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UNITED STATES
DEPARTMENT OF THE INTERIOR

EMERGENCY CONSERVATION WORK
PROJECT TRAINING

CONSTRUCTION OF TRAILS

P.T. SERIES NO. 7

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UNITED STATES
DEPARTMENT OF THE INTERIOR
National Park Service
Washington

Emergency Conservation Work
Project Training

CONSTRUCTION OF TRAILS

This text, originally entitled "Recommendations for Trail Construction", was compiled by the Landscape and Engineering Departments of Great Smoky Mountains National Park, "for all trails within the park area".

It is being distributed to all camps as an effective outline of trail construction, and a presentation of good practice and procedure in general. It is not to be taken as a set of standards. Specific dimensions, such as the trail width, slopes, grades, and other figures, are accepted practice in Great Smoky Mountains National Park, but may not be elsewhere. The design, location, grades, widths, drainage plan, and so on for all trails in other areas, must be determined by the technicians in charge.

The section on Drainage has been expanded to give more information on drainage conditions and structures. Some additions have been made to the section on Waterbreaks. A few additions and alterations have been made to meet the views of the technical branches of the Service. And two short sections have been added; one entitled "Templates", and the other "Work Organization". Also three paragraphs, concurred in by two or more of the technical branches, are inserted in parentheses.

The text may be used for training on the project, and also as the foundation of a short course in the camp educational program.

February, 1937.

HD 5715 .C58 A777 1937 c.2
Arthur, Guy B.
Construction of trails

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PROJECT TRAINING

"CONSTRUCTION OF TRAILS"

STARTING CONSTRUCTION

Construction should not be started on a trail until the line has been flagged through to its destination (or to a definite control) and approved.

(This approval should be from all of the Branches which may have an interest in its construction. These Branches will include the landscape architect who is charged with utilizing the scenic features and blending the trail with the landscape; the engineer who is concerned with the problems of construction; the forester whose duties involve the protection and propagation of natural cover; the geologist who will assist in locating the trail so as to take advantage of geographic and geologic features and protect them from destruction; and the wildlife technician in whose care the zoological and botanical values are entrusted.)

METHOD OF PROCEDURE

The following method of lining out construction ahead is followed by several of the best trail builders in the Park with satisfactory results. Always keep well ahead of construction, lining out the trail with stakes as shown in Sketch No. 1.

Stake "A" is at the trail grade where the cut section begins. Stake "B" is at the inside edge of the trail floor. The distance between these stakes will vary according to the steepness of the side-slope. On 1 to 1 slopes or slopes steeper than 1 to 1, the width on solid earth for a four foot trail should be three and one-half feet (See Sketch No. 1); as the cross slopes approach a 3 to 1 slope the width on solid approaches two feet (See Sketch No. 2). Trails built in places where no side slope exists should be built in accordance with Sketch No. 3.

Clearing or swamping-out of existing growth is not permitted until the exact location of the trail is determined and then is done only for the width of the trail floor plus the distance to the top of the cut. Later it may be necessary to clear wider spaces, but the policy of clearing ahead on the flag line often results in taking out considerable growth that could have been saved if the exact location had been staked out in advance.

In staking this location the foreman should closely follow the flag line but may depart from it a few feet occasionally since he is in position to give the location much more detailed study

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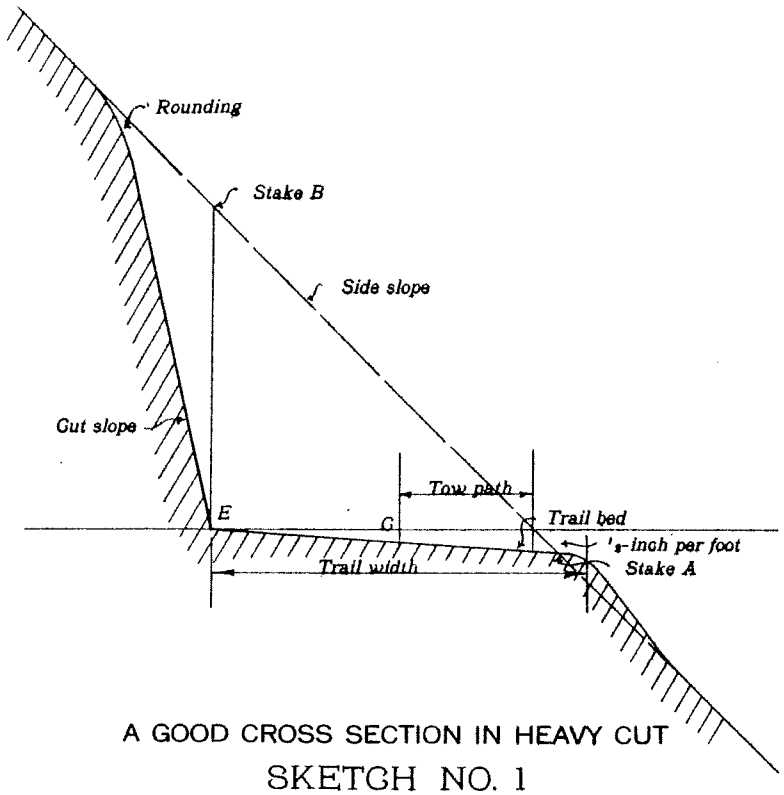
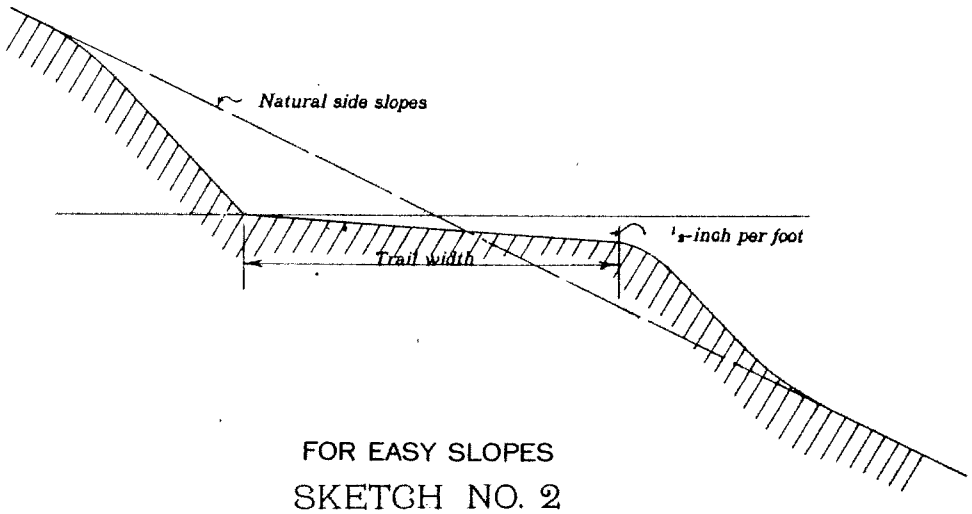


A GOOD CROSS SECTION IN HEAVY CUT

SKETCH NO. 1



FOR EASY SLOPES

SKETCH NO. 2

FOR FLAT GROUND

SKETCH NO. 3

than was given by the locator when the line was flagged.

Stakes should be spaced closely along the line so those doing the excavation can follow from one to another easily. On curves, stakes should be placed very close together so that there will be no variation from the alignment set.

Methods of starting the excavation differ with various foremen but the following is recommended:

A narrow tow path, about 18" wide is worked out at the base of the cut along line "A" and excavated back to "C". This tow path is kept well ahead of construction (See Sketch No. 1). This narrow trail then establishes the line of excavation on the trail and the grade of the trail. In the event that it is necessary to alter the grade or the location, this can be done with less loss of time and money than if the entire floor of the trail were graded. This narrow trail acts as a lead for others to follow and should be done by capable men.

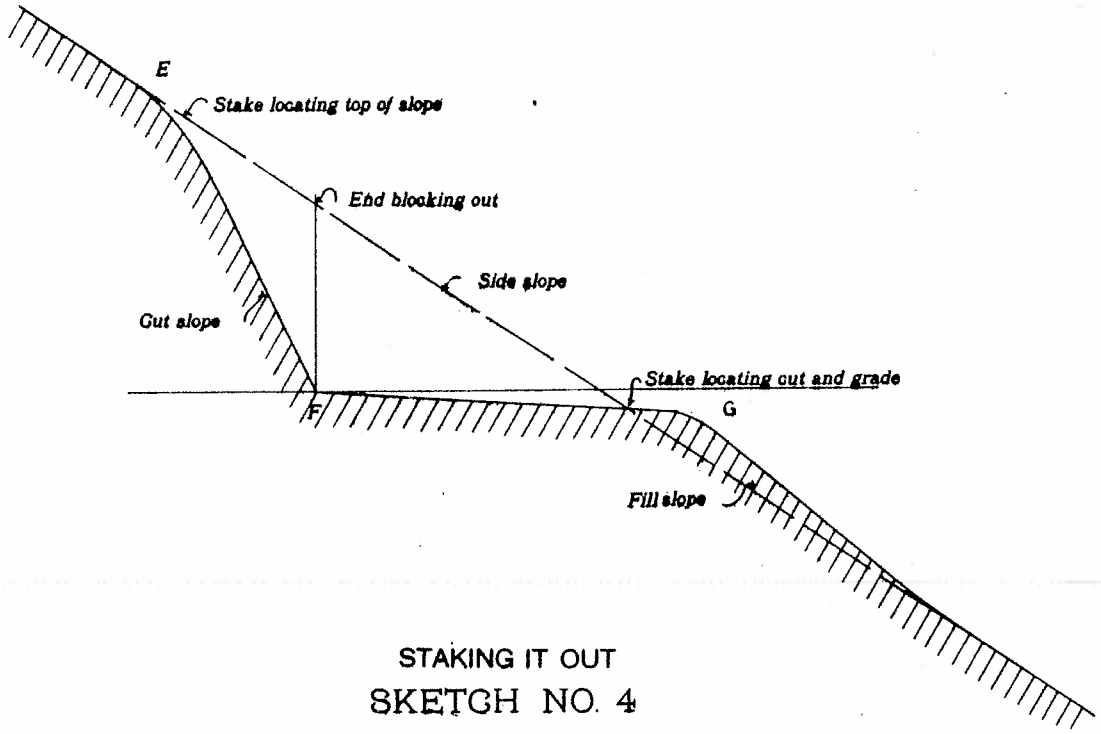
The next operation consists of excavating the trail back to its full width. This is best done by spacing men 15 or 20 feet apart who excavate to the back edge of the trail floor at "E" (See Sketch No. 1). The bank "E"-"B" is left straight up at this stage of the work.

