SYMPOSIUM ON THE MICROSCOPE.

THE symposium and general discussion on the microscope, held on January 14 by the Faraday Society, the Royal Microscopical Society, the Optical Society, and the Photomicrographic Society, in conjunction with the Optical Committee of the British Science Guild, attracted a very large audience, which the meeting-room of the Royal Society proved quite inadequate to accommodate. The objects of the symposium, as stated by Sir Robert Hadfield in his introductory address, were:—

(*a*) Improvement in the technique of the microscope itself, including its manufacture.

(*b*) Improvement in lenses, including eyepieces and objectives of high power.

(*c*) Improved application of the microscope for research in ferrous and non-ferrous metallurgy.

With such extensive ground to be covered it is not surprising that the programme of papers presented was much longer than could possibly be read during the meeting. Many of these were of great interest, and, as the majority were in type before the meeting, the aims of the symposium might perhaps have been more fully achieved had these been taken as read and the time thus saved utilised for discussion. It will only be possible in the space available for this article to record a few of the more salient points brought forward at the meeting.

Sir Robert Hadfield, who was in the chair, opened the afternoon session by giving a brief history of the microscope and its applications in metallurgy down to the present day. In addition, he contributed papers on the Faraday Society and on the work of Sorby, a bibliography of the chief literature relating to the microscope, and a series of photomicrographs of steel and iron sections at magnifications ranging from 9 up to 8000 diameters. He was followed by the presidents of the various participating societies, by microscope manufacturers, and by other prominent workers, who each dealt with some special aspect of microscopy. Prof. Cheshire indicated the importance of microscope production as a measure of the standing of the optical industry of any country. Other speakers touched on ground which was to a considerable extent traversed by many other contributors. On one subject, at any rate, all the speakers were agreed—the necessity for proper training in the use of the microscope, whether for visual or photographic use. This will be clearly realised by those who note how frequently those with extensive experience in microscopical research refer to the importance of securing proper conditions of illumination. The absence of proper courses in this subject was compared by Sir Herbert Jackson with the very thorough courses now available in spectroscopy. That instruction is needed in our universities in the use of the microscope and in the interpretation of the effect seen—nay, more, in the proper appreciation of optical theory itself—was proved beyond any doubt to the meeting.

Compared with the unanimity on the need for education, there were very marked divergences in the views expressed by nearly all the speakers on detailed matters. Consider, for instance, the desirability of obtaining increased magnification with greater resolving power. Many of the most experienced metallurgists who expressed their views anticipated that any considerable increase in resolving power would be likely to afford clues to some of those problems which to-day are most baffling in the production of metals with specific properties. It is suggested, for instance, that with improvements in the resolving power the mysterious alterations in the mechanical properties of metals brought about by cold working would be explained. The papers abound with examples of the valuable information that has been derived from past increases of aperture; nevertheless, some workers are satisfied that further advantage in this direction is not to be expected, and it is even suggested that the N.A. of objectives has already been increased too greatly.

The same extent of disagreement was shown in discussing the relative merits of British and German stands and lenses. For some purposes, at any rate, very experienced workers give decided preference to the English stand, though this is said to be less convenient for metallurgical work. No stand now made, it was said, is sufficiently rigid to enable the microscope to be changed from the vertical to the horizontal position without disturbing the relative adjustment of the specimen and the optical system. Modern designers were recommended to study Powell's model of 1841 as an admirable example of what is required. One important criticism was to the effect that the materials employed by the British makers were too soft, particularly for such working parts as the racks and pinions, with the result that after a few years all the movements were too loose. In this respect German instruments had been found more satisfactory by some workers, though this was not the experience of all.

As regards objectives, it was not denied that the best home-made products were fully as good as those made abroad, but it was contended that this standard of excellence was reached in a smaller proportion of the objectives produced than in the foreign lenses. The importance of a highly trained test-room staff was emphasised in this connection. It may be noted as a point of interest, mentioned by Mr. F. Twyman, that good objectives have been found to show differences of phase in the emergent wave-front of about one wave-length.

During the meeting it was announced that one or two makers would shortly place upon the market new designs of objectives made from English glasses. It is satisfactory to learn that the different varieties of glass required for these objectives have been produced in this country. To determine how these glasses compare with the German lenses of Zeiss, a committee of expert microscopists was appointed to investigate and issue a report. In view of what was said regarding the general standard reached, it would be as well if this proposal were carried a step further, and it became customary for manufacturers to issue with their objectives a certificate issued, say, by the National Physical Laboratory. If the required standard for a certificate were maintained at a reasonable level, with due regard to periodical improvements, such a system should go far to remove the impression that it is *necessary* to go to Germany for a thoroughly good objective.

There are many other points to which attention might be directed, but for these reference must be made to the printed papers. The apparent lack of enterprise on the part of the manufacturer since the war has, however, been fully explained. He has been busy for the first time in making arrangements for the mass production of microscopes by modern machine methods. This is of the first importance, for in the past few years nearly all the microscopes required for biological work—and this covers possibly as much as 90 per cent. of all microscopes made—have been imported. The hand-made English instrument could not possibly compete either in price or in quality with the machine-made article. Should it be possible to regain a large share of this trade while retaining the best features of the more expensive and elaborate models, the future position of the industry in this country will be assured. It is to be hoped that this development will not be hindered, as was suggested, by lack of capital.

