Some Scientific Instrument Makers of the 18th Century.*

By ROBERT S. WHIPPLE.

ALTHOUGH numerous references are found in early British manuscripts to instruments of an elementary kind, chiefly for the determination of time or position, there is little evidence that before the sixteenth century scientific instrument making as a craft had obtained a position of any importance in Great Britain. The demand for instruments to assist navigation became more insistent as new lands were discovered and the length of the voyages increased.

Gradually the professional scientific instrument maker came into existence, two of the more distinguished being Humphrey Cole, the maker of the astrolabe used by Sir Francis Drake, and Elias Allen, the maker of Oughtred's double horizontal dial. In a book by Oughtred dated 1632 describing the double horizontal dial it is stated that it is printed for Elias Allen, "Maker of these and all other Mathematical Instruments and are to be sold at his Shop over against St. Clements Church without Temple-barr".

With the discovery of the telescope in 1608, and its development by Galileo in the following years, a great impetus was given to the instrument-making industry. Although Gregory and Newton propounded the reflecting telescopes known by their names in 1663 and 1666, they were unable to find makers capable of developing their ideas. Newton made his own instruments, but it was not until about 1730 that John Short of Edinburgh succeeded in making a Gregorian telescope.

The latter half of the seventeenth century was a great period of scientific development. Experimental science, under its leaders Boyle, Hooke, Newton, and others, created a demand for scientific instruments which could only be satisfied by skilled craftsmen. The work of Hooke and Leeuwenhoek did much to develop the microscope and to direct attention to the possibilities of the instrument. Fortunately an instrument made about 1670 and somewhat similar in its details to that described and illustrated in Hooke's "Micrographia" (1665) has been preserved. The evidence is, I think, convincing that this instrument was made by Christopher Cocks, the well-known telescope maker, who lived in Long Acre, and of whose telescopes there are at least three in existence. It is known that in March 1672 Cocks was ordered to make a four or five foot Newtonian reflecting telescope, but the instrument was not successful. About 1680 he was admitted a freeman of the Spectacle Makers' Company.

Owing to the publication of the "Micrographia", with its description of Hooke's microscope, great interest was created in microscopical work, and a demand arose for microscopes. Owing to the high quality of the optical and mechanical work the English microscope won a high reputation.

The greatest of the English instrument makers

who bridge the seventeenth and eighteenth Centuries is undoubtedly John Marshall. Nothing is known of his early life, but part of a diary recently discovered in the British Museum by Mr. H. W. Robinson, by whose courtesy I am able to publish an extract, has thrown an interesting sidelight upon Marshall's career. The record covers five years of Hooke's life, 1688 to 1693—with the exception of some few months—and was thought to be the diary of James Pettiver, an apothecary friend of Hooke. Mr. Robinson has been able to prove that it was written by Hooke. The following is an extract, December 14, 1688: "One John Marshall who told me he was Dunning apprentice and now worked at turning at the 3 keys in Ivy Lane came to shew me some microscopes of his own making he told me Mr. Boyle had bought such of him". He appears to have set up later at the sign of the Gun as a maker of spectacles and microscopes, and there is little doubt that the microscopes were of the Hooke type. By 1690 he had built up a large business, and had introduced a new method of grinding lenses on brass tools. Marshall's double microscope was undoubtedly the greatest advance made in microscope construction for many years. The instrument was fitted with coarse and fine focusing adjustments, and for the first time the limb which carried the eyepiece, the object glass, and the object, formed one complete system which could be inclined as one unit. All the features are retained in the modern instrument.

The first outstanding English instrument maker in the eighteenth century is undoubtedly Benjamin Martin, a man who, so far as is known, was not apprenticed to the trade. He was born at Worplesdon, Surrey, in 1704, and began life as a ploughboy, later becoming a teacher of the 'three R's' at Guildford. He devoted his spare time to the study of mathematics. A legacy of £500 relieved him from the necessity of teaching, and enabled him to travel and lecture. He appears to have assisted at the lectures given by Dr. J. T. Desaguliers, which were eagerly attended by the fashionable world and were illustrated by experiments. Horne, afterwards president of Magdalen College, Oxford, sarcastically remarked that Ben Martin "who having attended Dr. Desaguliers' fine raree gallantry show for some years in the capacity of a turnspit, has it seems, taken it into his head to set up for a philosopher". This is a hit at Martin's literary efforts, because he proceeded to publish a large number of text-books dealing with a great range of subjects. When it is considered that Martin was a self-educated man, the extent and thoroughness of his knowledge, as shown in his publications, are remarkable. He appears to have lived for some time at Chichester, where he kept a school, and also wrote several elementary text-books and pamphlets describing scientific instruments. There is little doubt that he commenced to make scientific

