TABLE IV.—GRAVIMETRIC AND VOLUMETRIC DETERMINATION OF STRYCHNINE.
(0.1066 Gm. strychnine taken.)

Total Volume, Cc.	Concentration $K_2Cr_2O_7$ in Excess Molar.	Time of Standing before Filtration, Hours.	Weight Ppt., Gm.	0.1N Fe^{++} Used, Cc.	Strychnine Found. Grav., Gm.	Strychnine Found. Vol., Gm.	Error. Grav. %.	Error. Vol. %.
25	0.08	0.7	0.1439	9.52	0.1064	0.1061	−0.2	−0.5
25	0.08	0.7	0.1439	9.52	0.1064	0.1061	−0.2	−0.5
50	0.08	1.5	0.1428	9.38	0.1055	0.1045	−1.0	−2.0
50	0.08	64.0	0.1428	9.35	0.1055	0.1042	−1.0	−2.3
50[a]	0.08	0.7	0.3607	..	0.2666	....	0.0	...
100	0.04	20.0	0.1411	9.30	0.1043	0.1036	−2.2	−2.8

[a] 0.2665 Gm. strychnine taken.

In the first three experiments the concentration of the strychnine was 0.012 molar; in the next two, 0.006 molar; and in the last one, 0.003. It is evident that the determination gives results accurate to within 1% if the concentration of the strychnine salt is greater than 0.01 molar.

SUMMARY.

1. Brucine salts yield a precipitate with potassium dichromate, which after drying over deliquescent sodium bromide has the composition $(C_{23}H_{26}N_2O_4)_2.H_2Cr_2O_7.5\ H_2O$. Strychnine dichromate prepared under the same conditions has the composition $(C_{21}H_{22}N_2O_2)_2\ H_2Cr_2O_7.1\ H_2O$.

2. Gravimetric and volumetric procedures are described for the quantitative determination of brucine and strychnine as dichromates.

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THE MICRO-PROJECTOR.*

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Projection of the microscopic slides is fundamentally the same as projection of transparent slides with the magic lantern, or of films with the moving-picture machine. The machines all have the same essential parts and differ only in their construction, being altered according to the condition under which they are to be used and the purpose for which they are intended. In micro-projection, on account of the small aperture of the lens and the very short focal distance, all these parts must be as nearly perfect as possible and must be assembled with the greatest care. The modern projection microscope is of comparatively recent origin.

In early times the lack of proper lenses and adequate light supply hindered the development of all projection apparatus and especially the micro-projector. It is not known who first discovered the phenomenon of projection. Aristotle and Euclid mention the use of the principle in their writings, and Arabian works from the eleventh century give a description of the "camera obscura," the forerunner

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of the modern projection machines. Until the year 1568, no lenses were used in these projectors; mirrors and pin-hole apertures were used with the sun as the only source of light. About that time, Daniel Barbaro used a convex spectacle-lens to increase the brilliance of the image. After this discovery, great strides were taken in the field, but the first workable magic lantern was produced by Walgensten, a Danish scientist in 1665. His machine was a crude contraption. A naked flame from a smoky oil lamp furnished the light; a single lens answered the purpose of both condenser and projection lenses, and the demonstration was in an absolutely dark room only a few feet square. The small room was necessary because the projector had to be outside the room, and its range was very short. The spectators stood inside a large camera and viewed the image exactly as it would be recorded on a modern camera plate, in most cases inverted, for the practice of inverting the slide in the machine had not then become popular.

In the early part of the 17th century, a number of scientists worked simultaneously but most credit must be given to Kepler for the development of the micro-projector. His work was chiefly with lenses, and in 1611 he published a treatise which set forth the value of using additional lenses in projection and advanced many theories which are applied to-day. While this short historical summary has been of the development of the magic lantern, it becomes also the history of the micro-projector which is simply a magic lantern with a relatively short projection objective. Its scope begins where that of the magic lantern ends and includes the very smallest of microscopic objects. One machine cannot be expected to cover the whole range, but the possibilities and value of the micro-projector to the teacher or lecturer are apparent. With a large screen image of the microscopic field, the teacher is able to show to a large group the important points of the specimen and point out peculiarities of structure and form. He can easily indicate the special points which, though less striking, are often most important. In this way, the need for individual help to those learning to use the microscope is eliminated, and more time is gained for study of the object.

