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Terracing Farm Lands

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TERRACING FARM LANDS.

CONTENTS.

SOIL EROSION, or the washing away of earth by water, costs the farmers of the United States $1,000,000 every year. Soil losses from this cause occur in every State of the Union and in almost every county of every State. Nine years ago the National Conservation Congress reported that 4,000,000 acres of farm land

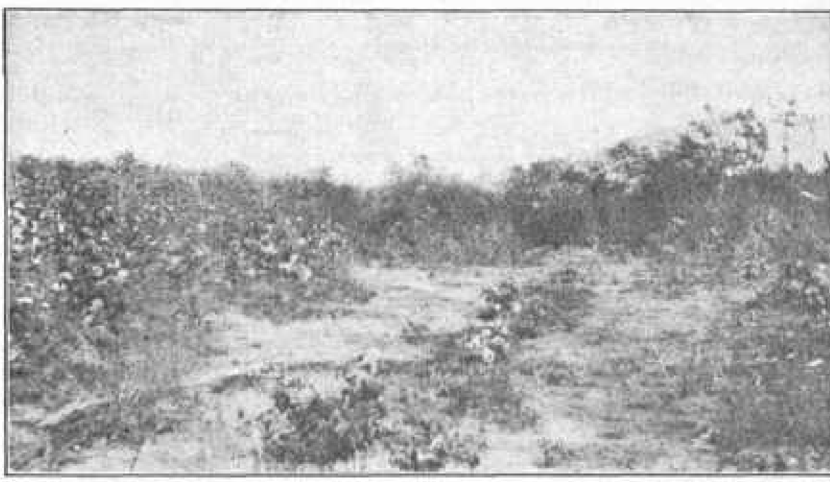

FIG 1.—Sheet washing in which upper and most fertile parts of the soil are washed away.

had been practically ruined by soil erosion. So serious is the condition that Dr. N. S. Shaler, formerly dean of the Lawrence Scientific School, was once moved to remark that "If mankind can not devise and enforce ways of dealing with the earth which will preserve this source of life, we must look forward to the time—remote it may be, yet clearly discernible—when our kind, having wasted its greatest inheritance, will fade from the earth because of the ruin it has accomplished.[1]

[1] Extract from article on Farms, Forests, and Erosion, 1916 Yearbook, U. S. Department of Agriculture.

Erosion injures or practically ruins fertile lands in a number of ways. The upper and most fertile parts of the soil are washed away until the land becomes barren and unproductive. (See fig. 1.) Deep

FIG. 2.—Gullying which causes a loss of land and a lowering of the water table.

gullies are formed which result in an actual loss of land for cultivation, a lowering of the water table and a deficient supply of moisture. (See fig. 2.) Drainage ditches are often filled up with sand, which

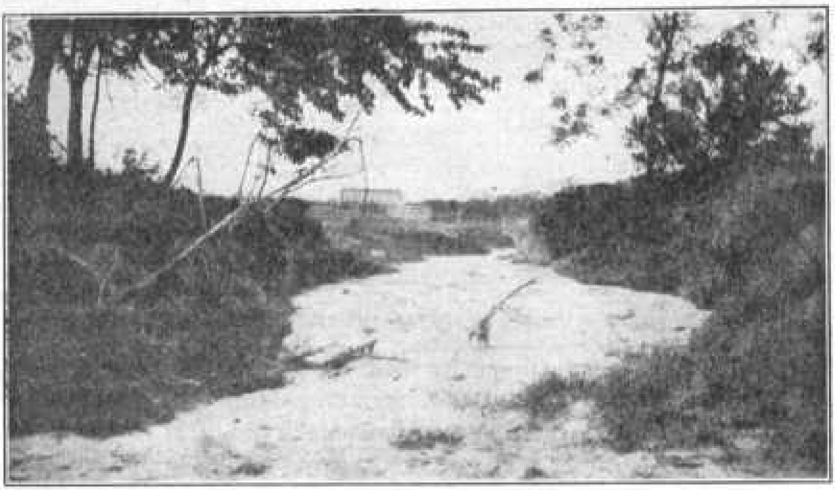

FIG. 3.—Drainage ditch partly filled with sand washed from eroding hills.

frequently results in the flooding of the adjoining bottom land and the destruction of crops. (See fig. 3.) Rich bottom lands are often covered with deposits of sand washed from the hill lands. (See fig. 4.)

Hence the direct losses of the upland farmer are the land occupied by gullies, smaller crop yields each year, and a continued decrease in the value of the land. Some of the losses of the bottom farmer are the land covered to a great depth with sand, crops damaged by overflows or deposits of sand, a continued decrease in the value of the land, and the money invested in the construction of drainage ditches that have been filled or partly filled with sand. Thus it is apparent that both the bottom and the upland farmer should be concerned in the adoption of effective measures for stopping erosion.

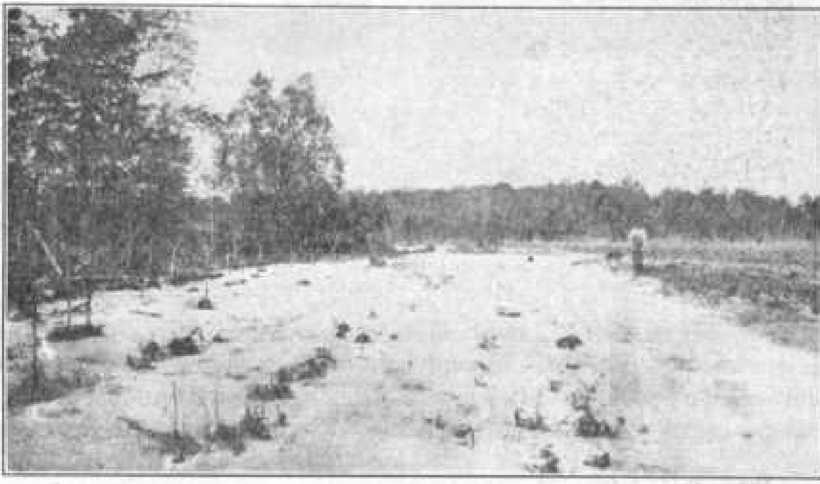

FIG. 4.—Portion of corn field covered with sand washed from hill lands. This deposit of sand is the result of one heavy rain. Picture taken May 4, 1918, Jackson, Tenn.

CAUSES AND FORMS OF EROSION.

Erosion is caused chiefly by the direct action of heavy rains beating upon the ground, by the rapid movement of the rain water down the slopes of the land surface, and by the combined action of the freezing and thawing of a saturated soil, followed by heavy rains. (See fig. 5.) The steeper the slope the greater is the erosive action of the running water. For instance, if the slope be increased four times, the velocity of the water down the slope is about doubled and the power of the water to carry away soil particles is increased about thirty-two times. (See fig. 6.) Rows that run up and down the slope when cultivated form small ditches that concentrate the water and increase the amount of erosion.

Where the upper soil is washed quite evenly from the surface of the land over wide areas due to the moving water being quite uniformly distributed over the surface, erosion in the form of sheet washing occurs. (See figs. 1 and 6.) Where gullies are washed down the slopes due to large volumes of water flowing over narrow strips of ground, generally in depressions or draws of a field, erosion known as gullying occurs. (See fig. 2.) Sheet washing is not so noticeable as gullying, and for this reason many farmers do not consider it very

FIG. 5.—Erosion chiefly caused by alternate freezing and thawing followed by heavy rains.

harmful. However, it is very destructive, since it robs the land of the surface soil which is known to contain a higher percentage of humus and other essential elements of fertility than the subsoil. Also it is practically impossible to secure the full benefit of expensive

FIG. 6.—View showing erosion between cotton rows where rows are run directly up and down the slope, a practice which is responsible for a large percentage of badly eroded lands.

fertilizers and manure where sheet washing occurs since they are rapidly washed away along with the surface soil. If methods were employed to prevent sheet washing, few gullies would ever be formed in a field, since sheet washing finally develops into gullying.

METHODS OF PREVENTING EROSION.

Since erosion is due largely to the rapid movement of the rain water over the surface of the ground, methods of preventing erosion must cause the water either to sink into the soil or flow away slowly over the surface to a drainage channel. If the rain water were absorbed by the soil as fast as it falls, there would be very little erosion.

In order to drink up surface water rapidly a soil must be very permeable, which means that it must contain fairly large open spaces through which the rain water can pass easily, or where it can be stored temporarily. Some soils are naturally very permeable. A number of ways of increasing the permeability of a soil are deep plowing, plowing under organic matter such as manure, stubble, stalks and cover crops; the practice of tile drainage, and, in certain soils, the use of explosives.

Vegetation covering the surface of the ground protects the soil from the direct action of the rain and checks the flow of the water over the surface, giving the soil a better opportunity to absorb the water. It is therefore important that some kind of cover crop, such as vetch, clover, oats, wheat or rye, be grown on the land during the winter or at any time that the land is not used for other crops.

Contour plowing, which consists of breaking the ground along level lines across the slopes, reduces the flow of water directly down the slope. Also in planting and cultivating the crops the same level lines are followed so that a shallow trough is made above each row. Most of the rain water is caught and held in this trough until it either evaporates or is absorbed by the soil. Contour plowing should invariably be practiced on all hill lands. The beginning of a great many gullies is due to the practice of plowing and cultivating directly up and down the slopes. (See fig. 6.)

TERRACING.[1]

Terracing is the most effective method of preventing erosion, and it is doubly effective when all of the above methods are employed in connection with it.

There are two distinct types of terraces—the bench terrace and the ridge terrace. In figure 7 is shown a drawing of a field of bench terraces, and in figure 8 a field of ridge terraces. A good idea as to the difference between these two types of terraces can be obtained by a comparison of these drawings. A field of bench terraces resembles a series of benches or a flight of steps. Ridge terraces, as the name implies, are simply ridges of earth thrown up across the slopes of hillsides.

[1] For a more technical discussion of the subject of terracing the reader is referred to Bulletin No. 512, U. S. Dept. of Agriculture.

