Use of Direct Illumination in Microscopic Examination of Textiles

By ALOIS HERZOG

Transmitted light is commonly employed for microscopic examination of textiles, while direct illumination is comparatively little used for the purpose, although it must be admitted that it would seem primarily to come into consideration in regard to microscopic vision. This disproportion is to a certain extent readily comprehensible, for microscopic examination of textiles is intended, as a rule, to reveal fine structural characteristics, which can only be properly observed by reflected light after the use of reagents. Besides this, the lack of knowledge of suitable optical apparatus for the fine examination of substances by direct light has, undoubtedly, induced neglect of this method of microscopic observation.

Some attempt, it is true, has been made to give due weight to the importance of adapting microscopic examination to the conditions of ordinary vision by reviving the method of dark field illumination. In its simplest form, this method gives pictures which are more in a line with ordinary vision, but it naturally shows its insufficiency when textiles are being examined, and another method must be sought. Thanks to the progress made in technical optics, there are today a number of devices at one's disposal, by means of which, without difficulty, microscopic investigation can be carried out by direct light, even with the highest powers. An instrument which will serve all purposes has not yet been evolved, so in each case one must be chosen which is adapted to the purpose.

Under these circumstances it is advisable to describe more closely the devices now available in respect to their uses and possibilities in the textile industry.

I

Direct Observation of the Preparation Under the Microscope

This extremely simple process requires no special accessories and is of the highest importance in fiber observation, even though it can only be used for a magnification of about 150. A higher magnification is not often necessary in ordinary work, for a magnifying glass is sufficient. It is greatly to be regretted that the younger generation in the textile industry is inclined to look down upon the magnifying glass and expects salvation from the use of the high-powered microscope. The magnifying glass is not often used in mills and selling houses, if we except the pick glasses which are in fairly general use, but which have many faults.

The optical trade at the present time produces a number of excellent low-power microscopes (apart from every possible kind of lens design), some even being equipped with variable self-magnification which, when combined with an ocular, are eminently adapted to replace the lens and enable the investigator to work with a position of the head which is not uncomfortable even when maintained for a long time. An excellent model in this class is Objective G, sold by Winkel, which gives magnifications up to 60 according to the adjustment and ocular used. Another good model is Objective A (now known as 1.2-1.4), made by Zeiss, although its field of magnification is rather narrower than that of the former one.

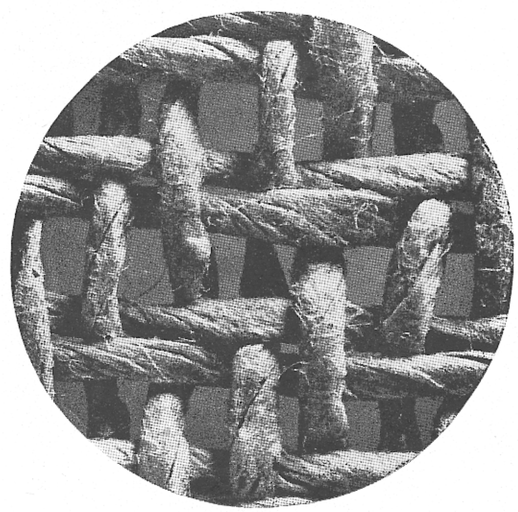

Fig. 1

The binocular preparation microscope

built by several optical firms on Greenough's system is an excellent substitute for the ordinary lens owing to its plasticity, which cannot be excelled. It is chiefly intended for low magnifications. The binocular microscope made by Leitz, Wetzlar, and the stereoscope by Reichert can also be used to advantage in combination with weak microscopic objectives and oculars for work in direct illumination. Plasticity plays a very great part in microscopic examination under direct illumination, as can readily be seen from a direct comparison. It is often difficult for one who is not well acquainted with the preparation and examines it with the monocular instrument to understand the confusion of details presented to the eye, but he will have no difficulty at all in this respect if a binocular microscope or a stereoscope is used (Figure 1). A wide field of application here presents itself to stereomicrophotography in which there are no more technical difficulties to be met with than in ordinary microphotography, provided that the object is properly prepared and illuminated, and that proper photographic technique is assured. These provisos at the present time are not always met even in many large laboratories.

