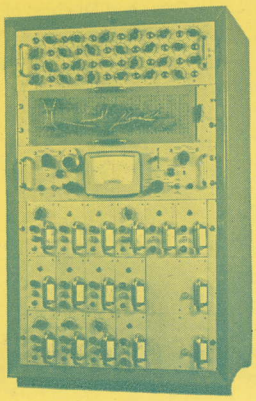
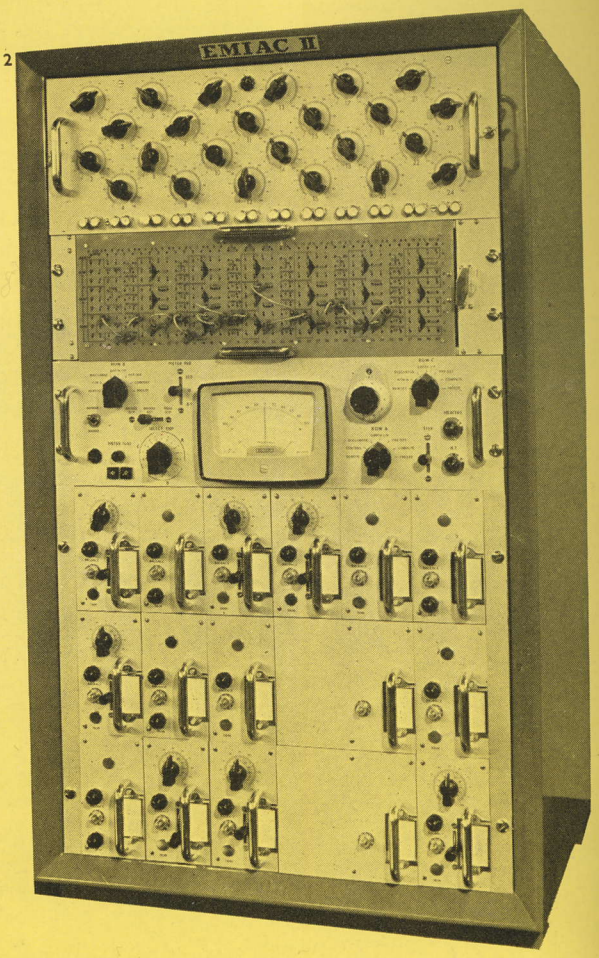




1 The prototype computer. 2 The latest version redesigned according to ergonomic principles. MAKER E M I Electronics Ltd.

