in 1698, replying to a query by the celebrated philosopher G. W. F. Leibniz at Hanover, with whom Papin had been since 1692 in close correspondence, he says: "The manner in which at present I employ fire for raising water is always on the principle of the rarefaction of water. Only I do so at present in a manner much more easy of execution than that which I have published; furthermore as well as using suction, I employ also the pressure that water exerts on other bodies in expanding (by heat) the effects of which are not limited like those of suction. Thus I am persuaded that this invention if it can be pushed as it should be could prove of very considerable utility, but I have not yet made great progress."

The outcome of this was that, in 1707, Papin set down his conclusions in a work published at Cassel entitled "Nouvelle Manière pour lever l'eau par la force de feu". In this he advocated an apparatus similar to, though perhaps not so efficient as, the 'fire engine' patented and introduced in 1698 by that prolific inventor Thomas Savery, in which steam at high pressure was used to raise water much in the way that is done by the pulsometer of to-day. Evidence that Papin's engine was made and used is lacking, but had it been so there is no reason to believe that it would have been any more successful than that of Savery; the latter, unlike Papin, was a practical man, with a workshop in Salisbury Court, Fleet Street, London, and if anyone could have made the fire engine a success he could. The fact was that both the philosophers and the practical men of the day were thinking along the wrong lines, for in the then state of the mechanic arts steam boilers could not be made to stand the high pressure that they required. It was reserved for Thomas Newcomen, an ironmonger of Dartmouth, Devon, who, recognizing the limitations of craftsmanship and of the materials at his hand, employed steam of no higher pressure than that of the atmosphere under a piston in a cylinder and condensed the steam with a jet of water, thereby succeeding by 1712 in inventing a practical engine. Papin can be awarded the credit that he was the first to suggest that by creating a vacuum under a piston in a cylinder the pressure of the atmosphere could be made to do work.

The truth is that Papin was a most fertile inventor —his brain teemed with ideas—but time and opportunity did not allow, or was not allowed, to serve to reduce them to practical working machines. We may instance the Hessian pump, which was the undoubted forerunner of the centrifugal pump of a century and a half later. Papin took up many other schemes that it would be tedious to enumerate, and we shall only mention his mechanically propelled boat, by which, having decided in 1707 to return to England, he had the crazy idea for a man in his sixtieth year of paddling down the River Weser to Bremen. Starting from Cassel along the River Fulda, he got as far as Münden, the junction with the Weser, when he was stopped not only by the customs authorities but also by the bargemen, who feared that their livelihood was threatened by the new-fangled craft. The statement that he employed his steam engine to propel the boat is more than doubtful. Undeterred, he continued his journey overland, and on arrival in England, he seems to have received a cool reception. Several of his good friends had died while he had been away: Boyle in 1691; Sir Joseph Williamson, who had been president (1677–80) of the Royal Society; and Hooke in 1703; Richard Waller, appointed in 1682 to succeed Hooke, was now secretary to the Society.

On February 11, 1708, Papin submitted to the Royal Society a proposition to "construct a boat to be rowed by oars moved with heat", following on the lines of the one he had built at Cassel; but the Society would not advance the requisite sum, estimated at £15, for the experiment, and so the project fell through. How he lived during the next four years we can only surmise. In 1711 alone he submitted six papers to the Royal Society. In the last letter extant from him, addressed to Sir Hans Sloane and dated January 23, 1712, he concludes pathetically but bravely, "Certainly, Sir, I am in a sad case since even by doing good I draw ennemi's upon me, yet for all that I fear nothing because I rely on God Allmighty". We hear nothing further about him, and the supposition is that he died a few months later in Soho, where he had been living. All efforts to find out particulars of his death have been unsuccessful. Thus passed away an acute natural philosopher, a clever mechanician and a fertile inventor, who sowed the seeds of several inventions that were to bear fruit in after years.

