REED RESEARCH FOCALMATIC

Auto-Focusing Projector [1]

The Reed Research Focalmatic is a reflecting projector with automatic focusing at all positions between reduction of 1/4 to enlargement of 4. This unique instrument offers a rigorous mathematical solution by mechanical means to the problem of continuously sharp focusing. It is capable of projecting opaque aerial maps or photographs, up to 9" × 9" in size, in sharp focus and proper orientation on a horizontal work table, so that detail in the photographs or maps may be compiled to true scale on a map manuscript as required in original map compilation or map revision.

The projector may readily be broken down into component parts for transport if necessary. For moving through narrow doorways the table assembly may easily be removed, the maximum width then being only 26". Sturdy enough to withstand road shock while in transit, it still weighs but 415 pounds. Leveling screws and bubbles are provided for plumbing the instrument.

The projector has two stationary and three moving components. Fixed in position are the horizontal plotting table, 30" × 40" in size, and the main column supporting the entire equipment. The plotting table is 1" thick and made of a hardwood multiply core, completely enclosed in 24 gauge stainless steel with dull finish. The edges and all fasteners in the underside are sealed against moisture. The 3-1/2" diameter, centerless ground and chrome plated, steel tube main column provides a keyed track for the vertical movement of the lamphouse, with its object photograph or map, and the independently adjusted travel of the lens system carriage. The floating member, which carries the drive screw and two pulleys, is the third moving component and is the heart of the autofocusing mechanism. It travels upon a second smaller precision ground steel tube which also serves as the lamphouse support tube and carries the electrical cable to the lamphouse.

The electrical system is readily accessible at all points and incorporates plug connectors to facilitate disassembly. The switch box and control panel contains main line fuses, power switch, warning light, motor control switch and the voltage control knob.

Mounted vertically within the lamphouse, and symmetrically located about the image erecting mirror, are two 500 watt projection lamps backed with 3" radius spherical reflectors concentric with the lamp centers. This positioning of lamps and reflectors yields point sources of light, sufficient to provide a light intensity of two footcandles, at the projected image of a sheet of white bond paper, with the lens at full aperture and the projector set at a magnification of two diameters.

The erecting mirror is an aluminized first surface type, shaped into a six-sided kite form to cover the 20° tilt, either side of center, of a 9"×9" square object. This first surface mirror is aluminum coated directly upon the front surface of the glass. The light does not have to penetrate the glass once before reflection and once after reflection, as is the case with an ordinary second-surface mirror, but instead is reflected directly by the mirror film covering the glass. The result is an avoidance of distortion due to refraction, and freedom from the necessity of using perfectly transparent, homogeneous glass for the supporting surface. It reflects light without loss of optical definition.

