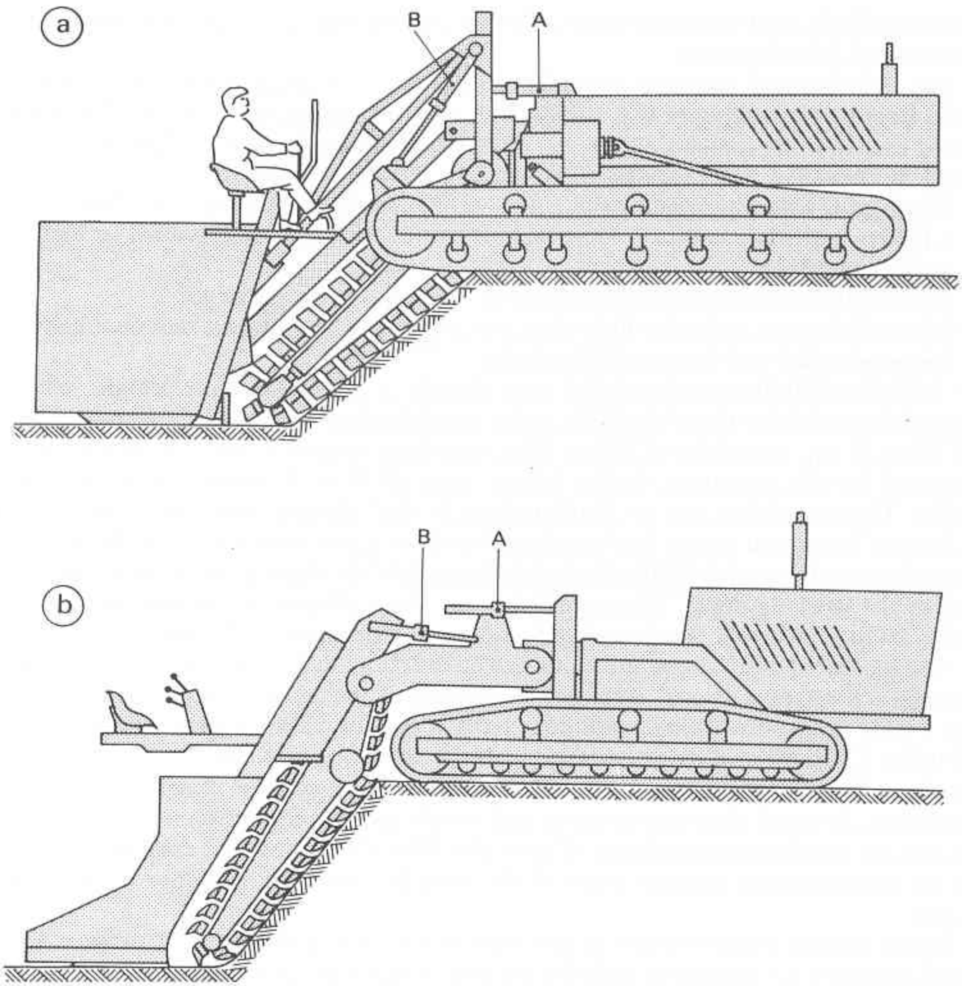

Figure 1 Two main types of trencher drainage machines. Principle of depth regulation: while trenching, the shoe rests on trench bottom and the lifting cylinders A are in float position; depth is regulated by expanding on retracting cylinders B

the field beforehand and then guided through the machine.

The depth and grade of the drains was initially controlled by means of sighting targets installed on each drain line at a constant height above the drain alignment. The machine driver's position was attached to the digging mechanism, and he would keep a sighting bar on the machine in line with the targets, by actuating the switch for the hydraulic valve of the depth control cylinder as required. The accuracy depended very much on the constant attention of the driver and on good visibility conditions, and the system limited the speed of the whole operation (Figure 2).

Figure 2 Trencher drainage machine, flat chain type, laying prewrapped corrugated pvc pipe in The Netherlands

Nowadays the grade control by sighting targets has largely been replaced by an automatic control system. The laser system, developed in USA, consists of a command post mounted on a tripod in the field, and a receiver and control box mounted on the machine. The command post contains a small laser emitter sending out a narrow laser light beam. The laser beam falls on a rotating prism, so that it is deflected to describe a horizontal plane. The prism rotates at a frequency of 5 to 10 times per second. The plane of rotation can be tilted at the command post according to the required drain gradient. A reference plane is thus established above and parallel to the drain alignment. The receiver, mounted on the machine's digging mechanism, contains a vertical series of five photoelectric cells. Its height is adjusted before digging commences, so that the laser beam hits the middle cell when the trencher is at the correct depth. When the laser beam hits the receiver at a higher or a lower cell during digging the machine is digging too low or too high, and the signal from the receiver is processed in the control box to actuate the hydraulic valve of the depth control cylinder which will automatically adjust the digging depth. A set of lights on the control box indicates the position of the digging mechanism continuously. The digging depth is constantly checked in this way, small deviations are immediately detected and automatically corrected. The system is effective in a radius of 300 metres, so that several drains can be installed without having to move the command post. Using the laser control system, the process of staking out the drains is very much simplified, and the setting and resetting of sighting targets for each drainline is completely eliminated.