Following these graders are others sloping banks. The top of the slope, point "E", Sketch No. 4, should be marked or staked on the ground and the slope cut straight from "E" to "F".

Following these graders are two or three men selected as good finishers who round over the sharp edge at "E", put finishing touches on the cut slope, finish the trail bed with a slope of 1/2" to the foot toward the outside, (2" in 4'), round over the edge at "G", and dress down the filled slope drawing it well down and feathering it out into the natural grade.

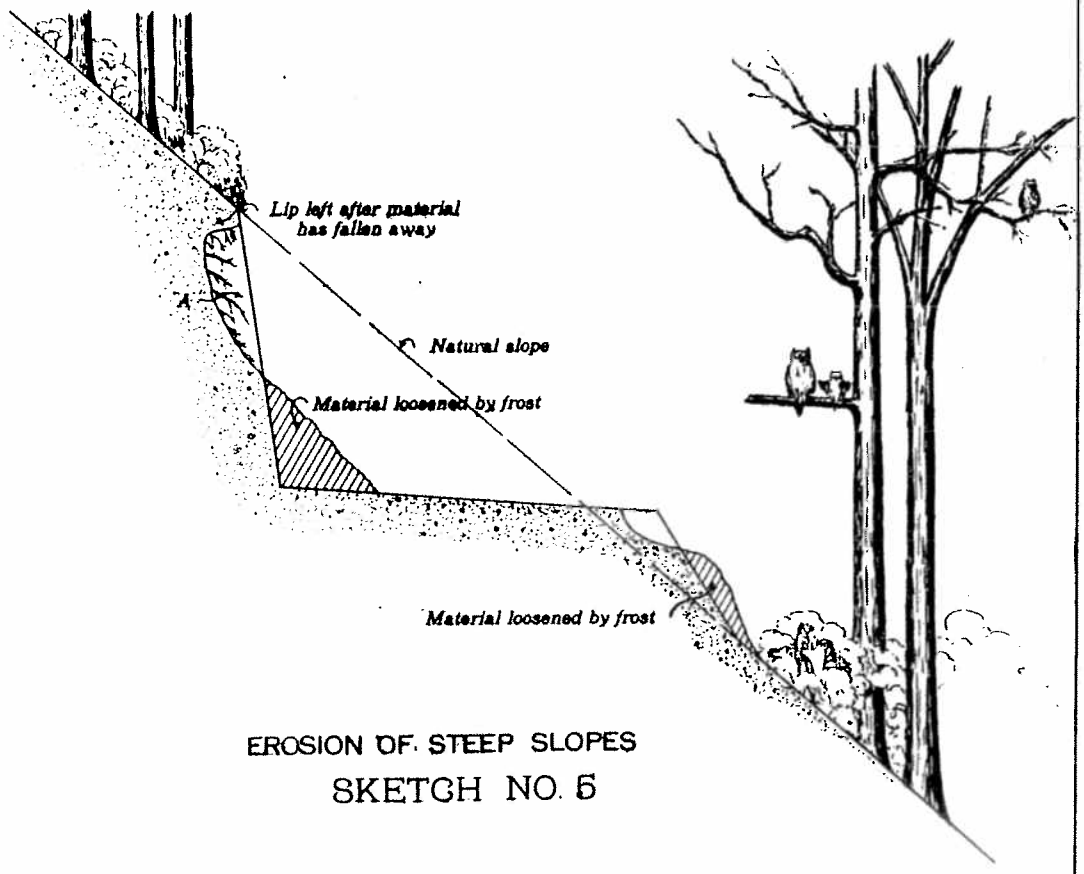
BANK SLOPING

Contrary to the general conviction that bank sloping is purely a beautification project there are two primary objects in sloping of trail and truck banks: (1) It is a particular aid to the control of erosion in that it establishes slopes that are more nearly natural, thus enabling growths of various types to catch quickly and cover the new cut and fill surfaces; (2) It eliminates materially the possibility of having the trail narrowed by earth loosened through the action of frost and rain water. (Sketch No. 5 shows the action of frost on a poorly constructed trail.) The combined action of water and frost at "A" loosens the material which drops to the trail, in some cases to



STAKING IT OUT

SKETCH NO. 4



EROSION OF STEEP SLOPES

SKETCH NO. 5

such an extent that the trail is impassable. This is aside from the fact that as this action goes on from time to time, the trail appears more and more ragged and less attractive.

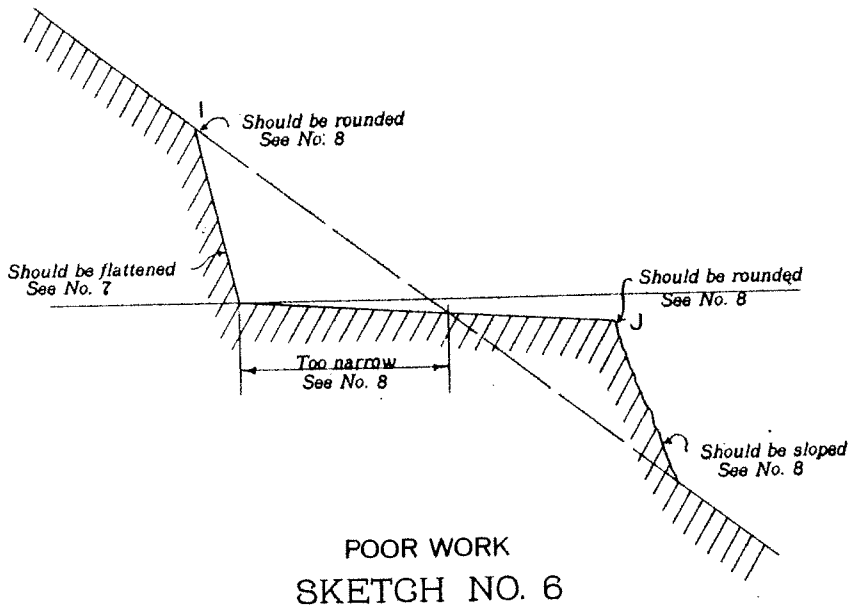
Putting off sloping operations is merely delaying operations which will have to be done later in construction and at a higher cost.

Sketch No. 6 illustrates a section of a poorly finished trail. The filled edge at "J" will soon be washed down the hillside by storm water leaving the narrow bed of the trail on solid ground. In this case the builder did not go far enough into the side slope to get the required amount of trail floor on solid earth. Earth should never be finished to corners as at "I" and "J" but should be rounded over to meet the existing grade above and below the trail. Cut slopes should never be finished as shown in Sketch No. 7.

Sketch No. 8 illustrates an ideal trail section, well finished, with banks and trail bed properly sloped and corners of cuts and fills properly rounded.

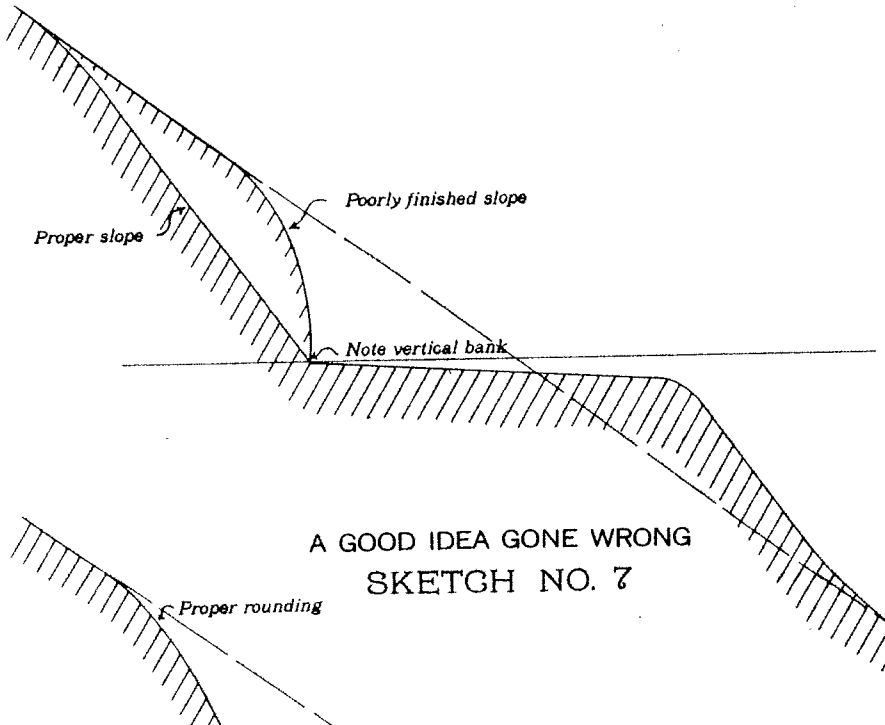
The question of how far to cut back a slope (or bank) is often a problem. Where the cross slope is easy the bank may be taken back on a 2 to 1 slope, that is, two feet back for each foot in height. A 1-1/2 to 1 slope is good, and a 1 to 1 slope is about as steep as earth will lie on a slope. The 1 to 1 slope should be regarded as a maximum slope to give a bank except in the situations where it would be necessary to grade 30 or 40 feet up a steep bank to get this 1 to 1 slope. This would require removing much established growth and of course is not to be considered. Such situations should be solved by the staking of the top of the cut bank to get the best solution possible. Trail foremen should call for the advice of Landscape and Engineering technicians on problems of this type.

