for almost every condition and kind of work, and will understand why one will not suit the work of another.

As the briefest and clearest way of giving general suggestions for the type of explosive best for different agricultural work, a table follows: (Detailed recommendations are given on pages 21 and 25.)

Explosives Recommended for Different Work

| | |
|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Stone blasting—mudcap. | Straight nitroglycerin or ammonia dynamite, 50% or 60%. |
| Stone blasting—undermine. | To break, same as for mudcapping; to throw out, use any dynamite or powder of 20% strength. |
| Stone blasting—blockhole. | To shatter well, any high percentage dynamite or powder; to break into large pieces, 20% ammonia dynamite or powder. |
| Soil blasting—for subsoiling and for tree planting. | 20% ammonia dynamite or powder. |
| Ditching—electric firing. | 20% to 40% ammonia explosives; (nitroglycerin is equally effective); in loose dry ground, high percentage nitroglycerin explosives. |
| Ditching—transmitted detonation | Straight nitroglycerin dynamite or powder, 50% strength. |
| Stump blasting—in medium and heavy soils, wet or dry | 20% nitroglycerin or ammonia dynamite or powder. |
| Stump blasting—in dry sand and other light soil. | 50% nitroglycerin or ammonia dynamite or powder. |

If you are in doubt as to the best explosives for your particular work it is well to write to the manufacturer you prefer, asking which of their grades and brands would be most suitable.

Detonation

It is well known that black powder is fired by a spark, and that dynamites and high explosive powders cannot be fired by a spark but require a shock and heat. It is not so well known that there are great differences in the nature and effect of the explosion of any powder or dynamite, due to variations in the way it is fired.

An explosion of powder or dynamite is the result of a very sudden creation of a great volume of gas from a smaller volume of powder. The kind and amount of gases produced by any

high explosives depend on the kind and amount of shock used to fire the charge, and on its confinement.

The effect of lighting a piece of unconfined dynamite with a piece of fuse without a cap on, is that the dynamite will burn fast without exploding and make a dense smoke which has a bad smell and produces severe headaches. This is simple combustion. If the piece of dynamite is confined closely and lighted in the same way it will explode, but will give off similar bad fumes. If a weak cap is used on the fuse, or the dynamite is set off by a fall, the dynamite will be partially detonated, and explode with considerable force, but it still will give off the bad fumes and smoke. The same piece of dynamite fired with a No. 6 or 8 cap will be completely detonated, and will explode with great violence and force, even when unconfined, except by air, and will give off very little smoke.

The last-named explosion is detonation. It is produced by a violent shock in connection with intense heat. Nitroglycerin is 5 times as strong as black blasting powder when exploded by fire, and 10 times as strong when detonated. This explains the enormous force given by detonation as compared to simple explosion.

But detonation itself is no set thing that always takes place the same. There is good, or complete, or full detonation, and there is partial detonation. In case of incomplete detonation, or any detonation at a less speed than the greatest for any particular explosive, the gases formed are not what they should be. For one thing, they are more noxious or poisonous. The more powerful and severe the blow delivered by the cap, the more quickly does the chemical action take place in the explosive. It is only when high explosives detonate with their greatest speed that their maximum power is generated.

Air spaces about the cap in the stick of explosive cushion its blow and weaken detonation. It is the nature of the initial detonation of the powder right around the cap which governs the nature of the explosion of the whole charge. A blaster should understand the importance of setting up *complete* detonation in order to get the greatest amount of force out of explosives. Sometimes explosives lose as much as 20% of their effectiveness when fired with weak caps. Lack of confinement has a similar effect. Sixty per cent. dynamite poorly detonated is less effective than 40% well detonated.

When explosives become chilled it is difficult to detonate them properly with the usual cap, hence the advisability of using a very strong cap in cold weather—a No. 8. Many of the holes are frequently loaded for some time before firing, and even if the powder is soft and normal while charging, it afterwards becomes somewhat chilled in the cold ground.

Throughout this and other bulletins in this series, the terms caps and electric blasting caps are used in speaking of the exploders used to fire the charges of dynamite or powder, although in the field and among manufacturers the same articles are called by the terms "detonators," or "electric exploders."

Cap Means Detonator

Thawing Explosives

It has been pointed out (on page 51) that regular explosives chill or freeze at temperatures of 45 to 50 degrees. With the increase in the number of low freezing explosives that seldom need thawing, the necessity for doing the thawing on farms is not as frequent as it used to be.

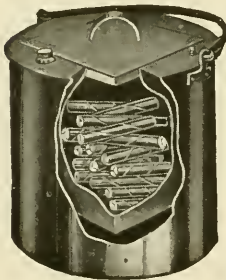
Frozen dynamites and powders are dangerous materials, and whenever the temperature is near the freezing point for them, the sticks should be

inspected before using to see if they show any of the hardness that indicates chilling. If so, handle them very carefully till they are thawed. Dynamites and high explosive powders will be a little soft to the pressure of your thumb when they are not frozen.