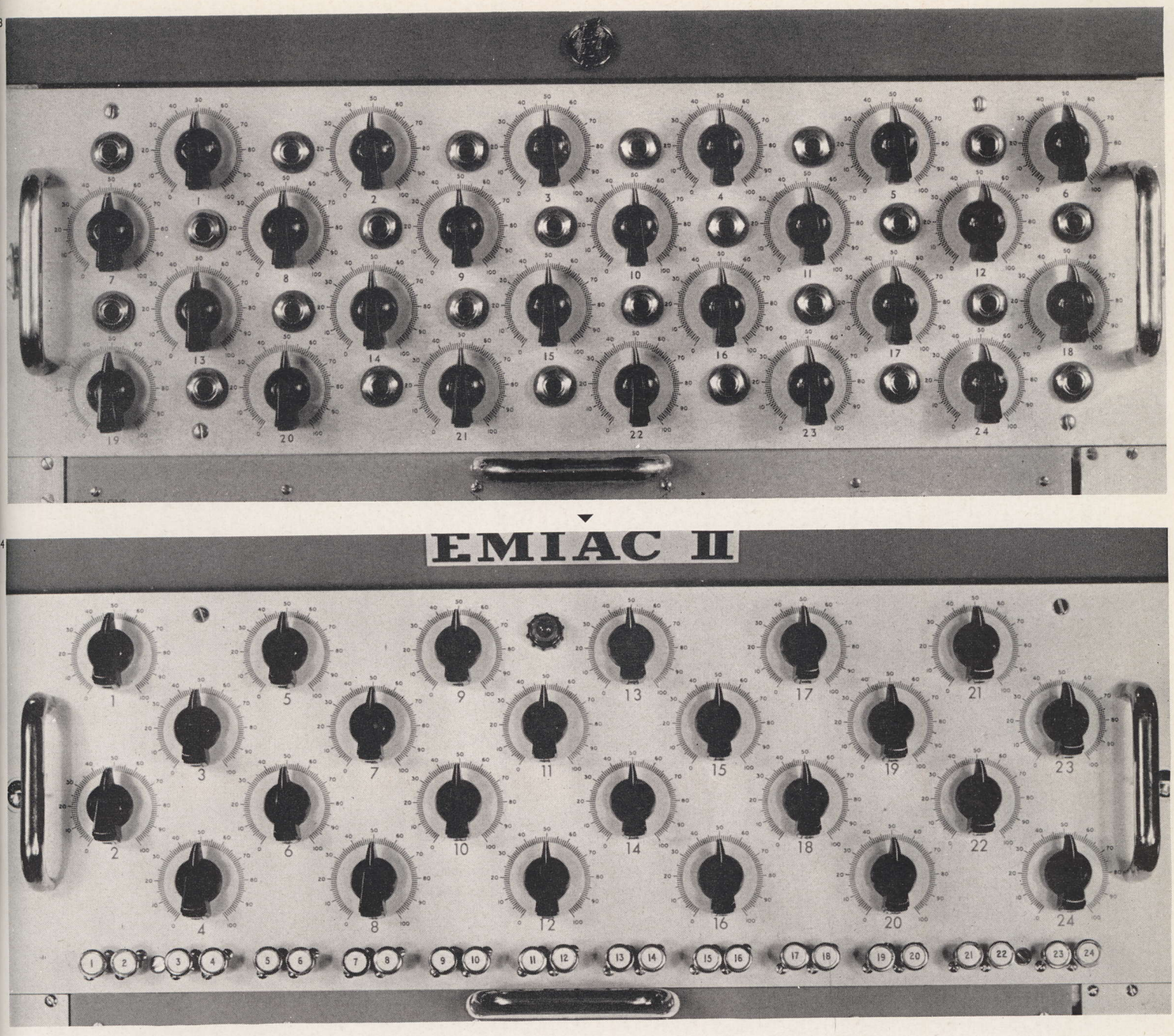
Ergonomics for a computer

AN ANALOGUE COMPUTER is an assembly of many, similar, electronic 'building bricks' which can be connected together in a multitude of different ways. The input and output leads of the amplifiers, integrators, and function potentiometers are all brought out separately to sockets on the 'patch panel', which is thus very similar to a telephone exchange switchboard. By making the appropriate interconnections the operator can 'patch up' the computer to solve most problems which can be defined in suitable mathematical terms.

Analogue computers are particularly useful to simulate and optimize the design and working of complex devices with several interdependent variables, such as suspension systems of motor cars or chemical processing factories with continuous flow.

Flexibility is an important feature of an analogue computer, so that it can quickly and accurately be reset from one problem to solve another; ease of operation and avoidance of operator mistakes are therefore essential. Such mistakes are far more troublesome than loss of speed or machine inaccuracy. A correct setting, but on a wrong potentiometer – or a switch left in the wrong position – can ruin the solution of a problem and cause much delay while the fault is found. Even worse, the error in the solution may not be discovered. Therefore the risk of these mistakes must be reduced to the minimum by proper attention to ergonomic factors.

During the redesign of EMIAC II, at EMI Electronics Ltd, advice from the firm's engineering psychology laboratory was sought on various aspects of the operational layout; the prototype, 1, was already fairly satisfactory, but the project team wished to make every possible improvement.



Potentiometer panel

The major problem in this study was the panel of 24 potentiometers, all of which may have to be selected one at a time by an appropriate switch and adjusted very carefully to an exact value on the meter. Unless the layout is clear and simple, there is a risk of setting up the wrong potentiometer or of starting to adjust one which has already been set, with consequent annoyance and risk of error.

On the prototype, to economise in space, the potentiometers were staggered at 45° to each other and the jack sockets, through which electrical connection is made to the potentiometers, were set in between them. The result is somewhat confusing and there is no room for numbers to identify each jack socket, **3**. Despite added electronic complication and slight increase in panel size it was agreed to use push-pull switches with a number on the knob to replace the jack sockets; the design problem therefore was to find a layout with which the sequence of operations – *first*, find and operate the switch, *second*, find the potentiometer, *third*, adjust it, and *fourth*, turn off the switch – would be done most easily and with the least error.

