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TWO EQUIPMENTS FOR INVESTIGATION
OF SOIL LEACHINGS

A PIT EQUIPMENT

BY

C. A. MOOERS

A HILLSIDE EQUIPMENT

BY

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KNOXVILLE, TENNESSEE

The Agricultural Experiment Station

OF THE UNIVERSITY OF TENNESSEE

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The Experiment Station building, containing the offices and laboratories, are located on the University campus, 15 minutes' walk from the Custom House in Knoxville. The experiment farm, the barns, stables, dairy building, etc., are located one mile west of the University on the Kingston Pike. The fruit farm is adjacent to the Industrial School and is easily reached by the Lonsdale car line. Farmers are cordially invited to visit the buildings and experimental grounds.

Bulletins of this Station will be sent, upon application, free of charge, to any farmer in the State.

A PIT EQUIPMENT FOR INVESTIGATION OF SOIL LEACHINGS

BY

C. A. MOOERS

A cement pit, surrounded by thirty-four drainage cans for soil investigation work at the Tennessee Experiment Station, was completed in the fall of 1911. This plant differs materially in design from any other with which the writer is acquainted, and may therefore be of interest to other investigators.

The plant is located on a terrace, which is of advantage in the disposal of the waste water. A general view of the exterior is shown in Plate 1, and of the interior in Plate 2. The inside dimensions of the pit are as follows:

Length.....	81.5 ft.
Width.....	5.3 "
Height.....	6.5 "

The walls are made of reinforced concrete, 9 inches thick at the base and 5 inches at the top. The roof, which is arched and of like construction to the walls, is 4 inches thick, and contains four windows, each 2 feet square. These, together with a 2-ft.-square glass in the door at one end of the pit, furnish ample light. The cement floor was constructed with a slight grade, so that a trough about 5 inches deep, which runs the length of the pit and empties into a tile from the outside, easily carries the water discarded from the containers.

Round openings about 4 inches in diameter were left in the walls for the block tin tubes. The large size of the openings facilitates the work of adjusting the cans to the proper level at the time of setting, and also of making any later change which may be necessary. After the cans were set these openings were closed with cement on the inside of the pit, and the pipes are held securely at the proper levels. Since block tin does not endure being sharply bent, provision was made for removing the water from the containers without disturbing the tubes. This was accomplished in the case of the eighteen containers for the shallow cans and the rain gauges by drawing off the water by means of large faucets, which were high enough from the floor to allow a low-wheeled carriage, holding the scales and a weighing can, to pass freely under. The eighteen deep cans had outlets so near the floor that it was necessary to move the containers in order to empty them. In this case each drainage tube passed lightly through a cork stopper, about $1\frac{1}{4}$ inch in diameter, set in a thimble, to a raised cover about 6 inches in diameter. This cover can be easily pushed up on the outlet tube, where it holds itself in place. The container can then be withdrawn without coming into contact with the tube, and the opening

for the cover serves as a discharge opening for the water.

In the two winters that have passed since the construction of the pit, the water in the containers has not frozen, although near-zero weather has occurred. In the summer, of course, the air in the pit is of appreciably lower temperature than that on the outside.

Sunk in the ground about the pit are thirty-four heavy galvanized iron cans and two rain gauges, one at each end of the pit. Each can and rain gauge is 1-5000 acre in surface area. The cans are of four different depths. One set of eight are 1 foot deep, and hold 9 inches of soil, another set of eight are 2 feet deep; a third set, of fourteen cans, are 4 feet deep; and a fourth set, of four cans, are 6 feet deep. Every can is provided with a block tin outlet, which passes through and is cemented in the pit wall, and empties into a receiver as outlined. The cans are made of No. 14 galvanized iron, and each has a strong iron band, $\frac{1}{4}$ in. x 1 in., at the top to give stability.

The containers for the drainage water are of galvanized iron, but are well paraffined on the inside. Each container holds nearly 200 pounds of water, and has proved of adequate size. Before the cans were filled, a strainer, consisting of a small wad of glass wool, was placed over the block tin outlet tube, and about one inch of clean river sand was placed in the bottom of each can to facilitate drainage.