Frozen Explosive

Frozen explosives are dangerous because they are very much more easily exploded in the course of ordinary handling. They are more sensitive to friction and to blows of tools. The sticks may explode when dropped to the ground or floor, when sticks are broken in two, when wrappings are cut with a knife, when cap holes are punched with a stick, or when they are shoved into a hole with a tamping stick. At the same time they are so much less sensitive to the direct shock of a detonating cap that they cannot be fired properly with a cap. Therefore the rule must be laid down that frozen sticks of high explosives never must be cut or ruptured or used until they are thawed.

When nitroglycerin freezes it crystallizes, therefore the nitroglycerin in dynamite or powder tends to separate from its absorbing materials into small crystals. When the dynamite is thawed slowly with sticks lying on their sides, the nitroglycerin is reabsorbed as fast as it liquefies. But when thawed too fast, the nitroglycerin is liable to run out of the sticks before it is reabsorbed. Quick thawing will damage explosives a great deal more than they would be damaged by freezing followed by long, gradual thawing.



One type of thawer on the market.

Thawing is a dangerous operation when not done right. It probably is correct to state that more accidents with dynamite have occurred in the course of improper thawing than for all other reasons put together. At the same time proper thawing is entirely safe.

Two of the most frequent causes of accidents while thawing explosives are in putting the sticks into water or steam, and putting them on hot stoves or stones. Water, and especially hot water, forces the nitroglycerin out of the sticks. The free nitroglycerin goes to the bottom, and explodes at the time of the first increase in heat, or first light blow. When sticks of explosives are laid on hot material the nitroglycerin also runs from the paper wrappings and drops of it fall to the stone or metal. This almost always causes an explosion. **Causes of Accidental Explosions** At about 350 F. degrees of heat, which is only a little more than that of boiling water, the nitroglycerin will explode without a shock

Examine your explosives a day or so before you are ready to use them, and if they show that they are frozen, proceed to thaw them in one of the following ways: Use only a *DRY* warmth. Use no temperature higher than is comfortable to the hand, or the limit may be set at 100 or 110 degrees. Use no heat of any kind that cannot be controlled with certainty. If you do this you will be safe.

Every large maker of explosives will supply thawing apparatus that is safe. Sometimes this is a double kettle arranged so that the sticks of explosives can be placed in the inside vessel, while the outside vessel can be filled with warm water and a blanket can be spread over the top. Other more elaborate thawers consist of a vessel containing watertight tubes just big enough to hold

sticks of explosive, running through a space to be filled with warm water. The catalogs describe these ready-made thawers in detail.

Home-made thawers can be arranged with two buckets, one small enough to hang inside the other. Put the sticks inside the small one and warm water around the outside, in the big bucket. Another good way is to put a five-gallon can of warm water inside a barrel, or box, and pile the sticks of explosives in the barrel around the can. The top of the barrel should be covered with a blanket. Or put the water in the barrel and the explosives in a can or bucket. A small closet of course can be used instead of a barrel. A can of warm water can be set inside a magazine to keep the temperature up.

The old-fashioned manure pile method of thawing is reliable and safe, though a good deal of trouble. This consists in burying a box somewhat larger than a box of explosives in fresh horse manure, and placing inside it the box of explosives to be thawed. A foot or more of manure must cover the box, and a small pipe or tube should be inserted for ventilation. The manure must be fresh. Allow at least 10 hours to thaw a box of dynamite or powder in this way. Twenty hours is better.

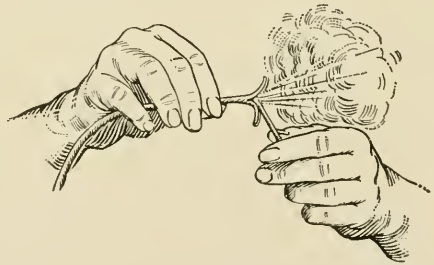
The box of explosives can be taken into any warm place that is dry, but if this is a building you must take your own risk of fire and accident. Watch the box and the sticks to see if the freezing and thawing causes the sticks to leak free nitroglycerin. If any of this leaks out of the stick and gets on the floor it must be washed up according to directions in paragraphs on storage. (Pages 67 and 68.) The sticks of explosives had better be piled irregularly rather than in tiers, for thawing. They will rise in temperature quicker in this way. They always must lie on their sides rather than stand on end.

Sticks on Sides

Electric and Fuse Firing

The very best way to light fuse is to split the end for an inch or less, and stick the burning head of a freshly scratched match right against the exposed powder at the head of the split. This will light the fuse even in a strong wind.

Where there are very many fuses to light in succession, as in subsoiling, it sometimes is of advantage to use a gasoline or other torch, holding



Fuse and Cap Firing

the hot flame under the fuse for an instant. Whatever the method, do not leave till you see the fuse spitting sparks and smoke swiftly and regularly. Further discussion of fuse firing, except as to its adaptations, is not needed.

Farmers who have only a few stones or stumps to blast, or who are planting a few trees or doing a little subsoiling, will not need any other method of firing than by caps and fuse. Ditch blasting in ground not water-soaked demands electrical firing, while the blasting of large stumps, particularly if green, and in sandy soil, as well as the blasting of large rocks, is made easier and cheaper by electrical firing. For large amounts of almost any blasting except that of tree beds, subsoiling and very small stumps and isolated small

Electric Firing

boulders, the purchase of an electric blasting machine and the necessary wires is justified by the advantages of the electric methods of firing.

