

Report on Reclamation and Drainage  
of Alkali Lands in Hungary.

By

G. G. Hawes



Government of Bombay  
Public Works Department

Technical Paper No. 48

Report on Reclamation and Drainage  
of Alkali Lands in Hungary

BY

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FIRST EDITION

[Price—Annas 7 or 9d.]

BOMBAY

PRINTED AT THE GOVERNMENT CENTRAL PRESS

1933

Obtainable from the Superintendent, Government Printing and Stationery,  
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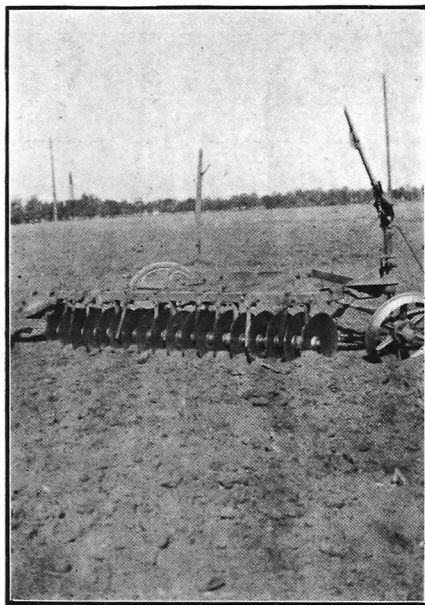
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DISC CULTIVATING MACHINE USED FOR  
HEAVY CLAY SZIK SOILS

## SECTION I—ALKALI LANDS.

### GENERAL.

#### REASONS WHICH HAVE LED UP TO THE VISIT DESCRIBED IN THIS REPORT.

1. The Lloyd Barrage and Canals project in Sind, which is now under construction (and which will commence irrigation in May 1932) has many large areas in which the subsoil water level is high and where alkali lands exist. In 1930 it was decided to form a Research Division in Sind. This division is to carry out investigations into subsurface conditions in the area referred to and to deal generally with problems on the borderline between Irrigation and Agriculture—such problems as possible waterlogging, land reclamation, the prevention of alkali formation, and the collection, compilation and investigation of data in regard to all factors affecting the subsoil water in the area to be irrigated by the Barrage Canal systems. The writer was informed that he would be placed in charge of this division and obtained permission to undertake eight months' study at the Rothamsted Experimental Station in order to learn something about soils in general and about alkali soils in particular. A period of some eight months has been spent at the Rothamsted Experimental Station and the visit described in this report has been undertaken to round off the course of study.

In Europe, alkali soils exist over very large areas in Hungary, and in Russia, but, for many reasons, it was decided to visit those in Hungary. Investigation into, and reclamation of, alkali lands has been going on for many years in Hungary and certain classes of these alkali lands appeared to be very similar to the salt lands in Sind. It seemed certain, therefore, that much valuable information and data could be obtained regarding methods of investigation and reclamation from a visit to the laboratories and reclamation works in Hungary. As some of the reclamation is by drainage it appeared that useful hydraulic data regarding the design of channels, costs, etc., might also be available. Dr. Alexius A. J. de 'Sigmund, Professor of Agricultural Chemistry in the Royal Hungarian University of Technical Science at Budapest, has actively investigated the alkali soils of Hungary for some forty years and has written a most valuable paper entitled "Hungarian Alkali Soils and Methods of their Reclamation", in which he has described the various soils, their chemical and physical properties and methods of reclamation in great detail. This paper was written in 1923 and has supplied much of the information contained in this report—being supplemented and brought up to date, where possible and necessary, by later data obtained during the visit.

#### BRIEF DESCRIPTION OF THE MAIN TYPES OF ALKALI SOILS IN HUNGARY.

2. Dr. de 'Sigmund has divided the alkali soils of Hungary into two main classes:—

- (a) Heavy Clay Szik Soils, and
- (b) Saline Soda Soils.

This classification of soils is based upon (1) Soil Profiles, (2) Mechanical Composition, (3) Physical Properties, and (4) Chemical Constitution. The characteristics of the two groups are, very briefly, as follows:—

##### (a) Heavy Clay Szik Soils—

(1) *Soil Profile*.—The surface layer varies in colour from black to mouse-gray—the colour depending on the humus content. Next is a tarlike sticky layer, black or brown in colour. This layer is greasy to the touch and, when fresh, cuts easily. Next is a sandy or clay-like marl containing lime concretions and sometimes merging into a sandy silt permeable layer, which may be very thin or entirely absent. Below is the *typical subsoil* of this group, consisting of a thick layer of yellow, or gray, clay containing few or no concretions of lime. This layer is impermeable.



(2) *Mechanical Composition*—

*Note.*—Classification adopted in this report is as follows :—

Rock, stones, etc.	..	..	>20 mm. dia.
Gravel	..	..	20 mm. to 2 mm. dia.
Coarse sand	..	..	2 mm. to 0·2 mm. dia.
Fine sand	..	..	0·2 mm. to 0·02 mm.
Silt	..	..	0·02 mm. to 0·002 mm.
Clay	..	..	<0·002 mm. dia.

The sand fraction varies from 30 to 50 per cent. and the largest sand particles are 0·5 mm. in dia. There are no stones or gravel.

The silt fraction varies from 25 to 50 per cent.

The clay fraction varies from 10 to 40 per cent.

Typical analyses are given below :—

*Heavy Clay Szik Soils.*

	1. Szik Soils.		2. Szik Steppes.	
	(a) Dusty szik of Pusztadecs.	(b) Cracked szik of Csabacsud.	(a) Without Na <sub>2</sub> CO <sub>3</sub> of Osi.	(b) With some Na <sub>2</sub> CO <sub>3</sub> Bekescsaba.
Coarse sand .. ..	40·74	31·36	1·31	0·43
Fine sand .. ..			27·57	40·57
Fine dust .. ..			10·06	6·07
Silt .. ..	47·80	28·31	41·99	26·03
Clay .. ..	11·46	40·33	19·07	26·90

(3) *Physical Properties.*—Owing to their compact nature these soils crack on drying, the capillaries are very fine and permeability is, consequently, very low. Soils with a high colloid content or with 0·2 to 0·3 per cent. of sodium carbonate tend to swell on wetting and so become absolutely impermeable. When dry the surface becomes stone-hard and cracks while the soil below the crust remains wet. The crusts are of two types : (1) a glittering gray-white crust consisting of fine micaceous sand and silt—this crust forms on surfaces from which water can drain off, and (2) a brown or black leafy crust composed of silt and clay coloured by humus. This crust forms after the evaporation of stagnant water.

(4) *Chemical Composition.*—Dominant metals Aluminium and Iron. Dominant Acid Radical SO<sub>4</sub>. Calcium Carbonate is concentrated in the lower horizons.

Sodium carbonate is only present if calcium carbonate and water-soluble sodium salts are associated under conditions suitable for the production of free carbonic acid. Sodium chloride is found in limited quantities only and sodium sulphate is the predominant sodium salt. This group has been subdivided as follows :—

(A) Productive szik soils which contain not more than 0·2 per cent. of total salts and no carbonates. Among these are the dusty szik soils containing not more than 10 per cent. of clay and having silt as the predominating fraction, and the cracked szik soils containing 30 to 40 per cent. of clay.

(B) Szik prairies having more than 0·2 per cent. of total salt containing chiefly sodium sulphate but in some places also sodium chloride, sodium carbonate and calcium carbonate.

This group is further divided into two—those which contain no sodium carbonate and in which calcium carbonate occurs in the lower layers only, being often associated with gypsum, and those in which the sodium carbonate and calcium carbonate occur in the upper layers.

(b) *Saline Soda Soils.*—The chief characteristic of this group is their content of sodium carbonate which is the chief cause of their unproductivity—

(1) *Soil Profile and Mechanical Composition.*—The mechanical composition varies widely from coarse sandy soils through loamy soils to clay soils.

One feature is *always present* in the soil profile—the impermeable layer in the subsoil, and also, unlike the heavy clay szik soils, saline soda soils always occur in “basins”.

(2) *Chemical Composition*.—Chiefly characterised by the quality and quantity of water soluble salts, the maximum amount being from 2 to 2·5 per cent. Half of the salts consist of sodium carbonate and the other half of sodium chloride. Sodium sulphate, the characteristic soda salt of the heavy clay szik soils, is not present in any considerable quantity. These soils show the true salt crust and efflorescence. The crust is always moist and dissolves easily in water, forming an alkaline solution which attacks the skin of the hands. They contain very large quantities of calcium carbonate, the percentage varying from 16 to 37. The dominant metals are calcium and magnesium and the dominant acid radicle is CO<sub>3</sub>.

Saline soda soils are subdivided as follows :—

(A) Clay soils, containing 15 to 35 per cent. of fine sand, 30 to 50 per cent. of silt and 15 to 50 per cent. of clay, with a small amount of sand greater than 0·5 mm. diameter. Sandy soil at a depth of 170 cm. and no hardpan.

(B) Loam soils, containing 55 to 75 per cent. of fine sand, 10 to 20 per cent. of silt and 15 to 20 per cent. of clay and a small amount of coarse sand. A sandy layer often occurs at from 20 to 40 cm. depth, in which case a line hardpan is found from 1 to 2 metres depth.

(C) Sandy soils containing 80 to 95 per cent. of sand, 4 to 8 per cent. of silt and less than 1 per cent. of clay with considerable quantities of coarse sand greater than 0·5 mm. diameter. Sandy subsoil with a line hardpan similar to (B).

Typical analyses are given below :—

*Saline Soda Soils.*

—		1, clay Telelen.	2, loam Halas.	3, sandy Makraszek.
Coarse sand	.. ..	1·44	4·39	12·56
Fine sand	.. ..	26·10	63·61	77·87
Fine dust	.. ..	5·23	1·65	0·87
Silt	.. ..	29·13	11·43	8·55
Clay	.. ..	38·10	18·92	0·15
		32·77	69·65	91·30

Plate II shows, diagrammatically, the very striking differences in chemical composition between the two main classes of soils. The first two soils belong to the group of heavy szik soils, the last two soils to the saline soda soils. The third soil is intermediate between the two main classes and belongs genetically to the first main group.

THE FORMATION OF ALKALI SOILS IN HUNGARY.

3. Dr. de'Sigmond concludes from his investigations and from the observations of other workers, that the szik soils of the Great Hungarian Plain were formed under arid or semi-arid conditions in areas subject, periodically, to excess of water and having impermeable subsoils. The arid climate caused weathering of the soil particles and decay of organic matter and there is, consequently, a high content of clay and humus in szik soils. The periodical excess of moisture led to the flooding of land, the formation of temporary marshes and the solution from the soil of the water-soluble salts. The arid climate caused the disappearance of these collections of water by evaporation, resulting in the concentration of the water-soluble salt which, in turn, resulted in the formation of alkali zeolites and humates. The impermeable subsoil contributed by preventing the leaching away of salts by the standing water.

The conditions contributing to the formation of szik soils may thus be summarised as follows :—

- (1) the arid climate,
- (2) the impermeable subsoil, and
- (3) meteorological conditions which bring the soil periodically under the influence of excess moisture.

The evolution of szik soils may be described as having taken place in three distinct steps—

(1) The formation of an impermeable subsoil which hinders the filtration and drainage of water and causes the accumulation of salt solutions on the surface.

(2) Surface evaporation of water and the consequent concentration of the solution of soluble salts from the soil, combined with intensive mineral and organic decomposition.

(3) Base exchange produced by the sodium salts reacting with the soil zeolites and humates, resulting in different types of szik soils according to the quantity and quality of the different sodium salts and to the original composition of the soil material.

#### THE DISTRIBUTION OF ALKALI SOILS IN HUNGARY.

4. The first main group of alkali soils, the heavy clay szik soils, occurs mainly on the left bank of the Tisza river beginning, very roughly, from the junction of the Szamos and Kraszna rivers with the Tisza and stretching south to the line Naka-Arad on the Moras river. The second main group of soils, the saline soda soils, occurs in the areas between the Tisza and Danube rivers, and lies, very roughly, between Budapest on the north and the line Baja-Szabadka-Szeged on the south. I hope to be able to attach a soil map showing more accurately the distribution of alkali soils, as Dr. Telegdy Kovats has promised to obtain copies of such a map for me. A copy of the soil classification map is available but is too large to reproduce. This map will be lent to anyone interested.