(If the trail passes a rock face or has been of necessity cut into a rock exposure, the only work required is the removal of loose rock which might endanger users of the trail. No general instruction can be given for procedure in such a case, except that a geologist should be consulted because the treatment of each rock exposure will depend upon the character of the rock. It should be remembered that exposures of bare rock are just as "natural" as slopes covered with soil and vegetation. Exposures of the bare rock often contain important stories which enhance the value of the trail. This is also true of some cut banks of unconsolidated material. The processes of soil manufacture, the history of the advances and retreat of glaciers, the story of pre-historic lakes and beaches are told in such bare slopes. These should not be obliterated promiscuously, but should be preserved as irreplacoable examples of earth processes which, in some instances, cannot be



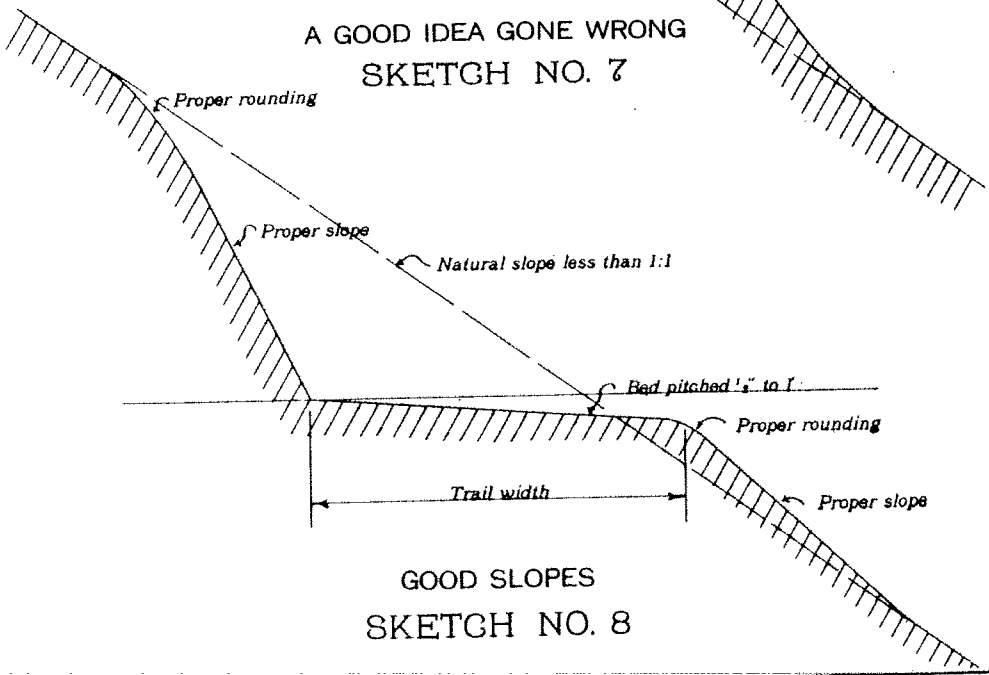
POOR WORK

SKETCH NO. 6



A GOOD IDEA GONE WRONG

SKETCH NO. 7



GOOD SLOPES

SKETCH NO. 8

duplicated elsewhere. The geologist's advice should be sought in these matters.)

TO KEEP THE SLOPE UNIFORM

Men sometimes have difficulty in keeping a slope uniform when the bank varies in height. Have the leader get a stick as long as the bank is high, and show him how to use it to measure back for the slope stake. If the slope is to be 2 to 1, he will measure the height of the bank, holding his thumb at that height on the stick. He will then measure back twice this distance from the vertical face of the cut, and set his slope stake. These stakes should be set from five to ten feet apart to maintain a smooth, uniform slope.

WALL CONSTRUCTION

A natural slope is preferable to wall construction on trails where an earth slope can be made. A slope is a more natural condition and will cover over with a natural growth. However, walls are necessary in many situations. Great care should be taken in their erection. Generally one must depend on the stone that is available nearby for this construction. Nevertheless, it is worth while to go to some trouble in selecting stone that is adaptable. Stone with a weathered face, if it can be obtained, is better than stone that is broken. There should be sufficiently large rock used so that the wall will tie into the slope. Generally, there is not enough chipping or shaping of stone to make it fit, on trail construction. A better result would be obtained if this were done. Stones should not be laid up in a haphazard way as they are handed to the builder; they should be slected to fit the position in the wall thatthey are to occupy and should be rejected if not of the right shape and size.

(It is usually inadvisable to attempt to make a retaining wall look like a natural outcrop. This requires a great deal of skill and critical choice of rock. When attempted, it should be done only under the supervision of a geologist. It is usually better, however, to admit that a wall is an artificial structure. Its justification lies in the work which it performs, and its attractiveness depends upon good design and creditable execution. An attempt to camouflage such a structure usually violates both of these principles and is so patently artificial that the result does not deceive even a casual observer.)

To assure solid construction and good appearance the following rule should be followed in the selection and setting of rock: Start the construction with proportionately large rock at the bottom of the wall; grade the size to smaller rock in the center

section and again increase the size toward the top of the wall. The top course of the wall should be of rock sufficiently large to be solid.

The following method of wall construction has been used with good results in various sections of the park during the past year:

1. The outside edge of the base of the wall is carefully staked on the alignment.

2. Batter boards are set at intervals along this line at the proper slope. It has been found advisable to allow about two inches of clearance between the batter board and the wall surface. Care should be taken in placing the batter boards to see that the top of the wall is located sufficiently far out to give the proper width of trail when finished.

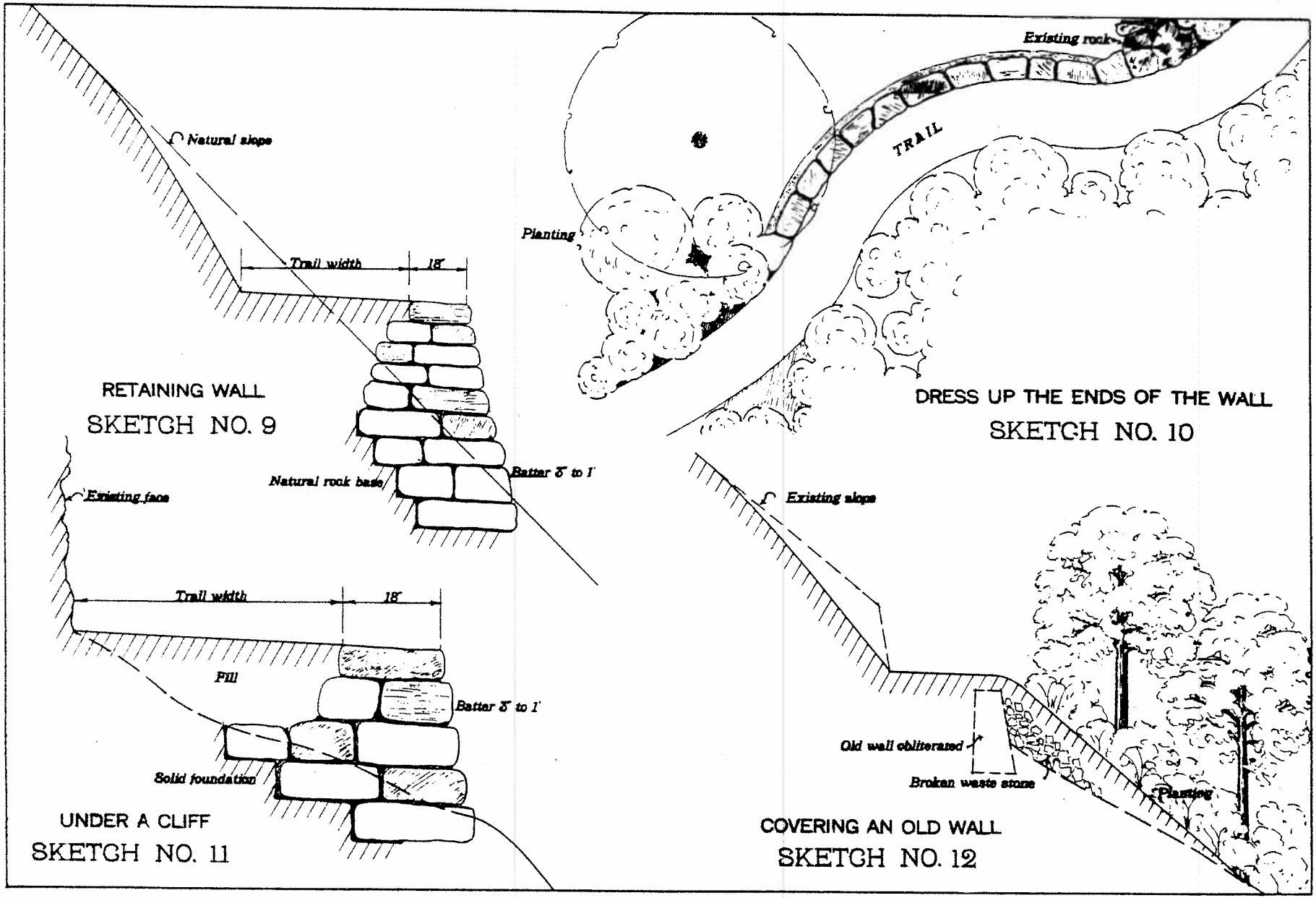
3. After the batter boards are set, excavation is started. Wherever possible, walls should be built on rock base; however, if rock is not present, excavation should be made to solid earth, and below the frost line, before any wall construction is begun. Never build walls on filled earth bases.

4. Where the trail is built of earth-fill back of the rock wall, the wall should be built to the following dimensions: The base of the wall should approximately equal one-half of the height. The front face of the wall should be battered 3" to the foot in all cases. The back of the wall should be built in steps starting at the bottom and finishing at the last stone course with a width of wall at least 18". (See Sketch No. 9)

5. Particular care should be given to locating the beginning and ending of the wall. Wherever possible the wall should begin and end in some natural formation leaving no sharp ends exposed above the natural surface. Where this is not possible, arrangements should be made for planting to obliterate the ends of the wall, as in Sketch No. 10.

