LOGICAL MACHINE

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Logial Machine: Ger. *logische Machina*; Fr. *machine logique*; Ital. *macchine logistiche* (E.M.). An instrument devised to facilitate by mechanical means the handling of logical symbols or diagrams.

There are three such instruments which merit attention: —

(I) The first was constructed by W. Stanley Jevons in 1869 (announced in his *Substitution of Similars*, 1869, 60; described in *Philos. Trans. Roy. Soc.*, 1870, 497–518; brief description in *Proc. Roy. Soc.*, 1870, 166–9, and *Princ. of Sci.*, 1874, 123–31). This instrument was preceded by the logical slate and the logical ABACUS (q.v.) (*Proc. Manchester Lit. and Philos. Soc.*, Apr. 1866, 161; *Substitution of Similars*, 1869, 54–9). In the logical slate the combination of letters, representing all the possible combinations of a definite number of characters or qualities in a logical universe, were engraved in vertical columns upon a common writing-slate. The combinations inconsistent with given premises were then crossed off with a slate pencil, and the conclusions read off from the untouched combinations.

In the logical abacus the combinations were marked on flat slips of wood arranged in horizontal lines on an inclined blackboard having a series of ledges. The slips of wood were furnished with pins, so that those which represented combinationsnconsistent with the premises could be lifted by means of a ruler to the ledge above.

In the logical slate, great care was necessary to cross off all the inconsistent combinations, and in the logical abacus similar care was required in picking out all the consistent combinations. The logical machine of Jevons is a logical abacus in which all that is required of the operator is to press the premises upon a series of keys; the operation of lifting the combinations consistent with the premises to the higher level being

accomplished mechanically by a series of levers. By means of a lattice-work with horizontal slits, the combinations expressed in the premises and consistent with them, and these only, are exhibited to view. This machine, while manifesting considerable ingenuity on the part of the contriver, was nevertheless a cumbersome piece of mechanism. The key-board required two sets of keys, one series for the subject and one for the predicate, and four operation keys, known as the finis, conjunction, copula, and full-stop keys. The combinations were marked upon vertical rods, anmd a double set of these rods were required. The complex character of this machine rendered it unfit to be extended to problems involving more than four terms. At one time Jevons contemplated constructing a machine like it for ten terms, but found that he would have to sacrifice the entire wall-space of one side of his library.

(2) John Venn in 1881 devised a more compact instrument, which he called a logical diagram machine *Symbolic Logic*, 1881, 122). It was also constructed for problems of four terms. For problems of three terms he had used diagrams consisting of intersecting circles, shading out those portions which represented combinations inconsistent with given premises. For four terms, circles were impracticable, hence he used ellipses. His logical diagrm machine represents four intersecting ellipses, arranged so that each section represents one of the sixteen possible combinations. These sections are arranged so as to fall below their original level when they are to be rejected as inconsistent with the premises. They are held in place by pins, and when required to fall, the appropriate pin must be removed. What corresponds to the key-board is therefore a series of sixteen pins, each of which must be individually manipulated. There is no device by which a number of sections may be moved at once. There machine is therefore merely a more cumbersome diagram. The method involved is also practically limited to problems of four terms, since the intersections made by four ellipses are already complex enough. An extension of this system would, in the words of Venn, be probably distasteful to any but a mathematician.

(3) A third logical machine was constructed by Allan Marquand in 1881 (announced in *Johns Hopkins University Studies in Logic*, 1883, 16; published in *Amer. Acad. Arts and Sci.*, 1885, 303–7). It is based upon his logical diagrams (London, Edinburgh, and Dublin, *Philos. Mag,*, Oct. 1881, 266–70). These consist of large squares, subdivided vertically and horizontally into a series of smaller squares, each of which represents one of the logical combinations. The squares which represent combinations inconsistent with the premises may the be shaded off. In his logical machine the combinations are represented by indicators which are arranged like the squares in his logical diagrams. At the outset the indicators are all pointing in a horizontal direction; the premises are then pressed upon a key-board of eight letter and two operation keys, and the indicators which represent combinations inconsistent with the premises fall to the vertical position.

In 1882 Marquand constructed from an ordinary hotel annunciator another machine in which all combinations are visible at the outset, and the inconsistent combinations are concealed from view as the premises are impressed upon the keys. He also had designs made by means of which the same operations could be accomplished by means of electro-magnets.

The characteristic of this machine lies in its simplicity, which may be the better appreciated as the machine is extended for problems problems involving more than four terms. For problems of ten terms Venn would require a new diagram of complicated form, and 1,024 keys to operate the instrument. Jevons for a ten-term machine would require 10,240 letters for his combinations, and a key-board with forty-four keys. Marquand's machine for ten terms needs only 124 letters and twenty-two keys.

There is a further difference between the machines. Jevons' presents as the conclusion not all the combinations consistent with the premises, but only those which involve the terms of the premises. For example, in a series of premises, he assumes that the only conclusion desired is the relation of the first to the last term in the series. In Venn's and Marquand's machines the inconsistent combinations only are thrown out, and all the combinations consistent with the premises are exhibited as the conclusions. Hence any term or combination of terms may be made the subject of the conclusion.

In 1883 Marquand published an account of a machine for producing syllogistic variations, which he constructed in 1881 (*Johns Hopkins University Studies in Logic*, 1883, 12–15). The two premises and the conclusion of a syllogism are written on three rectangular flaps, which are made so as to revolve on a horizontal axis. The contraposed forms of premises and conclusions are then written on the backs of the flaps. By turning a crank, the eight possible combinations of premises and conclusion are then exhibited to view.

This mechanism could be readily extended so as to exhibit similar variations for arguments involving a larger number of premises or conclusions. Marquand's logical machines are now in the Princeton Psychological Laboratory.