#### DESCRIPTION OF TOUR.

5. I left England on the 14th July for Budapest, travelling by the Ostend-Constantinople Express, and arrived at Budapest at 23·50 on the 15th. The 16th and 17th were spent in Budapest. On the 16th I called, with Dr. Telegdy Kovats, at the British Legation to report my arrival, and afterwards, at the Ministry of Agriculture on Dr. Ujhelyi, Chief of the Department of Agricultural Experimentation, and on Dr. Viczenik, Deputy Chief of the Department. Dr. Ujhelyi had very kindly arranged that Dr. Telegdy Kovats should accompany me on my tour in Hungary so as to be able to act as interpreter when meeting the various officials. I then went to the Agricultural Museum in Budapest and met the Director of the Museum, Dr. Nagy, and the Sub-Director of the Meteorological Section, Dr. Savoly, who very kindly showed us round. The museum contains a very complete collection of exhibits regarding all sections of agricultural work and all matters which have any connection with agriculture. The collections are so vast and complete that a considerable time would have been necessary to study them properly, but I was not able, owing to shortage of time, to do more than walk round the various sections. The most interesting section, to me, was the Hydrological section, dealing with all matters concerning river control, drainage, river protection, etc. The whole museum is arranged primarily for the general public and not for the technical expert, and the method of imparting information about the various exhibits by pictures or diagrams is very clear and easy to follow. In the afternoon I met Dr. Becker at the Royal Hungarian Chemical Institute and was shown round the laboratories there. I obtained details of the Government scheme for assisting in the reclamation of alkali lands, details of which are given in a later paragraph of this report. Dr. Becker is the head of an organisation known as an "agricultural experimental circle". This is a private organisation, to which its members pay a small subscription, obtaining in return the advantage of expert advice from the leader (who is a trained scientist) regarding all practical agricultural problems. The circle encourages its members to make field experiments on manurial treatments, varieties, etc., to adopt new methods of cultivation, and provides the necessary expert supervision to see that mistakes are not made. The agricultural experimental circle, of which Dr. Becker is the head, is the first of its kind in Hungary; but similar organisations exist all over Germany and are very successful indeed, being entirely self-supporting, employing many experts, and maintaining their own laboratories. It is expected that additional circles will come into existence in Hungary in the near future. Full details of the German organisations are available (printed in German) and can very easily be obtained

if required. Voluntary societies on similar lines in Sind, in the area commanded by the Lloyd Barrage canals or in the Bombay Deccan, might perhaps be organised in connection with existing co-operative societies and would be of the greatest assistance in propaganda work.

On the 17th morning we called on Dr. Rohringer, Professor of Hydrology at the University of Technical Science. Dr. Rohringer described the system of river control in Hungary for the protection of low-lying lands from flooding, and described also a large drainage project which has recently been completed. Short descriptions of the system of river control and of the drainage project are given in Section II of this report. Dr. Rohringer showed us round his hydraulic laboratory and explained the various experiments on models which were being carried out. One model, of a section of the Tisza river, made to ascertain the effect on river flood levels of bunding one side of the river to protect some 80,000 acres of land, was most interesting, and Professor Rohringer arranged to have the model working during the afternoon for us to see. This model is described later in the report. We then called on Dr. Böckh, Director of the Royal Hungarian Geological Institute and late Under Secretary of State in the Ministry of Finance. (Dr. Böckh was also for some years Geological Superintendent to the Anglo-Persian Oil Co.) Dr. Böckh showed us some of the maps of the Geological Survey of the Great Hungarian Plain, which is now complete, and other maps of the Agro-Geological Survey of the Great Hungarian Plain, which is in process of being made. An agro-biological map of the same area is also to be undertaken. An agro-geological map is really a soil survey made from the agricultural, as distinct from the geological, point of view. In the afternoon we saw the Tisza river model working at the University of Technical Science, and then went to the Royal Hungarian Central Chemical Institute, where Dr. Becker demonstrated field methods of measuring pH and total salt content of a soil sample by means of Dr. di Gleria's apparatus. Particulars of this instrument have been obtained, as it might very likely be of use for field investigation in Sind. The instrument is also suitable for laboratory work.

18th July.—We left Budapest at 07:30 and proceeded by rail to Karczag, where we saw the Agricultural Elementary (Peasant) School and the experimental farm attached to it. We also saw several areas of heavy clay szik land which had been reclaimed by lime dressings and one area which had been reclaimed by the "Digo" method. Details regarding these methods are given in paragraph 8. We saw a reclaimed area on which there was a flourishing growth of trees; on part of this area the young trees were being shaded by a growth of tamarisk (the "Lai" of Sind). The tamarisk grows faster than the trees initially and serves to shield the young trees from the sun and also to reduce evaporation from the surface of the soil. As the trees grow stronger and increase in size it is found that the tamarisk dies out. Karczag has very little rain during the summer months and tube-well water is used for the irrigation, by spraying, of crops such as lucerne. Photographs were also taken of a special type of disc cultivating machine which is used for the cultivation of heavy clay soil (Photograph No. 1). The school appeared to be a most efficient organisation, in which *practical* training in all branches of farm work was the chief feature. The farm attached to the school is run very largely by the students, who have, in turn, to carry out all the work necessary in connection with agricultural dairying, pig keeping, gardening, tree nurseries, etc. Simple theoretical instruction in these subjects is given in addition. At Karczag we were shown also some experimental plots where treatment with acids had been compared with lime dressings. The acids used were sulphuric, acetic and hydrochloric acids. The acid-treated plots showed some improvement when compared with the untreated control plots, but the improvement was insignificant when compared with that on the lime-treated plots. Acid treatment is not to be compared in its effect with lime for heavy clay szik soils, apart from the fact that it is more expensive and is difficult to apply to the land. From Karczag we went to Hajduszoboszló and saw two deep artesian wells originally made to explore for oil, but now supplying natural gas and water at 73 and 78 degrees C. The natural gas from one of the wells is now being used for generating electricity in the power station and the water, which contains 5 grammes of solid matter per litre and 6 milligrammes of iodine per litre, is being used for medicinal baths and for a large open-air swimming bath. This well is over 1,000 metres (3,250 feet approximately) deep. The other is over 2,000 metres (6,500

feet approximately) deep, and yields water at 78 degrees C and natural gas, neither of which is yet in use. From Hajduszoboszló we proceeded to Debrecen, arriving at 20·30.

*19th July.*—We proceeded by train to Halasto on the Hortobágy plain to see fish ponds established on bad szik lands. From Halasto by train to Kónya, where we were shown round a typical Hungarian farm of 10,000 acres. The fish ponds are described in paragraph 8. On the farm we saw some very fine horses and cattle and also large areas of heavy clay szik lands which had been reclaimed by lime treatment. We were also able to see the typical soil profile of the heavy clay szik land, in which there was first a very thin humus layer, then a leached horizon of a light gray colour from 7 to 10 cm. thick, then an accumulation horizon of black colour from 25 to 35 cm. thick, followed by the typical yellow clay containing calcium carbonate concretions. We went by train to Debrecen in the evening, arriving at 21·00.

*20th July.*—At Debrecen. We were shown around the sewage disposal farm at Debrecen by the Chief Engineer in charge of the drainage projects and other works in a large area surrounding the town. The sewage is settled in open tanks, sludge being made into compost and used for the lands of the farm. Effluent (and crude sewage as well) is used to irrigate 200 acres of market garden crops, and, in the summer months, the demand is so great that all the effluent is used for this purpose. Effluent, if not required for irrigation, is passed into a small river and eventually reaches the Tisza river. During the winter the sewage is stored for two or three weeks in open natural depressions on the sewage farm and is then flushed into the river. No difficulty is experienced in getting rid of the effluent in this way in spite of the intense cold. The proprietors of market gardens pay 100 pengoes (72 s. or Rs. 48) per acre during the summer for the effluent. The system of cultivation and irrigation is known as the "Bulgarian" system, and is exactly the same as is used for market gardens in Sind and the Bombay Deccan. We were shown the plans of several drainage projects which had been carried out by the Chief Engineer. These are described briefly in Section II of this report. In the afternoon we saw the Royal Hungarian Chemical Experimental Station for Agriculture at Debrecen, and were fortunate enough to meet Dr. Arany, from whom I obtained details of the field and laboratory tests usually made for the investigation of an area of heavy clay szik soil for reclamation. Details in regard to these tests are given in paragraph 6.

*21st July.*—We left Debrecen at 07·06 and proceeded by train to Szarvas arriving at 11·00. At Szarvas we met Director Csabal of the Agricultural Middle School and some of his staff, and were shown round the Middle School buildings and the experimental farm attached to the school. We were also shown various areas of heavy clay szik soils which had been reclaimed by the Digo method and also by lime dressings. Details of these methods are given in paragraph 8. It is interesting to note that some 12,000 acres of heavy clay szik soil were reclaimed about 160 years ago by the "Digo" method introduced by Pastor Samuel Thessedik and that this land remains good to this day. Director Csabal mentioned an interesting point in connection with the formation of szik soils. In the area around Szarvas it is found that lands, whose surface is now 82 m. above mean sea level are very good, lands whose surface is now 83 m. above mean sea level are szik lands, while those whose surface is now 84 m. above mean sea level are first class lands. I was able to obtain, from Director Csabal, details of the system of agricultural education in Hungary, and a separate note has been written on this subject in Section III. We left Szarvas at 16·30 and proceeded by train to Békéscsaba, arriving at 19·30.

*22nd July.*—At Békéscsaba. We were shown round the municipal irrigation reclamation scheme by Agricultural Manager, Zahorán Pál. This reclamation scheme has been carried out on an area of heavy clay szik land, and details are given in paragraph 8. We were also shown, by the Assistant Forest Engineer, a forest nursery of some 7½ acres where trees of all kinds were being grown, for free issue to land owners, to encourage the planting of trees on estates and the formation of forests. In this nursery there was a plot of land which had been successfully reclaimed by gypsum treatment. The soil was a loam. We left Békéscsaba by train at 16·09 and reached Szeged at 19·20 the same evening.

*23rd July.*—At Szeged. We called at the offices of the “Szegedi Armentesítő és Belvízszabályozó Társulat” (Company for Drainage and Control of Inland Water at Szeged), and were shown by Chief Engineer and Managing Director Pap, the plans of the area protected, a very brief description of which is given in Section II of this report. The Chief Engineer also explained the system of river control in Hungary and gave me copies of the daily hydrographical reports which are issued to all concerned from Budapest, and which show at a glance the rainfall, barometric pressure and the discharges of the various rivers. We then inspected, by motor car, the river bund line, pumping stations, etc., maintained by the company. In the afternoon we went to the Royal Hungarian Experiment Station for Soil Research and Agro-Chemistry in Szeged, where Chief Chemist, Herke, gave me details regarding a soil survey carried out in the catchment area draining into the land protected by the company. He also gave me details regarding the characteristic flora to be found on saline soda soils and the methods of sampling and the field and laboratory tests made when investigating an area of land for reclamation. Details are given in paragraphs 6 and 8.

*24th July.*—At Szeged. In the morning we were shown, by Chief Chemist Herke, some experiments which he had carried out for the reclamation of land by various treatments. Details of these experiments are given in paragraph 8. We were also taken, by the Chief Engineer, round the new works being carried out for the construction of a system of fish ponds, which are to make use of an area of bad alkali lands lying in the area protected by the company. A short note on this scheme is given in paragraph 8. An attempt is being made to use some of these bad alkali lands for the growing of rice on artesian water. We saw, at one place, several acres of very flourishing rice crop, and at another place some rice which was not very good, presumably owing to the high salt content of the land. We left Szeged at 15·33 hours, and reached Budapest at 18·50 hours.

*25th July.*—At Budapest. I called at the British Legation to report the completion of my tour, and then, with Dr. Telegdy Kovats, at the Ministry of Agriculture to see Dr. Ujhelyi, Chief of the Department of Agricultural Experimentation, and Dr. Sajo, Chief of the Department of Hydraulics, to express my great appreciation of their kindness in arranging the tour for me and in according facilities for the inspection of the various works.

*26th July.*—Sunday. Spent in writing up notes.

*27th July.*—We were taken, by Professor Rohringer, to visit the large drainage scheme referred to at the beginning of this paragraph. The journey was made by car, leaving Budapest at 08·00, returning at 21·15 in the evening, after covering more than 300 kilom. A description of the drainage scheme is given in Section II of this report. During the tour we saw many of the drainage ditches, an excavator at work clearing the main drainage canal, the workshop and store for the maintenance of the excavators, and many acres of drained land. We also saw two methods of preparing the drained swamp land for cultivation. Swamp land is covered with clumps of reeds and coarse grass, and when drained the surface is covered with many hummocks containing the roots and dry stalks of the reeds, and it is thus not possible to plough the land. One land owner had had all the hummocks removed by hand, so that the land was level. The parts removed consisted chiefly of roots with some earth intermixed. These were stored in long heaps by the sides of the fields, and are now being used to make a compost consisting of 50 per cent. hummocks and 50 per cent. farmyard manure. The compost is made by stacking the farmyard manure and the hummocks in alternate layers and allowing them to rot. The land owner stated that he had found these hummocks to be very valuable as manure. The second method adopted, by the manager of a very large farm, was to fit wide flanges on to the wheels of two steam ploughing engines and use them as steam rollers, thus rolling the hummocks flat and breaking them up, and enabling ploughing to be done. This method was very successful also, as the wheat crop off the land so treated this year amounted to 8 to 8½ centnars (1,750 to 1,925 lbs.) per acre. We also saw, at Kunsentmiklos, an area of land prepared for reclamation by the “Boxing” method. The land was divided into plots of suitable area by small bunds, which are intended to catch and retain rainfall. The water is then supposed to leach through the soil, taking with it the water-soluble salts. The “boxes” seen had not had any water in them, as there had been no rain, and Professor Rohringer is of opinion that this method of

reclamation is not of much use unless there is ample natural precipitation or unless a supply of irrigation water is available to keep the boxes full. We were not able to see some experiments which were being made on irrigation (using the water from the main drain) in order to ascertain the increased yield which would be obtainable by irrigation. The rainfall in the drained area is deficient in the summer months, and there is a proposal to take water from the Danube, which is controlled for navigation, to irrigate some 15,000 acres of land in the drained areas.