Although there are many micro-projectors on the market to-day, there are several reasons why it is advantageous to build rather than to buy a machine. The first of these is the cost factor. In spite of the fact that most manufacturers have reduced their retail price recently, it is possible to build a micro-projector for about half the cost of the lowest priced instruments. Many of the parts can be made or assembled from discarded material, and the few parts that must be purchased are very reasonably priced since the cost of assembling is eliminated. Another advantage is that the machine can be constructed to meet the requirements of specific conditions under which it will be used. The commercial machines are all made to operate perfectly in certain definitely stated conditions, and if these conditions are changed, as they are almost certain to be, the efficiency of the micro-projector is reduced. In building a micro-projector the conditions become the constant factor, and construction is altered accordingly.

There are comparatively few parts needed for an efficient micro-projector, but those used must be of good quality and adapted to the type of machine that is to be built. The light must be the most brilliant possible; the condenser lens must be of clear white glass and should be corrected for chromatic and spherical aberration. The mirrors and objective lens should be as nearly perfect as can be obtained. The stage for supporting the slide may be as simple or complex as desired, but, for ease of operation, a mechanical stage of some kind should be used. An efficient water cell for cooling the light rays is also necessary to prevent damage to the specimen and apparatus. These are the essential parts and, if assembled carefully, are all that are needed. These can all be modified in many ways to make operation easier and results more certain. A very important factor to be considered is the room and screen for the demonstration. The room should be absolutely dark; even a small ray of light striking the screen will lessen the brilliance of the image. The screen must be of the best, but, as most screens in common use will give satisfactory results, this subject requires no discussion. It may be stated that a pure white, entirely opaque screen has been found best.

Probably the most important part of the micro-projector is the source of light, for with a poor light the most perfect of machines cannot be satisfactory. In passing through the various units, a portion of the light is absorbed by each, with the result that less than ten per cent of the light produced ever reaches the screen. This necessitates the use of a very powerful light if the image is to be brilliant at any great distance. From early times various light sources have been used, the first being sunlight which remains the most brilliant of all. Since it is seldom convenient to use sunlight for projection, other lights were invented and developed for use in its stead. From the naked flame of the animal and vegetable oils developed the kerosene lamp with a glass chimney. With the discovery of electricity came many types of electric lights, the first of which was the arc light, and, though many types of incandescent lamps have been produced and are used to-day, it is next to sunlight, the most brilliant of all. The carbon arc lamp is the best suited for micro-projection, although recently several concentrated filament bulbs have been produced which are more convenient to operate and give good results under limited conditions. Of all the arc lamps, the one with the carbons at right angles has been found to be best for micro-projection. The reason is that the crater of the horizontal carbon produces a brilliant light in a concentrated area, which can be kept constantly in the axis of projection. This condition is very important where a variation of a fraction of an inch might throw the light completely outside the small opening of the objective. The light used in the machine about to be described, was an automatic carbon arc lamp with carbons, six to eight millimeters in diameter at right angles, and operated on a current of four to ten amperes. It was manufactured by the Bausch and Lomb Optical Co. of Rochester, N. Y., and gave splendid results on direct or alternating current.

THE RHEOSTAT.

With any arc light, a rheostat or resistance is necessary to regulate the amount of current and prevent overloading of the circuit when the carbons are brought together. This rheostat may be of the variable type, which permits adjustment of the current without interruption, or of the fixed type, which gives satisfactory results if the current is fairly constant. The amount of resistance to use is determined by the current required by the arc lamp. A constant current of the correct amperage must be supplied if a steady, brilliant light is to be expected. If possible, this unit should be purchased with the arc lamp, although a good resistance can be made from iron, German silver or nichrome wire of the correct diameter and length.