* From a Friday evening discourse delivered at the Royal Institution on May 23.

instruments in Chichester, not improbably being asked by the readers of his books where it would be possible to obtain the instruments mentioned.

About 1750 Martin moved to London to a house in Fleet Street, three doors below Crane Court, where he became famous as a scientific instrument and spectacle maker at the sign of "Hadley's Quadrant and Visual Glasses". Martin was essentially a teacher, and continued to write after he had made his home in London. The books impress one with the care he takes to make every individual step in an explanation clear, and with the detailed drawings and references with which he explains the construction and use of an instrument. This is strikingly illustrated in his description of the various orreries he constructed. The orrery was almost the latest scientific novelty, and Martin appears to have been much impressed with the educational possibilities of the instrument. In his "Young Gentleman and Lady's Philosophy in a continued survey of the works of Nature and Art"—a book which had a great vogue—he uses planetaria to describe the difference between the Ptolemaic and Copernican systems, and the phenomena of eclipses, etc. He was evidently prepared to supply either form of planetarium to suit his customers' wishes. In one of his tracts published in 1771, "The Description and Use of an Orrery of a new Construction", he gives full details of the capabilities of the instrument, and also "the theory of calculations for the wheel-work of an orrery to the most extreme Degree of Accuracy". The prices of the instruments ranged from £12 12s. upwards, depending on the number of bodies demonstrated, and the accuracy of their movements, or as Martin himself states "proportional to the work". That Martin must have continued to lecture until late in life is shown by the fact that the apparatus made is adapted to show "all the Phaenomena [*sic*] of the Transits of Mercury and Venus over the Face of the Sun such as I shewed in Public to Thousands on the late memorable instance of 1769".

In 1740 Martin published a useful text-book on optics, "A New and Compendious System of Optics", and in many other writings took immense trouble to explain optical systems and instruments. His microscopes and especially his cabinets containing two or three instruments of various types were much sought after, and still remain as examples of first-class workmanship and ingenuity. There is little doubt that he invented the drum type of microscope (see Fig. 1) which had a great vogue and is still made in large numbers on the Continent. If the invention of the glass micrometer as applied to a microscope was not actually due to him he was undoubtedly one of the first to employ it. He was also one of the first to apply rack and pinion focusing adjustments to the compound microscope, and to fit inclining movements to the pillar carrying the stage and mirror.

It is a cause of wonder to me how Martin was able to produce such a large number of books. The "Dictionary of National Biography" mentions thirty-one, although some of them are only leaflets.

Many of his books passed through several editions, and at least one was translated into French. They undoubtedly helped to popularise science and to create an interest in scientific instruments. Shortly before his death at the age of seventy-seven, he took his son into partnership, and unaware of the state of his affairs was adjudged bankrupt. He thereupon attempted suicide, and the wound hastened his death. His valuable collection of fossils and curiosities was sold by public auction

FIG. 1.—Microscope, drum type, by Benjamin Martin.

for a trifling sum—a tragic ending to a more than usually successful career.

George Adams, the elder, perhaps the greatest of English scientific instrument makers, was born about 1704. It is known that he was apprenticed in 1718, and that he was established in business on his own account at Tycho Brahe's Head in Fleet Street in 1735. It is also known that he was making instruments for the East India Company in 1735–36. He obtained a world-wide reputation as a maker of globes. In 1766 he published the first edition of his book "A Treatise describing and explaining the construction and use of new celestial and terrestrial globes". Dr. Samuel Johnson, the lexicographer, wrote the dedication to the King, and for so doing received a present

of "very curious meteorological instruments of a new and ingenious construction". The book had a great vogue, passing through thirty editions.