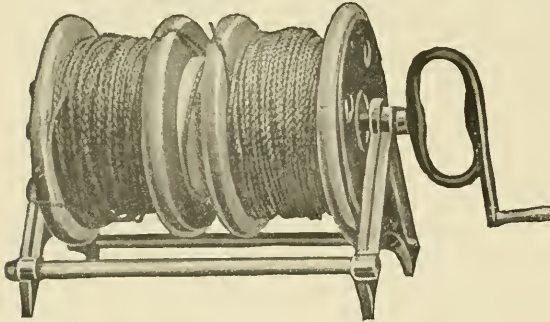
The primary reason for the superiority of electric firing over fuse firing is that several charges may be exploded at once; the different charges will increase

the efficiency of

Advantages each other.

Thus in ditching,

you can fire many charges in a row and



A good reel for leading wire.

make a perfect ditch. In stump blasting several small charges very often will take a stump out better than one large charge, and in orchard, and garden subsoiling the simultaneous blasts frequently are of advantage.

Electric firing is more certain when the charges are under water. The danger from misfires due to moisture as well as from some other cause is reduced. Should misfire occur, you are safe in going to the charges as soon as the wire is disconnected from the blasting machine. With a fuse you must wait some hours to be safe. When several charges, as for instance, several boulder blasts are to be fired, you can make one trip to safety do for the lot, instead of having to travel back and forward for each shot. Finally, the intelligent and careful use of electric firing, with its possibilities of two or more small charges doing the work of one large one, and its other economies, will save considerable explosives.

All the makers of explosives supply electric blasting machines. The machines are small boxes of wood or metal, containing a modified magneto with a handle on top that you either push down or pull up, depending on the make of machine, to operate and to fire the charges. The machines are made in various sizes and capacities to fire 3, 10, 30, or more charges at once. The 10 charge machine weighs about 10 pounds. Full directions for operating and caring for the machines always accompany them.

For electric firing, in addition to the machine, you will need electric blasting caps, connecting wire and leading wire. The leading wire is copper wire large

Electric Machine



Duplex Leading Wire. (Actual size.)

enough to carry the amount of current required for the number of charges to be fired simultaneously. It is covered with insulating material, and is made strong and durable to stand much use. To make the circuit from the blasting machine to and through the charges and back again, you must have two strands of leading wire. It comes from the

Wiring

explosive makers in single-strand form, which must be doubled, and in what they call duplex form, which has two strands of insulated wire twisted together or wrapped together under one cover.

The two small copper wires that are fixed in the electric blasting caps (see page 64) should be long enough to reach out of the holes. They may be bought in a variety of lengths, but 4 or 6 feet are regarded as standard.

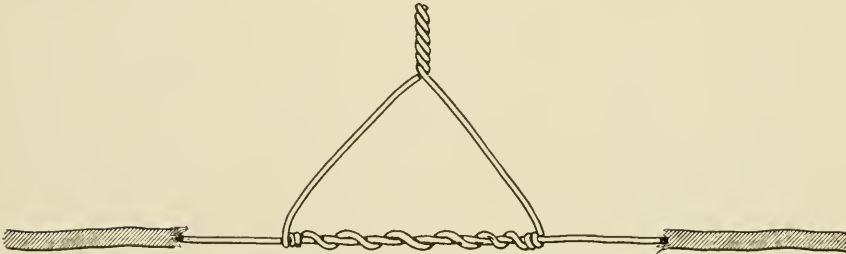
If the charges are close enough together so the wires can be connected, no connecting wire will be needed; but whenever the distance between is more, the charges must be connected, and connecting wire is the right thing to do it with. There is no particular limit for the distance between charges that may be connected for firing together, up to 25 feet or more.



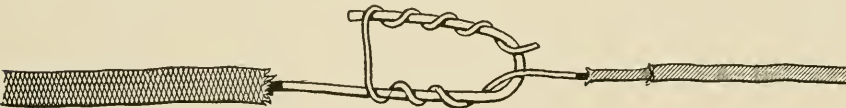
Connecting wire comes on spools.



A very bad connection—a cause of misfires.



Good connection for electric cap wires.



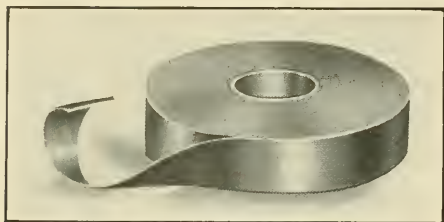
Good connection for small cap wires and large leading wire.

The diagrams in these pages will show how to make electric wire connections. Cut away the insulating on the wire ends and wrap the ends together tight. Wrap them for two inches. Looping the wires will not do. Be careful to scrape with a knife or stone the wire ends to make them bright before wrapping them together. Corroded or dirty connections are a cause of misfires.