Of course, good results will only be obtained when the laser is correctly set up, solidly mounted, and not disturbed during operation.

In The Netherlands, the installation of corrugated pipe with a trencher machine with laser grade control and a crew of 3 or 4, rates of about 600 m pipe per hour have become normal, resulting in a labour input of 4 to 7 manhours per 1000 m drain.

In a trencher drainage machine the major part of the engine power is used in excavating the trench while the machine moves forward. The machine is a carrier rather than a puller. Because of the long and wide tracks, the ground pressure is low, so that the trencher drainage machines – as opposed to the trenchless machines – can still generally work under rather adverse conditions on wet and soft land. The technical development of trencher drainage machines, together with the invention of the corrugated plastic pipe, has not only increased the productivity in drain laying tremendously, but also made pipe drainage a practical possibility in situations where it was previously considered unpractical, as e.g. in irrigated lands where large drain depths are required and in soils with little cohesion where a trench will not stay open. Pipe drainage is then only feasible when the trench is excavated, the pipe installed, and the filter applied in one single operation before the trench caves in after the machine has passed.

Trencher drainage machines of the steep digging-chain type are nowadays built in a range of sizes, from 100 kW (140 hp) engine power – 150 cm trench depth and 12 tons weight, to 200 kW (270 hp) – 300 cm trench depth – 20 tons weight for lateral drain installation, and the very large machine with 300 kW (400 hp) – 350 cm trench depth – 60 cm trench width – 40 tons weight for large diameter collector drain installation. They are successfully used in the temperate climatic regions of Europe and North America, and in irrigation areas in semi-arid countries (Figures 3 and 4).

Trenchless drainage machines

A parallel development has been that of the trenchless drainage machine, also called drain plough. As the name implies no trench is excavated to lay the pipe, but a blade – something like a large ripper tine – is pulled through the ground to break and lift up the soil to make room for the pipe which is guided into position through a hollow part of the blade or through a pipe guide, trailed behind the blade. This method only became practical after the availibility of flexible corrugated drainpipe increased and the laser grade control was perfected. Several makes of drain ploughs are used in Europe, North-eastern USA and Canada, mostly for the smaller diameter pipes in lateral drains. The drain plough is manufactured either as an attachment to a standard heavy crawler tractor (e.g. Caterpillar D8 or Komatsu), or as an integral unit.

The shape of the vertical blade has been much improved. It is generally curved forward with a flat front to lift up the soil rather than push it aside, to create the space needed for the drain pipe and to reduce the force required to pull the blade through the soil. Because of the large amount of pull required for the trenchless system, the machines are heavily built and need a relatively dry topsoil for the crawler tracks to find enough grip to develop the high traction power needed.

