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ERGONOMICS AND SYSTEMS DESIGN LABORATORY.

THE COLLEGE OF AERONAUTICS, CRANFIELD, BEDFORD.

# AN APPRAISAL OF THE GUTTINGER STATISTIC 611.

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CONTENTS.

Summary.

Using the Systems Design procedure developed at Cranfield, an appraisal of the Guttinger Statistic 611 has been carried out; in particular, the interface of the machine has been redesigned.

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(All from 1st year Operational Research, 1965 - 1966).

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Mr. J. Fox, Automobile School, The College of Aeronautics - for his advice on "man - machine interface".

Duration of the Project.

The Project Group held weekly meetings over a period of 7 weeks during the Easter Term. The purpose of these meetings was to discuss the allocations and progress of work on the Project.

Introduction.

The Ergonomics Laboratory at the College of Aeronautics, Cranfield, acquired for the purpose of the Project a Guttinger Statistic Type 611 machine.

Fig. 1. shows a photograph of the machine interface.
Fig. 2. shows a photograph of the inside of the machine viewed from below.

The machine was a standard production model and was operated as follows:-

Raw data is grouped into classes numbering 10 or less and the number of readings in each class is fed into the machine by means of push buttons. The mean and standard deviations corresponding to this data are then indicated on an analogue meter, the desired statistic being selected by the appropriate button below the meter. These outputs are, as are the inputs, in class interval form, and have then to be converted back into "real" data form.

The aim of the project was tc redesign the interface without appreciably altering the method of operation of the machine as indicated above. This reappraisal was carried out as per the Cranfield Systems Design Procedure and the following sections in this report follow the format specified therein.

Definition of Objectives.

It was decided by the project group that the object of the Guttinger machine was to calculate automatically the mean and standard deviation from numerical data fed-in on a keyboard. It was agreed that the machine could be used by both office and factory personnel alike, and should therefore possess a high degree of accuracy and be capable of being used by a semi-skilled operator. The utilisation of a machine such as this in a large factory would probably entail it being moved from place to place during the course of a day, to check machine or processes, in which case the machine should be relatively light, and robust enough to withstand everyday knocks. The speed of the calculation was also an important requirement, and with the existing machine it was noted that feeding in data through the keyboard was a lengthy procedure: for this reason, the group spent a lot of time looking into the design of keyboards and their optimisation.

Separation of Functions.

The two functions of the machine were generally accepted as

1. Calculation of Means.
2. Calculation of Standard Deviations.

Allocation of Functions.

The functions are allocated to either man or machine. In this case, the allocation of function at present employed was accepted without any alterations.

Thus the machine will perform the following functions.

1. The calculation of the Mean.
2. The calculation of the Standard Deviation.

The functions performed by a human operator are:-

1. The grouping of numerical data into class intervals.
2. The feeding-in of the numerical data.
3. The selection of the appropriate scale.

## Critical Analysis of Existing Interface

During the meetings in the laboratory, many criticisms were made of the layout of the control surface, i.e. the 'man-machine interface'. For convenience, these criticisms have been broken down into sub-headings - dial, switch, buttons and general.

1. Dial

(a) There were three scales serviced by the one pointer. It was not immediately clear, therefore, which scale should be read.

(b) The three small lights at the side of the dial puzzled many of the operators, until it was realised that they were meant to show which scale should be read.

(c) A square dial is not so pleasing to the eye, nor is it ergonomically desirable. A round dial is better, since the pointer can then swing through a much larger angle. In fact, this square dial has a pointer which traverses 90°, whereas a pointer in a round dial could traverse about 240° (with correspondingly easier readability).

2. Switch

(a) The switch has four positions (including 'off'), and yet there are three scales on the dial. This is potentially confusing.

(b) One of the switch positions is denoted by $\sigma_4$, meaning that it relates to the dial scale which has four as a maximum (as opposed to the other maxima of ten and two). Again, this is confusing particularly since the switching order is $\bar{X}_1$, $\sigma_4$ and then $\sigma_2$.

