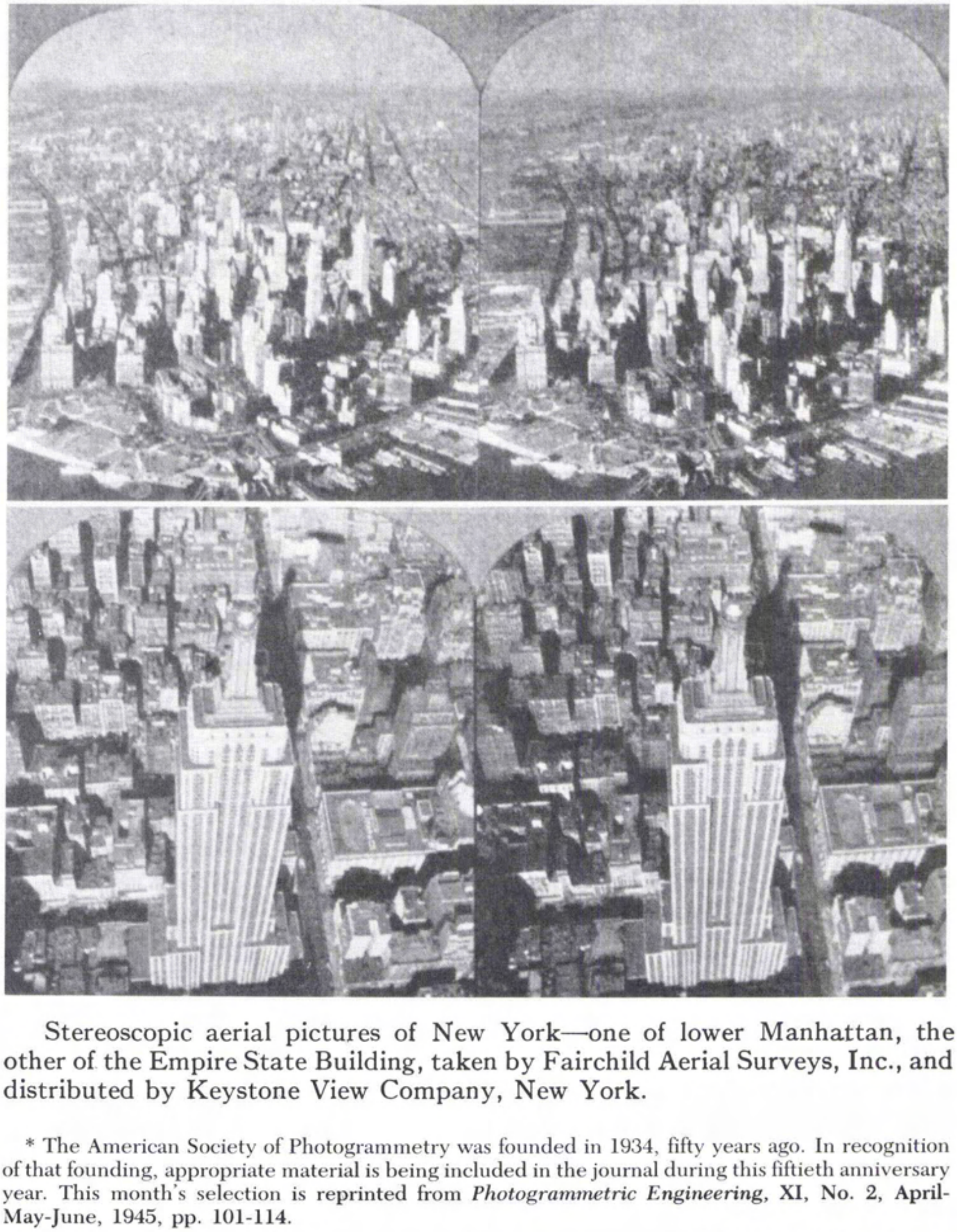
*Fiftieth Anniversary Highlights**

Stereoscopy, Its History and Uses

REVERE G. SANDERS
Fairchild Camera & Instrument Corporation

"WE ARE looking into stereoscopes as pretty toys and wondering over the photograph as a charming novelty, but before another generation has passed away it will be recognized that a new epoch has started in the history of human progress." This prediction owes its existence to Oliver Wendell Holmes



Stereoscopic aerial pictures of New York—one of lower Manhattan, the other of the Empire State Building, taken by Fairchild Aerial Surveys, Inc., and distributed by Keystone View Company, New York.

* The American Society of Photogrammetry was founded in 1934, fifty years ago. In recognition of that founding, appropriate material is being included in the journal during this fiftieth anniversary year. This month's selection is reprinted from *Photogrammetric Engineering,* XI, No. 2, April-May-June, 1945, pp. 101-114.

(Footnote continued on page 1359)

