puting Engine (ACE)

l of own onal the The the ACE, which will be built later, is itself a complete computer, which has already been used for practical work and we learn that the superintendent of the Mathematics Division, National Physical Laboratory, will be glad to hear of industrial problems involving long and intricate arithmetical calculations.

The ACE is capable of tackling the computation work in any mathematical problem, and it is therefore more versatile than some similar machines which have been built to handle only one particular kind of recurring operation. For example, vital considerations in the safety of civil aircraft—such as the design of wings for a given loading, or the determination of their flutter characteristics—can, ultimately, be reduced to the solution of sets of simultaneous equations. The process of calculation involving, perhaps, fifty equations and fifty unknown quantities, would require six or seven months' work by a computer using a desk calculator. The same computation could be done on the ACE calculator in under 10 minutes.

Optical work also offers a promising field of activity for the ACE. Thus, the art of designing a complex lens consists in making an informed guess as to what change in lens contour is likely to help and then working out the paths of the rays through the lens. If there are, say, ten refracting surfaces, the calculations may take about fifty-six working hours. In practice the process of trial and error is usually curtailed and the best solution is sometimes missed. The ACE has done calculations of this kind in less than 15 minutes. It should be appreciated that the instructions for making the machine do these calculations took about a week to make. However, the machine was then ready to work out any similar problem in lens design, using the prepared instructions.

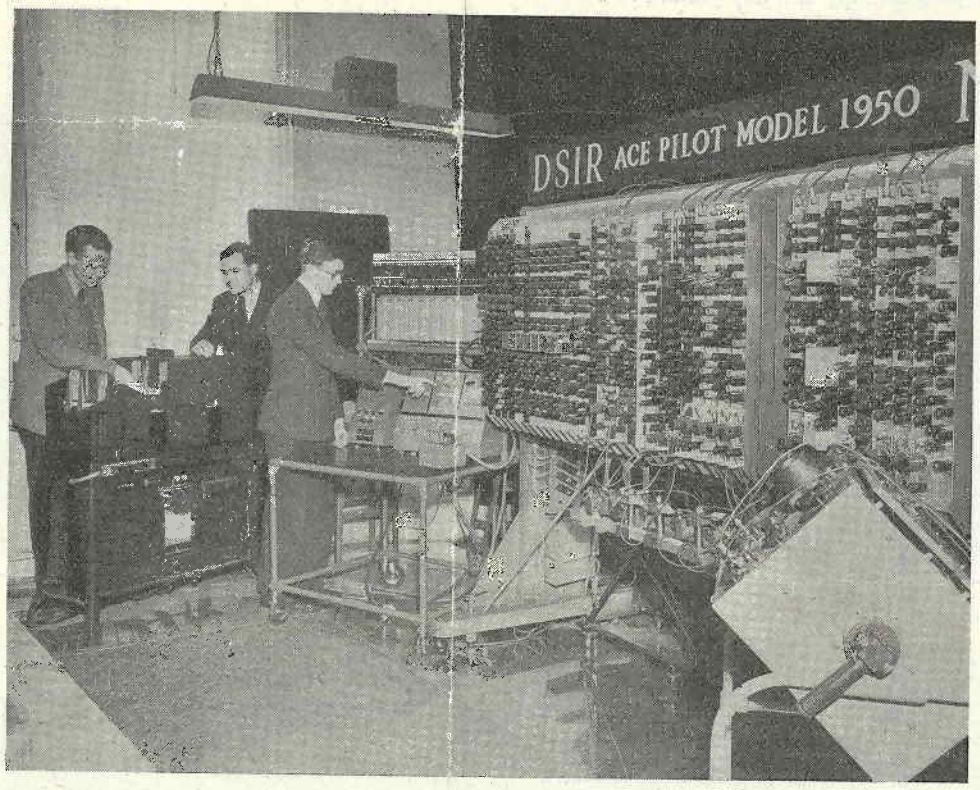
Other likely uses for the ACE, and machines that may be developed from it, include the solution of electrical network problems, the preparation of radar navigational charts, surveying and crystallography. Crystallographers, for example, can often determine the structure of important substances, such as penicillin and vitamin B12, by a combination of mathematics and experimental work with X-rays; the mathematics, however, may involve some thousands of tedious calculations requiring months of work by a team of computers.

