

bring in food. The hunting was done entirely by the male, but the female fed the young, and cleaned up the eyrie by carrying away any old carcasses of prey.

It is stated that the young eagles remain with

their parents until winter, but I would say rather that the month of October is the time they usually separate; they may then often be seen perched on some tree or on some rock, and permit of a comparatively near approach. S. G.

MATHEMATICS OF THE ARMAMENTS RACE

Generalized Foreign Politics

A Study in Group Psychology. By Dr. Lewis F. Richardson. (*British Journal of Psychology*, Monograph Supplements, 23.) Pp. viii+91. (Cambridge: At the University Press, 1939.) 8s. 6d. net.

THE application of mathematics to group phenomena such as those of the kinetic theory of gases and statistical mechanics has long been accepted by physicists. The extension of such methods to biology, economics, and psychology is also widely accepted. Dr. L. F. Richardson, who is well known for his work in physics and meteorology, but who also holds a degree in psychology, makes the daring attempt to deal mathematically with foreign politics, particularly with the growth of armaments and the motives which produce this growth. The author's method is to take a verbal argument of a leading statesman and replace it by differential equations. Thus, Sir Edward Grey said: "The increase of armaments that is intended in each nation to produce . . . a sense of security, does not produce these effects. On the contrary, it produces a consciousness of the strength of other nations and a sense of fear." This statement is replaced by a pair of differential equations, the meaning of which is certainly not exactly the same as that of the original statement. The differential equations really assert that for two nations, the rate of increase of expenditure on armaments by either is directly proportional to the total expenditure on armaments by the other. This variation of Grey's words is adopted because it is easy to deal with mathematically. However, it is immediately corrected by adding other terms, with a negative sign, to represent the restraining influence due to the burden of expense and fatigue, an influence not mentioned by Grey. The next step is to take account of an objection by Mr. Amery: "It was . . . in those insoluble conflicts of ambition and not in the armaments themselves that the cause of the War lay." An additional positive constant term is added to each equation to represent the extra rate of growth of the armament burden due to national grievances or ambitions.

Having set up the differential equations, it remains to solve them, and then to give the

political interpretation of the solution. The exact solution offers no difficulty to mathematicians or mathematical physicists, as the equations are of a well-known type. Curiously enough, somewhat similar equations occur in a paper on "The Ignition of Explosive Gases". To meet the needs of those without much knowledge of mathematics, Dr. Richardson gives also a simple graphical treatment, which is similar to Marshall's diagram for the economics of international trade. In both the mathematical and the graphical treatment, the most important part of the work is to find out in what conditions the solutions become infinite. An infinite cost of armaments is interpreted as denoting war, though it might have seemed more natural to have taken it as bankruptcy. The final conclusions are difficult to state accurately in concise form, but they are roughly that there is a general tendency for peace to be unstable. This instability can be reduced by removing grievances, decreasing threats, and increasing international trade and other forms of co-operation. It is emphasized that increase of armaments, though undertaken as a measure of defence, tends to lead to war.

Opinions will differ as to the validity of this reasoning. Some may think that the author has made the first rough approximations in a new branch of science, which can be polished and corrected later. The mathematician, who knows that a small change in a differential equation can sometimes produce a large change in the solution, may be distrustful of the way in which the fundamental equations were obtained. Students of human affairs will assert, perhaps too hastily, that foreign politics cannot possibly be treated mathematically. However, the subtitle of the monograph is "A Study in Group Psychology", and possibly the method may be valid so far as the effects are entirely due to the group mind, to which a kind of statistical mechanics may be expected to apply. The author gives a numerical test of his theory for the years 1909-14, and it seems to accord closely with the facts for that period. One great defect is that the theory does not include the effect of "intelligent aggression planned by a leader as moves in a game of chess". Unfortunately, this is the aspect of the question which is of vital interest to millions to-day. H. T. H. PIAGGIO.