*28th July.*—I left Budapest by train and reached Zurich on the 29th July.

*30th July.*—I called on Professor Weigner at the Technical High School, and was shown round the laboratories there. Professor Weigner introduced me to Professor Edouard Diserns, of the Federal Polytechnic School, who showed me many interesting plans of drainage schemes in Switzerland. In the afternoon I went to the hydraulic laboratory of the Federal Polytechnic School and saw many interesting models of works which were being tested in the laboratory. One model was of a fish ladder in which were tested the best form and position for the openings in the compartment walls of the ladder. Another was a model of a section of river and the intake to a power station. This model had been made in order to find the best method of excluding sand from the power station intake channel. A third model was of a spillway dam and the river below the dam, and the model had been constructed in order to find out the best shape for the spillway itself and the best method of dissipating the energy in the water at the foot of the fall, and of preventing scour in the river channel. I was shown a cinematograph film of the latter, in which the various stages of the experiment were seen, and the movement of the water in the model was shown by slow motion pictures. The film showed the model and the effect of the various changes in design very clearly indeed. The slow motion pictures facilitate the analysis of water movements and it is quite clear that a modern hydraulic laboratory is not complete without a cinematograph camera capable of taking slow motion pictures. This experiment was undertaken by the laboratory at the request of a company in Morocco, and the design, arrived at from the model tests, has been accepted for construction. Professor Weigner very kindly arranged for me to see some drainage schemes and schemes for the regrouping of lands which had been carried out in the vicinity of Zurich. These were inspected on the 31st July in company with the engineer in charge. The drainage schemes have been carried out on areas of low-lying land near the Rhine or in valleys. Drainage is by means of open channels, assisted, where necessary, by pipe drains. In the scheme seen near the Rhine the drainage water is lifted by pumps into the river; in the valley schemes the water is disposed of by gravity. In all cases the discharge of the drains is controlled by valves so that, if rainfall is deficient, the subsoil water level can be raised under control so as to give water to crop roots. The reclaimed areas seen, which used to be swamps, are all now thickly cultivated. The Canton Government are doing their best to persuade land owners, whose holdings are generally made up of small and scattered areas, to agree to the consolidation of their holdings and the building of new farm houses on these consolidated holdings, the object being to increase the efficiency of agriculture. The Government prepare schemes for such consolidation of holdings, and these are subject to the vote of the people concerned. If there is a sufficient majority in favour of the proposal the Government carries it out, and also gives assistance towards the cost of building the new farmhouses. I saw several areas in which such consolidation of holdings had been carried out, and the difference between the plans of the areas before, and after, consolidation was very striking.

I left Zurich on the 31st July and reached England on the 1st August.

The various places visited can be seen on the accompanying map of Hungary, Plate I, on which they are underlined in ink.

#### METHODS OF INVESTIGATION OF ALKALI LANDS.

6. Land may be unproductive for several reasons, e.g. lack of water, very high clay content, high content of water-soluble salts, high content of sodium carbonate, etc. The method to be adopted for making land productive, or for improving its productivity, must depend on the properties of the soil and will vary according to the dominant property. It is, therefore, essential to know exactly the cause of unproductivity before deciding on a possible remedy. It has

been abundantly proved in Hungary that the reclamation of alkali land *must be preceded* by a thorough examination of the area in order to find out the reason for its unproductivity, and, thus, to ensure the working out of the best method of reclamation. When the investigation is completed, it is easy to go into the economic side of the question and to decide whether the land will repay reclamation. The investigation of an area of alkali land, with a view to its reclamation, is carried out as follows. The classification of an area of land for reclamation is now made, primarily, from the natural flora growing on its surface. If nothing is growing the appearance of the land surface itself is some guide. A map of the area is prepared, and on this is marked the preliminary classification, from the natural flora. The system of classification is that developed by Dr. de Sigmond, which is described later on in this paragraph. Soil samples are then taken in sufficient numbers to give an idea of the composition of the soil in the areas classified, and tests are made on the samples as follows:—

*For heavy Clay Szik Soils* (data given by Dr. Arany of Debrecen):

*Field Tests—*

- (a) For calcium carbonate content with 10 per cent. hydrochloric acid. If calcium carbonate is found it may be assumed that sodium carbonate is present also.
- (b) pH by Kuhn's colorimetric system.
- (c) The surface water should be tested for sodium carbonate.
- (d) Total salt content (if required) can be found by Dr. di Gleria's method.

*Laboratory Tests—*

- (a) Calcium carbonate quantitatively.
- (b) pH.
- (c) Determination of soluble carbonate, sulphate and chloride ions. Determination of calcium and magnesium.
- (d) Exchangeable bases.

The results of the above tests are shown on the plan referred to, as also are the places from which samples were taken. From the results of the laboratory tests it is possible to calculate the lime requirements for the various areas classified. The best way to take a sample is to dig a pit at each place to be sampled so that the various horizons in the soil profile can be seen. Samples are then taken from each horizon. If this cannot be done, samples should be drawn in layers, 0 to 10 c.m., 10 to 20 c.m., and so on up to 60 c.m. depth. Post-hole augurs 10 c.m. (4 inches approximately) in diameter are used for sampling. For heavy soils a very suitable tool can be made by splitting a piece of wrought iron pipe longitudinally and providing it with cutting edges at its lower end and with an extensible handle. The tool seen was approximately 60 mm. (2·37") diameter and 35 c.m. (13·75") long. This tool removes a clean core of earth and so enables the various horizons of the soil profile to be identified. Soil samples should weigh about 1 kilo. (2·2 lbs.) each, and are packed in double paper bags of strong paper. Particulars regarding the site, horizon, etc., are written in indelible pencil on the outer paper bag. They are also written on a small wooden label which is put, with the soil, into the bag. The depth of subsoil water below the surface is recorded on each sample. No special records of temperature, snow, rainfall, etc., are taken when the reclamation of any area is being investigated, as the ordinary data available from the Meteorological Department are sufficient.

*For Saline Soda Soils:*

Classification of land is done by the dominant flora in the first place, and soil samples are taken as described above.

*Field tests—*

- (a) A test for sodium carbonate using phenol phthalein as an indicator and comparing with a colour scale.

*Laboratory tests—*

- (a) Prepare a sample by air drying, breaking down and putting through 2 mm. sieve.
- (b) pH colorimetrically and electrometrically.



- (c) Estimation of calcium carbonate (Scheibler's method).
- (d) Titration for alkali, calculated on sodium carbonate and using  $\frac{N}{20}$  potassium hydrosulphate with phenol pthalein as indicator.
- (e) Total content of water soluble salts—electrometrically.
- (f) Mechanical analysis (Atterberg) in two ways:—
  - (i) with the soil as drawn and dispersed with distilled water and a soft brush only.
  - (ii) on the soil after removing the calcium carbonate with  $\frac{N}{20}$  hydrochloric acid and washing free from chloride.
- (g) Exchangeable bases. (This test is done on occasional samples only.)

The amount of gypsum, sulphur, sulphuric acid or other material to be used for reclamation is calculated from the content of sodium carbonate of the soil samples. This can also be ascertained approximately by testing the effect, on the flocculated volume of a dispersed sample of the soil, of solutions of gypsum, etc., of varying strengths. By comparing the volumes of sediment after an equal settling time, the strength of the gypsum, or other solution, giving the lowest volume can be found, and the requirement of gypsum or other material can thus be ascertained. The information given above regarding the method of classification, the method of sampling, etc., and in regard to field and laboratory tests for saline soda soils, was given by Chief Chemist Herke of the Royal Hungarian Experiment Station for Soil Research and Agro-Chemistry in Szeged. The method of classification adopted for the investigation of alkali lands is that worked out by Dr. de Sigmund, which depends on (a) the total soluble salt contained, and (b) the content of sodium carbonate. This system was worked out by the classification of the natural flora which grew on the land, combined with the sampling of the soil from the classified plots, one sample being taken from the upper horizon, 0 to 30 c.m. and one from the lower horizon, 30 to 130 c.m., in each case. The class of a soil is thus fixed in the order of value of its natural flora and in order of the tolerance, of the flora concerned, for total soluble salts and for sodium carbonate. The system of classification is as follows:

- (1) On the basis of total soluble salt content—
  - I 0—0·10 per cent.
  - II 0·10—0·25 per cent.
  - III 0·25—0·50 per cent.
  - IV more than 0·50 per cent.
- (2) On the content of sodium carbonate—
  - I 0—0·05 per cent.
  - II 0·05—0·10 per cent.
  - III 0·10—0·20 per cent.
  - IV more than 0·20 per cent.
- (3) Combined classification in which the numerator of the fraction refers to (1) and the denominator to (2) above—
  - 1st Class .. I/I
  - 2nd Class .. A II/I or I/II  
B II/II or III/I
  - 3rd Class .. A III/II or II/III  
B III/III or IV/II
  - 4th Class .. A IV/III or III/IV  
B IV/IV.

The characteristic flora of the various classes of alkali land are given in paragraph 7.

#### CHARACTERISTIC FLORA OF HUNGARIAN ALKALI SOILS.

7. Classifications of flora have been made to correspond with Dr. de Sigmund's classifications of alkali soils based on (i) the total content of

soluble salts, and (ii) the content of sodium carbonate. This classification is described in paragraph 6 of this report.

(a) *Heavy Clay Szik Soils* (Hortobágy Steppe soils)—*Dry*.

- Class I .. *Poa angustifolia*—*Cynodon dactylon* Association, Groups 5 and 6.
- Class II .. *Achillea*—*Inula britannica* Association.  
On Class IIA land groups 4 and 5.  
On Class IIB land groups 4 and 3.
- Class III .. *Festuca pseudovina* Association, group 3 for Class IIIA land and with groups 3, 2 and 1 for Class IIIB land.
- Class IV .. *Camphorosma ovata* Association, groups 1 and 2.
- Group 1 .. *Camphorosma ovata*.
- Group 2 .. *Puccinellia limosa*, *Artemisia monogyna*, *Statice Gmelini*, *Festuca pseudovina*, *Plantago tenuiflora*, *Aster pannonicus*, *Matricaria chamomilla*.
- Group 3 .. *Festuca pseudovina*, *Plantago maritima*, *Szorzonera cana*, *Pholiurus pannonicus*, *Hordeum Gussoneanum*, *Atriplex litorale*, *Bassia sedoides*, *Polygonum aviculare*, *Kochia prostrata*, *Eragrostis pilosa*, *Polycnemum arvense*, *Bupleurum tenuissimum*.
- Group 4 .. *Festuca pseudovina*, *Inula britannica*, *Plantago lanceolata*, *Achillea setacea*, *Achillea collina*, *Agropyron repens*, *Centaurea pannonica*, *Bromus hordeaceus*.
- Group 5 .. *Festuca pseudovina*, *Cynodon dactylon*, *Lotus tenuifolius*, *Alopecurus pratensis*, *Trifolium repens*, *Heleochoa alopecuroides*, *Euphorbia cyparissias*.
- Group 6 .. *Poa angustifolia*, *Lolium perenne*, *Agrostis tenuis*, *Trifolium pratense*, *Ononis spinosa*, *Potentilla reptans*, *Cichorium intybus*, *Eryngium campestre*, *Thymus*, *Galium verum*, *Andropogon ischaemum*, *Hieracium pilosella*, *Verbena officinalis*, *Taraxacum officinale*.

(b) *Heavy Clay Szik Soils* (Hortobágy Steppe soils)—*Wet*.

- Class I .. *Glyceria poiformis*—*Alopecurus pratensis*, *Lysimachia nummularia*, *Veronica scutellata*, *Potentilla reptans*, *Trifolium repens*, *Mentha pulegium*, *Agrostis alba*.
- Class II .. *Agrostis alba*—*Alopecurus geniculatus*, *Lotus tenuifolius*, *Heleochoa alopecuroides*, *Polygonum aviculare*, *Mentha pulegium*, *Heleocharis palustris*, *Agropyron repens*.
- Class III .. *Beckmannia eruciformis*, *Heleocharis*, *Pholiurus pannonicus*, *Plantago tenuiflora*, *Roripa Kernerii*, *Artemisia monogyna*.
- Class IV .. *Bolboschoenus maritimus*—*Puccinellia limosa*, *Heleocharis*, *Plantago tenuiflora*, *Salsola soda*.

