

of business and common honesty, but in general there is no such thing as an ownership of mechanical combinations, or at best only a limited ownership for the term of a patent.

After having produced a rough sketch that looks meritorious, it is advisable to make a sketch showing the principal parts to scale within the limits of free-hand sketching. Here is where the underlay and the thin bond paper come in handy. A small pine board and a celluloid angle with a few thumb-tacks are all the drawing instruments needed, and with the underlay sheets and these accessories quite presentable sketches may be made. Pin the bond paper down to the board with the underlay under it and draw in the principal parts with a soft pencil without bothering about one part cutting off the view of another. That is, lay in every piece as if it were the only piece on the sheet and do not bother about dotting or omitting lines

that would not appear on a true view of the mechanism.

Before going very far, the designer will begin to wonder what is going to happen when some of the parts assume another position than that in which he is drawing them. The best way to find out is to take a scrap of tracing paper or linen and make the part on this separate piece. This scrap can then be slid around and its action noted. It may be desirable to preserve a record of such positions and a separate sheet of bond paper may be started to show the relation of the mechanism at various points, a separate sheet being generally used to show each position. No attempt should be made to show fastenings.

After a lot of juggling the design begins to breathe or it doesn't. If it doesn't it is generally best to make a fresh start, preserving the papers and the scraps pending the failure or success of this start. After several trials a layout will be evolved that seems to be satis-

factory. It is now in order to make the final sketches from the several sheets and scraps that have accumulated. Take a sheet of tracing linen and a soft pencil and trace in free-hand from the scraps the various parts with due regard for their position, dotting important hidden lines and omitting unimportant ones. This final sketch is made only partly for the information of the draftsman. Its chief value is to show whether the work will stand the test of an assembly sketch. Very often it will not and the designer will have to make a fresh start or modify his sketch to avoid the difficulty.

When the designer is through he should have some pencil sketches on letter size tracing linen that fully express the work that he has done. Very often he will do in a few hours what would take as many days to accomplish working cut-and-try with a draftsman, and the chances are that he will have applied himself so that the quality of the work is much better.

Soil Sterilization*

Wanted—Cheap Antiseptics for Use in Horticulture and Agriculture

By E. J. Russell, D.Sc., Director of Rothamsted Experiment Station, England

RECENT investigations made at the Rothamsted Experimental Station have shown that antiseptic substances may, under proper conditions, considerably increase the productiveness of soils, and there seems to be a prospect that large amounts could be usefully employed in horticulture, and if the price fell low enough, in certain branches of agriculture also.

The function of the antiseptic is to simplify somewhat the micro-organic population of the soil. A soil kept in a glass-house during a whole season, well watered, manured, and at a temperature distinctly

is not as convenient in practice as the addition of more complex compounds which undergo bacterial decomposition in the soil.

Fortunately the food-making organisms are on the whole less easily killed than the harmful varieties, and a certain degree of soil purification can therefore be effected by treatment with antiseptics or by heating to a temperature somewhat below 100 deg. Cent. Such treatment is commonly followed by an increased amount of plant growth and a healthier plant growth; bacteriological investigations show also that the numbers of bacteria have increased, and chemical analysis shows a marked increase in the rate of production of ammonia in the soil.

It is not our present purpose to discuss the scientific problems involved but to direct attention to the cultural experiments. "Sick" soils from several large nurseries were treated with various antiseptics or by heat and then sown with crops; the untreated soils gave poor, diseased crops, while the treated soils gave larger and healthier crops. Large scale experiments have shown that the treatment is perfectly feasible for the practical man, but they have brought out several difficulties which, however, ought not to be beyond the power of the chemist to overcome.

When a "sick" soil is heated by steam to 98 degrees it entirely regains its original productiveness, in fact, it commonly does more because of the decomposition that has taken place. Treatment with antiseptics has so far not proved so effective. In testing the effect of various antiseptics we therefore have a definite and hitherto unattained standard to aim at. The general conclusion of our work up to the present time is to place the antiseptics in the following order of effectiveness:

Class I. (The best antiseptic although not as good as steam).—Formaldehyde, pyridene, collidene and lutidene (i. e., the fraction containing the higher bases).

Class II. (Less effective).—Benzene, calcium sulphide, carbolic acid, cresylic acid, "light solvent naphtha," heavy solvent naphtha (i. e., homologues of benzene), gasoline, toluene.

Class III. (Least effective).—Naphthalene, and certain derivatives obtained during its isolation.

