

Extract from:

**The Engineer**

Established 1856.

Date..... - 8 DEC 1950

**Computing Engine (ACE)**

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.

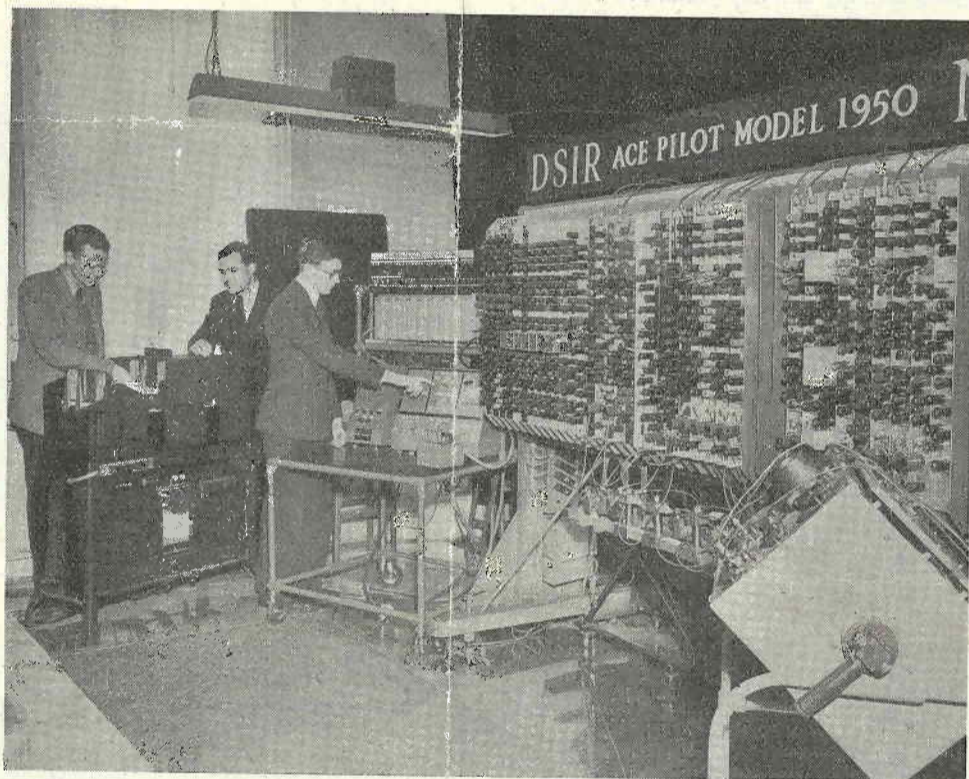
The ACE is capable of tackling the computation work in any mathematical problem, and it is therefore more versatile than some similar machines which have been built to handle only one particular kind of recurring operation. For example, vital considerations in

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

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 super-sonic 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

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

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,

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# 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 wire-less 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

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# 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.

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# 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 F. C. Ballard (director of the laboratory) said that most of the complications were due to the elaborate "memory" 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.

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19, GROSVENOR PLACE, LONDON, S.W.1  
Extract from  
Morning Advertiser, London

# 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 astrue 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 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 answer problems as complicated as those which are 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 mathematician many days 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.

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Extract from The

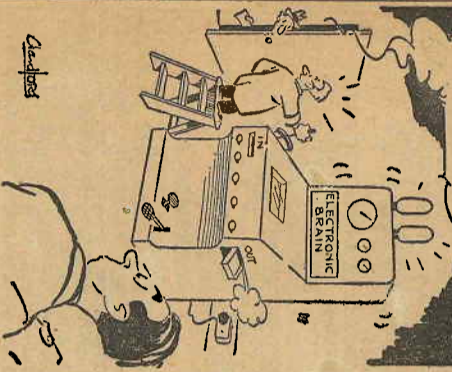
# LIVERPOOL ECHO

Date .....

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19, GROSVENOR PLACE, LONDON, S.W.1

Extract from  
Daily Telegraph, London

I WONDER IF YOU COULD  
WORK OUT MY  
PERMUTATION?



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

## MATHEMATICS MADE EASY

FROM OUR OWN CORRESPONDENT  
LONDON, Wednesday.