Sketch No. 11 is a typical walled section where the entire trail width is obtained without going into the side slope and creating a large scar. This is particularly useful on very steep cross slopes and in places where outcroppings of rock must be avoided.

Sketch No. 12 indicates a treatment that is practical when the trail is over an old railroad or road grade on which walls have been built that must be obliterated. This method creates an opportunity for the disposal of waste rock after blasting operations since it can be placed below the existing wall and



RETAINING WALL
SKETCH NO. 9

DRESS UP THE ENDS OF THE WALL
SKETCH NO. 10

UNDER A CLIFF
SKETCH NO. 11

COVERING AN OLD WALL
SKETCH NO. 12

covered with earth which will soon grow over and present a natural appearance. In new trail construction it is sometimes necessary to use this method for the disposal of scrap rock from blasting operations.

Sketch No. 13 illustrates a type of wall used where it is necessary to drop below the line of the trail to find firm foundations for wall construction. The slope between the top of the wall and the trail grade is built similar to the fill slope on the trail in ordinary circumstances. Care should be taken to leave a small ditch for drainage above the wall.

Sketch No. 14 indicates a type of wall that has been used in the past but is not practical and has been washed out or turned over by frost action. It is merely a rock veneer and cannot be depended upon to retain a fill where there is pressure against it.

Sketch No. 15 indicates a wall on the cut side of the trail serving to retain loose earth and rock above the trail floor. This may be justified in a few exceptional cases, but as a rule, wall construction above the bed of the trail should be avoided, as well as any laid-up job above a trail such as veneer construction to eliminate a hole in the upper bank where a stump has been removed. Where it is necessary to retain a bank above a trail it may be done by placing the rock in such a manner that it gives the appearance of a natural outcropping or formation. This area should be planted in a natural manner. The natural condition should prevail down to the trail edge.

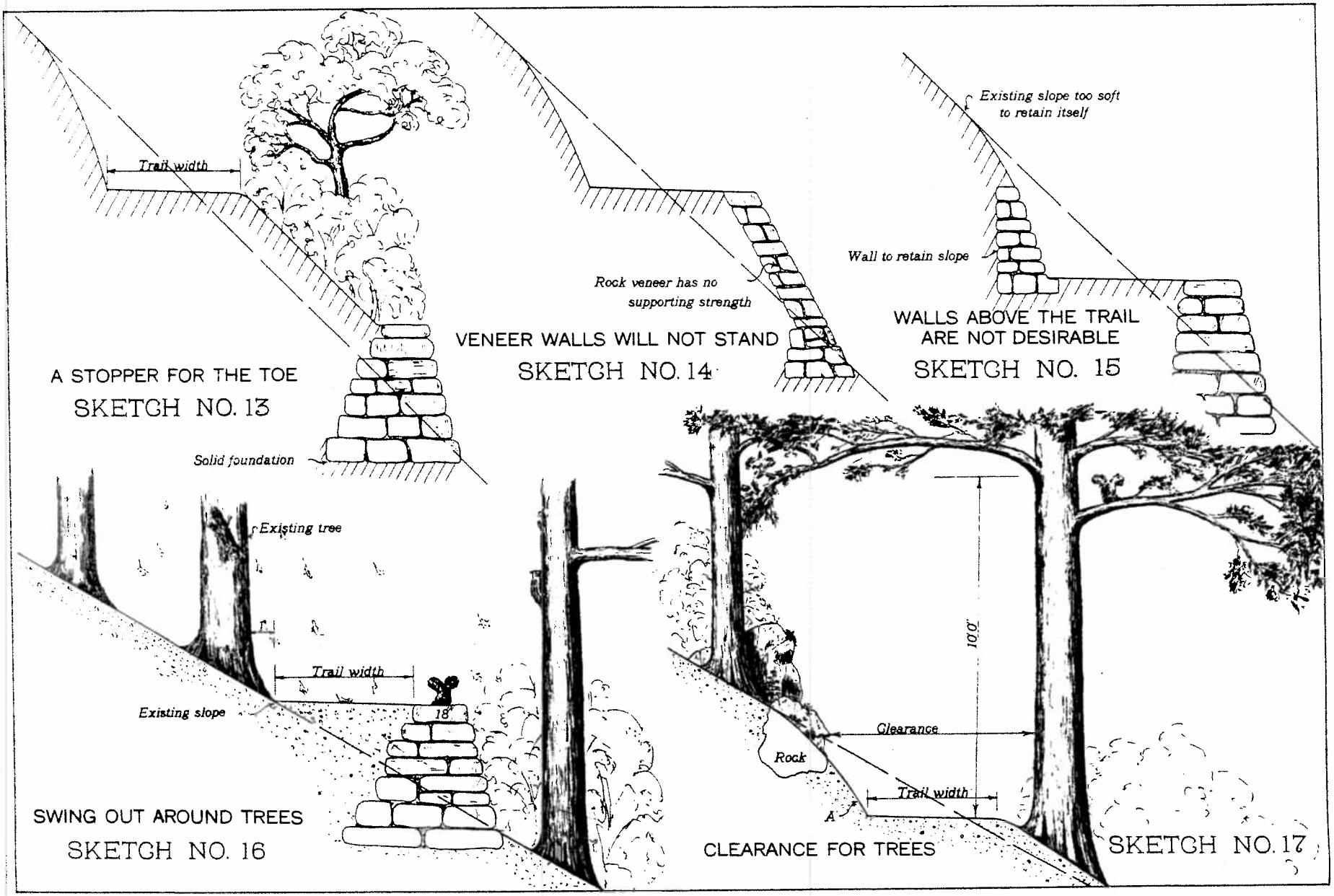
Where trails pass close to large trees and the location is kept below the tree, the type of construction shown in Sketch No. 16 should be adopted. This will make it possible to build the trail to the proper grade and location without injury to the tree roots.

TRAIL WIDTH

A four foot width is desired for horse trails.* This width should not be measured out to a sharp edge which is not substantial. It should be measured from the outside of the trail where the fill slope starts to round over, to a point just out from the base of the cut slope, allowing for rounding out at point "A". (See Sketch No. 17)

Where there is a wall on the lower side of the trail, the width should be measured from the inside of the wall. The top of the wall should not be included in the four foot width of trail. It is sometimes advisable to widen the normal four foot

* This width applies to Great Smoky Mountains National Park. (See Page 1, Paragraph 2)


Trail width
Solid foundation
A STOPPER FOR THE TOE
SKETCH NO. 13
Rock veneer has no supporting strength
VENEER WALLS WILL NOT STAND
SKETCH NO. 14
Existing slope too soft to retain itself
Wall to retain slope
WALLS ABOVE THE TRAIL ARE NOT DESIRABLE
SKETCH NO. 15
Existing tree
Trail width
Existing slope
18"
SWING OUT AROUND TREES
SKETCH NO. 16
10'0"
Clearance
Rock
Trail width
A
CLEARANCE FOR TREES
SKETCH NO. 17

width at such places as on curves where the trail turns in a hollow or rounds the point of a ridge (where people may stop at a good view point) and at intervals along the trail to permit the passing of animals.

Where there is a steep dangerous bluff or drop-off below the trail, the trail bed should be widened to seven or eight feet, exclusive of wall width. On the normal trail there should be at least one foot clearance beyond each side of the trail to permit passage for pack animals. This distance may be increased where there is a dangerous condition below the trail. Tree branches that overhang the trail should be removed to permit passage of a man on horseback. (See Sketch No. 17)

TEMPLATES FOR GRADES

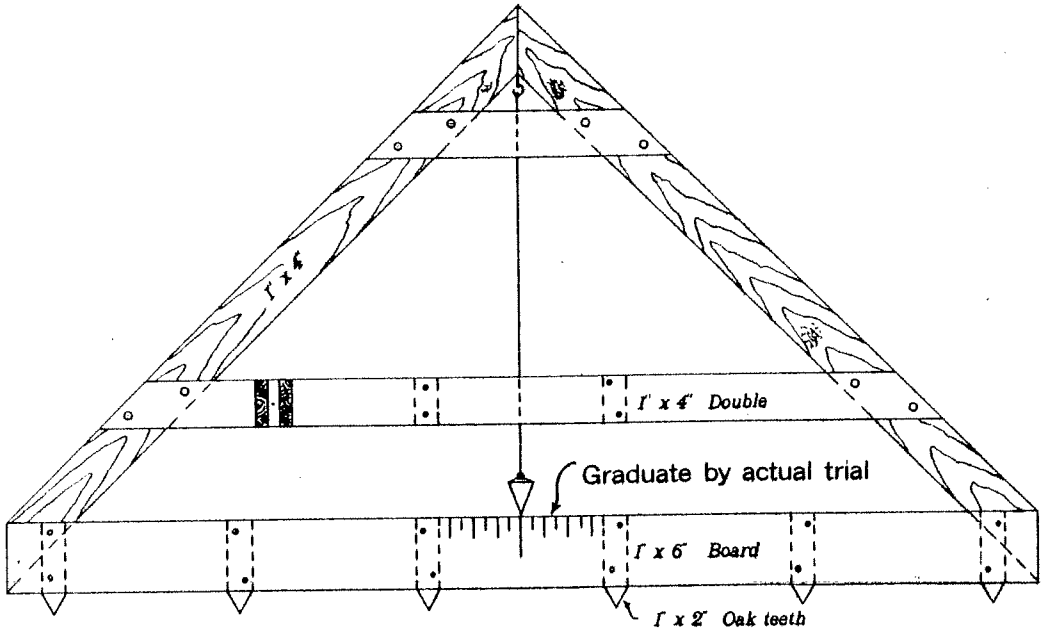
There are two kinds of templates which help in constructing trails, shown in Sketch No. 18. The triangular form is for grading trail surfaces. The bottom member is graduated, by actual trial, to give grades of 1/8, 1/4, 3/8, 1/2, 3/4, and 1 inch per foot. It may be made in any proportions, but the higher the triangle the wider the plumb bob will swing, and the easier the graduations can be read. The teeth on the bottom give a better check on the grade than a straight-edge can, since they cut into high places.

