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A New Method of TERRACING

A New Method of
TERRACING

A Bulletin for Technicians

This bulletin has been prepared for technicians who are responsible for the layout of terrace systems, and who are familiar with the surveying procedures involved.

It explains a new method of terrace layout and construction that reduces the curvature of terraces and the point row areas between them.

—BY R. P. BEASLEY

Part I: Design

HOW TO SPACE TERRACES: It is desirable to space terraces as far apart as possible. Wide spacing makes it easier to operate machinery in the field and reduces the cost of terracing. However, a number of factors limit the spacing between terraces: (1) erosion increases with length of slope; (2) if water tends to concentrate between the terraces, small gullies will form and build up deltas in the channel of the terrace below; (3) runoff from wide spacing may overload the channel of the terrace, causing break-over and damage to the terrace involved and to the land below.

TABLE 1--A GUIDE FOR TERRACE SPACING

Slope of Area Draining into Terraces (Percent)	Vertical Interval for Conventional Terraces (Feet)	Spacing for Parallel Terraces: Surface Distance Between Terraces (Feet)	Spacing for Parallel Terraces: Number of 40-inch Crop Rows
1	1.3	133	40
2	2.1	107	32
3	2.8	93	28
4	3.4	87	26*
5	4.0	80	24
6	4.4	73	22*
7	4.8	73	22*
8	5.2	67	20
9	5.6	67	20
10	6.0	60	18*
11	6.2	60	18*
12	6.4	53	16

*These numbers are adaptable to two-row equipment only. Use multiples of four for four-row equipment.

The recommended spacing varies with the rainfall intensity expected, the land slope, and the soil type. Vertical intervals that have been used widely in spacing terraces in Missouri are given below. When terraces are made parallel, it is desirable to space them so that an even number of crop rows may be planted between terraces. The spacing for parallel terraces is also given in Table 1.

WHAT GRADE TO USE: The terrace grade must be great enough to prevent ponding but not so great as to cause erosion in the channel. Grades in this bulletin will be given in percent (feet drop in 100 feet of terrace).

1. *Minimum Grade*—It is difficult to construct the terrace to a greater accuracy than plus or minus 0.10 percent, and tillage processes tend to build up barriers in the channel. Ponding in the terrace channel, damage to crops and interference with farm operations will result if the terrace is constructed with too little grade. The following minimum grades are suggested.

a. Soils with slow internal drainage—0.20 percent.
b. Soils with good internal drainage—0.10 percent.

2. *Maximum Grade*—If the terrace is constructed with too steep a grade, the velocity of flow will erode the channel, carry soil from the field and cause destructive deposition in the outlet. The maximum grade that can be used safely will vary with the erosiveness of the soil and the length of the terrace. The following maximum grades are suggested.

SUGGESTED MAXIMUM GRADES

Terrace Length	Erosive Soil (Silt Loam)	Less Erosive Soil (Rocky or Gravelly)
a. Terraces over 500 feet long	0.35 %	0.50 %
b. Terraces under 500 feet long or upper 500 feet of long terraces	0.50	0.65
c. Terraces under 200 feet long or upper 200 feet of long terraces	1.00	1.50
d. Terraces under 100 feet long or upper 100 feet of long terraces	2.00	2.50

WHAT SIZE TERRACE: A terrace cross section should provide sufficient capacity to carry the runoff; it should have slopes that can be easily farmed with modern machines; and it should be economical to construct on the slope where it is to be located. The dimensions for terrace cross sections given below should be considered as minimum values for new terraces which are well compacted during construction. The terrace may be constructed wider and the side slopes flatter to facilitate the operation of large farm machinery. Keep in mind that side slopes become less steep and the terrace height is reduced as the terraces are farmed.

Terraces with the cross sections given in Table 2 will have sufficient capacity to carry the runoff that accumulates in 1600 feet of terrace.

TABLE 2--CROSS SECTIONS OF TERRACES ON DIFFERENT LAND SLOPES.
TERRACE HEIGHT IS 1.5 FEET.

Land Slope Percent	Front Channel Slope (Horizontal Distance per Ft. of Rise)	Front Ridge Slope (Horizontal Distance per Ft. of Rise)	Back Ridge Slope (Horizontal Distance per Ft. of Rise)	Ridge Top Width (Ft.)	Channel Bottom Width (Ft.)	Effective* Channel Area (Sq. Ft.)	Depth of Cut Required; "Normal Cut" (Ft.)
2	6:1	6:1	8:1	3	6	12.0	0.9
4	6:1	6:1	7:1	3	6	12.0	1.0
6	6:1	5:1	6:1	3	6	11.5	1.0
8	5:1	4:1	5:1	3	4	8.5	1.1
10	4:1	4:1	4:1	2	4	8.0	1.1
12	$3\frac{1}{2}$:1	$3\frac{1}{2}$:1	4:1	2	3	6.5	1.2

*Allowing 0.5 foot for construction irregularities and lowering of the ridge by farming operations.

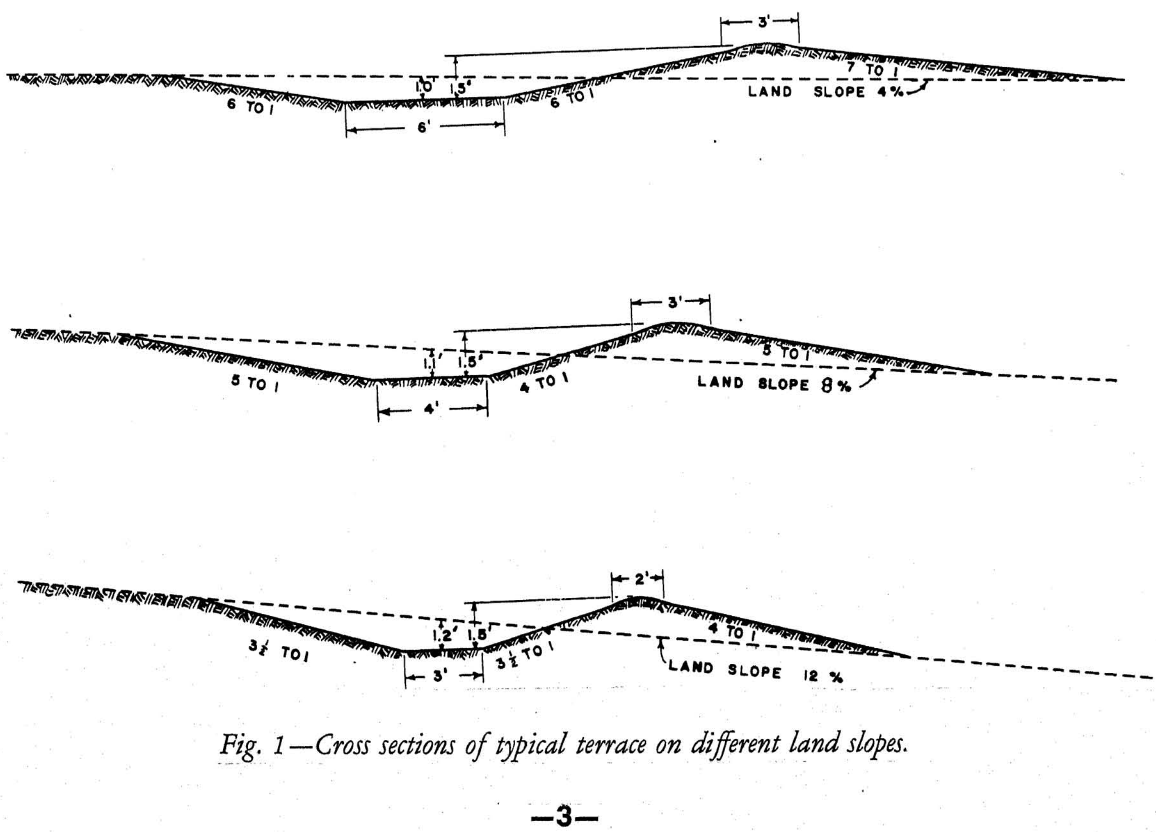


Fig. 1—Cross sections of typical terrace on different land slopes.

