

TERRACING TO REDUCE EROSION



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TERRACING TO REDUCE EROSION

By

DAVID S. WEAVER, *Head, Department of Agricultural Engineering*

and

H. M. ELLIS, *Extension Agricultural Engineer*

This bulletin will deal strictly with terracing as one phase of a well-rounded soil conservation practice. Terracing alone will not solve the problem of soil erosion, but terracing, on slopes and in soil types where terraces are practical, forms the basis upon which a well-rounded soil conservation program may be developed.

When we speak of soil erosion we mean the mechanical movement of soil. Two natural agencies are responsible for this movement—water and wind. While both types of erosion are found in this area, our losses in North Carolina from wind erosion are negligible when compared to our losses from water erosion. Wherever the slope of the land is great enough to cause rain water to flow over its unprotected surface, soil is being washed down the slope. This type of erosion is divided into two classes: gully erosion, and sheet erosion. Where channels are washed out because of water being concentrated on narrow strips of land we describe it as gully erosion. Where the moving water is fairly uniformly distributed over large areas, but the land is sufficiently steep for the upper soil to be moved down the slope, we describe it as sheet erosion. Under cultivation a field may be almost entirely stripped of its top soil before gullies form. Where the slope of the land is such that the run-off is concentrated, gullies may appear before sheet erosion reaches an advanced stage.

Gullies are easily recognized by anyone, but in many cases the farmer doubts that his land is washing, when in reality sheet erosion is taking a heavy toll. Our problem in terracing is to intercept this surface run-off, at intervals down the slope, and conduct it from the field in a graded channel, the grade being such that there will be no channel erosion. The terrace which experience has shown to be most satisfactory in North Carolina is the broad-base, drainage type which incorporates the best features of the various terraces which have been developed in this and other states. The vast majority of terraces now being constructed by all agencies in this state is of this type. This bulletin deals with the proper spacing, grade, cross section, and maintenance of this terrace.

GENERAL CONSIDERATIONS IN DESIGNING THE TERRACE SYSTEM

THE METHODS DESCRIBED BELOW SHOULD BE FOLLOWED AS CLOSELY AS POSSIBLE, BUT IT SHOULD NOT BE ASSUMED THAT THEY ARE TO BE FOLLOWED BLINDLY, WITHOUT APPLYING

COMMON SENSE AND GOOD JUDGMENT TO THE PROBLEMS PRESENTED, IN PLANNING A SYSTEM FOR A PARTICULAR AREA.

Certain fundamental principles of terracing, which to some extent have been neglected in the past, are in reality of greater importance than proper construction of the terrace. In this chapter an attempt will be made to outline these steps in their proper order. Experience gained in the past few years in connection with the widespread program reveals that too much time cannot be spent with the preliminary study of the particular area to be terraced. The logical procedure is as follows:

A. Walk over the entire area to be included in the system, keeping in mind that adjoining areas may be included later. This preliminary survey should not be a casual one, but a definite study should be made of the following factors:

1. Slope, or Lay of the Land.

The primary consideration in establishing a system of terraces is that of slope. Obviously level land does not require terracing. Other factors being equal, the steeper the slope the more severe the degree of erosion. On most soils the terrace described in this bulletin is practical and will aid materially in controlling erosion on slopes up to 14%. In the mountain area and the rougher sections of the Piedmont where it is considered practical to construct terraces on land steeper than 14% the standard terrace must be modified.

2. Natural Drainage System.

This includes the natural flow of water across, and from the area. Points where the effects of concentration of water are found should be noted as they will affect the location and construction of the terraces in the system.

3. Kind of Soil.

Generally speaking North Carolina soils, from the standpoint of terracing, may be placed in three general groups.

a. *Red, or yellowish red clay soils, with or without sandy top soils.* These soils are found usually throughout the Piedmont, and terrace systems on them are easily constructed and maintained.

b. *Deep sands with yellowish sandy clay subsoils.* These soils are found in the lower Piedmont and upper Coastal Plains and terraces on them are easily constructed, but require constant maintenance. Because of the loose open nature of these soils, terrace channels are quite likely to become filled with sand, which will cause breaks. Often this leads to rather severe gullyng. It is for this group of soils that we vary our general recommendations in regard to terrace grade, and recommend a uniform fall of 4" in each 100 ft.

c. *Heavy, tight clays, yellow, brown, or yellow and red, commonly called pipe clays, gumbo, buck tallor, or beeswax.* These soils are found throughout the Piedmont section of North Carolina. They may occur in bodies ranging in extent from a few acres to several hundred acres. Because of their tight, heavy nature these soils do not readily lend themselves to

terrace construction. Maintenance of systems is so difficult, and the results are so unsatisfactory that other methods of control are recommended.

4. Existing Obstructions.

a. *Existing terraces.* Existing terraces which do not conform to specifications as to grade and spacing should be eliminated before the system of terraces is staked. Only in exceptional cases has it proven worth the time and labor expended to attempt to incorporate them in the new system.

b. *Rock outcrops, or stumps.* It is often possible to make minor adjustments in the terrace spacing so as to avoid passing through an outcrop. Where this does not seem advisable, blasting may be resorted to.

c. *Immovable objects.* Immovable objects, such as cemeteries and buildings should be noted, as the system of terraces will have to be made to conform to their location.

d. *Gullies.* Because many areas which require terracing are badly gullied special treatments are explained on pages 11 and 27.

B. Go to the highest point in the area. From this vantage point, and with careful consideration of conditions observed while making the field study, determine all possible outlets. If more than one outlet is practical, carefully examine each. Select the one having the most practical advantages, keeping in mind that natural cover requires less maintenance and that frequently it is possible to reduce concentrations by outletting terraces at both ends. All terraces should be kept as short as conditions in the field will permit and if it is necessary to construct a terrace greater than 1,500 feet in length, it should be constructed with more channel capacity than is shown for the completed terrace, Page 22. A further and very important consideration is to be sure that the water from the individual outlet, or from the outlet channel, will not cause gulying farther down the slope.

CONCENTRATED WATER IS DANGEROUS. BE SURE IT IS KEPT UNDER CONTROL.

For further information refer to page 23.

C. Determine if the run-off from other areas must be diverted from the proposed terrace system.

Frequently land which naturally drains across the area to be terraced cannot be included in the system. This may be true because it is in forest, or owned by someone else. In such cases, it will be necessary to divert this run-off from the upper terrace. A diversion ditch of sufficient capacity should be constructed to intercept this water and conduct it to a proper outlet. This may be a natural drain or an extension of the main outlet channel. For information on the construction of diversion ditches, refer to page 24, Prepared Channels. Diversion ditches are constructed exactly as other prepared channels.

D. Location of the Upper Terrace.

Determining the best possible location of the upper terrace is of sufficient importance to have it explained in a separate paragraph. In the mechanics of staking terraces, it will again be referred to, but at this time, we wish to place emphasis on the importance of this step. Under ideal conditions it is

a simple procedure, but in a great many cases it will require special study and time.

The best written instructions that can be given are: After completing the field study, space the upper terrace the proper vertical interval down hill from the top point of the crest or from the diversion ditch in case the area to be terraced does not extend to the top of the hill. The tendency is to place this first terrace too far down the slope. Usually the factors influencing the instrument man are: flat areas on top of the knoll, small areas from standpoint of acreage for instance where the corner of the field is the high point, etc. In these cases a good rule to bear in mind is—it is not necessarily the volume of water that does damage but the distance the water flows down the slope before being intercepted by a terrace. Water falling on top of the ridge or just below the diversion ditch starts moving off slowly but gains velocity. According to Mr. C. E. Ramser in *Farmers' Bulletin*, No. 997, if the slope is 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 32 times.



A diversion ditch intercepting water from the area above a badly eroded section, which is to be terraced.

Assuming a uniform slope there is a point below the top of the hill, or diversion ditch, at which water flowing down the slope will reach a velocity sufficient to move soil particles and start scouring. This point should be the location of the upper terrace. If the terrace is placed below this point, the soil moved by the force of the water will be washed into the flow line. After entering the flow line the velocity of the water is checked and it no longer has the power of transporting the soil. Consequently, the flow line of the terrace will fill with soil and unless it is cleaned after each heavy rain will

eventually break. The upper terrace is referred to as the key terrace and if it fails, the chances are that all terraces below it will break.