Data for (a) and (b) above have been obtained from a paper by Magyar Pál entitled "Adatok a Hortobágy novényszociológiai és geobotanikai viszonyaihoz," of which I have a copy (in Hungarian and German).

(c) *Characteristic Flora of Saline Soda Soils* near Szeged—

*On dry areas.*

- Class I .. *Andropogon ischaemum*, *Cichorium intybus*, *Potentilla anserina*, *Achillea asplenifolia*.
- Class II .. *Carex distans*, *Plantago lanceolata*.
- Class II or III .. *Plantago maritima*, *Cynodon dactylon*, *Festuca pseudovina*.
- Class IV .. *Camphorosma ovata*.

*On the basins or damp areas.*

- Class I .. *Agrostis alba*.
- Class II } .. *Plantago maritima*, *Plantago lanceolata*.
- Class III } .. *Lepidium cartilagineum*.
- Class IV .. *Camphorosma ovata*, *Sueda maritima*, *Salsola soda*.

The above information was obtained from Chief Chemist Herke of the Royal Hungarian Soil and Agro-Chemical Research Station at Szeged. The flora named are the chief flora which occur; there are, of course, others. Those named may be taken as characteristic of the various classes of land.

#### METHODS OF RECLAMATION.

##### 8. (A) *Physical Methods*—

(i) *The "Digozas" method*.—This is the oldest method of reclaiming szik land in Hungary, having been used in the 18th century by Pastor Thessedik at Szarvas. The method consists of giving the land to be reclaimed a dressing of the yellow marly subsoil layer (known as "digo" soil) which contains concretions of calcium carbonate and some gypsum. This method is only used for the heavy clay szik soils. The digo soil consists chiefly of fine sand and silt and so acts in two ways: the sand and silt particles tend to lighten the heavy clay soil and make it more workable, while the calcium operates by flocculating the clay fraction of the original heavy soil and so improving its permeability and workability. Examples of reclamation by the "digozas" method were seen at (a) Karczag where a small area had been treated with "digo" soil obtained from a drainage ditch—the reclamation is quite satisfactory and the land is now growing trees; and (b) Szarvas, where very large areas have been reclaimed successfully by this method.

The general Scheme of work for obtaining the "digo" soil is as follows; trenches 2 metres (6·5' wide are dug at 25 metres (81' approximately) apart and the soil above the digo soil is removed from the trenches and stacked evenly on the two sides of the trench. The digo soil is then removed from the trench and spread, in a layer about 6 cm. (2·2") thick on the land, working for a distance of 12·5 metres (40·5' approximately) at each side of each trench. During the process the digo soil is undercut below the surface layers on the sides of the trench, which then fall in, carrying the deposited surface material with them and leaving a ditch which acts as a drain. The digo soil is levelled off, any small hollows being filled up and then rolled. The crop is then sown. Some 12,000 acres around Szeged were reclaimed by Pastor Thessedik's Digo method 160 years ago and are still in perfect condition.

(ii) *Lime dressing*.—The most successful and economical method of reclamation for heavy clay szik soils at present in use is the application of lime combined with farmyard manure and careful cultivation. The materials used are (a) ground limestone, (b) sugar beet sludge, (c) a ground soft limestone which is found as a deposit near mineral springs and is non-crystalline in structure. Other materials, such as waste calcium carbonate and tanners' refuse, have also been used. The two materials most used are apparently ground limestone and sugar beet sludge. Heavy clay szik lands reclaimed with lime were seen at (a) Karczag, (b) on the Hortobágy Plain, (c) at Szarvas, (d) experiments at Szeged. Details of the amount of lime used, etc., are given below.

(a) *Karczag*.—The materials used at Karczag were sugar beet sludge and ground calcium carbonate. Applications amounted to from 10 to 15 tons per acre, and the method of applying was as follows: From one-quarter to one-third of the total lime dressing is applied in the first place and the land then shows up the bad spots, which can receive additional dressings. Farmyard manure—a minimum of 15 tons per acre, maximum 30 tons per acre—is given with the first dressing of lime. Heavy clay szik soils are not ploughed after the lime and farmyard manure dressing is applied, but are cultivated by means of a special disc cultivator (Photograph No. 1) which loosens the surface but does not form clods. If sugar beet sludge is received wet from the factories double quantities must be used. The costs of treatments are as follows:—

Calcium carbonate, including the application of 15 tons of farmyard manure, 160 pengoes (115s. or Rs. 80 approximately) per acre including supply, loading, transport and application.

For sugar beet sludge (which is valueless at the factory) the cost including the application of 15 tons of farmyard manure is 100 pengoes (72s. or Rs. 48) per acre.

These costs do not include the value of the farmyard manure.

Areas of bad szik land were reclaimed by lime dressings at Karczag and yielded in 1929-30 13 centnars (2,900 lbs.) of grain per acre, and in 1930-31, 3,300 lbs. of grain per acre. Before these lands were reclaimed they were marshes in spring and in winter, and, if the season was very favourable, might give from 4 to 5 centnars of grain, but if the season was too wet or too dry would yield no crops whatever. The Director of the experimental farm at Karczag stated that the best results with reclaimed lands were obtained on the depressions, because of the higher moisture content. Higher areas were found to require, in addition, more lime and farmyard manure than the lower areas.

(b) *Hortobágy Plain*.—Large areas of land on the farm at Kónya had been reclaimed by liming and the condition of the land showed very marked improvement when compared with untreated areas.

(c) *Szarvas*.—Director Csabal of the Agricultural Middle School and Farm at Szarvas prefers sugar beet sludge to ground calcium carbonate for the reclamation of heavy szik soils. His method is as follows. Half the farmyard manure dressing is applied to the land and is turned in by the disc cultivator to a depth of 25 cm. (approximately 10") if possible. The remaining farmyard manure is then applied and the field is rolled, after which the lime dressing is applied and turned in 6 to 8 cm. (2.2 to 3 inches) and the crop is then sown. Wheat is usually grown for three years, and is then followed by lucerne. It is found, if the reclamation is successful, that lucerne can be grown for six to seven years continuously. Doses—15 tons farmyard manure per acre and 15 tons of lime per acre. On local bad spots of alkali Director Csabal increases the lime doses up to as much as 80 tons per acre.

(d) *Experiments with calcium carbonate at Szeged*.—Chief Chemist Herke of the Royal Hungarian Experiment Station for Soil Research and Agro-Chemistry at Szeged, has carried out experiments comparing the effect of gypsum, sulphuric acid, bauxite decomposed by sulphuric acid, and calcium carbonate in the reclamation of saline soda soils. These experiments are described later, but it will suffice to mention here that the calcium carbonate was found to be of no use. The calcium carbonate application was at the rate of 200 tons per acre. This result is not surprising, as the saline soda soils themselves contain large quantities of calcium carbonate.

(iii) *Preventing Evaporation*.—Evaporation of moisture from the surface of land causes the deposition of the water soluble salts on the surface. The water evaporated is replaced by capillary action from the subsoil water and again evaporated. The process continues and results in the accumulation of salts on the surface and in the surface layer of the soil. This evaporation can be much decreased by shading, mulching or loosening of the soil surface. These methods are apparently successful in California, but I saw no land reclaimed in this way during my tour. In fact, with the heavy clay szik soils, the rate of movement of soil moisture is so slow that very little surface accumulation of salts can occur from evaporation. The method seems to me to be a preventive rather than a cure, and might well be used to prevent, or to retard, land once reclaimed from reverting to an alkali soil. Shading (i.e., growing a crop such as lucerne), and covering the surface of land with straw between fruit trees, for example, would also assist in conserving the soil moisture and make it available for the crop. The use of tamarisk (*Lai*) at Karczag to act as a shade for young trees would appear to be an application of this principle, but in this case the land had been reclaimed before planting the trees and tamarisk.

#### (B) *Removing the salts*—

(i) *Sweeping the salts from the surface*.—In some areas in Hungary the surface accumulations are so heavy that the salts can be swept up and removed. Indeed, in the past, the supply of sodium carbonate for the soap factory at Szeged was obtained in this way. This method cannot be more than the first step towards reclamation, as the soil itself must contain a high concentration of toxic salts, which would have to be dealt with, before crops could be grown on it.

(ii) *Leaching the salts into the subsoil*.—This has been done in Hungary by the "boxing" method, in which the land to be reclaimed is divided into suitable blocks by bunds, which retain all natural precipitation, thus allowing the water to stand on the land and to leach the salts into the subsoil. To be successful this method would appear to require three conditions, (a) a certain degree of permeability in the soil, (b) a sufficient supply of water, and (c) that the

level of subsoil water should be below the limit of capillary rise. I saw no examples of the "boxing" method during my tour (except that at Kunszentmiklos, *vide* paragraph 5, where some land had been prepared in accordance with this method), but I understand that it is used only for meadow land. The method of reclamation by leaching salts into the subsoil is used extensively in Sind when an ample supply of irrigation water is available.

(iii) *Surface Irrigation*.—This system consists in dividing the land to be reclaimed into suitable blocks by means of bunds, leading water to these blocks by channels and flooding them in turn. The water is allowed to run over each plot and then let out into a drain, or into a lower plot and thence to a drain, which removes it from the area under reclamation. The salts on the surface, and presumably also those in the first inch or two of the soil, are dissolved by the water and removed with it. This method is used in Hungary for meadow and pasture land. "Meadow" land is the term used for reclaimed lands in which a good seed mixture of clovers and grasses is sown. Such lands must, subsequent to reclamation, be farmed as meadows, being manured, etc., in order to maintain their productivity. "Pasture" land is the term applied to land growing its natural flora only. Such lands may give hay crops or may only be used for grazing. I saw one example of surface irrigation reclamation at Békéscsaba. This scheme had been carried out on an area of approximately 177 acres of szik land, which is chiefly of Class II, III and IV. Plate No. III shows a plan of the area and the irrigation and drainage channels which have been excavated for the purpose of flooding the various plots with water and removing the water from them. Dr. de 'Sigmund has carried out extensive investigations in regard to this area of land and his paper entitled "Hungarian Alkali Soils and Methods of their Reclamation" contains very complete data, with maps and plans showing the classification of the area and the distribution in depth of the total salts and sodium carbonate. The manager of the Municipal Irrigation Reclamation scheme stated that it was not economical to reclaim lands of the third or fourth classes, as they require treatment for too long a period, and that this was prohibited by the cost of the water, which is pumped electrically from a canal near the area under reclamation. After being irrigated the meadow plots are treated with compost, which is made from the street sweepings and night soil of the town, and are then sown with proper seed mixtures. These areas are then farmed as meadows in the usual way. Reclamation of lands of the first and second class have been very successful and heavy crops of hay have been grown.

(iv) *Fishponds*.—Land belonging to Class III-B or Class IV cannot economically be reclaimed, and the use to which they are put in Hungary is to make them into fishponds. I saw two examples during my tour, one at Halasto, which is in operation, and a second at Szeged, which is under construction and will commence operations in the spring of 1932. The idea of the fishpond is to improve the land by dissolving the water soluble salts in the standing water of the ponds. The fish, in addition to the plankton on which they feed, appear to consume a certain amount of the soluble salts and generally also have to be fed artificially. It has been found, after four or five years, that the bottoms of the fishpond can successfully be cultivated with crops, though, as Class IV lands are usually very heavy, very little leaching down of salts occurs and the land is liable to become alkali again by capillary action. The fishponds at Halasto apparently pay very well and will, I presume, continue to be run as fishponds only.

*Fishponds at Halasto*.—The fishponds at Halasto cover an area of 2,800 acres. There are twelve main ponds, the largest of which is 300 acres in area. The ponds are arranged with suitable canals between them for the removal of water, and there is a canal from the Tisza river which is used to bring water to the fishponds to supplement natural precipitation and drainage. Pumping stations are placed at suitable intervals along the dividing canals, and are used for moving water from one main pond to another, so as to enable the ponds to be cleared of weeds, etc. The canal from the Tisza river is 24 kilom. (15 miles) long and carries a discharge amounting to from 250,000 to 300,000 cu. m. daily. This water is pumped from the river into the canal. In addition to the main ponds there are 82 smaller ponds, 400 sq. m. area on the beds. These ponds are used for storage of fish during the winter months. Fish are moved from the main ponds in the autumn by lowering the water level so that the fish follow the water into a drainage channel, which is excavated along one side of each of the main ponds.

The fish are caught in this channel by hand nets, sorted into size by increments of one pound and by varieties, and carried in large tubs on a light railway to the small ponds referred to above, in which they are stored for the winter. It is found that the fish grow chiefly during the summer months, and that they are more or less dormant during the winter months. During the summer month the fish are fed with wheat and maize, which is soaked for 24 hours in large tubs before being put into the water. When the main fishponds are empty, the small fry of fish, of varieties which are not required, are killed with quick-lime to reduce the uneconomic consumption of plankton. During the process, of course, a certain number of small fish of the cultivated varieties are also lost. Fish are bred on the spot for stocking purposes. The varieties of fish which are cultivated are as follows :—

Cyprinus Carpio	..	This variety forms 95 per cent. of fish.
Tinca vulgaris	..	} These make up the remaining 5 per cent.
Lucio perea sandra	..	
Siluris glamis	..	
	..	