The method of tackling this, as with all ergonomic problems, was first to refer to results of all relevant research[1]; it was found, however, that the evidence in the literature was not adequate to allow of reliable extrapolation to solve the problem. Therefore an experiment[2], had to be made which resulted in the optimum layout, **4**.

It was suggested initially that a rotary selector switch should be used instead of the jack sockets. This proved impractical electronically, but the discussion and explanation brought to light a way in which part of the basic engineering circuit could be improved. This is quite a common experience during ergonomic redesign studies; explaining the machine to someone with a different specialist approach stimulates the engineering team to reconsider its system from a fresh viewpoint.

1 See for instance: *Applied experimental psychology*, A. Chapanis, W. R. Garner and C. T. Morgan, Chapman and Hall Ltd, £2 12s.

Human engineering guide for equipment designers, W. E. Woodson, CUP £1 6s.

Data on human performance for engineering designers, K. F. H. Murrell, reprint from *Engineering*, 3s.

Human factors in equipment design, Edited by W. F. Floyd and A. T. Welford, The Ergonomics Research Society Proc. Vol II H. K. Lewis & Co Ltd, £1 1s.

2 *A note on panel layout for numbers of identical items*, B. Shackel, to be published in *Ergonomics*, Taylor and Francis Ltd.

continued

Photographs of the panels by R. Oliver

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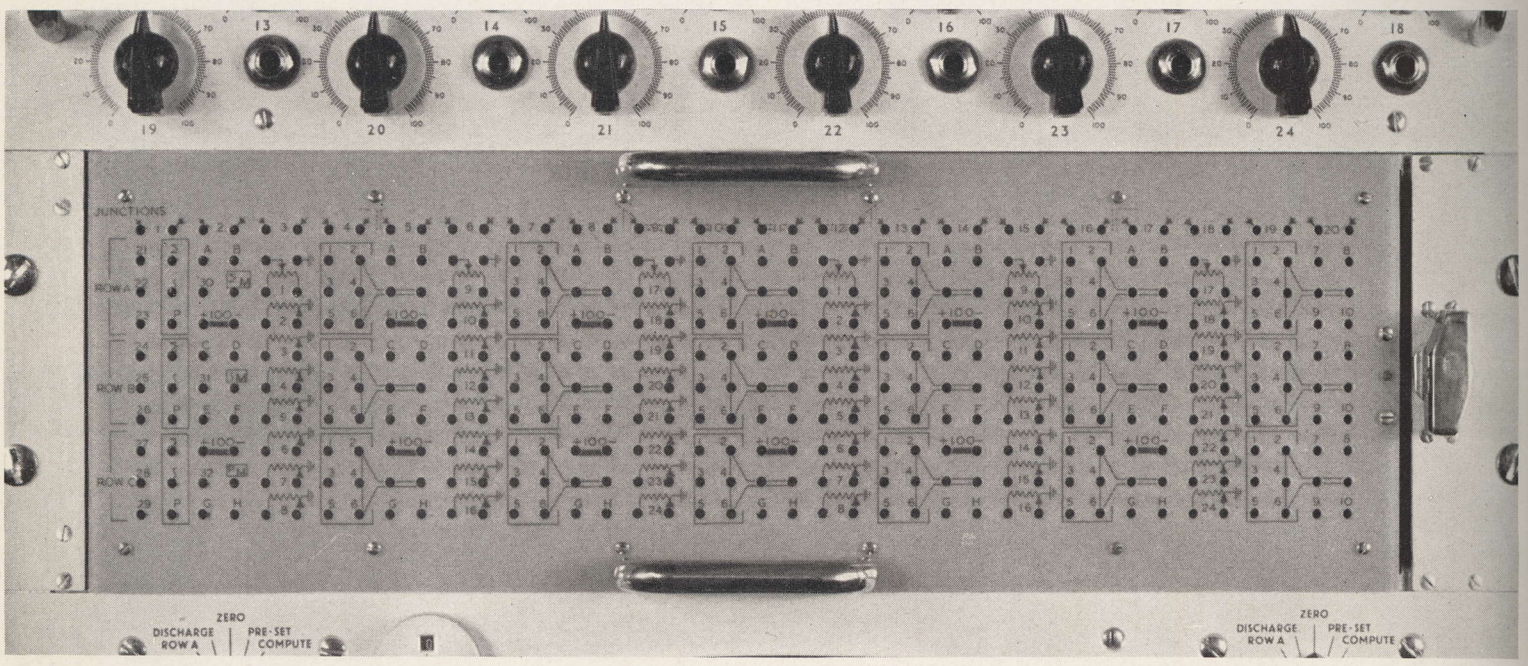

