NEW USES OF EXPLOSIVES IN AGRICULTURE.

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BLASTING EXPLOSIVES have been used for a good many years for clearing new land of stumps and boulders and for cleaning up an occasional obstruction of this kind from land already under cultivation. Naturally the quantity of explosives required for this purpose has not been great because most of the larger farms started in the past twenty years are on prairie land where there are neither stumps nor boulders. An exception to this is found, however, in the Pacific Northwest where but little land is available for farms or orchards except that which is covered with stumps of great size. Here, land companies do the clearing on a large scale and use many carloads of dynamite every year.

The employment of explosives for clearing land cannot, however, be considered in any sense a new idea and farmers in all of those parts of this country where stumps or boulders have existed are well acquainted with its value for getting rid of them.

The new idea in farming to-day and one which bids fair to have remarkable and far-reaching results in relation to the growth and bearing of trees and plants is the deepening of the moisture-holding and vegetation-producing surface soil by using dynamite. The increasing demarkation between our wet and dry seasons, has made it necessary to adopt some artificial method of distributing more evenly to vegetation the moisture requisite to its proper development.

The first plan for overcoming uneven moisture distribution was a system of draining and irrigating. This seemed logical and effective because it disposed of the surplus water of the wet season and provided that which had been lacking in the dry season. There were, however, drawbacks to this plan, the principal ones being the prohibitive cost to private enterprise of systems of any considerable capacity, the impossibility of establishing them at any cost in certain localities and the forming of "alkali soil" by superirrigation in many places where draining and irrigating had been in effect for a few years.

Next, the soil-deepening theory was propounded. This was evidently a capital idea because it not only disposed of the surplus water of the wet season by making it possible for it to sink deep into the soil to be conserved there until it was drawn up when needed by the plants in the dry season, but it also provided open soil for plant roots to develop through, and made available to the plants a greatly increased quantity of the soil foods which they require. It appeared at first that deeper plowing would answer the purpose and it was strongly advocated by many agricultural authorities. The difficulty about deep plowing is that in many localities the subsoil is entirely unfitted for plant food until it has been exposed to sunlight, air and rain for a year or more. As the ordinary plow always turns the deepest soil that it reaches directly onto the surface, the depth of the surface soil could not be increased more than an inch or so each season without injuring the succeeding crops because the surface soil could not absorb a greater quantity of the subsoil and remain properly fertile. This was a very slow method of increasing the depth of the surface soil and was also limited because the ordinary plowing depth is only from five to eight inches with an occasional maximum of nine or ten inches, or twelve inches if the ground is plowed over the second time. The special subsoil plows go down fifteen to eighteen inches but they naturally require great power to operate.

With the drainage and irrigation idea almost prohibitive in cost and partly unsatisfactory in result, and the deep soil plowing plan slow and limited, the outlook for the establishment of new and maintenance of the old vegetation-producing areas in this country was not bright until the soil-blasting plan was suggested. It is not recorded just who first evolved this idea but it apparently originated in Kansas where in some places a very compact and well defined hard pan has prevented the satisfactory growing of crops. Samuel J. Crawford, once governor of Kansas, has been an advocate for some years of subsoil blasting, and it was his enthusiasm that led one of the large dynamite manufacturers to make an extensive study of the question a year ago which has resulted in demonstrations in the past six or eight months of its great value and practicability in many parts of the country.

The object when blasting subsoil is to shatter and break up a maximum area at a minimum cost without mixing it with the

surface soil. To do this it is necessary to vary slightly the kind of explosive, size of charge and spacing and depth of bore holes to comply with the different subsoil conditions met with in different places.

The usual custom, however, is to space the holes either fifteen feet or twenty feet apart, make them two and a half to five feet deep and explode in them a quarter pound or a half pound of slow-acting dynamite of 15 per cent. to 25 per cent. strength. If the holes are twenty feet apart and four or five feet deep, best results may be given by a half pound of 25 per cent. dynamite in each hole. If on the other hand, the holes are only two and a half feet deep and fifteen feet apart a quarter of a pound of 15 per cent. dynamite may be sufficient. With the four factors of spacing of bore holes, depth of bore holes, weight of charge and strength of explosive it is possible to adjust this work so as to exactly suit almost every soil condition encountered and a little experience with close observation will determine just how any particular piece of land can be most economically blasted. If there is any uncertainty about this and a considerable area is to be blasted, it is a good plan to try a few experimental shots at different depths and distances and with different quantities of explosives, then dig a hole with pick and shovel midway between the holes blasted and observe the effect of the blast on the subsoil. If there is any evidence of fissure or breaking midway between the holes, the blast can be considered satisfactory and the remainder of the work carried out accordingly. As the standard size dynamite cartridge for this work is $1\frac{1}{4} \times 8$ inches, which weighs approximately a half pound, the charges consist of either a half cartridge or a whole one.