(c) The 'off' position is denoted by '0', when it would be better denoted by the word 'off'.

(d) The switch positions ($\bar{X}_1$, $\sigma_4$ and $\sigma_2$) suggest that the machine will calculate three different statistics, whereas in fact, it only calculates two (mean and standard deviation).

3. Buttons

(a) The array of buttons is too uniform. The first impression is that of a sea of buttons, logically laid out admittedly, but in fact difficult to differentiate one from the other.

(b) Linking with (a) above, the row numerals at the bottom of each vertical column of buttons are too small, and not easy to see. This makes it difficult to single out the required column.

3. Buttons (Continued).

(c) Round buttons are better than square ones - they stand out better, since there is more blank space around them.

(d) There is a tendency in certain lights for there to be reflection from the black buttons, which obscures the figures on the buttons' surfaces.

(e) The numerals on the buttons are not big or distinctive enough.

4. General.

In general, the fascia layout looks old fashioned and unexciting. The black square rim of the square dial contributes to this.

At the top of the grid of buttons there is a black plastic channel, to be used to hold a strip of card so that class intervals can be written above the appropriate columns. When the strip is not used in this way, the empty channel looks ugly, since it shows screw heads and empty fixing holes.

With the present dial, it is necessary to read the instrument, rather than read off a reading.

## Suggested New Interface Design.

Having analysed what was considered wrong, or undesirable, with the existing interface, the new interface was designed in an attempt to eliminate all these factors. They will be considered under the same headings as before.

On reading what follows it is recommended that frequent reference is made to the exhibit showing the new interface design.

### 1. Dial.

It was decided to use numerical indicator tubes in place of a dial, so that the reading would be shown directly. (In other words, there is no need to read the instrument; the reading can be read off).

To enable the operator to see the result easily, these tubes are mounted in a small display console at 45° to be horizontal, the decimal point being shown by small illuminated neon between the tubes.

The small console is itself mounted in the centre of the board, immediately above the operating buttons. (i.e. "mean" and "standard deviation" buttons). It is mounted above the buttons rather than below, since the natural place to look for the result of an action by the fingers (punching buttons) is beyond them. (c.f. a typewriter). To mount it below would mean pulling the head back to observe the result.

A small panel at the top lefthand side of the display console shows the words "mean" and "standard deviation", which light up individually from behind when the appropriate operating button is pressed. This serves as a visual check, and is colour coded to the button,

### 2. Switch.

The old four position switch has been replaced by a separate "on - off" button at the top lefthand side of the machine, and two centre buttons for mean and standard deviation.

The "on - off" button is square, and illuminated from below when on. Thus once the machine has been plugged into a power supply, the machine itself is switched on by pushing this button, whereupon it will light up green (for go). To switch the machine off, the button should be pushed again, and the green light will go off.

To show the action of this switch, there is a small plate beside it saying "Power Supply --- Press On - Press Off".

2. Switch (Continued).

The fuses for this switch are mounted on the lefthand vertical side of the machine, next to the point where the power cable enters the "works".

Note that the button, after having been pressed, springs back up again - it does not stay down. (If so, another button would be necessary to bring it up again). Visual indication that the machine is on is provided both by the green light and the illumination of the neon decimal point indicator on the small display console.

The operating switches for mean and standard deviation are large round buttons, mounted in the centre of the machine. The rationale behind their shape, colour, etc. is as follows:-

(1) They are round to link visually with the round numerical indicator tubes.

(2) They are larger than the data buttons to distinguish between their functions.

(3) They are centrally placed for convenience; in fact, since the input "punch" buttons are split into two groups of five double columns, there is a natural gap which these operating buttons can fill.

(4) They are one above the other, (and not side by side), since the later disposition might lead someone new to the machine to think that one button was for the left hand display of "punch" buttons, whilst the right hand button was for the right hand display.