The ACE uses electrical pulses generated at a frequency of a million a second. In the machine the pulses represent the numeral 1 and the gaps between the pulses represent the numeral 0. All calculations are done with the help of these two numerals only, using the binary scale. Accordingly, when a sum is put into the machine the numbers must first be translated from the decimal scale into the binary scale; then, after completion of the calculation, the answer is retranslated into a decimal number.

Briefly, a programme of operations is given to the machine by coding the instructions in the form of holes punched in cards, the holes being used to make electrical contacts. For this purpose the cards are fed into a specially adapted Hollerith accounting machine connected to the ACE. The holes in the cards initiate momentary electric currents. These currents, in turn, release corresponding trains of pulses, which are distributed to "memory loops" in the ACE, where they are stored until the calculation is completed. When the ACE is loaded with numbers and instructions it begins the calculations, extracting the trains of pulses from the "memory loops," as required, and performing the necessary arithmetical calculations. The results of these calculations are passed back, in the form of trains of pulses, to the Hollerith machine, which punches another set of cards to correspond with the impulses it receives from the ACE. Finally, the punched holes are decoded into ordinary numerals. Although the ACE can only calculate in terms of binary numbers, it is completely versatile in that it can accept an input of numbers and instructions in either binary or decimal form and give its output in either form.

The "memory" element, mentioned above, is necessary to allow the machine to carry out long sequences of operations; it may, for example, have to combine the results of a dozen or more separate calculations and, since it can only do one computation at a time, it must "remember" each one until it is wanted. The storage of this information is achieved, briefly, by arranging that each electrical pulse train, representing a number, is shunted into a loop, comprising a supersonic delay line of mercury in a steel tube. At the incoming end of the delay line there is a crystal, through which the train of pulses is converted into corresponding supersonic signals and is passed along the mercury column. At the other end of the tube the pulses are amplified and fed back to the input end. The system forms a closed loop, around which the train of pulses circulates unchanged until wanted. Electronic relays at each end of the delay line allow the necessary switching to be carried out. Any number can be retained in one of these "memory" loops for hours, if necessary. If the same number is required at two stages in the calculation it can, in the first instance, release a copy of itself and then, by appropriate operation of the relays, the number can continue to circulate until it is wanted again. The "memory" capacity of the pilot computer is 8000 binary digits and the machine can deal with numbers up to nine decimal digits or the binary equivalent.

A general view of the ACE is reproduced herewith. On the left is the Hollerith machine, which deals with the punched cards. In the centre is the control desk and, on the right, is the pilot model of the ACE itself. In this form the ACE consists, essentially, of forty-plug-in chassis mounted on a rack about 12ft long. A number of spare racks are provided, to allow for extensions of the scope of the machine. The mercury delay lines are supported on a rack, which is mounted centrally on the main board and below the row of plug-in racks, as shown in our illustration. At present ACE incorporates a total of about 800 valves, the power consumption being about 5kW, which is derived from a separate stabilised power pack.



AUTOMATIC COMPUTING ENGINE, PILOT MODEL

INTERNATIONAL PRESS-CUTTING BUREAU
19, GROSVENOR PLACE, LONDON, S.W.1

Extract from

LLOYD'S LIST
AND SHIPPING GAZETTE

(SEE OVERLEAF)

Date 30 NOV 1950

THE N.P.L. "ELECTRONIC BRAIN"

Arithmetical Aid to Industry

A pilot model of an automatic computing engine (popularly known as an "electronic brain") has been designed and constructed at a cost of £40,000 at the National Physical Laboratory, Teddington. The Ace, as it is called, can be made to tackle any industrial problem whose solving requires lengthy and intricate arithmetical calculations. All mathematical calculations in the end resolve themselves into addition, subtraction, multiplication and division, so that for practical purposes, there is no limit to what the Ace can do in this field.

