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XXXIII. On logical diagrams for n terms

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concerned, have been overlooked. It is therefore perhaps not astonishing that the result is not, on this very point, in accordance with experimental fact. While molecules are in close proximity, forces must act which depend on their vibrations; and the relative phase of vibrations will be an important factor in the determination of the strength and sign of these forces. As the molecules approach each other they try to place themselves in unison; that is to say, the vibrations of those already in unison will be strengthened, while the vibrations of those the phases of which are in disagreement will be weakened. At the moment of the shock a sudden alteration in phase may take place; and observations on natural light seem to show that it does take place. If this alteration takes place according to fixed laws, the forces acting between the molecules during the second part of the shock will be altogether different from those acting while the molecules are approaching. Boltzmann assumes that all the phenomena of an encounter take place as often in a reverse order; but if forces such as those suggested act, this need not be true.

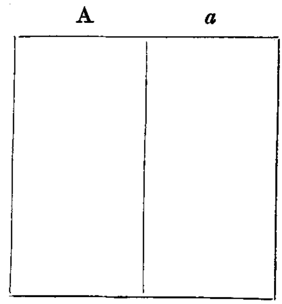
XXXIII. *On Logical Diagrams for* n *terms. By* Allan Marquand, *Ph.D., late Fellow of the Johns Hopkins University**.

In the Philosophical Magazine for July 1880 Mr. Venn has offered diagrams for the solution of logical problems involving three, four, and five terms. From the fact that he makes use of circles, ellipses, and other curvilinear figures, the construction of diagrams becomes more and more difficult as new terms are added. Mr. Venn stops with the five-term diagram, and suggests that for six terms "the best plan would be to take two five-term figures."

It is the object of this paper to suggest a mode of constructing logical diagrams, by which they may be indefinitely extended to any number of terms, without losing so rapidly their special function, viz. that of affording visual aid in the solution of problems.

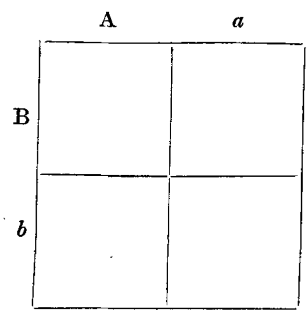
Conceiving the logical universe as always more or less limited, it may be represented by any closed figure. For convenience we take a square. If then we drop a perpendicular from the middle point of the upper to the lower side of the square, the universe is prepared for a classification of its contents by means of a single logical term.

* Communicated by the Author.



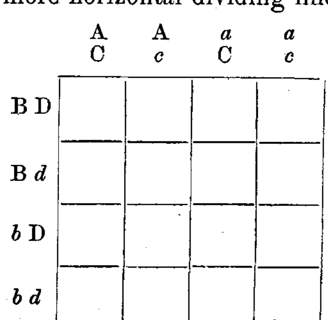
This represents a universe with its A and not-A "compartments." The quantitative relation of the compartments being insignificant, they may for convenience be represented as equal.

The introduction of a second term divides each of the existing compartments. This may be done by a line drawn at right angles to our perpendicular and through its centre, thus:—



The four compartments represent the sub-classes A B, A *b*, *a* B, *a b*.

A diagram for four terms would require two more perpendicular and two more horizontal dividing lines, thus:—



The sixteen compartments here represent the formal division of a universe into the classes A B C D, A B C d, A b C D, &c.

Thus by continued dichotomy we may reach a diagram for any number of terms. A diagram for n terms, if n be any even number greater than 2, requires $2+2^2+2^3+\ldots+2^{\frac{n}{2}}$ dividing lines; diagrams for $n-1$ terms require $2+2^2+2^3+\ldots 2^{\frac{n}{2}}-2^{\frac{n}{2}-1}$ such lines.

As the number of terms increases, the labour of writing out a quantity of letters may be considerably lessened by the use of brackets. This will appear in the solution of the following problem.

The are eight arguments, A, B, C, D, E, F, G, H, thus related to each other:—When E is true, F is true; and when F is true, either E is true or B and C are both false. When either G is true or E and F are both false, D is true. If B is false when either F or G (but not both) are true, then H is true and either C is false or D true. It is true only when an even number of the remaining arguments are true; it is false only when an odd number of the remaining arguments are false.