As nearly as possible this is the absolute effectiveness, all subsidiary questions such as difficulty of application or distribution in the soil being obviated. The order in the various classes is, alphabetical only, the experiments hardly being numerous enough to justify closer differentiation.

The antiseptics in the first class proved very useful. They killed the disease organisms, the eelworms (*Heterodera*), the damping-off fungus (*Pythium*), etc., and they conditioned a satisfactory increase of bacterial numbers and of plant food.

The antiseptics in the second class were not so good in either direction and consequently gave less increase in crop.

There is no short and easy way of ascertaining the absolute effectiveness of an antiseptic. Our experiments have invariably consisted in five series. Part of the soil is treated with 0.1 per cent of antiseptic, part is heated for an hour to 95 to 100 deg. Cent., while the remainder is left untreated, and then:

(1) Chemical analyses are made at periodical intervals extending over a month, to ascertain the rate at which ammonia and nitrates accumulate in the treated and untreated soils.

(2) At the same time bacteriological counts are made by the gelatine plate method to ascertain the rate of development of bacteria.

(3) Some of each lot of soil is inoculated into test

tubes containing sterilized hay infusion, and after six days' incubation drops of the infusion are examined under the low power of the microscope for protozoa. If these organisms are killed by the treatment, it commonly happens that other harmful organisms are killed also.

(4) Seeds are sown in the soils and the young plants are carefully watched to observe the development of "damping-off," root knots, or other diseases.

(5) Plants are grown right through to fruiting, and the produce weighed.

The results of all the series are usually concordant,

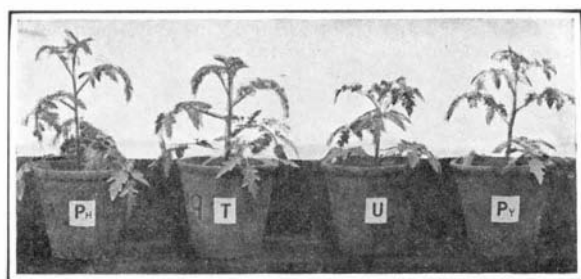


Fig. 1.—Tomato Plants Growing in Soils Treated With Small Quantities of Antiseptics.

U = Untreated soil. T = Soil treated with toluene. Ph = Soil treated with phenol. Py = Soil treated with pyridene. The soils were initially all alike; the plants were sown on the same day, and all treated alike. The antiseptics caused very considerable crop increase.

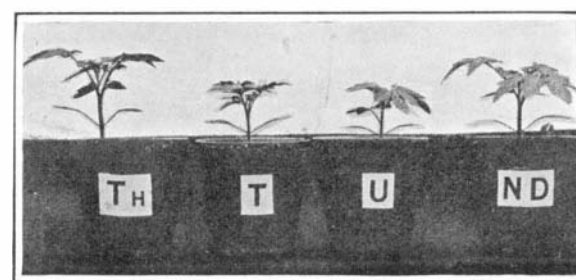


Fig. 2.—Effect of Small Quantities of Antiseptics on the Soil.

U = Untreated soil. T = Soil treated with toluene, the effect being much less than in Fig. 1. Th = Soil treated with thiophen, the effect being very marked. ND = Soil treated with a residue obtained during the purification of naphthalene.

but it is not safe to dispense with any of the five, and we should view with suspicion any results so obtained. For preliminary sorting out (1), (2) and (3) give useful results in a short time and without requiring any special apparatus. But for final examination of an antiseptic all five are needed. It is essential to the proper carrying out of the experiments that the treated and untreated soils should be stored under similar conditions of moisture, temperature and reaction, and this can most conveniently be accomplished by allowing the excess of antiseptic to evaporate as far as it will, then making up the soils to uniform moistness, and finally putting up 800 gramme lots in clean liter bottles and plugging with sterilized cotton wool.