Part II: Layout

Straighter Rows—Fewer Point Rows

PROCEDURE AT A GLANCE

This new method of terracing will result in terraces with less curvature and with fewer point rows between them. It will be easier to farm a terraced field with modern machinery and the farming operations can be done faster and with less damage to the crop than is possible with conventional terraces. In this bulletin terraces as constructed by past methods are called *conventional terraces.*

SYSTEM FOR UNIFORM SLOPES

If the topography is quite uniform over the area to be terraced, it may be possible to make all terraces parallel. If this condition exists, the following procedure is suggested.

1. Measure the slope of the land draining into each terrace.
2. Select the spacing for each terrace from Table 1.
3. Stake out a key terrace to grade. This key terrace will usually be located about midway down the slope. It should be so located that the terraces above it will have the correct spacing.
4. Stake the other terraces parallel to the key terrace. This can be accomplished by two men using a string, wire, or tape of a given length. One man walks the terrace already staked, holds one end of the tape and checks to determine if the tape is perpendicular to his terrace at the time that the other man sets a stake on the next terrace.
5. The procedure for completing the layout of these terraces for construction is discussed later under Surveys for Construction, pages 11 to 13.

SYSTEM FOR IRREGULAR SLOPES

In most areas of Missouri the topography is too irregular to make all of the terraces in the field parallel. In these areas the first step in improving the terraces is to lay out a system of conventional terraces. The conventional layout is then modified to reduce curvature and point rows.

The aerial photograph below is used to illustrate the procedure to follow. The outlet into which the terraces will discharge has been constructed on the left side of the field. The field entrance is on the right. The white line in the upper part of the photograph is a temporary road to another field. Because of the angle at which the photograph was taken, it is not possible to scale distances directly on the photograph.

Fig. 2—Field used for illustration. The outlet is in and the field is ready for terracing.

Fig. 3—Location of the high point in the field is at A. Land slope was measured at x, y, and z. The vertical interval between the preliminary terrace location, dotted line, and the top of the slope is indicated. Final terrace location shown by solid line.

First, Lay Out Conventional Terraces

Step 1. Locate the High Point: Set up the level at some point where you can see over top of ridge. Have rod man check points along the ridge, indicated by the broken line in Fig. 3, until the high point, A, is located.

Note: In some fields there is a large flat area at the top of the slope. If drainage or erosion is a problem on the flat area, drainage-type terraces with deeper channel and less ridge can be constructed. The excess earth can be used to fill low areas between terraces. Such terraces serve a double function, diverting excess runoff and providing drainage for the area. If neither drainage nor erosion is a problem on the flat area, a diversion channel may be used at the point where the slope begins to steepen to carry the excess runoff.

Step 2. Find the Average Slope of the Land that Will Drain into the First Terrace: Take a rod reading on the top of the ridge, as at x. Take another reading directly down slope, either 50 or 100 feet, as indicated by the arrow. Compute the percent slope (feet drop per 100 feet).

a. For land slopes less than 6 percent go down slope 100 feet. The difference in the rod reading is the percent slope.

b. For land slopes more than 6 percent go down slope 50 feet. The difference in the rod reading times 2 is the percent slope.

Take a number of slope readings, as at arrows x, y, and z (3.6%, 3.3%, and 2.7% in this illustration for an average of 3.2%).

Step 3. Locate First Terrace: Table 1 suggests a vertical interval (difference in elevation between terraces) of 2.9 feet for a 3.2 percent slope. Take a reading on the rod at high point A. For our example, assume this reading is 1 foot. Add this reading to the 2.9-foot vertical interval (1 + 2.9 = 3.9 feet). Have the rod man set the target on 3.9 feet and go to the approximate point in the field assumed to be the midpoint, lengthwise, of the first terrace. Have him move up or down slope until you can sight on the target with the level. At this point (B) the rod will be resting on a spot 2.9 feet below the high point of the field. Have the rod man begin staking the terrace to grade at this point. The line of small dashes represents the temporary staked terrace line in Figure 3.

The grade used should be slightly less than is desired in the completed terrace since the improved terrace will be somewhat shorter than the conventional terrace. A grade of 0.3 percent was chosen for this field. The terrace is staked at 50-foot intervals. The rod man moves the target up 0.15 foot (half the drop per 100 feet) for each stake as he moves toward the outlet and down 0.15 foot for each stake as he approaches the upper end. At each 50-foot interval, the rod man stops and moves up or down slope until the level man can sight on the target. The rod man sets a stake at this point and moves on another 50 feet.

Step 4. Check Location of First Terrace: Due to variations in topography, this first terrace location may not be correct. It may have to be moved up or down the slope. Check the vertical interval between the terrace and the top of the slope at several points along the terrace. In this example, the difference in elevation between the terrace and the top of the slope is 2.7 feet at the outlet end, 2.4 feet at the middle, and 1.8 feet at the upper end of the terrace. Compare these values to the vertical interval recommended for the land slope at these points. Tabulate these values in the following manner:

Location	Slope in Field (Percent)	Vertical Interval-Feet As Measured	Recommended	Variation
Outlet End	3.6	2.7	3.2	-0.5
Middle	3.3	2.4	3.0	-0.6
Upper End	2.7	1.8	2.6	-0.8
			Average Variation	-0.6

The average variation from the recommended spacing is –0.6 foot; therefore, the terrace should be restaked at a location 0.6 foot lower in elevation as shown by the solid line in Figure 3.

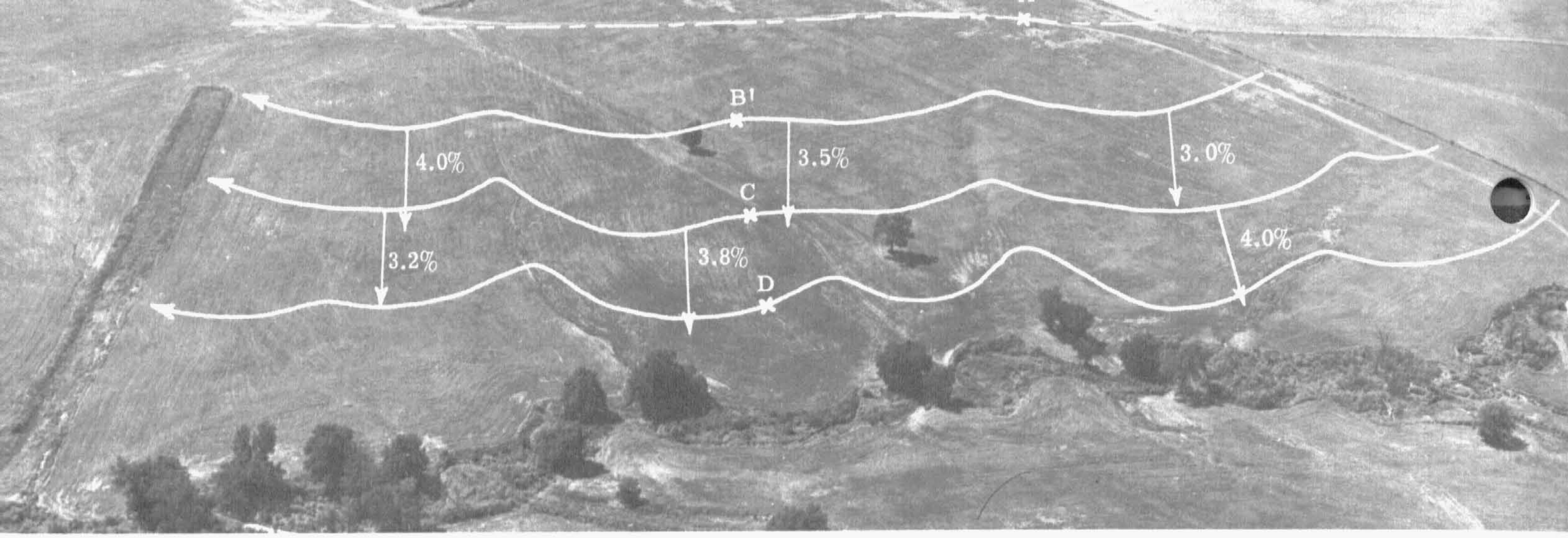


Fig. 4—Arrows indicate where land slope was measured to determine the slope of the land draining into terraces 2 and 3. The land slope at each point is indicated on the arrow.