The pilot model of an automatic computing engine was demonstrated to-day at the National Physical Laboratory, Teddington, where it was designed and constructed. The machine is one of those mathematical calculators popularly known as "electronic brains," and is the latest and fastest in this country, and perhaps in the world.

Dr. E. C. Bullard, director of the laboratory, said that the machine would eliminate months of mathematical drudgery in scientific and industrial research.

The engine secures results, which seem almost miraculous to the unscientific mind, by the utilisation of the latest wireless and electronic techniques. About 800 television-type valves are embodied in its construction, and it has a "memory," a complicated portion of the "brain," animated by the controlled use of electrical pulses. The "memory" enables intricate calculations, which would take a month to work out by old-fashioned methods, to be given correctly by the "brain" in a few minutes.

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Extract from  
Northern Echo, Darlington

30 NOV 1950

## A real master of 500 maths.

AN "electronic brain," capable of solving any problem requiring arithmetical calculation, has been devised. Already, a pilot model of the "brain" is working at the national physical laboratory of the Department of Scientific and Industrial Research at Teddington, Middlesex.

The automatic computing engine as it is called, will be built later, although the pilot model is a complete computer.

Dr. E. C. Bullard, director of the laboratory, claimed at a Press conference in London yesterday that had the computer been able to print the figures it had dealt with, it would have solved a recent arithmetical problem, 500,000 sheets of foolscap paper would have been required.

The "electronic brain" was able to answer the problem in 15 minutes, whereas it would have taken a mathematician, working with paper and pencil, several months. Instructions are given to the machine by coding them as holes in cards and, using the holes to make electric contacts, these cards are fed into a specially adapted Hollerith accounting machine.

### Memory loops

The holes in the cards start momentary electric currents which release corresponding trains of pulse which are then designed and constructed "memory loops." The answers, experts are passed back to the Hollerith machine which records the pulse and translates the punched holes into ordinary printed numerals.

The pilot model cost £40,000 and occupies an area of about 60 square feet.

Romeike & Curtice Ltd.

EXTRACT FROM

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19, GROSVENOR PLACE, LONDON, S.W.1.

Extract from

## The Ace Birmingham Post

30 NOV 1950

### A Challenge to Mathematicians

The Electronic Brain

From Our London Staff

An "electronic brain," which works out abstruse calculations at phenomenal speeds, was demonstrated yesterday at the National Physical Laboratory, Teddington. Scientists and mathematicians who astonished a Press audience with its performance, threw out an open invitation to industrialists to send along problems. The more involved they are the more they, and "The Brain," like it.

Its prodigious speed of calculation is made possible by the use of wireless valves and modern electronic techniques. Checking can be done by the use of a rack and pinion mechanism. The machine has been evolved by the 12ft. long, with a separate Computing Machine—

This time it is the Ace of Spades. "Institutions" are given to the machine by coding them as holes in cards and, using the holes to make electric contacts, these cards are fed into a specially adapted Hollerith accounting machine.

The pilot model cost £40,000 and occupies an area of about 60 square feet.

The cost of producing the pilot "Ace" was in the region of £15,000. The estimated cost of "Ace" proper, which will be twice as large and have 20 times the "memory," is £40,000.

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Extract from  
Daily Telegraph, Belfast

## New electrical "brain" knows the answers

"Ace," a new electrical "brain" which has cost £40,000 to produce, has been produced by 14 young scientists at the National Physical Laboratory, Teddington, Middlesex, and was demonstrated on Wednesday.

Here are some of the things it can do:  
In one 500th of a second it can perform calculations which would take a human being eight days to do.

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Extract from the

**Daily Dispatch**

MANCHESTER

Date.....  
(See.....)