The level-board is used for length-wise grades on the surface, and for getting grades on walls and on the floor of culverts. A small level is screwed to the board near the top. The legs have slots in them which run on bolts in the board, and these legs may be graduated in inches. The bolts in the board must be a definite distance apart, such as 10 feet. If the grade desired is 1/4" per foot, and the bolts are 10 feet apart, one leg must be 10 x 1/4" or 2-1/2" longer than the other. The board will be level when the desired grade is reached.

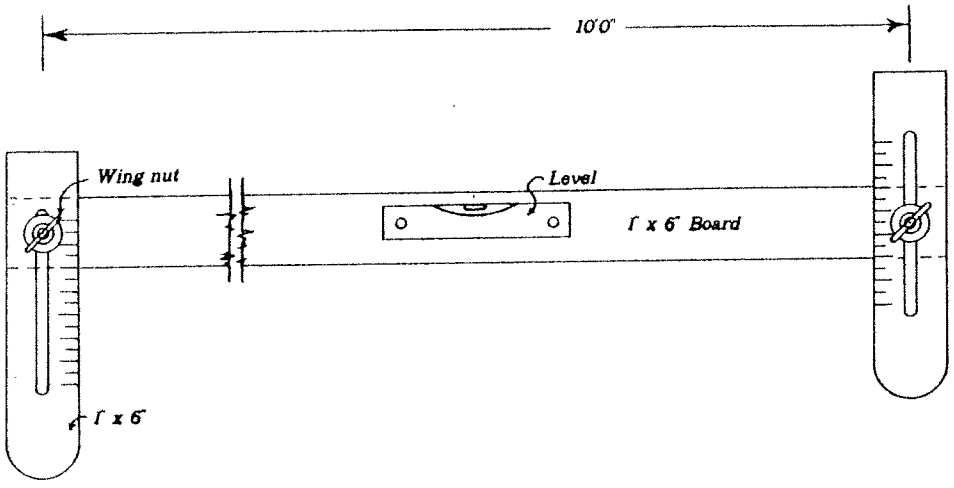
STREAM CROSSINGS

Care should be taken in the development of fords to see that as little damage as possible is effected by the entrance of the trail to the stream at either side.

Visitors will stop at stream crossings, which should be made as attractive as possible. Horse bridges are recommended at stream crossings only where the stream is of such size that it will be dangerous for a horse to cross at high water and where the construction of the ford would mar the surrounding area. The ford crossing is preferable because it is more natural and permanent and offers facilities for watering horses. The trail grade should dip at the ford to prevent water from flowing down the trail when the stream is in flood; however, this grade should not pitch sharply up or down at the approach or when leaving the ford, but should gradually rise to



Triangle



Level board

SKETCH NO. 18

the normal grade.

At ford crossings, if the current is swift, the stream should be slowed and widened to prevent washing out the ford. (See Sketch No. 19.) This may be done by removing the obstructions above the proposed ford that tend to force the water into narrow channels or divert the water in the wrong direction. Thus in Sketch No. 19, "A" may be a group of boulders that force the water between it and another boulder at "B". If these obstructions can be removed without marring the site, it should be done.

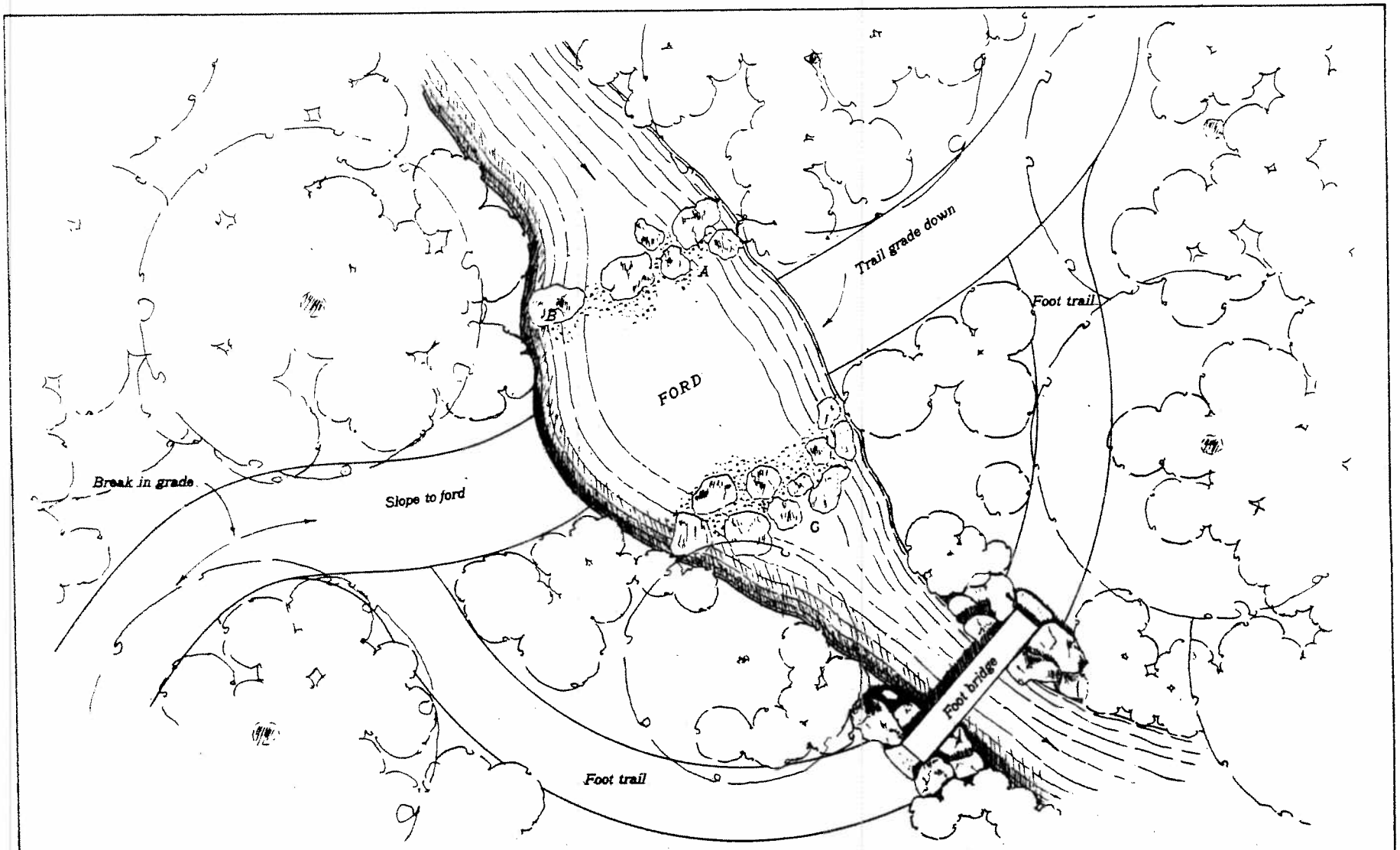
In most cases it is necessary to build up the lower edge of the ford to make the trail crossing more nearly level. This should be done by placing weathered boulders at the edge of the ford at "C" in a natural manner and not in a definite wall. This so slows the water that gravel is deposited and any fill that is made will not be washed out. These stones, when properly selected will serve as stepping stones for pedestrian traffic except on the occasions when the water is exceptionally high. Foot logs and foot bridges are not recommended except where the stream is sufficiently large to justify them.

Where foot logs are used they should be placed below the ford, adjacent to it and close enough that they can be easily seen and used by passing pedestrians. In construction of foot bridges, any natural formation that is available should be used to make the structure fit into the surrounding country. Existing boulders and rock formations make excellent abutments for use in bridge construction. In the absence of these natural formations, abutments should be built of native stone to appear as nearly natural as possible. The advice of Landscape and Engineering technicians should be obtained in determining the location of all bridges and no construction started until plans for the structure have been given proper clearance.

Horse bridges will be recommended only for those stream crossings which are too large for convenient fords, in places where the stream banks are too high for ford construction and in places where ford construction would cause much damage to the immediately adjacent area. All horse bridges will be designed by the Branch of Plans and Design and approved by the engineering Department before construction is started.

DRAINAGE

No factor in trail construction is more important than proper drainage, and many sections of good trail are damaged and destroyed by erosion which could have been prevented. All drainage should be planned far ahead of construction. The method of carrying surface water off of each trail section should be determined in advance, along with the location, type, size, and construction details of all drainage structures.



STREAM CROSSINGS FOR HORSE AND FOOT TRAILS
SKETCH NO. 19

Three general drainage conditions are encountered in trail construction: Sheet Water, Water Concentrating in Natural Basins, and Water in Natural Channels. Larger channels are not considered here because they require bridges, and it is assumed that all bridges will have been designed beforehand.

Sheet Water. Where water comes to a level section of the trail from an uphill slope it does not concentrate in drainage channels, but flows across in a sheet. In rare cases it is permissible to concentrate sheet water by cutting screened ditches across the hillside, with an open ditch bringing the water to a culvert under the trail. The approved practice is to tilt the trail bed so as to carry sheet water across the surface with the least concentration, and thus with the least danger of erosion.

Water Concentrating in Natural Basins. Since we like variety in foot trails, they go uphill and downhill, crossing ridges which shed water, and hollows which collect it. These hollows may concentrate water from a considerable area or watershed. The bottoms of these hollows, touching the trail, may be flat and wide, or steep and narrow. This topography calls for drainage structures, and the shape and area of a hollow determine their location, type and size.

Surface water should not be forced to concentrate in channels to a greater extent than it does naturally. To compel it to back up behind culverts in new locations is to invite destructive erosion and unsightly ditches. Several small culverts should be used rather than one large one. And the trail should be raised enough to impound a rush of storm water until it can flow through the culverts, without cutting new channels in the drainage basin, or across the trail.