Terraces not properly spaced, graded, and constructed are worse than no terraces at all.

METHOD OF PROCEDURE

This chapter will deal with the actual process of staking terraces. In preceding paragraphs, general considerations, and the importance of properly locating the upper terrace were explained. Some exceptions will be described, but in order to keep this bulletin from becoming too lengthy many actual variations will be omitted.

A. Instruments used in laying off terraces. Because satisfactory farm levels are available at a very reasonable price, home-made equipment, including the "A" frame, and other devices formerly employed should be discarded. The accuracy necessary for determining the proper grade and spacing for terraces cannot be obtained with such equipment. Not only will time and the expense of construction be wasted if the terraces are not properly laid out with respect to grade and spacing, but the damage done by the use of such systems is likely to leave the field in worse condition than before terracing was done. It is recommended that the instrument be checked often for accuracy and that a self-reading rod, graduated in inches, be used. The instrument should be adjusted as frequently as is necessary.*

No matter how accurately the instrument may be adjusted, knowledge of its use is essential. No one should attempt to lay out a terrace system until he is familiar with the use of the instrument. It is recommended that a person who wishes to construct a terrace on his farm, first consult someone who has knowledge and has had experience in the work.

B. Locating and Staking Terraces. The field has been studied, special problems have been considered, the outlet locations have been observed and we are now ready to locate the upper terrace.

The vertical fall between terraces depends entirely upon the slope of the land immediately above it. This means that the slope of the land must be determined for each terrace.

A TERRACE PROTECTS THE LAND IMMEDIATELY BELOW IT AND IT DOES THIS BY INTERCEPTING THE WATER FROM THE AREA IMMEDIATELY ABOVE IT.

To determine the vertical fall per 100 feet, set the instrument so that the rod can be read when it is placed on the high point of the field. The rod is read at this point and the reading recorded. The rodman then walks directly down the slope 100 feet. The rod is again read and the first reading is subtracted from the second. The difference is the slope of the land for the first 100 feet. Find this difference in Table 1, Line A. Directly under it in Line B, will be found the figure representing the vertical fall between the top of the hill and the first terrace. If the land is so steep the rod is not long enough to be read at the point 100 feet down the slope, then the rodman will

*Information on the care and adjustment of instruments may be obtained by writing to the Department of Extension Agricultural Engineering, N. C. State College, State College Station, Raleigh, N. C.

TABLE NO. 1

This table gives suggested spacing for terraces according to the slope of the land.

Line A	Slope of land in feet per 100 feet	1'-0"	1'-6"	2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	0'-0"	7'-6"
Line B	Vertical fall between terraces in feet	1'-6"	1'-9"	2'-0"	2'-3"	2'-6"	2'-9"	3'-0"	3'-3"	3'-6"	3'-9"	4'-0"	4'-2"	4'-4"	4'-6"
Line A	Slope of land in feet per 100 feet	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"
Line B	Vertical fall between terraces in feet	4'-8"	4'-10"	5'-0"	5'-2"	5'-4"	5'-6"	5'-8"	5'-10"	6'-0"	6'-2"	6'-4"	6'-6"	6'-8"

SIMPLE RULE FOR TERRACING SPACING

NOTE: By "slope of land" we mean the feet of fall for 100 feet directly down the slope.

The following rule may be used in spacing terraces rather than referring to or memorizing Table No. 1.

On all land slopes up to and including 6 percent take the slope of the land in feet and add 2 feet and divide by 2. For example, if the slope of the land is 4 feet, then $\frac{4 \text{ feet} + 2 \text{ feet}}{2}$ equals 3 feet which is the proper vertical spacing for this slope.

On all land slopes above 6 percent take the slope of the land in feet add 6 feet and divide by 3. For example, if the slope of the land is 9 feet, then $\frac{9 \text{ feet} + 6 \text{ feet}}{3}$ equals 5 feet, which is the proper vertical spacing for this slope.

return to a point 50 feet from the original reading on top of the hill. The rod is read at this point, the first reading is subtracted from it, and this difference for the 50 feet distance is multiplied by 2 to obtain the slope for 100 feet.

When the vertical fall between the upper terrace and the top of the hill is determined, by use of the table, it is added to the original reading taken on the high point. The sum of these two figures is set on the rod and without moving the instrument this point is located on the ground. This point is located by moving the rod up or down the slope until the line of sight of the instrument cuts through the center of the target. The point located is one point of the terrace line. This point may be near either the outlet or the crest, or at any intermediate point between these two.

In determining by rod-reading, the slope of the land for spacing the upper terrace or any other terrace, where the slope is not uniform, readings should be taken on the predominating slope rather than on either of the extremes. The vertical fall between terraces depends on the slope of the area immediately above the lower terrace. The predominating slope of the area is the average slope of the major part of this land. If the fall is read on the steepest section the terraces will be too far apart on the flatter section, and if the fall is read on the flatter section, the terraces will be too close together on the steep section. The predominating slope will space the terrace to the best advantage from the standpoint of both protection and tillage.

When one point on the terrace has been located, the rodman, by walking as near as possible along the contour walks to the upper end of the terrace. Then staying as near as possible on the contour he paces the length of the terrace noting the distance from the original stake to the outlet. Having thus determined the length of the terrace and knowing the rod reading the original point and the distance to the outlet he then refers to TABLE NO. 2 and calculates the total fall of the terrace from the original point to the outlet. This total fall is added to the rod reading of the original point and the target is *raised* to this figure. This point when located is the terrace outlet.

The following example will serve to explain the above procedure. Assume that the field is of red clay soil; that the rod reading at the original stake was 6'-0"; the terrace 900 feet in length and the original point 400 feet from the outlet. According to Table 2 the total length of the terrace should be divided into thirds; in this example the third will be 300 feet. The table shows that for each 100 feet of the lower third the terrace should fall 4 inches. Therefore, the lower third should have a total fall of 12 inches. Similarly, each 100 feet of the middle third will be found to have a fall of 3 inches per 100 feet. As the original point was 400 feet from the outlet the first 300 feet will give 12 inches fall and the remaining 100 feet will give 3 inches fall, making a total fall of 15 inches from this point to the outlet. Since the rod reading on the original point was 6'-0" the target is still set on this reading. The total fall of 15 inches is added to the rod reading and the target is set on 7'-". This point when located is the terrace outlet.

TABLE NO. 2
TERRACE GRADES

Soil Classifications	Terraces	Grades
Red or yellowish red clay soils with or without sandy top soils. Note: Refer to Page 4, Section 3-a.	Less than 400 feet long.	Uniform per 100 feet. 3"
	Over 400 feet long	Lower 1/3 of terrace length from outlet per 100 feet. 5"
		Middle 1/3 of terrace per 100 feet. 4"
		Upper 1/3 of terrace per 100 feet. 3"
Deep sands with yellowish sandy clay subsoils. Note: Refer to Page 4, Section 3-b.	All except tobacco land.	Uniform per 100 feet. 4"
	Tobacco land	Lower 1/3 of terrace length from outlet per 100 feet. 6"
		Middle 1/3 of terrace per 100 feet. 5"
		Upper 1/3 of terrace per 100 feet. 4"

It is often found that the theoretical point of outlet does not afford the best outlet within reach. Slight variations are permissible when the outlet can be improved.

In doing this the rodman knows exactly the number of inches (up or down) it was necessary to move his target. From this he knows almost exactly how far up or down the hill the terrace will be moved on the predominating slope, and whether or not this will be wise. No time has been lost in staking terraces that will have to be moved.

When the outlet has been located and the target set the terrace is staked. In marking points along the terrace use stakes of sufficient size that they may be easily identified later. A stake should be set on each 50 foot station except for sharp bends, gullies, etc. Critical points of this nature should be marked every 25 feet, or nearer, depending on the trouble they will cause in constructing the terrace.

Stake all succeeding terraces down the slope with the same procedure. For each terrace, measure the slope of the land, using the last terrace staked, as the upper point.