The very simple method of examination by direct illumination is most useful for textiles, especially when examining for defects and in determining the weave-relative yarn size and the density of cloths (Figures 2 and 3), and if the original surface of a fabric has been altered by finishing in some way, for instance, calendering (Figure 4). Apart from its simplicity, the method has the advantage that the object can be examined without having to cut it, a point which often may be of weight in actual practice.

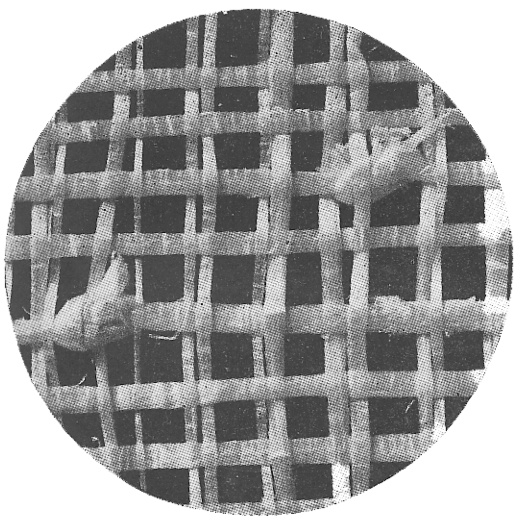

Fig. 2

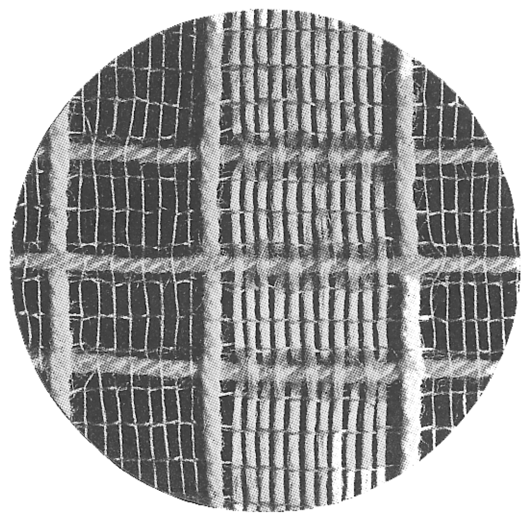

Fig. 3

Owing to the formation of shadows caused by the illumination from one side, the plastic effect of microscopic views is very satisfactory. It is often very desirable, however, to illuminate the shadows thrown by larger objects, say, for photographic purposes, as otherwise the pictures would be too hard and show no details in the shadows. For this purpose either a sharply bent strip of white paper is used which is placed vertically on the shadow side of the object, or a small mirror is affixed to the microscope by a special holder. As far as the author's experience goes, it is not generally advisable to avoid cast-shadows when photographing coarser objects, for instance by laying them upon a glass plate that is weakly illuminated from below, because the pictures have an unnatural aspect due to the absence of cast-shadows and are more difficult to understand. It is more advantageous to use a dark gray background, i. e. very fine mat black glass, upon which the cast-shadows are not so evident in proper illumination. The object can be covered by a coverglass or by a thicker glass plate, in order to keep down any projecting fibers, preventing their movement in a draught and changes in the humidity of the air. A small illuminating lens can be used to strengthen the daylight. It is attached to the table by means of a clip.