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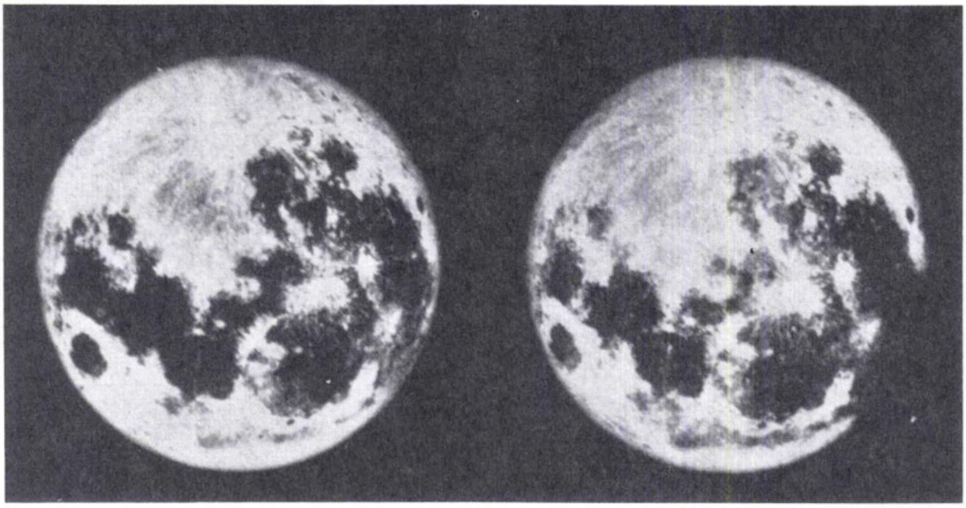
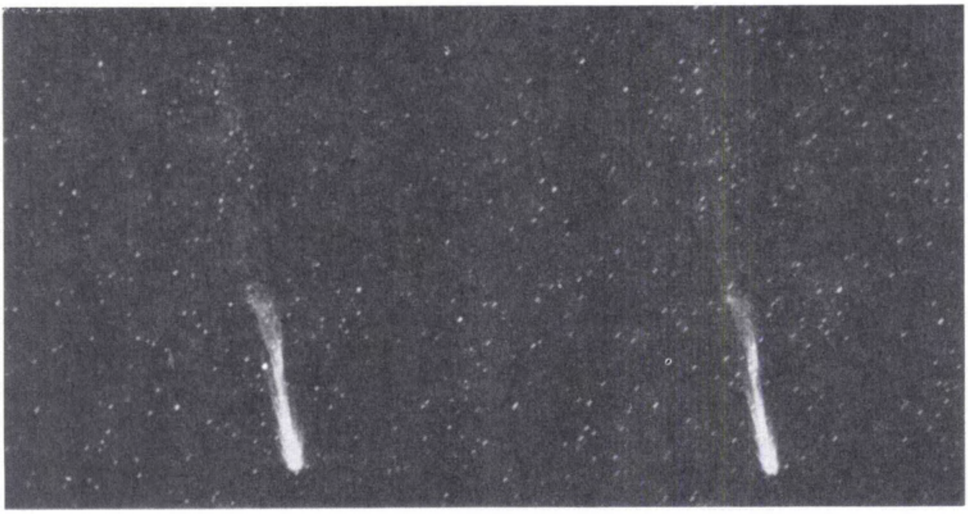


Stereogram of the moon. The photographer had to wait four years between shots to obtain the proper difference in the views.

Keystone View Company, New York

and was made seventy years ago. The stereoscope and the camera were, at the time, about thirty years old, which makes them a century in age today—a century during which they have more than attained the degree of importance that was foretold for them.

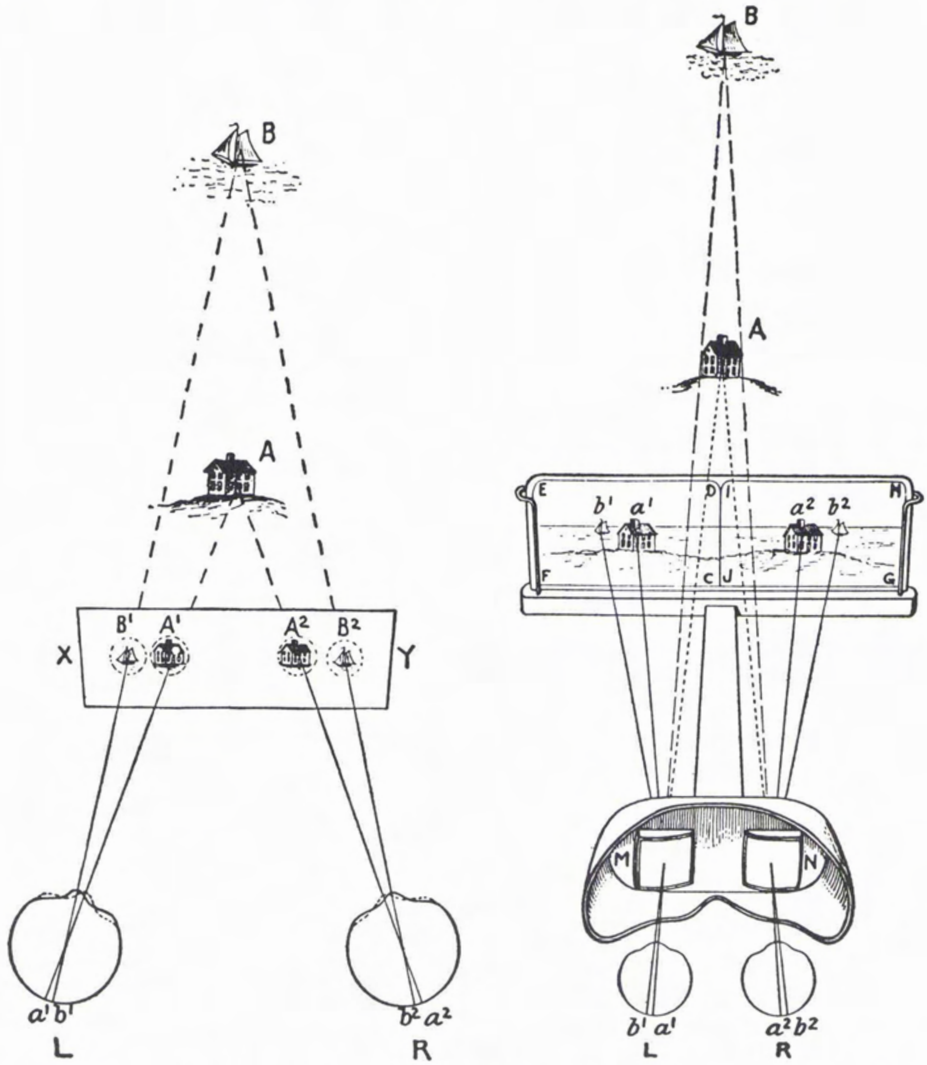
Of these two instruments, without which the science of photogrammetry could never have come into being, the stereoscope is no less vital than the camera. It has proved its use in a variety of fields that range from map-making, hydrography, camouflage detection, through photo-interpretation and geology to surgery, education and astronomy.