Step 5. Locate the Second Terrace:

(a) Take slope readings as indicated by the arrows in Figure 4, and compute the average slope for the second terrace (3.5 percent in the example).

(b) Take a rod reading on the stake at the midpoint of the first terrace (point B'). Select the vertical interval for the average slope from Table 1. Add the vertical interval to this rod reading to obtain a rod reading for the first stake on the second terrace. Set the target on this reading and move downslope from point B' until the target is sighted through the level. This is point C, the place for the first stake of the second terrace.

(c) Stake the second terrace to grade by setting a stake each 50 feet as was done on terrace 1.

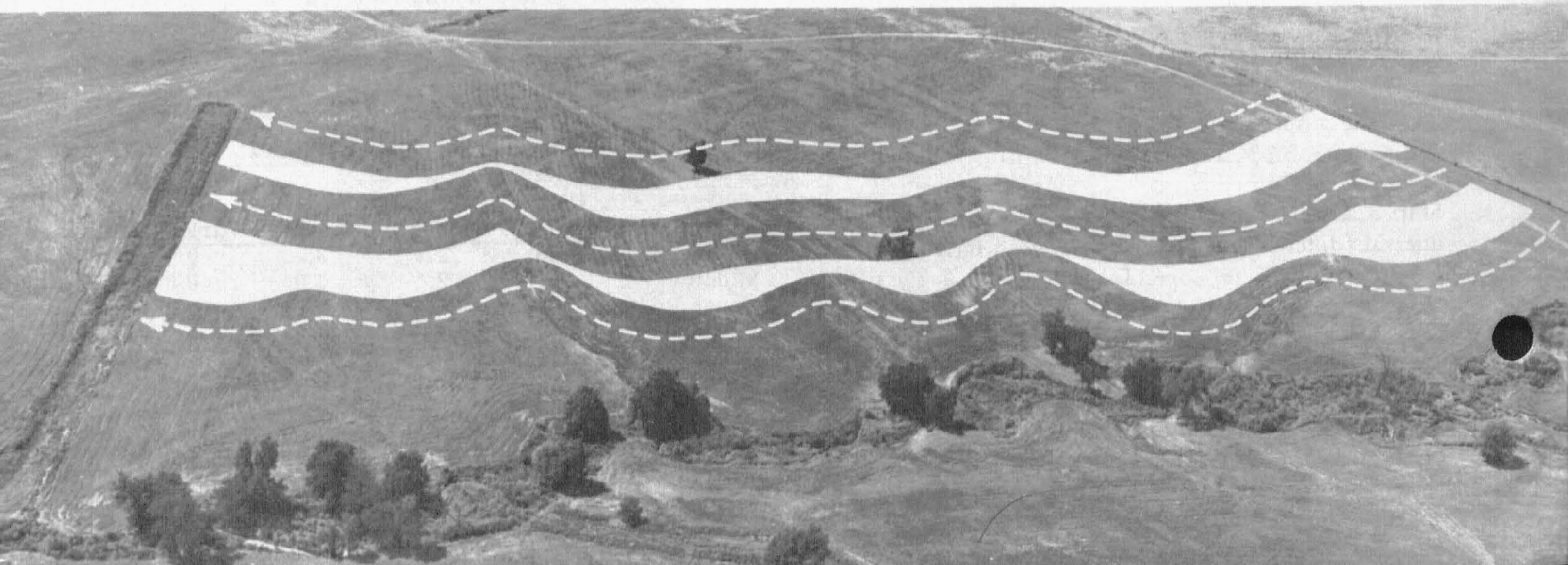
Note: When the terraces are of equal length, the layout of the second terrace may be started at any point along the terrace—just so the difference in elevation between this point and a point directly above it on the first terrace is equal to the vertical interval.

Step 6. Check the Spacing of the Second Terrace: If there is a wide variation in the length of the terraces and the topography is quite irregular, it is advisable to check the spacing of the second terrace at several points to determine if it is properly located. Follow the same procedure used in Step 4 to check the first terrace.

Step 7. Lay Out Additional Terraces in the Same Manner as the Second Terrace.

Note: No definite set of rules can be strictly adhered to in terrace layout because each field has its individual problems. Good judgment and consideration of all design factors are required for the best layout on a particular field. Figure 5 shows the location of conventional terraces on the field. The terraces are quite crooked and a considerable area of the field would be in point rows.

Fig. 5—Point row areas between conventional terraces are shown in white. It would be necessary to turn in the field at either one or both ends of the row in farming these areas.



Second, Modify Conventional Layout To Reduce Curvature and Point Row Area

After staking out the conventional terrace system as in Figure 5, study the layout with a view to eliminating sharp curves and making the terraces as nearly parallel as possible. The terraces should also be made as nearly parallel to field boundaries as possible to eliminate point rows in these areas. In improving the terrace layout, it is usually necessary to shift sections of terraces up or down slope. This can be accomplished by:

(a) varying the depth of cut,
(b) varying the grade, or
(c) by a combination of the above.

In general, variation in grade is used to shift relatively long sections of a terrace up or down slope to make the terraces more nearly parallel. Varying the depth of cut is used most effectively in moving short sections of a terrace up or down slope to reduce the sharpness of curvature.

The distance that a terrace can be shifted up or down slope will depend on the slope of the land and difference in elevation between the original and the proposed location. This distance can be determined from Table 3.

TABLE 3--DISTANCE IN FEET (D) THAT A TERRACE CAN BE SHIFTED ON DIFFERENT LAND SLOPES (S) BY A CHANGE IN ELEVATION (E). $D = \frac{E \times 100}{S}$

Change in Elevation	Land Slope - Percent										
	2	3	4	5	6	7	8	9	10	11	12
0.1	5	3	3	2	2	1	1	1	1	1	1
.2	10	7	5	4	3	3	3	2	2	2	2
.3	15	10	8	6	5	4	4	3	3	3	3
.4	20	13	10	8	7	6	5	4	4	4	3
.5	25	17	13	10	8	7	6	6	5	5	4
.6	30	20	15	12	10	9	8	7	6	5	5
.7	35	23	17	14	12	10	9	8	7	6	6
.8	40	27	20	16	13	11	10	9	8	7	7
.9	45	30	23	18	15	13	11	10	9	8	8
1.0	50	33	25	20	17	14	13	11	10	9	9
1.1	55	37	28	22	18	16	14	12	11	10	9
1.2	60	40	30	24	20	17	15	13	12	11	10
1.3	65	43	33	26	22	19	16	14	13	12	11
1.4	70	47	35	28	23	20	18	16	14	13	12
1.5	75	50	38	30	25	21	19	17	15	14	13
1.6	80	53	40	32	27	23	20	18	16	15	13
1.7	85	57	43	34	28	24	21	19	17	15	14
1.8	90	60	45	36	30	26	23	20	18	16	15
1.9	95	63	48	38	32	27	24	21	19	17	16
2.0	100	67	50	40	33	29	25	22	20	18	17

When the terraces are relocated, the depth of cut and the terrace grade will vary from that used in the conventional terraces. You will need to increase the depth of cut in sections of the field where the relocated terrace falls above the original location, and reduce the depth of cut in sections where it falls below the original location in order to maintain the proper grade in the terrace channel.