In gullies, nature has already determined the type of structure to be employed, which is a culvert big enough to carry all the water that comes down. The gully has already established a temporary balance between the scour of the stream and its bed. This balance should not be disturbed, so the floor of the culvert should be at the level of the gully bed. Then the elevation of the trail, compared with the elevation of the gully bed, may dictate a wide, shallow culvert, or a deep, narrow one. But the wider the culvert the easier it will take water, and the less danger there will be of destructive cutting on the discharge side.

There is no satisfactory information on the size of culverts required for different watersheds. The area of the watershed, the steepness of its slopes, the amount of natural impounding in its basin, the amount and kind of cover, and the condition of the soil, combine to absorb or shed water. The best practice is to judge as competently as possible from local conditions how large a drainage structure should be. It should not be less than one foot in width or height, to avoid choking.

In many places where a small culvert seems to be needed it would be better to build a low-water crossing, which is merely a depressed section of the trail paved with flat stones. This device is used in Great Smoky Mountains National Park at the heads of coves where there may be a rush of water during storms, but only a light flow from springs during dry weather. Culverts have been built in some cove crossings with the roof of the culvert below the grade of the trail, and the trail depression above it is paved for a distance on each side. Water in excess of the capacity of the culvert can go over the top with no damage. (See Sketch No. 20)

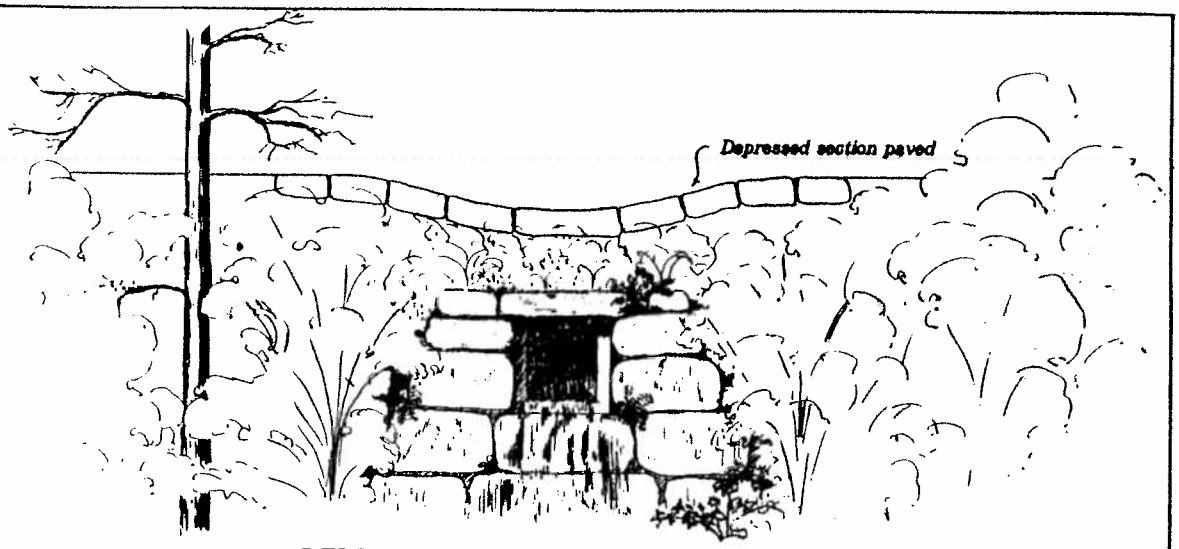
Side Drainage Combined with Trail Surface Drainage. Sometimes it is necessary to drain a trail surface to the inside, against a bank, providing a catch basin, or "duck's nest", at the end of the culvert. The amount of water shedding off the trail, as compared with the amount coming from the side, may be large or small. Draining a surface in this way should be avoided, but where it is necessary, the side ditches should be paved with flat stones, to prevent undermining of the back slope. (See Sketch No. 21)

The only particular requirement for this type of culvert is to carry the catch basin well into the bank, even channelling into the slope to keep it away from traffic. The back wall of the catch basin should be carried far enough up the slope to be stable, and all danger of erosion around it should be foreseen and prevented.

Water in Natural Channels. Established channels determine the location of culverts, and the amount of water to be served can be estimated with reasonable accuracy. Any depression, even one coming from a small spring, is the established drainage channel in that area. This can be proved by the absence of erosion, and the presence of cover, on nearby surfaces. The amount of run-off at flood stage can be estimated by lines of drift left by high water, scouring at the bases of trees, root systems exposed by scouring, fresh surfaces on rocks below old stain-bands, shrubbery tilted down hill, and other signs.

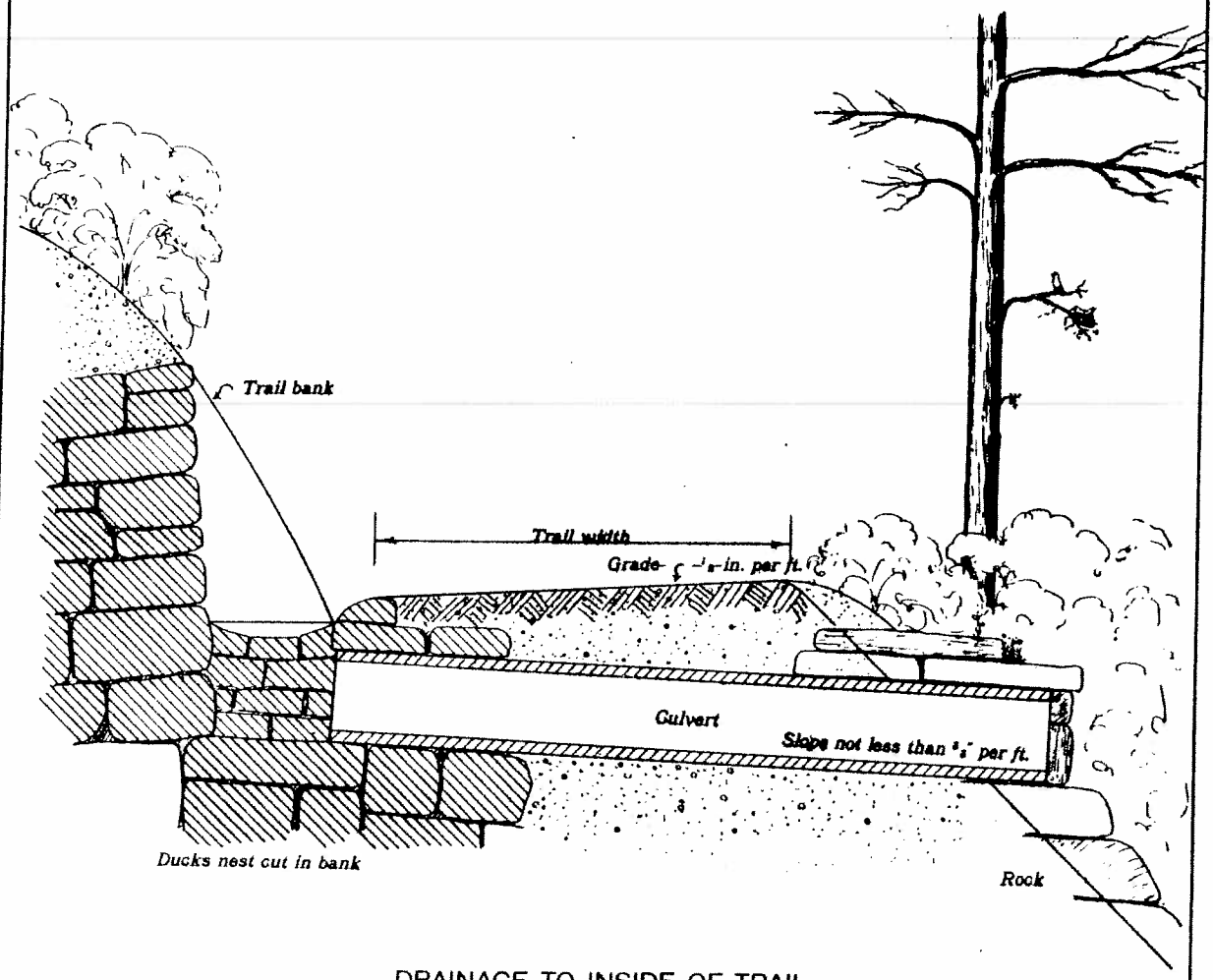
The culvert must be large enough to carry flood water. And its floor must be at the level of the channel bed. These two factors determine the size and shape of the structure. Where there is any choice, the culvert should be wide, rather than deep.

If the drained slopes are bare, and erosion is to be retarded until cover grows, a catch basin can be built at the intake end of the culvert with dry walls built high enough to form an impounding basin behind them, where the flood water can deposit its silt before seeping into the culvert. But in such a case special care



DEPRESSION IN TRAIL ABOVE CULVERT

SKETCH NO. 20



DRAINAGE TO INSIDE OF TRAIL

SKETCH NO. 21

must be taken to protect the culvert with wing walls, so that impounded water will not find a passage along the walls of the structure and eventually wash out the trail.

Types of Culverts. Preferably all culverts should be made of stone, using dry or mortar joints as prescribed by plans, general instructions or local conditions. The ends of the walls should be flared, as a usual practice, to hold the fill above, and to prevent scouring by flood water. Care should be taken to keep the inside surfaces uniform and smooth, to prevent debris from catching. A culvert should extend a foot or two beyond the edge of the trail on each side, and the trail widened to the head walls of the culvert. The bottom of the culvert should slope not less than 3/8" per foot.

Blind Drains. These are not as desirable as they might be. At first they carry water very well, but there is always the likelihood that their surfaces will clog with silt, so that they will not continue to function. Their worst fault is that they remain frozen in the spring after the trail surface has begun to thaw. At the time when the trail surface is least able to carry traffic and withstand erosion, the frozen drain will not take water.

