SCIENTIFIC BOOKS

Opticks or a Treatise of the Reflections, Refractions, Inflections and Colours of Light. By SIR ISAAC NEWTON, Knt. Whittlesey House, McGraw-Hill Book Company, Inc., New York. $2.50.

THIS book is a reprint of the fourth edition of Newton's "Optics," which was printed in 1730 from a corrected copy of the third edition furnished the bookseller by Newton himself before his death. There are prefixed to the text an enthusiastic foreword by Einstein and a short but clear and valuable introduction by Whittaker, in which the development of Newton's views on optical theory is discussed and some of the analogies between Newton's views and those of modern times are pointed out.

In February, 1672, Newton presented to the Royal Society a paper on a "New Theory about Light and Colours." He begins with the analysis of sunlight by the prism and goes on to show, by a few fundamental experiments, that the different colors of the spectrum have an individuality which they do not lose by any subsequent reflections or refractions, and that white light is a compound of these individual colors. In his treatise on optics, the first edition of which was published in 1704, Newton begins by showing that if the two halves of a card are painted red and blue, respectively, and the card is then viewed through a prism, the refracted images of the two halves will be differently displaced. He then proceeds to the analysis of light from the sun, describing the experiments of his early paper but adding many others, as if he felt that the theory which he had proposed was open to question and needed all the support from experiment which could be given to it. Many of the experiments are well known and are exhibited to all students of the subject; others which are not so frequently shown are of equal interest, and some of them are noticeable for their simplicity and their convincing force. Newton shows that the principal cause for the failure of the telescopes of his day to give distinct images was the dispersion of the light. He proves this very conclusively and then presents his plan for a reflecting telescope and describes instruments which he had made on that plan.

Another set of experiments, even more elaborate than those of the first part, deals with the general phenomena of color. It is shown that colors are not caused by any new modification impressed on the incident light by the material of the body, but that in every case these colors may be analyzed into the simple colors of the spectrum, and that all colors are either those of the homogeneous rays or are compounded from them. In this part of the book he also explains the colors of the rainbow and of natural bodies.

In Book II, we find the study of the reflections, refractions and colors of thin transparent bodies. Newton describes at length the rings that are seen in the light reflected from a thin film of air confined between a sheet of plate glass and the slightly convex face of a lens. He tabulates the successive colors which appear in these rings, when viewed with white light, and studies them also when the light used comes from one part of the spectrum only. In this way he recognizes that there is a certain periodicity exhibited by the light and that the light seems to change its properties at certain equal short intervals of distance so as to be, in one condition, capable of easy reflection and in the other, of easy refraction. These conditions he calls by the name of "fits" of easy reflection and of easy transmission. They are not specified or described in any definite way and no attempt is made to present a model of the light in these fits or to describe its operation. Newton does say that if any one wishes to have a scheme by which he can visualize the action, he can imagine that the rays of light, when they impinge on any surface, may set up vibrations in the refracting or reflecting medium, and that these vibrations are so transmitted as to overtake the rays, and that when a ray is in that part of the vibration which combines with its motion, it easily breaks through a refracting surface, but when it is in that part of the vibration which impedes its motion, it is easily reflected, but he says: "Whether this hypothesis be true or false I do not here consider. I content myself with the bare discovery that the rays of light are by some cause or other alternately disposed to be reflected or refracted for many vicissitudes."

Newton goes on to apply this theory of alternate fits to explain certain colors of thick plates which were first observed by him.