(5) They are coloured red and yellow to provide a visual link with the display console, which itself has a small panel that lights up the words "mean" and "standard deviation". (If this were not so, the operator could press, say, the "mean" button, and absentmindedly write down the reading as standard deviation. This is unlikely to happen if there is a visual cross reference, serving as a reminder, or check).

(6) They are coloured red and yellow rather than anything else, since this pair of colours is the least likely to be confused by persons suffering colour blindness.

2. Switch (Continued).

(7) They are above the 'clear' button and near the display console to be asscciated logically with the console (see later for 'clear' button).

(8) They are slightly concave so that the fingers will not slip off them.

(9) They have the words "mean" and "standard deviation" written up on them in black to act as the prime link with the console. (Their colour differentiation is a secondary "check").

(10) They stay down when pressed so that all fingers can be removed from the machine and used to pick up a pencil, paper, etc. and write down the result.

The "Clear" Button.

This serves to clear all circuits, to clear the numerical indicator tubes, to return whichever of the two operating buttons was last pressed, and to return all input "punch" buttons. (Note that the two readings can be taken in either order, depending on which button is first pressed, and that the second button, when pressed, returns the first.)

The clear button has been placed near the bottom of the machine for two reasons: firstly, dissociation with the two operating buttons (in case it gets pressed by mistake), and secondly, by analogy with typewriter convention, where the "clear" bar is at the bottom of the keyboard.

It is square to distinguish its function from that of the operating buttons (and other buttons).

It is white, or even translucent, i.e. clear, to provide a mental 'verbal' link with its function.

3. Buttons.

It was decided to separate the mass of buttons into two equal halves (columns 1 - 5, and 6 - 10 inclusive), so that two main blocks were formed. Each block of five columns is also sub-divided so that there is a larger space between the centre column and its adjacent column than there is between any two other adjacent columns.

3. Buttons (Continued).

The effect of this is to give each column a characteristic position. Thus, 3 and 8 are at the centre of each block; 1 and 6 are at the beginning of each block; 2 and 4 are one up and one down from the easily identifiable column 3 ( and ditto 7 and 9); and so on.

The centrelines of each block of buttons have been spaced exactly 15" apart, this being the average shoulder width of an operator: thus, the operator can adopt two-handed punching of the buttons if he wishes. As mentioned before, separation into two main blocks in this way leaves a space in the centre which can conveniently be filled with the operating buttons.

When considering one column of buttons, (i.e. two vertical rows of ten buttons, giving "tens" and "units") it was thought best to split them into four groups: 0; 1,2,3; 4,5,6; 7,8,9. The reasoning behind this decision was as before, namely, that separation into small groups leads to speedier visual selection of the button required.

It was felt that round buttons were preferable to square buttons, since more space is left around them, and there is more "individuality" to a button. Reference to standard works on ergonomics confirmed this, and gave $\frac{3}{4}$" space as the best horizontal separation between vertical rows of buttons on a keyboard. This has been adopted. Again, the recommended button diameter was given as $\frac{1}{2}$" minimum: after drawing out two full size keyboards on paper, one with $\frac{1}{2}$" diameter buttons and the other with $\frac{5}{8}$" diameter buttons, a compromise diameter of 9/16" was selected as being the easiest to use.

The buttons themselves are white, with large legible numerals engraved in black. By adopting black on white it is hoped that there will be no troublesome reflections, as there was occasionally on the original machine.

Each button stand 5/16" above the surface of the panel, and needs a pressure of between 10 and 20 ozs. to operate it: when pressed, it gives an audible click and stays 1/16 above the panel surface. The button top is concave to prevent finger-slip.

NOTE. All depressed buttons, in whichever column or columns, are returned by pressing the "clear" button on the centre of the machine (see previous discussion on this button).

4. General.

In case the operator needs to have special codings above each column, a $\frac{3}{4}$" deep paxolin strip has been fixed to the control panel above the columns, so that codings can be written on and rubbed off conveniently.

