

passed into the domain of atomic or molecular physics. We know little enough about gelatine, and want to know a great deal more. Gelatine has proved to be a better medium than collodion, but there seems no reason to suppose that a better than gelatine may not be found. We seem to have realised the maximum aperture (or

rapidity) in lenses, but there is no such absolute boundary to the sensitiveness of photographic plates, and here we look for continued progress. One fundamental question: Why should silver occupy such a unique position among all the elements with regard to the sensitiveness of its salts?

REPRODUCTION OF ILLUSTRATIONS, 1869-1919.

By EMERY WALKER.

FIFTY years ago illustrations for books or periodicals were printed either from engraved wood blocks, steel plates, or were lithographs. In the earliest numbers of *NATURE* examples may be seen of the first method—in that of January 20, 1870, we find a diagram of a section of the tube by which it was proposed to construct the Channel tunnel; and in that of February 17 an illustration of the Newall telescope at Gateshead: these could scarcely be bettered now. The map illustrating the main drainage of London, in the issue of March 31, is an example of the inadequacy of wood for such a purpose.

Two years later Mr. Alfred Dawson patented a method of engraving designed to supersede wood, and though his object was not attained in subjects requiring tone, diagrams and simple maps were found at once to be better and more cheaply engraved by his process.

Dawson's typographic etching, as he named it, is produced thus: A metal plate is coated with a ground of wax composition; the drawing is made upon the plate through the ground down to the surface of the plate with steel points, similar to those used in etching, but they are faceted to different dimensions at the points. If lettering is wanted, as for a map or a diagram, the letters are stamped in the wax with ordinary printer's type. The spaces between the lines and letters are then raised upon the plate by the addition of melted wax, which unites with the ground and runs up to the line, and in the hands of a skilful operator stops there, thus forming a mould. This is then blacklead, and upon it copper is deposited by a galvanic battery. When the copper is about the thickness of fairly stout brown paper it is taken off the mould and the outer surface tinned and "backed up" with antimonial lead. The leaden surface is turned in a facing lathe and mounted upon wood or metal, which brings the printing surface of the block to the height of type. It is then practically a piece of type and can be "set up" and printed with the text of the page.

This process was a development, with some refinements, of a method patented by Edward Palmer about 1840, and called by him "glyphography"; it was used to a limited extent for book illustration.

Dawson's typographic etching is still in use, and it may be interesting to note that the line blocks for the maps in Fortescue's "History of the British Army," and the greater part of those for

the last edition of the "Encyclopædia Britannica," were engraved in this way.

In France a method called, after its inventor, "Gillotage" had been in use a few years earlier than this, by which blocks for the cheaper kinds of newspapers were made by transferring to zinc drawings made in reverse upon lithographic transfer paper, and the "whites" bitten away with dilute nitric acid. This process was introduced into England after the suppression of the Commune in 1871. The application of photography to this process was the beginning of a revolution in book illustration. For though wood-engraving held its own for many years after this for subjects in which chiaroscuro was required, it was gradually disused for drawings made in line, and the art of pen-and-ink drawing for reproduction began.

Artists soon got used to the new method, and there was a general demand for a process which would reproduce not only drawings in line, but also those made in washes or body colour, and would be suitable for the direct reproduction in the printing press of a photograph from nature. This was met simultaneously by F. E. Ives, an American of great photographic distinction, and by a German inventor, Meisenbach. Ives's process, though beautiful results were obtained, was too complicated for general use, and Meisenbach's process, called in English "half-tone," held the field. The negative of the drawing to be reproduced was made by photographing through a screen of parallel lines placed close to, but not touching, the sensitive surface of the photographic plate, and when the exposure was half-completed the lens was covered and the screen turned round so that the lines ran in the opposite direction to that in which the screen was first placed, and the exposure completed.

This was in 1882. The result was rather crude and deficient in variety of tone. The real advance was made by the invention, by Max Levy, of Philadelphia, of a new screen composed of two ruled glasses placed in contact at right angles. Max Levy's screens were imported largely, and from this time England, which had been, in the earlier stages of the invention, dependent upon Vienna, and to a smaller extent upon Paris, for half-tone blocks, went ahead, and now half-tone work made here is not second to that of any country in the world. It is used, not only in books, but also for the illustration of daily papers.