Fish are sent away from the fishponds alive, in special tank wagons, and go as far as Warsaw and Hamburg. These tank wagons carry cylinders of oxygen which is used to replace, in the water, the oxygen used by the fish. A very interesting point was noticed at Halasto. The soil of the area is so heavy that a well which was dug only 3 m. (approximately 10') from the surface of standing water in the main canal between the fishponds has its water level from 5 to 6 metres (16 to 19 feet) below the water level in the canal, showing that there can be practically no movement of water from the canal into the soil.

*Fishponds at Szeged.*—The fishponds at Szeged are being constructed on a plan which is very similar to the plan of the fishponds at Halasto. They are intended to use an area of 700 to 800 acres of Class IV land near the town of Szeged. The four main ponds will be 200 acres each in area. There will be, in addition, two smaller ponds of 60 and 40 acres and a number of small ponds for the winter storage of fish and for breeding purposes. Water is to be supplied to the fishponds from the drainage of the catchment of the protected area, but arrangements are being made to supplement this supply from the Tisza river, in case of deficiency, by means of a canal. This canal will be used also to take surplus water from the drainage of the catchment to the river in case of necessity. Arrangements are made so that, in an emergency, the water in the fishponds can be let out into the drainage system, which connects up with the existing pumping stations of the protected area, and so can be pumped into the river. For the supply of water to the fish storing basins during the winter, three tube wells have been constructed. These wells are artesian, and discharge, in all, 4 cu. m. (130 cu. ft. approximately) per second. This water is at present being used in an attempt to grow rice in some 40 acres, but the crop has not been a good one, presumably owing to the concentration of salts in the soil. There are no special points about the design of tanks, etc. The main canal from the ponds to the river has a capacity of 11 cu. m. per second (350 c. f. s.) and a slope of 25 cm. in 1 kilom. (1 in 4,000). The sluice through the river protection bund at the end of this canal is interesting, as the culverts through the bund itself (two rectangular culverts built in situ and side by side) are made in three sections, the joints between these sections being made of copper strips and bitumen. The idea is to allow for unequal settlement of the earth composing the bund.

### (C) Chemical Treatment—

The materials which have been used for chemical treatment of alkali lands are: gypsum, bauxite decomposed with sulphuric acid, sulphur, sulphuric acid, hydrochloric acid, acetic acid, and others. Experimental plots for comparing various chemical treatments were seen at (i) Karczag and (ii) Szeged—

(i) *Karczag.*—The soil experimented on was a heavy clay szik soil, having a pH value of 5.6, but the soil was nevertheless an alkali soil. The effect of treating with sulphuric acid, acetic acid and hydrochloric acid was compared with the effect of lime dressing and with control plots of untreated soil. The result of this experiment was that, although the acid treated plots showed some improvement on the untreated soil, the improvement was nothing when compared with the lime

treated plots. Acid treatments, besides being expensive, do not therefore appear to be of much use for the heavy clay szik soils.

(ii) *Szeged*.—Chief Chemist Herke has carried out a number of experiments on small plots to compare the effects of various chemical treatments. The soil experimented on was saline soda soil of Classes II, III and IV. One experiment was made on Class II land to compare the effect of reclamation by gypsum with the untreated soil. This experiment has given most marked results. It has been going on for five years since the gypsum was applied to the land, and crops have been grown as follows: wheat, sugar beet, oats, meadow grass mixture, and oats. The treated plots give from 2 to  $2\frac{1}{2}$  times the crop that is obtained from the untreated ones and show no signs whatever of deterioration. The soil is a heavy soil and subsoil water is 1.8 m. (5.9 ft. approximately) below the surface. In a second set of plots a comparison had been made of reclamation by gypsum, sulphuric acid and sulphur in equivalent quantities and in varying proportions. The gypsum and sulphuric acid plots were most successful. The sulphur plots were successful, but not to the same extent as the other two. The Chief Chemist considered sulphuric acid to be the best treatment, but said that it is expensive and that it gives a lot of trouble in application, as it damages the clothes of the workpeople who are applying it. The difference between the gypsum and sulphuric acid treated plots and the untreated plots in this experiment was most marked. This experiment was made on Class III land and the plots were each 4 sq. m. (42.5 sq. ft.) in area. On Class IV land similar experiments had been made, with results which showed that gypsum was the best treatment which could commercially be used, but the Chief Chemist was of opinion that the land at Szeged in the fourth class could not be reclaimed properly by gypsum treatment unless this was accompanied by leaching. Another series of experiments had been made to compare the effect of equivalent doses in varying amounts of gypsum, sulphuric acid, bauxite decomposed by sulphuric acid, and calcium carbonate. This experiment indicated that calcium carbonate was of no use at all. The other applications were all good, sulphuric acid giving slightly better results than the other two. The calcium carbonate was applied at the rate of 200 tons per acre.

A further series of tests had been carried out on Class IV land on plots 4 sq. m. in area each, by removing and separately stacking from each plot four horizons; 0 to 20 cm., 20 to 40 cm., 40 to 60 cm., and 60 to 80 cm. In one series of plots the soil from the various layers was mixed with the calculated amount of gypsum necessary (this being obtained from analyses of soil samples). The horizons were then replaced in the excavations in the correct order. Doses of gypsum were applied as follows:—

- (a) Horizon 0 to 20 cm. treated only, the remaining three horizons being replaced without treatment.
- (b) Horizons 0 to 20 and 20 to 40 cm. being treated, the remaining horizons being replaced untreated.
- (c) Horizons 0 to 20, 20 to 40, and 40 to 60 cm. being treated, the remaining horizon being replaced untreated.
- (d) All four horizons were treated with gypsum.

In a second series of plots the untreated soil was replaced in the plots without treatment. In a third series of plots exactly similar horizons of good wheat soil from a neighbouring field were obtained and filled into the pits in correct order. The object of excavating the soil in four separate horizons and replacing these again in the untreated and the good soil plots was to ensure that all plots should receive equal agricultural treatment. The result of the experiment was that the gypsum treated plots gave better yields than the plots of imported good wheat soil. Germination was good in all the gypsum treated plots, but the crop went off as soon as the roots reached the untreated layers in the 0 to 20 cm. and 0 to 40 cm. treated plots, showing that the reclamation to these depths was insufficient. The difference between the crop on the gypsum treated plots and the untreated plots was most marked. Chief Chemist Herke considered that it would be sufficient to put on, as a surface dressing, the gypsum required to reclaim a depth of 60 cm. and then to leach the land. This process would in his opinion effect reclamation.

The crops had, of course, all been removed from the experimental plots described above, but the difference in the condition of the soil between the gypsum treated plots and the untreated soil was indeed remarkable. Chief Chemist Herke has made experiments with alum, aluminium sulphate, iron sulphate, and with a material which has been manufactured by a chemical company in Hungary, the composition of which is a secret. The results of these experiments were good, but reclamation with alum, aluminium sulphate and iron sulphate is not possible economically in Hungary. The other material is, I understand, yet under test.

#### THE ORGANISATION OF THE RECLAMATION OF SZIK LANDS IN HUNGARY.

9. The reclamation of alkali lands is encouraged by the Hungarian Government, which is prepared to assist land owners for this purpose.

Reclamation work is under the Ministry of Agriculture, Department of Agricultural Experimentation, and is controlled by a permanent central committee, which advises the Ministry in connection with reclamation work in general, controls the investigation of all cases in which assistance has been applied for, and recommends the action to be taken. The President of this committee is Professor de 'Sigmund. The general sequence of events in connection with an application for assistance to reclaim land is roughly as follows. The land owner makes an application to the Ministry of Agriculture giving particulars regarding the land which he wishes to reclaim, the committee arranges for two experts (*a*) a soil chemist and (*b*) an agricultural expert, to visit the land in question. These two experts examine the land, make pertinent enquiries and report the result of their observations to the permanent central committee on form A, an examination of which will show that it contains all relevant data regarding the soil itself, the position and the capacity of the land owner, and the recommendation of the experts regarding the area of land to be reclaimed and the lime required for this purpose. The central committee makes its recommendation to the Ministry of Agriculture, which issues orders for the despatch of the ground limestone (or sugar beet sludge). The application of the lime and farmyard manure and the cultivation of the land is done under expert advice, and the lands are inspected from time to time to see that proper farming methods are being used. Owners have to report yearly, on form B, regarding the progress of reclamation. Heavy clay szik soils with no sodium carbonate, or with only a small amount of sodium carbonate, can be reclaimed with lime. Calcium carbonate dressings are of no use for saline soda soils.

Government assistance can be given to land owners in two ways:—

- (*a*) By payment of part of the cost of the lime dressing, the land owner paying the balance; or
- (*b*) By the loan of the money for paying the whole cost of the lime dressing, subject to repayment under certain conditions.

The average cost of lime dressing (15 tons per acre) is 145 pengoes (104·25s.) per acre. This includes the supply and delivery of the lime to the unloading point on the railway. The owner is responsible for transport to site, application to land, etc. The Hungarian State Railways give facilities for the unloading of lime for reclamation at any place named (on the open line or otherwise) which is nearest to the land to be reclaimed.

*Scheme A.*—The owner pays 40 pengoes (28·75s.) per acre of land reclaimed. This amount is paid in two instalments; 20 pengoes (14·37s.) per acre is paid to his village authorities on his making application for assistance in the reclamation of his land, and 20 pengoes (14·37s.) is paid when he is informed that the Ministry of Agriculture has approved of his application. The land tax on land which is reclaimed cannot be revised for 15 years from the year of reclamation. This scheme is applicable to peasants and small holders only.

*Scheme B.*—The whole cost of 145 pengoes (104·25s.) per acre is given by the Government as a loan. The land owner pays nothing for the first five years and no interest is charged for this period; but from the sixth year to the fifteenth year he repays the loan by instalments, plus interest at 5 per cent. The land tax on the reclaimed area cannot be revised for 15 years from the year of reclamation. If the land owner, during the period of repayment, does not cultivate the reclaimed



land properly, giving proper dressings of farmyard manure, etc., he is liable to be called on to pay, at once, all the sum outstanding on the loan. The loan is secured by a mortgage on the land owner's property. Scheme B applies to all land owners who are not eligible for Scheme A. The most noteworthy features of the organisation are (1) the joint inspection of the land by two experts, thus making available both theoretical and practical agricultural knowledge for the investigation, and (2) the permanent central committee of experts which advises the Ministry of Agriculture.

Samples of forms A and B are given.

#### GENERAL CONCLUSIONS.

10. The reclamation of alkali lands should not be undertaken without careful investigation of the land, and such investigation should be done by scientifically trained observers, one of whom should be a soil chemist, and one should have practical agricultural knowledge and experience.

The most economical method of reclaiming heavy clay szik soils appears to be by treatment with ground calcium carbonate or with sugar beet sludge, combined with a dressing of farmyard manure and careful cultivation. Sugar beet sludge seemed to be preferred by the various officials whom I met to ground calcium carbonate. If there are soils in Sind similar to the heavy clay szik soils of Hungary, ground calcium carbonate will have to be used, as sugar beet sludge is not available. For saline soda soils treatment with gypsum appeared to be the most economical method, combined with a dressing of farmyard manure and careful cultivation. Sulphuric acid gives, according to Chief Chemist Herke, slightly better results than gypsum, but is expensive in Hungary and so cannot compete with gypsum. Whatever system of reclamation is found satisfactory in Sind, the use of farmyard manure will be essential, and the importance of conserving the farmyard manure now available and of increasing the number of animals so as to increase the supply of farmyard manure cannot, therefore, be sufficiently emphasized.

Confidential.

FORM A.

*To—The Permanent Central Committee for Soil Reclamation, Budapest.*

## ROYAL HUNGARIAN MINISTRY OF AGRICULTURE.

Report of the Experts sent out into District in accordance with  
the order of the Ministry No. 50500/1930/IX2 regarding Field Investigation  
of Alkali Lands to be reclaimed.

1. City (Village).
2. County.
3. Name of Owner.
4. Residence of Owner.
5. Size of area to be reclaimed in acres.
6. Despatching instructions for lime—
  - (a) Railway station.
  - (b) Section of Railway System.
  - (c) To be unloaded on \_\_\_\_\_ or \_\_\_\_\_ side of railway embankment.
  - (d) Reference to attached sketch.
7. The owner has paid for \_\_\_\_\_ acres.

*Form A.*—At the time of signing contract \_\_\_\_\_ pengoes to the Treasury  
of \_\_\_\_\_ Village.

*Form B.*—Desires a loan of \_\_\_\_\_ pengoes.

*Results of Investigations.*

8. Depth of Humus layer on the Szik land (cms.).
9. Is there efflorescence from a sample of the ploughed layer when treated with Hydrochloric Acid ?
10. Other observations relating to soil profile.
11. General financial position of owner—
  - (a) Number of draft animals kept.
  - (b) Amount of farmyard manure available on farm.
  - (c) Can owner afford artificial fertilisers ?
12. Crops cultivated on the Szik land up to present.
13. Average yields per acre.
14. Remarks.