Each column is numbered by a large black numeral (From 1 - 10) on a $\frac{3}{4}$" square white indentation just below each column. Bold numbering in this way will add to the ease with which the operator can single out a given column.

The machine itself has a 15° slope on its top surface, so that buttons and controls come easily into view. In addition, when the machine is used by wheeling it from station to station on a trolley, the sloping fascia makes it easy to read when the operator is standing.

In general, the machines fascia has been "streamlined". Without any effort to make it look modern, the total effect of all the improvements and changes made is that of a more up-to-date product, and one that is more pleasing to the eye. It is also easier to use, since the reading can be read-off without tedious examination of an instrument dial.

Revision of Instruction Manual.

It was decided that the instruction manual was very poorly laid out with regard to its supposed basic function, that of supplying instructions to the unimitiated for the operation of the machine. The sequence in which the various aspects of the machines functions were covered and the ease of comprehension of the information contained therein were both of such a standard that trying to operate the machine for the first time with the manual as the only source of information, led to a certain amount of confusion.

To rectify this situation, it was recommended that the layout of the manual should be amended to a form approximating to the following,

Contents.

Introduction (Brief, relatively non technical description of machine's capabilities).

Specification.

1. Operation.

Operating Instructions.

(a) Preliminary Instructions.

(b) Operation.

(c) Checking Accuracy.

Solution of a Problem (example).

The Basic Equations.

2. Technical Information.
3. Calibration.
4. Circuit Diagrams.

} as per present manual.

It was felt that this layout was logically better for a person trying to operate the machine for the first time with no previous experience, rather than the layout in the present manual. This, it was felt, was illogical in its presentation of information.

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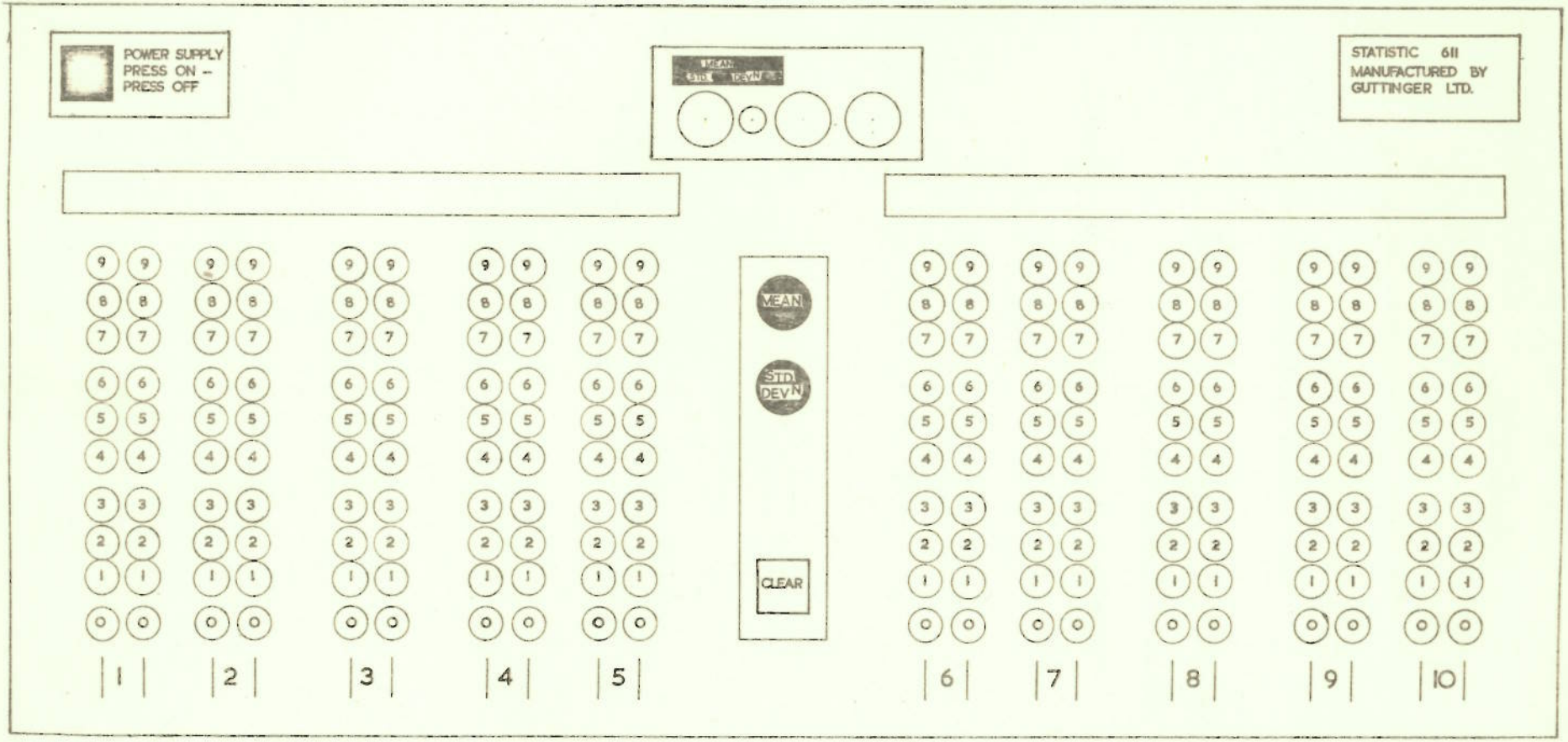
POWER SUPPLY
PRESS ON --
PRESS OFF
MEAN
STD DEVN
STATISTIC 611
MANUFACTURED BY
GUTTINGER LTD.
MEAN
STD DEVN
CLEAR
1
2
3
4
5
6
7
8
9
10