The absolute effectiveness of an antiseptic having been ascertained in comparison with one or two of the substances in the list just given, the next step is to determine the ease of distribution in the soil. Like other colloids, soil has the remarkable power of withdrawing many dissolved substances from their solutions. It is therefore unsafe to argue that an antiseptic can be mixed with the soil simply because some gallons of its solution are easily watered on to the surface. Some of the antiseptics in the second class (e. g., carbolic and cresylic acids) are fairly readily abstracted in this manner, so that if a solution is poured on to a layer of soil 3 inches in thickness (e. g., contained in a Buchner funnel), the percolating water may be practically free from the antiseptic and the bottom layer of soil remains unaffected. From this disadvantage the vapors (formaldehyde, carbon, disulphide, etc.) are free, but if they happen to be only sparingly soluble in water, they do not readily penetrate. Calcium sulphide also does not appear to suffer in this way. All substances are not equally affected, and some soluble materials will pass fairly readily into the soil. It is not necessary that the material should be wholly unabsorbed; the soil is mixed up to a considerable extent by the cultivation processes and a certain amount of distribution is thereby effected. But it is undesirable

above that normally obtaining outside, soon becomes inhabited by a great and various crowd of organisms. Especially is this true of commercial houses run at a high pitch to obtain maximum crops and subject to invasion by organisms from remote quarters of the globe. Growers of cucumbers, for example, who are perhaps the most intense cultivators in the country, buy quantities of stable manure and other refuse from London to fertilize their borders. This often contains all kinds of imported material, banana skins, orange peel and the innumerable trifles rejected by the city, many of which are capable of carrying spores from their country of origin. Once any of these undesirable aliens get introduced it spreads rapidly, for the conditions of the industry rather favor a transfer of pests from one house to another.

In consequence, the soil used for cucumber growing is thrown away at the end of the year and its valuable manurial residues sacrificed. A new lot is brought in, often at considerable expense, which is justified only by the consideration that the new soil is free from many of the disease organisms. In the picturesque language of the practical man the old soil is "sick" and is therefore rejected.

A second factor in soil sickness lies in the lowered efficiency of the micro-organisms in producing ammonia and nitrates. This has been traced to the abnormal development, under the circumstances of glass-house cultivation, of groups of organisms detrimental to the ammonia-producing bacteria.

The horticulturalist cannot afford to deal with a wholly sterilized soil free from all micro-organisms. The manures that he uses are not, as a rule, plant foods, but have to undergo decomposition and hydrolysis before they are reduced to compounds sufficiently simple to be taken up by plants. Of course he could grow his plants with the aid of sodium nitrate or ammonium sulphate alone, but this course, although possible,

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that absorption should be too complete, or the distribution becomes too local for the best results to be obtained.

A further important point is that the antiseptic must disappear from the soil after its work is done. This may come about in several ways. The low boiling substances simply evaporate. Calcium sulphide and bleaching powder decompose, leaving among their residual products a certain amount of valuable calcium carbonate. Carbolic acid, cresylic acid, and apparently other allied compounds are slowly oxidized by bacteria, a wholly remarkable change which deserves fuller investigation. Pyridene also is decomposed. Only an actual experiment avails to determine whether

the antiseptic persists in the soil long enough to injure the young plant.

As only cheap substances are likely to be used, it is clear that some waste product is indicated. There must be many such products available. Solids would no doubt be most convenient, but liquids that are soluble or miscible with water, or could be made so by suitable admixtures, would also serve the purpose. Nitrogen compounds would possess an added advantage that they may decompose to yield plant food. Experiments indicate, however, that some degree of standardization is necessary and that the effect of the separate constituents of the mixture should be known. Thus, it was found that samples of commercial toluene, which

appeared to be fairly similar, differed pretty considerably in action. Later work showed that thiophen was a very potent agent, and left no doubt that variations in the amount of this impurity had caused the discrepancies observed. And further, the grower would probably not hesitate to put in a claim for compensation if any product supplied to him had done actual damage.

These are the difficulties the works chemist would be called on to deal with; that they are not insuperable is shown by the action of several enterprising firms in putting out soil antiseptics. There seems little doubt that, given suitable antiseptics, the chemical treatment of soils is likely to develop considerably.