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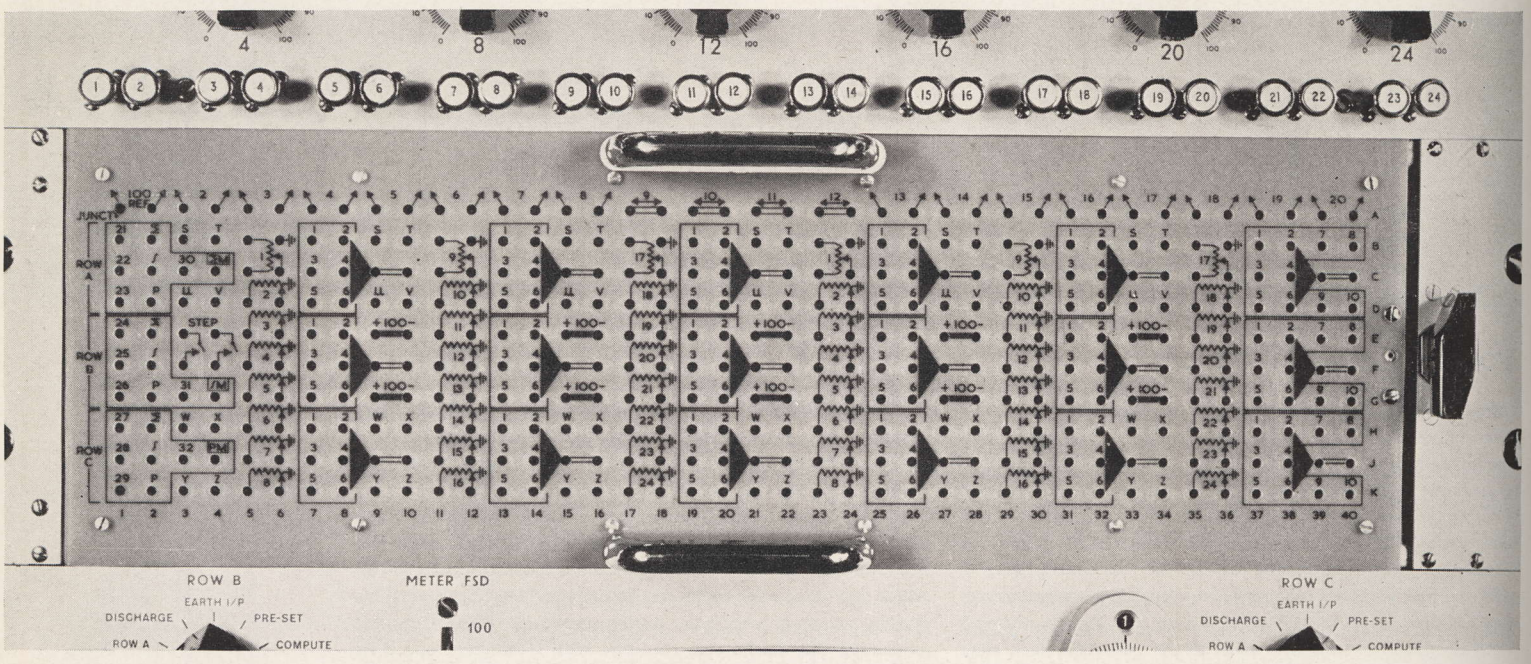

Patch panel

Although apparently confusing and even frightening to the uninitiated, this panel, **5**, simply consists of input and output sockets for the 18 amplifiers and 24 potentiometers, along with some interconnecting junction lines. The basic grouping into 18 blocks of almost identical sockets, along with the special switching group at the left hand end, required extra emphasis, **6**, to ensure easy selection of the right socket even when many plugs obscure much of the panel surface. Colour-coding was considered, but about six different hues would be needed; the resulting dazzle in a crowded area would probably be more of a distraction than a help. Rationalisation of a number of details to minimise the risk of error can be seen by comparing the two layouts.