Stereogram of Morehouse's Comet. Ten minutes is enough of an interval between shots in this instance.

Keystone View Company, New York

Its development.—The stereoscope's reason for existence, the human faculty of binocular vision, is a subject which received the attention of students and thinkers for many centuries before the actual building of the instrument.



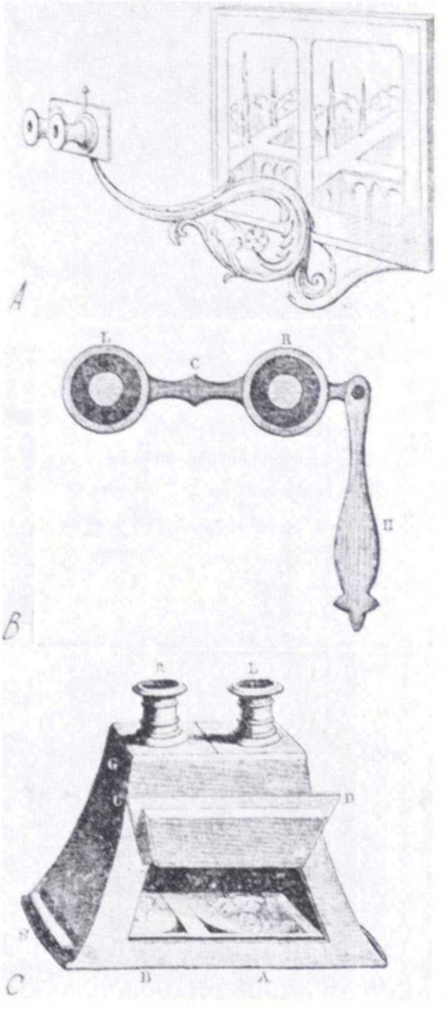
The diagrams, drawn up by Albert Osborne in 1909, demonstrate how the dissimilar pictures seen by the two eyes fuse into one which gives the sensation of depth.

Underwood & Underwood, New York

Two-thousand years ago Euclid devoted space in a treatise on optics to the fact that our eyes perceive dissimilar pictures. The same fact puzzled Galen 500 years later and he discussed it in his "Use of the different parts of the body" after some practical observations which he performed standing behind a column and hiding first one eye and then the other.

The theories of these two Greeks were later discussed by Baptista Porta, a

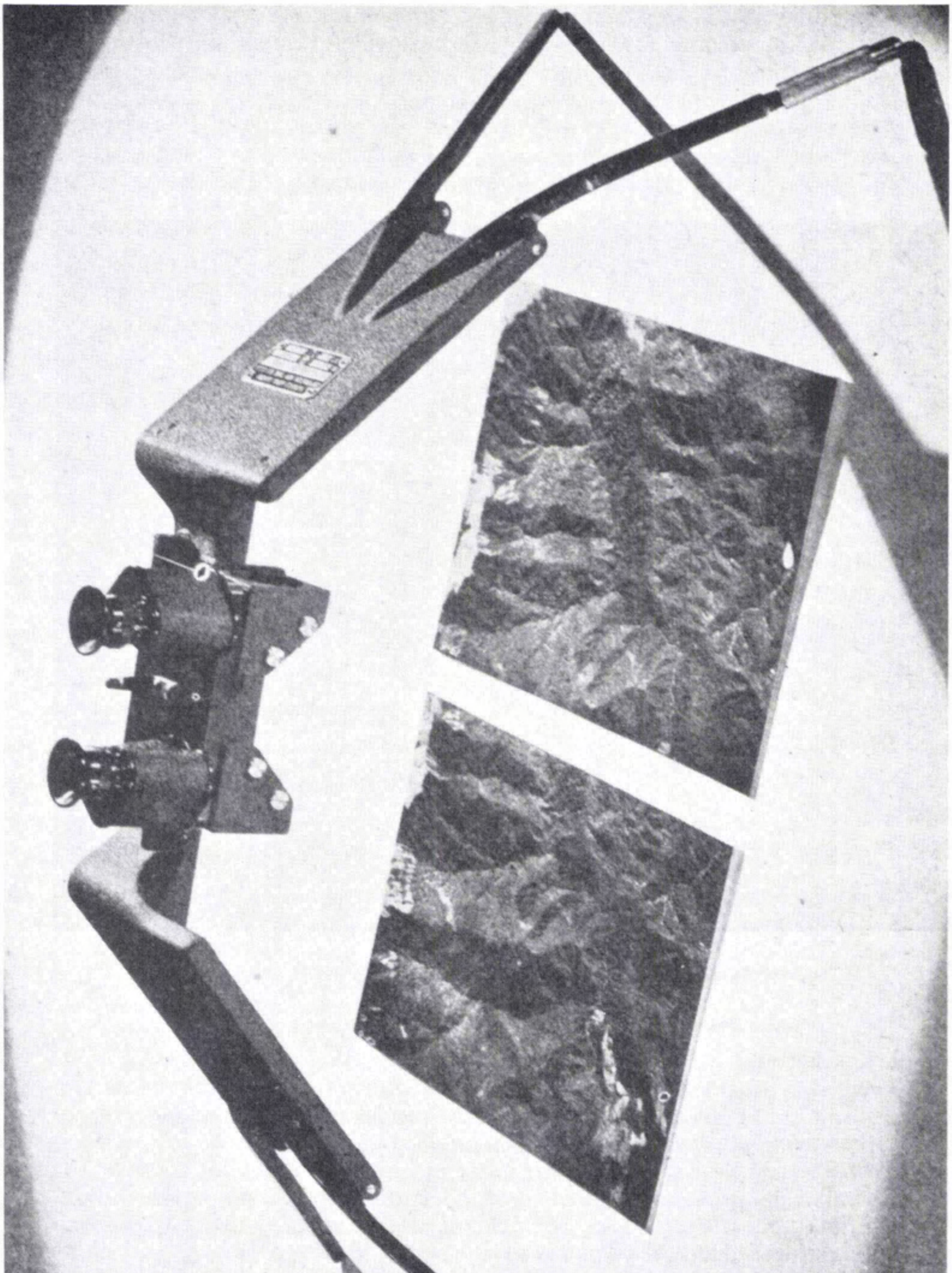
Neapolitan philosopher who made a diagram illustrating Galen's views on the dissimilarity of the three pictures which are requisite in binocular vision. Leonardo da Vinci also gave the subject his attention. In a treatise on painting which he left behind in manuscript form he made the point that a painting, even though perfect in detail, color, contour, etc., could never show up in as much