Move earth from the sections of deeper cut to those of lesser cut to maintain sufficient cross-sectional area in the terrace channel. The allowable range in the depth of the cut will vary with the type of soil and the equipment used to construct the terrace. A depth of cut up to 3.0 feet is possible under most conditions. In some cases a fill may be made in the channel to bring it up to grade. The depth of fill may be appreciable where a rather deep gully is crossed. Figure 6 illustrates the change in the terrace cross section that occurs when the depth of cut is varied from 0 to 3.0 feet on a 6 percent slope.

The grade of a terrace may be varied, within the limits given (pg. 2), to reduce the curvature in the terraces and to make them more nearly parallel. The grade is selected by studying the profile of the ground surface along the adjusted terrace line. This procedure is explained on page 12.

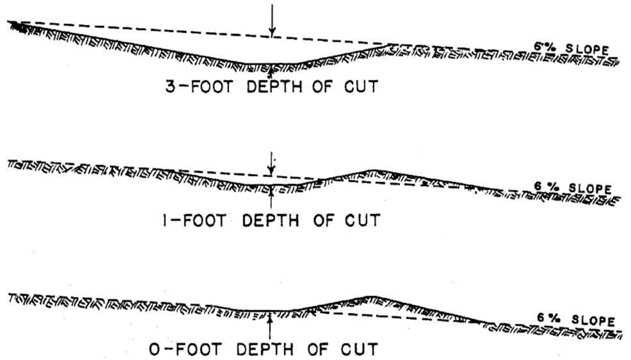


Fig. 6—Change in terrace cross section with variation in depth of cut. Land slope 6 percent.

METHOD A—Planning the Terrace Layout in the Field.

If the conventional terrace lines are not too crooked or unevenly spaced, the necessary modification of them can be made directly in the field.

Step 1. Select a Terrace Which Can Be Used as a Key Terrace: This terrace should be so located that other terraces can be made nearly parallel to it with the least correction. This is usually a terrace located near the middle of the slope. On long slopes with a large number of terraces, it may be necessary to divide the terraces into groups and select a key terrace for each group.

Step 2. Restake the Key Terrace: Move the stakes up or down slope where necessary to reduce the curvature of the terrace.

Step 3. Restake other terraces as nearly parallel to the key terrace as possible.

METHOD B—Planning the Terrace Layout from a Map.

On irregular slopes where many terraces are required, it is difficult to visualize the best way to improve the terrace layout simply by observing the conventional terrace lines on the land. In these cases it is advisable to make a map of the conventional terrace lines and to use the map in planning the best layout. The advantage of the map in planning is that adjustments in terrace location can be made much quicker on the map than would be possible by restaking the terraces in the field. Also it is possible to determine the change in depth of cut that will be necessary as the terraces are relocated.

Step 1. Obtain Measurements for the Map: A number of methods can be used in making the map. Two methods are given: (1) Measuring distance and angles, to be used if a level with stadia hairs and horizontal circle or a transit is available and (2) the modified grid method which can be used if only a tape is available.

By Measuring Distance and Angles: In this method the measurements necessary to make the map are taken as the conventional terraces are staked out. Points along the terraces are located by measuring the distance from the level to the points and determining the direction to the point by reading the angle from the horizontal circle on the level.

The distance to the point can be determined easily and quickly by stadia. A level with stadia hairs has 3 horizontal hairs in the telescope. The outer hairs are so spaced that the number of feet they span on the rod times 100 will give the distance to the rod, in feet.

At the first level setup, A in Figure 7, the horizontal angle is set to 0° when the telescope is sighted at the first point (1) on the terrace. The rod reading on the upper stadia hair was 7.34 feet and on the lower hair 2.00 feet. (7.34 − 2.00)times 100 = 534 feet, the distance to point 1.

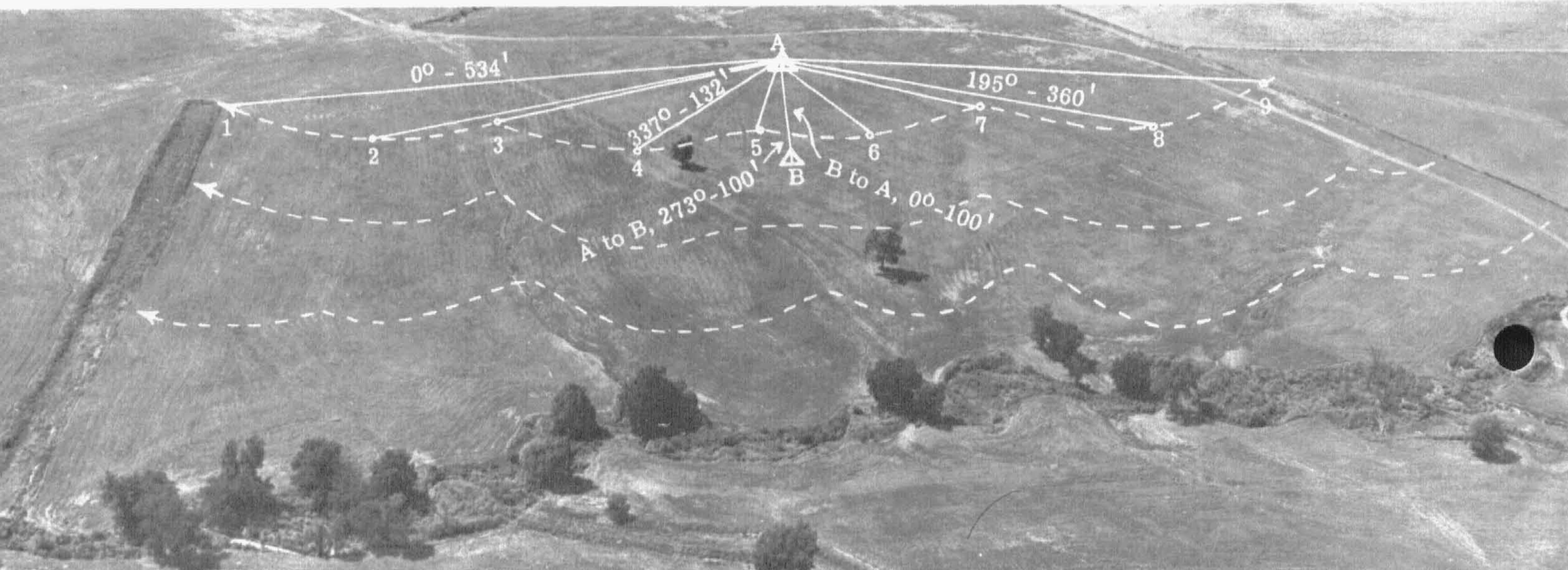
Additional points along the terrace are located by measuring the distance by stadia and reading the horizontal angle, clockwise, from the first point. The distance and angle to points 4 and 8 are noted on Figure 7. The number of points located will be determined by the irregularity of the terrace and the accuracy desired. Nine points were located on Terrace 1 in the example.

Before the level is moved, the location of the next setup (B) is selected and the distance and angle to it measured. The level is moved to this point (B) and the horizontal angle set to 0° when sighting at the preceding setup (A). Points on the second and succeeding terraces are located as for Terrace 1.

If a transit is available, the above measurements can be taken more readily.

Take down field notes similar to the sample, right, for use later in making the map.

Fig. 7—Procedure for mapping conventional terraces with a level equipped with stadia hairs and a horizontal circle. First level setup is at A. Distances from level to points 1, 2, 3, etc. on the first terrace are measured by stadia. Direction to these points is determined by reading the angle on the horizontal circle. Level setup for terrace 2 is at B. Record field notes as shown in sample , page 9.