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EXTRACT FROM  
Daily Herald

## Mr. Ace works like lightning

Herald Reporter

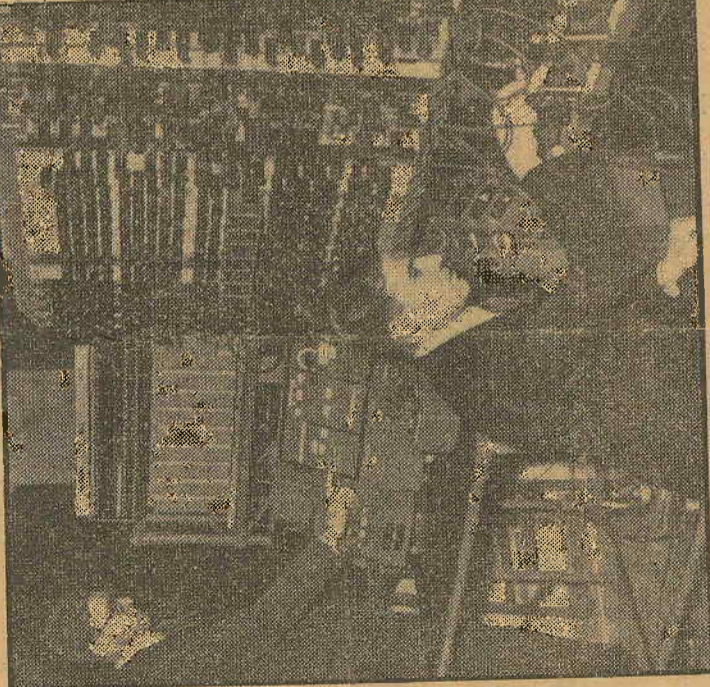
HOW long would it take you to find the cube root of 397,142,873 (just supposing that you wanted to)? Yesterday I got the answer in seconds, provided by the nation's fastest-working mathematician — a mechanical brain that solves difficult problems at the speed of light.

It has been built by 14 young physicists at the National Physical Laboratory, Teddington, Middlesex. Yesterday they showed it a 500th of a second it can multiply two numbers each containing 10 figures. (Average paper-pencil time by the most skilled mathematicians: eight minutes).

### 900 valves

15 minutes it can work out a sufficient, if done by the book method, to cover half-a-dozen sheets of foolscap paper. The brain, named ACE, looks a glorified telephone switch-board, took 18 months to build and works by electrical impulses. Part of its vital organs are 900 vision-type valves. Running a minute Mr. Ace does calculations that would take a month by hand.

Answer to that sum at the top? The brain says there is no exact root for that number, but the nearest figure is 735.



The electronic brain now working at the National Physical Laboratory has its "memory" section adjusted during a test. On the left is the control board.

**Romeike & Curtice Ltd.**

EXTRACT FROM  
Daily Graphic

## MACHINE WITH GOOD MEMORY 'THINKS' NOISILY

By Daily Graphic Reporter  
A MACHINE with a "memory" that can retain figures for hours was demonstrated yesterday at the National Physical Laboratory, Teddington, Middlesex.

It is Britain's newest and fastest electronic brain—the Ace—a £40,000 machine which took 14 scientists 18 months to produce.

The new Thinking Machine has 800 valves instead of the 20,000 used on the first electronic brain to be built.

It looks like the inside of a giant television set—and works with a noise like a battery of hair driers all going at once.

In one 500th of a second the brain can multiply numbers that would take a mathematician eight minutes.

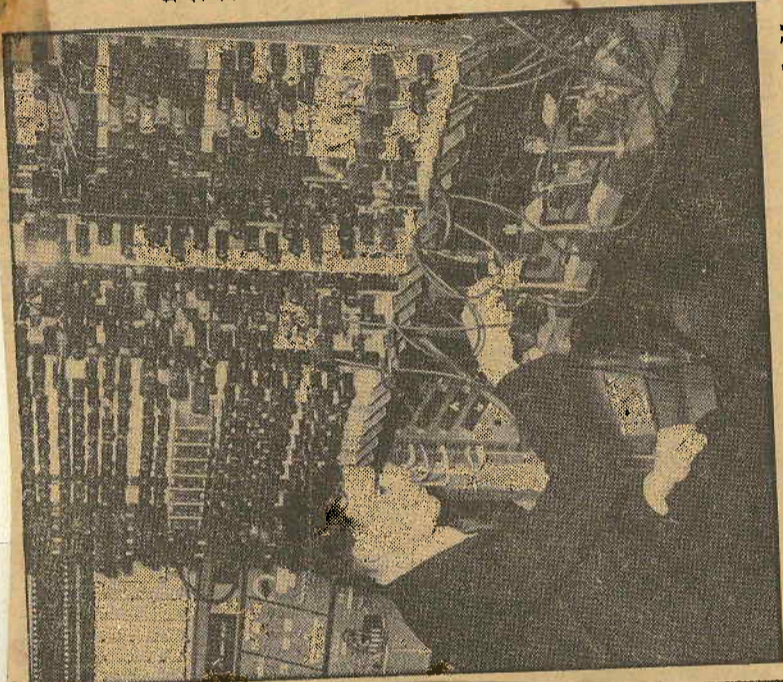
Figures buzz about inside the machine at the speed of light—186,325 miles a second.