Three early types of stereoscopes. From "The Stereoscope" by David Brewster. J. C. Hotten, publishers, London, 1870.

relief as a natural object unless the latter was viewed at a distance and with a single eye.

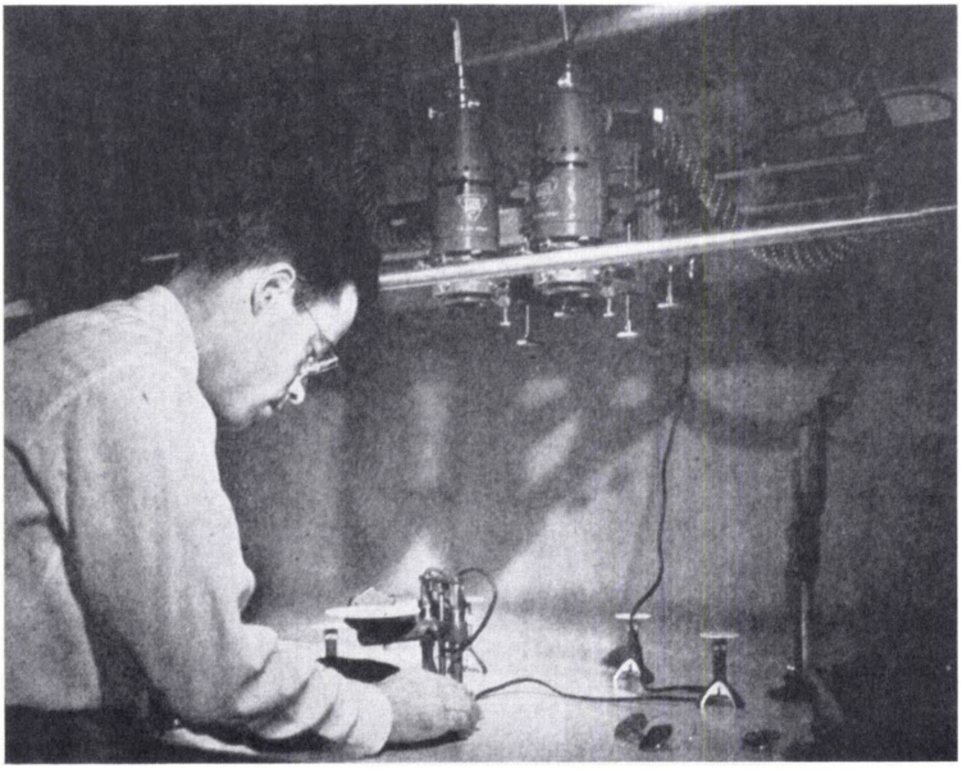
It was realized that the phenomenon had a purpose: to insure us the all-important sensation of depth and perspective in what we behold. Explaining binocular vision and its purpose is not an easy task and each student to give the matter his attention juggled words around trying for an apt description.



The Fairchild Camera & Instrument Corporation's stereoscope, with four-power binoculars in place.

"When an object is seen with two eyes," wrote Francis Aquillon, a learned Jesuit, in 1613, "two optical pyramids are formed whose common base is the object itself and those vertices are in the eyes."

Two and a half centuries later Oliver Holmes commented on this explanation. "It is not correct," he wrote. "A body is seen clearly and distinctly with both eyes when the optic axes are converged upon them; the common sense exerts its power and brings the images together and rectifies the picture." The



The Bausch and Lomb Multiplex Mapping Projector and Tracing Tables.

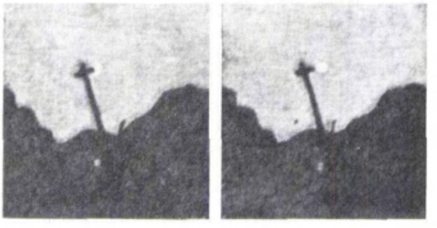
Bausch & Lomb Optical Company

way he chose to put it was "our two eyes feel around an object, which is an illustration of fact rather than an explanation of the actual mechanics. Our two eyes see somewhat different pictures, which our perception combines to form one, representing objects in all their dimensions and not merely as surfaces."

It was in 1834 that the first instrument was built for bringing together the two dissimilar pictures seen by the eyes. Elliot, professor of Logic at the University of Edinburgh, wrote an essay on binocular vision entitled "Means by which we obtain our knowledge of distances by the eye" and eleven years later decided to demonstrate his theory in practice. The instrument he devised could not be equipped with photographs because there were none available at the time—they had not yet been invented. But he made up for this lack with a transparent drawing of a landscape. To point up the sensation of depth, he incorporated three distances in his drawing: a tree in the foreground, a cross in the middle distance and a moon in the background.