A device for illuminating the coverglass is indispensable for low magnifications. Artificial illumination must be resorted to if the daylight is not strong enough to permit investigation. Small lamps of low voltage have proved to be very effective. If alternating current is used, they can be connected directly with the lighting system by some type of transformer. They are generally enclosed in a metal casing which has a collecting lens in front, so that the light can easily be concentrated on the object being examined. A very handy lighting device of this kind is attached, for example, to Greenough's preparing stand. The adjustable lamps made by Leitz, Busch, and

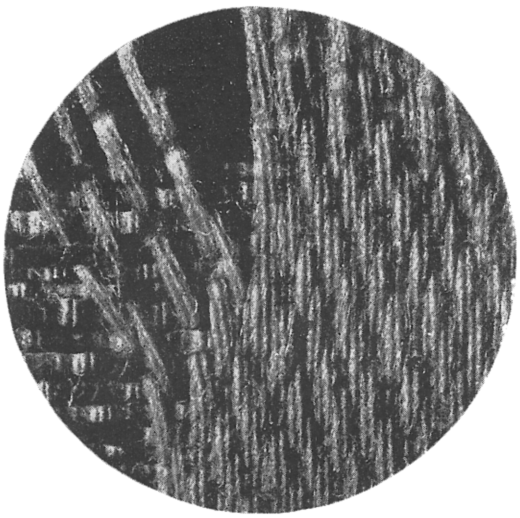

Fig. 4

Reichert, according to my directions for the rapid examination of cross-sections of rayon are very useful. In case of need, an ordinary pocket flash light will be found quite serviceable. The device mentioned by Greil, chiefly used for photographing low magnifications, is very good. It is supplied by Zeiss, but it is so expensive that it ordinarily can not be considered. Investigations of this kind impose no limits upon the mounting of the objective, and it is not necessary to correct the objectives for uncovered preparations with the low magnifications in use. The ordinary low microscopic systems are adapted for use as objectives for photography and they are used in combination with a Homal or projection ocular. At any rate they are superior to the anastigmatic objectives with short focal distance made by a number of optical concerns because of their perfect correction, and as they can be used with or without an ocular. Experience induces me to recommend the following:

Zeiss Planar, or
Busch Glyptar..f—100 millimeters
Leitz Summar..f— 64 "
Busch Glyptar..f— 50 "
Zeiss Planar....f— 35 "
Busch Glyptar..f— 25 "
Zeiss Planar....f— 20 "
Winkel Luminar f— 8 "

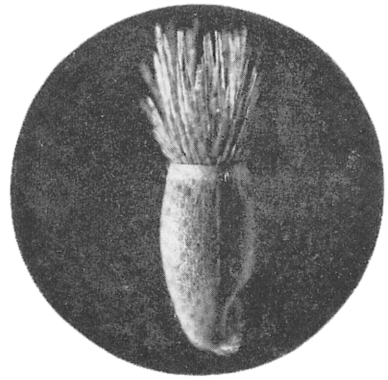

Fig. 5

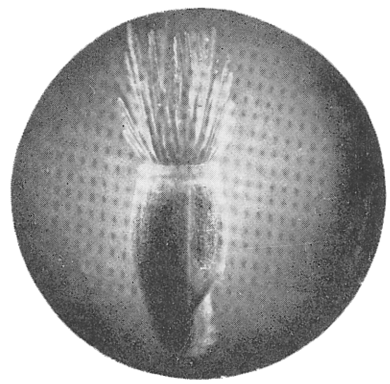

Fig. 6

By pulling the camera out 50 centimeters, the last named objective permits of a magnification approximately of 60. The excellent very low-power apochromatic lens made by Winkel (f-40 and 25 millimeters), with a complanatic ocular of 3 or 4 can often be used for the preparation of comprehensive pictures (Figures 5 and 6).

II.

Investigations with the Dark Field

The plankton condenser, made by Zeiss, gives good results with transmitted light up to a magnification of about 100, but it is adapted only for very small cuttings of fabric. It gives wonderfully sharp pictures which are well suited for photography when well corrected objectives of the short focal anastigmatic objective are used.

III.