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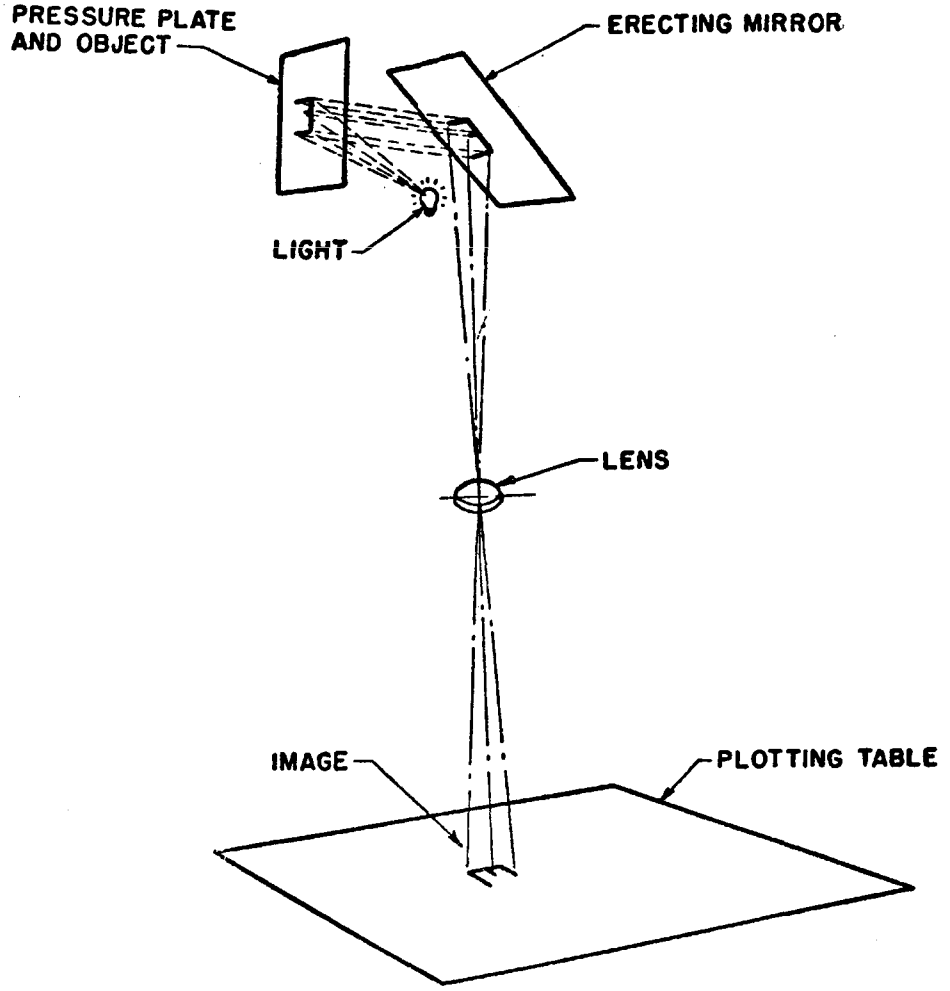
(1) Reed Research Inc., Washington.

The erecting mirror, positioned at 45° to maintain the optical axis of the lens perpendicular to the pressure plate holding the object, is mounted with seven clips on an aluminum plate of the same shape faced with felt. This mounting plate, in turn, is attached to a rigid bracket on the house assembly by a ball end bolt and four thumb screws. Proper alignment of the mirror is easily accomplished by means of these screws.

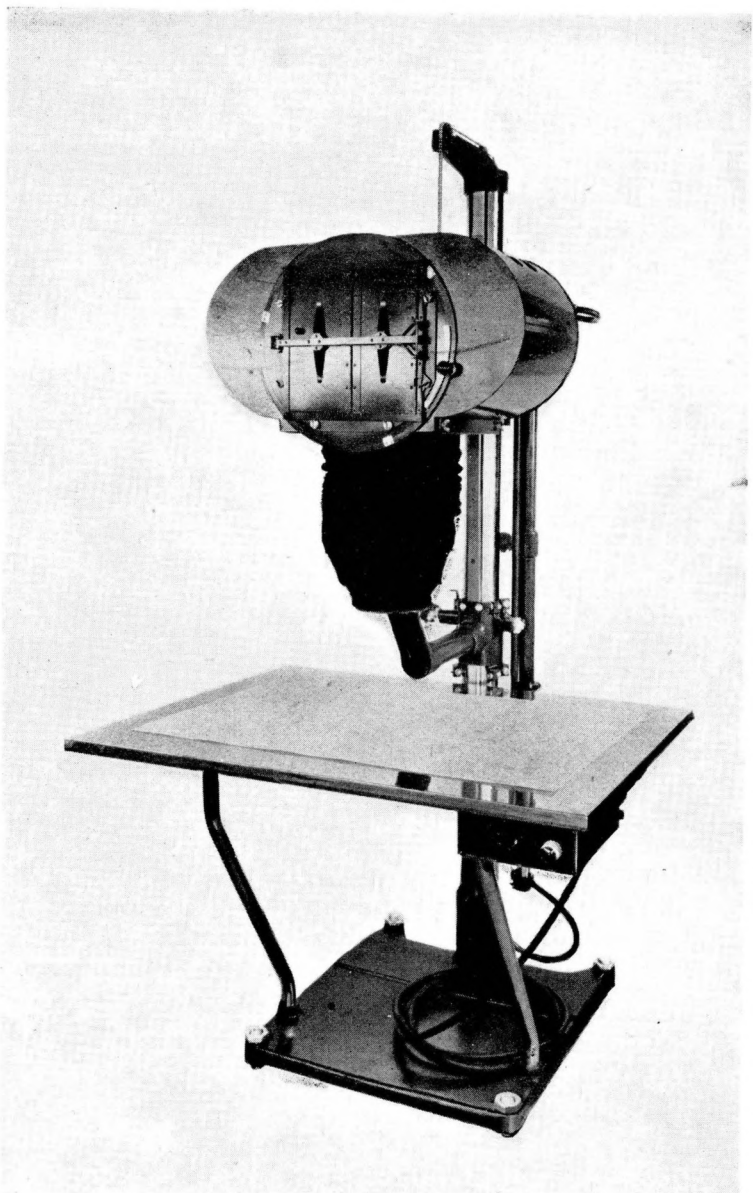
The inside of the lamphouse is readily accessible through two doors, one on each side, hinged at the top and fastened with wing nuts on the bottom.