*Experts' proposals.*

15. On the basis of these investigations we propose, for the reclamation of \_\_\_\_\_ acres of arable szik land, the despatch of \_\_\_\_\_ 15 ton wagons of ground calcium carbonate.

Dated \_\_\_\_\_ day \_\_\_\_\_ month \_\_\_\_\_ year.

Signature.

Signature.

## REPORT.

*Results of Reclamation made in (year) in accordance with the  
Reclamation Scheme of the Ministry of Agriculture to the Royal Hungarian  
Government.*

[To be sent to the Department of Agricultural Experimentation, Ministry  
of Agriculture, Budapest, before (date) ]

## I. GENERAL DATA.

1. Name of owner or tenant.
2. Residence.
3. Position of reclaimed land.
4. Area of reclaimed land in year 19 .
5. Material used—
 

(a)	wagons (15 tons) ground limestone for	acres.
(b)	wagons (15 tons) sugar beet sludge for	acres.
(c)	wagons (15 tons) ground soft limestone* for	acres.

## II. OBSERVATIONS RELATING TO IMPROVEMENT OF THE SOIL.

1. *Permeability.*—Are there any areas on which water stands after rain, or the melting of snow ?
2. *Tilth, Ploughing.*  
Condition after ploughing, are clods soft or hard ?  
(a) For autumn cultivation.  
(b) For spring cultivation.
3. Was the dressing of lime sufficient ?
4. Is there any improvement this year over last year ?

## III. OBSERVATIONS RELATING TO THE CULTIVATION OF CROP.

1. Was there any improvement in germination ?
2. What differences have been noted in regard to the growth of plants ?
3. Did the crop mature at the same time as on unreclaimed land or not ?
4. Has the crop in the reclaimed land wintered better than in the unreclaimed land ?

## IV. CROP YIELDS.

1. What crops were cultivated on the reclaimed land ?
2. What were the average yields of these crops obtained in the summer of 19 ?
3. What were the average yields of the same crops on unreclaimed areas ?
4. If an increase in yield has not been obtained, can it be ascribed to disadvantageous meteorological conditions, act of God, plant disease or insect pests ?

Dated

(Owner's signature.)

Certified that the above data are correct.

Dated

(Signature of village authority.)

Official stamp.

\* NOTE.—This material is obtained from deposits round mineral springs and is non-crystalline.

## SECTION II—RIVER CONTROL, DRAINAGE AND IRRIGATION WORKS.

### THE SYSTEM OF RIVER CONTROL IN HUNGARY.

1. Before the war Hungary was, as will be seen at a glance from Plate I, practically a complete geographical unit. The frontiers were on the mountains practically all round the country, and water which fell on Hungarian land practically all drained into the two main rivers of Hungary, the Danube and the Tisza. The Danube passes through Hungary and receives some replenishment from Hungarian territory, while the Tisza drains practically the whole of the North and east of Hungary as constituted before the war. Only a very small area of Hungary on the north actually drained out of Hungarian territory. The fact that Hungary was a geographical unit made the co-ordination of control on the rivers a very easy matter. There are very large areas of low-lying land along the Danube and the Tisza which, in the past, were very often entirely flooded with water from the rivers, and the necessity of making these areas (some six million acres on the Tisza river alone) available for use led to the gradual building up of the control system as it existed before the war. The country was protected by the building of bunds along the rivers, similar to the bunds which exist along the Indus in the Punjab and in Sind (Typical sections of river bunds in use on the Tisza river are shown in plate IV) and by the removal of bends from the rivers by means of cuts. The actual construction of the bunds and the arrangements for drainage of the protected areas have been carried out by private companies. These companies recoup their outlay by a charge on the land protected. The position of bunds, their size and sections, and all other engineering matters, are controlled by a central authority in Budapest. This was found essential in order to ensure that uniform standards were adopted by the various companies operating. On the Tisza river all the lowlands, except an area of 80,000 acres, are now protected, and this remaining area is now also to be protected. The model, which I saw working in the hydraulic laboratory of the University of Technical Science, is one of this area, and the experiments on the model are being carried out to ascertain the effect on river levels, during flood, of the construction of the new bund to protect the area. The model is constructed on a scale of 1 to 10,000 for length, 1 to 1,000 for width, and 1 to 250 for depth. The results obtained from the model experiments are only qualitative, but show that the maximum rise in the water level of the river, during flood, above levels which have been attained in the past, may be expected to be about 50 cm. (19·5 ins. approximately). The positions, at which variations in the new flood levels from old flood levels will occur, can also be found from the model. The results of this experiment will be used to fix the top levels of the new bunds and to fix also any raising of existing bunds which is necessary. From the model it is possible, also, to measure the rate of travel of the peak of a flood.

The straightening of the Tisza river (111 cuts, in all, were made for this purpose) and the building of the bunds has resulted in the surface fall of the river during flood increasing from 2 cm. per kilom. (1 in 50,000) to from 4 to 5 cm. per kilom. (1 in 25,000 to 1 in 20,000), and has reduced the period of high water level in the river from three to four months to three to four weeks. The system of recording, and reporting, meteorological data in Hungary is very complete, and it was found possible for the Hydrological Department to predict the times and levels of floods at various points in the rivers with very great accuracy. I was informed that river levels could be predicted to within 1 cm. (1/5th of an inch). The various drainage companies are responsible for the maintenance of their own bunds, but the numbers of men employed on patrol, the stores held on the bunds for emergencies, and all other matters in connection with maintenance, are controlled by the orders of the central controlling authority. Every effort is made to grow trees on the land between the bunds and the river channels, as these are found to be the best protection against wave wash. In addition, the surfaces of the bunds are all covered with grass. Where there are no trees the water faces of bunds are protected by a face, sloping at 1 to 1, of brickwork or reinforced cement concrete. The town of Szeged was flooded, and practically destroyed, in the 19th century, and is now surrounded by a bund in order to prevent the flooding of the town should the river bunds be breached. (Typical sections of the bund surrounding the town of Szeged are shown in plate V.) This bund is faced with brickwork protection against wave wash. Typical sections of

this bund, and of the brickwork protection, have been obtained. The discipline of the patrolling staff on the bunds is very good, and it is extremely seldom that there is ever any trouble with the bunds during river floods. Bund sections appear to be much heavier than those in Sind, and typical cross sections have been obtained. Where bunds have to be built on heavy clay szik soil, the top metre (3ft. 3ins.) thickness of the water face is made from imported good soil to enable the growing of grass and to avoid the bad cracking which takes place when szik soil is dried by the sun. The Tisza river runs through heavy clay soils for most of its course, and no trouble is experienced from erosion on bunds.

As a result of the peace treaties, the sources of all the rivers of Hungary are now in other countries, as also are lengths of the rivers themselves. The proper control of the rivers in Hungary, without all the information from the head reaches and without the control of the upper reaches themselves, is now a matter of some difficulty. In addition, the losing of practically all the mountain regions on the north and east has rendered infinitely more difficult the development of irrigation in Hungary as it is now constituted.

#### DRAINAGE WORKS.

2. The construction of bunds along the rivers protected the low land behind them from the river spils, but it was very soon found that the surface precipitation on the protected areas and the run-off from higher land which drained into them (the protected land being always low-lying) caused nearly as much trouble from flooding as the river water. It was therefore found necessary to combine protection from river spils with interior drainage work and the control of the drainage water. I saw one scheme near Szeged in which the protected area is 40,000 acres, but the catchment area which drains into the protected area is a further 300,000 acres. A brief description of this scheme is given below. In addition to the low-lying lands along the rivers, much drainage work has been carried out on small areas of swamp and water-logged land lying in valleys. Plans of several such schemes were shown to me by the Chief Engineer at Debrecen. All such drainage work is done by the Government and is in charge of the Department of Hydrology of the Ministry of Agriculture. The lay-out and design of the drainage systems involve no unusual features, except that the greatest care is taken to mark on plans (similar to the Deh maps of Sind) the exact areas of land which are to be drained, so that the owners can be made to pay towards the cost of the work by lump sum or spread-over payments on capital cost or by an increase in the land tax. All channels on these small drainage schemes are dug by hand (this has been ordered by the Government to assist unemployment), but the Chief Engineer stated that the cost of excavation by machines and hand labour was about the same. The channels are all small and surface slopes are flat as a rule. The water is usually disposed of by gravity.

*The protection and drainage scheme for 40,000 acres at Szeged.*—The area protected is some 40,000 acres and lies on the west bank of the Tisza river, surrounding the town of Szeged. As a result of the peace treaties, a part of the original scheme has now become Yugo-Slavian territory. Protection is afforded by a bund built along the river bank. Behind this bund at intervals are small houses for the bund guards, and stores of materials, such as lengths of timber, brushwood, fascines, mats, etc., are maintained for dealing with emergencies. Breaches are exceedingly rare. The bund line is connected by telephone and very complete instructions are laid down for the action to be taken at each stage of the rise of the river and in any emergency. The discipline of the staff is very good, and patrolling and maintenance work appear to be most efficient. Bunds are not open to the public during the flood season, but are sometimes used during the low river season. Protection from wave wash is arranged, as far as possible, by the growing of trees on the land between the bunds and the main channel, and this form of protection has been found to be most efficient. The 40,000 acres protected serves as a drainage basin for some 300,000 acres of sloping land lying to the west and north of the area protected. Arrangements are made to collect drainage water in a system of drains which lead to sluices through the bund line. Pumps are also situated at these outfalls, but pumping is only resorted to if the water level in the river is too high to permit the drains to discharge. During the construction of the river bund a large loop of the river was eliminated and now lies behind the bund line. This old channel is used as a reservoir for the storage

of drainage water when this cannot be passed by gravity to the river. Pumping into the river is only commenced when the reservoir is full. The catchment area draining into the protected land consists of fairly long narrow valleys running from the north-east to south-west. The slopes in the Southern valleys are steepest and the land slopes gradually flatten out towards the north of the catchment area. The bottoms of these valleys consist of a series of depressions, which fill with water and from which the water overflows. The catchment area is composed almost entirely of a sandy soil. A soil survey of this catchment area, which was carried out by Chief Chemist Herke, has brought out many interesting features. In the depressions along the valley bottoms referred to above the soil tends to be alkaline, due to the standing water. In the southern valleys these alkaline areas are not bad, belonging mainly to Class I of Professor de Sigmond's classification, but the quality of land in the depressions becomes worse towards the north, until at the northern end of the catchment the land in the depressions is mostly of Class III. At the lower ends of the northern valleys nearest to the river there are large areas of Class IV lands, which are so badly alkaline as to be useless. Chief Chemist Herke attributes the change in the character of the alkaline areas to the flatter slopes of the northern valleys, which result in much slower movement of the water down the valleys. Drainage projects have been prepared for the whole of this area of 300,000 acres, but only one or two of these projects have yet been carried out. Drainage channels are designed by Kutter's formulae and their capacities are estimated by allowing a run-off of 1/20th of a litre per acre for the catchment of each drain for sandy soils, and 1/10th of a litre per acre for other soils. Slopes in the Drainage channels are not steep, and channels have to be cleared every year of weeds, etc., in the autumn. One interesting point was noticed at the discharge from one of the main pumping stations through the bund line. The pipe discharge enters a small cistern, which is provided with a baffle similar to the Primary Baffle in Barrage designs for Falls. This cistern was put in to prevent scour down-stream of the masonry work, and is very effective. Quite a small stone apron on the down-stream side of this channel is a sufficient protection. A photograph of this outfall was obtained. The total capacity of the pumps for this drainage scheme is 7 cu.m. (230 cu. ft.) per second.

Some 800 acres of Class IV land lying close to the town of Szeged are to be converted into fish ponds. Details of this scheme have been given in paragraph 8 of Section I.