Lieberkuhn's Mirror

This consists of a small metallic concave mirror which is perforated in the center and is arranged above the objective co-axial to the tube of the microscope. The light arriving from the plane mirror of the microscope passes through an orifice on the objective table at least three centimeters in diameter round the object, strikes the concave mirror, and is reflected on the object which rests upon a glass plate set over the orifice in the table and blackened in the center.

The aluminium mirror made on Lieberkuhn's system by Busch is very useful and experiments have shown that it gives well illuminated views. A good device of this type is also supplied by Himmler, as part of the stereoscopic cradle on Schmehlik's system. If the object is coarse and very glossy, it is advisable to use a concave gypsum reflector in place of the metallic concave mirror, to eliminate the unpleasant glare frequently a nuisance in photography. A mat disk placed between the lamp and the mirror is often of service. The effect is very much the same as that obtained with the gypsum reflector, so there is no need to have both devices (Figure 6). The microscopic view looks rather flat and does not bring out contrasts owing to the light from above coming from the side, but a slightly oblique illumination with shadow effects can be given to the object (although, as a rule, only to a very limited extent) by setting the plane mirror at a corresponding slant. In case of need, slightly plastic effects can also be obtained by raising and lowering the Lieberkuhn mirror, but the plasticity cannot be called particularly marked (Figure 7).

When coarse objects are photographed stereoscopically, the pictures make a rather unnatural impression owing to the elimination of shadows, so that in these cases it is better to work with the first process. Lieberkuhn's mirror is, however, excellently adapted for use when slight differences in color are to be observed. In this respect, in fact, it is unsurpassd.

The optical effect corresponds approximately to Abbe's color view when examined by transmitted light. This fact will often be found of use in examining textiles for the presence of extraneous matter, provided that there are actually differences in color. Lieberkuhn's mirror has been used for examining the spirality of very fine fibres according to the method explained, using the same sources of light described under number I. It is the opinion of the writer that Lieberkuhn's mirror being very cheap, should be in the hands of every textile microscopist.

IV.

Vertical Illuminator

This consists of an intermediate member which is introduced between the tube and the objective and contains a small totally reflecting prism or a polished cover glass set at an angle under 45°. The member carries laterally a sleeve which contains a small illuminating lens. Light is passed by means of a special illuminating stand through the lens to the glass prism or the cover glass, from which it is reflected through the objective to the preparation. Several optical firms have placed vertical illuminators on the market which are quite suitable for the examination of textiles. It should be borne in mind, however, when purchasing an instrument, that not all the types offered show quite satisfactory views free from fog. It is worth mentioning that there is no limit at all to the strength of the objective when using a vertical illuminator and even oil immersions can be used. In order to avoid disturbing reflexions, the microscope objective must be as short as possible and specially corrected for uncovered preparations, at least for objectives with a shorter focal length than 8 millimeters.