Of the two types the bench terrace is much the older. The ridge terrace has come into general use only during the last 25 years. Bench terraces for agricultural purposes were used by the ancients of Europe, Asia, and South America. The ancient Peruvians in South America [1]

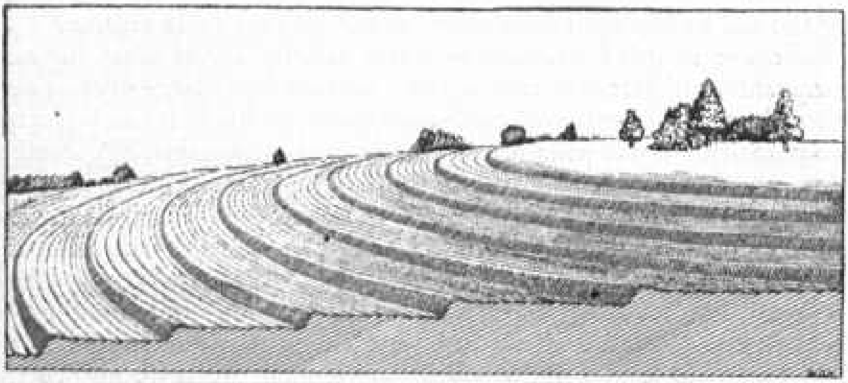

FIG. 7.—Bench terraces.

terraced the steep slopes of mountains, the walls of the terrace embankments being built of stone. (See fig. 9.)

THE BENCH TERRACE.

The bench terrace is essentially a steep-land terrace. Ridge terraces are much superior for lands of moderate slopes, as with them it is possible to eliminate the steep uncultivated strips that interfere with farming operations and often are seed beds for weeds.

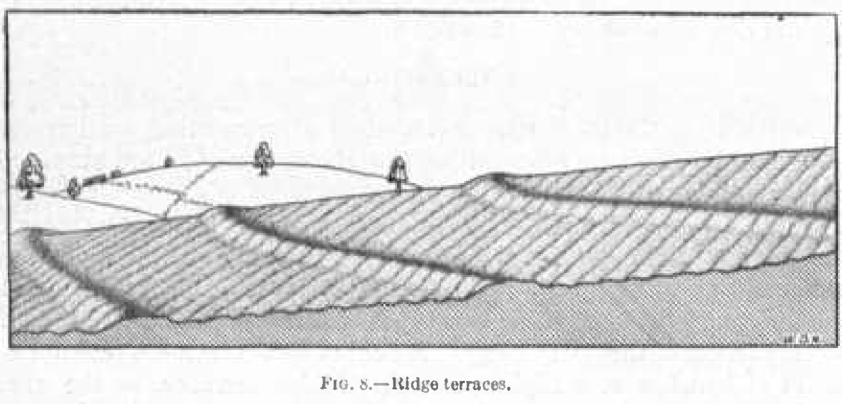

FIG. 8.—Ridge terraces.

The bench terrace is usually built with the reversible hillside plow by which the soil is always thrown down the hill. (See fig. 10.) This is done for a number of years until the bench becomes level or

[1] See article entitled Staircase Farms of the Ancients by O. F. Cook, p. 274, Vol. 29, National Geographic Magazine.

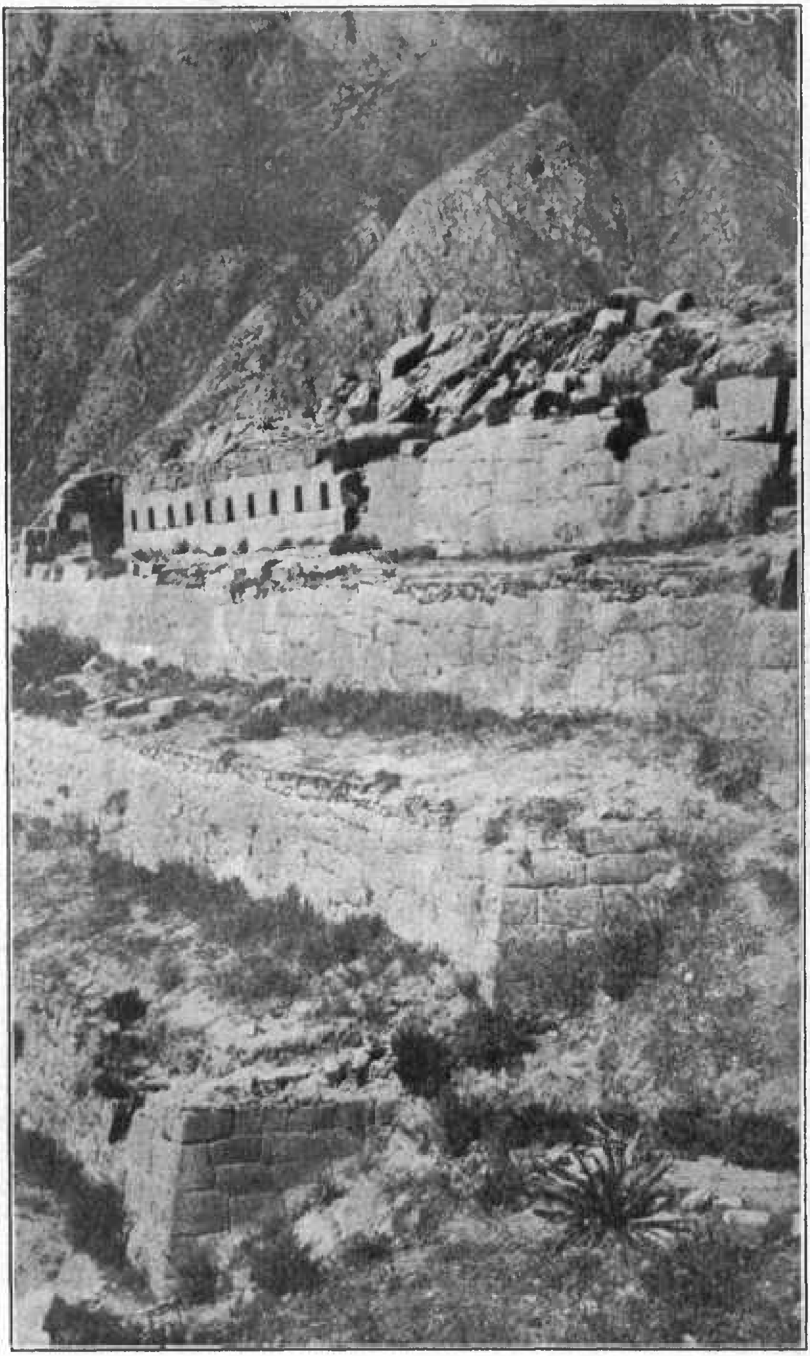

FIG. 9.—Bench terraces of the ancient Peruvians. (Copyright, National Geographic Magazine, vol. 29, p. 495, 1916.)

the slope of the bench is slightly reversed as shown in figure 10 B. A ridge of earth is kept at the outer edge of the bench to prevent the surface water from running from one bench to the next bench below. Bench terraces should be level; that is, they should have no fall along the direction of their length. Before the bench between the terrace embankments is made level by plowing the soil down the slope the surface water is held above the shoulder at the outer side of the bench. Part of the water may move off slowly to the ends of the terrace and the rest will either sink into the soil or evaporate. A heavy sod should be kept on the shoulder and embankment to prevent erosion should the shoulder be overtopped, due to heavy rain. (See figs. 11 and 12.)

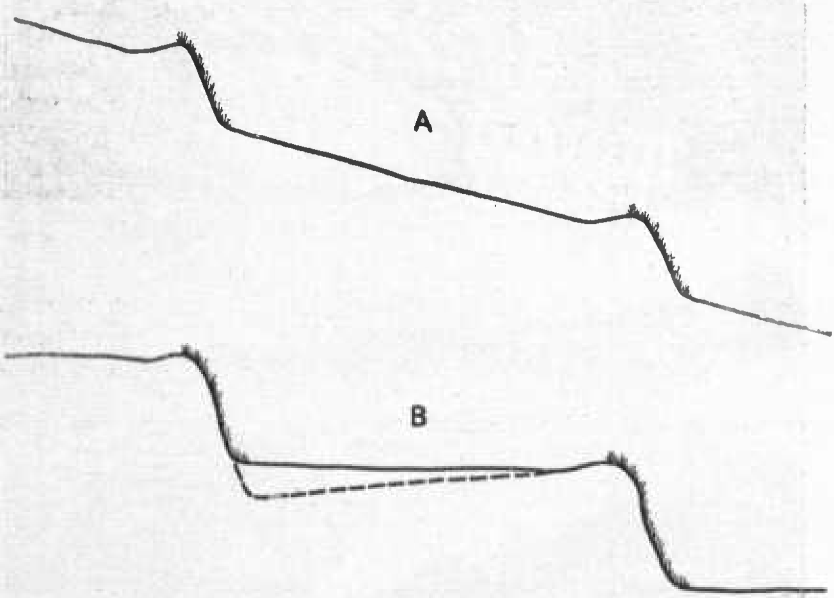

FIG. 10.—A, profile across relatively new bench terrace; B, profile showing level (or reverse) slope of bench terrace that has been maintained for several years.

When a bench terrace is first started, the shoulder should be built about 1 foot high and 3 feet wide at the base. These dimensions can be reduced some as the leveling down of the bench proceeds. When the bench has become level it is only necessary to maintain a small shoulder about one-half foot high at the outer side of the bench. This will prevent possible damage to the terrace due to an excessively heavy rain.

The distance between the terraces is governed by the vertical distance or drop and not by the distance along the surface of the ground. The distance along the surface of the ground will be different for different slopes of the land where the same vertical distance between the terraces is used.