The mounting can be made on any non-inflammable non-conductor. Some provision should be made for conducting away the heat formed, such as the free circulation of air or immersion in water. The resistance for the light mentioned above was constructed of coiled nichrome wire, wound on grooved porcelain, which also aided in conducting away the heat. A fuse plug or other circuit breaker, on or near the machine, is necessary to prevent damage to the wiring system in case of accident. The fuse should be of slightly lower capacity than those of the lighting system so it will be the one to burn out as the result of an overload.

THE CONDENSING LENS.

The next unit to be considered in the construction of a micro-projector is the condensing lens. As its name suggests, the purpose of this lens is to condense or converge the rays of light to a point. This is necessary in order to concentrate as much of the light as possible on the specimen at a certain point so that most of it will enter the opening of the objective. This condensing lens may be composed of one, two or three elements. Those of one element are rarely used because of their very long focal distance. Those with three elements have proven best for micro-projection because the focal distance is convenient, and they are entirely free from chromatic aberration. The two element lens, although of slightly longer focal distance and more liable to chromatic aberration, has been used successfully in many cases. This type was used in the foregoing experiments, because it was less expensive and absorbed less light than the three-element condenser. A slight spectrum was produced but was entirely eliminated by careful adjustment of the substage mirror.

THE COOLING CELL.

Another important part of the micro-projector which should be considered with the light and condenser is the water-cooling cell. This is a necessity because a great deal of heat is produced by the arc lamp, and both the light and the heat are brought to a point by the lens and concentrated in a small area. This heat would quickly destroy any inflammable substance placed in the point of focus, which is the position of the slide to be projected. The water cell, when placed in the path of light, absorbs a large part of the heat but permits most of the visible light rays to pass through. The cell is very simple of construction, consisting essentially of a narrow glass cell with parallel sides, filled with water. It may be from one to ten centimeters thick, but more than five centimeters is rarely necessary and should not be used, since more light is absorbed by thicker layers of water. A cell one centimeter thick will absorb about seventy per cent of the heat and usually prevent serious damage when used with the ordinary small arc lamp. Good results were obtained with a cell one and a half centimeters thick, constructed of ordinary window glass mounted in a ring of tinned sheet iron and made water-proof with aquarium cement. No other substance was added to the water except a trace of copper sulphate to prevent the growth of algæ and molds.

PROJECTION.

These parts mentioned may all be considered as units of the light source for they all aid directly in producing the light and making it suitable for use in projection. The remaining parts are those for utilizing the light to project the image. The most important of these is the microscope or microscope objective which is also the projection lens. An ordinary microscope can be used and will give good results in some cases, but, for the best results, the microscope should be modified to adapt it for its position in the machine. The narrow barrel should be replaced by one of larger diameter, and such mirrors and extra lenses added as necessary for conditions under which the machine is to be used. By describing the modifications of the microscope used, these changes can be pointed out. In the first place it was found that the eyepiece of the microscope absorbed much of the light and diffused the image to such an extent that the light would not reach the screen from any great distance. The eyepiece was discarded, and it was possible to project a concentrated beam which produced a sharp image at a distance of thirty feet, but the field was small. The area was increased by using a tube of larger diameter, but best results were obtained by removing the barrel entirely and using only the objective. It was desired that the microscope be in its natural vertical position so that the stage be horizontal for showing water mounts, glycerin mounts or living specimens. This made it necessary to use a mirror below the stage to reflect the light from the arc lamp up through the slide and the objective. For this purpose the regular plane sub-stage mirror was used, and was brought into position by moving the microscope. The correct height was attained by placing the microscope on a platform. This mirror was adjusted at an angle of forty-five degrees from the horizontal so that the reflected beam would be exactly vertical. It was also placed a little nearer the light than the exact focal point so that the reflected rays would converge at the stage level rather than at the mirror. Another mirror was necessary above the objective to reflect the light beam at right angles in order that it could be focused on the screen. Because of its position and function it may be called the projection mirror, just as the last lens in a magic lantern or moving picture machine is called the projection lens. At this point the microscope could hardly be identified. The stand and base had been left intact, but the barrel had been removed, and a mirror had been mounted above the objective. This modified microscope was found to give good results at a distance of thirty feet, but the image was very large and was not brilliant, on account of the diffusion. Since the projection stand was over forty feet from the screen, experiments were necessary to find means of reducing the size of the image and thus increasing the brilliancy. After several unsuccessful attempts, it was found that a projecting lens such as those used in magic lanterns, placed immediately in front of the projection mirror, greatly reduced the size of the image and increased the brilliance. It was also found that moving the lens nearer to or farther from the projection mirror, decreased or increased the size of the image. The lens was mounted on the microscope so that it moved with the objective and was always in the same relation to it. A rack and pinion adjustment in the mounting of the lens, permitted easy adjustment of image size.