The only exception to the above procedure is the recommendation for loose sandy soils described on page 4, Section 3-b. For these soils it is recommended that terraces be given a 4 inch uniform grade for all crops except tobacco. On tobacco land it is recommended that a variable of 6"-5"-4" fall per 100 feet be used. Refer to Table No. 2, section on terrace grades for tobacco land. These grades for tobacco land terraces are in accordance with the best practices being recommended at this time. Definite information, based on research regarding erosion control, on soils of this type for tobacco, is not available. Observations made and reported in all

tobacco growing areas indicate that the question of row arrangement is definitely as much a part of this important problem as that of terrace grade. Recommendations regarding row arrangement will be found on page 26.

After terrace lines are located it will be found in many cases that slight variations in the spacing will have to be made in order to miss existing obstructions, such as buildings, tight rock, etc. When such changes are required the danger point is in increasing the drainage area of that terrace beyond the point of safety. On highly erosive soils, particularly for tobacco, this change in spacing should be to decrease the drainage area rather than to increase it.



Filling a gully preparatory to constructing a terrace across it.

Crossing Gullies. When staking terraces, cross gullies directly. Of course wide gullies which would require a long earth fill, make it necessary to swing the terrace upward, but where it is practical gullies should be crossed with a straight line. When fills are made, be sure to allow for settlement. Fills will settle approximately one-fourth their height in the terrace ridge; therefore, always add 25% to the normal height.

When active gullies, too large to cross with terraces are encountered, plan the system so that a terrace will divert the head water from entering the gully. Small diversion ditches, or terraces, may be constructed to intercept water that would flow into the gully from the sides and conduct it to a more suitable outlet.

Upper End of Terrace. It is a common occurrence for a pond to form at the extreme upper end of a terrace, regardless of the machinery with

which it was constructed. This is not a serious fault but can be easily prevented when staking the terrace. The last stake at the upper end of the terrace may be set uphill an additional 4 inches. Very little water finds its way into the upper 50 feet of the terrace and no harm will be done. In many cases this variation can be used to advantage.

Never Increase Grade Beyond Allowable Limit at Terrace Outlet.

Lowest Terrace In System. If in staking lowest terrace at proper vertical fall, it does not protect at least one regular terrace interval below it, it may be omitted.

Staking Outlet Channels. Whenever it is necessary to prepare outlet channels they should be outlined by two rows of stakes as a part of the regular staking process. Refer to Terrace Outlet Channels, page 24.

Review. When completed, the entire staked out system should be carefully reviewed. Very often it is possible to make slight changes the need for which was not evident when the terraces were staked. Such changes may make the difference between a satisfactory and an unsatisfactory system. This is particularly true when the row arrangement problem is difficult. This problem is discussed under Row System, page 26.

TERRACE CONSTRUCTION

There are a number of general requirements to be kept in mind in connection with the proper design and construction of a terrace:

1. It must not cause any loss of cultivated area.
2. It must be so constructed that it can be easily crossed by farm machinery.
3. The channel must be wide and flat with just enough slope to carry the water off, but not enough to cause washing.
4. The ridge must be high to prevent overtopping during heavy rains.
5. There must be a continuous grade toward the outlet, to prevent excess ponding of water.

From our experience we are convinced that the broad base, drainage type, terrace, described in this bulletin, page 22, with a width of ridge of from 12 to 24 feet, height of ridge above channel, of 16 to 20 inches, and a width of channel of 12 feet, when properly located and constructed, comes nearest to meeting these requirements for this state.

Location Of Finished Flow Line With Regard To the Line Of Stakes. A wonderful saving in both time and labor will be realized, if the terrace is so constructed that the finished flow line falls directly along the original line of stakes. Obviously, on a perfectly uniform slope, no difference in the grade of the channel would be made if the flow line, or the center of the ridge, fell along the line of stakes. In this state, however, we have a relatively small number of fields with uniform slopes, and with variable slopes the grade of the finished flow line is not the grade of the staked line, unless the terrace is constructed so that these two lines are the same. Unless this procedure is followed, it is possible for the finished flow line to have a reverse grade, for a short section.

Importance Of First Cut. Too much emphasis cannot be laid on the importance of the first cut in the construction of a terrace. This applies whether the terrace is to be constructed with large tractor and terracer, or plow and V-drag. In reality, this is the foundation cut, and the finished terrace usually conforms to its location. With large equipment and experienced operators, the problem is quite different than it is when the line is to be marked out with a plow, but its importance remains the same. Sharp turns may be reduced by drawing a little closer, or pulling a little farther, from the line of the stakes. If this is done, the cut should not be quite so deep, when pulling away from the line of stakes, and a little deeper, when pulling nearer the lines of stakes. In crossing a badly eroded area with all the topsoil gone, it will be impossible to cut as deep and the amount of fill



The first cut is made three feet below line of stakes. Care in making this cut is essential if a good terrace is to be constructed with a minimum number of rounds.

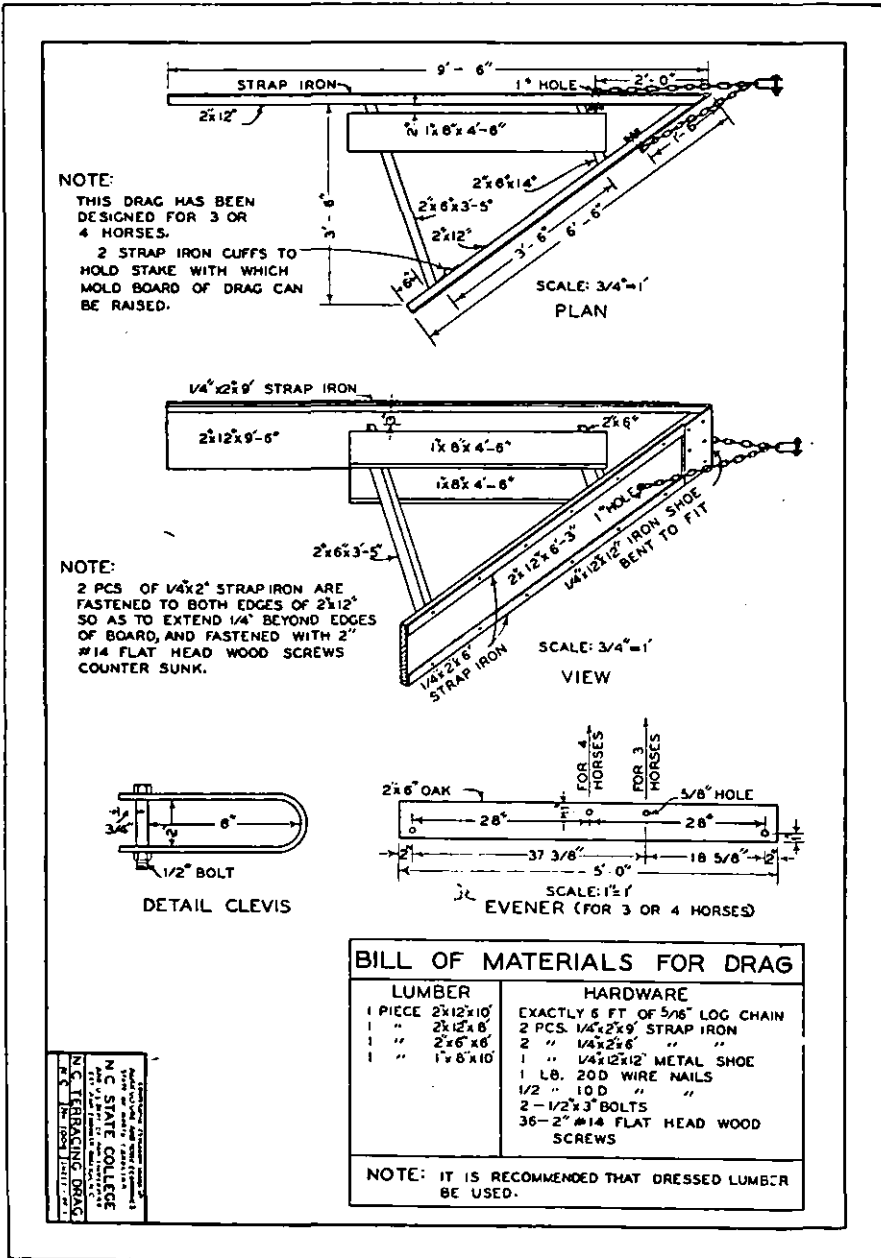
that will be required in such a case will be smaller if the first cut is pulled a little nearer the line of stakes.