A Chinese Railway Bridge

Spanning the World's Most Treacherous River

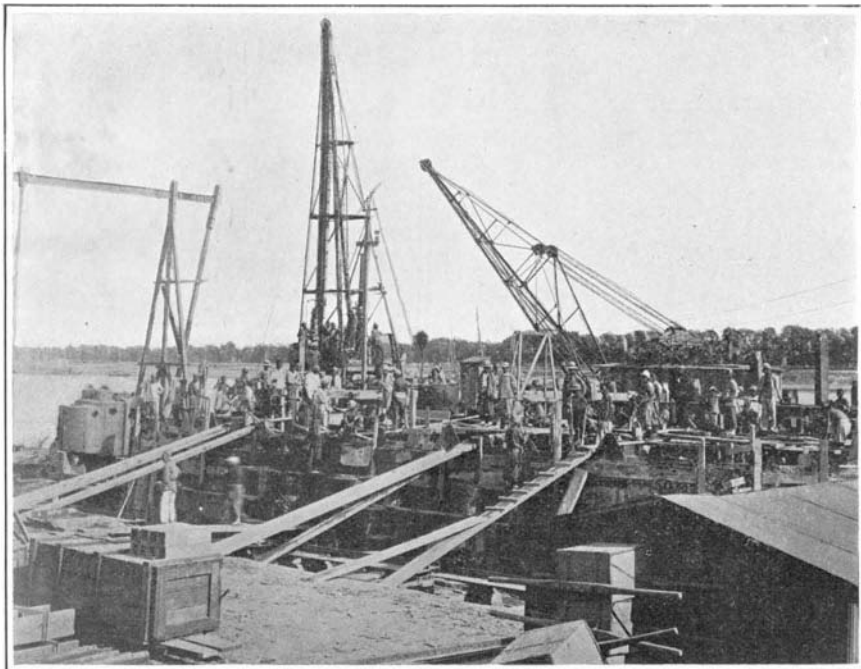
By F. C. Coleman

The northern (German) section of the Tientsin-Pukon railway has recently opened to traffic a new bridge over the Hwang Ho. This river, which is one of the principal waterways of China, originally flowed eastward to the coast 650 miles distant, but in 1851-3 this wayward and turbulent stream, which is said to have shifted its course nine times in 2,500 years, turned off north-eastward near Kaifung-foo. Since then it has discharged its waters

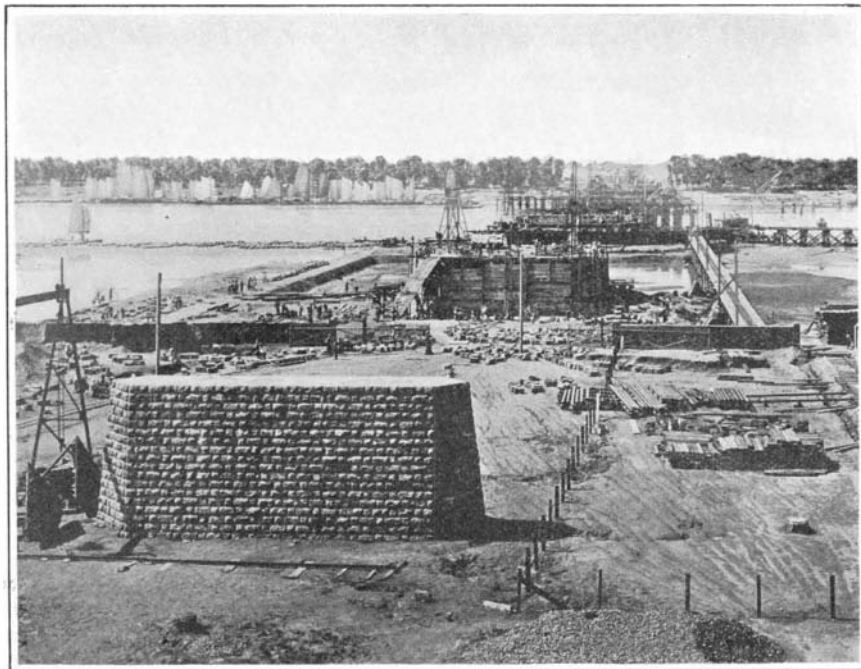
forced concrete piles. The number of these is such that even in the event of scour as far as the foundation base, the piles themselves will be able to safely bear the bridge, even under heavy traffic. At the abutments and the piers to approach spans, where the water covers them only at high tide, and then only with a low velocity, the reinforced concrete piles have a length of 50 feet. The bottom of the foundations lies 20 to 24 feet below the river

almost ready, she rose to the highest water mark recorded during the whole of the time of building and, later, just when the first work of the piers began, there was a powerful flow of ice, the river finally becoming frozen over so that passengers and carts traveled over the ice.

For the erection of the sub-structure extensive use was made of rammed concrete, especially for the foundation and masonry work, the exposed surface of the latter



The Pile Driver at Work.



