On the other hand, the low temperature of the cylinder walls would greatly lessen the effective pressure of expansion, as the cooling effect of the walls on the gas would be very marked. It would, however, be impossible to avoid this action. The only way to increase the efficiency would be to increase the speed of rotation, this giving less time for an exchange of heat between the gas and cylinder walls.

The increased shock on the parts of the engine due to the greater pressure of explosion would necessitate greater area of bearing surface at each end of the connecting rod and in the main bearings of the engine shaft, as well as a stiffer construction throughout.

camera bellows can be contracted or expanded to bring the ground-glass in the focus of the lens and can be fastened in adjusted position by means of a set-screw. Diaphragms are employed to cut out those parts of the field not to be photographed. The image is sharply focused by means of a focusing-glass mounted above the camera.

After the prepared object to be photographed has been placed upon the stage, the microscope is moved beneath the camera with the tube below the bellows. Over the eye-piece of the microscope and the small end of the bellows a flexible cloth is slipped, which excludes all light. To one side of the microscope a Welsbach

The chief cause of disadjustment is to be looked for in the contraction and expansion of the microscope parts as well as of the object on the stage, and in the elastic reaction of the fine-adjustment screw, which reaction, though it be ever so small, is nevertheless sufficient to destroy the focus of an object magnified 1,000 times. When it has been found that the image is permanently sharp, the glass is removed from the back of the camera and the plate-holder containing the sensitive photographic plate substituted. The microscope-mirror is then covered and the slide of the holder drawn out. During the time of exposure, the microscope-mirror is uncovered.

FIG. 1.—VERTICAL MICROPHOTOGRAPHIC APPARATUS.

FIG. 2.—MICROPHOTOGRAPHY OF OPAQUE OBJECTS.

This would, however, be partially arranged for by giving the engine less pressure of compression by increasing the per cent. of clearance or by other means, thereby lessening the force of explosion and consequent shock on the parts.

The great range of explosive mixtures would lend itself very readily to the control of the speed of the motor by an adjustment of the supply of gas.

That acetylene may be used as a motive power is assured, but whether it will prove popular cannot at present be stated. It has many of the desirable qualities of gasoline, but at present is more expensive, and the motor in which it is used would probably be subject to more wear and consequently more repair than if used with its milder rival.

The acetylene motor must necessarily spend a considerable time in the experimental stage, and with the knowledge gained from other explosive motors it is not unlikely that one may be built which will prove not only successful, but popular.—Horseless Age.

MICROPHOTOGRAPHY AS AN AID IN SCIENTIFIC RESEARCH.

By Dr. CURT SCHMIDT.

RICHER and more varied in its forms than the firmament swarming with stars overhead is the microcosm, the world of the infinitely small, the world which the penetrating eye of the microscope reveals to the scientific investigator. The plan of fixing upon a photographic plate images of the manifold forms to be found in this miniature world was first broached by François Arago in the memorable meeting of the French Institute of August 19, 1839, in which he explained Daguerre's grand invention to the learned members and proposed to photograph the heavens.

The first microphotographs were made by projecting an image of the object to be photographed upon a plane, white surface by means of the solar microscope, and by photographing this projected image on a reduced scale. Some experimenters threw the image directly on the photographic plate, the room having previously been darkened. As early as 1840, A. Donné exhibited before the Parisian Academy photographs made in this way. In 1845 he published with the collaboration of Léon Foucault an atlas of the humors of the human organism, the numerous illustrations of which atlas were produced with the aid of daguerreotypes made by means of the solar microscope.

Early in the history of microphotography scientific men tried to dispense with a darkened room and an auxiliary camera. Microphotographic apparatus of various types were invented, the earliest of which was the photomicroscope devised by the Frankfort druggist Mayer, in 1844. It is not my purpose in the present article to trace in detail the historical development of microphotographic apparatus, but to describe our modern instruments of precision. For that reason I must leave to others the chronicling of the steps in the evolution of microphotography.

Our modern instruments for photographing microscopic objects may be roughly divided into vertical and horizontal apparatus, each type having certain merits distinctly its own.