Each successive cut is made up or down hill a certain distance from the first cut, so if this cut is properly made the resulting terrace will have the correct grade.

A. Construction With Home Made V-Drag. A V drag is a valuable piece of farm equipment. Its use is not wholly limited to the construction of terraces since it can be used in smoothing farm roads, dragging in gullies, etc. It is used to move dirt and can be designed to do this efficiently, but it requires the use of a plow. In travelling with a load it must have a furrow in which to track.

As with all types of construction the first cut is very important. Since

the man plowing cannot properly locate this first cut and plow too, someone should walk just ahead of the team, with the plow following in his path.

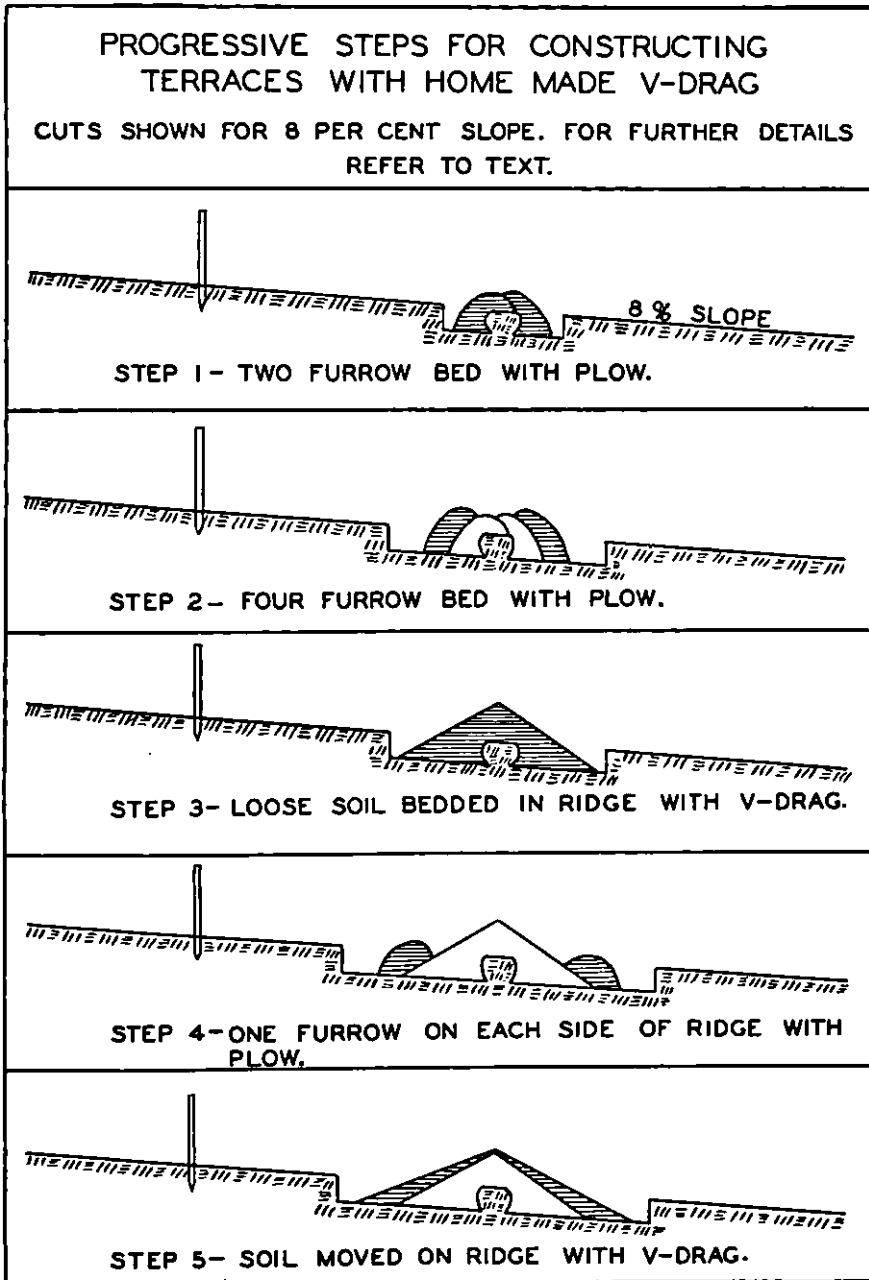


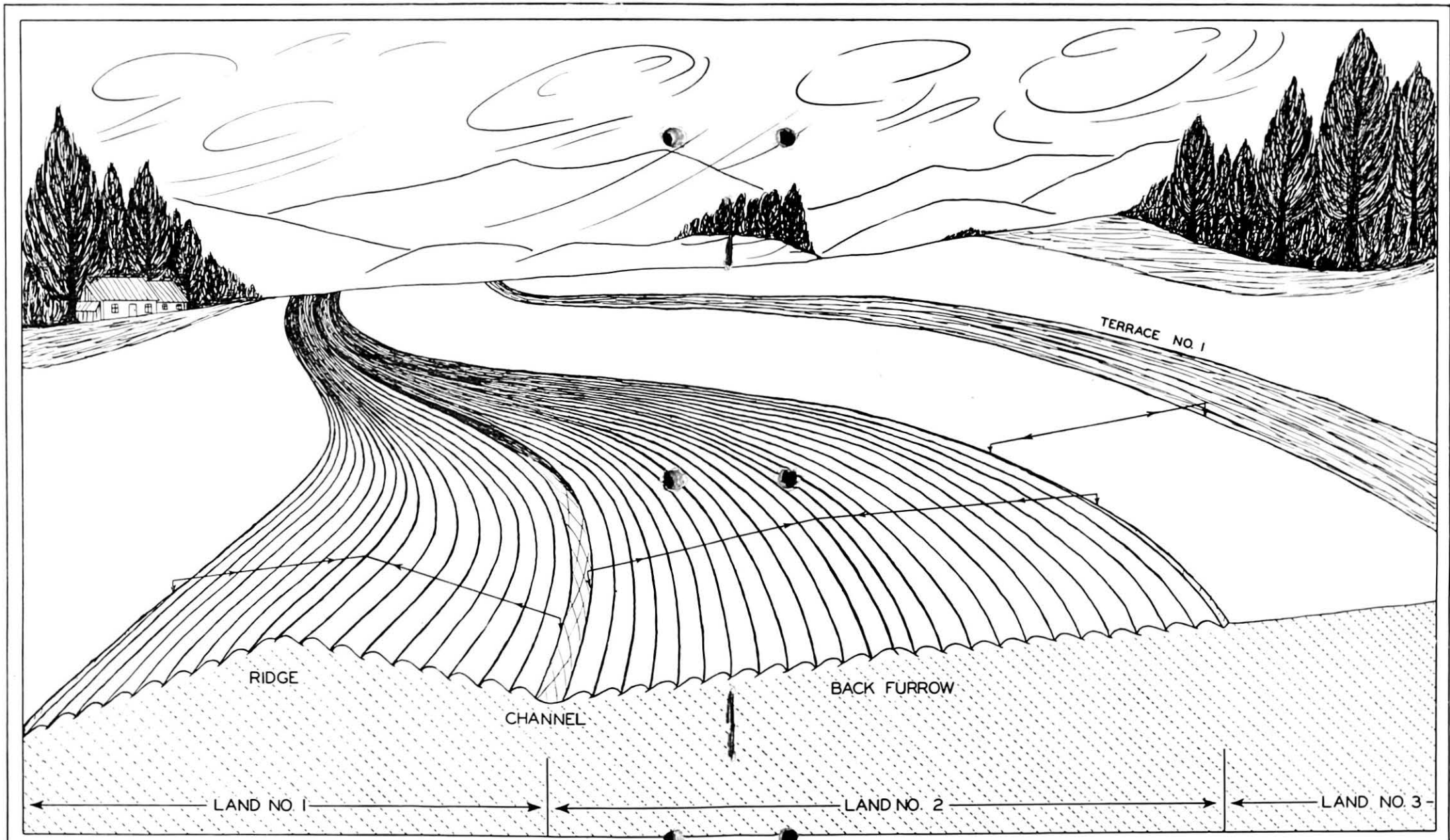
Picture on cover shows this V-drag carrying out Step 4 on page 15.