The proper drop or vertical distance between bench terraces depends largely on how much care and attention is given to the terraces, the greater the drop the more care required. The greater the

FIG. 11.—View of lower side of bench terrace embankment, showing growth of weeds and grass on embankment.

drop the higher will be the embankment, and it is much more difficult to maintain a high than a low embankment. The best practice indicates that the drop between bench terraces should never be less

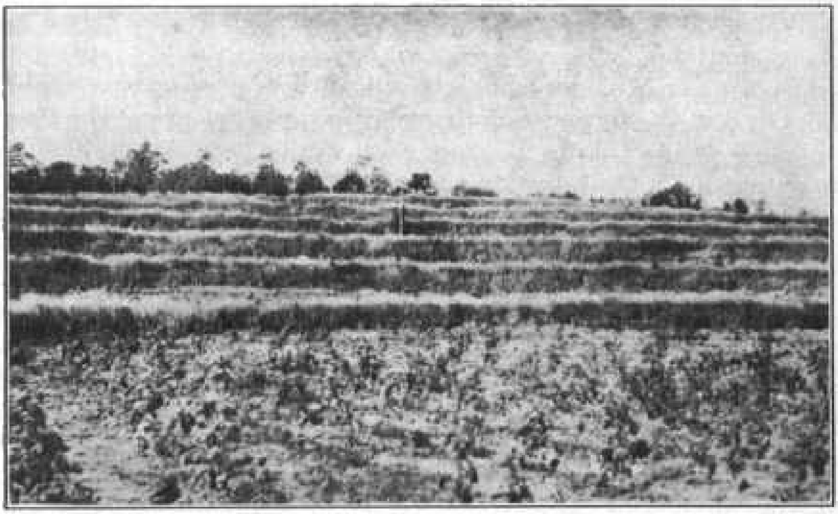

FIG. 12.—Field of bench terraces. The benches in this view are almost level owing to always plowing the soil down the slope. Note the well-sodded embankments.

than 3 feet nor more than 6 feet, although a drop of 8 feet has been used successfully on steep slopes where the terraces were carefully maintained.

The drops or vertical distances between terraces, and the width of the benches for land slopes with from 5 to 30 feet fall in 100 feet, are given in Table 1.

TABLE 1.

Slope of land per 100 feet.	Drop or vertical distance between terraces.	Width of benches.
Feet.	*Feet.*	*Feet.*
5	3	58
10	4	38
15	5	31
20	6	27
25	7	25
30	8	23

The values given in the table represent the best practice with bench terraces, yet many farmers favor wider benches because of the fewer terraces needed and because it is easier to cultivate the field in a few broad strips than in a greater number of narrow strips. However, with the wider benches and greater drop between terraces it is much harder to control the surface water. Generally the result is that erosion takes place, with consequent injury to both terraces and field.

The slope of the lower side of the terrace embankment should be made as steep as possible, since this will reduce the area of waste land in the field. A slope of about 50 per cent, which is one-half foot in horizontal distance to 1 foot in vertical distance, is used quite generally.

Where the land is cultivated, the bench terrace is not used very successfully on slopes exceeding 20 feet fall in 100 feet. However, where a permanent sod is maintained, such as in pasture or meadow land, it is used very successfully on much steeper slopes. The steeper the slope of the hillside the more work will be necessary to build and maintain the high embankments required.

As previously stated, the bench terrace is essentially a steep-land terrace. Some of the objections to this type are the great amount of labor required for maintenance, the difficulty of moving farm machinery from one bench to another, the inconvenience of cultivating each bench separately, the loss of land occupied by the uncultivated embankments, and often the growth of objectionable grass and weeds on the embankments which rob the near-by soil of its plant food and tend to seed the entire field. The terrace embankment could be utilized for small fruits or grapes, which would yield a profitable crop and to a considerable extent prevent the growth of objectionable weeds and grasses.

THE RIDGE TERRACE.

Ridge terraces are divided into two classes with respect to width of base, the narrow base and the broad base. The narrow-base ridge terrace has long been in use throughout the South. The broad-base ridge terrace is more recent, and as yet has been used in only a few localities. However, it is rapidly coming into general use, and is gradually taking the place of the narrow base because of its superiority for most, if not all, conditions.

NARROW-BASE RIDGE TERRACE.

The narrow-base ridge terrace is usually built 3 to 6 feet wide at the base and from one-half to 1 foot high. It is best adapted for use on open, permeable soils and moderate slopes, although where properly laid out, heavily sodded, and carefully maintained it renders fairly satisfactory service on steep slopes. On open, permeable soils it is usually run level, while on soils that soak up water very slowly it is generally given a fall which should not exceed 6 inches in 100 feet. The drop or vertical distances between these terraces should be about the same as given in Table 1 for bench terraces.

Level terraces of this type slowly develop into terraces of the bench type due to erosion between the terraces and to the gradual movement of the soil down the slope. This can be prevented to a certain extent by throwing the soil up the slope in plowing. A method sometimes employed to prevent the formation of bench terraces is to plow down the terraces every few years and build new terraces between the old ones. This practice also prevents the accumulation of most of the rich top soil above the terraces and the development of a thin unproductive strip or soil below them. However, there is a tendency for all the top soil to move down the hill and to leave the top of the hill barren so that the superiority of this practice over that of allowing the terraces to develop slowly into bench terraces is very much questioned. Also the expense of building new terraces every few years and the difficulty of maintaining new terraces as compared with old ones are points to be considered.

Some objections to the narrow-base ridge terrace are the loss of land occupied by the sodded terrace, the growth on the terrace withdraws plant food from the adjoining soil, weeds are usually allowed to grow on the terrace, tending to seed the entire field, and the small terraces are easily broken by heavy rains, which usually results in the breaking of all terraces below and the beginning of a bad gully. When the terrace is made with a fall greater than 6 inches in 100 feet erosion usually takes place. As a result much of the surface soil is carried away and a gully is cut along the upper side and near the end of the terrace. Even with a fall of 6 inches in 100 feet some washing takes place.

The narrow-base level-ridge terrace is used sometimes on very sandy soils on moderate slopes of from 3 to 8 feet per 100 feet, and the terrace is cultivated, one row of cotton or corn being planted on the top. The above-mentioned objections would not apply to this terrace under these conditions, since sandy soils absorb a large amount of the rainfall, and cultivating the terrace removes the other objections.

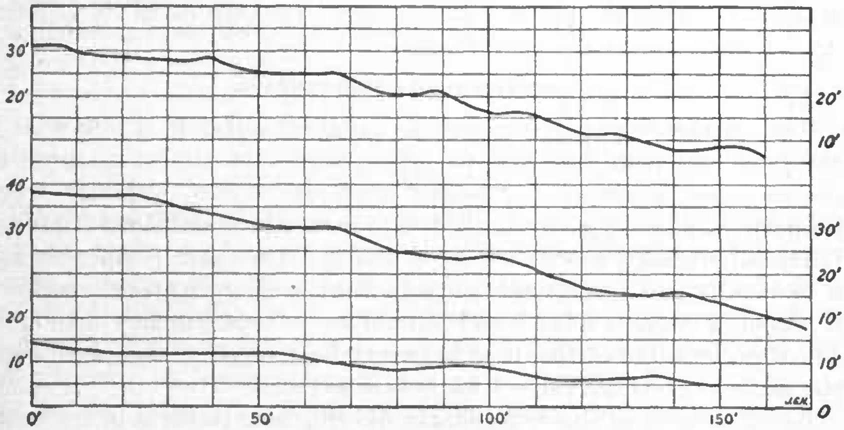

FIG. 13.—Profiles across typical fields with broad-base ridge terraces.

BROAD-BASE RIDGE TERRACE.

In order to overcome the many objections to the narrow-base form of ridge terrace, terraces with broad bases were built, the entire surface of the terrace being cultivated. (See fig. 13.) They are readily crossed by large farm machinery and therefore do not interfere with the usual farm operations. The broad embankment of

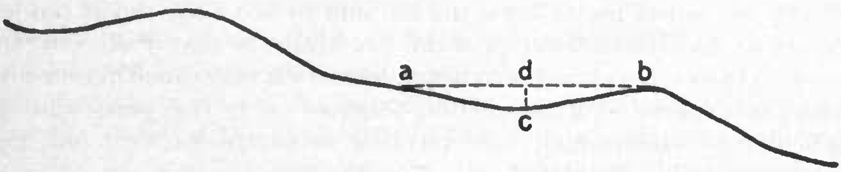

FIG. 14.—Showing how water is ponded above broad-base level-ridge terrace.

earth gives the terrace the necessary strength to withstand the pressure of water above and prevents breaks due to seepage. For these reasons the broad base is recommended instead of the narrow-base type.

The broad-base terrace is built either level or with fall and will be referred to in the following as the broad-base level-ridge terrace and the broad-base graded-ridge terrace.

BROAD-BASE LEVEL-RIDGE TERRACE.

This terrace is built absolutely level, and the rain water that falls between the terraces is collected and held above the lower terrace until it evaporates, sinks into the soil, or finds its way slowly to an outlet at the ends of the terrace. The dotted line a–b in figure 14 shows how high the water above the terrace may rise before the terrace would be overtopped. The terrace should be built not less than 15 inches high; that is, the top of the terrace should be 15 inches higher than the lowest point in the depression above the terrace. This height is shown as c–d in figure 14. The terrace never should be built less than 10 feet wide at the base, and the width may be increased each year by throwing the soil to the center of the terrace in

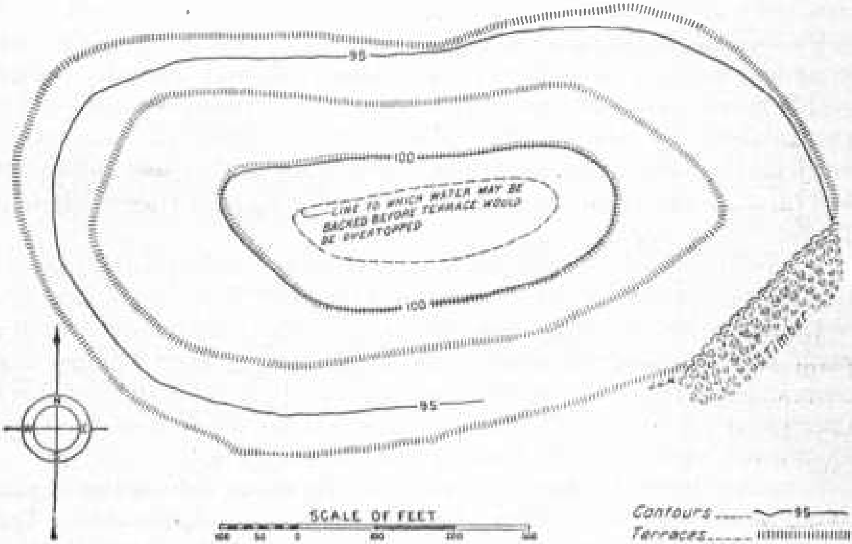

FIG. 15.—An example of level terraces encircling the top of a knoll.

plowing. This building-up process should be continued until the terraced field would look in profile like the profile views shown in figure 13.