Further steps to commemorate the tercentenary are being taken. An exhibition of documents, models and drawings concerning him and his work was held at Blois during August; to this the Royal Society contributed microfilms of all Papin documents still in its possession. His baptism was commemorated on August 22 in the church at Blois; and a ceremony will take place at Angers to recall the conferring of his doctorate of medicine. In October an exhibition will be held at the Conservatoire des Arts et Métiers, Paris, including much of the material shown at Blois; finally, a commemorative meeting at the Sorbonne is being arranged.

PLANT BREEDERS' CONFERENCE AT CAMBRIDGE

A COMPREHENSIVE picture of all the phases of plant breeding work at Cambridge was seen by plant breeders assembled for the first conference called by the Agricultural Research Council and held during July 9–11, for workers from the Aberystwyth, Cambridge and Corstorphine Plant Breeding Stations and the John Innes Horticultural Institution, Merton. Such conferences were recommended by the Plant Breeding Survey Group of the Agricultural Research Council and in future years will meet at the other stations in turn, enabling workers at breeding stations supported by the Council in Great Britain to learn the main outlines of the work at the other institutions and to discuss their common problems.

The conference was rather informal; talks and laboratory and field demonstrations were used to describe to the visitors the work of the Cambridge University Plant Breeding Institute, and visits were also paid to the Imperial Agricultural Bureaux Empire Potato Collection, the Horticultural Research Station and the National Institute of Agricultural Botany.

The Plant Breeding Institute, one of the research institutes of the School of Agriculture, is engaged in the improvement of wheat, barley, oats, potatoes, sugar beet and forage crops. The staff of the Institute at present consists of Dr. G. D. H. Bell (acting director), Sir Frank Engledow, Mr. C.

Barclay, Dr. A. B. Bauer, Mr. A. Bolton, Mr. J. L. Fyfe and Dr. H. W. Howard. Much of its work follows the well-established methods of breeding, being based on inter-varietal crosses, with pedigree selection leading to small-scale trials. An example of a breeding programme of this kind was seen in wheat—the continuing work of combining the good milling and baking qualities derived ultimately from Red Fife with the characteristics required in an English wheat variety. This work has already led to the production of Yeoman and Holdfast, the latter a typical successful modern wheat with high yield and short straw suitable for fertile soil and for 'combine' harvesting. It is a white-grained wheat with something of the tendency to sprouting in a wet harvest which is so often found in white wheats. From crosses with red-grained varieties, selections have been obtained with red grain (and therefore less sprouting), and some of these have reached the stage of N.I.A.B. trials. Similar methods are being used in the improvement of wheat varieties for biscuit-making and of spring wheat varieties.

With malting barleys, three main lines of improvement are being followed:

(1) The general improvement of Spratt–Archer and Plumage–Archer, the two main spring varieties for Britain. This has led to the production of Earl, a selection from Spratt–Archer with the characteristics of that variety coupled with 7–10 days earlier maturity.

(2) The breeding of varieties more resistant to lodging by crossing with the short-strawed Danish varieties Kenia and Maja.

(3) The development of winter-hardy malting varieties of which Pioneer, a two-rowed winter form, and Prefect, a six-rowed form, are already on the market.

Attention is also being given to the breeding of feeding barleys, especially for soils the fertility of which precludes the growing of first-class malting barley. Camton is an example of a variety with high yield and good standing powers produced with this requirement in view, though it has since proved to be a reasonably good malting barley.

In oats the most important line of work is the development of winter oats of good grain quality (low husk percentage) and good standing power. A great handicap in this work is the lack of a highly winter-hardy parent, the British variety Grey Winter and the similar French variety Avoine Grise d'Hiver being the main sources of winter-hardiness. From crosses between Grey Winter and a stiff-strawed spring oat of unknown origin called Argentine, the varieties Resistance and Picton were bred. Picton practically equals Grey Winter in hardiness and has white grain and much better standing power. Resistance also has much better standing straw but is not sufficiently winter-hardy; by crossing it again with Grey Winter, a hardier type, *C.A.*10/3, has been developed and is now in trial at the N.I.A.B.'s substations. The breeding of spring oats suitable for the drier conditions of the Eastern Counties is also in progress, and here again one selection has reached the stage of N.I.A.B. trials. Special attention is also paid to the development of spring varieties resistant to frit-fly.