This man ahead can locate the next stake and consider how best to cross washes and straighten the line of stakes. Under average conditions he walks out a line six feet below the line of stakes, starting at either end.

Procedure For Construction.

The following procedure is for V-drag construction using either a team or farm tractor for power. The steps of construction are shown on the following pages.



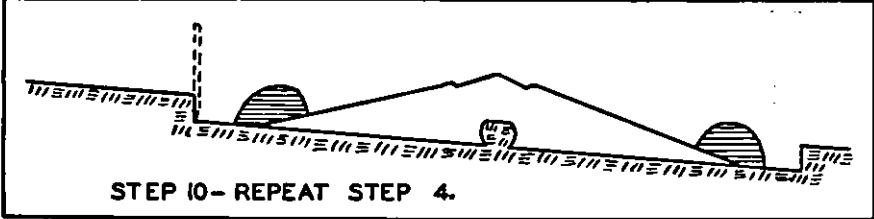
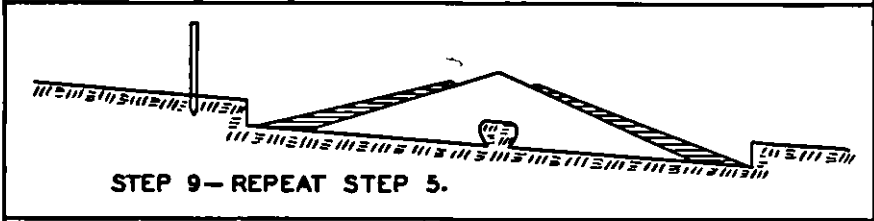
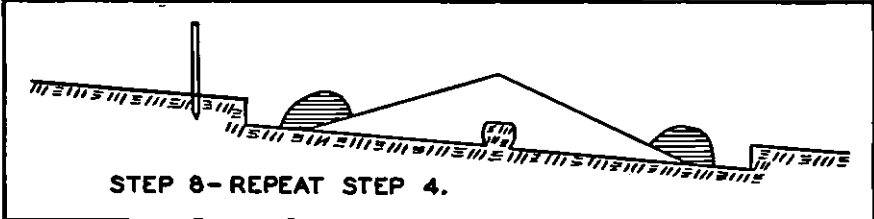
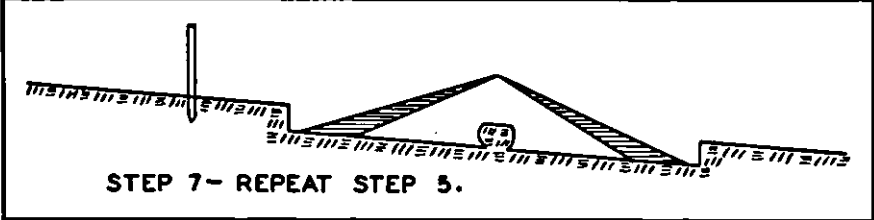


THE RECOMMENDED METHOD OF PLOWING TO MAINTAIN TERRACES

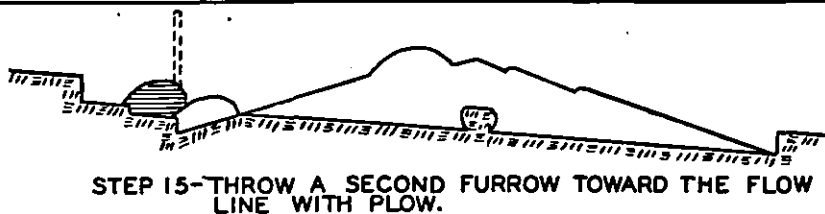
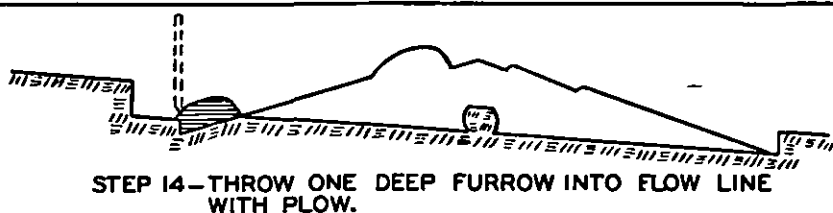
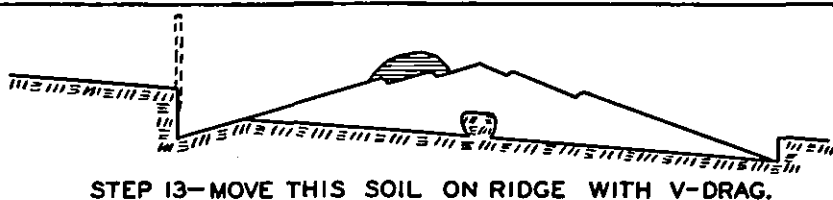
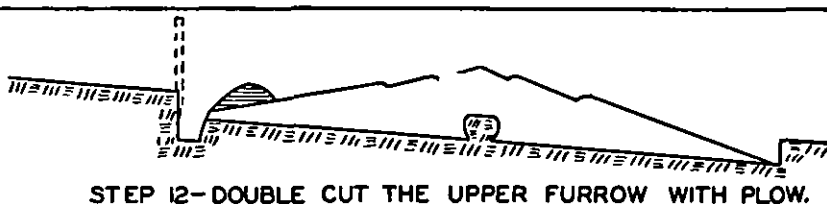
NOTE: SPECIAL CARE SHOULD BE TAKEN IN CROSSING RIDGE WITH PLOW AT BOTH ENDS OF LAND NO.1. IN LAND NO. 2 DISTANCE OF BACK FURROW SHOULD NEVER BE LESS THAN 12 FEET FROM THE CHANNEL BUT THIS DISTANCE SHOULD BE VARIED EACH PLOWING. THE DIRECTION OF THROW IN PLOWING LAND NO. 3 SHOULD BE VARIED WHEN NECESSARY.