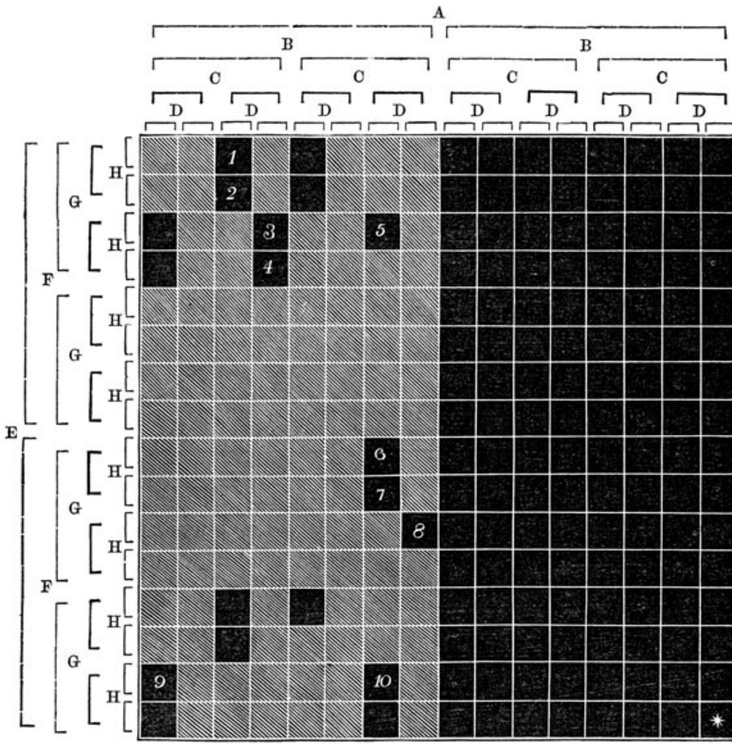
Supposing any combination not inconsistent with the premises to exist, (1) What follows from A being true either when B is true and D false or C false and F true? and (2) From what combination of arguments may we conclude that A and H are both true when E and G are both false?

Representing truth by a capital and falsity by a small letter, all possible combinations of the truth or falsity of the eight arguments are indicated by the small squares in the following diagram.

The shaded squares indicate the A combinations which are inconsistent with one or more of the premises; the non-A combinations, not being required in the conclusion, may be neglected. The first part of the conclusion calls for the eight combinations numbered 1 to 8 on the diagram. These are:—

A B c D E F G H
A B c D E F G h
A B c d E F g H
A B c d E F g h
A b c D E F g H
A b c D e F G H
A b c D e F G h
A b c d e F g H

and one or other of these is true. It will be observed that in all the combinations C is false and F true. Many subordinate conclusions may be drawn, such as A, B, and D being all true, E, F, and G are also true; A being true when B and G are both false, H is true, &c.



The second part of the conclusion calls for the three combinations marked 8 to 10 on the diagram. These are

A *b* *c* *d* *e* F *g* H
A B C D *e* *f* *g* H
A *b* *c* D *e* *f* *g* H.

Hence from either B C D *f* or *b c* D *e* or *b c d e* we may conclude A *e g* H.

Attention may be drawn to the fact that these diagrams differ from those suggested by Mr. Venn in having a compartment for the *absence of all* the characters or objects. Thus in the 8-term diagram the compartment marked with a star stands for the combination *a b c d e f g h*. This compartment may need to be shaded out, and hence should be indicated on a complete logical diagram. This is parenthetically acknowledged by Mr. Venn ('Symbolic Logic,' p. 271), and practically in the construction of his logical-diagram machine ('Symbolic Logic,' p. 122).

I have constructed a logical-diagram machine on the basis of these diagrams. Blocks, corresponding to the squares or rectangles on the diagrams and resting on two sets of slides, the one set below and at right angles to the other, may be made to drop when the combinations which they indicate are inconsistent with the premises. 32 such slides are required to operate the 256 blocks of an 8-term machine.

But this machine, though simple enough, is practically inferior to the diagrams which I have had printed at a trifling expense for problems of 7, 8, 9, and 10 terms.

XXXIV. *On the History of the Theory of the Beats of Mistuned Consonances. By* R. H. M. Bosanquet, *Fellow of St. John's College, Oxford.*

To the Editors of the Philosophical Magazine and Journal.

Gentlemen,

In a paper recently published in the Philosophical Magazine, I have given an account of my recent experiments on an important branch of this subject. I wish to contribute further to the appreciation of the bearing of my results, by means of a critical notice of a few of the most important points connected with the history of the subject; to which I propose to add some remarks on König's recent paper (*Annalen der Physik und Chemie*, 1880, p. 857).

Passing over the early history of the subject, we come to Smith's 'Harmonics' (1759), a treatise always regarded as important, but difficult. Smith was mainly concerned with the reduction of the phenomena to rule, for the purpose of his studies of musical temperament. His fundamental principles do not really reach beyond the numerical or geometrical appearances or patterns which arise from the superposition of certain sequences of forms at regular intervals. Causal explanation, reference to laws of sensation, analysis of the functions of the ear, were not attempted by Smith. But his work is of great importance. Is is still much appreciated as the first and, in one sense, almost the most powerful exposition of principles still largely held, which are entirely incompatible with the point of view originated by Helmholtz, or its developments.

Freed from the singular phraseology in which Smith's propositions are enveloped, they are not difficult in themselves. I will shortly state in an example the effect of his reasoning, so far as it purports to deal with the causes of beats.