The pressure plate, fixing the object photograph or map in position for the erecting mirror, is mounted in a vertical plane to the front of the lamphouse and has cross-lines etched on its glass surface for orientation. The photograph holder and map holder are interchangeable and are fastened outside the pressure plate with thumb screws. The entire unit may be rotated 20° either side of center for point matching ease by means of a convenient knob on the front of the lamphouse.

The air temperature within the unit is kept well below 200° F after continuous operation by a fan which is located on the exterior framing of the lamphouse. This fan directs a stream of filtered air through ducts to the pressure plate within the



OPTICAL SYSTEM OF REFLECTING PROJECTOR



The Focalmatic

assembly. The air is circulated throughout the house, finally exiting through holes in the top and back.

The maximum height of the projector is 80" and the table is set approximately 29-1/2" above the floor. The lens used is the Wollensak's 7-1/2", f/4.5, Enlarging Raptar Lens with variable diaphragm aperture stop.

The interrelation of the two seemingly independent motions (i.e., of the lens carriage and the object carriage) may be shown to yield the automatic focusing so unique in this instrument. The mechanism is an adaptation of the Pythagoras Inverter, described in « Photogrammetry, Collected Letters and Essays » by O. von Gruber.

The mechanical linkage is such that the Sheave A, which is part of the floating member, is always midway between the object and the fixed plotting table image. Sheave B, which is part of the lens system carriage on the main column, is always traveling on the parallel line one focal length away from Sheave A. Sheaves A and B are the same diameter. The link chain is fixed to Sheave B, rolls over Sheave A and is attached to the rigid bar of the lamphouse. In this manner a motion of two units by the object causes a change of one unit in the distance L between Sheave A and Sheave B. The resultant vertical displacement between Sheave A and Sheave B is the heart of this automatic focusing mechanism.

For IX magnification, the distance between the object and the lens, d_o, is the same as the distance from the lens to the image, d . From the lens formula:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{2}{d}$$

so that $d = 2f$. In this position, Sheave A is in the same horizontal plane as Sheave B, and their distance apart is f. The vertical displacement is zero.

Now, if the object moves up two units (2u), the total distance from the plotting table to the object is $4f + 2u$. Sheave A is then positioned at the midpoint, $2f + u$ or $f + L$, where $L = f + u$, above the fixed table. Sheave B is now $f + u$ or L from Sheave A. The vertical displacement between Sheaves A and B may be designated as h.

From the lens formula :

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$\frac{1}{f} = \frac{1}{f + L + h} + \frac{1}{f + L - h}$$