Adams was essentially a mechanic and delighted in good workmanship. There can be little doubt, I think, that the microscope was his favourite instrument, and he developed several types of it. In 1746 he published his "Micrographia Illustrata: or The Knowledge of the Microscope explained in several new inventions etc.". The preface to the "Micrographia Illustrata" emphasises the religious side of Adams's character, and also shows that he must have had the artistic and poetic temperament highly developed. The first edition of the book contained an account of a "New Universal Microscope" which was made to an entirely original design, the object being, as Adams states, "to have a Microscope which would be Portable and Universal, that is to say, ONE ONLY INSTRUMENT, by which all Sorts of minute Objects might be observ'd". The microscope was provided with six single lenses of different foci with a common focusing screw. Adams remarked of this focusing screw that it "is to be turned as your hands and arms are resting on the table, which is a conveniency to be met with in no other

Microscope". A second edition of the "Micrographia Illustrata" appeared in 1747, and a fourth in 1771. Despite exhaustive researches it has not been possible to find a copy of the third edition—if it were ever published.

The fourth edition commences with a description of the variable microscope of which Adams was evidently very proud. He states that "We owe the construction of the Variable Microscope to the ingenuity and generosity of a noble person", and we know that the "noble person" was the Earl of Bute. By having a compound eye lens and by introducing an auxiliary lens placed some distance above the objective the definition was improved. Adams also introduced the method of screwing two or three objective lenses one on top of the other. By drawing up the eyepiece relative to the object glass the power of the combination could be altered and hence the name "variable". Adams, in common with Martin and other makers of the period, developed the solar microscope with the large mirror projecting out of the window, by means of which brilliant illumination could be obtained, and magnified images of the object projected on to a screen.

(To be continued.)

Biometry and Evolution.

WHEN an entirely novel and revolutionary view is put forward by a man of scientific eminence, the critic must endeavour to form a decision between two alternatives, for both of which he must necessarily be, to some extent, unprepared. Either a scientific discovery has been made of such a magnitude as to subvert a whole body of apparently well-founded opinion, or, what is more disturbing still, some incredible error has frustrated in its effect all that we might hope from trained ability, industry, and patient thought. We owe it to science to keep this latter possibility in view, whatever may be the weight of authority which is in the balance.

Under the title of "On a New Theory of Progressive Evolution" (*Annals of Eugenics*, vol. 4, pp. 1-40) Prof. Karl Pearson puts forward a theory which, as he realises, will be difficult to bring home to the biologist. In his own words, "The intensity of heredity is such that with isolation and inbreeding any individual characteristic, or deviation from racial type, will be gradually emphasised and become a factor of progressive evolution. Thus all organisms if isolated are in a constant state of evolution, and it is only interbreeding and the selective action of environment which preserve a type. In other words, natural selection controls evolution, but the progressive urge is provided by heredity itself."

It is obvious that in this statement Prof. Pearson is using the word 'heredity' in a sense somewhat different from its popular and biological meaning. There is, however, little occasion for surprise in this, for those familiar with his writings will know that the term is used to cover all the statistical

relationships between the measurements of related individuals. What is asserted is that these relationships require that when a group of individuals, differing, however little, from the mean of their species, is isolated, so that they and their descendants interbreed without further selection, then the mean of this isolated population will continue to depart further and further from the mean of the population from which their ancestors were originally selected. A diagram on p. 10 of the monograph shows this process in detail. The first generation following isolation shows, indeed, some regression towards the mean of the original population and differs from it by only about 70 per cent as much as its parents. In the second generation, however, the mean has progressed to nearly 95 per cent and, thereafter, the successive means actually exceed that of the foundation stock, and increase so rapidly that by the eighth generation the deviation is nearly seven times as great as it was at first.

For the formulæ from which these astonishing results were derived recourse should be had to the mathematical appendix, where, on p. 23, we find that they are the result of applying a certain recurrence formula, based upon a system of formulæ for the correlations between the averages of different groups of ancestors of the same individual; the numerical values come ultimately from three correlations found in human stature, namely, parental correlation 0.50625, fraternal correlation 0.53367, and marital correlation 0.2804.

Prof. Pearson has been content to apply his recurrence formula numerically, but it is capable of algebraic solution. It appears that the deviation