Wire Connections

If the leading wire gets broken and must be spliced, solder the connection after wrapping the ends together, then wrap the joint with tape to

insulate it. Ordinary tire-tape is good, but a better way is to wrap the joints with special rubber tape underneath and to cover this with the tire-tape.



Tape for wrapping joints and broken insulating.

When only one charge is to be fired, connect the ends of the 2 strands of the leading wire to the 2 electric blasting cap wires and connect the other leading wire end to the blasting machine posts. The connection with the electrical blasting machine should

be made the last thing before firing, after you are sure that the charges are all ready and after every person and animal is out of the way of the flying pieces.

When the blast is all connected together ready to fire, except attaching the leading wire to the machine, give the handle of the machine one or two light strokes, to make sure that it is working smoothly and to charge the magnets. Then attach the leading wires to the binding posts on the machine, making sure that both the binding posts and the wires are bright and clean where they come together. Raise the handle of the machine to its full height and push it down with speed. When the handle starts on its downward stroke, the pinion immediately clutches the armature and starts the generation of current. The current, growing stronger as the stroke proceeds, causes considerable resistance toward the end of the stroke. The current generated is directly in proportion to the speed with which the handle is pushed down, especially just before reaching the bottom. Any let up toward the bottom will cause a drop in the current and may result in misfires. Therefore, make it an invariable rule, whether the shot be large or small, to bang the handle down hard and carry the stroke with all possible speed to the bottom. Try to knock the bottom out of the box. Machines which operate by the twisting of a handle must be handled equally quick.



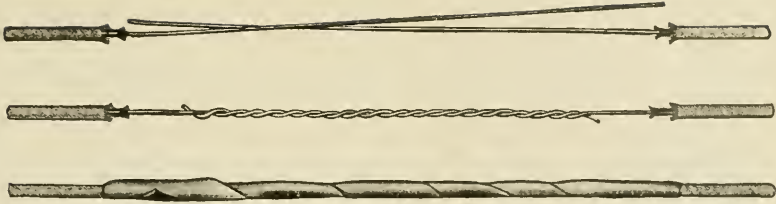
Very best wire connection, ready for soldering if need be. (Excellent for leading wire.)

When more than one charge is to be fired the different charges must be connected together. The diagrams will help you to understand how this should be done. For nearly all agricultural blasting the connection in one series is the best—that is, connecting each charge to the next one and so on until they are all joined, with one loose electric blasting cap wire from the two end charges of the series. (See diagram A and D, page 62.)

Once in a while, where the series is long and the charges are in a line, you can arrange to have the 2 loose wires at the same end of the series by making the connection, not to each next charge in the row, but to the one beyond and at the farther end doubling back and connecting the missed charge. Do not use this method where it involves many splices with connecting wire.

Connections in parallel sometimes are desirable in the case of ditches, or other extensive blasting. To make them run a piece of wire away from one leading wire strand along the lines of charges and connect one wire to each charge. Then run another similar piece of connecting wire connected to the other strand of leading wire, and attach to it the other cap wire of each charge.

But to fire charges by means of parallel connections takes so much electric current that a blasting machine cannot be used. Generally speaking, parallel



Method of wrapping wires together to make electrical joint, and of taping joint.

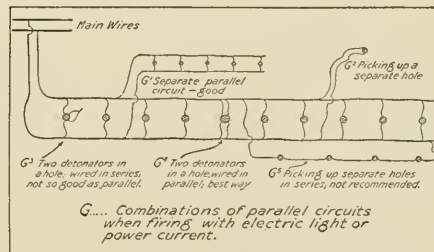
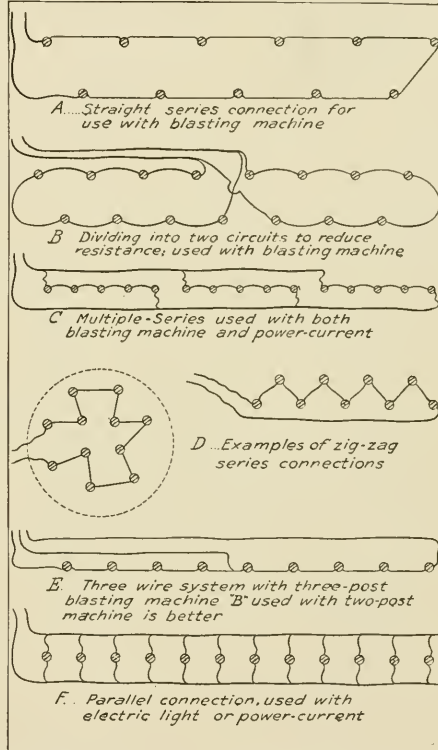
connections require current from an electric light or power plant. If your work is such that the charges cannot be connected in series or that parallel connections are desirable, it is well to communicate with an expert or authority on electricity for special suggestions and advice as to how best to fire your charges.

In a bulletin of this size it is impossible to give a comprehensive statement of

Current Required electric firing. But to give some idea, it can be stated that an electric blasting cap requires 1 to 1½ amperes to insure firing. This amount of current will fire one cap or many in a series. To force this amount of current through the wires requires a certain voltage, the amount depending on the size and length of all the wires, and on the joints. One bad or poorly wrapped joint will increase the resistance of the circuit more than several caps. The voltage of the current required to fire any circuit usually can be computed by an expert when the details of the wiring system are explained to him.