The Ace works at prodigious speeds, made possible by the use of 800 wireless valves and modern electronic techniques. For example, a sum involving the multiplication of 10 figures by a further 10 figures would take a skilled arithmetician about eight minutes with paper and pencil, whereas the Ace would do the sum in about one five-hundredth of a second. The computer has been developed by a composite group of four mathematicians and 10 electronic engineers, all members of the N.P.L., together with a

INTERNATIONAL PRESS-CUTTING BUREAU
19, GROSVENOR PLACE, LONDON, S.W.1

Extract from
Manchester Guardian

30 NOV 1950

A NEW ELECTRONIC CALCULATOR

Month's Work in Minute

From our Science Reporter

LONDON, WEDNESDAY.

One of the latest electronic or valve-operated calculating machines, the "Ace," was given a trial run for the benefit of the press at the National Physical Laboratories this afternoon. It is called the Ace (automatic computing engine) to distinguish it from other ingenious members of the family in Britain and America which already includes the Eniac, the Edvac, Seac, Swac, and even (in Massachusetts) the Maniac.

The Ace is working but it is said still to be "in the pilot model stage." In Britain there are two other related machines, one at Manchester and the other at Cambridge: a third is being built at London University, though the Ace is considered—at Teddington anyway—to be the best, if for no other reason than that it is the latest and most simplified.

It has, for instance, a mere 800 valves. It costs about £1 a minute to run, and in that time it was said to be able to do rather more calculating work than could be done by a girl using a hand-cranked machine in a month. It has been made from Government funds provided by the Department of Scientific and Industrial Research.

In general appearance, the apparatus is not unlike an automatic telephone exchange. Numerical problems were punched into cards and fed into the Hollerith control device, which snored harshly every three seconds as phases of the calculation rushed through the circuits and valves.

TWO DIGITS

The ace, it was explained, uses pulses of electricity generated at the rate of a million a second. These pulses thus pass one particular point at the rate of one pulse every millionth of a second. On the machine the pulses are used to indicate the figure 1 and the gaps the figure 0. All calculations are done using only these two digits on the binary scale.

However, the input and output are such that it can convert ordinary decimals into binary form, or the opposite, or both together. The "memory" of the apparatus is composed of tubes filled with mercury which vibrate under the stimulus of electric impulses which can be cycled and stored.

This particular calculator will eventually be used for commercial problems (largely from trade associations) which are sent to the National Physical Laboratories. Like all electronic calculating machines, it embodies ideas envisaged theoretically some fifteen years ago by Dr A. M. Turing, now of Manchester University. But the supreme genius to whom tribute was repeatedly paid to-day was Charles Babbage, who devised a calculating engine in 1835.

INTERNATIONAL PRESS-CUTTING BUREAU
19 GROSVENOR PLACE LONDON, S.W.1

Extract from The

LIVERPOOL
DAILY POST

Date 30 NOV 1950

'BRAIN' MACHINE

Takes minutes to do months' work

By a London "Daily Post" Representative

The pilot model of an "electronic brain," which cuts the time taken in making elaborate calculations from months to minutes, was demonstrated at the National Physical Laboratory, Teddington, yesterday, when it was claimed that a problem which might take six or seven months' work with a desk calculator would be done in less than ten minutes on this machine.

Indicating that the arithmetical unit was only a small part of the "brain," Dr E. C. Ballard (director of the laboratory) said that most of the complications were due to the elaborate "memory."

Examples given of uses for which such a machine may be used include the making of radar navigational charts and research into the structure of the atom.

It was claimed that in the last field, among others, there were problems which had so far not been attempted at all because their computation would take years.

INTERNATIONAL PRESS-CUTTING BUREAU
19, GROSVENOR PLACE, LONDON, S.W.1

Extract from
Morning Advertiser, London

30 NOV 1950

New £40,000 electric brain—it's 'Ace'

"Morning Advertiser" Reporter

FOURTEEN young British scientists working at the National Physical Laboratory, Teddington (Middlesex), have produced a new electric "brain" which, it is claimed, works faster than either of the other mechanical "brains" in Britain and as fast as any similar machine in the world.

The "brain," which has taken 18 months to build, will calculate abstruse arithmetical sums with immense speed. In 1-500th of a second it can multiply two ten-digit numbers, which would take a skilled mathematician eight minutes.

Yesterday the pilot model, named "Ace," was demonstrated by Mr. F. M. Colebrook, who supervised the group of scientists who developed the machine.

