The Discovery of Peking Man*

IN his Croonian lecture on *Sinanthropus* or Peking man, Prof. Davidson Black gave a full and detailed account of the circumstances leading up to the discovery of the skeletal and cultural relics of this primitive human type and of the conditions, geological and other, in which they were found.

The first indication of the presence of early man to be found on the site was in 1921 when Dr. J. C. Anderssen, then mining adviser to the Chinese Government, noticed fragments of white quartz among loose talus at the foot of fossiliferous deposits exposed in the south wall of a disused quarry in the Ordovician limestones at Choukoutien. As no quartz of any kind occurs naturally in this part of the Choukoutien area, he at once inferred the presence of primitive man. From this point Prof. Black described the investigations which led to the discovery of a fossil tooth, first announced in 1926 on a report from Uppsala, where material from Choukoutien was under investigation; the discovery of the fossil tooth by Dr. Böhlin in 1927, upon which was based the recognition of a new human genus, *Sinanthropus*; and the discovery of the first and second of the two skulls in 1929 and 1930 by Dr. W. C. Pei, under the Cenozoic Research Laboratory, which was organised by the Geological Survey of China in 1929 and now functions as an integral part of that service. In 1930 the Geological Survey acquired by purchase full title to the *Sinanthropus* site, which is thus preserved to science for all time.

In 1931 Dr. Pei discovered artifacts and evidence of Peking man's use of fire in an undisturbed fire-blackened stratum. Prof. Black also referred to the other skeletal fragments recently described, as well as to six lower jaw fragments, of which an account is to appear shortly. The endocranial cast which has been prepared indicates that *Sinanthropus* was right-handed and possessed a nervous mechanism for the elaboration of articulate speech.

In his account of the conditions of the discovery Prof. Black was on what was probably to most of his audience less familiar ground. Channels and caverns have been hollowed out of the Ordovician limestone by the solution action of ground water; and after the elevation of the formation, erosion removed the overlying strata. Fissures which formed have been filled and these deposits converted into travertine.

The cavern occupied by *Sinanthropus* was large, of irregular shape, and opened towards the river valley to the east. Throughout the time it was being gradually filled by detritus, it was wholly or in part occupied by *Sinanthropus*. His occupation must have extended over hundreds, probably thousands, of years, for more than thirty metres of undisturbed strata remain, showing evidence of his presence throughout. During the later part of his occupation the fauna did not change, but remained typically that of the upper part of the Lower Pleistocene.

Most of the northern limestone wall limiting the original cave has been removed by modern quarrying operations exposing the solidified detritus. Up to 1932, excavations of the actual deposits have been confined to the regions accessible from the northern face. Work is now progressing along the line of contact between the accumulated deposit and the southern wall of the original cave.

The modern cave of Kotzetang is really the result of recent excavation, made probably by quarrymen, in the relatively unconsolidated portion of the great stratified breccia comprising the eastern portion of the main Choukoutien deposit. The northern wall is part of the original northern wall of the cavern.

Prof. Black also referred to the artifacts and the recent study of them by Dr. W. C. Pei and P. Teilhard de Chardin, from which it is concluded that *Sinanthropus*, "culturally speaking, is to be considered as an early representative of the Old Palæolithic cycle, but his craft displays a crudity which indicates that he but obeyed and never mastered the materials with which he worked"

* Substance of the Croonian lecture delivered by Prof. Davidson Black before the Royal Society on December 8.

Capacitance Hygroscopy and some of its Applications

By Dr. W. LAWRENCE BALLS, F.R.S.

SOME experiments were briefly noted in this journal last April[1] whereby the high dielectric constant of water was used to indicate variations in the water-content of substances contiguous to a leaky condenser, by means of a resonance method. It would seem that other workers are exploring the same track, with the difference that they draw samples which are placed in special condenser-containers for measurement, whereas I prefer to take full advantage of the method in evading the ubiquitous 'sampling-error' so far as possible; even at the sacrifice of some accuracy in the actual determination. Great accuracy is probably unobtainable in any case; the dielectric constant even of free water is not a constant, but the margin of difference between water around 80 and most other common substances below 8 is large enough for most classes of comparative work.

The necessary apparatus is as portable as an attaché case, and is proving itself to be of versatile utility. Examples will shortly be given. On the analogy of resistance thermometry, I suggest that the general technique might be termed 'capacitance hygroscopy'.