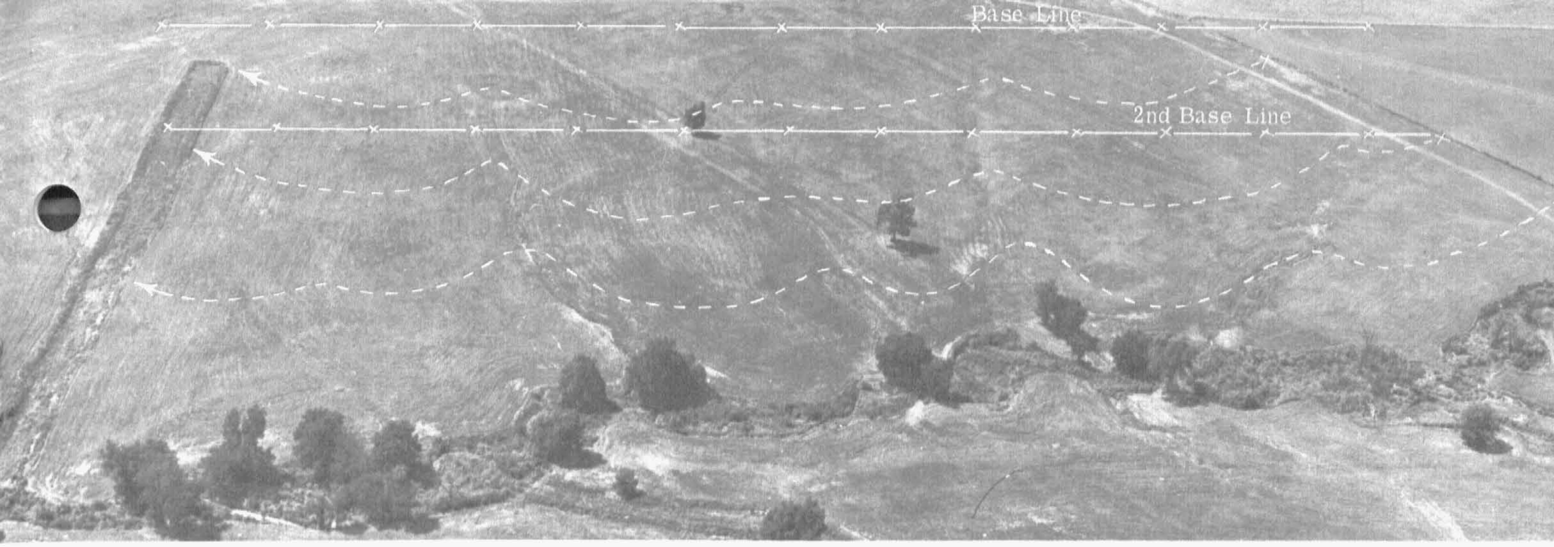


Fig. 8—Location of stakes on base lines when mapping terraces by the grid method.

SAMPLE FIELD NOTES

Station	Angle	Distance
	⊼ @ A	
1	0°	534'
4	337°	132'
8	195°	360'
B	273°	100'
	⊼ @ B	
A	0°	100'

By Modified Grid Method: First stake out the conventional terraces. Then lay out a straight line (Base Line) across the top of the slope as nearly parallel to the terraces as possible. Set stakes at 50- or 100-foot intervals on this base line as indicated by (x's), Figure 8. The distance between stakes is determined by the irregularity of the terraces.

Lay out a second base line parallel to the first one and 100 feet down slope. A line between corresponding stakes on the two base lines should be perpendicular to the base lines.

Measure the distances from each stake on one of the base lines to each terrace. The measurements should be in line with corresponding stakes on the two base lines. Additional measurements may be taken between stakes, if needed, to locate additional points on the terrace.

Step 2. Make Map to Scale: The terraces can be located accurately on a map by reproducing the measurements taken in the field to a given scale. Since the terraces are laid out to a given grade, the elevation at each terrace stake is known and can be noted on the map, as in Figure 9. The land slope at any point between the terraces can be determined from these elevations.

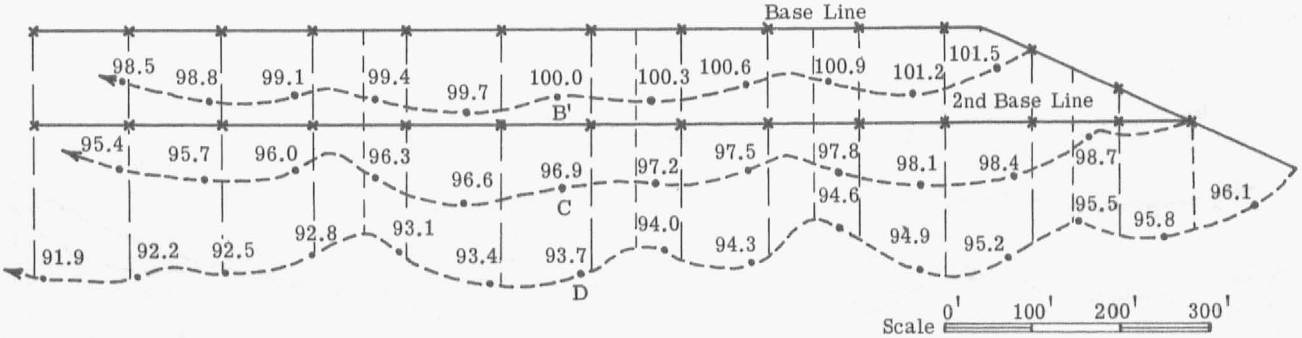


Fig. 9—A map of the conventional terraces prepared by the grid method. The distance from the base line to the terraces was measured with a tape along the vertical lines.

Step 3. Use Map in Planning the Terrace Layout: First, straighten the key terrace (solid line, center terrace in Figure 10). The variation in the depth of cut that will be required at the new location can be determined by Table 3. For example, the maximum variation from the conventional terrace (dashed line) was 12 feet at point A. Checking in Table 3, a shift of 12 feet on a 3.5 percent slope will require a 0.4 foot cut in addition to the 1.0 foot normal cut for this terrace, determined from Table 2.

Next, plot other terraces as nearly parallel as possible to the key terrace. The upper terrace in this example can be made parallel to the key terrace and 93 feet or 28 forty-inch crop rows up slope without excessive cuts or fills.

The lower terrace, however, posed a problem. It was first plotted parallel to the key terrace and 87 feet or 26 crop rows down slope. The outlet end of the terrace, at left, was 47 feet up slope from the conventional terrace. Table 3 shows that an additional cut of 1.4 feet or a total of 2.4 feet, would have to be made at this point to maintain the proper grade in the terrace channel. The elevation of the outlet was such that it would be impossible to drain water from the terrace channel into it.

The lower end was moved back down slope 13 feet, or 4 crop rows, as indicated by the solid line in Figure 10. The small, shaded area between the broken and solid line on the lower terrace is the only area of point rows in the improved terrace system. One turn must be made in the field when farming this area with two-row equipment.

Step 4. Use Map as Guide and Stake Out Adjusted Terrace System in the Field: In this example, Terrace 2 was straightened as indicated by the solid line and stakes set at 50-foot intervals on the new location. Terrace 1 was staked parallel to Terrace 2 and 93 feet up slope. The upper three-fourths of Terrace 3 was staked parallel to Terrace 2 and 87 feet down slope; the lower one-fourth was 100 feet down slope.

Third, Make Surveys for Construction

Step 1. Set Hub Stakes: Hub stakes are stakes set parallel to the adjusted terraces at such a distance up slope from each terrace stake that they will not be knocked down during construction. A distance of 25 feet is usually satisfactory. These stakes are used as reference points during construction. Pertinent information, such as depth of cut required at the various stations will be marked on the stakes (Figs 15 and 16).

Step 2. Make a Survey of the Adjusted Terraces: This is necessary, in most cases, to determine the depth of cut required at each station and the grade to use for the terrace. In making the survey, take rod readings at the adjusted terrace stakes and at the hub stakes. Record in columns 2 and 5 of the field notes. Field notes for terraces 1 and 3 are given in Figures 11 and 12.