Ten years later Sir Charles Wheatstone came out with his own theory that the difference between the two retinal images is essential to the perception of depth. It is he who is given credit for evolving the idea of the stereoscope. His theory was contradicted during the 1840's by Sir David Brewster and E. Brücke who stated that the perception of depth came from the continual change in the angle of convergence of the eyes' axes during observation and from muscular exertion and accommodation of the eye which brought about a simultaneous touching of the object. This theory, however, was contradicted by H. W. Dove, who showed that a stereoscopic viewing was also possible with momentary illumination of the object.

In 1849 Brewster built a lenticular stereoscope with geometrical drawings. Maurice Daguerre had made known his invention in Paris ten years prior to



Pair of stereoscopic drawings used in the first stereoscope built in 1834 by Prof. Elliot of Edinburgh, Scotland. The tree, the cross, the moon represent three different distances in the landscape.

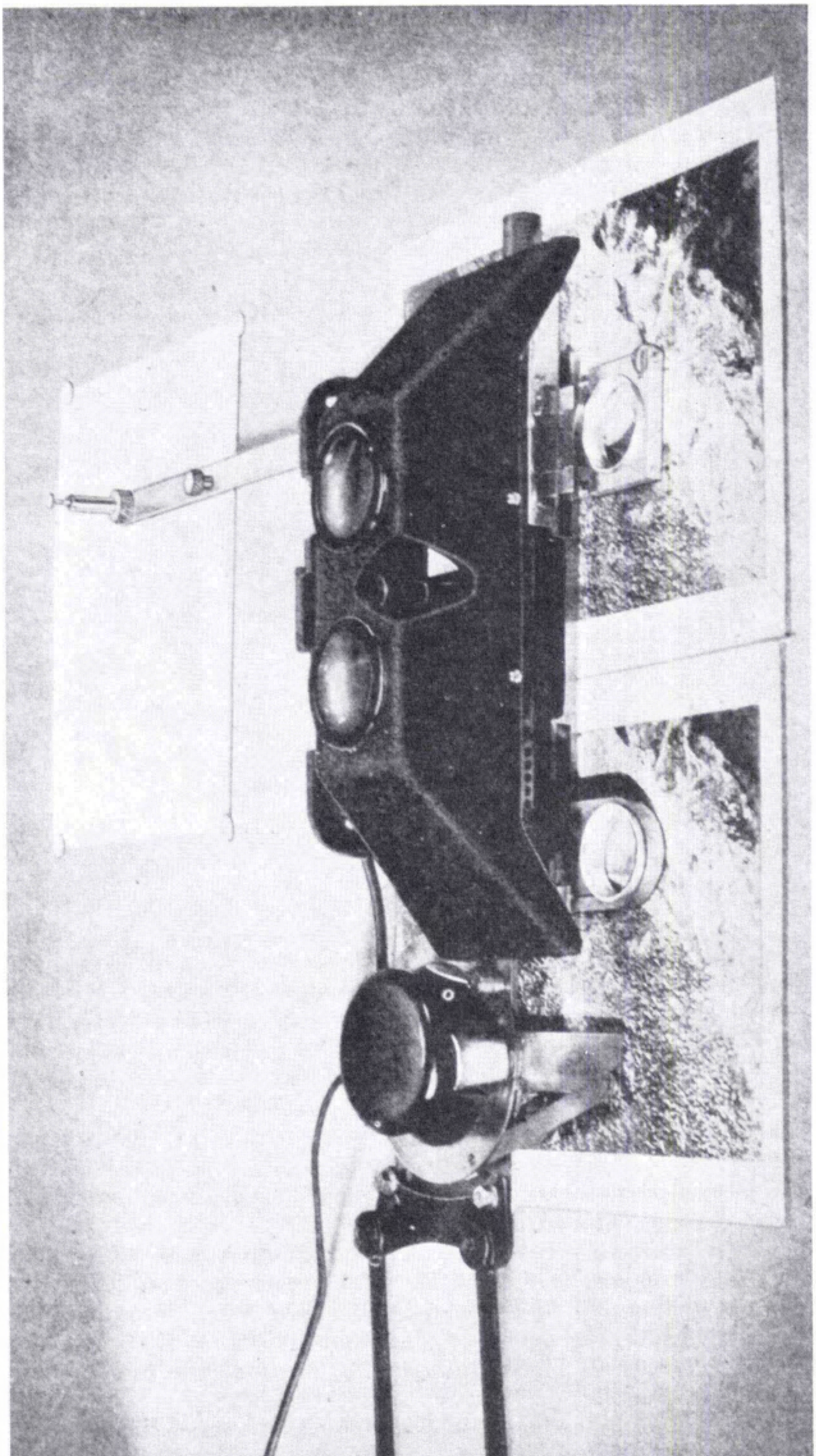
From "The Stereoscope" by David Brewster. J. C. Hotten, publishers, 1870, London.

that and the Abbe Moigno, author of "L'Optique Moderne," equipped Brewster's device with daguerrotypes. A Stereoscope Company was started in London and quite a thriving industry came into being. The variety of subjects that were dealt with in stereoscopic photographs was wide in range and today some of them are of great value, as being the only contemporary record of certain places and events.

The first stereoscopes were of the box type, followed in 1860 by a hand model developed in this country by Oliver Holmes. Then when the instrument began to progress beyond the stage of being purely a parlor toy, models of increasingly varied types came into being.

The first practical application that was found for the stereoscope was in the field of education. It is still used as an aid in the teaching of subjects that are made more vivid and easy to understand by means of third-dimensional views: to demonstrate figures in solid geometry, diagrams of light rays in optics, models of the structure of crystals in crystallography, parts of the human body in anatomy.

