

A REVERSE SLOPE DRAINING SYSTEM.

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The Tea Quarterly for February 1930 emphasized certain principles in the laying out of drains as preventatives of soil erosion. Chief among these were the following:—

- (1) It is known that the open drain with a gradient of 1 in 30 allows the majority of the silt and loam to be lost unless the velocity of the running stream can be arrested.
- (2) The retention and percolation of water bring great benefit to the soil since rain water contains dissolved oxygen which renovates the soil atmosphere. The distribution of this dissolved oxygen constitutes one of the major methods of securing soil aeration, particularly for sub-soils.
- (3) Trapped air in the soil capillaries is one of the most formidable barriers to water absorption.

Starting from these principles, the writer has been experimenting with a system of drainage which aims at embodying these points and which has the advantage that it can be readily constructed from existing drains. The results so far obtained seem to be of sufficient interest to warrant their being placed on record.

METHOD OF CONVERSION.

The special feature of the system is the provision of terraces or steps in the existing drains, these being cut so that the tread of the steps has a *reverse* slope which acts as an immobiliser of running water.

Starting at the highest point of the existing drain, a hole 6 ins. in depth is cut. With a road tracer set level, the point where this new level re-appears at the drain bottom is found. From this point the drain bottom is cut back giving a regular slope at such an angle that at the starting point the depth is 1 ft. 6 ins. below the original drain bottom, or 1 foot below the set off from the road tracer hole. Reference to the diagram shows the manner of working. The operation is then repeated and a new section is cut, and so on down the slope of the drain.

The length of the terrace is determined by the gradient of the original drain, and in the case of a 1 in 30 drain is 15 feet. With a drain width of 1 ft. 6 ins., each section will hold 11.25 cubic feet of water before overflowing, so that the cubic water holding capacity of 100 ft. of drain will be 75 cubic feet. Provided that the deep end of the terrace is 1 ft. 6 ins. below the drain bottom and that levelling is done at the 6 ins. depth, the cubic capacity of the drains is constant at all gradients, but the terrace length decreases with gradient and the

number increases. That this is so can easily be seen by means of the following calculation. The cubic contents of a 100 ft. drain equals $\frac{100}{A} \times B$, where A is the length of terrace, $\frac{100}{A}$ the number of terraces possible, and B the capacity of an individual terrace.

$$B = \frac{1}{2} (A \times 1.5 \times 1), \text{ so that}$$

$$\text{Capacity} = \frac{100}{A} \times \frac{1}{2} (A \times 1.5 \times 1)$$

$$= 100 \times 1.5 \times \frac{1}{2} = 75, \text{ since } A \text{ cancels out.}$$

The importance of this is that the length of terrace can be adjusted to meet practical requirements without decreasing the effective capacity.

Soils vary enormously in their capacity to hold water without water-logging, and in the rate of absorption of moisture. Therefore, as to when these drains overflow will depend upon the soil in which they are cut.

The holding capacity of these drains can be appreciably increased by deepening or widening by a few inches. Reference to the diagram shows that the capacity can be increased from 75 cubic feet to 93, or 131 cubic feet per 100 ft. of drain by making the steps respectively 21 ins. and 27 ins. instead of 18 ins. deep.

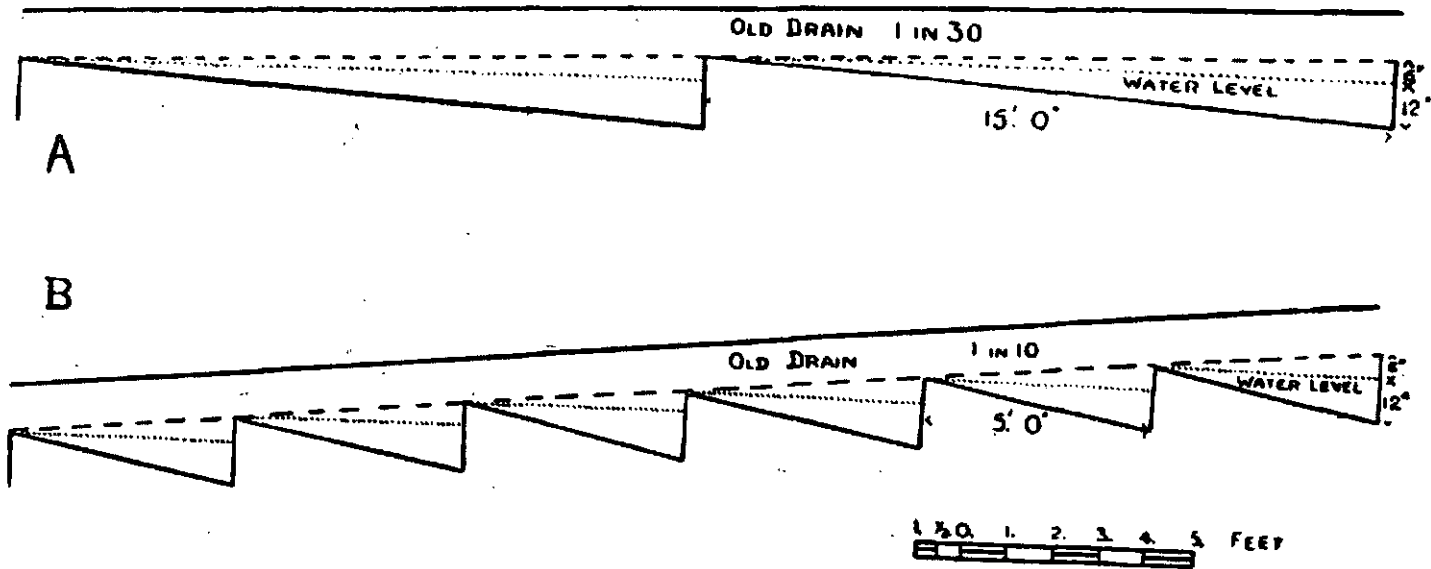
What is the optimum length? This can best be decided after consideration of the advantages of the system.