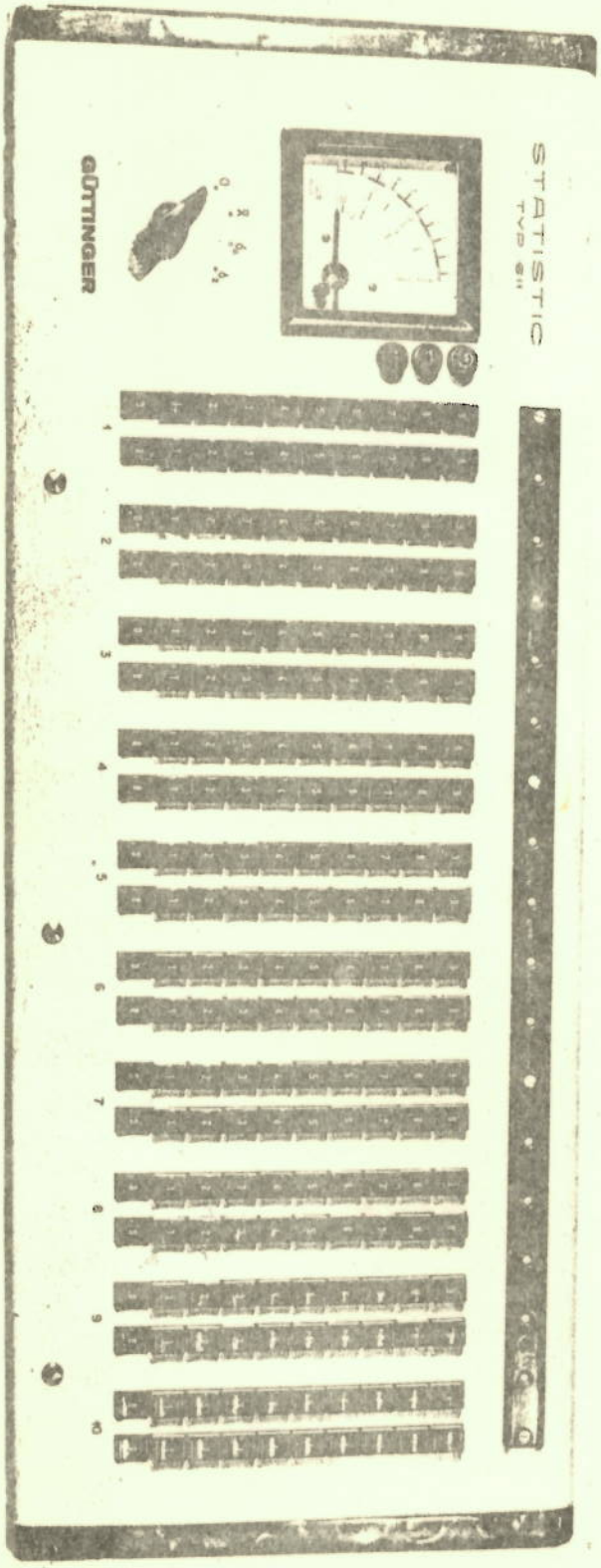


FIGURE 1.