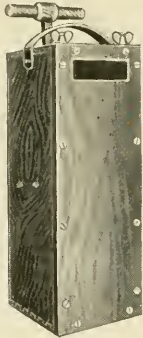
When charges are connected in parallel, instead of series, or in multiple series (see diagram C), each circuit requires 1 to 1½ amperes of current. That is, each cap requires 1 to 1½ amperes when connected in parallel. The voltage required, of course, depends on the resistance of the wires. A very much greater current than of 1 to 1½ amperes will do no harm; in fact it is desirable.

Electric blasting machines are constructed to give a sufficient amperage and voltage for



Ways of connecting up charges for electric firing.

firing properly the number of caps specified as the capacity of the machine when connected in a series. If too many caps, or more than usual wiring is connected to any machine, misfires will result. Other current can be used in place of that supplied by a machine, provided it has enough and not too much amperage and voltage. Too great a current will burn out wires without firing all the charges. Too little current sometimes will do the same, or it may do nothing. In emergencies dry cells or wet batteries can be used by skillful operators to fire a few charges, when great care is taken to have the wiring arranged for the purpose. Before attempting to fire charges with batteries of any kind, learn the amperage and voltage of their output and see that your shots come within their limits. The use of batteries is more expensive than the use of electric blasting machines.



Two post electric blasting machine—push down type.

Bare connections at the charges or back along the leading wire should be raised off the ground by stones, sticks or piles of dirt placed under insulated parts of the wires at each side of the splice. During a thunder storm, do not stand near any of the charges that have been connected. Avoid dragging the leading wire over bare or rough ground as much as possible, and particularly avoid kinking it. Be careful not to break or tear or scratch the insulating of any wires.

Do not attempt to fire through a long length of leading wire wound in a coil or on a reel. The induction, leakage or short circuit of current in the coil of wire causes the blasting machine to deliver a slow discharge, which is fatal to proper firing. Leading wire that is watersoaked or that is covered with mud will lose a considerable part of its current.

Misfires

Nearly half of the accidents noted each year in blasting operations are the result of attempting to examine misfires too soon. If misfires occur with fuse firing, stay away from the shot at least 2 hours. It is better to wait until the next day, for the spark may linger 24 hours and still cause an explosion. (See page 59.) Rock and stump misfires are to be avoided especially. When you are firing the charges electrically, you may approach the shot with entire safety as soon as the lead wire is disconnected from the blasting machine.

Misfires are due to the following named causes. The remedies for them are care in preparing the charges and in loading, the details of which are given in the proper chapters.

With cap and fuse firing, misfires are caused by having the end of fuse pulled back a little from the bottom of the cap, by crimping the fuse too tightly with a groove crimp and shutting off the spark, by damp or wet fuse, especially at the end of the cap, by defective cap, by the cap getting pulled out of the explosive, by kinked, damaged, broken or pinched fuse, by failure to light fuse. A great many misfires were never fired at all. With electric firing the reasons for misfires may be damaged wires in the hole, causing short circuits, defective caps, overloaded blasting machine, cap pulled out of explosive, bad wire connection at some point, or broken wire.

If you find after due time that for some reason the charge cannot be fired by lighting the old fuse or by sending current through the wires, you must deal with a real misfire.

The best thing to do is to put in another, lighter charge in a new hole made 6 to 12 inches of the original one. The explosion of the new charge will explode

the old one. Never touch the tamping in the old hole unless you know just how deep it is, or how many inches of it there are above the charge. Once in a while the tamping may be dug out of a blockhole misfire. It seldom pays to do this in stump blasting, and never in ditching, or soil blasting. At best it is a dangerous operation. Mudcap charges can be opened and new primers inserted without danger or difficulty. This should be done by removing part of the mud at another point, and inserting a new cap and fuse, or electric blasting cap, as the case may be.

Cap (Detonators)

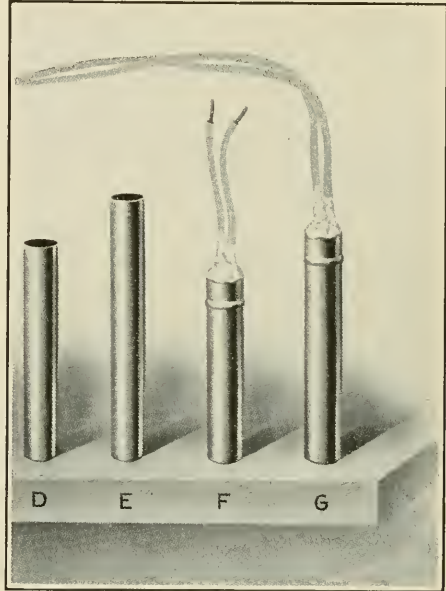
Blasting caps are little copper tubes closed at one end, $1\frac{1}{2}$ to 2 inches long and something less than a quarter of an inch in diameter. At the bottom is placed several grains of a high explosive that is very powerful and exceedingly sensitive to heat, shock and friction. This high explosive usually is fulminate of mercury, but often is other material. They are packed in small tin boxes, open end up, usually 100 to the box.