In case it is necessary to make more than one level setup on a terrace, the following procedure is suggested. Record the rod readings taken on the last set of stakes from the first setup opposite -S in the field notes. Move the level and take rod readings on the same set of stakes from the new setup and record opposite +S in the field notes. The difference between the rod readings gives the differences in elevation between the two level setups. See Figures 11 and 12.

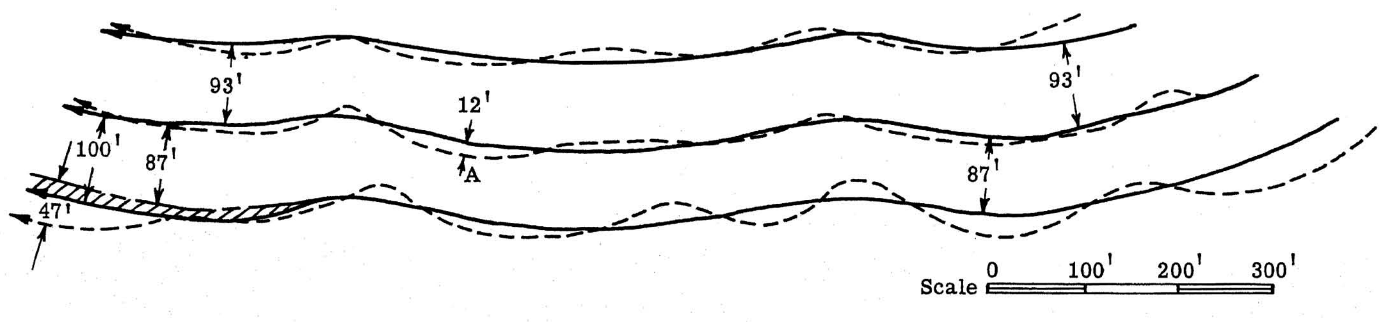


Fig. 10—Location of the conventional terraces is shown by the dotted lines. Location of the improved terraces is shown by the solid lines. The point row area between the improved terraces is indicated by cross hatching. Compare with the point row area between conventional terraces in Figure 5.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ground	Grade	Cut	Hub	G-H	Eye Rod	
Stake	Rod	Rod	(3)-(2)	Rod	(3)-(5)	5.6-(6)	Notes
0	5.8	6.60	0.8	5.0	1.6	4.0	Eye Height
1	5.4	6.44	1.0	4.7	1.7	3.9	5.6'
2	5.1	6.28	1.2	4.3	2.0	3.6	
3	4.8	6.12	1.3	4.0	2.1	3.5	Normal Cut
4	4.9	5.96	1.1	4.0	2.0	3.6	1.0'
5	4.8	5.80	1.0	3.9	1.9	3.7	
6	4.5	5.64	1.1	3.7	1.9	3.7	Stakes are
7	4.2	5.48	1.3	3.4	2.1	3.5	spaced at
8	4.2	5.32	1.1	3.3	2.0	3.6	50-foot
9	4.3	5.16	0.9	3.4	1.8	3.8	intervals
10	4.3	5.00	0.7	3.5	1.5	4.1	along the
11	4.0	4.84	0.8	3.1	1.7	3.9	terrace.
12	3.7	4.68	1.0	2.9	1.8	3.8	
13	3.5	4.52	1.0	2.7	1.8	3.8	Stake 0 is
14 (-S)	3.4	4.36	1.0	2.6	1.8	3.8	at the
TP							outlet end
14 (+S)	4.4	5.36		3.6			of the
15	4.2	5.20	1.0	3.4	1.8	3.8	terrace.
16	3.9	5.04	1.1	3.1	1.9	3.7	
17	3.8	4.88	1.1	3.1	1.8	3.8	
18	3.7	4.72	1.0	3.0	1.7	3.9	
19	3.7	4.56	0.9	2.9	1.7	3.9	
20	3.7	4.40	0.7	2.9	1.5	4.1	
21	3.8	4.24	0.4	3.0	1.2	4.4	
	Average Cut -		0.98				

Fig. 11—Field notes for terrace 1. Stake 0 is at the outlet end of the terrace. Terrace grade—0.32 percent.

Ground Rod (2) is the rod reading on the present ground surface at each adjusted terrace stake. Grade Rod (3) is the rod reading that would be obtained if the rod could be set in the channel of the completed terrace at each of these stakes. Step 3, page 12 tells how this Grade Rod is calculated. Part III: Construction, page 14, tells how to compute columns (6) and (7).

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ground	Grade	Cut	Hub	G-H	Eye Rod	
Stake	Rod	Rod	(3)-(2)	Rod	(3)-(5)	5.6-(6)	Notes
0	7.2	9.00	1.8	6.3	2.7	2.9	Eye Height
1	7.2	8.85	1.7	6.2	2.7	2.9	5.6'
2	7.3	8.70	1.4	6.4	2.3	3.3	
3	7.5	8.55	1.1	6.5	2.1	3.5	Normal Cut
4	7.4	8.40	1.0	6.5	1.9	3.7	1.0'
5	7.1	8.25	1.2	6.2	2.1	3.5	
6	7.0	8.10	1.1	6.0	2.1	3.5	Stakes are
7	7.0	7.93	0.9	6.1	1.8	3.8	spaced at
8	7.0	7.75	0.8	5.6	2.2	3.4	50-foot
9	6.5	7.58	1.1	5.7	1.9	3.7	intervals
10	6.1	7.40	1.3	5.2	2.2	3.4	along the
11	6.0	7.23	1.2	5.0	2.2	3.4	terrace.
12	6.0	7.05	1.1	5.1	2.0	3.6	
13	6.4	6.88	0.5	5.3	1.6	4.0	Stake 0 is
14 (-S)	6.1	6.70	0.6	5.0	1.7	3.9	at the
TP	Average Cut -		1.12				outlet end
14 (+S)	5.9	6.50		4.8			of the
15	5.2	6.33	1.1	4.4	1.9	3.7	terrace.
16	4.8	6.15	1.4	4.0	2.2	3.4	
17	5.5	5.98	0.5	4.4	1.6	4.0	
18	5.0	5.80	0.8	4.1	1.7	3.9	
19	4.4	5.63	1.2	3.6	2.0	3.6	
20	3.9	5.45	1.6	3.0	2.5	3.1	
21	4.0	5.28	1.3	3.0	2.3	3.3	
22	4.1	5.10	1.0	3.1	2.0	3.6	
23	4.2	4.93	0.7	3.3	1.6	4.0	
24	3.8	4.75	1.0	3.0	1.8	3.8	
25	3.0	4.25	1.3	2.2	2.1	3.5	
26	2.7	3.75	1.1	1.7	2.1	3.5	
27	2.4	3.25	0.9	1.4	1.9	3.7	
28	2.1	2.75	0.7	1.2	1.6	4.0	
	Average Cut -		1.04				

Fig. 12—Field notes for terrace 3. Stake 0 is at the outlet end of the terrace. Terrace grade, stake 0 to 6—0.30 percent, stake 6 to 24—0.35 percent, stake 24 to 28—1.0 percent.

Step 3. Analyze the Survey Notes: From the survey notes determine the grade of the terrace and the depth of cut at each stake. After experience is gained, this sometimes can be accomplished by a brief observation of the notes. In most cases, however, the following procedure is suggested.

Plot on graph paper, the rod readings at the adjusted terrace stakes from Column 2 of the survey notes. The line connecting these points will represent a profile of the *ground surface.* The profiles for terraces 1 and 3 of the example are labeled A in Figures 13 and 14. You can get a clearer idea of these profiles if you imagine yourself standing below the terrace line looking at an exposed slice of the ground surface along the terrace line. Note that the scale designating rod readings for the second level setup has been shifted by an amount equal to the difference in elevation between the two setups.