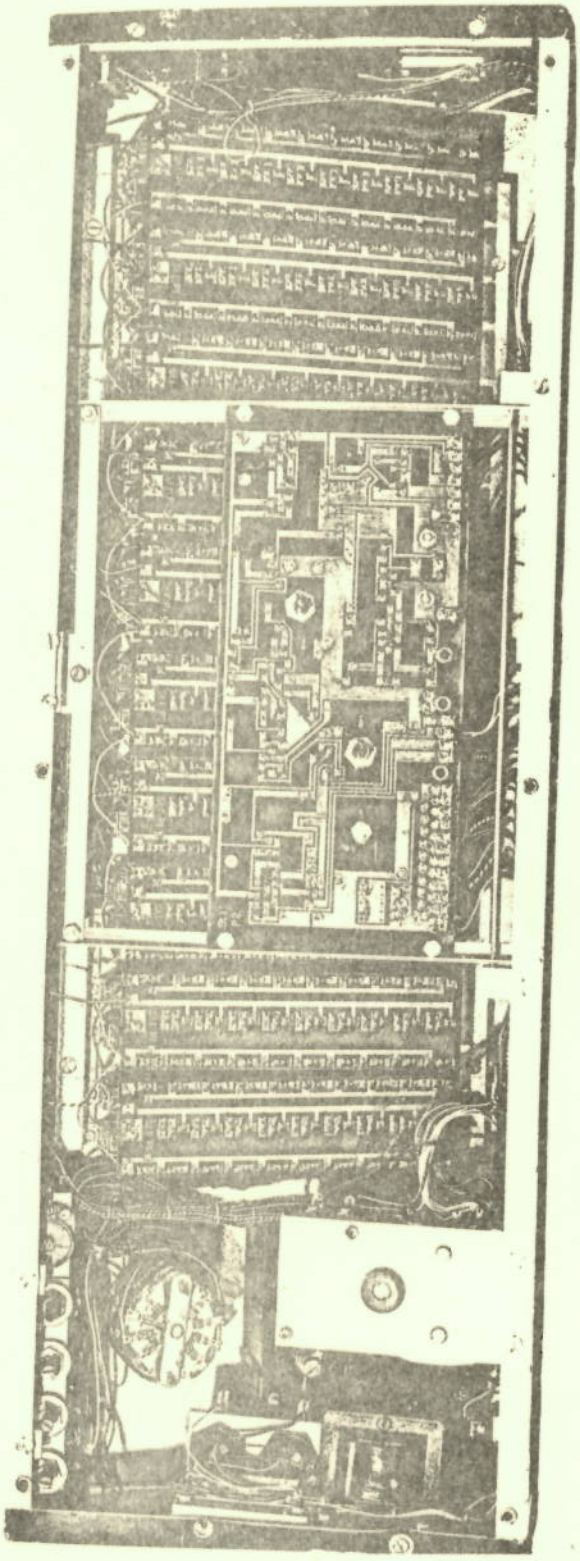

FIGURE 2.