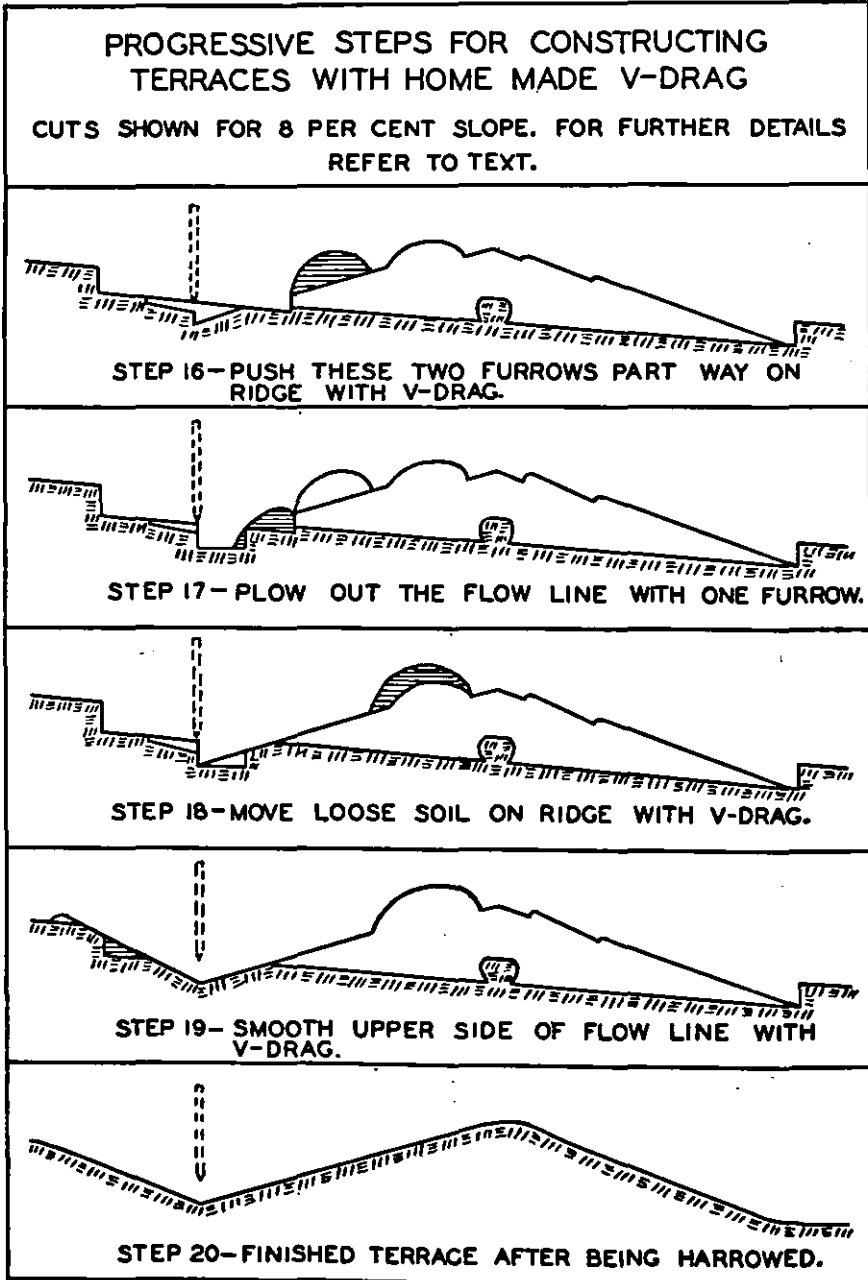
**PROGRESSIVE STEPS FOR CONSTRUCTING
TERRACES WITH HOME MADE V-DRAG**

**CUTS SHOWN FOR 8 PER CENT SLOPE. FOR FURTHER DETAILS
REFER TO TEXT.**



PROGRESSIVE STEPS FOR CONSTRUCTING
TERRACES WITH HOME MADE V-DRAG
CUTS SHOWN FOR 8 PER CENT SLOPE. FOR FURTHER DETAILS
REFER TO TEXT.





Step 1. The first furrow is made with the plow six feet downhill from and parallel to the line of stakes. The soil may be turned either up or down hill with this furrow, but for this procedure we will assume it is turned down hill.

A second furrow is made below this furrow and at a distance from it so that the two furrows will bed but that an unbroken core will remain below the center of the ridge.

Step 2. The third furrow is made just above furrow number one, a regular furrow's width, and the soil turned to the bed.

The fourth furrow is made on the lower side exactly as number three was made on the upper side.

Summing this up, a four furrow bed is made with the center of the ridge six feet below the line of stakes and parallel to this line.

Step 3. A round is then made with the V-drag and the broken soil is bedded in as high a ridge as possible. In some cases two complete rounds will be required to obtain the maximum height of ridge.

Steps 4-11. Another furrow is thrown to the ridge from both the upper and lower sides and is then moved onto the ridge with the V-drag. These steps are followed until the line of stakes is plowed out by the upper furrow. In plowing the upper furrows it is important to plow as deep as possible. This serves a double purpose in opening a larger channel and providing more soil for making the ridge.

Steps 12-13. When the furrow that cuts out the line of stakes has been moved onto the ridge, a second furrow is made in the line of this last furrow. In other words, this line is double cut to increase the depth of the channel. This soil is also moved onto the ridge.

From this step on, all plowing will be done in one direction so unless a reversible plow is being used the plow will always be at the opposite end of the terrace from the V-drag. In returning with the plow additional furrows should be laid against the ridge from the lower side. These furrows will reduce the steep back slope of the terrace and make it more satisfactory in all respects.

Feathering the Flow Line.

Steps 14-15. We cannot afford to leave the terrace with a vertical drop, two furrows deep, into the flow line. Such a flow line would not have sufficient capacity and would quickly fill with soil when the field was plowed. The vertical earth wall above the terrace is plowed into the flow line and then moved onto the ridge. In order to do this throw one deep furrow into the flow line, then plowing in the same direction throw a shallow furrow toward the flow line, being sure the two furrows are close enough together to break the earth between them.

Step 16. Use the last furrow as a track for the long side of the drag and by riding down the mold board side push the soil broken by these two furrows part way on ridge.

Steps 17-18. Make one furrow with the plow marking out the flow line again to afford a track for the drag and then move this loose soil onto the ridge.

Step 19. Smooth upper side of flow line with V-drag.

At this point measurements are made to determine how nearly the terrace

approaches the specifications of the ideal terrace shown on page 22. If it is necessary to make the terrace more nearly conform to the ideal, steps 12-19 should be repeated.

B. Construction With Small Commercial Terracers Drawn By Team or Farm Tractor.

1. With any type drag or terracer which requires plowing before its use the procedure of construction will be the same as that described for using the Home Made V-Drag.

2. Some small commercial terracers are designed with a cutting blade and do not employ the use of a plow. The procedure for constructing terraces with these terracers will vary between the procedure for using the V-drag and that for large tractors and terracers.

C. Construction With Large Terracing Units. Equipment used, crawler type tractor with minimum of 40 draw-bar horse power attached to 2 wheel terracing machine weighing at least 4,000 pounds and equipped with 9 or 10 feet blade.

1. The importance of the first cut remains the same for this equipment that has been explained in other paragraphs. With experience, operators place more and more importance on the first cut and the necessary time should be taken to start the terrace right.

2. With this type equipment soil can be moved easily and cheaply; therefore, the first step on a new terrace system should be plowing down existing terraces that cannot be used, plowing in gullies, etc. Concentrations caused by the channels of old terraces and gullies may be sufficient to cause breaks in new terraces.

Procedure for Construction. (See Progressive Steps of Construction, pages 21 and 22.)

First Trip. The first cut is made three feet down hill from the line of stakes and parallel to this line. The blade is set at a sharp plowing angle and the dirt moved down hill. On this first cut plow as nearly 12 inches deep as possible. In many cases it will not be possible to plow to this depth but the greater depth, up to 12 inches, the better the resulting terrace ridge.

Second Trip. The second cut is made on the down hill side, plowing about 8 or 10 inches deep, and just banking the soil against the ridge made by the first cut.

Third Trip. The third cut is made from 18 to 24 inches above the first cut and is as near 14 inches in depth as possible. The soil is deposited along the ridge and if practical, without making the slope too steep, the height of the ridge is increased with this cut.

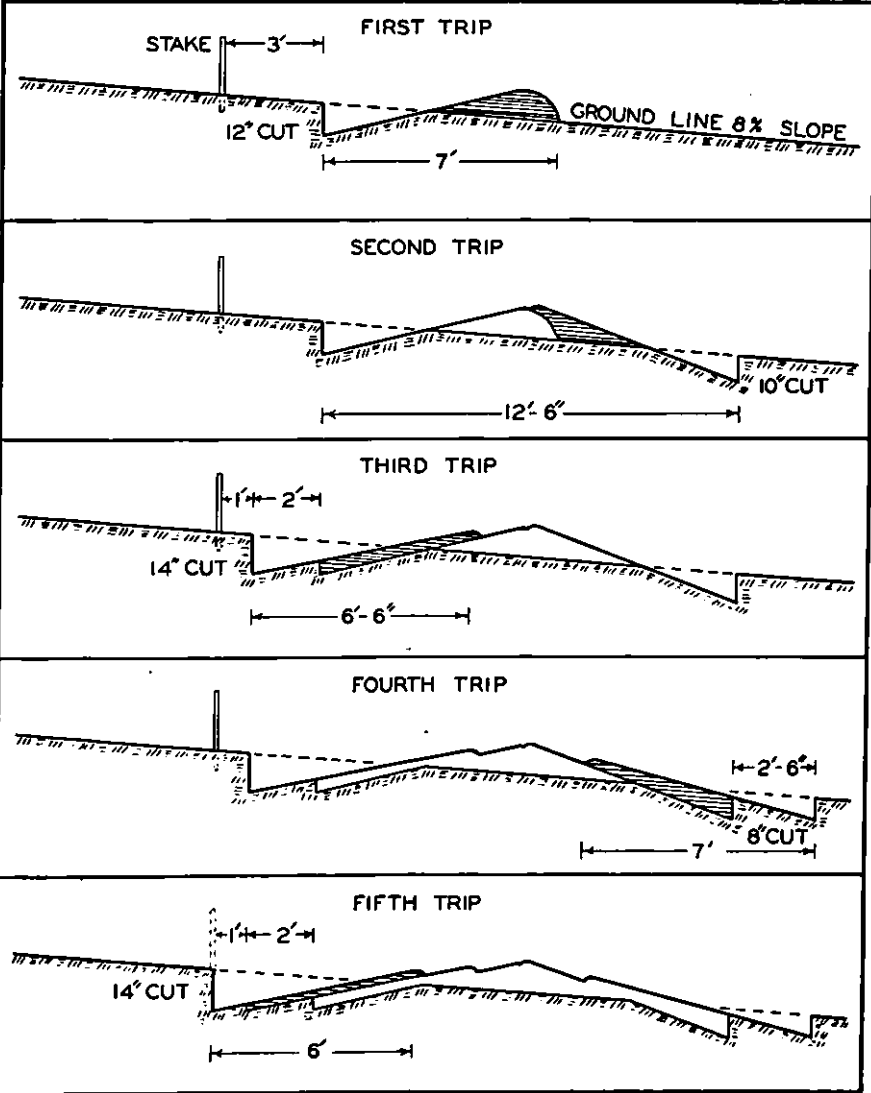
Fourth Trip. The fourth cut is made approximately 2½ feet below the second cut and the soil is pushed against the back side of the ridge. This cut should be held about 8 inches in depth so that a deep water channel will not be developed along the back of the terrace. This completes the work on the back side of the terrace.