Three distinct types of soil, each of prominent occurrence in the State, have been used in the experiments. One type fills four cans of each of the different depths; that is, four 1-ft., four 2-ft., four 4-ft., and four 6-ft. cans. Another type fills four 1-ft., four 2-ft., and six 4-ft. cans. The third type occupies only four 4-ft. cans. Each kind of soil was removed from the field in layers, and each layer, after being carefully mixed, was laid down in the same order in the can as it was removed from the field. The 6-ft. cans, for example, were filled as follows:

First 2 feet at the bottom with subsoil from 4- to 6-ft. depths; the next 2 feet with the 2- to 4-ft. layer as found in the field; the 1- to 2-ft. layer represents the subsoil between these two depths in the field; the 6- to 12-in. layer represents the subsoil between these depths; and finally there is the surface layer, or plowed part of the soil. The various layers were weighed out and tamped down in as uniform a manner as possible by hand. The whole plant is covered with a $\frac{1}{2}$ -inch-mesh wire cage, but is otherwise fully exposed to the weather.

Complete data are not at hand as to the cost of installation of the plant, because farm help was used in connection with the excavation—which in this case was not an important item—also in the setting and loading of the cans. The major items, however, are as follows:

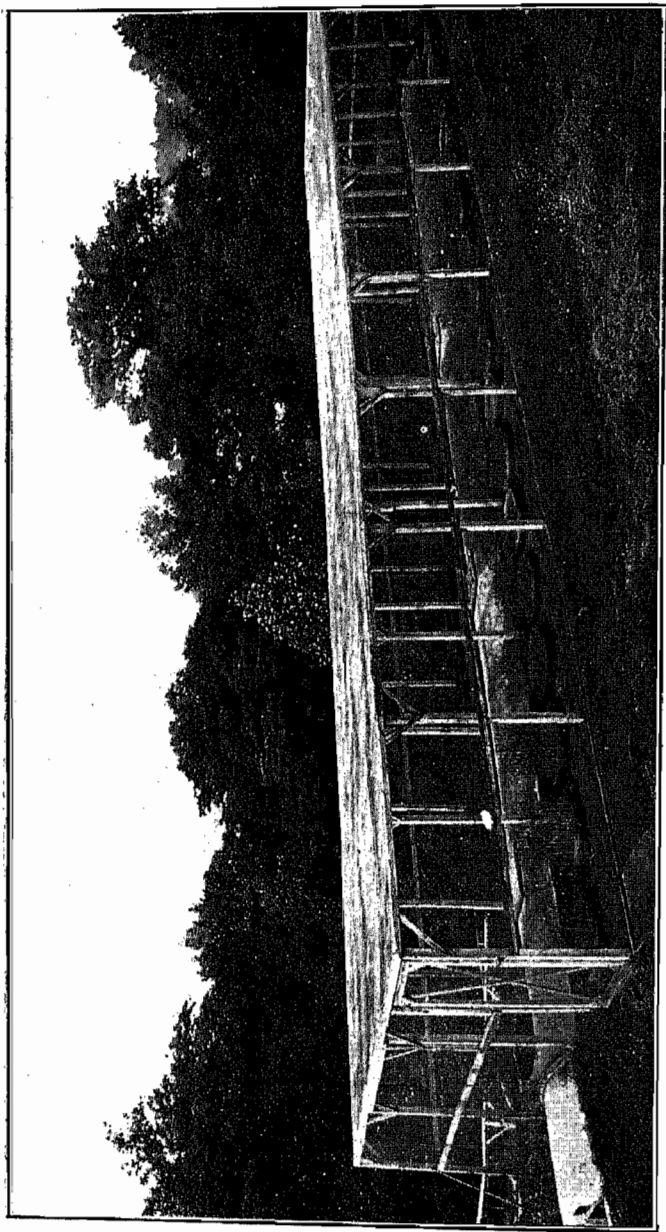


PLATE 1, GENERAL VIEW OF PIT SYSTEM