The purpose of the blasting cap is to supply the shock and heat necessary to detonate the charge of dynamite or powder to be fired. If it were not for safety in handling blasting explosives, they all could be made as sensitive as the material in the caps. But such explosives would be impossible to handle without accident. In fact, it would be impossible to handle the little bit of explosive in the caps if it was not protected by the copper shells. Even at that caps must be kept free from jars and from heat and sparks to avoid premature explosion.

The strength of caps is carefully regulated by the makers to fire the dynamites and powders on the market. The explosive material with which the caps are loaded is such as will deliver a shock and a degree of heat of the strength and violence required. The caps are numbered according to strength. All dynamites and powders used for agricultural blasting require at least a No. 6 cap. If they are chilled a little, but not frozen, they require No. 8. It is the part of wisdom to use No. 8 caps all the time if you can get them. They give you a margin of strength should moisture or other causes weaken them in storage.

Blasting caps must be used with fuse. And before they are inserted in the stick of explosive they must be fixed to the fuse properly. (See pages 43 to 46.) It is the spark which travels down the fuse that fires the cap.

Electric blasting caps are made on the same principle as ordinary blasting caps. They have the copper tube, the explosive at the bottom, etc., but they differ in the way this explosive is fired. Instead of by a powder spark they are fired by a red-hot wire that is heated by an electric current.

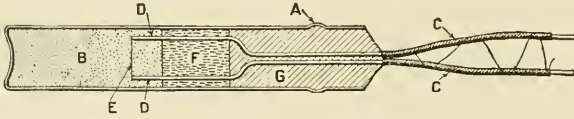


D and E are ordinary blasting caps ; F and G are electric blasting caps, often called fuzes.



Electric blasting cap or fuze.

Every electric blasting cap has fitted in it 2 small copper wires, which must be considered part of the cap. Down near the bottom of the cap is a delicate bridge of finer wire. The entire arrangement is held in adjustment and sealed by a casting of sulphur-like substance.

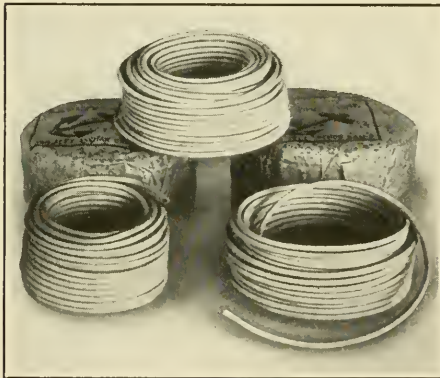


The interior construction of an electric blasting cap or fuze.

For fuse blasting you must use regular blasting caps, and for electric blasting you must use electric blasting caps. It is impossible to substitute one for the other. Never pull at the wires in an electric cap. It is dangerous and may loosen or throw out of adjustment the arrangement of wires inside. And never try to dig out the wires of an electric cap or to dig or to punch the explosive in the bottom of a blasting cap.

Fuse (Safety Fuse)

Fuse is used for firing black blasting powder and for firing dynamite and high explosive powders through the medium of a cap. It is made by enclosing within a covering a train of special black powder and an inflammable cotton string. The spark runs down this powder train.



Fuse as it comes in rolls.

The powder used in fuse is specially made for the purpose, is pulverized and is highly compressed by the covering of the fuse. The covering itself is made of varying materials, depending on the conditions under which the fuse is to be used. For dry work it is only enough to hold the powder in place and to keep the powder train from getting broken. For damp and wet work it is made waterproof by increasing the number of layers in

the covering and by adding varnish, coal tar, as other waterproofing material.

There are many brands of fuse on the market. In buying fuse you must bear in mind the character of your work. For work that is entirely dry you can use ordinary cotton or hemp fuse with satisfaction, if it is large enough to fit a blasting cap snugly.

For work in damp ground, use a fuse in which the cotton or hemp is covered with one layer of waterproof tape or other material. This is called single-tape grade or may be known by brand name only. For work where the ground is wet, such as in stump and stone blasting in damp or wet weather, use a double-covered fuse—fuse that has two layers of tape or other material over the cotton

covering and waterproofing material added. For work where water covers the charges it is best to use fuse with three layers of tape or other material and full waterproofing. This is called triple-tape fuse or may have special brand names. When buying fuse for general farm work, it is well to get a waterproof grade, since it can be used for both wet and dry work.

Most reliable fuse burns about 2 feet per minute when in perfect condition.

Rate of Burning

If it becomes damp, it burns much slower. Cases have been known where the spark smoldered in damp fuse for hours without traveling more than a few inches. Another source of uncertainty is where fuse has been pinched. It may take the spark a minute or an hour or a day to get past the pinched point.

When fuse is cold, it is hard and brittle, and may crack open when unrolled. If it gets too warm, its waterproofing material may penetrate to the powder train inside and ruin it; or the covering may first soften and then harden, in this condition breaking as though cold when unrolled. If grease is allowed on the cover it may combine with the waterproofing and ruin the powder inside.