Draw a line (B in Figures 13 and 14) along the profile at such grade and elevation that the amount of earth above the line will be approximately equal to the amount below the line. Where the profile is below this line, cuts less than normal will be required. Where the profile is above this line, cuts deeper than normal will be required. The excess of earth, in most cases, will be transported to the areas where the cut is less than normal. This length of haul should be limited to a reasonable distance, which will vary with the type of equipment being used.

The grade of this line must fall within the allowable limits of grade. The grade of this line for terrace 1 was 0.32 percent. For Terrace 3, grades of 0.30, 0.35, and 1.0 percent were used. See Figures 13 and 14.

Draw a line on the profile parallel to line B and below it a distance equal to the normal cut required for the terrace. See Table 2, last column, for normal cut. The location of this line represents the elevation of the channel of the completed terrace. It is designated as "grade line" in Figures 13 and 14. The "grade rod" is the rod reading that would be obtained if it were possible to place the rod in the channel of the completed terrace.

Record the "grade rod" for each stake along the terrace in Column 3 of the field notes. These values may be taken from the "grade line" on the profile; however, it is usually quicker and easier to compute them.

First, determine from the grade line on the profile the "grade rod" for the stake at the upper end of the terrace. For each succeeding stake add a value which will vary depending on the grade of the terrace.

For example, for Terrace 1, Figure 13, the grade rod reading at stake 21 was 4.24. The grade of this terrace was 0.32 percent so 0.16 feet was added for each 50-foot stake.

Step 4. Compute the Depth of Cut: Subtract the ground rod readings from the grade rod readings to obtain the depth of cut at each stake and record as "cut" in Column 4 of the field notes. Determine the depth of cut at all stakes. If extra earth is not needed to fill depressions or gullies between terraces, the average depth of cut should be equal to the normal cut. In such cases the excess of earth in cuts deeper than normal will be approximately equal to the deficiency where cuts are less than normal. If the average depth of cut does not equal the normal cut, adjustment can be made in one or more of the following ways:

(a) Raising or lowering the grade line elevation of the entire terrace. If, in general, the depth of cut is greater or less than normal throughout the length of the terrace, the grade line elevation can be raised or lowered so that the average depth of cut will be equal to the normal cut.

(b) Changing terrace grade. If there are certain sections of the terrace where the average cut does not equal the normal cut, the grade of the terrace may be changed in that section.

(c) Shifting terrace up or down slope. If it is not possible to vary the depth of cut or the grade of the terrace enough to avoid excessive cuts or fills, it will be necessary to shift sections of the terrace up or down slope. In which case, that section of the terrace is restaked and the process above repeated.

Special Consideration for Gullies. Some fields may have gullies that should be filled. The customary method has been to fill these gullies with earth from the ridges or from the area immediately adjacent to the gullies. This practice results in using valuable topsoil to fill gullies, and presents the additional problem of restoring production on the scraped area.

A better solution in some cases would be to have an excessive amount of cut in the terrace channels in the vicinity of the gully, using this excess earth to fill the gullies.

The deficiency or excess of earth for the terrace ridge with varying depths of cut in the terrace channel on different land slopes is given in Table 4. For example, in the lower 700 feet of terrace 3 the average depth of cut is 1.12 feet. See Figure 12. The land slope in the areas of excess cut is approximately 4 percent. By interpolation in Table 4 we find that the excess of earth will be 5.7 cubic feet per foot of terrace. In this 700 feet of terrace there will be an excess of 3990 cubic feet or 148 cubic yards of earth. This excess occurs in the vicinity of the gullies to be filled.

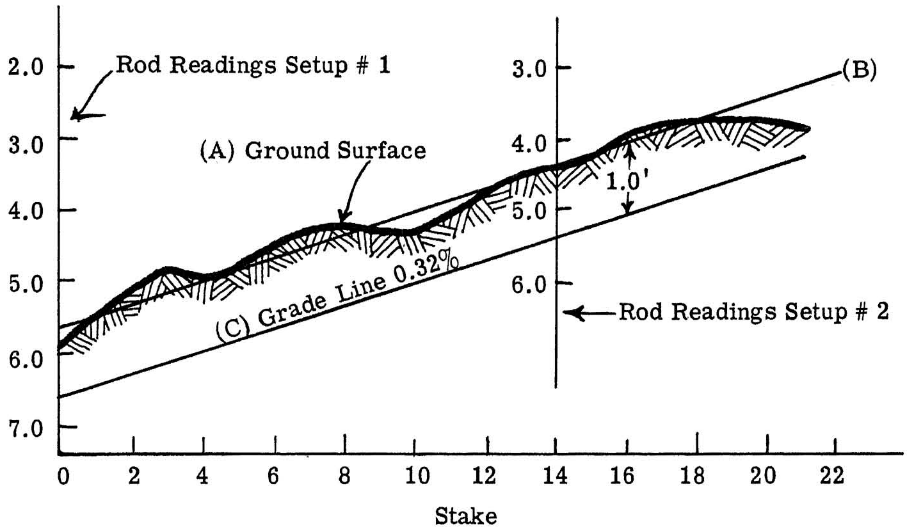


Fig. 13—Profile of ground surface along adjusted terrace 1 and the location of the proposed grade line for the completed terrace.

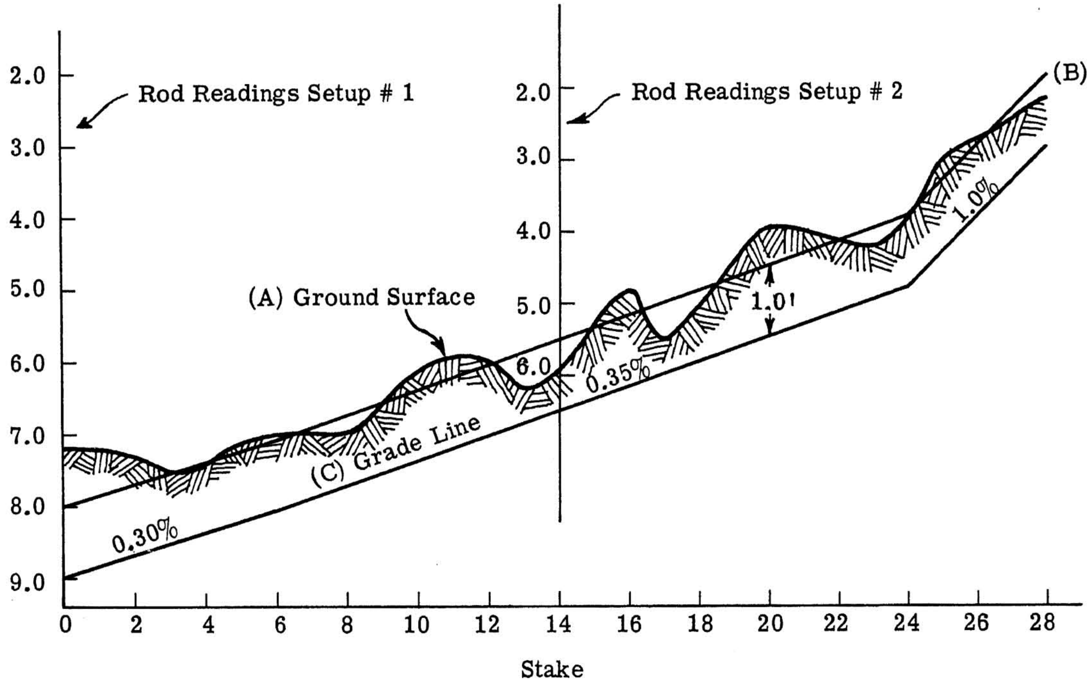


Fig. 14—Profile of ground surface along adjusted terrace 3 and the location of the proposed grade line for the completed terrace.