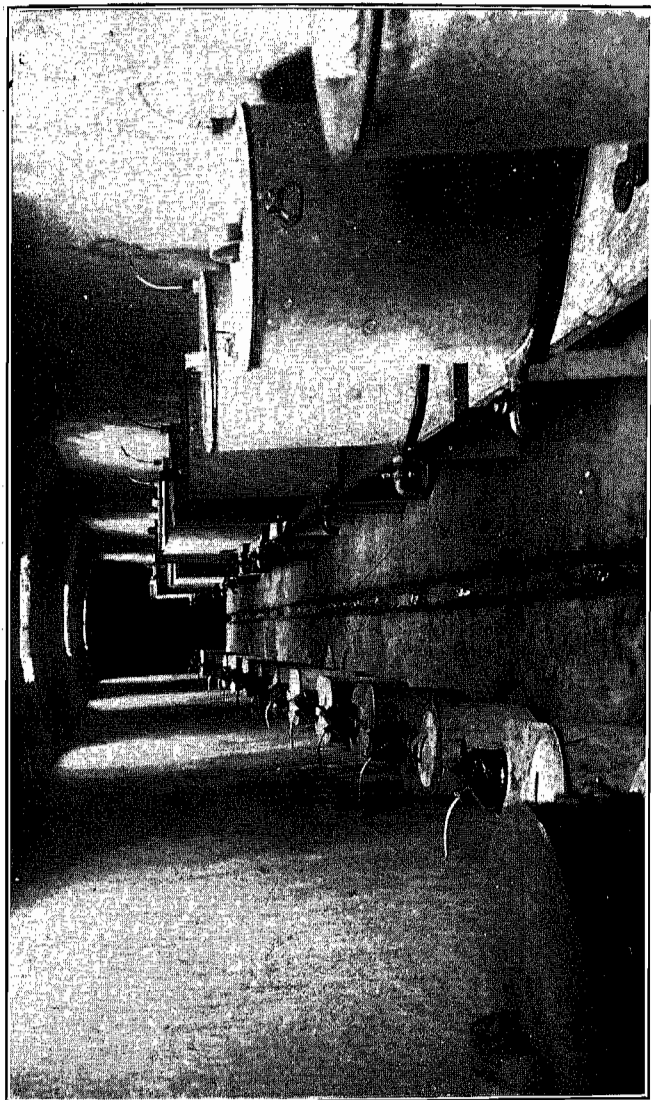


PLATE 2, INTERIOR VIEW OF PIT SHOWING TWO FORMS OF CONTAINERS USED

Construction of pit	\$ 453.00
34 Drainage cans	500.00
2 Rain gauges	25.00
36 Containers for drainage water	120.00
Labor of plumbers	10.00
4700 sq. ft. ½-in.-mesh wire cloth	131.00
Other materials, and labor in construction of cage.....	75.00
Block tin tubing	13.50
Benches for containers	15.00
	\$1342.50

The cans being of different depths permits data being obtained in regard to the amount of water which passes through the soil at each depth, and it is proposed to carry out the experiments under both cropped and uncropped conditions. Also data will be obtained on the yield of the crops as influenced by the different depths of subsoil. One of the main objects, however, is to determine the amount and form of nitrogen which is leached out under the various conditions, such as depth of soil, kind of soil and manurial treatment. The present plan includes the growing of non-legumes, two crops each year, for the first two years (which has now been done), to let the cans remain uncropped for the next two years, and then to grow legumes for two years. All of the crops are analyzed for nitrogen. Composite samples of the drainage water from each can are saved for mineral analysis at the end of each year. The soils were of course carefully analyzed at the outset, and analyses are made of the manure used. The manurial treatments per set of four cans are as follows:

1. Lime
2. Manure
3. Lime and manure
4. No treatment

A HILLSIDE EQUIPMENT FOR INVESTIGATION OF SOIL LEACHINGS

BY

W. H. MACINTIRE

CONCRETE STRUCTURE

The terraced hillside drainage plant for soil investigations shown in Plates 3 and 4 was constructed in July, 1914. The system differs somewhat from the pit type; the embedded soil tanks extend in a straight line and one side of the subway for collecting drainage is open. The structure is based upon a 6-ft. perpendicular concrete wall built against the side of a terrace. The top of the terrace, in which the soil tanks are sunk, is flush with the top of the retaining wall, and is about 6 feet wide. The wall is 100 feet long, not including the portion serving as a brace to the steps which lead from the top of the terrace to its base, where the drainage is collected. At its base the wall is 9 inches thick, grading to 6 inches at the top. During the building of the wall, 3-inch tin pipe was placed in the concrete, at right angles to the face of the wall, in order to furnish openings to permit the passage of block tin tubing from the tanks sunk in the ground above to the drainage reservoirs located in the subway. At the base of the wall and parallel with it, a floor 6 inches thick and 6 feet wide was laid. This floor contains a trough in the center, and a gentle slope was given from the steps at the upper end to the lower end, in order that the waste water might be drained and discharged through an opening in the retaining wall at the lower end. The floor is covered by a roof, extending from the top of the wall to a supporting row of 4 x 4 posts parallel to the long wall and set along the outside edge of the floor. The frame of the roof was constructed of 2 x 4 lumber and anchored to the row of 4 x 4 posts supporting the frame for the wire enclosure for the space where the tanks were sunk. The roof was made of No. 2 common tongue-and-grooved flooring and covered with "ruberoid" roofing. The steps leading from the top of the terrace to the floor serve as a retaining wall and as protection from weather at the upper end of the plant, while a 6-inch retaining wall, 6 feet in length and 6 feet high, and at right angles to the long wall, serves the same purpose at the lower end. The walls were built with a mixture of 1 of cement, 2½ of sand, and 5 of pea-sized gravel. The lower 4 inches of the floor were made of the same mixture, while the upper 2 inches were finished with proportions of 1, 1½ and 2. A "brush finish" was given the entire exposed surface of the concrete walls.