*Short description of the drainage scheme seen on 27th July.*—The area drained in this scheme is 123,000 acres, and lies on the left bank of the Danube south of Budapest. The area consists of a series of shallow basins not far from, and lying approximately parallel to, the river. The actual drainage work extends roughly as far as the town of Kiskoros, approximately 100 kilom. ( $62\frac{1}{2}$  miles) south of Budapest. The areas drained were previously swamp land from which water did not disappear until August or September in each year. The catchment area for the project is some 2,000 sq. kilom. (780 sq. miles approximately), and the territory is, generally speaking, of a sandy nature. There are, however, considerable areas of heavy clay lands, especially in the areas actually drained. Drains are laid out on the valley lines as ascertained from a contour survey, and are designed to carry 0.1 litres per second for sandy land per hectare (2 acres) of catchment (0.025 gallons per second), and 0.720 litres per second per hectare (2 acres) (0.05 gallons per second) for heavier soils, and 0.3 litres per second per hectare (2 acres) (0.075 gallons per second) for heavy clay szik soils. The run-off is calculated, of course, on the whole catchment area of each drainage channel, and the rates per hectare allowed are such as to remove the water from melting snow and ice, during the period between the last frosts and the beginning of March in each year. Channels were designed by Bazin's formula. The surface slope in the main drain is 5 cm. per kilom. (1 in 20,000). The calculated maximum discharge of the main drain is 20 cu.m. per second (690 cu.ft.) and the actual measured maximum to date is 12 cu.m. per second (approximately 410 c.f.s.). The scheme took five years to construct and has been completed two years. The subsoil water level in the drained areas is now from 1 to 1.5 m. (3.25 to 4.9 ft.) below the surface. The scheme is a great success, as large areas which were once swamp lands are now growing flourishing crops. An interesting feature of the scheme was that the classification of the lands to be drained for the purpose of

payment of a charge per acre on account of drainage was carried out by a committee of peasants, and the land was graded into three classes, first class land, medium class land and bad land. First class land pays 10 pengoes 60 filler per acre (approximately 7·5s.), and the worse class land pays 3 pengoes 96 filler (2·8s.) per acre, including all charges. The excavation of drainage channels was chiefly done by hand for the smaller channels, but, on the main drain, mechanical excavators of the bucket dredger type were used. These machines are of German make and deposit the soil on one side of the canal only; photographs were obtained of a machine at work. The rates for excavation with these machines varied from 1·5 to 1·8 pengoes per metre cube (10·1 to 12·1 pence per cu. yd.); the rate in deep cutting worked out to 1·2 pengoes per metre cube (8·1d. per cu. yd.). The rate for hand labour was 1 pengo per metre cube (6·75d. per cu. yd.). The large excavator used was working on a channel average depth 2·5 m. (8·125 ft.), bed width 7 to 8 metres (23 to 26 ft.), and top width 10 to 12 metres (32·5 to 39 ft.). The side of the excavation next to the machine is at 1—1 slope and that remote from the machine is at 1—1·5 approximately, but is actually a curve from the curvature of the bucket chain. Considerable trouble is experienced with the growth of weeds in the drainage channels, and it has been found necessary to clear channels every other year on this section, although the original provision in the project was to clear once in five years. A network of tube wells has been put down over the drained areas to allow of the observation of sub-soil water levels.

Frequent and careful observations are made of the discharge in the main drain at its tail and in the middle of its length and of the depth of subsoil water in the observation tubes. Meteorological data for the area are also recorded. It is hoped from this hydrological service to be able to correlate, after some years of observations, the discharges from the drain with the run-off from the surface due to rain and melting of snow and with the variations in the subsoil water level. The results of these observations should be of very great interest. The sections of the drainage channels are made with 1—1 side slopes unless the channel is in heavy clay szik soils. When this is the case, the upper portions of the sides are given a slope of 1—1 but the lower portions are excavated at 1—2 to 1—3. This is because heavy clay szik soils when wetted tend to form a sort of liquid mud and the sides, if excavated at 1—1, settle down at 1—3, and the channels are therefore excavated at 1—3 in the first place. During our tour of the area we saw many of the drainage channels and much land, under flourishing crops, which had previously been swamps. There were two large areas of land which had previously been swamps and which, when inspected, were quite dry, the subsoil water being 1 metre or a little more below the surface. These areas of land had not been cultivated by the peasants owing to the high cost of removing the hummocks, consisting of the roots and dried stalks of reeds with which the surface of the land was covered, and Professor Rohringer, who has had charge of the design and construction of this drainage scheme, emphasised the importance of working out complete details for the cultivation of the area to be drained before the undertaking of a similar drainage scheme. He also emphasised the importance of working out a system of payments for the drained lands which would be within the capacity of the peasants to pay. The success of the drainage scheme inspected is apparently in jeopardy for two reasons, firstly because of the non-cultivation of these two large areas of reclaimed swamp land, and secondly because the rates per acre charged, although these appear to be very low considering the benefits received, are beyond the capacity of the peasants to pay in the present depressed condition of trade and agriculture.

Natural precipitation during the summer months is deficient over a large part of the reclaimed area, and a scheme is under consideration for irrigating some 15,000 acres by taking water from the Danube. This is referred to in paragraph 3 of Section II.

#### IRRIGATION AND IRRIGATION PROJECTS.

3. Irrigation, as practised in India, does not exist in Hungary. Various schemes for irrigation of areas on the Great Hungarian Plain were under consideration before the war, but, as explained above, owing to Hungary having lost the upper reaches of all the branches of the Tisza-river as a result of the peace treaties,

these schemes cannot now materialise. All possible storage sites are now outside the borders of Hungary. The only scheme which appeared likely to be carried out was the irrigation of some 15,000 acres of the drainage scheme described in Section II, paragraph 2. For this area a small canal with a discharge of 5 cu.m. per second (165 cu. ft. approximately) is to be cut from the Danube. This discharge corresponds roughly to a duty of 12.5 acres per cu. ft. per second. Even allowing for the fact that this figure includes the losses in the canal from the Danube and losses in the water distribution system, the allowance made for irrigation would seem to be very high indeed, considering that the crops which are to be grown are presumably wheat and maize, for which our duties in the Lloyd Barrage are 175 acres per cubic foot per second at Distributary Head. The Danube is controlled for navigation, so that only the canal, its headworks and the distribution system will have to be constructed, no barrage across the Danube being necessary. Experiments were being made on some small areas in irrigating crops. Water for this purpose was taken, from the main drain of the drainage scheme, by pumping. The experiments are being carried out in order to ascertain the increase in yield which may be expected from irrigated crops, and so to obtain data for working out the economic aspect of the irrigation scheme, and presumably also the rate to be charged for the water. Professor Rohringer has promised to send me, later, a plan of the drainage scheme with details of the proposed irrigation scheme shown thereon.

### SECTION III—THE ORGANISATION OF AGRICULTURAL EDUCATION IN HUNGARY.

1. This matter is not one which is intimately connected with the subject of this report, but I had the opportunity of seeing, during my tour, two types of agricultural schools, and was so struck with the organisation of agricultural education in Hungary that I obtained material for a short note. It seemed to me that the system is designed to educate the sons of peasants and other land holders definitely for agriculture and thus to encourage them to remain on the land, and at the same time to teach them improved methods of farming. Very great stress is laid on practical work at all of the agricultural elementary schools, which are situated invariably on experimental farms, and students are made to do their own share of all work on these farms. In 1766 there was in Szarvas a Protestant Pastor, Samuel Thessedik, who was a very remarkable man. He had lived in various countries in Europe and had studied many subjects, such as Botany, Natural History, Physics, Chemistry, Veterinary Science, etc., in addition to Theology. Noting the very poor and uneducated state of the people in his parish, he started a school for children during the winter months, when there was no outdoor work to be done. In this school he taught handicrafts, etc. He was the first man in Hungary to make beet sugar and to introduce the indigo plant and the culture of silk. He was given, by the patron of his living, 20 acres of bad szik land as a parish garden, and having reclaimed this land by the digozas method, he established on it a flourishing garden. He cultivated trees, produced cultivated varieties of fruit from wild trees, distributed seed and trained the peasants in improved agricultural methods and in the reclamation of alkali lands. As a result of his efforts, some 12,000 acres of land around Szarvas were reclaimed before anyone else in Hungary had thought of trying to reclaim alkali lands. He was thus the father of agricultural education and of soil reclamation in Hungary, and the Agricultural Middle School at Szarvas bears his name. After the death of Pastor Thessedik there followed a period of wars in Hungary, and it was not until after the conclusion of the war of Independence, in 1867, that Count Festertich laid the foundations of the present system of agricultural education. Since that date the system has gradually been built up. The present system of agricultural education is as follows. There are three Agricultural High Schools in Hungary. These are organised as universities, and, although they do not confer degrees, are really similar in status to universities. Each high school has its own experimental farm. The course of instruction consists of six terms, equal to three years. In the first year the work is mostly practical, in the second year the amount of theoretical work is increased, and in the third year it is increased again. After passing through the course and obtaining their diploma, students go to big estates in Hungary as "practicants" on small salaries, in order to gain experience before they obtain employment.



There is one middle school for agriculture—that at Szarvas. Pupils, before they can go to this school, have to spend four years (from 6 to 10 years of age) in the ordinary elementary school of the country and four years (10 to 14 years of age) in the ordinary middle schools of the country. They are then eligible to enter the Agricultural Middle School at Szarvas, but all students who enter this school must belong to families which own land (the area of land owned does not matter), and they are expected, on completion of their course, to go back to their land and not to take appointments. The course of instruction is of eight terms, equal to four years, and is very comprehensive indeed, including ample practical work on the 400 acre farm connected with the school. The agricultural training for the peasants is carried out at peasant schools similar to the one seen by me at Karczag. There are at least twelve such schools in Hungary. They take boys of any age, and the only qualification is that they must be able to read and write. The course in these schools is of four terms, each of half a year, and comprises both practical and theoretical instruction. The practical work is particularly stressed. The schools are always associated with experimental farms, and take usually about 30 boys. Fees for board, lodging, etc., at the school at Karczag are 300 pengoes per annum only (approximately £10 to £15). No fees are charged for tuition. In these peasant schools during the winter term additional elementary theoretical courses on agricultural subjects are arranged for any persons who care to attend. These are called agricultural winter schools. In many villages where actual agricultural elementary (peasant) schools do not exist there is a building and staff maintained for the holding of the agricultural winter school courses. During the summer months the staff of these schools tour round their areas, giving lectures and demonstrations and holding discussions on agricultural subjects, and keeping in touch generally with their students. In addition to the above, there are travelling agricultural lecturers who give lectures to peasant audiences in the ordinary village elementary schools in the evenings.

In conclusion, I must record my very great appreciation of the kindness of the following gentlemen :

Dr. Ujhelyi, Director of the Department of Agricultural Experimentation of the Ministry of Agriculture, who kindly deputed Dr. Telegdy Kovats to accompany me on my tour, and afforded all facilities in connection with my inspection of matters pertaining to the reclamation of alkali lands.

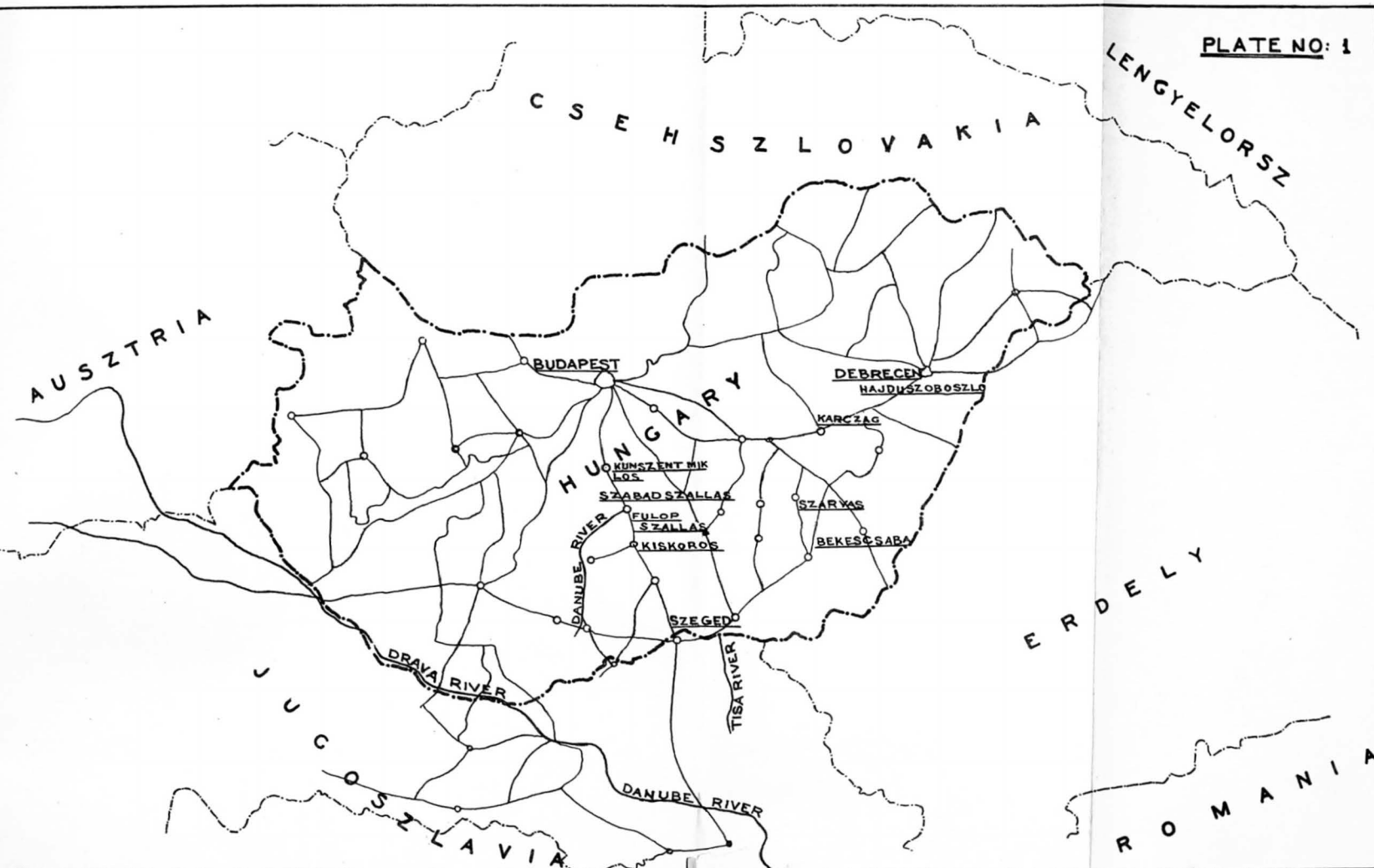
Dr. Sajo, Chief of the Department of Hydraulics, Ministry of Agriculture, who kindly afforded facilities for my inspection of the various drainage and other works pertaining to his Department.