TABLE 4--DEFICIENCY OR EXCESS OF EARTH FOR TERRACE RIDGE WITH VARYING DEPTHS OF CUT IN TERRACE CHANNEL FOR AN 18-INCH TERRACE (CUBIC FEET OF EARTH PER LINEAL FOOT OF TERRACE).

Slope of Land	Depth of Cut (Feet)													
%	-0.4	-0.2	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4
2	-50.0	-37.5	-28.5	-21.5	-14.5	- 8.0	- 1.5	5.5	11.5	18.0	24.5	31.0	37.0	44.0	52.0
4	-54.0	-45.0	-37.0	-28.0	-20.0	-13.0	- 6.5	1.5	8.5	16.0	23.0	30.5	38.0	46.0	54.5
6	-56.0	-48.0	-40.5	-33.5	-25.5	-17.5	- 9.0	-0.5	7.5	15.5	24.0	31.5	39.5	47.5	55.5
8	-52.0	-45.0	-37.5	-30.5	-23.5	-17.0	-10.5	-3.5	3.5	10.0	17.5	24.0	31.0	38.0	44.0
10	-46.0	-39.5	-33.5	-27.0	-21.0	-15.0	- 9.0	-3.0	2.5	9.0	15.0	21.0	27.0	32.5	38.0
12	-49.0	-42.5	-37.0	-30.5	-24.5	-18.0	-12.0	-6.5	-0.5	5.5	11.0	17.0	22.5	28.0	33.5

The example of terrace layout given in this bulletin illustrates how to solve some of the problems encountered. On some fields the terraces can be made quite smooth and parallel. On other fields, particularly those with long, irregular slopes, it may be impossible to eliminate many point rows. But in most cases it will be possible to make the terraces more farmable, either by reducing their curvature or by reducing the number of point rows or both.

Procedures of layout and construction are given in detail so that the principles may be understood. As you gain experience in building terraces by this method you can eliminate some of this detail.

Part III: Construction

In the construction of an adjusted terrace, it may be necessary to vary the depth of cut throughout the length of the terrace. The excess soil in the areas of deep cut must be transported to areas with cuts less than normal. Therefore, equipment that is best suited to transporting earth some distance, such as scoops and carryalls, is best. Bulldozers can be used satisfactorily if the length of haul is not too great.

The depth of cut that is to be made at the center of the channel at each stake can be obtained from Column 4 of the survey notes. (See sample notes, page 11). This depth of cut is marked on the hub stake. For example, if the depth of cut were 0.8 foot (as for stake 8, terrace 3), this value would be written on the hub stake 0.8 foot below the top of the stake. See Figure 15. By glancing at the hub stake, the operator can determine how deep he will have to cut at each channel stake.

It is desirable to check the depth of cut made at each stake. This can be done by one man, who may be the operator. This man uses a rod, with a spike on the bottom to hold it upright, and a hand level. The rod is set beside the hub stake. The man stands in the channel and sights to the rod through the hand level. See Figures 15 and 16. The line of sight through the hand level should coincide with the target. The setting of the target is determined as follows:

The difference in elevation between the ground surface at the hub stake and the grade of the terrace is determined from Column 6 of the survey notes. (See sample notes, page 11). This difference, subtracted from the eye heigth of the man checking, will give the distance that the line of sight through the hand level will be above the ground surface at the hub stake when the man stands in the terrace channel. See Figure 15. This value is recorded as "eye rod", Column 7, in the survey notes, and is written on the back of the hub stake with lumber crayon. The target is set on the rod at the "eye rod" reading. If the hub stake is long enough, a mark is made on the hub stake a distance above the ground equal to the "eye rod". The man checking depth of cut sights on this mark.

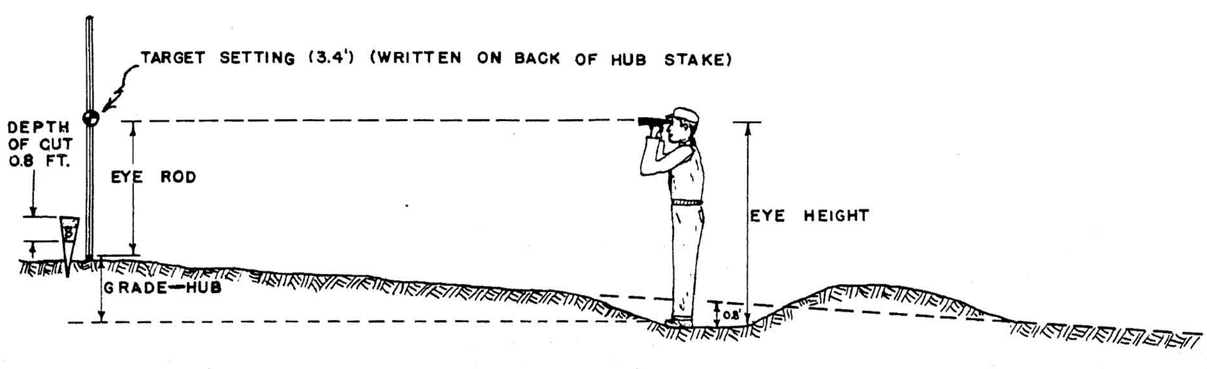


Fig. 15—Checking the depth of cut in a terrace channel.

Fig. 16—Checking to determine if the terrace channel has been excavated to the proper depth.

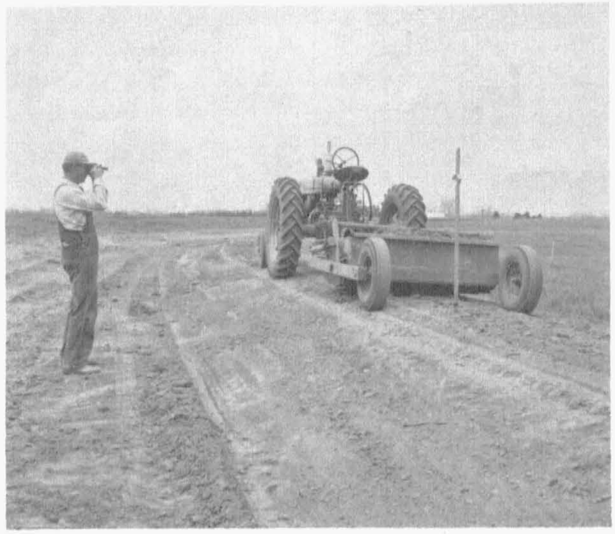


Fig. 17—Checking the height of a terrace ridge.

The height of the ridge can be checked by setting the rod on the top of the ridge with the target set at a reading equal to the eye height of the checker minus the ridge height desired. See Figure 17.

The terrace grade can be checked each 50 feet along the terrace with this procedure. This will make it possible to construct terraces to more exact grades than has been common with the conventional method of terrace construction. Thus, ponding in the terrace channel, which has been a serious objection to conventional terraces, can be greatly reduced.

Time Saved in Farming Pays Extra Planning and Construction Costs

Approximately 20,000 feet of terraces have been constructed by this method on the Agricultural Engineering Farm near Columbia, Mo. These terraces were constructed with a 1¾-cubic-yard scoop pulled by a farm tractor. See Figures 16 and 17. Forty-two percent of the area between terraces on this farm would have been in point rows if the terraces had been constructed in the conventional manner. Twenty-seven percent of the area between the improved terraces is in point rows, a reduction in point row area of 36 percent. The improved terraces are also straighter and easier to farm. The time required to produce a corn crop on this farm, if conventional terraces had been used, would have been 4.0 hours per acre. The time required with the terraces as constructed is 3.4 hours per acre. This is a saving of 0.6 hours, or $1.65 per acre per crop.

This method of terrace layout requires a little more thought and time than the conventional method. Construction requires a change in technique and in some cases may cost somewhat more. But the added convenience and the saving of time in farming these terraces offsets any increase in time or cost of layout and construction.

CONTENTS