Astronomy is another field into which stereoscopy was introduced at an early stage. The first stereoscopic picture of the moon was taken between 1857 and 1860 by Thomas de la Rue. He had to wait four years between shots so that there would be the proper difference in the angle from which each was taken.



The Fairchild Stereocomparagraph.

During this period the moon went through a libration or swinging motion, so that in the second picture it exposed more of its face and made it possible for the camera to see a little "around the corner." The two pictures, fused into a three-dimensional view, give a vivid idea of what our satellite would be if seen at close range and in all its solidity and detail. Similar pictures of constellations give a true representation of the component stars' distances apart and relative positions.

Still another application which was discovered in the last century, by Dr. J. Mackenzie Davidson of London, was the use of stereoscopy in X-ray work, for locating defects or foreign bodies inside solid objects.

In industry, for instance, it is possible to locate interior faults in timber and plywoods, blow-holes or slag inclusions in welded joints and hair-cracks in steel and iron castings.

In surgery this method of observation has been of immense value for locating the exact position of shrapnel, bullets, shot needles, etc., inside the human body. This precise knowledge makes the surgeon's task easier and many lives (especially in wartime) have thus been saved. Davidson also conceived the idea that stereoscopy could be used in conjunction with the fluoroscope, which made it possible to observe living human beings internally and three-dimensionally.

Aerial Photography

It is in connection with aerial photographs that stereoscopy has been the most active. Its value in photo-interpretation for military purposes was discovered in the last war and has seen much development during the present one. A peace-time application of this is in mining and petroleum geology, where the three-dimensional study of ground surface features from aerial photographs has saved many a dollar once spent on probings and field work.

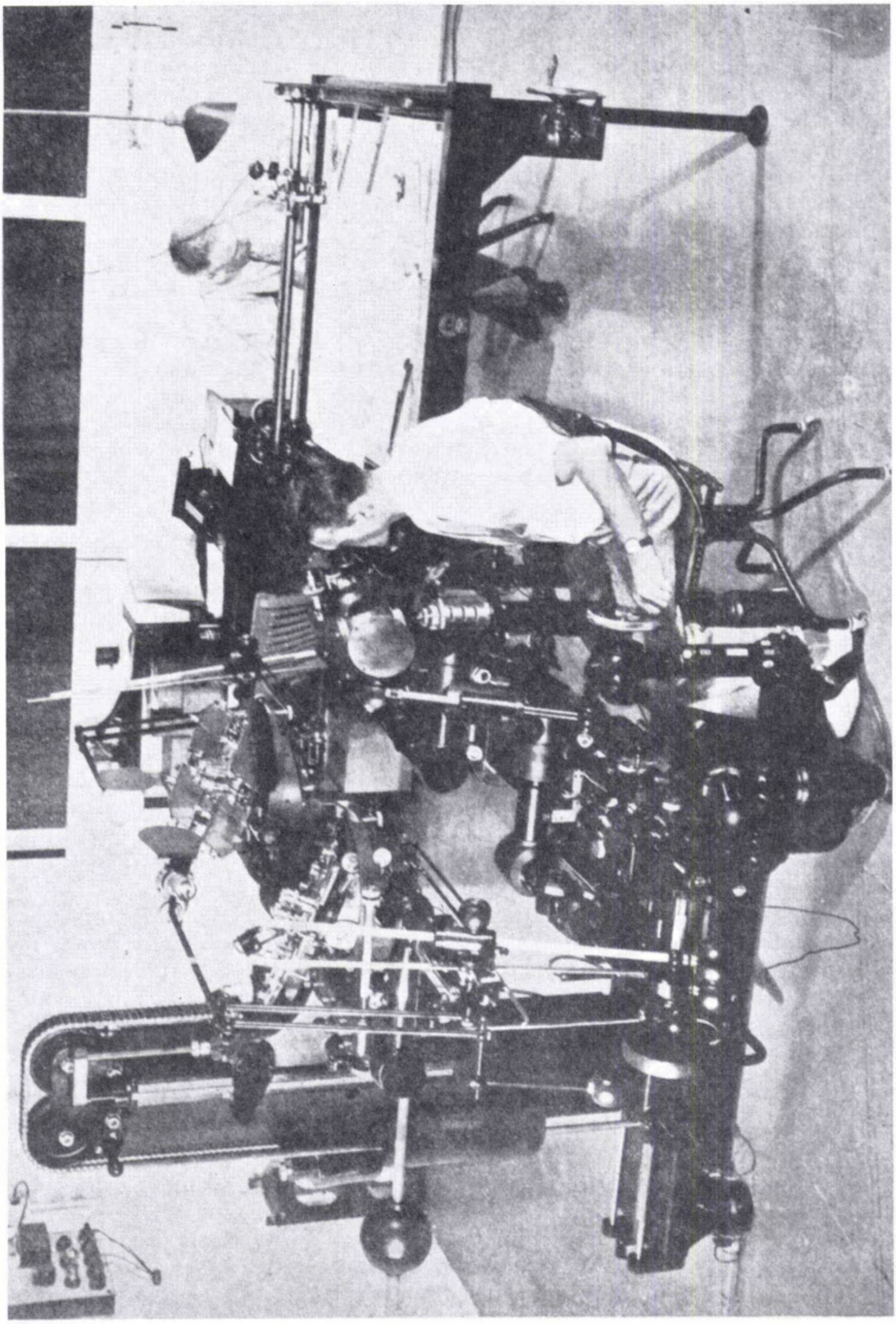
It is map-plotting from aerial photographs that has brought about the development of the most varied and elaborate line of stereoscopic instruments.

When surveying first took to the air the equipment used in plotting was the same that had been developed for use with ground photographs, such as the stereo-comparator developed by the young Austrian Lieutenant von Orel from an earlier model designed in 1903 by Pulfrich (this eventually led into the development by the Zeiss firm of the stereoautograph).