The parts mentioned are all necessary if efficient projection and ease of operation are to be obtained, and, on account of the number of times the light is reflected, all should be the best of their kind so that no more light is lost than is absolutely unavoidable. The assembling of these parts is also of prime importance. All parts must be mounted in the proper relation to the other parts, if the most good is to be obtained from the parts selected. The machine must be entirely light-proof so that only the light which has passed through the projection microscope will reach the screen. The center of the arc must be exactly in line with the center of the condenser lens and the sub-stage mirror, which, in turn, must have its center in line with the objective opening. The first step is housing the arc lamp. Since there are a number of satisfactory methods for doing this, no discussion is necessary; a satisfactory housing can be made from sheet iron or tinned sheet iron and will give good service. The next step is to determine the optical axis and to devise a means of keeping the parts in the axis while being adjusted to their correct position. For the purpose a track of brass rods or wooden molding can be used to good advantage.

In the machine built in this experiment the lamp housing was made of tinned sheet iron. An aperture large enough to accommodate the condenser lens was provided in one end, and the light mounted inside at such a distance that the focal point was about eight inches. The water cell was mounted between the light and the condenser. This unit of arc light, condenser and water-cell was mounted on a wooden base board, large enough to allow room for mounting the microscope in front, and the resistance unit, fuse plug and switch behind, the source of light. The microscope was attached to the stand to elevate the substage mirror into the axis of projection. This was mounted on the base board, the final adjustments being made with the light burning to insure exact centering. It was placed so that the sub-stage mirror was nearer the condenser than the focal point. This position caused the light to come to a point just at the stage and obviated the use of a sub-stage condenser. A support for the projection mirror and projection lens was made to bolt to the frame of the microscope. The mirror was attached to the support by a ball and socket joint, and the lens by a rack and pinion adjustment. A vertical shield of wood was placed in front of the microscope to prevent any stray light from reaching the screen, and the entire machine was painted black to prevent reflection. When completed the machine was small and compact enough to be easily carried, and was simple to operate, it being only necessary to connect the cord to a light socket, start the arc lamp and place a slide on the stage. Focusing was accomplished by the regular coarse adjustment of the microscope. No adjustment of the projection lens was necessary except to increase or decrease the size of the screen image.

In a trial demonstration slides of plant sections and microscopic animals were projected from a distance of fifty feet. The images were clear and brilliant and showed plainly the structure and points of interest. Its practicability has not yet been completely determined but indications are that it will be an aid in teaching all branches of microscopy, microbiology and histology.

THE MICROSCOPICAL LABORATORIES,
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"The Water of Crystallization of Quinine Sulphate," by H. Wales.—Scientific Section.

Drying a product in an oven shows the amount of water present but does not prove that it is present as a hydrate. Vapor pressure measurements on quinine sulphate show that it crystallizes from water at room temperature as the octohydrate. Upon drying this passes directly to a dihydrate. No evidence of the existence of a heptahydrate was obtained.