Control panel

The full operating sequence must be known before deciding important panel layouts; only by analysing the various sub-routines can related controls be properly grouped together. Critical adjustments and master controlling actions are usually made with the preferred hand (the right hand for most of the population) and therefore such controls should be placed easily for the right hand, leaving associated less critical switches to the left.

It followed that the main change, **7** and **8**, was to interchange the Meter FSD switch and the accurate potentiometer with the graduated dial; previously the operator would tend to operate the meter switch with the left hand, thus obscuring the meter he was about to read, so as to use his right hand for critical adjustment. The master control is Row A switch and is therefore in the correct position; the other groups of amplifiers are usually under its control, and therefore Row B and Row C switches are in the less important corners of the panel. Other changes in details improve the identification of switch positions and group related items together.

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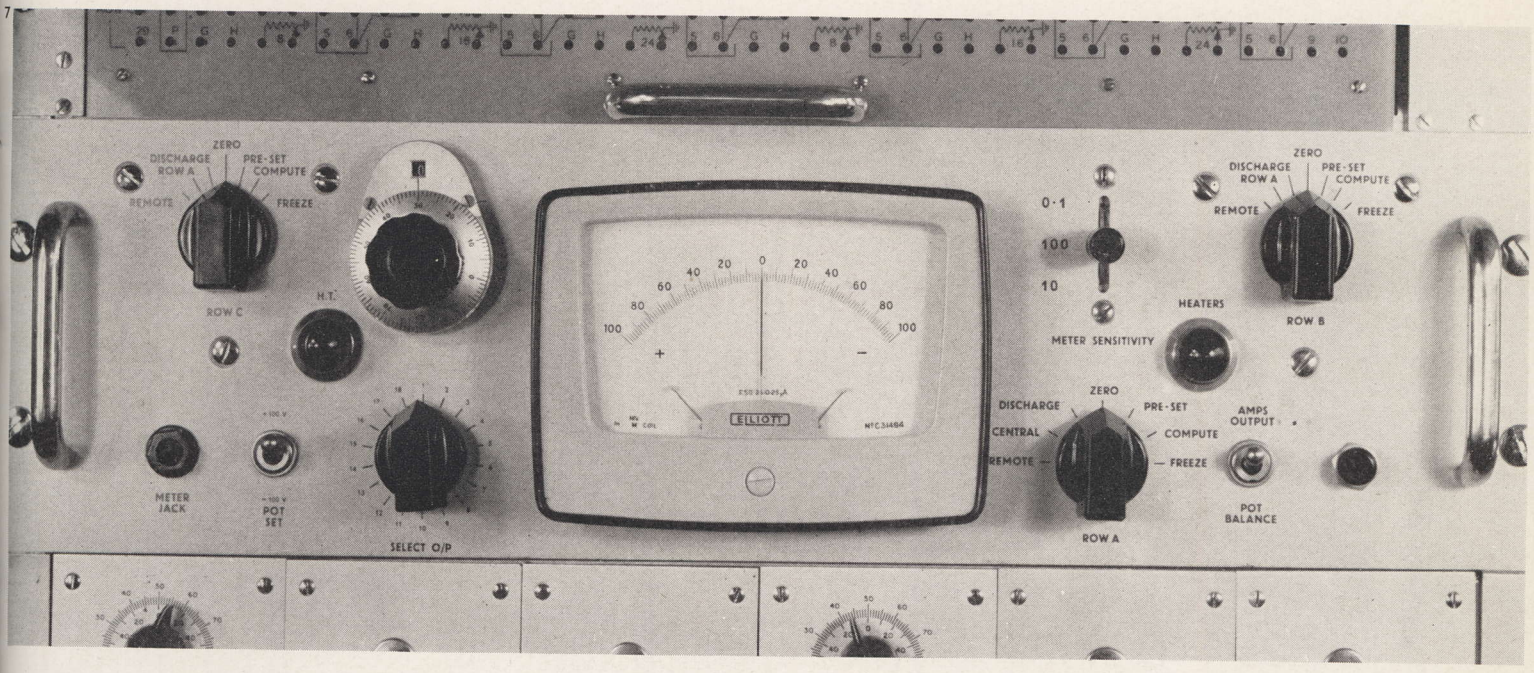