Among the cheapest and simplest arrangements are the vertical apparatus illustrated in Figs. 1 and 2. Upon an iron base-plate a standard is mounted, provided with guideways which receive a slidable camera support. By means of a wing-screw the support is held in any position in the standard-guides. The

burner is placed, the light from which passes through a condensing lens, falls upon the mirror of the microscope, and is reflected upwardly to illuminate the object on the stage (Fig. 1). Instead of a Welsbach burner, the light of the sun can be employed, in which case the condensing lens is dispensed with and a ground glass employed as a substitute to diffuse the rays. The apparatus is first adjusted to obtain an image of the proper size. Thereupon the coarse-adjustment screw is turned through the proper distance to bring the image approximately in focus on the ground glass of the camera. The ground glass is then removed and a sheet of plain glass substituted, in the middle of which a cross has been cut. Upon this cross the focusing-glass of the camera is brought to bear. The image observed through the focusing glass is brought sharply into focus by means of the fine-adjustment screw of the microscope. In order to ascertain whether the object is permanently in focus, the apparatus is left undisturbed for about fifteen minutes. If, after that time, the image has vanished or has become indistinct, the object must again be focused.

The camera can also be used in making magnified pictures of opaque organisms, such as insects and embryo structures, without the microscope. A lens of suitable construction—in Fig. 2 a Leitz periplane is shown—is inserted in its proper position in the camera, and the object to be photographed is placed upon an adjustable support.

A microphotographic apparatus which requires the utmost precision in its optical and mechanical adjustment, which possesses the merits of both vertical and horizontal micro-cameras, has been designed by Zeiss of Jena (Figs. 3a and 3b). On a triangular base, *F*, the plate, *P*, adjustable by means of the set-screws, *i*, is mounted. The plate, *P*, supports a microscope which can be held in adjusted position by the clamp, *m*. The front and back of the camera can be independently moved and clamped on a vertical guide-rod mounted on the base, *F*. The light-tight connection between the camera and the microscope consists of a tubular member on the front-board and a second tubular member surrounding the eyepiece of the microscope, the two members being designed to lie one with-

FIG. 3A.—ZEISS MICROPHOTOGRAPHIC APPARATUS IN VERTICAL OR INCLINED POSITION.

in the other and to form a light-tight joint. The guide-rod is pivoted at its lower end, so that the camera can be swung from vertical to horizontal position or vice versa. An optical bench, *o*, is provided, on which a Welsbach burner, condensing lens, *S*, light-filter, *C*, iris diaphragm, *I*, are mounted.

Often a microphotographer is confronted with the task of slightly magnifying transparent objects which are so large that they cannot be covered by the microscope-objective and which cannot be taken by an ordinary camera. For such cases the Edinger-Nieser apparatus illustrated in Fig. 4 is employed. With this camera prepared objects up to 35 mm. in diameter

jectives. The stage can be rotated on its center and the object-slide moved through minute measurable distances. The instrument is provided with a tube, *T*, of large diameter, which serves to overcome the indistinctness usually caused by internal reflection of light. To secure very fine adjustments at high magnifying powers the micrometer movement, *W*, is used.

The preparation of objects for microscopic examination, owing to the focal differences in objectives, caused no little difficulty in the early days of microphotography. The human eye is extremely sensitive to yellow light and far less so to blue and violet rays. The photographic plate, on the other hand, is more sensitive to

when one of the negatives revealed a short, sharply bent bacillus, from which there extended a fine, cork-screw-like funicle. Further experiments were made; photographs of the same slide were made from different points of view; other bacilli were found with funicles. It was not until Neuhauss had photographically proved the existence of these cholera funicles that Löffler succeeded in detecting them with the eye, in a specially stained slide.

It would be impossible in the brief space of the present article to review all the applications of microphotography. How important is the influence which this new art has exerted even on modern law is admirably told by the well-known Berlin chemical expert, Dr. Jeserich. In the hand of a murdered man hairs were found which in the death struggle had been torn from the head of the murderer. Two men were accused of the crime; the hair of each was carefully examined, and that of one of the accused men, when microscopically examined, was exactly the same as that clutched by the dead man. The evidence was incontrovertible.

It is well known to every photographer that the salts of silver are extremely sensitive to rays of short wavelength. The microcamera may therefore reveal unthought of wonders if the ultra-violet rays, to which the human eye is not sensitive, be employed. It may be that with light of such short wave-length, structures far more curious than bacteria funicles may be discovered.