The arrangement at present used is necessarily capable of improvement in electrical design, but it functions very usefully when its limitations are respected, especially since the discovery of papers by Lattey and his collaborators has allowed voltage-tuning to be incorporated.[2] This is done by applying the resonator voltage to the grid of a second valve, the anode current of which then indicates the voltage, as in the Moullin thermionic voltmeter[3]; the coupling between the generator and resonator can be kept very loose, and a feeble and portable generator used with safety. The triple circuit shown in Fig. 1 is also a plan of the arrangement. It undergoes small zero shifts due to temperature and also to earth-capacity, but these are eliminated by zero-setting with one variable condenser, prior to measurement on the other one. Variations of resistance in the unknown capacity can also alter the 'capacitance' readings, in spite of voltage tuning, as Lattey has recently pointed out; the elimination of these errors is no doubt possible, but even now it is practicable to obtain accurately comparative readings in repetition work, the voltage indications serving as a warning of abnormal conditions. Definite fixation of frequency by a quartz crystal, capacity coupling, and proper screening, are obvious improvements next to be made.

Three examples of very diverse applications will now be outlined.

SOIL-WATER DETERMINATIONS

The buried condensers are, as formerly described, made from purchased glass web-tube, or from home-made capillary web-tube produced by blowing two bulbs together and then drawing them out. Staybrite steel wire (33 s.w.g.) is used for the final lead-in, to avoid amalgamation. Gutta-percha seals these wires in the entrance to the web-tube. The larger tubes are wrapped in a thin skin of cotton fabric dipped in plaster of Paris, so as to stabilise the capillary water conditions in contact with the glass; an assumption is made here. The leads are made of thin widely-spaced wires inside gas-pipe, so that they may be as insensitive as possible to the soil-water variations until the web-tube is reached at depths of three metres or so, but their design is not yet properly worked out.

Some very complex curves for changes in soil-capacity with changes of moisture have recently been published,[4] determined by a compensated bridge method. They contrast very sharply with such simple curves as Fig. 2, which seem to me to be more inherently probable. Actually even these latter

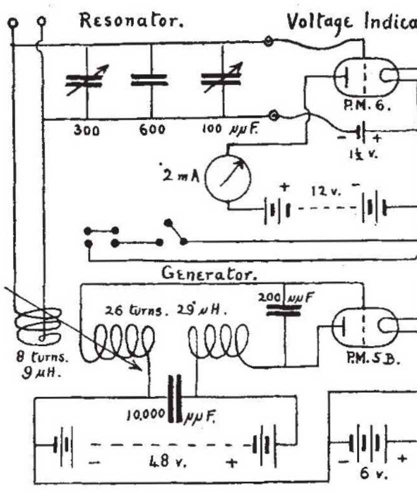

FIG. 1—Circuit diagram and plan. $\lambda = 150$ m.; $f = 2000$ kc.; $\delta = 0 \cdot 06$. Size: 12 cm. × 32 cm. × 38 cm. Weight 8 kgm.

are more complex than those obtainable in deep soil, because the capillary web-tube condensers were buried initially in air-dry soil which was allowed to swell freely on saturation with water, and then to shrink into a compact block as it dried. In the field one would not obtain the volume increase except near the surface. The inflection shown by both curves, representing two separate experiments, near the point at which deep soil becomes water-logged in the field,[5] marks the upper limit of capacitance under deep soil conditions. The fragment of hysteresis loop obtained after oven-drying and slowly damping again by exposure to air, is probably also abnormal in width, owing to minute air-space cracks developing between the soil and the bare capillary glass.