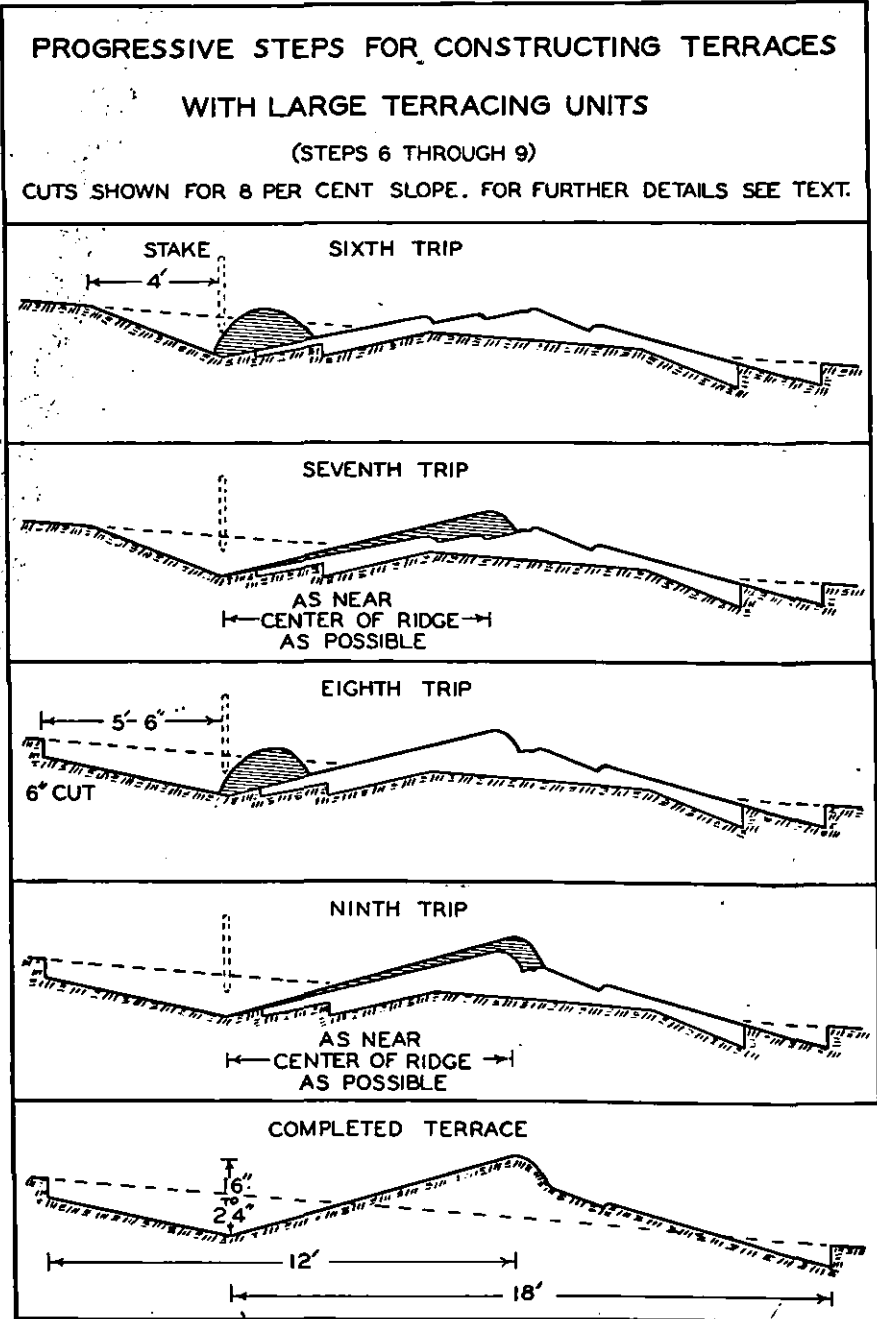
Fifth Trip. The fifth cut is made on the upper side. It should be a minimum of 12 inches in depth and should run along the line of stakes, or

PROGRESSIVE STEPS FOR CONSTRUCTING TERRACES
WITH LARGE TERRACING UNITS

(STEPS 1 THROUGH 5)

CUTS SHOWN FOR 8 PER CENT SLOPE. FOR FURTHER DETAILS SEE TEXT.





uniformly about 6 inches above the line of stakes. The soil is smoothed out along the ridge, holding the high point of the ridge as near as possible in the center.

Sixth Trip. The flow line is then feathered by plowing off the vertical earth shoulder and depositing it in the flow line.

Seventh Trip. This loose soil in the flow line is uniformly distributed along the ridge and since the blade is travelling light, the bottom of the flow line is smoothed out by cutting off the high places.

Eighth Trip. A second feather is made on the forward slope of the channel with the forward end of the blade actually cutting about six inches deep. This soil is deposited in the flow line.

Ninth Trip. The loose soil in the flow line is deposited uniformly along the ridge and at the same time a finished job of smoothing the flow line is made.

If the terrace at this point does not meet the specifications of a finished terrace, an additional feather and clean out should be made. No one can definitely state the number of rounds required to build a terrace of given cross section. Seldom will two fields work the same, because of difference in soil type, moisture content, etc. The above procedure is given as a guide. Always be satisfied that the terrace will perform the job for which it was designed. If the cost makes construction impractical, admit it, but do not sacrifice the quality of your work.

TERRACE OUTLETS

General Requirements. Failure of terrace systems in the past may be largely attributed to lack of appreciation of the possible damage, resulting from the concentration of water at the terrace outlets. Many gullies starting in the terrace outlet have eaten their way up the terrace flow-line and destroyed the very land the terrace was supposed to protect. A TERRACE SYSTEM IS NO BETTER THAN ITS OUTLETS. Numerous gullies in the immediate vicinity, on the same kind of soil on which outlets are to be located, indicate that outlets are likely to gully unless given proper protection. Where possible, natural outlets already established should be utilized. These consist of:

1. Natural meadows.
2. Well-sodded pastures.
3. Woods with good undergrowth.
4. Areas matted with vines and shrubs.

Before deciding on these outlets it should be certain that their usefulness as outlets will not be destroyed by the farmer making use of them for some other purpose. In any case where natural outlets are used, care should be taken to see that the water does not again concentrate and cause further erosion. Particularly is this true where water is discharged into woods where old gullies are located. Diversion ditches, plantings and brush dams may be used to eliminate this danger.

When making use of sparsely vegetated areas the natural growth should be supplemented by the use of shrubs, vines, seed or sod. To make these most effective, spreading devices such as buried logs and brush paving should be used.

