Remarks on the Statistical Use of the Arithmometer

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REMARKS *on the* STATISTICAL USE *of the* ARITHMOMETER.
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IT seems desirable to draw the attention of statists to the great
saving of time and mental labour, which may be effected by the
use of the Arithmometer, or French calculating machine. There
is no great novelty in this machine. In principle it is the same as
the original arithmetical machine invented by Blaise Pascal,* at the
age of 19 or 20, about the years 1642-45, and imitated by several
later mechanicians. The Arithmometer too, as actually manufactured
by the late M. Thomas, of Colmar, has been a good deal used by
actuaries, engineers, and others. It was made known to many people
at the Paris Exposition of 1867, and to many more at the recent
Exposition. English astronomers are now just beginning to use it
for the tedious computations continually going on in observatories.
Yet mercantile men, statists, and the English public at large remain
unaware of the immense saving of labour which may be derived
from the expenditure of 16*l.* or 20*l.* upon this beautiful machine.

It is true that the machine is of little use except for simple
multiplication and division. The work proceeds entirely by addi-
tion and subtraction, which, when repeated time after time, consti-
tute multiplication and division. But there is seldom any saving
of time by employing the machine to perform simple addition or
subtraction, because a computer of very moderate skill accomplishes
this work rapidly on paper, and the transfer of the numbers from
paper to the machine would occupy a good deal of time. The
machine may be used also to extract square and cube roots; but
it only does so by going through all the steps of the ordinary
arithmetical processes, which are lengthy, and when not done on
paper, liable to blunders. For these and various other operations,
logarithms would be more advantageous.

Nevertheless, the most common and troublesome operations of
the computer consist in multiplication and division, and it is in
this work that the machine can render inestimable service. A
long sum can be put on the machine in ten seconds, and then a
few turns of the handle give the product or quotient almost infal-
libly correct, and to as many places of figures as can possibly be
required. The work for which the statist will find the machine
most useful, is that of drawing percentages or ratios. There is
little or no significance in any statistical number, except as com-
pared with some other similar number, and in almost all cases that

* "Œuvres Complètes de Blaise Pascal," vol. iii, pp. 185—208, &c. Paris, 1864.

comparison should be made by calculating the ratio of one to the other. If then a statistical table is to be really intelligible and useful, every column of absolute numbers should be accompanied by a column of ratios. This accordingly is done to a certain extent in the Census Reports, the publications of the Registrar General's office, and some other important statistical tables; but it is never done as much as would be desirable. The reason is obvious. Each ratio can only be obtained by a tedious long division sum, or by the use of logarithms. Many hours of tedious mental labour must be endured before a large statistical table can be reduced to its proper intelligible form. The result is that, in the absence of an office full of clerks, the labour is almost always shirked, and the reader of our statistical publications is left to extract their meaning as well as he can—which means very badly.

With the Arithmometer at hand, however, the work becomes rather amusement than labour, especially to those at all fond of ingenious and beautiful mechanism. The amount of time saved will vary with the character of the operation and the nature of the calculations; but about the saving of mental exertion there can be no possible doubt. The machine will also be of great use in effecting the reduction of numbers from one denomination to another, as from pounds to francs, dollars, rupees, &c.; tons to kilogrammes, yards to metres, &c., &c. It is requisite, however, that all numbers should be expressed in the purely decimal form, so that our absurd systems of money, weights, and measures, present obstacles to the easy use of the machine. When frequent alterations of any numbers in a definite ratio have to be made, it will often be best to calculate at the outset a table of the multiples of that ratio; this can be done with the utmost facility by the machine, because each turn of the handle gives a fresh number for the table. A reduction table can thus be prepared as fast as the numbers can be written down, and all further labour of calculation is saved by reference to this table.

I should like to add, that if our science of statistics is to progress in the spirit of the times, frequent use must be made of the Method of Least Squares. This method is merely the method of means or averages employed in a more complete and elaborate way, to disentangle the probable values of several unknown quantities which happen to be involved together in our statistical data. The working of the process, as described in Merriman's "Elements of the Method of Least Squares" (Macmillan, 1877), in De Morgan's "Essay on Probabilities," and many other works on the same subject, can be carried on by mere rule of thumb; but it requires a great amount of multiplication. With Thomas' Arithmometer, however, the requisite calculations can be readily accomplished, and I conceive, therefore, that in this as well as in other cases, the fre-

quent use of the machine is indispensable as a condition of any distinct advance in statistical inquiry.   Familiarity with the arithmetical machine would gradually lead to the undertaking of intricate numerical inquiries, which are practically impossible without its aid.