The close relation between seed production and plant breeding is well illustrated by the work on sugar beet breeding. This was started during the War when Britain was cut off from Continental sources of seed, as a precaution to help safeguard the home-grown seed supply. From this beginning has developed a breeding programme a feature of which is the attention paid to ancillary criteria of selection such as cluster characteristics, seedling establishment, biochemical features and the physiology of development; low temperature and continuous light treatment are used to intensify any tendency to annual habit, and so lines susceptible to bolting can be detected even in a season when bolting is not prevalent.

Field peas, beans, sainfoin and lucerne are the principal forage crops worked on at the Plant Breeding Institute. The work on peas shows how the plant breeder can assist the farmer by making harvesting easier. New varieties have been produced, some with shorter haulms, others with earlier maturity, and yet others with several pods per node and therefore more nearly simultaneous ripening. Selection for resistance to black fly is the main objective in the work on spring beans. With sainfoin and lucerne, improvement by selection of parents which have been progeny-tested by inbreeding and by natural out-pollination is the basic procedure, and it is intended to include crude protein content as one of the criteria of selection. Other crops on which some work has been carried out include maize, sunflower, soya beans, red fescue, cocksfoot and other grasses.

The visit to the Horticultural Research Station provided further examples of plant improvement by the exploitation of diversity within a species, the crops concerned being cauliflowers, broccoli, brussels sprouts, carrots, peas and strawberries.

The later stages of this type of crop improvement were seen at the National Institute of Agricultural Botany, where the visitors were shown observation plots, large- and small-scale variety trials and propagation plots of standard and new varieties of agricultural and horticultural crops.

The breeding of blight-immune potatoes at the Plant Breeding Institute is a good example of the wider possibilities opened up—and the attendant difficulties—when related species are brought into the breeding programme. The foliage immunity to late blight which is being incorporated in the domestic potato (*Solanum tuberosum*, $2n = 48$) is derived from *S. demissum* ($2n = 72$), where it was discovered by R. N. Salaman. He began the work of hybridization, which was transferred to the Plant Breeding Institute on his retirement. Repeated back-crossing by the few domestic potatoes which are pollen-fertile, with continual selection for blight immunity in artificial tests, coupled with selection for the desirable attributes of a commercial potato, have brought the work in some twenty-five years to the stage where the release of a variety is within sight. Forms are now available which are worthy of trial against the standard varieties, and are resistant to the three strains of *Phytophthora infestans* known to exist in Great Britain. At the Empire Potato Collection, housed nearby, wild and cultivated South and Central American potato species and varieties are being systematically studied and maintained for distribution to Empire potato breeders.

Wheat is another crop in which these wider possibilities are being explored at Cambridge. A world collection of wheat species and varieties was maintained and studied there for many years before the War, and it is now being resuscitated. At the same time the widest survey is being undertaken of the possibilities of hybridization within the Triticinæ and the production of synthetic allopolyploids by colchicine doubling. On the more practical side the cross between *Triticum vulgare* and *T. turgidum*, followed by back-crosses to each parent, has been investigated and has led to the breeding of *vulgare*-like forms with the high floret fertility of *turgidum* and of *turgidum*-like forms with shorter straw and earlier maturity.

Phylogenetic and taxonomic investigations in relation to plant breeding formed one of the topics of a discussion held during the conference. J. G. Hawkes reviewed the taxonomy of the relatives of the potato. He showed how studies of the kind pursued at Cambridge and elsewhere, on the classification, geographical and ecological distribution, economically useful characteristics, chromosome number and range of possible hybridization, form a necessary background for the plant breeder's work. J. M. Munro reviewed the work on wide crosses among the Triticinæ. He outlined the relationships of certain species and genera in terms of genom-analysis and described briefly the two main methods of using colchicine to synthesize allopolyploids; the F_1 hybrid may be treated or the parents treated and the resulting forms with double chromosome number crossed to produce a fertile F_1. From the plant-breeding point of view most interest lies in the work of re-synthesizing hexaploid wheats by crossing tetraploid wheats with *Ægilops squarrosa, caudata* and *speltoides*. Special attention is being paid to this aspect of the work at Cambridge, the ultimate aim being to introduce the synthesized hexaploids into the wheat-breeding programme.