### HIGH AS NELSON

Mr. F. M. Colebrook, of the National Physical Laboratory's electronics section, said yesterday.

The machine is capable of any computation problem. It is so fast that if it wrote down on foolscap paper all the figures it used in a quarter of an hour, it would cover 500,000 sheets, a pile about the height of Nelson's monument.

Its chief creator, Mr. J. E. Womersley, a young scientist from Morley, near Leeds, said: "The arithmetic is done by an elaborate series of shunting operations."



The "electronic brain" in action yesterday with Mr. E. A. Newman, engineer, adjusting part of the memory and pulse generating section. There are 800 valves in the "brain" which was built in 18 months at a cost of £40,000.

...will be held as part of the celebrations, and it is hoped that a large number of overseas visitors from research associations, technical institutions and industrial firms will attend.

National Physical Laboratory, Teddington, Middlesex.

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EXTRACT FROM  
**Manchester Daily Dispatch**  
 Manchester

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EXTRACT FROM  
**MANCHESTER NEWS CHRONICLE**

30-11-50

**ACE is trumps**

YORKSHIRE mathematician J. R. Womersley took me to an 800-valve radio panel at the National Physical Laboratory, Teddington, yesterday and said: "Meet ACE."

ACE, short for Automatic Computing Engine, is the monstrous electronic brain which he and a team of "under-30" scientists have designed and built at a cost of £40,000.

It will solve any sum that can be solved by a human brain. It does it almost in a flash—faster than any other machine in Britain.

For example: 3,971,428,732 x

8,167,292,438 takes a quick worker eight minutes to do. (Try it.) With a desk calculator it takes one minute. ACE did it in 1-500th of a second.

"Very handy for abstruse scientific calculations and industrial measurements—even for football pool permutations," he agreed. "Yes, you'll be able to hire ACE for about £1 a minute. You can do some hefty sums in that time, you know, or we could build you one for about £15,000."

DATE

**ACE ROBOT WORKS FAST**

"DAILY DISPATCH" REPORTER

A TEAM of young British scientists have developed the world's most advanced electronic "brain," now working at the National Physics Laboratory.

The brain, called The Ace, was built in 18 months, and does in one minute calculations that would take a clerk a month. Development cost £40,000, and operating costs £1 a minute.

In a quarter of an hour it does enough figure work to equal 500,000 sheets of foolscap.

The Ace is much faster than the two other British electronic brains, built in Manchester and Cambridge Universities.

The man who inspired The Ace, Mr. J. R. Womersley, a Yorkshireman, said last night: "After we had made progress with this machine I discovered with great surprise that all the basic ideas and the possible things we could do with it had been foreseen by Charles Babbage, a Cambridge professor 130 years ago."

**AID FOR DEFENCE**

The brain will cut out a lot of drudgery in research, and may also speed up weather forecasting by working out complicated equations.

It has 800 television-type valves grouped in a 12ft-long rack. Taking up 60 square feet of space, it is by far the smallest and most compact brain devised.

INTERNATIONAL PRESS-  
 CUTTING BUREAU.  
 Extract from  
 GREENOCK TELEGRAPH.

NOV 1950

**New "Brain" Knows All the Answers**

"Ace," a new electrical "brain" which has cost £40,000 to produce, will calculate abstruse arithmetical problems with immense speed.

It has been produced by 14 young British scientists at the National Physical Laboratory, Teddington, Middlesex, and was demonstrated yesterday.