The ends of broad-base level terraces may be closed to prevent the escape of any of the surface water or left open to allow the water to pass away slowly. If the soil in a field is capable of absorbing all of the rainfall without the water standing on the surface long enough to injure crops, the ends are closed; if not, they are left open. Where the ends are closed, the terraces should be built 18 inches high. In figure 15 is shown a plan view of a terraced field where two of the upper terraces completely encircle the top of a hill, there being no way for the water to escape over the surface to a drainage outlet. These terraces have given complete satisfaction.

The drop, or vertical distance between the terraces, is made such that rain water falling between the terraces will not overtop them.[1] The vertical distances that should be used for different slopes and types of soil are given in the following table.

TABLE 2.—*Vertical distances between terraces for different slopes and types of soil.*

Type of soil.	Slope of hillside.	
	3 feet to 100 feet.	15 feet in 100 feet.
	Feet.	*Feet.*
Sandy	4½	4½
Sandy loam	3½	3¾
Clay loam	2½	3
Clay	2	2½

The vertical distances between terraces given in the table are intended for use on soils that are deeply plowed, contain considerable humus, and are naturally capable of absorbing a large part of the rainfall. In the second column of the table are the proper vertical distances to be used on a gentle slope with 3 feet fall in 100 feet, and in the third column are values for a much steeper slope of 15 feet fall in 100 feet.

In building a level terrace it is extremely important that the top of the terrace be made absolutely level. Since the water held above a terrace tends to seek its level it will quickly find any low point in the top of the terrace and start flowing over. When this occurs the terrace is invariably broken, a gully is generally cut down through the field and all the terraces below to the foot of the slope are usually broken by the rushing waters.

It is also desirable that the ground at the upper side of the terrace be as level along the length of the terrace as is practicable. This prevents the occurrence of pockets above the terrace that tend to hold water on the surface. In crossing a gully or draw in a field it is almost impossible to prevent the formation of such pockets unless the terrace is run quite a distance up the gully. This would make very sharp turns in the terraces which are undesirable for farm operations, particularly where the terraces are used as guides in plowing and laying out the crop rows. In order to avoid these sharp turns the terrace is built directly across the draw or gully and the top of the terrace at the crossing is built considerably higher than the rest so that when the high embankment of loose earth settles the top of the surface will be practically level.

A good practice recommended by some farmers experienced in building terraces is to build the terrace one-third higher than required to allow for the settlement of the loose earth. The width of

[1] See Bulletin No. 512, U. S. Dept. of Agriculture for discussion of rainfall.

the base of the embankment at the crossing is determined by the natural slope at which the loose earth will stand. Too much care and attention can not be given to the proper maintenance of these embankments as it is usually at such places that breaks occur in terraces. The breaks are due generally to the fact that the top of the terrace is too low, thus allowing all the water along the terrace to drain away over the low point and erode a deep gully down the hillside.

In order to remove the water that stands above the terrace at crossings of draws or gullies and to insure against the possibility of the terrace breaking, due to overtopping, it is recommended that a line of tile be laid down the middle of the draws to a drainage outlet at the foot of the slope. A profile view of a tile drain laid in a draw and provided with drop inlets above each terrace is shown in figure 16. The use of the drop inlets allows particles of soil in the water to settle before the water is drained away.

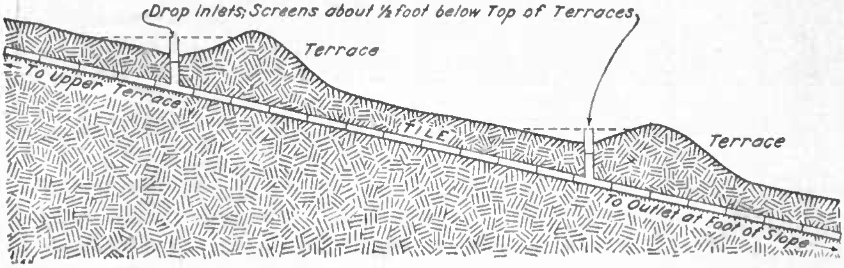

FIG. 16.—Method of removing water standing above terraces in a gully or draw.

The two most important advantages of the broad-base level-ridge terrace as compared with other types of terraces are that the entire terrace can be cultivated (see figs. 17 and 18) and that practically none of the soil or applied fertilizer is allowed to escape from the field. Level-ridge terraces also, in preventing the rapid escape of the rain water, retain a supply of moisture for crops which is often much needed on hill lands during the growing season and especially during periods of drought. The experience of a number of farmers showed that their best crop yields came from level terraced fields during very dry seasons as compared with adjoining unterraced or graded terraced fields.

The broad-base level-ridge terrace is best adapted for use on slopes not exceeding 15 feet fall in 100 feet, and on open, permeable soils. However it can be used successfully on any type of soil if methods are employed to remove surface water that may collect in low places above the terrace. This can be done best by installing a complete system of tile drainage to operate in conjunction with the terrace system.

COMBINED SYSTEM OF LEVEL TERRACES AND TILE DRAINAGE.

Some farmers who fully realize the importance and value of completely stopping erosion on their farms have gone to the expense of

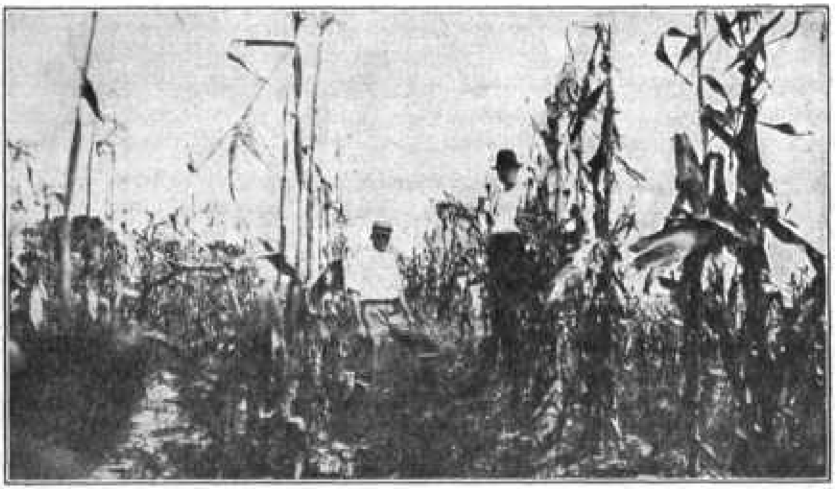

FIG. 17.—Row of corn growing on top of a broad-base level-ridge terrace. The best row of corn invariably grows on the top of the terrace.

installing complete systems of tile drainage in connection with systems of broad-base level-ridge terraces. This unquestionably is the most effective method known to hold the soil of a hill farm in

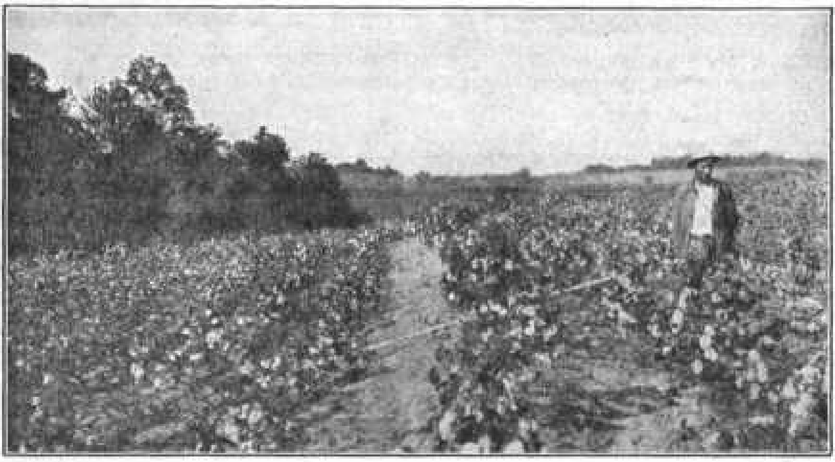

FIG. 18.—Three rows of cotton growing on broad-base level-ridge terrace. In this field by far the best cotton was found growing on the terraces.

place. In addition to the removal of the surface water and the reduction of erosion many other benefits to the soil result from the practice of tile drainage.

In a combined terrace and tile drainage system the tile drains are laid in the depressions along the upper side of the terraces and connect with main tile drains that are generally laid down the center of gullies or draws to a drainage outlet at the foot of the slope. If the surface water does not pass readily through the soil to the tile drain, it may be necessary to build surface inlets at intervals in the tile lines along the terraces to afford a direct flow of the surface water into the tile.

It is advisable to employ the services of a competent and experienced engineer to design and superintend the construction of a combined terrace and tile drainage system. "Instructions for the Construction of Tile Drains" and other information relating to the proper design of tile system can be obtained free upon application to

FIG. 19.—View showing water flowing off in a broad shallow channel of a broad-base graded ridge terrace. (From Bulletin B-23, A. & M. College of Texas.)

the Director Bureau of Public Roads, United States Department of Agriculture, Washington, D. C. Too much emphasis cannot be placed upon the value and effectiveness of this method of stopping erosion.

THE BROAD-BASE GRADED-RIDGE TERRACE.

The broad-base graded-ridge terrace, generally known as the Mangum terrace, is built in the same manner as the broad-base level-ridge terrace, except that it is given fall along the terrace for the purpose of carrying the surface water to outlet channels at the ends of the terrace. The channel along the upper side is made with a broad bottom, so that the water will flow off at a low velocity. (See fig. 19.) The entire terrace is cultivated and on moderate slopes the crop rows may be run at an angle across the terraces. (See fig. 20.) These terraces are built originally from 10 to 20 feet broad at the base; generally, the gentler the slope the broader the base. The wider base is always desirable. The top of the terrace should be about 15 inches higher than the bottom of the channel above the terrace. The terraces are broadened gradually by methods of plowing each year until often on moderate slopes the lower slope of one terrace embankment meets the upper slope of the next terrace above and the whole field becomes a series of terraces. (See fig. 13.) Some of the terraces on the P. H. Mangum farm near Wake Forest, N. C., are from 40 to 50 feet broad.