ADVANTAGES OF THE SYSTEM.

The effect of the terraces is clearly to break the continuous flow of water, thus allowing the suspended soil to settle. At the bottom of each spill there is necessarily a centre of disturbance, but ahead of this a bank of silt forms which adds to the effectiveness of the system by forming a supplementary barrier. In operation this silt bank seems to act as a filter, allowing surplus water to pass through and over the spill, but retaining solid material, so that even when the spills are operating the water runs over remarkably free of turbidity. The construction of the whole system minimises any head of water and undoubtedly this also plays a large part in ensuring success. Further, the system presents a slightly larger absorptive surface than the parent drain and the steps provide an outlet for trapped air which can make its way out under the pressure of the accumulated water. Having stopped the major portion of the direct flow, the water is kept on the land as sub-soil water. The system therefore conforms to the basic principles set out above.

In the light of the foregoing, it is seen that too long a terrace decreases the number of possible air escapes, too short a one brings the spill disturbance from one spill near to the next spill and may defeat the whole aim of the system. 15 feet appears in practice to be an optimum length and avoids both disadvantages.

PLATE I,



Old Drains converted into Reverse Slope Drains.

The cubic water-holding capacities of A and B are equal.

As previously stated, the length of the terrace is determined by the gradient of the original drain, in the case of existing drains being converted; but in a new clearing they can be made at such a gradient as to obtain a length of 12 to 15 feet. When tracing new drains the gradient may be varied to avoid any obstruction without impairing the effective capacity.

Existing drains can be converted at small cost since the work entailed is equivalent to deepening them by an average of 9 inches, whereas new drains may be cut to an average depth of only 1 foot.

The upkeep is not appreciably more than is at present spent on keeping drains clean, since the silt is deposited along the whole length of the drain, not as in a silt-pit where the silt along the drains has been accumulated into pits cut at intervals along the drain.

THE SYSTEM IN OPERATION.

It has been possible to a small extent to check up the actual performance of this system since its inception and to confirm the efficacy that has been deduced from general considerations.

The first severe test occurred on the nights of May 5th-6th when the rain-gauge registered a fall of 8 inches of rain on the estate. At 6 a.m. on the 6th the system was operating normally without overflow, and the high water marks of debris indicated that in the majority of terraces no direct overflow had occurred. The lightness of the soil on this particular area undoubtedly helped, but nevertheless it was a severe test. On one portion of the area, the terraced drain was fed from an unterraced section, and immediately above the terracing an ordinary silt-pit was located. This silt-pit was nearly full of silt, and turbid water was passing over it on to the terraces. At the end of the terracing, although water was passing over the spills (by reason of the unchecked supply from the ordinary drain) the flow was only very slightly discoloured. This section of the ordinary drain has now been cut to the reverse slope type with the result that the above-mentioned silt-pit now remains comparatively empty.

In one case where this system had been established in a 1 in 30 drain of 16 ins. width, 2.26 inches of rain fell in 1½ hours. Even in this case the spills did not overflow. The explanation of this fact would appear to be due to the principle of the system as well as the rate of absorption due to the particular soil. In the first place, some of the water entering the new drain from the commencement of rain is being absorbed, since its initial flow is prevented. For instance, the first ¼ inch of rain falling is directly absorbed into the drain, and while the remainder of the water is merely finding its own level in each section, it is at the same time being absorbed at a steady rate, which in this case was capable of preventing these drains from overflowing.

The system is still under observation, but its usefulness seems to be already assured. It can be carried out without stone, although a flat paving stone at the spill is an advantage so as to prevent erosion of the step, should this be found necessary in districts where exceptionally heavy plumps of rain are experienced. But, in practice, since the overflow is merely caused by the displacement of water in each section, no rapid stream is formed to cause any appreciable erosion on the lip of each section.