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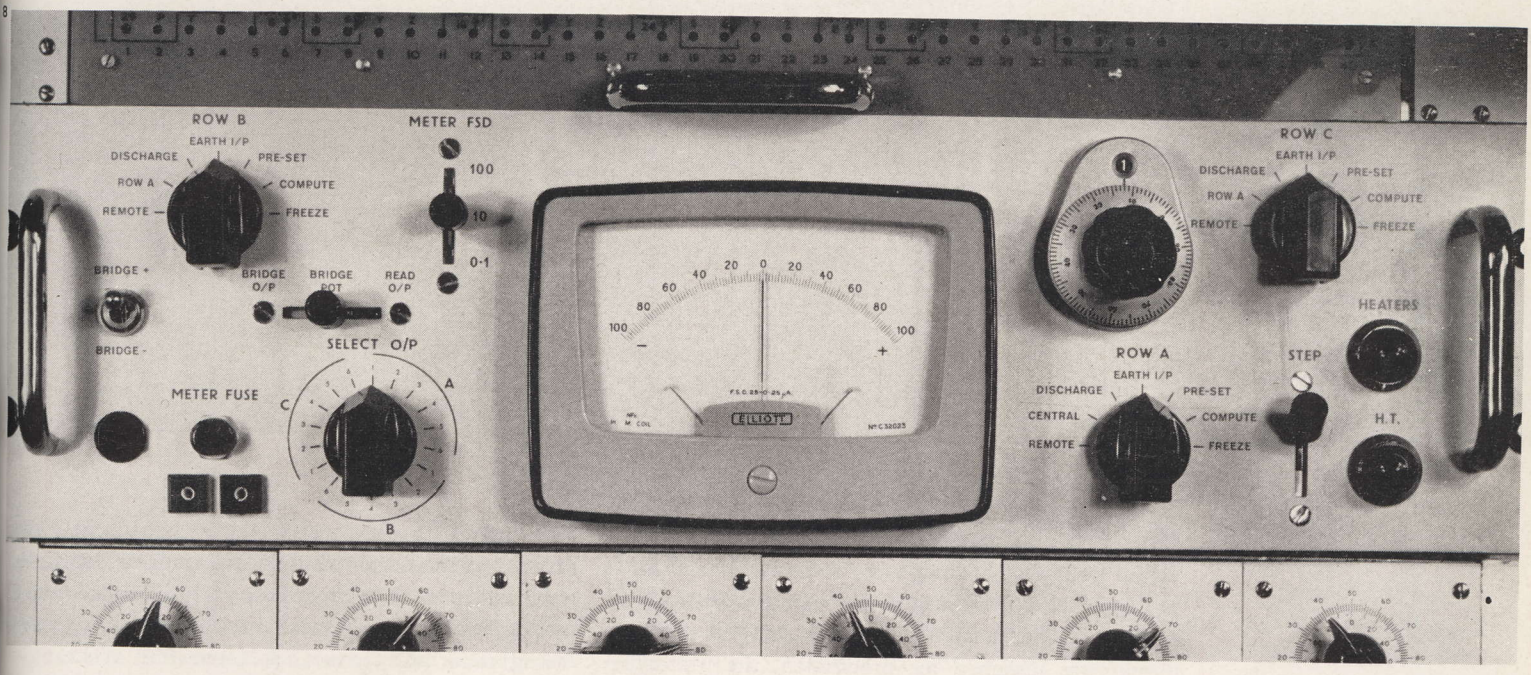

Conclusions

In this brief example of how an electronic machine is studied in order to improve the ergonomic aspects of its design, only the more obvious points have been mentioned. To the design engineers and technologists, who are at present the chief users of this kind of machine, some of the more detailed aspects will be obvious from the illustrations.

Some time after the study had finished an opportunity arose to ask the recipient of the prototype model, the Hawker Siddeley Nuclear Power Co Ltd, for criticisms of its operation. It was pleasing, if not unexpected, to find that comments from at least three months' operating of the machine had all been predicted by the ergonomic redesign study.