The first instrument designed especially for use with aerial photographs was the Hugerschoff Autocartograph, brought out in 1920 and given some improvement in 1925. It was cumbersome and elaborate and consisted of three principal parts: the stereoscopic observing system, the surveying system which was made up of two theodolites coupled by levers for computing, and a plotting system. The photographs were set up with reference to the horizontal plane and four ground control points. For one pair of photographs two days were needed for computation and preliminary work and one day for plotting.

In 1926 Fourcade evolved his stereogoniometer in which the setting of the photographs was related to the air-base. This omission in earlier instruments had caused great trouble because the air-base is rarely horizontal, due to the aircraft's inability to fly a true straight line.

During this same period the Wild Company of Switzerland produced the autograph. The Hugershoff autocartograph was superseded by the Hugershoff-Heyde Aerocartograph, following which Professor Hugershoff (in 1932) became associated with the firm of Zeiss and had a hand in the development of the stereoplanigraph. This last instrument has a drawing-board and plotting apparatus attached, through which the motions of the instrument are transmitted



The Stereoplanigraph, in use in the Fairchild Aerial Surveys laboratory at Pasadena.

by universal-link chains and reproduced on paper. It permits of adjustment for varying altitude of the camera and is adaptable to plotting from photos which are taken at low as well as high tilts.

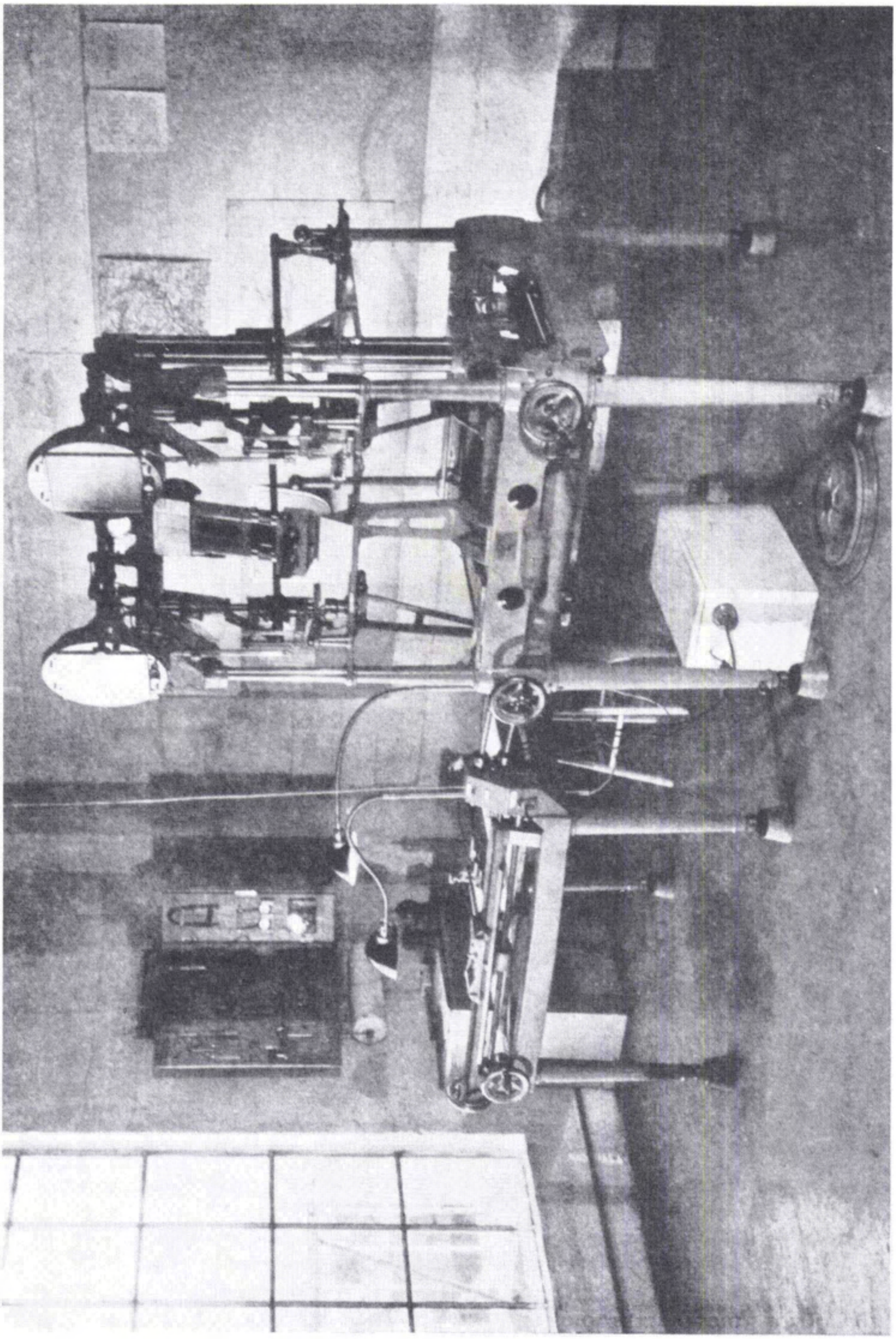
A still more recent product of the Zeiss company was the multiplex projector. This was a less elaborate instrument than those manufactured up until then and was devised by the Zeiss company upon request of such countries as the U. S. and Britain's larger colonies, whose mapping problems called more for wide and rapid coverage than for the extreme degree of accuracy achieved on European soil. This is now being manufactured by Bausch and Lomb, thanks to the forethought of the Army Corps of Engineers who, conscious of the approach of war, took steps to avoid dependency on Germany for the more advanced type of plotting equipment and wrote specifications for a multiplex to be built in this country.