TESTING COTTON BALES

As president of the Trustees of the new Alexandria Testing House, founded in consequence of an international trade agreement. I have been given exceptional facilities by the pressing firms of Alexandria,

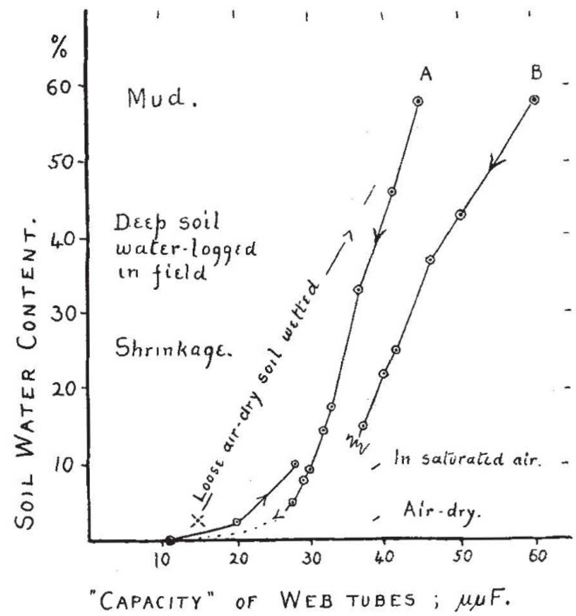

FIG. 2. Soil moisture.

to obtain data from bales specially prepared to various moisture contents, while Mr. D. A. Newby has collaborated in making the oven tests more exact. Capacitance tests are now being taken as routine on the hoops of all bales from which oven-tests are to be made, so as to accumulate several hundred pairs of observations. It already seems likely that so long as the test is limited to freshly pressed and homogeneous bales, as formerly suggested, we have a useful and rapid method of control which can test every bale made, and can do so at much less cost than the usual oven-testing of every tenth bale. Whether it can be trusted to the extent of dispensing with oven-tests at the press-foot remains to be seen.

I excluded the non-homogeneous bale from the original scheme of possible capacitance tests, but the finding of a solution for the special problems created by the presence of a wet or dry outer layer, or even more complex distributions of water in depth, is most alluring. It now appears that differential testing at various depths can be done by altering the grouping of the bale hoops upon which contact is made when the attaché case is hung on the bale. Fig. 3 shows how the drying of the surface during hot dry summer weather, from one day to another, is much more noticeable when successive hoops are 'contacted' (2,4,6 v. 3,5) than when deeper penetration of the field of force is secured by missing out three intervening hoops (2.10 v. 6). Such a figure is also a nomograph for determining moisture content. The case is analogous to resistance measurements in geophysics, but the curve of penetration seems unfortunately to be much flatter.

An incidental fact is that the 'capacitance' observed by our system of using the bale-hoops themselves as condenser 'plates' is almost exactly proportional to the volume of the triple dielectric—air, cotton, water —and not to its thickness. A similar departure from convention is shown by the capacitance of 'hoops in air', namely, a bale-skeleton of hoops spaced out on thin wooden rods; the capacitance of a few wide-spaced hoops is markedly higher than it should be in relation to the reading from close-spaced hoops.

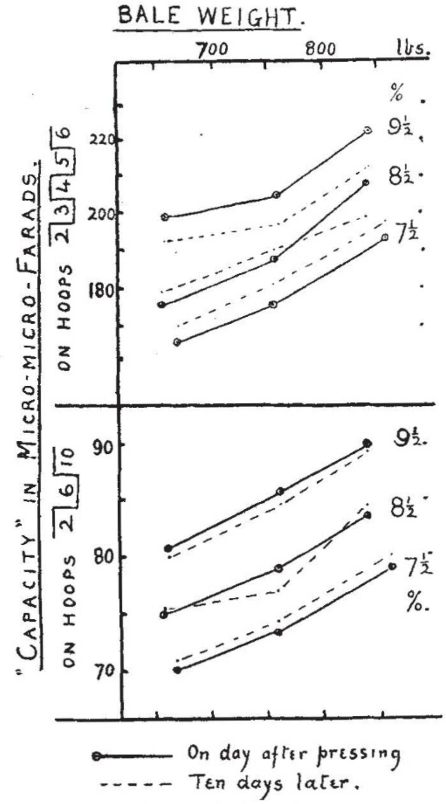

FIG. 3. Cotton bales.

A trial of the method at Manchester Docks on a day when the weather was typical for the locality, using a hoop-grouping which tested only the surface of the bale, gave the interesting result that the surface moisture content was so high as to be off-scale, although the average of the whole bale when oven-tested was near normal. The bale had gained two pounds in weight since being taken off the ship. The demonstration was a failure from the spinner's view-point, but very successful from the exporters'.

INDICATING THE GROWTH OF CROPS

It is common experience that the capacity of a radio antenna is increased by the increasing proximity of branches of trees, but we are not aware that the phenomenon has been used in the inverse direction, to measure the growth of the tree.