Handling Explosives

Dynamites and powders in boxes can be hauled freely in spring wagons. You should see that no bolt heads or other metal parts project from the wagon boxes to strike the boxes of explosives. Sweep all dirt out of the wagon. Have the beds clean or covered with straw or blankets.

Go over your wagon and harness before you load dynamite to make sure they will not break down while you have the explosive aboard. Be sure you have the hitching straps or tie-ropes along, and do not leave the horses standing without tying them securely. Break no colts while hauling explosives. If you use a motor, stop it and set the brake tight before you leave the load. In driving through a town stay away from dangerous crossings.

Keep the sticks of explosive in their original boxes until you are ready to use them. Don't have them around loose. In carrying them to the field, use a wood basket or a box and not a metal bucket. Always protect explosives from all possibility of being reached by falling sparks or from match heads or other source of fire. Rain, hot sun and the like must be kept away from explosives. Use care to lay sticks or set the boxes or baskets containing explosives where they will not fall down, be blown over by wind or knocked over by careless people or by animals. Cattle will eat sticks of dynamite, or powder, because of their sweet and salty taste. The explosive will make them sick, sometimes kill them.

Since nitroglycerin often will cause headache when absorbed through the skin it is best to wear gloves when handling the sticks. For this same reason some people punch holes for caps in the sticks with a piece of wood rather than with the handle of the cap crimper.

Caps should not be carried in the same basket or box as explosive, but should be carried separately. Take only enough along to do the work in view and carry them in the tin boxes they come in. Many serious accidents have been caused by blasters having loose caps in their pockets during work or afterwards. Sooner or later a chance jar is likely to set them off. When several caps have been taken out of the little tin box in which they come the rest will be loose and will rattle about. This should be stopped by filling up the empty space with paper.

The handling of caps is not dangerous provided you do it intelligently and with care. *Keep them safe from any jars or heat.* You can sometimes do

Handling

many foolish things with dynamite and powder without serious results to yourself, but not with caps. Letting a cap fall to the ground or floor likely will cause it to explode. For this reason you should keep the caps and explosives apart, in hauling, storing, and handling, bringing them together only at the last minute before you prepare the charge to be loaded in the hole. One cap can produce an explosion powerful enough to tear your hands off.

Electric blasting caps must be handled with the same care as regular blasting caps. All caps must be protected from dampness during handling. No trouble will be experienced if you use common sense at every turn, but thoughtlessness and carelessness in the handling of explosives will cause disaster. Bear in mind that when an accident happens with an explosive there is no time to save yourself, and no afterthought will prevent serious injury to you. Forethought is the thing with explosives. In an explosive you are handling an enormous strength. The fact that it occupies small bulk now should not interfere with your imagining it as an enormous engine with power enough to crush you easily, but under entire control if you do your part right.

Storing Explosives and Supplies

The storing of dynamites and powders on farms offers no serious problems, though it may call for some shifting of arrangements to meet proper requirements. The explosive must be kept dry. They should be kept cool. This means that any ordinary temperature of the air is all right, except that in hot weather the room where the explosive is kept should not get warmer than 80 or 90 degrees. If it is properly ventilated day and night it will not. Probably the best common storage place for explosive is in an outbuilding under the floor of which the air circulates freely and with a ceiling between the room and the roof. It should be strong, and should be provided with a lock. A responsible person should have charge of the key at all times.

The explosive should not be kept in a garret, because the hot sun beating down on a roof will raise the temperature under the roof away past the 100 degree mark.

Dampness is injurious to explosives, as noted on page 44, and dynamites and powders must be kept where moist air will not surround them. The ideal storage would be fireproof, but since this is out of the question on the average farm, the best that can be done in that respect is to guard against fire. It is well to make sure that the explosive is out of reach of any stray or malicious bullet that might be fired into it.

Look to your insurance policies and see whether they provide against the storage of explosives in any of your buildings. Store the explosive in a building not covered by the insurance.

Where large quantities of explosives are to be stored as a regular thing, or for any length of time, it is advisable to consult the makers of explosives or others experienced in their handling in regard to the location and construction of a magazine. A magazine can be set up cheaply and can be made fireproof, bullet proof, thief proof, well ventilated, dry and safe in every way. It should be built of brick. Any explosive maker will furnish plans without charge. In any case explosives should be stored at least 50 yards away from any other buildings and from roads or railroads.

Magazines

Blasting caps of any kind must not be stored with dynamite or powder.

Fuse is not explosive and can be stored with dynamite or powder.

Caps Blasting caps are even more subject to damage by moisture than explosive and must be stored accordingly. Caps must not be allowed to become heated.

A statement of the ways in which explosive deteriorates will help in selecting a proper storage place for it. In temperatures higher than 80 degrees troubles may begin. Long continued temperatures of 90 to 100 degrees may cause the nitroglycerin to leak out of the absorbing material and to gather inside the wrapping on the lower side of the sticks, or may even cause it to leak out of the wrappings through the

Deterioration

boxes and to the floor.