In Book III, Newton gives an account of his experiments on the general subject of diffraction, starting from the original observations of Grimaldi. The experiments are not very numerous or very precise. They convinced him that the action of the body on light which passes near its edge extends for some little distance beyond the material of the body itself. They did not lead him otherwise to any important extension of his views. Apparently his experimental activity ceased before he had carried out the experiments which he had planned in this part of the subject, and he was never able to resume the work. Instead of going on with experiments, he contented himself with introducing a number of queries, in some cases suggestive of additional experiments, in others presenting hypotheses as to the nature of light and explanations of the phenomena discovered. Only a few of these queries appeared in the first edition, but their number was increased in the second edition to thirty-one. They are of great interest as showing Newton's mind when it turned to speculation. No one was more adverse to speculation in science than Newton. In the present book he reiterates the *hypotheses non fingo* of the Principia, and yet he could not keep himself entirely from hypotheses. Indeed it is difficult to see how progress can be made in such a science as optics without the help of hypothesis. Yet even in this hypothesis making, Newton's caution is evident.

He supposes that the emission of light results from the vibrations of the parts of the luminous body and that light is seen by vibrations excited in the retina of the eye. He suggests that different rays make vibrations of different bigness and that these excite colors, just as the vibrations in air make sounds of different pitch, and that the most refringent rays make the shortest vibrations. He suggests again that the rays when they fall on the refracting medium may excite waves which overtake the rays of light and thus make the alternate fits which observation discloses. By experiment he proves that heat may be transmitted through vacuum and therefore, he suggests, through a much subtiler medium than air. This medium he thinks is possibly rarer in bodies than it is outside them, and on the supposition that its density increases slightly as the distance from the body increases, he suggests that gravitation may be explained by possible pressures in this medium. He insists, however, that this medium must be of excessive rarity and that a dense medium in which waves could be transmitted, such as is suggested by Huygens, can be of no use for explaining the phenomena of nature and he goes on to say that "as it is of no use and hinders the operation of nature, and makes her languish, so there is no evidence for its existence and therefore it ought to be rejected. And if it be rejected, the hypotheses that light consists in pression or motion, propagated through such a medium, are rejected with it." Earlier in this query he rejects the wave theory on the ground that "if light consisted of pression or motion propagated either in an instant or in time, it would bend into the shadow." From the consideration of the phenomenon of polarized light as discussed by Huygens he concludes that "the rays of light have four sides or quarters, two of which opposite to one another incline the ray to be refracted after the unusual manner, . . . and the other two . . . do not incline it to be otherwise refracted than after the usual manner." This property he thinks is proof positive against a wave theory. In query 29, he presents his corpuscular theory of light. He points out that if the rays of light are very small bodies emitted from shining substances they will travel in straight lines and will be able to preserve their properties unchanged as they pass through various media. They may also be reflected and refracted according to the ordinary laws. To produce the various colors, he suggests that the rays of light may be bodies of different sizes and that they may be put into the fits of easy reflection and easy transmission by stirring up vibrations in the bodies on which they act "which vibrations being swifter than the rays overtake them successively, and agitate them so as by turns to increase and decrease their velocities, and thereby put them into those fits."

In the introduction Professor Whittaker has pointed out that these speculations of Newton present analogies to those which are prevalent at the present day in quantum theory and in wave mechanics. They are of great interest as showing how far an acute mind may go in the speculative interpretation of a body of phenomena without really committing itself to a definite conclusion. What Newton would have thought if he had been shown Young's demonstration of interference and Fresnel and Arago's work on polarized light we can not certainly determine, but it is an interesting subject for speculation.

The book is well printed. In two or three places the long "s" of the original has misled the typesetter into saying that certain intervals "found a common chord," but generally it is remarkably free from error. The publishers should be thanked for this timely issue of a very important book.

W. F. MAGIE

PRINCETON UNIVERSITY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN ELECTRICAL DROP COUNTER

WHILE making a study of physiological secretions, a drop flow record over an extended period of time was desired. Several different types of apparatus for this purpose were designed, but the one presented here was found to be efficient. Besides its use to record such fluids as urine, saliva, bile, pancreatic and other such secretions, it might be used wherever a record of drop flow is desired over an extended period of time, *e.g.*, slow titrations, evaporation experiments or condensation rates, etc.

A glass tube with inside diameter of about three