In one 500th of a second it can perform calculations which would take a skilled mathematician eight minutes to do and can tell how light is bent by complicated lenses.

The machine answers the problem of the flutter characteristics of an aircraft wing and has a memory which will store 265 ten digit numbers at a time.

"Ace" costs about £1 a minute to run, but in that minute does work that would take a month of computing by hand.

...which would take a skilled mathematician eight minutes. It was built in 18 months at the National Physical Laboratory, Teddington, Middlesex.

...as part of the celebrations, and it is hoped that a large number of overseas visitors from research institutions, industrial organizations and industrial firms will attend.

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19, GROSVENOR PLACE, LONDON, S.W.1

Extract from  
Dundee Courier & Advertiser

### BRAINS BACKSEATED

News from the National Physical Laboratory will cheer some of those who never got over ponas ashorum. Fourteen young British backroom boys have made a new electric machine which makes brains unnecessary. It works faster than any other machine in the country, and equals any other in the world.

In 1-500th of a second it can multiply two ten digit numbers. This would take anyone with less calculating powers than Einstein some eight to ten minutes. It can do other problems in a quarter of an hour which would take a skilled mathematician many days of work.

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19, GROSVENOR PLACE, LONDON, S.W.1

Extract from  
Bath and Wilts Chronicle

### £40,000 MATHS 'WIZARD'

"Ace," a new electrical "brain" which has cost £40,000 to produce, will solve abstruse arithmetical problems with immense speed.

It has been produced by 14 young British scientists at the National Physical Laboratory, Teddington. Here are some of the things it can do:—

In one 500th of a second it can perform calculations which would take a skilled mathematician eight minutes to do. Can tell how light is bent by complicated lenses. Answers the problem of the flutter characteristics of an aircraft wing, or the making of radar navigational charts. Has a "memory" which will store 256 ten-digit numbers at a time.

"Ace" costs about £1 a minute to run, but in that minute does work that would take a month of computing by hand.

INTERNATIONAL PRESS - CUTTING BUREAU  
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Extract from

## Birmingham Weekly Post

Date ..... - 1 DEC 1950  
(SEE INFORMATION OVERLEAF)

5.—An "electronic brain," which works out abstruse calculations at phenomenal speeds, was demonstrated on Wednesday at the National Physical Laboratory, Teddington.

International Press-cutting Bureau

EXTRACT FROM THE

## Yorkshire Evening Post

LEEDS

### Yorks man is the 'brain' behind 'brain' machine

A YORKSHIREMAN has been the power behind the completion of Britain's latest computing "electronic brain" on which a month's work by a human is done by the machine in a minute.

He is Mr. J. R. Womersley, whose parents, Mr. and Mrs. G. W. Womersley, live at Scotchman Lane, Morley.

One 500th of a second is all the brain requires to multiply 3,991,428,732 by 8,167,222,436, a task that would take a skilled mathematician at least eight minutes.

A product of Morley Grammar School and the Imperial College, London, Mr. Womersley was appointed superintendent of the new mathematical division of the National Physical Laboratory, Surrey, five years ago.

After a visit to America he returned determined that Britain should have one of the wonderful machines, and set about preliminary planning. He formed a team of experts, and construction about 18 months ago.

Mr. Womersley told the Evening Post: "This is not our final machine. It is really only a model and a much larger one is to be built. When the brain works for 15 minutes it can deal with about 100 million figures." The machine has been used to obtain absolute accuracy in the design of lenses.

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Extract from

## The Press and Journal

ABERDEEN

### Biters Bit?

LABOUR-SAVING devices are all very well. The trouble is that, when they go wrong, the work we made light of before the machine came along now seems unbearably burdensome.

They have a new electronic "brain" at the National Physical Laboratory that can do in a minute sums that a skilled mathematician would need a month to do.

Can they be sure that the answers are invariably right? It is a dreadful thought that abstruse calculations, on which the synthesis of vital drugs or the designing of guided missiles for national defence depend, might work out wrong if the "brain" developed a defect.

And it would be a school-boy's nightmare to think of the months of sums to be done by normal means—except that this could only be done by the gifted mathematicians who think up vile problems for examination papers.