Strict watch should be kept of the sticks and the boxes to catch any such condition. If leakage occurs, turn the explosive over and reduce the temperature. Burn the empty boxes one or two at a time out away from buildings, and scrub the floor where the leakage occurred with a strong solution of sal soda. This will decompose the nitroglycerin. If it becomes necessary to destroy a little explosive without detonating it, the job can be done by immersing it until dissolved in such a solution, stirring it gently with a wood paddle.

If the sticks feel smeary it is possible they are leaking. The test is to lay them on white paper for a little while. If they are leaking they will stain the paper, otherwise not.

At a temperature of 105 degrees nitroglycerin explosives will lose 10% of their strength in a few days by evaporation. Repeated freezing and thawing is bad for explosives, especially if the thawing is rapid. Slow thawing will not damage them much. After explosive once is frozen and thawed, it will freeze much easier again.

When stored for many months explosives are liable to decomposition of some of their elements, especially if they get damp or too warm. One of the marks of this is greenish stains inside the stick wrappings. No length of time can be stated for the keeping of explosives, because it practically all depends on conditions. Under favorable conditions most dynamites and powders will remain in good shape for years. Again, a month of improper storage will ruin them and make them dangerous to handle. They develop troubles sooner in the light than in the dark.

Deteriorated explosives are likely to be dangerous—far more so than normal explosive. Keep watch over what you have in stock. Maintain proper conditions as far as possible, but if they show troubles do not hesitate to condemn them.

Shipping Explosives

The shipping of high explosives is controlled by the Interstate Commerce Commission, and the rules and regulations are very strict and rigid. Most of them are embodied in an Act of Congress of March 4, 1909, and violations are punishable with fines of not more than \$2,000, or imprisonment for not more than eighteen months, or both. The person making the shipment is responsible.

A copy of the rules and regulations can be secured from the Bureau of Explosives, Underwood Building, New York City, or can be read at any freight station where there is an agent.

The rules provide that no explosives (other than certain exceptions named) shall be carried on any train, boat, trolley, or other vehicle carrying passengers

for hire, and that no explosives under deceptive or false markings or understanding shall be delivered to a common carrier; and further, that all other regulations shall be complied with.

In shipping by railroad no caps or detonators of any kind can be sent in the same car with explosives. In practice the railroads usually send them by another train, which works out to be another day in the cases of nearly all shipments. This is responsible for some delay in delivery of explosive shipments. Do not expect to have explosives come through as quickly as you would other freight.

Explosives cannot be shipped by express or by mail, but are sent by freight, the same as groceries or dry goods. The railroad company is required to place the packages in a certain way inside the car and to brace them with lumber. In case of car-lot shipments the shipper must furnish this lumber and do the bracing.

The regulations provide that railroads must have 24 hours' notice of shipment of explosives, *and that shipments must be removed from the receiving station within 24 hours of their arrival there.* The packages must be plainly stenciled with the name of shipper and consignee, and bills of lading must conform with certain specifications.

Empty boxes which once have contained explosives must never again be used for shipments of any kind. Farmers who have attempted to ship vegetables or other farm products in such boxes have unwittingly gotten themselves into trouble on account of this regulation more than once.

Danger and Safety

Modern explosives have been developed to the point where they need not be feared by anyone who handles them intelligently. Speaking in a comparative way, they may be used with no greater dangers than there is in the using of horses, mowers, traction engines, sawmills, or other farm equipment, or than there is in using shotguns or rifles.

The general use of explosives on farms is so new that many people distrust them more because of their newness than from a clear understanding of any actual dangers their use may hold. A review of what the dangers are may help users of explosives to avoid them, and may help to build up the reader's belief in the *safety* of explosives.

There is some danger in the handling and transporting of explosives, but it depends very largely on the exposure of the dynamite or powder to heat, flame, sparks, blows and friction. The directions say to keep explosives dry, to keep them at a temperature less than 90 or 100 degrees F., to keep them safe from sparks, and to avoid blows and shocks. If these directions are followed there will be few accidents.

Probably the most common cause of accidents with explosives lies in violation of some of these primary rules while thawing frozen sticks of dynamite or powder. Freezing makes the high explosive less sensitive to the simple direct shock of a blasting cap, unaccompanied, as it is, by any friction. But at the same time freezing makes the explosive more sensitive to friction in any form.

For this reason, though a frozen stick of dynamite cannot be fired properly by a blasting cap, it is very likely to be fired prematurely by a chance light blow from any object touching it, by your slitting the wrapping paper with a knife, by breaking the stick in two, or by attempting to punch a hole into it to insert a cap. (These operations are entirely safe when the explosive is normal.) If the stick is dipped in warm water or exposed to steam, or is laid on anything which is warmer than about 125 degrees, free nitroglycerin likely will leak out

and fall in drops. And one drop of nitroglycerin falling only a few inches may be exploded itself and may explode all dynamite that is near it.

Throughout the entire course of handling the explosive, from the freight station to the hole in the stone or the ground, you should remember the five cautions which will be repeated: Keep it dry, keep it cool, keep it away from sparks and flame, and keep it safe from blows and friction. Be careful—as careful as you would in driving a big automobile or a traction engine. Then you will be secure from any accidents, and explosives will be entirely safe to handle.

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