Natural Draws Supplemented by Seeding and Sodding. In many cases natural draws make excellent outlets with a small amount of labor. Preparation of the area for seeding is usually sufficient, although in some cases a small amount of leveling and straightening may be required. These areas seeded to good pasture grasses provide a source of hay and require no maintenance except mowing. It is always best to establish a sod on these areas before the terraces are constructed. A sod may be more easily obtained if a temporary diversion ditch is built to prevent the flow of water across the area. When no longer needed the diversion ditch can be plowed in. If sharp drops occur within the area it may be necessary to protect these places with rocks or sod.



A meadow Strip Outlet prepared and seeded in advance of terracing. Carries the water from 60 acres and produced $7\frac{1}{2}$ tons of hay.

Make these meadow strips wide enough to justify their maintenance from the standpoint of hay production, and provide sufficient capacity to spread and carry the water.

Prepared Channels. When the outlets already discussed are not available it becomes necessary to prepare a channel. A wide V-type channel, 18 to 24 inches in depth at the center and 12 feet wide may be easily constructed with a V-drag or other terracing equipment. A channel of this size will take care of the average terraced acreage. It is best to have additional channels to take care of the drainage from large areas.



A natural untreated field outlet showing early stages of erosion.



Preparing the outlet for permanent seeding and protection.



The protected outlet, well vegetated, receiving the discharge from a terrace system. This outlet is wide and shallow so as to permit mowing.

Where these channels are constructed on slopes greater than 4 per cent it will be necessary to protect a strip approximately 4 feet wide in the bottom of the channel by paving with rock or sod. Brush mulching, using small limbs staked down to protect seeding, may also be used. In all cases sides of the channel should be seeded and mulched with straw or other suitable material. Bermuda sod has proven highly effective in controlling erosion in outlet channels and where possible its use is recommended. To prevent the spreading of the Bermuda grass from the channel into the field, narrow strips of close growing vegetation affording a dense shade are planted along the channel sides. As is the case with all outlets, it should be seen that water discharged by the outlet channel does no damage further down the slope.

Sharp drops in the channel, or at its end, should be protected by rock structures. These structures may be constructed with cement mortar when the expense is justifiable. In the majority of cases loose rock spillways with the rocks tied together with a thick growth of Bermuda grass or honey-suckle will prove satisfactory. Such structures can be easily built by the farmer, from materials on the farm.

Other Outlets. Where it is necessary to outlet terraces in stabilized gullies, old road beds, or into highway side ditches, these drops must be protected. Usually single terrace outlets can be protected with vegetation, and this is recommended wherever practical. Where vegetation alone will not be sufficient the loose rock structure supported by vegetation, described under "Prepared Channels," should be used.

ROW SYSTEMS

The practice being recommended by all agencies in planning the row system is that rows be run as nearly as possible with the terraces. A well designed terrace system with properly constructed terraces may be, and in many cases has been, completely destroyed by improperly planned row systems. In many sections, this state being no exception, terracing has been retarded to a great extent, as a result of failures caused in this way. The principle involved in running rows with the terraces is that each row carries its own water and acts as a miniature terrace. The grade of the row approximates the grade of the terrace, causing the water to run off more slowly and permitting the soil to absorb more water. In some sections the method of running rows down the slope and across terraces is still being carried on. This results in each row carrying its water directly down hill causing increased washing between terraces and depositing large amounts of soil in the terrace flow lines. A terrace with its flow line filled with soil cannot carry its water. When rows are run across terraces the flow lines are partially filled and the ridge is partially torn down. As a result such a terrace has from one third to one half the channel capacity for which it was designed.

For tobacco culture it is necessary to prevent water from standing in the rows as it causes the tobacco to "drown." As a result of this a large number of terrace systems have been ruined by running the tobacco rows straight down the slope, regardless of the terraces. In the cultivation and harvesting of this crop long rows, naturally, prove most convenient, but disregarding the terraces to gain this advantage accelerates erosion and eventually the

field will have to be retired from tobacco production. At this time, the most practical solution to this problem is a compromise between contour tillage and running the rows down the slope. This recommended system is to give the tobacco rows more grade than the terrace, to assure proper row drainage, but not enough grade to cause scouring between the rows. The upper end of the rows start on the ridge of the upper terrace and gradually pull away from it in going toward the outlet. Tobacco set in the flow line of a terrace has a very poor chance of maturing, so in pointing a row into the flow line of the terrace downhill, nothing will be lost if the row is stopped just above the flow line. This will help prevent the flow line from filling with sand and also afford a turn row for cultivating and gathering the tobacco.

In crossing old gullies, rows naturally sag and cannot carry their water across to the other side. Such rows fill with water in these places and break, causing large deposits of sand in the flow line of the terrace below them, and this may cause the terrace to break. These old gullies, even though they may be narrow should be seeded to grass or other close cover crop, and left out of cultivation for awhile. If this is done, the rows in crossing them will cause no damage. After each rain a certain amount of soil will be carried to the low spot. The vegetation will filter out this soil and the gully will eventually level up. Also, the water after having the soil strained from it will cause no damage to the terrace below.

TERRACE MAINTENANCE

A volume could be written on this chapter alone, but an attempt will be made to set down briefly certain fundamental principles. These principles must be supplemented by common sense and by careful planning on the part of the farmer. While the system of terraces is new, certain precautions should be taken until the ridges of freshly broken soil have had a chance to settle and become stabilized.

Under average conditions new terraces will settle approximately 25% of the height of the ridge. A great deal of trouble has been experienced in the past, because this fact was not considered when the terraces were constructed. Carefully study the following example, and the importance of allowing for settling will be better understood. We will assume a terrace 16 inches high has been built directly across a gully two feet deep. Assume that a fill was made in crossing the gully so that the top of the terrace ridge carried across the gully at a uniform height. (This is a great deal better than most fills are made.) The height of the terrace from solid earth to top of ridge on each side of the gully is 16 inches, while the corresponding height of loose soil in the gully is forty inches. If the ridge settles one-fourth its height, the terrace will settle four inches, on each side of the gully, while in the gully it will settle ten inches. The result is, that after settling, the ridge of the terrace will be exactly six inches lower across the gully. By simple mathematics it is determined that in crossing a gully two feet deep it is necessary to construct the ridge eight inches higher if we want the top of the ridge to be uniform in height after settling.

DON'T WAIT FOR THE RAIN TO FIND THE LOW PLACES IN YOUR TERRACES.

Inspect newly constructed terraces carefully. Cut out high places in flow line. Fill low places in the ridge. Be sure that outlets are open. Walk over them again after the first rain, when smaller irregularities can be detected.

It is an excellent plan to sow new terraces in a close growing cover crop for the first season. This will hold the disturbed soil in place while it is settling, and will form a uniform, compact ridge. The upper slope of the flow line should be broken as deep as possible, and sowed at the same time. This prevents loose soil from filling the flow line and will partly condition the exposed clay.

Method of Plowing Terraced Fields.

Terraces can be maintained and kept in first class condition by using proper method of breaking the land. This method is illustrated on page 28.

Break the ridge of the terrace as a land bedding toward the top of the ridge. Continue plowing this land until you have reached the flow line on the upper side, and the back furrow on the lower side. In breaking this land, the top of the ridge can be moved to the exact center of the ridge, thus reducing the steepness of the slope on the front side of the terrace.

Land number two is centered approximately twelve feet above the terrace flow line and the soil is bedded to this point. This land is plowed until the last furrow marks out the flow line.

The remaining land between land number two, and the next terrace uphill is then plowed to the best advantage, but for the first breaking it is best if the soil is bedded to the back of the terrace uphill. If this recommended system were followed for every breaking, we would soon develop a ridge in the center of land number two, and a low place in the center of land number three. To prevent this, we vary the width of land number two each breaking. For instance, if we started this land twelve feet above the flow line for the first breaking we would start it 18 to 20 feet above, for the second breaking. By varying the width of land number two, the width of land number three will automatically be changed. With a little care, a uniform slope can be made and maintained between terraces.

**NORTH CAROLINA STATE COLLEGE OF AGRICULTURE AND ENGINEERING
OF THE
UNIVERSITY OF NORTH CAROLINA
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N. C. AGRICULTURAL EXTENSION SERVICE
I. O. SCHAUB, DIRECTOR
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