The use of the machine as employed by actuaries has already been described by General Hannyngton in the "Journal of the "Institute of Actuaries," vol. xvi, p. 244, and a very able paper "On the Arithmometer of M. Thomas (de Colmar) and its Applica-"tion to the Construction of Life Contingency Tables," was printed by Mr. Peter Gray, in the journal of the same Society for 1874, and issued separately as a pamphlet.   The operations therein described are, however, far more complicated than what the statist will usually need to perform.

The working of the machine is so easy, that it can be learnt by any person of ordinary intelligence in the course of an hour, and with a few little precautions, which are stated in the explanatory book of instructions delivered with the machine, there need be no fear of its getting out of order.   It is said that machines are often worked daily for many years in succession, without any mishap or error occurring; but other operators find that certain springs are apt to break, and require replacement.   The machine, though constructed only in Paris, can be inspected and purchased at a depôt in London.   The smallest machine now made gives a product not exceeding twelve places of figures, which would be sufficient for most purposes; but the medium-sized machine, giving a product of sixteen places, is said to be more convenient in use, as there is greater scope and freedom of action.   My own limited experience of the machine leads me to think that this may be so.

I have been induced to bring the Arithmometer under the notice of the Society, by the feeling that there must be many who are (as I was myself a few months ago) imperfectly acquainted with the value of the machine.   Had I purchased a machine when I first saw it at the Paris Exposition of 1867, I should have been saved a great deal of mental fatigue during the eleven subsequent years, and I might have undertaken statistical inquiries which are beyond the power of a private unaided arithmetician.   The conviction that this machine must prove no inconsiderable factor in the progress of statistical and social science, renders it desirable for those acquainted with its value, to endeavour to overcome the inertia, which, especially in this country, impedes the introduction of any new labour-saving invention.   A machine which was in its essential features invented by the youthful genius of Pascal, in the year 1642, is only now coming into use.   For *two hundred and thirty-six years* (236 years!) practical men have ignored what may prove one of the most practically useful, as it is certainly one of the most beautiful products of human reason.

PROFESSOR JEVONS'S DESCRIPTION *of the* CALCULATING MACHINE.

Dr. FARR said the Society was indebted to Professor Jevons for bringing forward the machine and explaining its uses. It was of great use in the Registrar-General's office in determining the ratios and the percentage of deaths, births, marriages, and so on, and this was done on a very large scale. The clerks were allowed to work by logarithms or by arithmetic, but they invariably preferred the machine. Undoubtedly in order to make it of universal application, there should be a decimal system of calculation in weights, measures, and money; but at present he recommended its use for calculations on a large scale.

Dr. BALFOUR said that for the last five or six years, when he was at the head of the Army Medical Department, they could make all their calculations as quickly as they could by the machine, but he thought it minimised the chance of error. In working out logarithms there was a source of error, which was avoided by using the machine. All the time it was used in the office under his charge he never had any cause to complain of it except that the springs that were worked on the pegs were apt to go wrong. He was indebted to General Hannyngton, who pointed out how this could be remedied, and after he had done so he had never found the machine to go wrong once. On one occasion the clerk of the Department said that the machine had gone wrong, but it was afterwards found that the error was on the part of the clerk, and not on the part of the machine. In working out ratios it minimised the chance of error, which was a consideration of great importance.

Mr. WALFORD said he had been familiar with the machine some years ago. He had seen some sixty calculating machines, but he thought on the whole that the one exhibited was the most available for general purposes. He did not think it was a safe thing to use, except by persons familiar with it, because if it was not set with great care errors would arise, and if one number was wrong, the whole would be wrong. He would minimise that difficulty by having two machines to commence at decennial points, and work the one with the other—not, however, by the same operator—and if the results were both the same, they might be pretty well sure that they were correct. It would save a great amount of labour, money, and thought, and simply required care.

Mr. A. H. BAILEY, President of the Institute of Actuaries, said that the machine grew upon people the more they used it. There was a variety of purposes to which it could be applied. It was very useful in the distributing of a bankrupt's estate, for instance, and one of its great uses would be to introduce a decimal system of arithmetic; but even with our present system of weights and mea-

sures, and of pounds, shillings, and pence, the machine could be used. It should, however, be understood that it was entirely a decimal machine.

The PRESIDENT, in moving a vote of thanks to Professor Jevons, said that he had shown that it was an extremely valuable instrument, and he thought it might be looked forward to as one of the principal instruments in Government offices. Although it might not save time, it would save a good deal of mental labour, and that was one of the greatest considerations in a Government department.