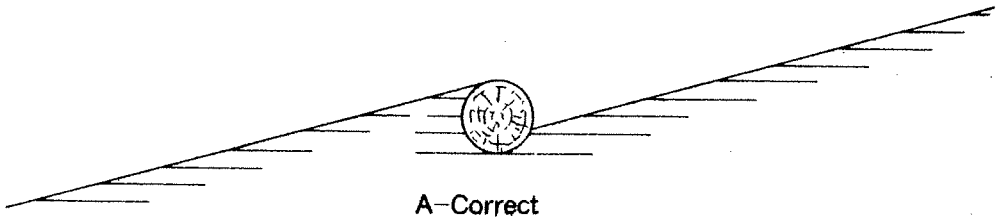
WATERBREAKS

A waterbreak should be extended far enough into the bank on the upper side of the trail to prevent water from cutting around it. It may be necessary to cut a trench into the bank to accomplish this, tamping the dirt back afterward. Both ends should be anchored behind rocks or trees, or firmly staked in place.

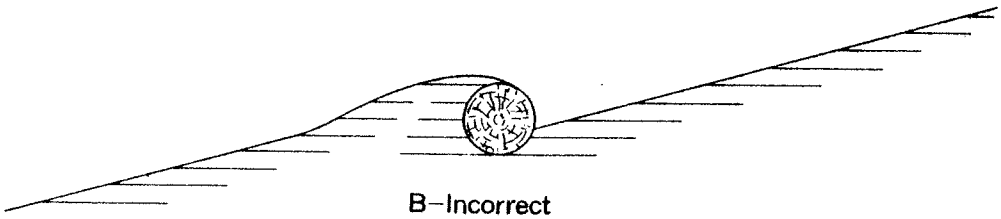
The pitch of a waterbreak, or the angle at which it lies across the trail, is very important. A definite relation between the slope of the trail, and the pitch of the waterbreak, must be established by experience in each location. This relation depends upon the nature of the soil, and may vary greatly on different sections of the trail. On one section there may be a stiff clay which does not wash. On another stretch there may be alluvial soil, which will wash badly.

As one of two extremes, take a section in tough clay on a flat slope. Here there is very little danger of washing, and the breaker can lie on a steep ditch carrying off all of the water quickly. If it were laid on a flatter pitch, there would be danger of depositing silt behind the breaker, and putting it out of use, as in Sketch No. 22, Figure D.

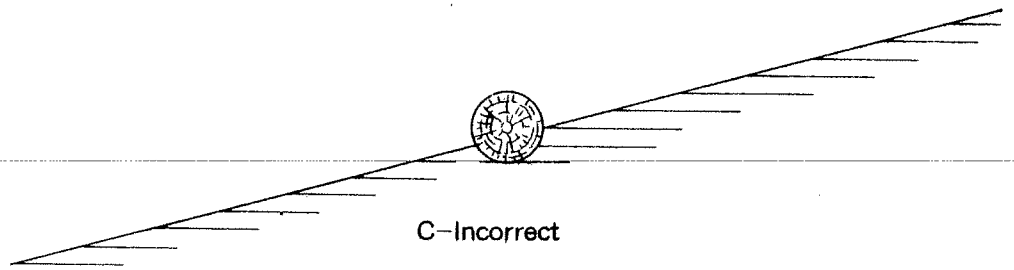
For the other extreme, consider a section in alluvial soil on a steep slope. Washing will occur here on the slightest incline,



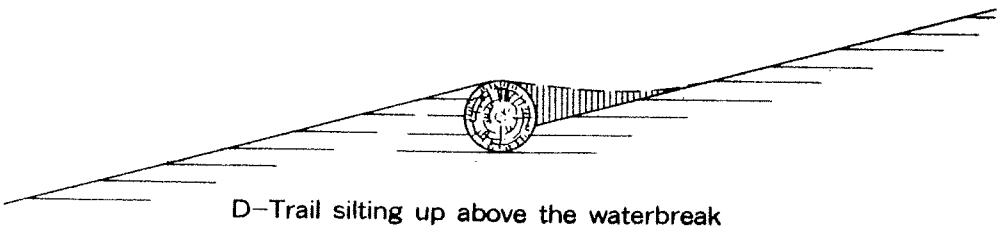
A–Correct



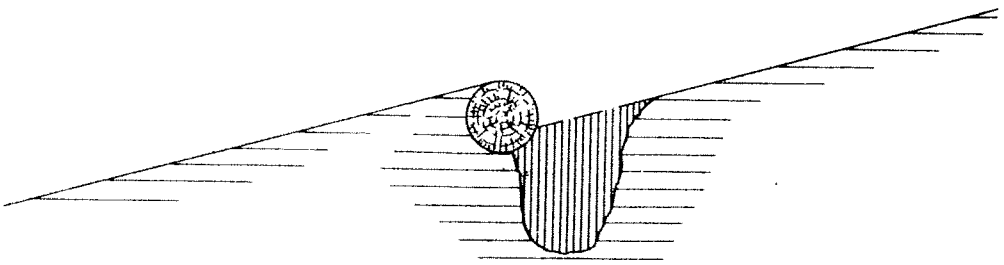
B–Incorrect



C–Incorrect



D–Trail silting up above the waterbreak
Pitch too flat



E–Trail cutting out behind the waterbreak
Pitch too steep

WATERBREAKS

SKETCH NO. 22

so the breaker must lie almost straight across the road. If it is given a more pronounced pitch the water will hit the breaker, turn off across the trail, and wash a cross-ditch as in Figure E. The breaker log will be washed out, and the water will go on down the trail, making an additional load for the next breaker to carry off.

The spacing of breakers cannot be determined by any rule, but there are three particular locations where they should be placed: (1) Where there is a depression or wash, the breaker should be set below; (2) On sharp curves, the breaker should be set at the uphill entrance of the curve; and (3) At changes in the trail grade, the breaker should be set just above the break in grade.

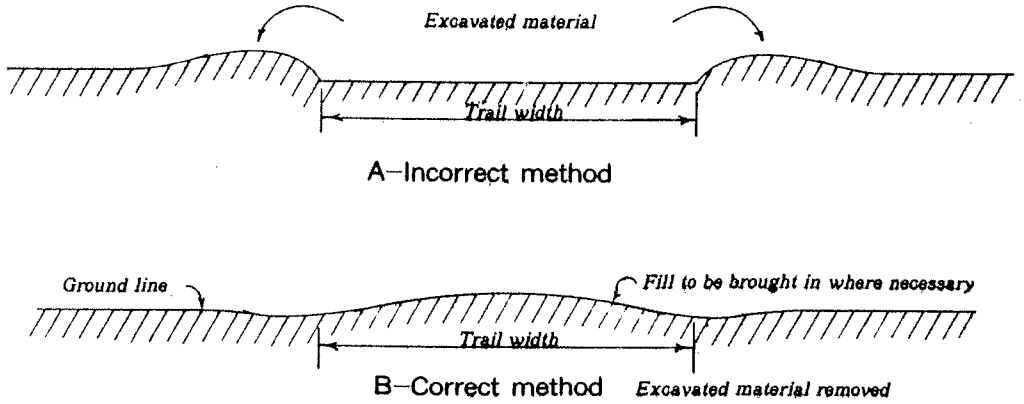
No harm is done if some excess water goes over a breaker that is carrying a full load off to the side. It is better to set them so that this occurs in heavy downpours, than to pitch the breakers so that excessive scouring occurs alongside the logs. If careful study is given to the behavior of breakers in different soils, and on different slopes, it will be possible to reach a reasonable balance between scouring, as one extreme, and silting up, as the other.

In Sketch No. 22, "A", "B", and "C" indicate three methods of setting breakers. "A" is the correct method with the grade below the breaker finishing flush with the top of the log. When setting it is better to fill rather full back of the breaker and then tamp the soil well to prevent settling and the consequent exposure of the breaker. The grade above and below the breaker should feather nicely into the grade of the trail and not leave a "bump" as shown in "B". When breakers are set in this manner they are secure and, since the grade at the lower side rides the breaker, these are not visible when one looks up the trail.

"C" indicates a method not desirable. It is not as secure, is more noticeable and forms a greater obstruction to stumble over.

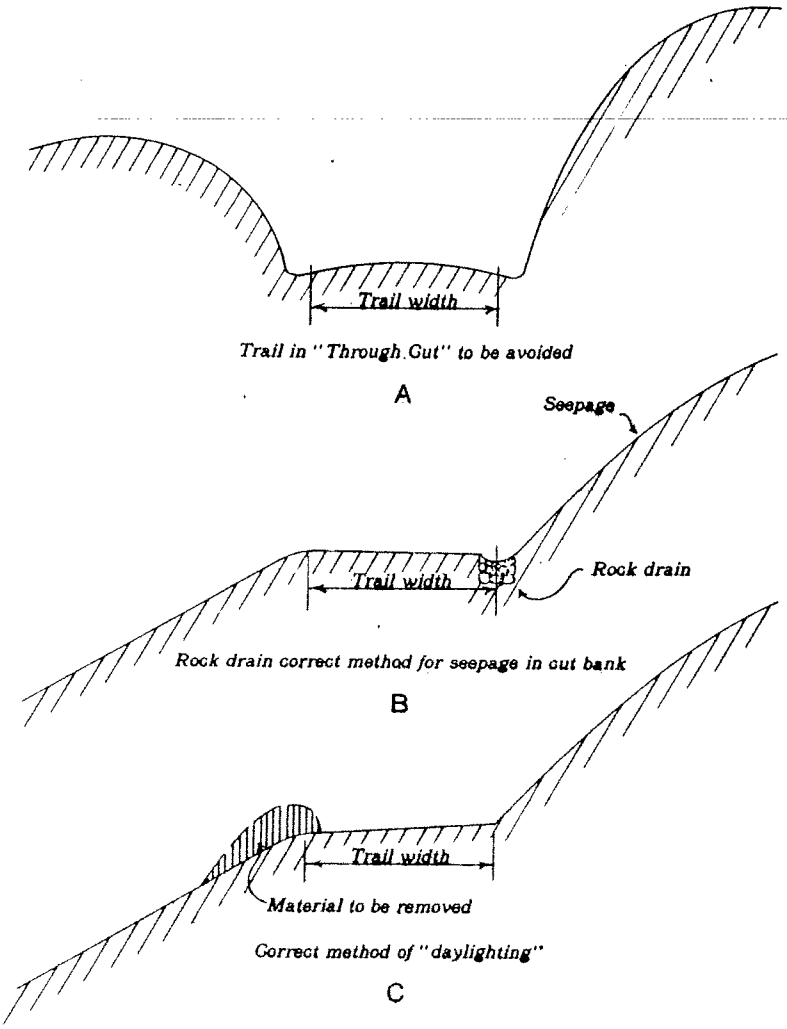
The following are conditions, frequently encountered, that require careful study to secure proper drainage.