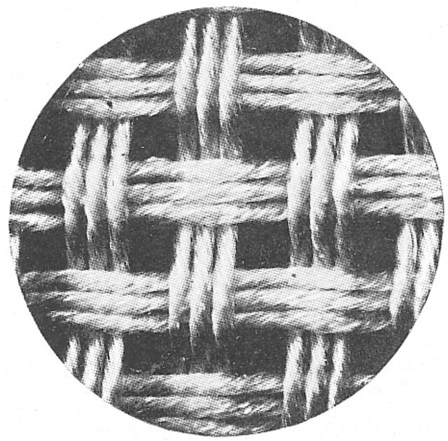

Fig. 7

Work with the vertical illuminator calls for a certain experimental dexterity, because it is not always easy to find the proper illumination. Under high magnifications it may even be advisable to insert a coverglass set at an angle of less than 45° instead of the reflecting prism, whereby the apparatus of the objective is better made use of. Rules of general application, however, cannot be given, so that it is the best plan to determine empirically the most favorable illumination for each case. The preparation must not under any circumstances be covered, as otherwise reflexions arise which make the view quite foggy and unfit for use. This is, of course, a drawback in the examination of fibers, because undesirable movements are hardly to be avoided, especially when the object must be illuminated for a considerable time in order to be photographed. On the other hand, this method imposes no limits upon the size of the object under examination. The illumination is derived centrally from above so that the preparation shows no shadows and the microscopic view appears even flatter and shows less contrast than with the use of Lieberkuhn's mirror. The reflexion prism can be adjusted to a certain limited extent, but cannot make such change in the final result. Since the surface structure does not show up much, all differences in the color and gloss of the fibers make themselves very noticeable. It must be borne in mind that the ultra-structure of the fibers is to be traced at many places under a high magnification. Artificial light is used almost exclusively for illumination and the low voltage lamps alluded to above can very well be used here too. In order to avoid having to centralize the source of light whenever the objective or the preparation is changed, the use of a microscope stand with a vertically adjustable table is to be recommended.

V.

The Dark Field (Direct Illumination) Busch Condenser

This device in its optical effect unites all the advantages of the methods described under I and III. As distinguished from groups III and IV, structural views are obtained with this condenser which are admirably adapted to give a clear conception of the appearance of textiles. According to the description given by Hauser, the light thrown vertically upwards by the flat mirror of the microscope passes through the glass plate lying on the central opening of the microscope table carrying the object, and then meets a mirror in the form of a truncated cone with an inclination of about 45 degrees. This conical mirror is provided with a central perforation for affixing or screwing the condenser to the objective. A disk is attached to the basis of the conical mirror which carries a circular concave mirror on its edge and is so arranged that its focus lies rather below the lower edge of the conical mirror. The horizontal rays reflected by the conical mirror in all directions are united after reflexion in the focus of the concave mirror. The mirror must be adjusted so that this focus lies exactly upon the surface of the objective when the mirror is sharply adjusted, whereby only diffuse reflected rays reach the objective.

The illumination is rather low if daylight is used, so that the use of a fairly powerful artificial source of light is to be recommended, and even an arc lamp is desirable for photography. As already mentioned, the objectives are fitted with special tightly fitting sleeves, but in spite of this they are quite well suited for use for all other purposes. Stronger systems must be specially

Fig. 8

corrected, if work is being done without a cover-glass, but this is not absolutely necessary. According to experiments, this condenser is of particular advantage when textiles are being examined for foreign bodies which differ only slightly in color from the fibers. Even traces of the presence of such matter can be shown by this means, so that I have no hesitation in saying that Hauser's direct light condenser is excellently adapted for the examination of textiles, in fact is indispensable. Particularly good results are obtained by using it together with a stereo-ocular, which gives the already strongly differentiated views (Figure 8) a most excellent plasticity. Only small cuttings can be used, as with Lieberkuhn's mirror, for the preparation must be laid upon a dark disk centrally disposed, while the light from the mirror is reflected round this disk on the condenser. The manipulation is very simple and the views secured are entirely free from fog, in pleasant contrast to the vertical illuminator.

The following table gives a summary of the devices used in the preparation of the various cuts:

Fig. 1. Material made of paper yarn, stereoscopic photograph x 8.

Fig. 2. Plaiting of fine Manila hemp (Musa textilis). Knots can be seen at two places. x 10.

Fig. 3. Yarn spacing and yarn size in a fabric. x 5.

Fig. 4. Finished cotton cloth. Calendered. x 10.

Fig. 5. Cornflower seed on dark background and thus without cast shadow; illuminated from the side. x 9.

Fig. 6. The same as Figure 5, but illuminated by gypsum reflector from above. x 9.

Fig. 7. Fabric made of cellulose acetate rayon yarns illuminated by Lieberkuhn's mirror. x 30.

Fig. 8. Finely hackled broom fibers; illuminated by the Busch direct light condenser. x 70.