T. J. Jenkin gave a brief account of the relationships within and between *Festuca* and *Lolium*. The general discussion brought out clearly the inter-relationship between cytogenetic and taxonomic work and the value of both to the breeder in providing him with a guide to the material at his disposal. There was some discussion on the naming of new allopolyploids in relation to the binomial system; it was generally agreed that it was desirable to use purely conventional names to indicate their origin and not to name them formally as new genera or species, at least unless and until they become established as more than purely experimental material.

This topic led naturally to the other subject selected for discussion—living collection of crop plants and their relatives. C. D. Darlington pointed out that we have inherited the needs which prompted the establishment of botanic gardens some 300 years ago, but that the existing botanic gardens no longer fulfil those needs. The provision of one garden to maintain a collection of the economic plants of temperate regions and their wild relatives and ancestors would greatly stimulate the improvement of crops. The staff should include cytologists and geneticists. P. S. Hudson recounted the more or less urgent resolutions which have been unanimously carried at a number of official and scientific conferences where this subject has been discussed. But the position, in fact, remains as it was: a few specialized collections exist in the British Empire, with no organised attempt to co-ordinate them, to extend them or to build up new ones. A lively debate followed in which the relative merits of special and general collections were discussed and the difficulty of maintaining collections at existing stations, unless special financial provision could be made, was stressed. A resolution was passed unanimously urging upon the Agricultural Research Council the present need for the appointment of a collector whose main duty would be the assembly of collections of the type indicated.

The conference clearly fulfilled a long-felt need, and those attending expressed a desire to hold future conferences annually at the four stations in rotation and during the growing season. Even though many of the crops were disappointing owing to the severe and prolonged winter, late sowing and spring drought, the value of having the living material there for discussion was obvious.

OBITUARY

Sir Clive Forster-Cooper, F.R.S.

SIR CLIVE FORSTER-COOPER, director of the British Museum (Natural History), died on August 23. He was born in London in 1880, and was educated at Rugby and Trinity College, Cambridge. At Cambridge he became greatly interested in zoology, and in 1900 joined Stanley Gardiner's expedition to the Maldives and Laccadives. Shortly after his return, he joined the staff of the North Sea Fisheries Commission research establishment, spending a year in this service, largely at sea in a converted trawler. He then returned to Cambridge to take part in another expedition designed to enlarge our knowledge of the marine biology of the Seychelles.

Forster-Cooper might thus have devoted his life to the study of marine biology and of fisheries problems, but a meeting with Dr. C. W. Andrews of the British Museum, who had himself worked on marine biology at Christmas Island, introduced him to fossil mammals, and especially to the wonderful fauna of the Fayum. The problems presented by these materials, and the wide importance of fossil mammals in general, seized Forster-Cooper's imagination, and he joined Andrews in an expedition to the Fayum in 1907, learning in this way not only the technique of collecting fossil bones, but also the manner in which an expedition into a desert country could be conducted.

On his return from Egypt, Forster-Cooper felt it necessary to see something of the immense collections of fossil mammals in the American museums, collections incomparably more complete and satisfactory than any in Europe. He therefore spent a year in the American Museum of Natural History, working under H. F. Osborn, who for the rest of his life remained an intimate friend. In New York also he was associated with W. D. Matthew, W. K. Gregory, Barnum Brown and Walter Granger, the group of very able palæontologists who, with Osborn, did very much to establish our knowledge of the history of mammals on a firm foundation; and by taking part in one of their expeditions to Wyoming, he added to his knowledge of collecting technique and to that of preparation.

On his return to Cambridge once more, Forster-Cooper was given the Balfour Studentship and made two arduous, dangerous and most successful expeditions to Baluchistan in 1910 and 1911, there collecting and afterwards preparing and describing the extraordinary rhinoceros *Baluchitherium*, the largest of all land mammals.

By this time Forster-Cooper had become an expert on all the processes of preparation of fossils, in plaster casting and other museum arts, and he had seen many great museums which were using new