Perhaps the most significant and satisfactory feature of the symposium is that it should have been possible to attract for a meeting which extended from 2.30 to 10.15 so large an audience for the discussion of the microscope and its applications to industry. It is more than doubtful if such interest could have been aroused before the war. The optical industry of the country, it is clear, will not fail to establish itself on a secure footing for want of a market. If the home products reach the necessary standard of perfection and keep abreast of the advances which scientific achievement in whatever field renders possible, the reward is certain. This, we are convinced, needs much more systematic investigation in advance of immediate requirements than has been undertaken in the past, greater readiness to be guided by scientific principles rather than by tradition, and not least the design of instruments with special reference to the accuracy obtainable in the various manufacturing operations by the best machine tools. It is a hopeless enterprise with one scientific adviser to attempt to compete with another firm of similar size which employs twenty such advisers. At present such assistance is difficult to obtain. It devolves upon our universities, no less than upon our manufacturers, to consider where they stand, and to do their part towards the country's well-being by making optics a living subject rather than resting satisfied with the knowledge of a hundred years ago. Research on their part and on that of other institutions is necessary; the field is wide. We look to them for that interest which we have every right to expect.

The afternoon session was preceded by an exhibition of microscopes and auxiliary apparatus. The historical collection of microscopes from the South Kensington Museum was of special interest. New models of microscopes attracted much attention. Messrs. Beck and Swift exhibited models fitted with the changing device they have adopted, and some exhibits by Messrs. W. Watson and Sons were greatly admired. Many other exhibits of much interest were shown, but for particulars of these reference must be made to the catalogue specially prepared for the occasion.

The publication of the proceedings of the symposium will be awaited with interest. We trust that all the papers will be collected into a single volume, and be available as a separate publication for all who have special interests in microscopy.

CONSTRUCTION AND USE OF MICROSCOPES.[1]

A CONSIDERATION of the microscope resolves itself of necessity into two parts, the mechanical and the optical. From the mechanical point of view there are two designs in general use, those referred to as the Continental and the English form of microscope. In the Continental type it has usually been customary to have what is known as the horseshoe foot, mainly, I imagine, because of its ease of construction by mechanical engineering methods; whereas the English design of microscope, which has hitherto been mainly made by hand, is of a more steady type, and the points of support are so distributed as to give more stability to the instrument in any position.

The essential parts of the instrument are a coarse adjustment, to give the body tube a quick motion in the direction of the optic axis, and a fine adjustment, which gives it a much slower motion in the same direction. The tube is adjustable in length, to enable correction to be made for varying thicknesses of cover-glass, although a large number of workers appear to regard it as a ready method of obtaining greater or less magnification, with disastrous effects on the resulting image.

There is only one fixed part of a microscope for biological purposes, and that is the stage. But metallographers require that the stage shall also be adjustable in the direction of the optic axis. The body tube itself should be made so that it can be closed to a length of 140 mm., including any objective-changing device that may be on the nose-piece; and it should be possible to lengthen it to at least 200 mm. or 250 mm. if long-tube objectives are used.

All these adjustments are in the direction of the optic axis of the instrument. Two others are usually provided which are at right angles to this direction—that is, a mechanical stage for actuating the object, and in certain of the best-class instruments an arrangement for centring the sub-stage condenser to the axis of the objective.

While there are many points which might be raised on the mechanical side, there are only one or two that I have time to mention. The main point about most microscopes appears to be that they are unstable. I have a considerable number in my own possession, but I do not think I have one even now which, if I centre an object on the stage with the instrument in a vertical position, still maintains its centration accurately if the instrument is put into the horizontal. The probability is, therefore, that there are few microscopes made at the present time that exactly fulfil the conditions necessary for high-class photomicrographic work or for observational microscopic work of an exacting order. I trust, however, that an instrument exhibited at this symposium will embody the necessary improvements to rectify this matter.

Some misapprehension appears to me also to exist as to the relative purpose of the coarse and the fine adjustments. The coarse adjustment appears to me to be one which should be sufficiently well made, and with which the user is sufficiently expert, to enable him to bring into view any object, whether it is being observed with a low- or a high-power objective. The fine adjustment is then used for accurate focussing and for getting a conception of the object in depth. In biological work, at any rate, this is very rarely the state of affairs as carried out. In using an oil-immersion objective, for instance, a common method is to immerse the objective, and then to lower it so that it all but touches the top surface of the cover-glass. The objective is then raised by means of the fine adjustment until the object comes into view. While this may act fairly well with very thin cover-glasses, it is a haphazard method when cover-glasses of varying thicknesses are used. It should be realised that when microscope-users are sufficiently educated they will be able to tell how far they are from the actual image by the appearance of the light in the field of view—that is, if the object is illuminated with reasonable accuracy.

Mechanical stages also appear to need some consideration. The stages which will on actuation cause no shift of the object other than in the direction intended, or any alteration of focus, are rare. Further, those in which the screws project for a considerable distance, with the result that any slight jar or knock causes them to be displaced, and, it may be, actually bent, are objectionable when used under laboratory conditions.

There is I think, much to be said for the type of stage which has either co-axial milled heads on a vertical axis, or, if inconvenient to make, milled heads which are on separate axes. This method of con-

[1] Opening paper of a discussion on "The Microscope: Its Design, Construction, and Applications," organised by the Faraday Society and held at the Royal Society on January 14. By J. E. Barnard, president of the Royal Microscopical Society.