CONTAINERS FOR TREATED SOILS

The tanks used for containing the treated soils were made of

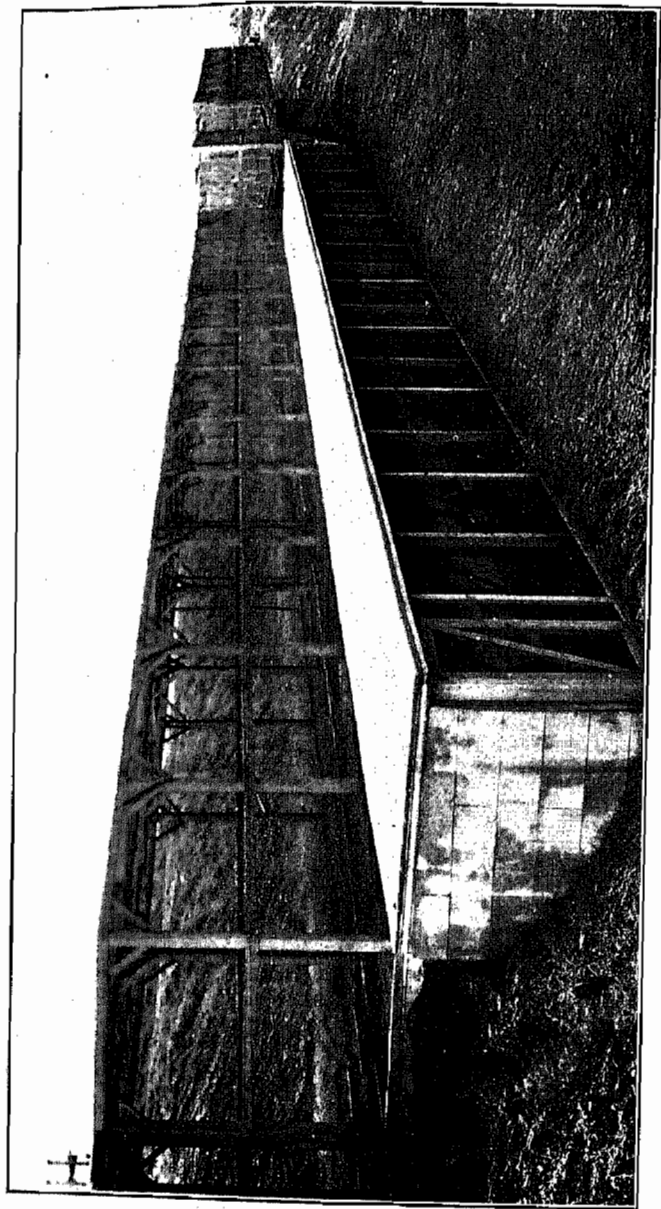


PLATE 3, GENERAL VIEW OF HILLSIDE SYSTEM

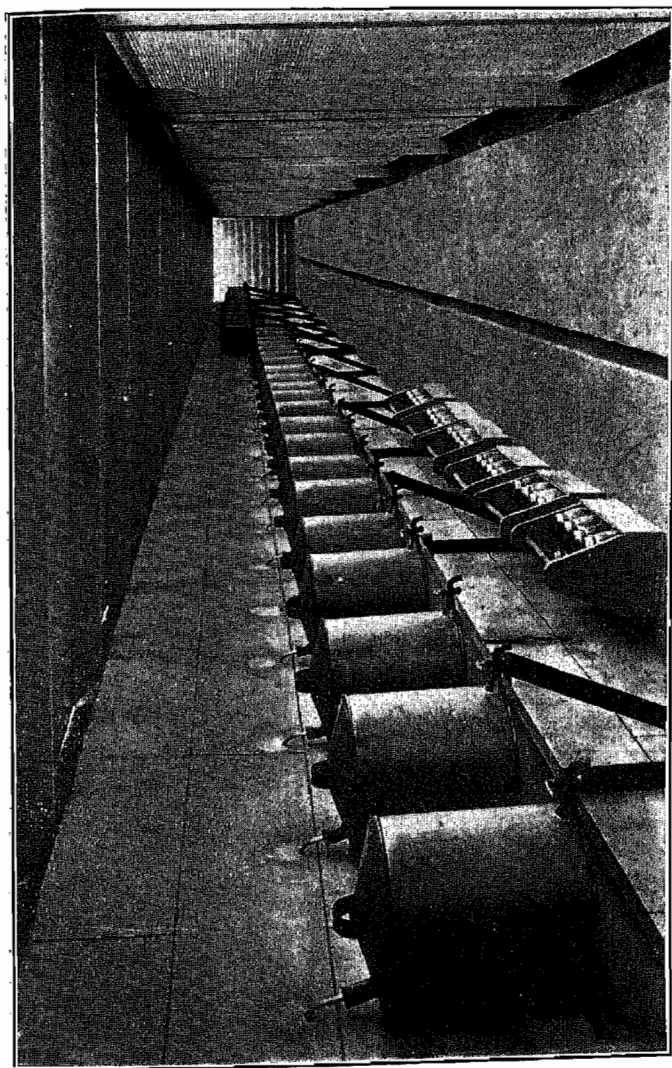


PLATE 4, INTERIOR VIEW OF HILLSIDE SYSTEM

14-gage galvanized ingot iron, strengthened at the top by means of a 3-16 x 3-4 in. wrought-iron band. Each container embraces an area of 1-20,000 of an acre. The outer circumferences of the tanks were placed 5 inches from the inner face of the wall. The outlets for delivery of the drainage were secured by the drilling of holes in the tanks just at the union of side and bottom, and the insertion and flanging of a $\frac{1}{2}$ -inch block tin tube, which was then soldered before the tanks were placed. The tanks were painted inside and out with black asphaltum paint.