View Looking Along the Line of Piers.

into the Gulf of Pechili, 321 miles north-northwest of its former mouth, the mountainous province of Shantung lying between the two. In some parts of its eastward course the river bed of the Hwang Ho is above the great plain through which it passes, and the embankments have been a source of never-ending expense and their yielding to floods a frequent cause of desolation to extensive districts. In its course through Tibet, Mongolia and China, the Hwang Ho touches lands, in the provinces of Shan-hsi and Shen-hsi, which consist of loess, and the vast quantity of sediment conveyed to the sea by this river gives to it and to the sea in which it empties itself its yellow color and hence its name, "Yellow River." The site of the new bridge is about 660 feet from its mouth and here the Hwang Ho measures at low water 1,320 feet, while at high water the distance between the south and north high-water dams is 7,260 feet. The land liable to inundation on the north bank is 6 to 9 feet higher than low-water level, while there is a difference of 9 to 15 feet between low and high-water levels. On the south side the high-water dam is approximately at low water level. At low water the river deposits considerable quantities of sand in its bed, which, at rising tide, when the current increases in speed, disappears again in a few hours. The speed of the current at the site of the bridge is 13 to 16 feet per second, or nearly 9 miles an hour, and it is clear that obstructions in the river way—and as such piles would be regarded—would cause scour. In the construction of the bridge the foundations were taken to such a depth that scour must be considered as impossible. In order to secure to a greater extent the deposited strata of the Hwang Ho and also the piles and to prevent the ravages of the flowing water, the piers which lie between rammed piles, were surrounded by stone pitching.

With the exception of the pier which stands in the middle of the stream, the whole bridge is carried by rein-

bed, and the piles were driven 42 feet below the foundations.

The work was carried out by excavation and the use of sheet piling. The river piles are exposed to a much stronger and more frequent attack from the current, and according to observations made during the building and the experience gained the bottom foundation was taken 56 feet below low water. Under the bottom of the foundations the reinforced concrete piles (56 feet in length) were here rammed down 26 to 33 feet. The piles were sunk by means of caissons strongly braced and ballasted with concrete. These were then taken 43 feet below low water, and, being 46 feet high, still projected above water. On the upper end of the caisson a pile driver, the ram of which weighed $4\frac{1}{2}$ tons, was erected. The pile driving proved to be a particularly slow and troublesome work because not only did the loess prove to be very hard, but the ground became compressed by the driving in of the piles and these advanced only by millimeters under the blow of the ram. After the stake driving, the ground between the stakes was taken out and the caisson sunk 4 feet deeper. In this way three river piers were built. For the fourth, which stands in the middle of the stream, for various reasons which asserted themselves during the building, another method had to be employed. The piles were entirely left out in this case and the pier was taken down 82 feet below low water so that at that place with a depth of water of $16\frac{1}{2}$ feet it stands 66 feet in the river bed.

The sinking work of this pier as well as of the three others was undertaken by means of compressed air. For the piers in the middle of the river the pressure upward rose to two and one half atmospheres and made short working periods necessary. During the building of the pier in the middle of the river, the Hwang Ho showed herself in her most dangerous mood, as, when the scaffolding for the staying and sinking of the caisson was

being covered with limestone and the piers faced with stone. The bearings are carried upon granite blocks. Between abutments, the bridge has a length of 4,120 feet. This comprises the river bridge, which is divided into two side openings of about 420 feet span, and a middle opening of 540 feet span; and the nine flood approach bridges, each with 300 feet span. One of the latter lies on the south, and eight on the north bank. The approach spans are simple parallel girders, while the middle span is a cantilever with a suspended span of 360 feet. The top chord of the middle span is carried high above the middle piers, which lends a pleasing appearance to the bridge. The permanent way on the main span is level, the rail upper edge being 44 feet above low water. The approach spans connecting on both sides of the cantilever opening have a fall toward the abutments of 1 in 150. Some unusual difficulties presented themselves in the design. The railway authorities required a single-track bridge which could at any time be converted at a minimum cost into a double-track bridge. This consideration was met as follows: The distance between the main girders was so chosen beforehand (31 feet) that two of the cantilever arms as well as the approach spans of the river bridge were effected by means of falsework, and the middle opening on the north was completed by the cantilever arrangement. This method was found necessary because the building in of the falsework in the main stream would have produced a contraction of area which would have been dangerous to the falsework itself. This work ranks as one of the most important bridge contracts ever carried out in the Far East, and the bridge is one of the longest in any part of China. After having been under construction a little over three years the bridge was formally opened to traffic in December last.

The total amount of the steel work was 8,700 tons, of which 3,700 tons were used in the main span and 5,000 tons in the flood bridges.