It has been the custom to make the holes for subsoil blasting either with a dirt auger or with a pointed bar which is driven to the required depth with a sledge or maul. It is probable, however, that as subsoil blasting becomes more general, these primitive tools will be replaced by either geared hand drills or power drills. A power drill operated by a gasoline engine is now in use in some of the Western States. As the dynamite should expend as much force as possible in the subsoil, the holes must be filled compactly with damp clay tamping from the top of the dynamite charge to the surface of the ground. It is generally the custom to explode the charges with blasting cap and fuse.

When this is done the fuses are cut so that from four to six inches will extend above the ground after the charge has been properly tamped in the hole. These are then lighted one after the other. A small torch is very effective for the purpose but unless a high wind is blowing, matches may be used. If the charges are properly gauged, located and tamped, there should be only a slight disturbance of the surface of the ground when they explode.

Sometimes the charges are exploded electrically with a blasting machine. Then electric fuses are used instead of fuse and blasting cap and from ten to a hundred and fifty charges are exploded simultaneously, depending on the capacity of the blasting machine. This method may be a little more effective but is also a little more expensive.

When a clearly defined clay hard pan from two to five feet thick is to be blasted, best results will usually be had if the charge of explosives is located about six inches above the bottom of the hard pan.

The cost of blasting subsoil, including explosives, blasting supplies and labor is between twelve dollars and twenty dollars an acre and this is not infrequently paid for by the increase in the first crop after the blasting has been done. As the beneficial effect of the blasting lasts many years it can be readily seen that it is an excellent investment.

The quantity of explosives required to blast an acre of ground with bore holes spaced at different intervals and loaded with different size charges is given in Table I.

TABLE I.

Distance between holes, feet.	No. of $1\frac{1}{4}$ x 8-inch cartridges in charge.	Approximate No. of pounds of dynamite per acre.
15	$\frac{1}{2}$	50
15	1	100
20	$\frac{1}{2}$	27 $\frac{1}{2}$
20	1	55

Subsoil blasting is not only done on land producing cotton, cereals, small fruit, vegetables, etc., but has proven of great value in orchards. Here it helps to dig the hole for the new tree, makes ample room for roots to spread and provides a reservoir for conserving the moisture required to support the tree. After these orchards have begun bearing, and particularly in old

orchards where the trees are beginning to fail, root cramping, "wet feet," wet rot and many other obstructions to their growth, are overcome by blasting between the trees or in some cases directly under them. Blasting between the trees is done in the same way as other subsoil blasting except that the holes should not be less than four feet deep and the method of spacing them is governed by the distance apart the trees stand. A charge of a quarter of a pound of 25 per cent. dynamite in each hole, is generally sufficient.

When the trees are planted on the "square system" and are fifteen to twenty feet apart, the holes should be located midway between the trees on diagonal lines, making one hole to each tree (Chart I). Trees planted on the "square system" twenty-five or thirty feet apart require the holes for blasting midway between them on the square lines or an average of two holes to the tree (Chart II). If the trees are more than twenty-five feet apart three holes should be put down on three sides of the tree, about ten to fifteen feet away from it, these holes being located at the points of an equilateral triangle with the tree in the centre (Chart III).

Explosives are now being employed very largely for digging ditches. In much of this ditching dynamite does the whole thing and neither pick, shovel nor ditching machine is used. Although ditching may be done almost entirely with dynamite under nearly any condition, it is particularly economical and effective in swampy clay ground and many ditches are now dug with dynamite in land of this character. To dig these ditches holes are punched with sharp bars at intervals of two feet along the line of the proposed ditch, to a depth six or eight inches less than the ditch is to be. These holes are not perpendicular, but at an angle of from 25° to 45° with the perpendicular, and all pointed toward that side of the ditch where the material excavated is to be thrown. All of the holes but the middle one are loaded with one cartridge ($1\frac{1}{4} \times 8$ inches) of 50 per cent. or 60 per cent. nitroglycerin dynamite. The middle hole is loaded last with two or three cartridges of the same explosive, one of which has been primed with a section of waterproof fuse and a No. 6 blasting cap. It is not necessary to use tamping in any of the holes provided the ground is sufficiently swampy for water to cover the charge of explosives when it is in place in the bottom of the hole. The detonation of the charge in the middle

CHART I.

Diagram showing location of holes for blasting when trees are 15 feet to 20 feet apart.
 X = tree; O = hole for dynamite.

CHART II.

Diagram showing location of holes for blasting when trees are 25 feet to 30 feet apart.
 X = tree; O = hole for dynamite.

CHART III.