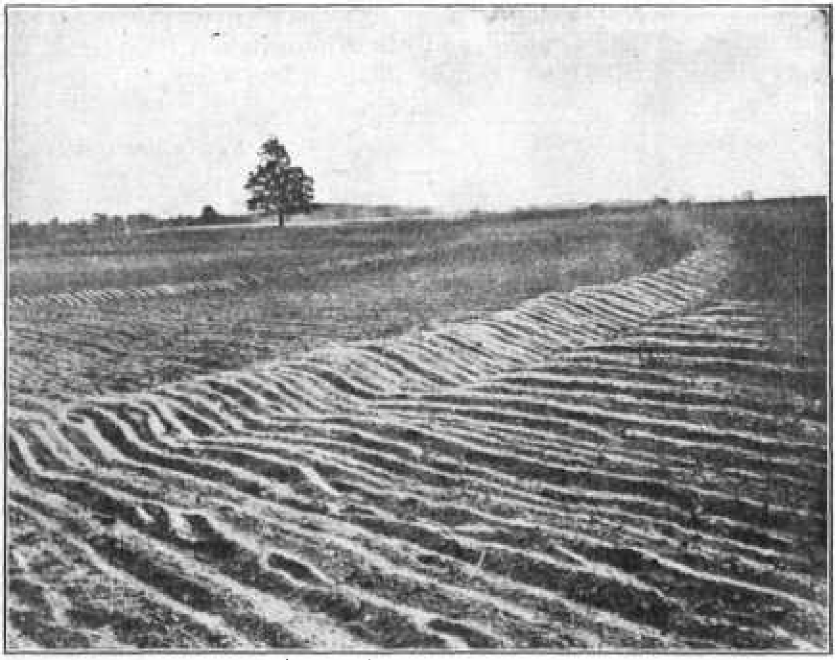

FIG. 20.—View showing rows crossing Mangum terraces. However, where this practice is followed considerable care and attention should be given to the proper maintenance of the terraces. (From Circular 94, Bureau of Plant Industry, U. S. Dept. Agr.)

It has been found that washing of average soils in the channels of graded terrace takes place when the grade or fall of the terrace is greater than 6 inches in 100 feet. Even with this fall some of the fertile parts of the soil are carried away in the water flowing off. It is therefore advisable to use as little fall as possible and never to use a fall exceeding 6 inches in 100 feet.

A vertical distance or drop of 3 feet between the terraces is recommended for land with moderate slopes. This value should be increased for steeper slopes. The following table gives the vertical distances between terraces recommended for use on different slopes:

TABLE 3.—*Vertical distance between terraces.*

Slope of land in feet per 100 feet.	Vertical distance or drop between terraces in feet.
Up to 5 feet	3
5 to 10 feet	4
10 to 15 feet	5

The fall or grade of a terrace may be either uniform or variable. By uniform grade is meant that the fall in each 100 feet is the same from the upper to the lower end of the terrace and by variable grade is meant that the fall increases from the upper to the lower end of the terrace. The variable graded terrace is much superior to a terrace with uniform grade, since it removes the surface water with less washing in the terrace channel and with less probability that the terrace will break near the lower end because of the piling up or concentration of the run-off water. A good practice is to change the grade every 300 feet along the length of the terrace. The following table gives the fall in inches per 100 feet for use in laying out terraces with a variable grade.

TABLE 4.—*Fall in inches per 100 feet for use with variable graded terraces.*

Length.	Slope of land.		
	5 feet fall in 100 feet.	10 feet fall in 100 feet.	15 feet fall in 100 feet.
Feet.	*Inches.*	*Inches.*	*Inches.*
0 to 300	½	¾	1
300 to 600	1	1½	2
600 to 900	2	3	4
900 to 1,200	4	6	[1] 7
1,200 to 1,500	6	....	....

[1] A terrace 1,100 feet long should have a fall of 6 inches in 100 feet at the lower end where the land has a fall of 15 feet in 100 feet.

The steeper the slope of the land the greater the fall required, since the size of the channel above a terrace grows smaller as the slope increases. A long terrace should have more fall than a short one because the volume of water to be removed increases as the length of the terrace increases. By giving the terrace less fall near the upper end the tendency is to store or hold back the upper water until the water below has a chance to flow off. This tends to prevent the piling up of the water and the occurrence of breaks near the lower end of the terrace.

Since the volume of water increases as the length of the terrace increases, there is a limit to the length of a graded terrace where a fall of 6 inches per 100 feet is not exceeded. If it is necessary to lay out a terrace longer than this limited length as given in Table 4 without using a fall greater than 6 inches per 100 feet, then the terrace should be built higher for the additional length near the lower end or the terraces should be placed closer together. Another method which is very satisfactory on open soils is to make the terrace level for several hundred feet near the upper end.

The failure of graded terraces occurs most commonly at sharp bends, crossings of draws or gullies, and at points where either an abrupt reduction in grade or size of channel has been made. Breaks at bends are due to the water washing against the terrace and cutting through the embankment of earth, and occur more commonly where the terrace has considerable fall and the water a high velocity. No attempt should be made to cultivate the terrace at bends where scouring is apt to take place, but the terrace should be seeded to grass. Breaks at crossings of gullies or draws are usually due to failure to build the top of the terrace to the proper grade across such places. The grade of the top of the terrace leading into a draw never should be greater and should preferably be less than the grade of the top leading out, because a greater grade would result in much more water being brought into the draw than could be carried out on the smaller grade.

In all terraced fields some washing is bound to occur on the slopes between the terraces. The rich soil particles washed from the slopes collect in the channel above the lower terrace. If the terrace is level this soil remains in the channel and tends to fill it up. If the terrace has fall, all or part of this soil is carried off the field, depending in extent upon the fall given to the terrace. From this it is seen that a terrace should have no more fall than is absolutely necessary. Wherever the conditions of soil will permit, terraces should be laid out level. Where the soil is poorly drained or incapable of absorbing much water, such as close, tight soils or shallow soils underlaid by an impervious subsoil, then the terrace should be made with a variable fall. For the best results this fall should preferably be less and should never be greater than 6 inches in 100 feet at the lower end of the terrace.

TERRACE OUTLETS.

The provision of suitable outlets for the removal of surface water at the ends of graded terraces is often the biggest problem in terracing work. Natural water courses make ideal outlets. However they are not always available since the disposal of the water generally is limited to the field that is being terraced. In order to make the best use of natural drainage outlets, it is often advisable for neighboring farmers to cooperate in terracing adjoining fields.

If this were done the terraces could be run across the property lines and there would be no cause for the development of gullies at property lines as is often the case when it is necessary to end the terraces there.

Roadside ditches are commonly used for terrace outlets. Where they are not protected in some way, bad washing often occurs, causing considerable injury to the road. This washing should be stopped by building dams of brush, rock, or concrete across the ditches at suitable intervals down the slope or by lining the ditches with some hard material such as stone or concrete. Usually where a terrace discharges into a roadside ditch a considerable drop of the water occurs at the end of the terrace and a gully invariably forms along the upper side of the terrace. This can be prevented by the use of a wooden box trough which discharges the water with a free overfall into the ditch

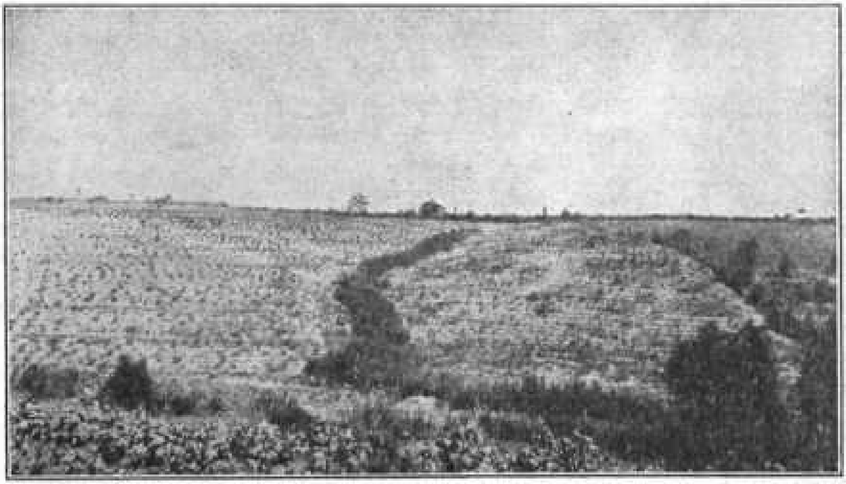

FIG. 21.—Terrace outlet in draw, seeded to grass to prevent erosion.

at the end of the terrace. Sometimes a protection for both the terrace channel and the ditch is built of concrete. Erosion is most active near the end of a terrace, where the largest flow of water occurs. For this reason the last 25 to 50 feet of the terrace should not be cultivated, and the terrace and terrace channel should be seeded to grass for protection against erosion. Where convenient the water from terraces is discharged at the edge of timberland.

Sometimes it is found necessary to use a natural draw in a field as a terrace outlet. Where this happens the draw should either be seeded to grass (see fig. 21) or some other means should be employed to prevent the erosion of a deep gully. Figure 22 shows a view of stop-plank dams built in a terrace-outlet channel at ends of terraces to prevent the erosion of a gully. The same method is employed to catch sediment and fill up a gully that is used as a terrace outlet.

This method is used quite extensively in Hunt County, Tex., by J. A. Erickson, county agent. In the view shown there was formerly a gully down through the field along the line of the present stop-plank dams.

FIG. 22.—Stop plank dams built in terrace outlet channel at ends of graded terraces to prevent the erosion of a gulley down through the field. Note the sediment above the dam. A gully which formerly existed along the line of the stop plank dams has been completely filled up.