On ground where there is no appreciable cross slope, the trail is frequently built as shown in "A" of Sketch No. 23. Turf is cut from the trail bed and raked off to the sides, making piles that confine water to the trail and wash it out. On such locations, the proper method of construction will usually be to work out shallow, rounded depressions, not ditches, at the sides, and the good soil from these excavations used to slightly raise the trail bed forming a dry, well drained trail bed in wet weather. In some cases it will be necessary to gather additional fill from another section to raise the trail bed. "B" in Sketch No. 23 indicates the correct method of construction in this type of topography.



WRONG AND RIGHT CONSTRUCTION ON FLAT SECTIONS

SKETCH NO. 23



TRAILS ON OLD ROAD BEDS

SKETCH NO. 24

Water should be directed away from these drainage depressions wherever conditions will permit.

Sketch No. 24 indicates types of construction used when trails follow old road or railroad grades.

"A". This sketch indicates the method used in "through cut" sections. It is not a desirable solution, however, and should be avoided wherever possible.

"B". This shows a condition frequently encountered where there is a seepage of water for some distance from the bank above the trail which will keep the trail bed continually wet if the water is not disposed of satisfactorily. Here the trail bed is raised and the seepage caught in a rock fill which should extend along the trail for the distance that the seepage exists, and from there connect with one or more culverts.

Mounds of earth similar to those shown in "C" should be graded off, or "daylighted", when they exist on an old road location that is being converted into a trail or truck trail.

REMOVAL AND OBLITERATION OF SCARS MADE BY CONSTRUCTION

The ideal trail is one that appears to be old, with natural conditions prevailing along the sides and no signs of construction such as axe marks, freshly broken stones, rock walls, freshly cut stumps, or raw banks exposed to view. Also one that has but little construction work visible such as rock walls, etc. While time itself will eliminate or obliterate many of these signs of artificial work as is shown on some of the existing railroad grades that have grown over, this should not be used for an excuse, as it often has, for leaving disorderly conditions along newly constructed trails. It is the desire of the Park Service to hasten the healing process by sloping banks, and in every way create conditions that will assist nature in restoring natural conditions. For this reason broken rock and debris should be removed, covered over or laid flat on the ground where it can be easily concealed by natural growth.

A careful foreman will not turn loose all the rock that is taken from the trail excavation but will use this in fills below the trail as part of the trail construction.

SECURING FIRM TRAIL BED

Trails should not be built on top of peat or leaf mould beds. When this condition is encountered as is the case many times when passing through heavy growths of Rhododendron, the entire depth of soft material should be excavated to make a solid bed that is well

drained and will remain solid. The leaf mould and peat removed should be used as topsoil on other parts of the trail and for planting operations.

PLANTING

Some planting may be done by the foreman (during his construction) with the material he takes out of the right-of-way when he is clearing. Good plants should be carefully taken up when clearing and planted naturally in places that are bare or they may be used to conceal signs of construction. In all planting the guiding policy should be to create a condition that is as nearly natural as possible. No planting should be so placed that when finished it will be evident that the planting has been artificially set out. To accomplish this it is necessary to use like varieties and each variety in a like proportion as it is found growing naturally in the area. Leaves and leaf mould may be scattered over the ground around new planting for protection and to assist in catching natural growths in new construction areas. Planting is best done during the fall and winter months, yet one should not neglect the deciduous (non-evergreen) types in his planting. The result of using a solid evergreen planting may be the creation of a solid belt or new material along the trail that is quite different from the nearby natural growths.

LANDSCAPE FEATURES ADJACENT TO TRAIL

Foremen, in their enthusiasm, often depart from the trail location and attempt to landscape nearby areas such as springs, streams, etc., and cut side trails to nearby features. These side features are important but they should not be attempted without consulting a representative of the Landscape Department. If a landscape foreman is not present in the camp, a request by the Project Superintendent will be immediately recognized.

CLEARING THE RIGHT OF WAY AND TRAILSIDE CLEANUP

The instructions given by the representative of the Branch of Forestry should be followed in the disposal of material cut from the trail and in the cutting of dead timber.

The Landscape Department is principally interested in this operation in areas immediately adjoining the trail and at particular locations where there may be more attractive views. In such cases the Landscape and Forestry representatives will jointly work out a satisfactory solution.

The following is a set of instructions issued by the Branch of Forestry for Road and Trailside Cleanup:

1. Dead and down timber shall be placed flat to the ground and parallel to the contour on a strip a reasonable distance back on each side of the trail. In most cases this strip will be 100 feet. The only exception to this general rule is that a reasonable number of dead trees should be allowed to stand along the trail so for wildlife.

2. In case of extreme concentration a portion of the down timber may be removed in order to place the remainder flat on the ground.

3. All limb wood should be removed from the boles of the trees and either burned or scattered.

4. Burning shall be done in the road or trail.

5. When limb wood is scattered it shall be carried beyond the 100 foot strip.

6. Do not remove the forest litter or ground cover.

7. Treatment in the past has been too intensive.

8. The treatment is fire hazard reduction rather than cleanup. (The term is misleading.)

The time that this cutting is done, in relation to procedure, however, is of great importance. It will facilitate trail construction greatly if this cleanup is done in advance of construction, since it has been proven in many cases that where cleanup follows construction, walls are knocked down by falling trees and finished slopes and trail beds are torn up with the result that much work must be done over. If for any reason this cleanup must be delayed, or is not done at the time of trail construction, the foreman should cut those trees that are likely to fall on the trail.

Postponing trailside cleanup until after construction is a wasteful, poorly planned method of procedure.

TRAIL FINISHING

The question of how far to go on trail finishing is frequently asked. It is not practical to do such refined grading as will not stand up under the relatively small amount of maintenance that those trails will probably receive in the future. The best answer to this question is that trail finishing should be carried to such a point that erosion will be discouraged and natural growth will be encouraged. Such finishing can be justified from the practical

standpoint. All trails will require occasional maintenance work in the future to keep them in good condition. Finishing them so that this upkeep will be kept to a minimum, is one of the guiding factors in trail construction. When banks are not properly sloped, walls not well built, and drainage not properly provided, there will be a constant maintenance job necessary with the resulting increase in cost of upkeep.

DYNAMITE

Care should be taken in the use of dynamite to see that all surrounding vegetation is properly protected from possible scarring by flying chips of rock. This can best be done by wrapping of small growths and by the use of mats in places where large areas might be scarred.

Where blasted and broken rock can be concealed without much additional work or damage to adjacent vegetation this should be done. Otherwise the fragments should be scattered so as to appear naturally placed rather than appearing as though placed by hand.

In blasting, it is well to use in some way all of the rock that is blasted in order to eliminate the scar unless the remnant is of such size that further blasting operations will be necessary to make the remaining pieces small enough to handle with the available equipment.

WORK ORGANIZATION

A raw cut through a woodland is not a trail. A trail should look as though it has always been there; an integral part of the landscape. Traffic and weathering are necessary to bring this about, even with the best workmanship, but much can be done to hasten the process. Organizing the work so as to leave every section of the trail complete as soon as possible has most to do with this result.

Work Organization means that:

1. The cleanup along the location should be kept far ahead of construction.

2. Drainage plans should be made for every section in advance of construction. The method of carrying off the water should be determined, along with the location, type, size and material needed for every drainage structure.

3. Some use should be found for all material, wasting as little as possible.

4. A minimum of material should be brought in from the outside.

Starting Point. It is not necessary to start a trail at the beginning, if some other point is accessible for transporting men. If a green crew is to do the work, mistakes will be made which may leave scars. Such scars can be more easily eradicated at some point farther up the location, or they will not be so noticeable there as at the beginning of the trail. The first section of the trail should rather be left for some unusually good work after the crew has acquired skill and experience.

On every trail there is an accessible point where excess material will be taken out, with other points nearby where this material can be used. The rock is needed for culverts and walls, and dirt for fills. The top soil is needed for finishing slopes, and the plant material for protecting them. Even an excess of litter may be used somewhere to cover a raw fill or a pile of rock spalls.

There is no reason why a trail must be finished progressively from beginning to end, if any economy of time or material can be realized by finishing one section and then starting again at some distance. Or if two crews are to work on the trail they need not work at random points, when they can be so placed as to exchange material and equipment between them:

One Crew to a section. Each crew should be complete in itself, and finish one section of the trail, except for clean-up and blasting. Sometimes it is better to have a separate crew for building culverts and walls. But once a crew begins a section, certain members can be cut out for special work. One enrollee will become especially good at bank sloping, another will show more understanding of fine grading, two or three will learn how to take up and plant shrubs, and some leader may be trusted with setting side stakes and slope stakes ahead of the crew.

Removing Trees from the Location. If it is left for the trail crew to remove trees from the location, a squad should be sent forward to remove them in the right way. Where possible these trees should be heeled over, rather than sawed off--leaving stumps to be grubbed out. This calls for two men to uncover roots and cut them, and two others to rig the tackle for pulling them over. Considerable skill will be developed in heeling trees so as to pull the tap roots. After they are down they must be disposed of in whatever manner is prescribed.

Finishing the Trail. Each section of the trail should be finished at a reasonable distance behind the rough excavation. This means that the bank sloping has passed inspection, the new

surfaces are planted with suitable native species procured nearby, and litter has been cast over all fresh soil. All timber, brush, refuse at burning places, and construction materials have been removed. All drainage structures have been obscured or faced down with planting. Within a given section the transformation from untouched woodland to park trail should be complete.