The most important invention since Meisenbach's is the three-colour half-tone process. This was based upon James Clerk Maxwell's researches made so long ago as 1861. The drawing or object is photographed successively through three colour filters: for the red negative a green filter is used; for the blue, a red; and for the yellow, a violet or blue filter.

A half-tone block is made from each colour negative, an operation requiring the utmost accuracy to get register, and the screen is placed at different angles to get white into the interstices of the grain and to prevent an effect like that of "watered silk."

In all these processes intended for the letterpress machine, the metal plate, for rough work of zinc, and for more delicate work of copper, is mounted "type-high" in the manner described above.

A more recent invention obviates the use of the objectionable but necessary shiny coated paper: An impression is made from a half-tone plate upon an india-rubber roller and transferred to the paper, which may have an ordinary or even a slightly rough surface. Excellent work has been done with some subjects by the application of this method to the three-colour process, but so far the average results are not equal to those obtained by the use of blocks upon glossy paper. This is called "Off-set."

A very important photographic process, used until lately more on the Continent than in England, where it was first introduced in 1870, is collotype; or, as it was known in earlier days here, "heliotype." Mungo Ponton, in 1839, used bichromate of potassium, and Fox Talbot, in 1851, discovered the action of this chemical in making a gelatine film sensitive to light. When a negative is printed upon a film of gelatine so sensitised, it absorbs moisture in inverse ratio to the amount of light it has received, and when by means of a roller a greasy ink is applied to it, it takes the ink in the ratio of its dryness, and so gradation in the print is obtained. The advantage of this method of reproduction is that it is not necessary to use the glossy coated paper, which is essential if one is to obtain the best result from either a half-tone block in black or from a set printed in three colours. The disadvantage is that it cannot be printed on a letterpress machine in the same way as a block.

This process is unrivalled for facsimiles of documents and early manuscripts. But for the reproduction of pictures and illustrations requiring a greater depth of tone, photogravure remains without a rival at present. It is interesting to note that Niepce de Saint-Victor, in 1847, had produced a photogravure plate. He coated a copperplate with bitumen of Judea and exposed it to the action of the sun under a line engraving, which acted as a photographic positive, afterwards biting the protected lines into the copper, and etched a plate which could be printed on a copperplate press.

Since that time many modifications have been made, the more important being the process invented by Rousillon based upon a beautiful invention of Walter Bentley Woodbury, patented in 1866, and introduced by Messrs. Goupil, of Paris, early in the 'seventies, which was an electrotype from a gelatine mould in relief; and that by Klic, of Vienna, who invented the method now most generally used: A copperplate is covered with an aquatint ground made by dusting powdered resin or bitumen of Judea on it and then melting it with a gentle heat. This causes the particles to run together in little "hills," leaving minute "valleys" between them. Upon this plate an ordinary carbon positive made from a reversed negative is squeegeed down and developed. When it is dry it is placed in a bath of perchloride of iron. This acid bites through the gelatine of the carbon positive and into the copper, the depth being graduated by the varying thickness of the gelatine of the carbon positive. When the biting is completed the gelatine is cleaned off, the copperplate inked by filling the interstices or pits and the excess of ink wiped off, first with canvas and fine muslin, and, finally, with the printer's hand, and an impression taken upon damped paper in the same way as from a copperplate engraved by hand.

An adaptation of photogravure to machinery was made at Lancaster about twenty years ago. It consists in applying Klic's method to a copper cylinder by the use of a half-tone screen instead of a grain produced by bitumen or resin. After inking the surface of the cylinder it is wiped to remove the superfluous ink and impressions on paper are made by a rotary motion at a great rate. The process is now largely used for illustrations for weekly illustrated newspapers and magazines.

PROGRESS IN SCIENCE TEACHING.

BY SIR WILLIAM A. TILDEN, F.R.S.

A MAN who remembers clearly the first Great International Exhibition in 1851, and was at school through the period of the Crimean War, can no longer claim to be ranked among young men or even the middle-aged. But, with all the disadvantages of age, there is something to be said for the satisfaction and practical use of personal reminiscence. The days of school life

which I can recall were practically pre-scientific, for, though one or two schools, such as the Quaker School at Ackworth, included elementary science in their programme, the utmost attempted, as a rule, was a visit from a peripatetic teacher, who came, like the dancing-master and the drawing-master, once a week or a fortnight. This was the practice at a school in Norfolk at which