The construction of the stop-plank dam is very simple. The terraces from both sides of the field are made to meet at the draw or gully. Bottomless boxes are set in the ground 1 to 2 feet deep op-

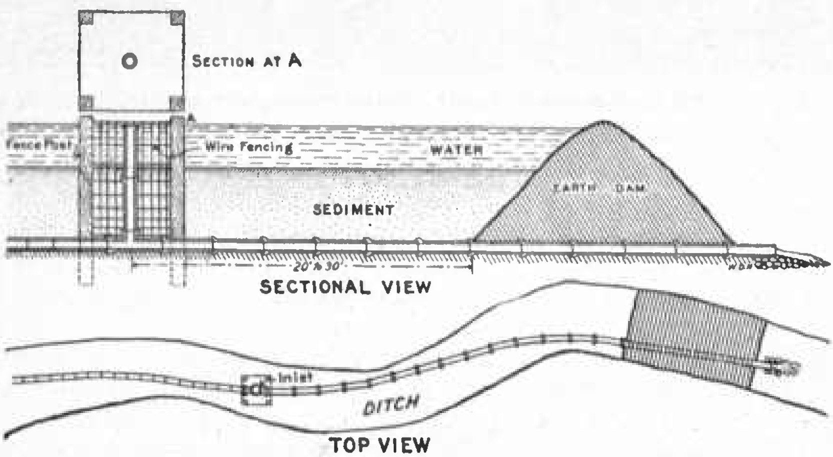

FIG. 23.—Soil-saving dam.

posite each other at the ends of the terraces. The boxes are filled with earth to hold them in place. They are built of 1-inch lumber with 2 by 4 inch posts at the corners, are usually made about 4 feet square, and placed 6 to 10 feet apart. The size of the boxes and the distance between them depends upon the area of land drained above. A 2 by 12 inch plank extending between the boxes forms the dam that causes the deposit of sediment above. Two parallel vertical wooden strips, about 2 inches apart, are nailed to the sides of each box, which forms a groove into which the stop planks can be slipped. Where a deep gully is being filled up, additional stop planks may be added from time to time. A wooden apron should be built below the stop plank to prevent washing, and means should be employed to prevent any leaking under the stop plank or along the sides of the boxes.

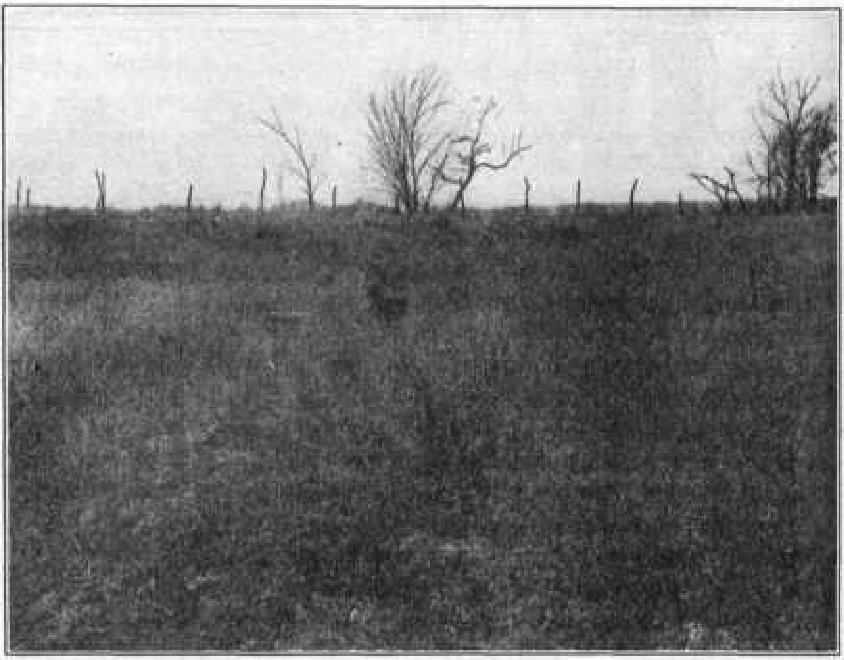

FIG. 24.—Upper side of soil-saving dam, showing two inlets; fence is on top of dam. Additional sections of tile will be placed on top of the two inlets as the surface of the land is raised by the accumulation of sediment.

Where large gullies are used as terrace outlets, further enlargement of the gullies may be prevented by what is known as the soil-saving dam, which is generally known to have been originated and developed by J. A. Adams, of Johnson County, Mo. (See fig. 23.) By means of such a dam erosion in the gully is not only stopped but the gully is soon filled up with sediment and made available for farming purposes. By this method the run-off water is caught and stored above the dam, the sediment in the surface water is deposited quickly, and the surface water passes down through the vertical inlet pipe and through the dam by means of the pipe as shown in figure 23. Figures 24 and 25 show the upper and lower sides and the inlet and outlet pipes of a soil-saving dam on Mr. Adams's farm. This dam is about 10 feet high; the tile through the dam is 15 inches in diameter and drains an area of about 40 acres above the dam. At the outlet the water is discharged through a concrete box trough about 6 feet in length, which prevents erosion in the channel below the dam. Two vertical inlet pipes are provided to insure the working of the pipe under the dam to its full capacity. The inlets are apt to be clogged by trash floating on the water, and for this reason they are not set near the dam, where the greatest accumulation of trash occurs. Additional lengths of pipes are placed on the tops of the inlet pipes as the draw is gradually filled up.

FIG. 25.—Lower side of soil-saving dam, showing end of outlet pipe discharging into a concrete trough to prevent washing below the dam.

The tile or pipe through the dam must be made large enough to prevent the overtopping of the dam during heavy rains. The following table has been suggested for determining the size of pipe to be used for different-sized drainage areas:

Diameter of pipe in inches.	Acres drained.	Diameter of pipe in inches.	Acres drained.
12	15	24	61
15	24	27	77
18	33	30	95
21	47	36	137

However, the proper size of the pipe depends largely upon the intensity of individual storms (not upon the total monthly or yearly rainfall) and upon the amount of storage above the dam. The larger the storage the smaller may be the pipe. In locations where storms are heavy or where the storage is small it may be advisable to make a considerable increase over the sizes given above. Figures 26 and 27 are views of the upper and lower sides of a newly-constructed soil-saving dam. Trash is prevented from entering the inlet pipe by means of the hog wire encircling the four posts set around the pipe.

Where suitable outlets can not be found for a system of terraces it becomes necessary to construct a hillside ditch to carry off the water.

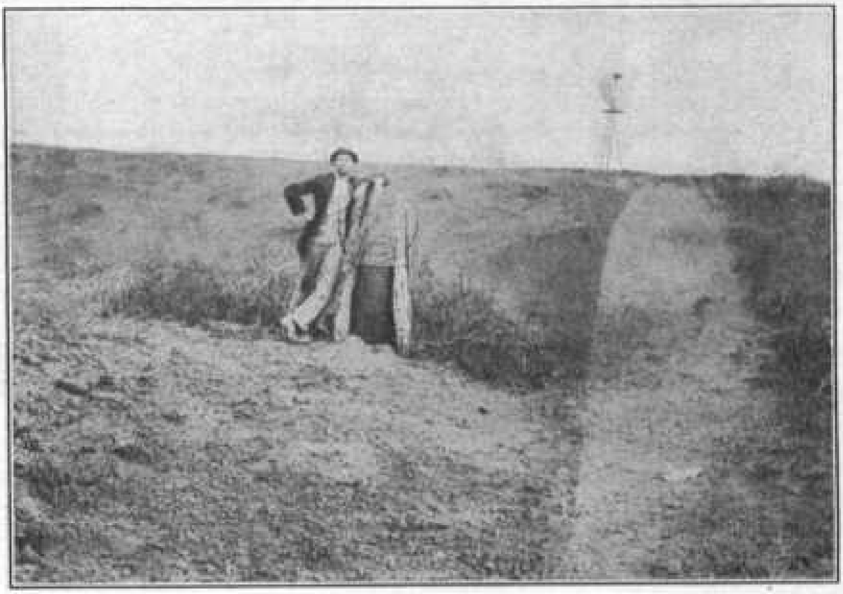

FIG. 26.—Upper side of newly constructed soil-saving dam, showing inlet pipe.

It is better not to locate such a ditch directly down the slope. It should be large enough and should have sufficient fall to remove the water from all the terraces.

The problem of providing terrace outlets for systems of level terraces is not so difficult as for graded terraces since much less erosion occurs from water that is discharged quite slowly at the ends of level terraces. On some soils that readily absorb a large percentage of the rainfall no provision need be made for terrace outlets. Figure 15 shows a plan of a field of level terraces in which the terraces completely encircle the top of the hill, there being no chance for the escape of the water over the surface of the ground. In fields where tile drains are laid above level terraces the outlets consist of main tile drains laid down the slope to a drainage channel below.

LAYING OFF TERRACES.

In laying off a system of terraces it is first necessary to provide for suitable outlets. This of course especially applies to systems of graded terraces. Wherever possible outlets should be provided for at both ends of terraces. This divides the water of the field and gives each terrace less to handle. Short terraces are less liable to break than long ones and are therefore more desirable.

Where a draw or depression occurs somewhere near the middle of the field it is desirable to begin the terraces in the draw, so as to avoid building a high embankment required for carrying the water across the draw. Of course this practice depends upon the size of the draw

FIG. 27.—Lower side of newly constructed soil-saving dam, showing outlet pipe.

and whether it is located so far from the middle of the field as to make one of the terraces unduly long. Sometimes it is found necessary to use such a draw as a terrace outlet where suitable outlets are not available at the border of the field.

The type of terrace best adapted for given conditions, the vertical distance between the terraces, and the fall that they should have are discussed in the foregoing pages.