Some small scale experiments in my English garden, made chiefly on the exceptionally difficult subject provided by a grass lawn, show that the capacitance hygrometer apparatus is usable to give instantaneous readings of the changes in capacitance consequent on increased water-content due to enlargement by growth. Two forms of 'condenser' have been used, the first being bare wire netting half a metre square, supported on insulation at 5 cm. above the surface of the lawn, with a counterpoise earth of similar netting below it, pegged down firmly; the grass and clover grew through this lower plate of the condenser, the capacity of which rose as shown in Fig. 4, evidently following the varied weather of the period, and the final removal of one-fifth of the grass with a hot iron.

Such arrangements of bare wire suffer from instability, on account of defective insulation, especially when water-drops are present after rain or dew. This is more easily examined by using miniature antennæ of wires stretched under constant tension. If rubber-covered wires are used, including a counterpoise wire, the 'capacity' observed is inversely as the voltage, due to dielectric absorption.

A workable arrangement consists of three such wires, each 3 metres long. One is pegged firmly down to the surface of the freshly mown lawn as a counterpoise, the other two supported above and parallel, forming an equilateral triangle in end view, of 3 cm. side. The field of force between the two upper wires on one hand, and the counterpoise on the other, passes through the growing grass; the initial capacity is about 100 μμF., and may rise as much as seven or eight μμF. in a day. From this starting point we can design longer and more widely spaced antennæ, and it should be a simple matter to string such antennæ across a field of growing crops; the reading could be made continuous by coupling my universal recorder to the condenser dial and operating it by a contact on the milliammeter; the decrement of the circuit as well as the capacity

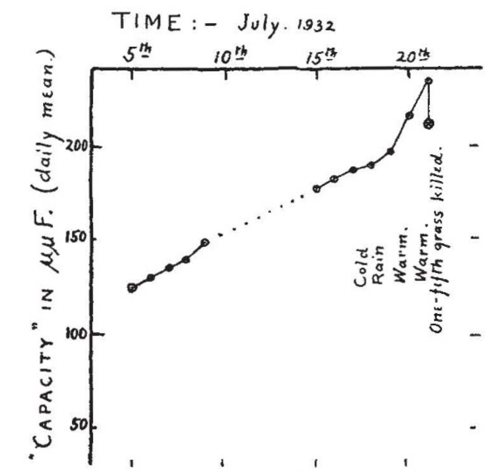

FIG. 4—Condenser of wire-netting on a grass lawn.

would thus be recorded. The method seems eminently suited to cereal crops, which have hitherto presented serious difficulties in growth-measurement. As before, the sampling error becomes trivial.

In all such arrangements it is evident that the capacitance increment for a given volume of growth will change progressively, so that it would be difficult to establish a quantitative relation over long intervals of time. But this is relatively unimportant, since long-period growth is obtainable by cruder methods;

the discrimination between growth-rates on successive days is easy, and this has been the difficult part of field-growth measurement.

An extensive publication of the results obtained in the many thousands of readings which have been taken by this method during the past year does not seem justifiable, since so many of them have been devoted to elucidating electrical difficulties which could probably have been solved *a priori* by a more competent worker. Some detailed publication on the special case of the cotton bale will in any case be necessary, on account of its commercial importance. On the other hand, it is clear, from letters received, that the application to soil alone is of interest to an unexpected variety of scientific students. Therefore it seemed desirable to put together an outline of all the essential facts, difficulties and limitations thus far encountered, so that other workers may be able to develop the application of the technique to their own special problem, and yet may realise that such application is in itself an experimental investigation of the technique and of its many side-issues. The method is qualitative rather than quantitative, and is best used under standardised conditions, until such time as it is more fully worked out; meanwhile, advice and independent effort in so doing would be welcomed.

[1] W. L. Balls, NATURE, **129**, 505, April 2, 1932.
[2] For example, Lattey and Davies, *Phil. Mag.*, **12**, 1111; 1931.
[3] Moullin, E. B., "Radio-Frequency Measurements". Griffin, London, 1931.
[4] *J. Agric. Sci.*, 1932.
[5] W. L. Balls, *J. Agric. Sci.*, 1913.