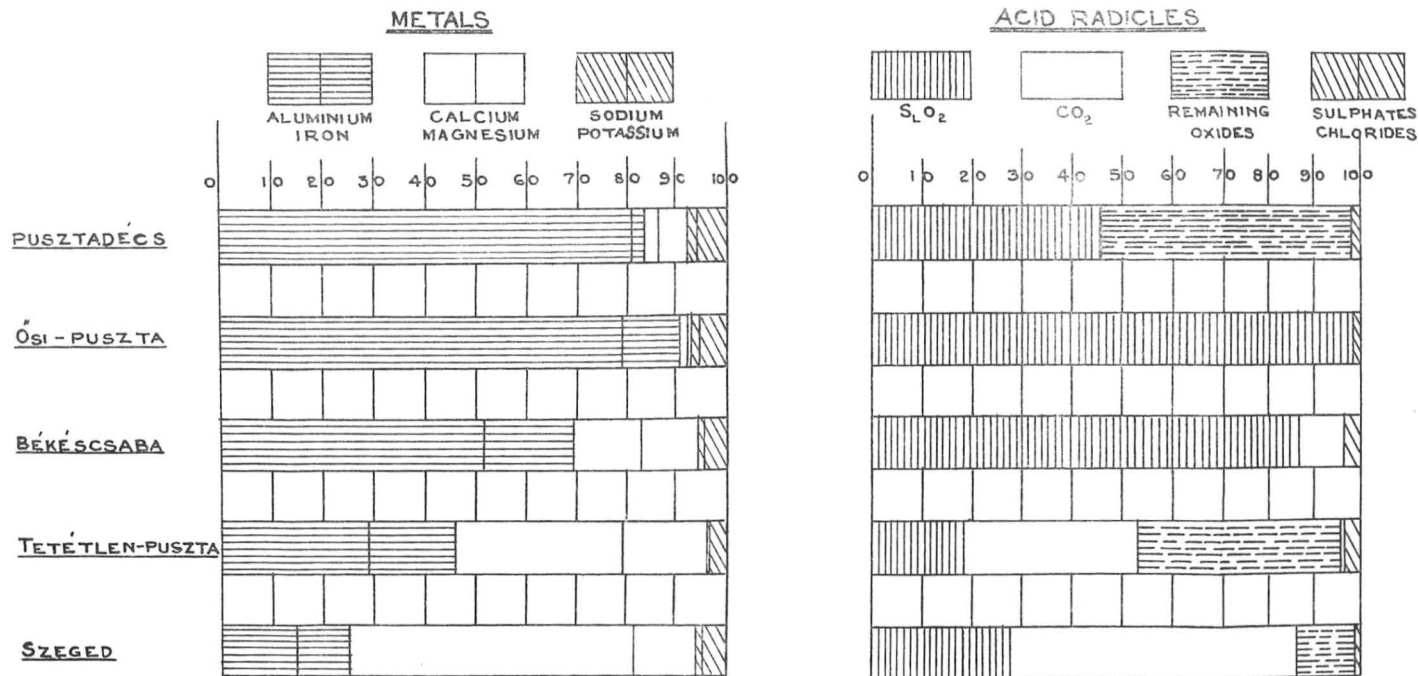
Dr. Telegdy Kovats, who organised my tour of inspection, accompanied me during the tour, acted as interpreter and placed freely at my disposal his own vast store of information on subjects in connection with alkali reclamation. The success of my tour of inspection is almost entirely due to the extraordinarily hard work put in by Dr. Telegdy Kovats.

Professor Rohringer of the University of Technical Science, who very kindly conducted me round the drainage scheme referred to in Section II of this report. Professor Rohringer, at considerable inconvenience to himself, put in a very long day during this inspection and placed at my disposal all information, plans, etc., which would help me to understand the scheme.

Finally, I should like to record my very great appreciation of the kindness and unbounded hospitality accorded to me by all the various officials and gentlemen whom I met during my tour.

C. G. HAWES,  
Executive Engineer, I.S  
Bombay Pro



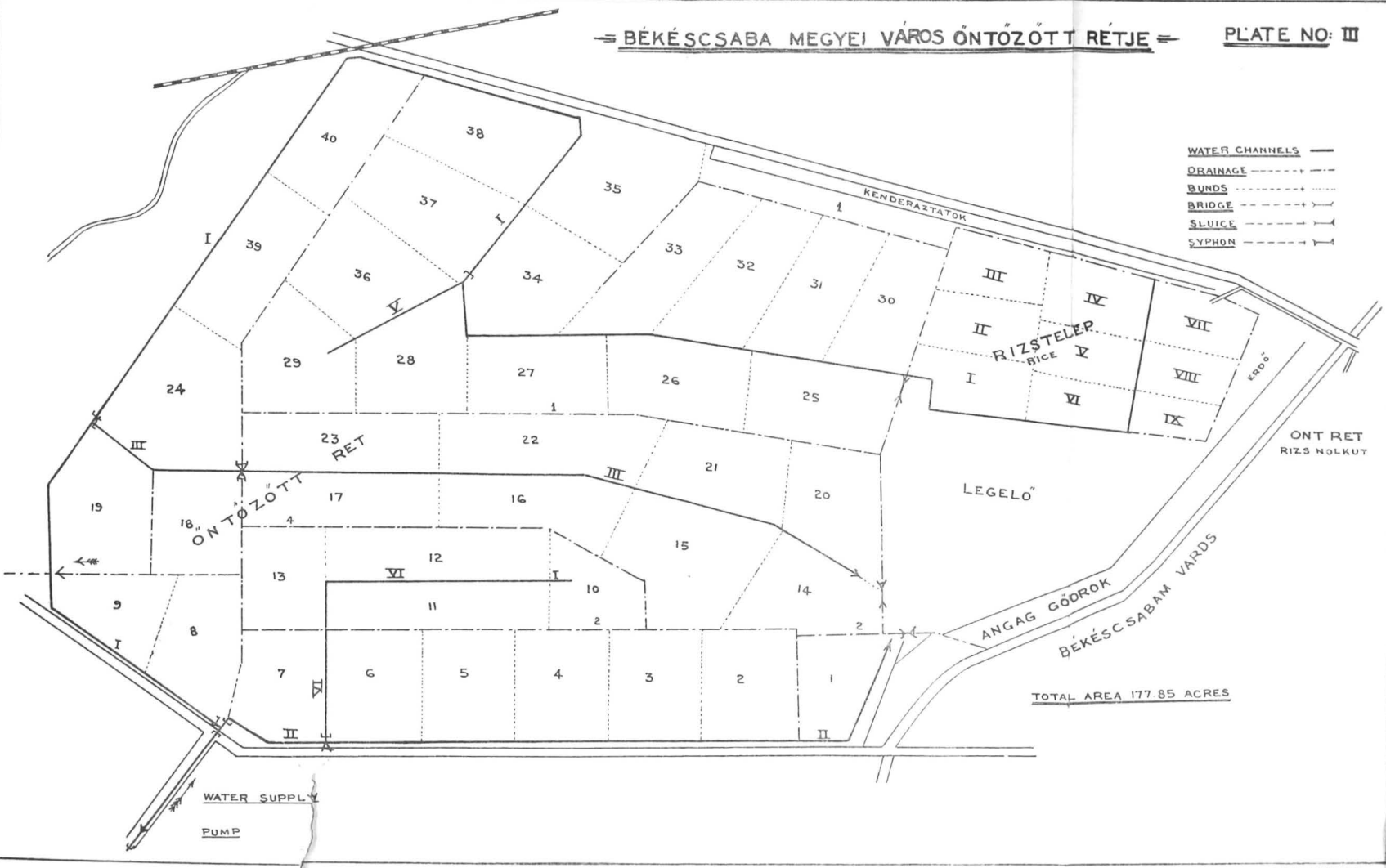


CHEMICAL CHARACTERISTICS OF HUNGARIAN SZIK SOILS

PLATE No. II

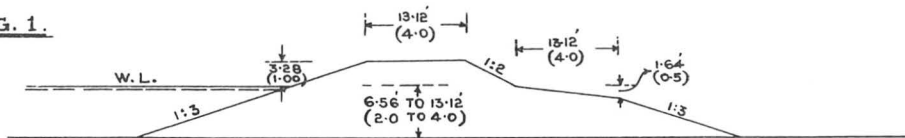
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PLATE NO: III



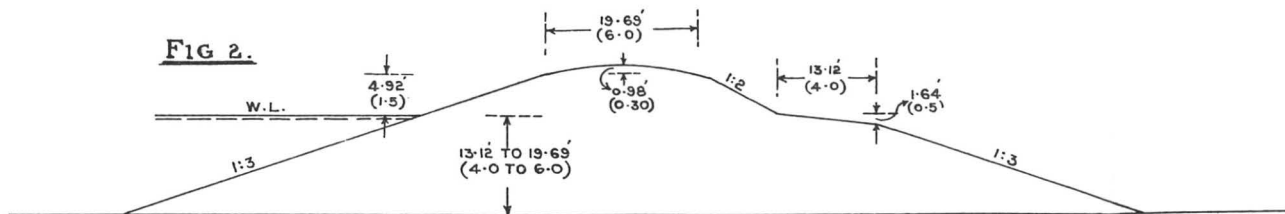
TYPICAL CROSS-SECTIONS OF RIVER BUNDS  
IN  
HUNGARY.

FIG. 1.



TYPE SECTION OF RIVER BUNDS IN THE UPPER REACHES OF THE TISZA RIVER.

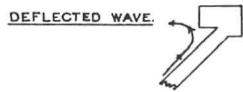
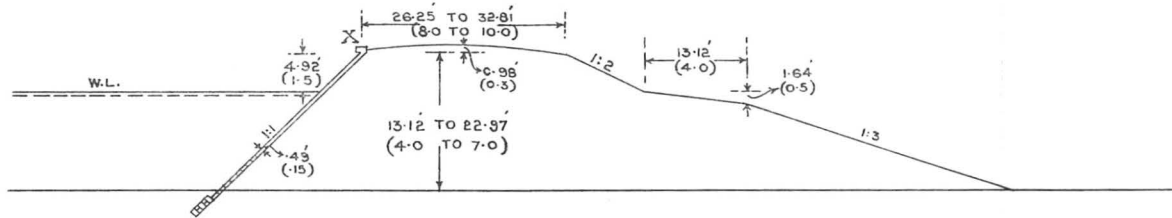
FIG 2.



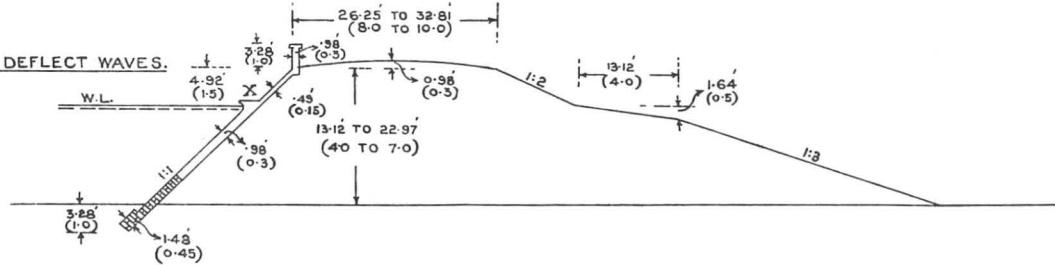
TYPE SECTION OF RIVER BUNDS IN THE LOWER REACHES OF THE TISZA RIVER.

DIMENSIONS ARE GIVEN IN FEET. FIGURES IN BRACKETS  
INDICATE EQUIVALENT DIMENSIONS IN METRES.

TYPICAL CROSS-SECTIONS OF RIVER BUNDS IN HUNGARY.



DETAIL AT X TO DEFLECT WAVES.



FIGS. 3 & 4

SECTIONS OF BUNDS PROTECTED AGAINST WAVE-WASH AS ADOPTED IN THE BUND SURROUNDING THE TOWN OF SZEGED, WHICH SOME 30 YEARS AGO, WAS ENTIRELY FLOODED BY THE TISZA RIVER.

DIMENSIONS ARE GIVEN IN FEET. FIGURES IN BRACKETS INDICATE EQUIVALENT DIMENSIONS IN METRES.