It is always best to lay out the upper terrace in a field first. The starting point on the upper terrace should be obtained by measuring down the proper vertical distance from the top of the hill or field. If a terrace midway down the slope is laid out first and a point from which to start is selected at random without respect to the top of the hill, the chances are that the upper terrace will drain either too large or too small an area. When the upper terrace of a field is made to drain too large an area, which is a very common mistake in terracing, the excessively large volume of drainage water generally breaks the upper terrace and usually all the terraces below are broken in turn. If the upper part of a hill belongs to a neighboring farmer an effort should be made to induce him to terrace it. Otherwise it will be necessary to dig a hillside ditch along the upper side of the field to intercept the water draining from the neighboring farm above. In figure 28 is shown a plan of the location of terraces in an actual terraced field. The irregularity in the direction of the terraces is due to changes in the direction of the slopes of the field

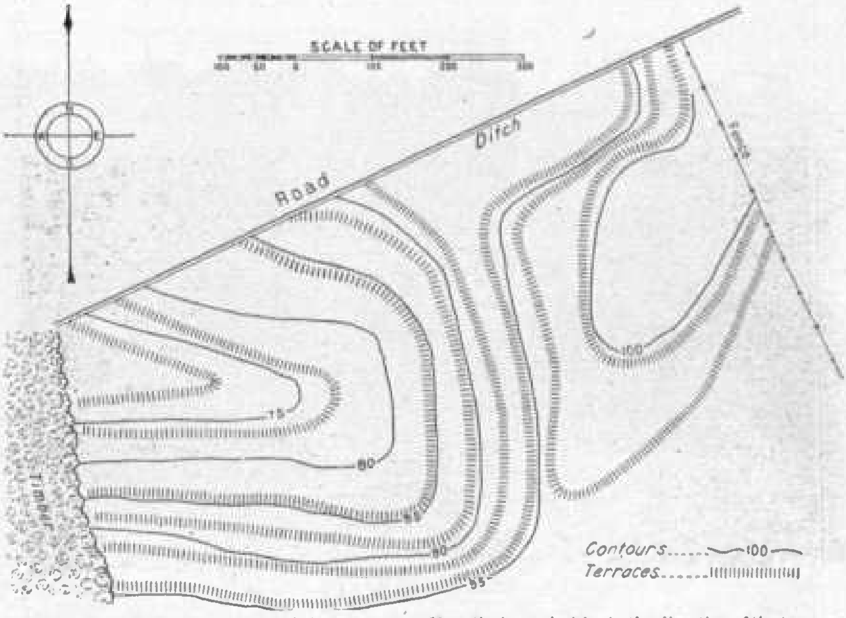

FIG. 28.—Field of broad-base graded-ridge terraces. Note the irregularities in the direction of the terrace lines due to changes in direction of the slopes of the field.

Where the slope of a field is uniform and with no changes in direction the terraces are practically straight and lie in parallel lines.

A number of homemade instruments are used for laying off the terrace lines, such as the A frame with plumb bob or spirit level, but unless the work is done very carefully the results are generally poor. A cheap form of level, costing about $18 (see fig. 29), is widely used for laying off terraces. With this level in the hands of an experienced operator very good results are obtained. The best results are obtained with an engineer's large level.

In laying off a system of graded terraces it is best to begin near the middle of the upper terrace. By beginning at the middle instead of at either end there is less variation in the vertical distance between the terraces. In fields where the terraces curve around a hill each terrace is generally much longer than the one immediately above. If the vertical distance between the terraces is laid off at the upper end, the terraces will be too far apart at the lower end owing to the greater amount of fall in the longer terrace. If the vertical distance is laid off at the middle of the terraces, the average distance between the terraces from the upper to the lower ends will be about right.

The field work required in laying off a system of graded terraces is as follows: Set the leveling instrument about halfway between the ends of the proposed terraces and high enough so that when it is

FIG. 29.—View showing level and rod widely used in laying off terraces.

level the line of sight will pass over the highest point in the field. If, for instance, the average slope of the field is about 10 feet in 100 feet then the drop between the terraces should be 4 feet as given in Table 3. To obtain a starting point on the first terrace, measure down a vertical distance of 4 feet from the highest point in the field. This is done by first reading the rod when set on the highest point and then finding a point below on the slope where the reading of the rod is 4 feet larger than the first reading. If the first reading is 1 foot the second reading should be 5 feet. Points on the proposed terraces may be located every 25, 33, 50, or 100 feet apart, the straighter the terrace the greater may be this distance. The distance should be either paced carefully or measured with a tape. A very common practice for average conditions is to establish points 33 feet apart or eleven 3-foot steps. If the terrace is given a uniform fall of 6 inches every 100 feet and is being laid out toward the outlet, the target on the rod should be raised 2 inches every 11 steps, or 33 feet; if in the opposite direction then the target should be lowered 2 inches each time. In pacing the distances the rodman should try to estimate as nearly as possible where the next point will be, and when directed up or down the hill by the levelman should try to keep the proper distance from the last point. In order to avoid mistakes the target should always be changed before starting to pace off the distance. If the field has been cultivated in ridges, the points should all be located by setting the rod either on top of the

FIG. 30.—View showing a party laying off terraces. The man with hoe digs a hole at each position of the rod to guide the plowman in laying out the first furrow of the terrace.

ridges or in the depressions between them. If, after the proper distance between points on the terrace line has been determined, it is found that the rod is too low when set in the depression between the ridges and too high when set in the next depression above then the proper location for the line of the terrace lies somewhere between the two positions of the rod. A man should follow the rodman and dig holes with a hoe or spade (see fig. 30) or set stakes at points on the proposed terrace lines. A plowman should follow immediately and lay out the first furrow. (See fig. 31.) Care should be taken to see that no abrupt turns are made with the plow. All changes in direction should be made by smooth, regular curves. Where gullies or draws are crossed, stakes should be set on each side and the terrace run directly across.

Long sights with the level should be avoided. Much more accurate results are obtained where short sights are taken. When it becomes necessary to move the level so as to avoid taking long sights or in order to see around a hill, the rodman should remain at the last point located. When the level is set up at the new position, the rodman changes the target so that it coincides with the new line of sight of the level and the work proceeds as already described.

Where a variable fall for the terrace is used instead of a uniform fall, it should be taken from Table 4. For instance, if the land has a fall of about 10 feet in 100 feet and the proposed terrace is 1,200 feet long, the fall to give the terrace would be three-fourths inch per 100 feet for the first 300 feet, 1½ inches per 100 feet for the second, 3 inches per 100 feet for the third, and 6 inches per 100 feet for the fourth 300 feet.

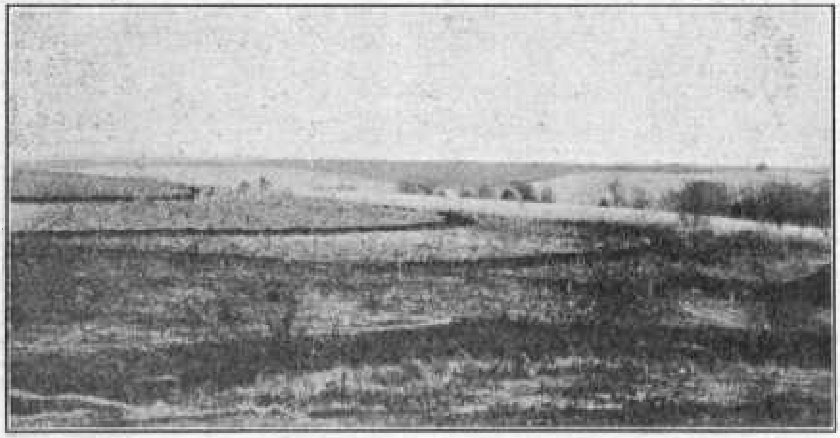

FIG. 31.—View showing lines of terrace located by plowing two furrows together.

The level terrace is much more simple to lay off than the graded terrace, since it is not necessary to measure distances along the terrace line and the target on the rod is kept at the same position for all points on each terrace. Other points to be observed in laying off a system of level terraces are similar to those discussed for graded terraces.

BUILDING TERRACES.

The plow and the V-shaped drag are the most generally used implements for building terraces. In figure 32 is shown a view of a terrace drag widely used in Texas. This drag is very easily built. In place of this drag a steel ditcher or terracer is frequently used, a view of which is shown in figure 33.

In terracing a field, the upper terrace should always be built first. If a lower terrace is built first and there is not time to build the upper before a rain comes, then the lower will be badly washed and broken by the large volume of water drained from all the land above. In building the terrace a back-furrow strip about four furrows wide is first thrown up as shown in figure 34. The steel terracer or V drag drawn by four horses is then used to move the dirt toward the center

FIG. 32.—View of homemade wooden V drag used for throwing up terraces.

FIG. 33.—A steel ditcher and terracer. Four horses are generally used with this implement in terracing work.

of the strip and as high as possible. The plowing is then continued and the best results are obtained where each round with the plow is followed with the V drag. The short wing of the V drag is sometimes hinged so that the distance the dirt is moved can be varied as the terrace grows wider. For the best results the weight of two men is required on the drag. They can shift their weight so as to raise or lower the end of the short wing as desired. The process of plowing and dragging is continued until the terrace is 15 to 20 feet wide. If the terrace is not high enough after it has settled, as found by testing the height in a number of places with a level, the plowing and dragging should be repeated. A view of a freshly built broad terrace is shown on the title-page.

FIG. 34.—The first step in building a terrace is to backfurrow a strip about four furrows wide.

Terraces are sometimes built with a plow alone. Several plowings are required to throw up the terrace to the desired height. A large 16-inch plow with an extra large wing attached to the moldboard is used very successfully for throwing up high terrace embankments. The disk plow and the ordinary road grader are very effective implements for use in building terraces. Graded terraces on steep slopes are often built with a plow and slip scraper. A strip is backfurrowed with the plow and the loose earth on the upper half of the strip is scraped up and dumped on the lower half. By this method the terrace is built up mostly from soil moved down from the upper side. (Fig. 35.)

In order to finish up terraces properly, some work with the slip scraper is generally required. The top of the terrace should be tested with the level and rod to see that it conforms to the proper grade. Any low places detected should be filled with a shovel or scraper. All large embankments across draws and gullies should be built with the slip scraper, and it is necessary to build such embankments considerably higher than the rest of the terrace to allow for settling of the loose earth. Figure 36 shows a view of a high terrace across a draw built with a slip scraper. Most breaks in terrace systems occur at crossings of gullies or draws, and it is therefore very important that a high, broad, substantial embankment be

FIG. 35.—View of a newly completed broad-base ridge terrace.

built across these places. In order to remove any water that collects above the terrace embankment across draws or gullies, a pole drain can be laid under the terrace down the middle of the gully. Such a drain is made by simply laying three poles together in the shape of a triangle. It will serve the purpose until the depression above the terrace is filled with silt and a drain is no longer required. This drain is particularly adapted for use with systems of graded terraces. Where level terraces are used, the tile drain described on page 15 is recommended.

Any obstructions, such as rocks, stones, and stumps, that lie along the line of the terrace should be removed, since their presence might permit seepage and result in the failure of the terrace. In some parts of Texas the fields contain numerous large earth mounds generally known as gas mounds. These mounds cause considerable difficulty in terracing fields. Where they lie along the lines of graded terraces, it becomes necessary to provide a passageway through them by means of the plow and scraper.