The system contains two sets of tanks; the first set of twenty-one being 12 inches in depth, and the second set of twenty-three being 24 inches in depth. The tanks of the first and second sets are embedded 8 and 20 inches, respectively, in the ground. One inch of a 2-mm-sieved river-bottom sand was placed in each tank before the treated soil was introduced. The sand was prevented from washing into the drainage tubes by pads of glass wool. The whole plant is protected from interference by a $\frac{1}{4}$ -inch-mesh wire cloth enclosure.

CONTAINERS FOR COLLECTING LEACHINGS

The ends of the block tin drainage delivery tubes are beveled and pass through corks, which fit into raised necks in the convex tight-fitting lids of the cans used to catch leachings. The cans were made of 20-gage galvanized iron, and are of $7\frac{1}{2}$ gallons capacity. They are painted inside and out with black asphaltum paint, except the brass spigot for drawing off the water. The insides of the cans were further treated by the application of a thin coat of hot paraffin. The cans receiving the drainage waters rest upon 14-inch board shelves, which are supported by wooden braces, extending to the floor. The shelves are attached to iron shelf brackets, by means of which the shelving is anchored to wooden strips sunk at 8-foot intervals in the perpendicular concrete wall. The drainage waters run into containers on the platform of scales resting upon a carriage, and are weighed. Two-quart jars are used to convey portions of the water to the laboratory for analysis.

SOIL TREATMENTS

The twenty-one tanks of the first set contain only surface soil, which rests directly on the sand filter bed. In the first twenty-one tanks of the second set of twenty-three the surface-soil treatments constitute a duplication of the treatments of the first set; but in the second set 1 foot of clay subsoil was placed upon the sand filter before addition of the treated surface-soil. Several days were allowed for the tanks to settle after the treated soil was added and before the block tin tubes were sealed in the openings of the concrete wall.

One hundred pounds of moisture-free surface loam soil, representing a depth of approximately 8 inches, was used for each tank. The soil used for treatments was thoroughly screened through a $\frac{1}{4}$ -inch sieve, carefully mixed, and closely covered during the overnight period required for the making of moisture determinations, and during the

mixing of soil and materials. The soil and treatment of each tank were thoroughly mixed in metal-lined boxes before being placed.

The plan of the experiment calls for a study of the activities of various forms of lime and magnesia. The scheme involves a study of the activities between the soil and the various materials applied, and the analyses of drainage waters are to be supplemented by periodic chemical examination of the residual materials. The plans of the project call for exclusion of all plant growth from the soils. Future analytical work may, however, make it appear advisable to introduce this factor.

COST OF THE SYSTEM

The installation cost of the system is given in detail in the following estimate. All costs are included except salaries of scientific men assisting in installing the system and making the various treatments before placing the soil:

Concrete walls, steps and floor	\$252.47
Lumber for enclosures and roof	49.75
Gravel, plus freight and hauling of same	30.00
Grading	30.00
Wire cloth for screening	86.72
44 soil tanks and 44 cans for leachings.....	289.55
Roofing material	18.00
Carpenter work	20.00
Block tin tubing	7.50
Painting	16.00
Labor in placing cans and obtaining soil	12.00
Hardware incidentals	3.50
	\$815.49

FEATURES OF THE HILLSIDE SYSTEM

The terrace drainage system shown is so arranged that no direct sunshine can reach the containers for the accumulating drainage waters. The cans used to collect drainage rest upon shelves and are close to the wall, where a fairly low temperature is maintained. The subway, though open on one side, is amply protected from inclement weather because of its location against the terrace, and the soil tanks are exposed to natural weather conditions in the same manner as in the pit system. We do not anticipate any weather conditions which will make the operation of the plant to any extent infeasible. In colder climates the cans might be protected by felt jackets.

The system lends itself to educational purposes, since the entire plant can be plainly seen by spectators without their entering the enclosures.

Because of the many mechanical difficulties to be met and overcome in the installation of such a system, the plant is described in detail and illustrated, with the hope that some benefit may be derived from our experience by investigators anticipating the inauguration of such methods of soil study.