RESULTS OF EXPERIMENTAL WORK IN AGRICULTURE IN CANADA UNDER GOVERNMENT ORGANIZATIONS.*

FOR some years prior to 1884 agriculture in Canada was in a depressed condition, and during that year a Select Committee was appointed by the House of Commons to inquire into the best means of encouraging and developing the agricultural industries of Canada. From the investigations of this committee it was shown that farming in Canada was at that time in a very defective condition, that there was a lack of thorough tillage, that no sufficient measures were taken to maintain the fertility of the soil, that there was a want of knowledge in regard to rotation of crops, and of the selection of improved varieties of seed; that lack of information existed also in reference to many of the principles underlying the successful rearing of stock, the manufacture of dairy products, and fruit growing.

This committee recommended that the government establish an experimental farm where experiments might be carried on in connection with all branches of agriculture, horticulture, and arboriculture, and that the results of these experiments be published from time to time and disseminated freely among the farmers of the Dominion.

In 1886 an Act was passed by the Parliament of Canada authorizing the government to establish a central experimental farm and four branch experimental farms in different parts of the Dominion, and during the two years following these farms were established and set in operation. The results of twelve years' experience have shown that these institutions have been highly beneficial to the farming community. Experimental research has been carried on along the lines prescribed by the Act by which these farms were established, and much information has been accumulated and distributed freely to the farmers of Canada in reports and bulletins. Benefits have thus been conferred on Canadian farmers in connection with all the more important farm crops, in the development of the

* Abstract of a paper read before Section F of the British Association at Bradford, by William Saunders, LL.D., Director of Canadian Experimental Farms.

FIG. 3.—ZEISS MICROPHOTOGRAPHIC APPARATUS IN HORIZONTAL POSITION.

can be photographed. Upon a polished wooden base an adjustable standard is mounted, provided with a condensing-lens and a mirror, and with a movable stage driven by rack and pinion. The standard carries a reflector-lamp. The light of the lamp is concentrated upon the mirror by the lens and reflected upon the object on the stage. The camera is provided with a small slide or cover, which when pushed aside or removed, permits the photographer to bring the image into focus. Diaphragms are used to secure good definitions.

As a general rule, any microscope provided with an accurate adjusting mechanism can be used in microphotography. Zeiss of Jena has designed a new instrument for general as well as for photographic use, which may be regarded as the most complete and improved apparatus of its kind. The microscope (Fig. 5) is provided with a stage so large that objects of considerable size can be examined with the strongest ob-

violet and blue than to yellow light. Moreover, the rays of various colors are not refrangible to the same extent, so that it is difficult to bring all the rays to a single optical focus, thus causing the rays to which the eye is sensitive, viz., the chemical rays, to meet at a point without the focus of the lens. If a photographic plate be placed at the focal point of the optical rays, a very indistinct negative would be obtained. To overcome the obstacle special photographic objectives have been made, which are designed to bring the optical and chemical rays to a common focus. Such objectives are called apochromatic lenses and are exceedingly costly. The invention of orthochromatic photographic plates and the use of color screens have also assisted in avoiding the difficulties presented by the focal differences of objectives.

Microphotography is far more trustworthy than drawing; for the reason that it can make no mistake. The photographic plate is more efficient and more sensitive than the retina of the human eye. Not only is the human eye easily fatigued, but it is also unable to perceive differences of illumination beyond a certain limit. The photographic plate is never fatigued. It is true that the plate is also sensitive to light only of a certain intensity, but the limit beyond which no chemical action takes place in the silver is much lower than the limit of vision of the human eye. By correct exposures it is possible to photograph details which are imperceptible to the eye. Dr. Neuhauss succeeded in proving the existence of funicles in the comma-bacilli of Asiatic cholera. Every possible stain was employed; but no funicles could be seen. Dr. Neuhauss therefore resolved to employ the camera. A goodly number of plates had been sacrificed, and the attempt almost given up in despair,

FIG. 5.—ZEISS MICROSCOPE FOR PHOTOGRAPHIC USE.

FIG. 4.—EDINGER-NIESER CAMERA.