Where terraces are continued from one field to another across a fence row, it is necessary to build that portion of the terrace near the fence by hand labor, using the spade and shovel. It is very important that this portion of the terrace and channel be built the

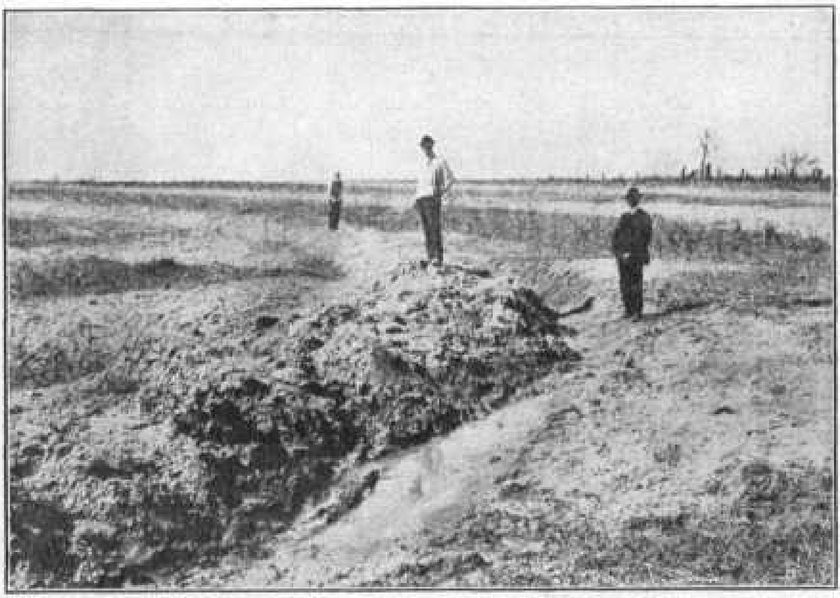

FIG. 36.—High terrace embankment built across a draw with a slip scraper.

same size as the rest of the terrace, and considerable attention should be given later to see that the waterway is always kept open, so that the free flow of the water shall in no way be obstructed.

Narrow-base and bench terraces are built in the same manner as the broad-base terraces, but not so wide. The bench terrace is gradually developed by always plowing the soil down the hill with a reversible plow.

The old maxim, "What is worth doing at all is worth doing well," is especially applicable to terracing work. If one has not time to terrace all of a field properly, it is far better to terrace the upper part well than to attempt to terrace the whole field and do a poor job.

CARE AND CULTIVATION OF TERRACES.

Terraces require considerable care and attention, especially during the first year, before the loose soil has had time to become settled thoroughly. All apparently weak places should be visited after every heavy rain and any breaks should be repaired immediately with a shovel. It is best not to cultivate the terraces the first year, but to seed them to some kind of cover crop. (See fig. 37.)

It is advisable to run the crop rows parallel to the terraces, one row being planted on the top of the terrace. The cultivation of the top row tends to keep the top of the terrace at the proper height. Where the rows are run across the terraces, as is done commonly on moderate slopes, the top soil is moved down the side slopes by cultivation. As a result, the terraces are more liable to break, and

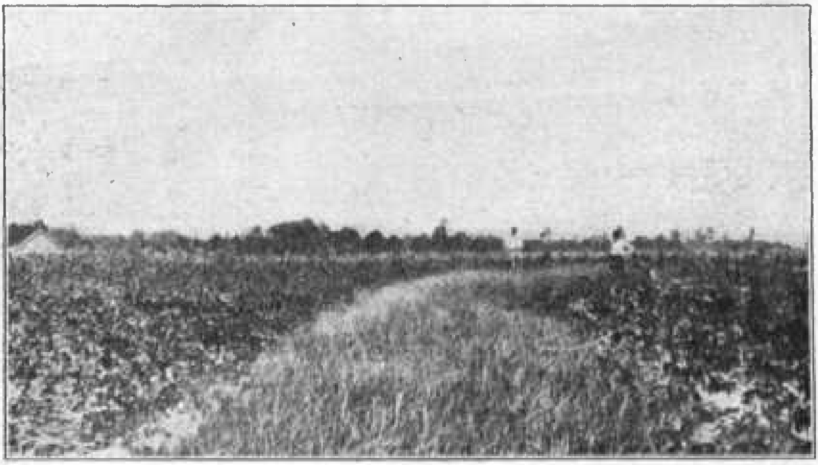

FIG. 37.—Newly built terrace seeded to cover crop to insure against breaking before the loose earth becomes thoroughly settled.

much more maintenance work is required than where the rows are run parallel to the terraces.

All terraces that are cultivated should be plowed at least once a year, and the soil should be thrown to the center. In this way the height of the terrace is kept up, and the base may be broadened each year.

Steep land that washes badly between the terraces should not be cultivated. The terraces should first be well built and the entire field seeded to grass and used for pasture or meadow.

When it is found necessary to cross a farm road in terracing a field, the building of the terraces should be continued across without regard to the road. Where the terraces are as much as 20 feet broad, no provision need be made for passing traffic across them, but they should be carefully maintained to prevent possible breaks. Where the terraces are not more than 10 feet broad, considerable inconvenience to traffic and injury to the terraces generally results where no provision for crossing is made. Sometimes the water is carried under the roadway by means of a culvert, as shown in figure 38 but the principal objections to this are that the capacity of the waterway is greatly reduced and the free flow of the water through the culvert is often obstructed by stalks or other trash washed from the field. A wooden bridge spanning the channel, so as not to reduce very much the cross sectional area of the waterway, makes a more desirable and satisfactory crossing.

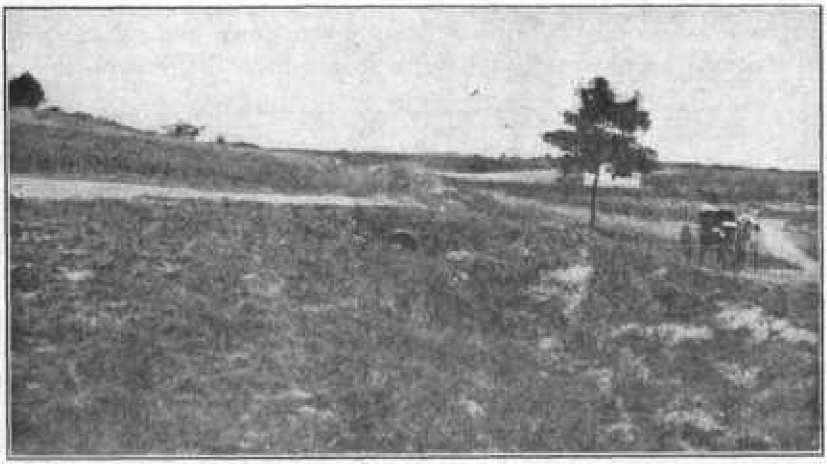

FIG. 38.—Method of carrying terrace water under a roadway by means of a culvert.

SUMMARY.

Erosion injures or practically ruins fertile land. Bottom as well as hill lands suffer from the ravages of erosion.

Terracing is the most effective method of stopping erosion. Other means of reducing erosion that should be employed in connection with terracing are deep plowing, growing cover crops, plowing under organic matter, contour plowing, and underdraining.

There are two distinct types of terraces, the bench terrace and the ridge terrace. The bench terrace is particularly fitted for use on steep slopes, while the ridge terrace is especially adapted for use on moderate slopes.

The ridge terraces are divided into two classes, the narrow base and the broad base. Both may be laid out level or with a fall along the terrace to carry the water off at a low velocity. The broad-base terrace can be cultivated and can be crossed readily by large farm machinery without injury to the terrace. The narrow-base terrace does not possess either of these advantages, and under ordinary circumstances is less desirable than the broad-base type. However, when laid out level it is sometimes cultivated successfully on very sandy soils that are capable of absorbing large quantities of water.

The broad-base level-ridge terrace is laid out absolutely level. This more nearly meets the requirements of an ideal terrace than any other type. Its distinct advantage over a terrace with fall is that practically none of the fertile parts of the soil are removed from the field. It is particularly suitable for use on open, permeable soils. When used in connection with tile drains on any type of soil it unquestionably is the most effective method ever employed to stop erosion.

The broad-base, graded-ridge terrace, generally known as the Mangum terrace, possesses all the advantages of the broad-base level-ridge terrace with the exception of the one stated in the preceding paragraph. It may be used on any type of soil, but is recommended for use only on soils where the broad-base, level-ridge terrace without tile drainage can not be used successfully. Erosion is reduced to a minimum in the terrace channel by carrying the water off the field in a broad, shallow sheet at a low velocity. It has been found that average soils are not washed much in broad-terrace channels where the fall does not exceed 6 inches in 100 feet and it is recommended that this fall never be exceeded. However, even with this fall some washing occurs and some rich soil particles are carried off the field. Hence a graded terrace should be given no more fall than is necessary to remove the run-off water without danger of the terrace being overtopped. The terraces may be laid out with a uniform or a variable fall. The best results are obtained where the variable fall is used, since it tends to prevent the concentration of the water at the lower end of the terrace. Also less washing occurs where the variable fall is used.

The provision for suitable outlets is one of the biggest problems in terracing work. Natural water courses make the best outlets. Sometimes it is necessary to construct ditches for use as outlets. Where natural draws, gullies, or roadside ditches are used they should be protected from erosion by building across them brush, concrete, stop-plank, or soil-saving dams. The growing of grass in draws used for outlets is especially recommended.

The work of laying off terraces should be done carefully, preferably by an experienced man. The best instruments are the farmer's small telescopic level and the engineer's large level.

The plow and the V drag are most generally used for building up terraces. Other implements sometimes used are the steel ditcher or terracer, the slip scraper, the disk plow, and the road grader. At crossings of draws and gullies the slip scraper is used to build up the high terrace embankment. It is very important that the top of the terrace be built to the proper grade. The upper terraces of a field should always be built first.

Terraces require considerable care and attention, particularly during the first year after they are built. They should be inspected after every heavy rain and any breaks or weak places repaired immediately. The best results are obtained when the crop rows are run parallel to the terraces.

In order to maintain the height and width of the terrace, a cultivated terrace should be plowed at least once each year, and the soil should be thrown to the center of the terrace.