This uses the anaglyph principle, in which photographs are projected alternately in red and blue and then observed through spectacles of complementary colors. This gives a plastic effect to the landscape, and by using a plotting table of variable height and carrying a floating mark, the plan and contours can be plotted.

A simple and typically American type stereoscopic instrument is the Fairchild stereocomparagraph designed in 1936 by Lt. (now Brig. Gen.) B. B. Talley of the Corps of Engineers. This instrument has been of great value during the war, under the frequent conditions where speed of compilation and mobility of equipment and personnel are of prime importance. It consists of a stereoscope (of the mirror type with matched lenses for magnification), a floating mark system and a drawing attachment which is added on for the plotting. It is capable of measuring differences in elevation by means of micrometer screw adjustments which may be read to the nearest 0.01 mm., and it can be used for the compilation of form line maps. When enough control exists, the form lines approach the accuracy of contour lines and therefore serve as topographic maps.

Another wartime development which is being investigated for peacetime use by such companies as Fairchild Aerial Surveys is vectography. This was evolved for military purposes through the joint efforts of Lt. Hubert Dogan (USMC), Commander Roswell Bolstad (USN), Clarence Romrell (Polaroid War School) and others. A vectograph consists of a stereoscopic pair of pictures printed on both sides of a sheet of special film. It can be used either as a transparency or as a reflection type print (for the latter it is painted with clear lacquer on the front and with aluminum lacquer on the back). It is viewed through spectacles fitted with polarized disks. The process is the invention of Edwin H. Land, president and director of research of Polaroid Corporation, working in collaboration with Joseph Mahler. Announced as a laboratory achievement in 1939, it was quickly developed into practical form for war use with the encouragement of the Navy, Marine Corps and the Army Air Forces. It has been found of great value in briefing combat teams, in staffwork, intelligence reports and in training large classes of gunners, mechanics, pilots, etc. Possible peacetime applications have been seen for it in flood control, soil conservation and, according to Commander R. S. Quackenbush, "wherever the lay-of-the-land is an important part of the message that the aerial photograph is expected to convey."

It has been observed that the general tendency in the future will be to examine the various mapping problems, define the characteristics of each and from there determine which type of equipment can best accomplish the job. There will be an increase in the use of aerial photographs for engineering as well as



The Aero Cartograph, shown in the Fairchild Aerial Surveys laboratory.

military purposes and this is bound to result in photogrammetry courses being offered in engineering colleges—to insure well trained and skillful users of photogrammetric equipment and consequent efficiency and speed.

It took man many centuries to discover and make full use of his optical powers. In the last hundred years, however, we have made great strides. We have learned to look through objects, around them, into the far distance and three-dimensionally. What further strides lie ahead we have yet to find out, but when peace comes and the smoke clears we will discover that the ground has been laid for much far-reaching progress along these lines

(Footnote continued from page 1347)

The article by Revere G. Sanders, which began on page 1347 was selected as the winner of the first Talbert Abrams Award. This Award, which has been offered annually for the past forty years by Talbert and Leota Abrams, recognizes the best article published in *Photogrammetric Engineering* during each year.

In presenting the award to Mr. Sanders at the twelfth Annual Meeting of ASP, President Gerald FitzGerald said:

"It would be a sad state of affairs if photogrammetrists were unaware of the history of the development of stereoscopy. The actual extent of photogrammetrists' knowledge on this subject is open to conjecture. Because Mr. Sanders' article on this subject, which is one of the principal tools of the science, is both interesting and instructive, he has been chosen as the recipient of the Abrams award. In an orderly, logical manner there is outlined the factual development of stereoscopy from the early ponderings of the Greek philosophers to the modern applications in photogrammetry. These applications now are an integral part of modern life, with X-rays for many industrial uses, in medicine, and in astronomy, in addition to the more well known one of cartography."

Forthcoming Articles

Fouad A. Ahmed, A Parallel Case of Photogrammetry and its Application in Narrow Transits.

G. Begni, D. Leger, and *M. Dinguirard*, An In-Flight Refocusing Method for the SPOT-HRV Cameras.

M. L. Benson, B. J. Myers, I. E. Craig, W. C. L. Gabriel, and *A. G. Swan*, A Camera Mount and Intervalometer for Small Format Aerial Photography.

P. F. Crapper, An Estimate of the Number of Boundary Cells in a Mapped Landscape Coded to Grid Cells.

Barry M. Evans, and *Larry Mata*, Acquisition of 35-mm Oblique Photographs for Stereoscopic Analysis and Measurement.

D. C. Ferns, S. J. Zara, and *J. Barber*, Application of High Resolution Spectroradiometry to Vegetation.

Barry N. Haack, Multisensor Data Analysis of Urban Environments.

Kenneth E. Kolm and *H. Lee Case, III*, The Identification of Irrigated Crop Types and Estimation of Acreages from Landsat Imagery.

L. Daniel Maxim and *L. Harrington*, On Optimal Two-Stage Cluster Sampling for Aerial Surveys with Detection Errors.

H. Schreier, J. Lougheed, J. R. Gibson, and *J. Russell*, Calibrating an Airborne Laser Profiling System.

C. Scott Southworth, The Side-Looking Airborne Radar Program of the U.S. Geological Survey.

I. L. Thomas and *G. McK. Allcock*, Determining the Confidence Level for a Classification.

John A. Thorpe, CPS: Computed Photo Scale.

J. C. Trinder, Pointing Precisions on Aerial Photography.

John F. Watkins, The Effect of Residential Structure Variation on Dwelling Unit Enumeration from Aerial Photographs.

Richard S. Williams, Jr., Thomas R. Lyons, Jane G. Ferrigno, and *Michael C. Quinn*, Evaluation of the National Archives Program to Convert Nitrate Aerial Photographs of the United States to a Stable-Base Safety Film.