Diagram showing location of holes for blasting when trees are more than 30 feet apart.
 X = tree; O = hole for dynamite.

hole communicates to the adjacent charge in both directions and so on, almost instantaneously to either end of the row and a comparatively regular ditch about three feet wide at the bottom, five feet wide at the top and from three feet to five feet deep, according to the depth of the holes, is the result. The length of the ditch which can be blasted at one time is only limited by the time required to charge the holes. A mile or more may be blasted simultaneously provided enough men are punching and loading the holes to finish the work quickly, but nothing is gained by attempting to blast so much at once that the dynamite in holes first loaded will be kept under the water longer than an hour or so before blasting. The middle hole is always charged just before blasting so that the blasting cap and fuse will not remain under water longer than a few minutes. This work should be done in comparatively warm weather because when most nitroglycerin dynamite has been under water having a temperature lower than 50° F. it is likely to become more or less insensitive, which might prevent the charges from exploding the adjoining ones. The explosion may also fail to communicate from one charge to another through dry soil and when ditches are dug in this ground, each charge should be primed. The additional expense brought about by priming each charge can, however, be offset to some extent by placing the charges farther apart, and using a lower grade and cheaper dynamite—30 per cent. to 40 per cent. usually being satisfactory. In damp clay soil it is not often necessary to prime each charge but they should not be spaced farther apart than eighteen inches. Ditches from six to ten feet wide are blasted with two parallel rows of holes, the rows being from eighteen inches to three feet apart. With three parallel rows of holes ditches fifteen feet wide at the top and five feet deep can be dug with dynamite.

Blasting ditches has several advantages over other methods. Under many conditions it is cheaper, usually costing eight to ten cents per cubic yard of excavation, including explosives and labor and with the material excavated all disposed of. It is always much quicker than any other method, three men, under ordinary conditions being able to dig a thousand feet or more in a day. In swampy land covered with stumps, trees and underbrush it is the only feasible method, and is little if any more expensive there than in open country as the blast clears out all

obstructions along the line of the ditch. It does not, like the hand or machine method of excavating, heap up the earth along the side of the ditch where it prevents drainage into the ditch and occupies ground that might be producing crops, but spreads it evenly over the adjoining land for some distance. Blasting also opens and fissures the ground on either side forming an almost perfect subsoil drainage into the ditch.

Blasted ditches are usually somewhat ragged looking at first but will square up almost immediately when the water enters them. They cave but little, if any, as the blast gives the sides a good slope.

When the location of ponds and swamps is such that the cost of draining them by ditching would be prohibitive, they can frequently be permanently dried up by blasting openings through the impervious subsoil underneath them which is responsible for their existence.

As this subsoil may be from five to thirty or more feet thick and the charge of dynamite should be located deep enough for it to break through into the stratum of sand, gravel or rock underneath, it is sometimes necessary to provide augers that will drill thirty feet deep. These augers are usually made by welding a two-inch dirt auger to a four-foot section of one inch or larger gas pipe. Other four-foot sections of the gas pipe, each with a collar or coupling, are also provided. The auger section is turned by means of a bar through a tee screwed on the upper end. As soon as this section is down as far as it will go, the tee is unscrewed, another section of pipe with the coupling permanently attached to the lower end is screwed on to the first section, and the tee is screwed to the second section. This process is repeated until the hole has reached the required depth. The explosive will usually give best results if located a foot or so above the bottom of the clay stratum, for if the charge is placed almost or quite in the more open stratum below it will expend its force in chambering that instead of shattering the clay above. It is necessary, of course, to use the first hole as a test hole and drill it down to the lower stratum. When the clay is underlaid by rock the charge of explosives should be put down on the rock. The explosion then breaks up the clay, opens fissures between the rock and the clay and may even crack and split the rock.

As this work is always wet, gelatin dynamite should be used. The 40 per cent. grade is about the proper

strength. Holes six to ten feet deep usually require about five cartridges, holes ten to twenty feet deep ten cartridges and holes twenty to thirty feet deep, fifteen cartridges of the $1\frac{1}{4} \times 8$ inch size. It will usually answer the purpose if the holes are forty to fifty feet apart. Sometimes two or three properly blasted holes put down in the lowest part will drain a large pond. The blasting should always be done electrically as a fuse is likely to give trouble under water. No tamping is required, the water in the holes answering the purpose.

If the surface water is more than a foot or so deep, the holes can be drilled and charged from a raft. After the auger has been withdrawn the cartridges of explosives can be pushed to the bottom of the hole, one or two at a time, with a long straight stick. If given a good firm push when they are at the bottom, they will remain in the proper position. It is well when loading to use a section of one and a half inch pipe pushed down a few inches into the hole and extending a foot above the surface of the water. The cartridge primed with the electric fuse should be loaded last or next to the last. Then the section of pipe used in loading the hole should be lifted over the upper end of the electric fuse wires. These wires must next be connected to the two leading wires which should be carefully paid out while the raft is poled a hundred feet or more from the hole. The free ends of the leading wires may then be attached to the blasting machine, the operation of which will explode the charge.

The use of dynamite for other work about the farm, such as grading roads; digging cellars; excavating trenches for foundations, pipe lines, tiling, etc.; digging holes for poles and fence posts and sinking wells is too well understood to require more than casual mention. Nevertheless all of this work is necessary and cannot be economically accomplished without using dynamite and using it according to approved methods.

The Red Cross explosives are generally preferred for most of the blasting necessary about the farm because they do not freeze so readily as many of the other high explosives and are also somewhat safer to handle. They are too insensitive, however, to use satisfactorily for ditching when the whole line of charges is to be detonated by the one in the middle, and the fumes which they give off when detonated are more objectionable in close work like well sinking than the fumes from gelatin dynamite.