University and Educational Intelligence

BIRMINGHAM.—At a meeting of the Council on December 7 the Pro-Chancellor (Sir Gilbert Barling) announced a generous gift by Lady Barber, widow of Sir Henry Barber, founder of the Faculty of Law in the University. The benefaction consists of securities providing an annual income of about £12,000, to be devoted "to the provision of an Institute of Fine Arts in the University; to the advancement of music and musical education in the University, and to further developments in the Faculty of Law which was brought into existence by the founding of the Barber Chair of Law". The deed of trust provides for the erection of a building on the University site at Edgbaston to include galleries for exhibition of works of art, a chamber for musical recitals, and a musical department with a library and a museum for the accumulation of musical manuscripts.

The Pro-Chancellor, Sir Gilbert Barling, has announced his intention of retiring from office at the end of the year. Sir Gilbert Barling, who succeeded the first Vice-Chancellor (Alderman C. G. Beale) in 1913, has an extraordinary record of personal service to the University, in which, at the age of seventy-seven years, he still takes a very active interest.

A grant of £50 has been made from the Lapworth Research Fund to cover the cost of cataloguing pamphlets, maps, etc., of the late Prof. Lapworth for the Lapworth Library of the Department of Geology.

LONDON.—The Mercers' Company and the Fishmongers' Company have decided to make grants to the University in the shape of annual payments extending over a series of years and amounting in each case to a total of £10,000. These gifts will be applied by the University towards meeting the cost of the new Ceremonial Hall to be erected on the University's site in Bloomsbury.

THE Institution of Naval Architects scholarship, valued at £130 a year for three years, will be offered for competition in 1933. This scholarship is open to apprentices under the age of twenty-three years, from the royal dockyards or private shipyards, and is tenable at the Royal Naval College, Greenwich, or the Universities of Glasgow, Durham (Armstrong College) or Liverpool. Full particulars may be obtained from the Secretary of the Institution of Naval Architects, 2 Adam Street, Adelphi, London, W.C.2.

THE twenty-first annual Conference of Educational Associations will be held at University College, Gower Street, London, W.C.1, on January 2–9, under the presidency of the Right Hon. the Earl of Athlone. On January 2 there will be a joint conference on "The Trend of Education" at which Mr. H. Ramsbotham, Parliamentary Secretary to the Board of Education, Miss W. Mercier, principal of Whitelands College, and Mr. J. E. Barton, president of the Association of Head Masters, will speak.

Calendar of Geographical Exploration

Dec. 21, 1605.—Torres Strait

Pedro Fernandez de Quiros, accompanied by Luis Vaez de Torres in a second ship, left Callao. Quiros, while pilot on a previous expedition to the Santa Cruz group, had become fired with the idea of a great southern continent, thought by him to lie near Santa Cruz. Quiros passed through the centre of the Low Archipelago, thence north of Samoa and the Fiji group and finally discovered Espiritu Santo in the New Hebrides. Quiros then returned, but Torres continued, discovered the strait named after him and proved the insularity of New Guinea. His discoveries passed unheeded at the time, but after the capture of Manila in 1762, his narrative fell into the hands of Alexander Dalrymple and the value of his work was realised.

Dec. 21, 1835.—Exploration of Oman

Lieuts. Wellsted and Whitelock reached the fertile district south of Jabal Akhdar, the main range of Oman. There they were astonished to see "verdant fields of grain and sugar cane . . . and streams flowing in every direction". Wellsted was the first to explore this south-eastern corner of Arabia scientifically and was, for part of the time, assisted by Whitelock. Political disturbances prevented Wellsted from crossing the desert to Nejd and he returned to India in 1836.

Dec. 23, 1558.—An English Trader in Russia

Anthony Jenkinson reached Bukhara. He was a trader who had travelled in the Levant and went to Russia in 1557. There he set out from Moscow, reached the Volga and sailed down it to the Caspian, making a rough survey of the north of that sea. Thence he travelled to Bukhara, where he spent three and a half months, returning to England through Russia. In 1561 he went to that country again and, following a route along the west of the Caspian, reached Kazvin, the capital of Persia, in October 1562. Though his journeys did much to increase our knowledge of Russia, and the lands to the south-east of it, English trade via that route ceased in 1581, thus giving an impetus to voyages in the Levant.