The main advantage of the trenchless technique lies in its greater working speed

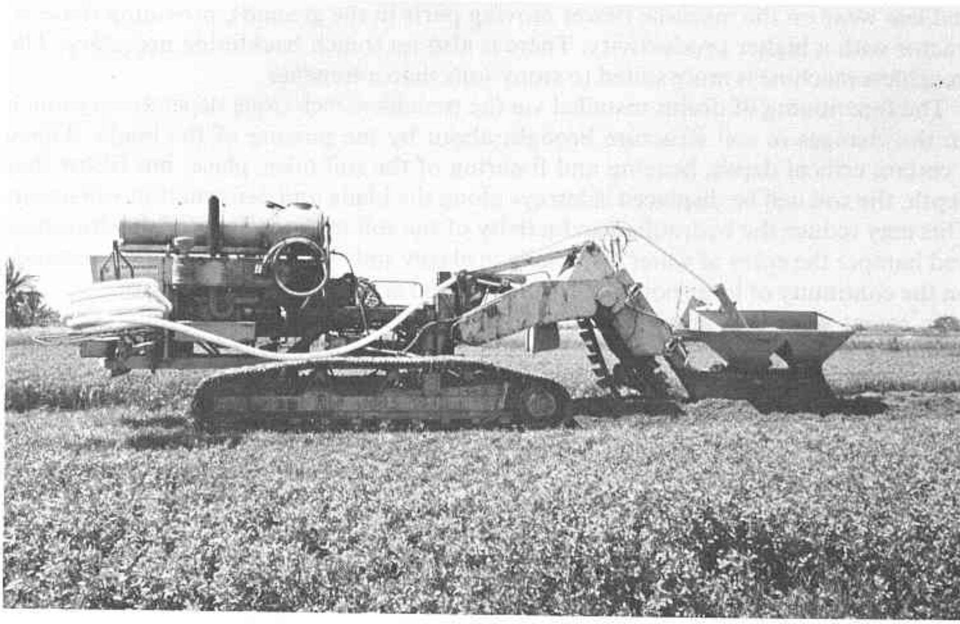

Figure 3 Trencher drainage machine, steep chain type, installing corrugated pvc pipe with gravel surround in Egypt. Note water tank for wetting chain and trench box sides to avoid sticking of clay.

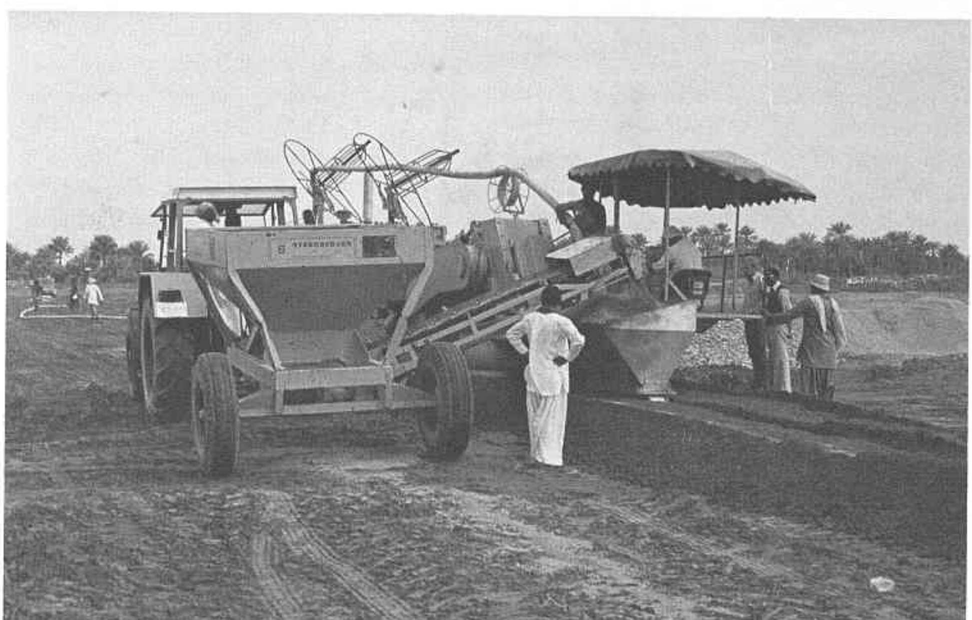

Figure 4 Self unloading gravel trailer for supplying into hopper of drainage machine, Pakistan

and less wear on the machine (fewer moving parts in the ground), providing the contractor with a higher productivity. There is also no trench backfilling necessary. The trenchless machine is more suited to stony soils than a trencher.

The functioning of drains installed via the trenchless technique depends very much on the changes in soil structure brought about by the passing of the blade. Above a certain critical depth, heaving and fissuring of the soil takes place, but below that depth, the soil will be displaced sideways along the blade and deformation will occur. This may reduce the hydraulic conductivity of the soil in the vicinity of the drainpipe and hamper the entry of water, especially in clayey soils where the water flow depends on the continuity of large pores like rootholes and cracks.

In recent years a drain plough with V-shaped blade, known as V-plough or delta-plough, has found increasing application in The Netherlands. A triangular soil wedge is cut loose and lifted up with the V-shaped blade. The corrugated pipe is guided into position at the lower tip of the V through one of the sides of the blade. Deterioration of soil structure around the pipe is largely avoided with this system, and there is very little disturbance of the land surface, which is especially an advantage for grassland. The working depth of the trenchless machine does not exceed 1.8 – 2 metres; larger models have around 225 kW (300 hp) engine power and weigh up to 35 tons (Figure 5).

Up to the present trenchless drainage machines have not found much application in the semi-arid irrigation areas, because of their limited depth range and because the method is not well suited to the application of a gravel filter around the drain pipe.

Figure 5 Trenchless drainage machine 'delta plough' installing prewrapped corrugated pvc pipe in The Netherlands. Maximum installation depth 1.8 m

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