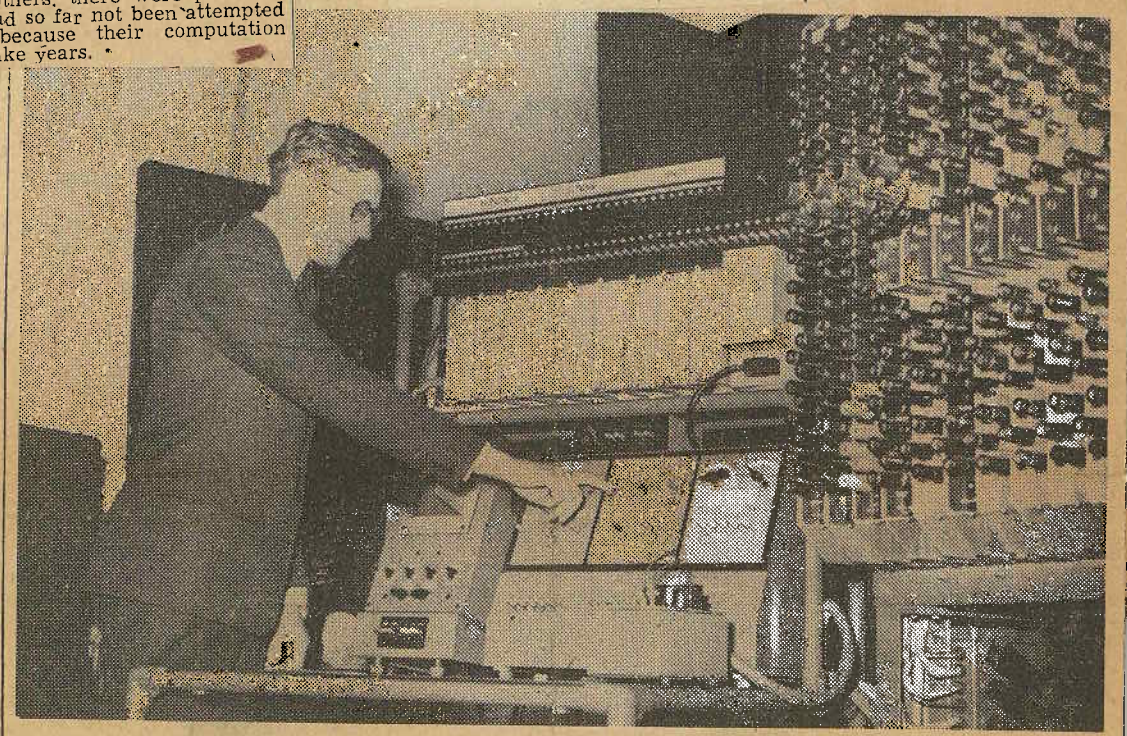
Looking like a queer telephone switchboard with 35 metal racks each containing tiny television valves, the machine, which has cost about £40,000 to produce, can can answer, by means of complicated lenses, such problems as exactly how light is bent, or the "flutter" characteristics of an aircraft wing, and can help in the making of radar navigational charts.

"Ace" works with electrical impulses at the rate of 1,000,000 a second. It has only 800 valves instead of the 20,000 used in the first electronic brain ever built. The "brain" has a memory which will store 256 ten-digit numbers at a time. By simply feeding in prepared cases a problem can be set which would take mathematicians many days of work, and the machine will produce the answer in less than 15 minutes.

BEER FOR CORRECT GUESSES

The director of the laboratory explained that the machine will be used for solving commercial problems sent in by firms. It costs about £1 a minute to run—but in that minute the machine does the work that would take a month of computing by hand.

Pressmen, inspecting the machine, were invited to guess prime numbers—those indivisible by other factors—and the machine tested their guesses. Two reporters who guessed prime numbers were rewarded with bottles of beer.



ELECTRONIC BRAIN.—Delivering the answer in one five-hundredth of a second to a calculation which would take a skilled mathematician eight minutes, a pilot model of an "electronic brain" is now working at the National Physical Laboratory, at Teddington. The "brain" also has a memory that enables it to carry out long sequences of operations.