Solving for « h »,

$$h = \pm \sqrt{L^2 - f^2}$$

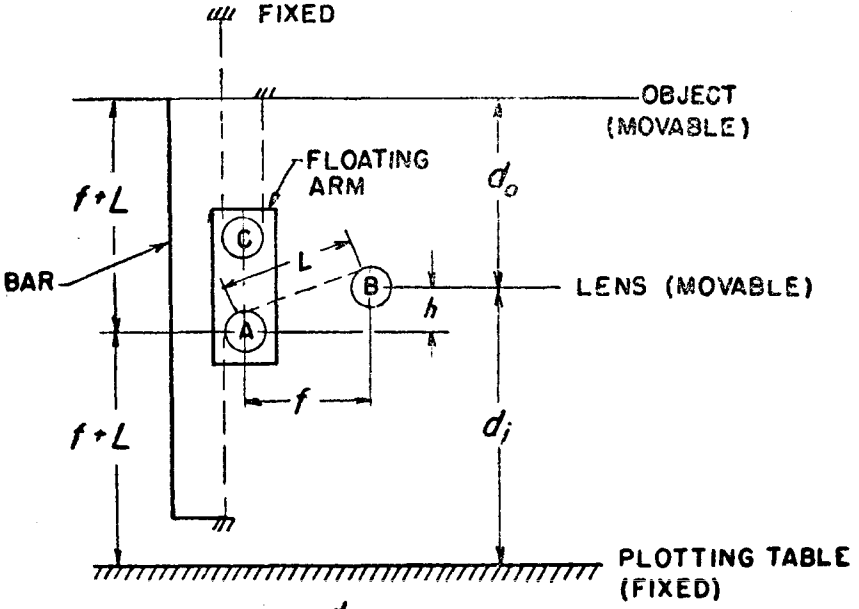
This same relationship is also obtained from the right triangle positioning of the Sheaves A and B. Here is indicated the solution of autofocusing for all ranges of magnification.

The method of attaining this mechanical arrangement for the projector follows :

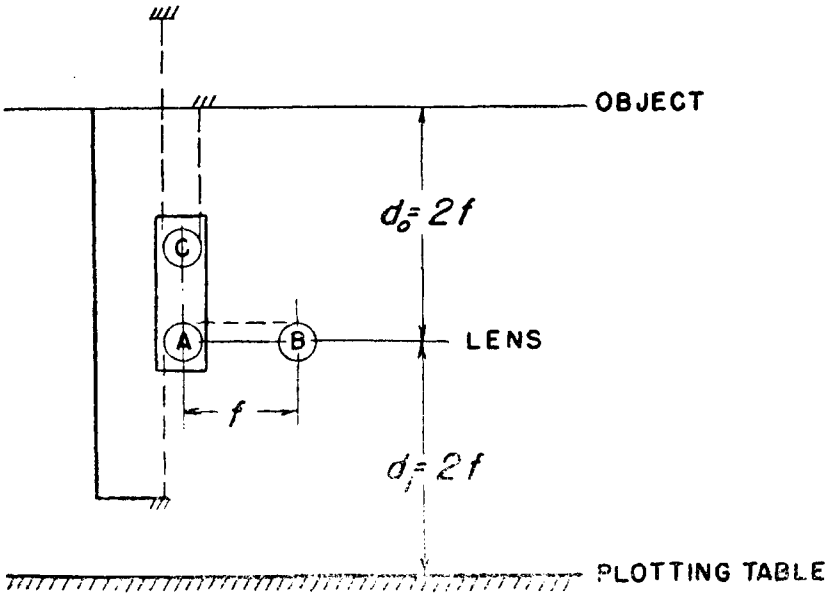
A floating arm having two sheaves, the upper designated as C and the lower as A, is guided in its vertical travel by a rigid bar attached to the lamphouse. One end of the link chain around Sheave C is fixed to the movable lamphouse ; the other end is fixed to the bracket atop the main vertical column. Since there is a given length of chain, if the lamphouse moves two units, the floating arm moves but one unit. The total travel of the lamphouse is taken up, one-half from the fixed end of the stationary bracket to Sheave C and one-half from Sheave C to the lamphouse.

On the lens system carriage is fixed Sheave B with a second link chain fixed to it. This link chain rides over Sheave A of the floating arm to the fixed bar attachment of the lamphouse. The vertical displacement of Sheaves A and B is accomplished by a Janette 1/12 HP, 144 rpm capacitor motor. The jack screw, 3/4", 12 Acme Thead, mounted ont the floating arm, is driven by the motor through a square shaft sliding inside the screw. The motion is picked up directly by the lens carriage through a brass nut, but the floating arm is positioned through the link chain arrangement.

Control by the autofocusing device permits small segments of non-rectified aerial photographs to be used for map matching. Normally, an aerial photograph to be used for plan projection must be rectified for tilt of the airplane camera at time of exposure. Compensation for this error at small angles may be made by slight differential magnification of the individual points on the object photograph. The ease by which the autofocusing is accomplished makes this instrument more than a projector. It is in a small degree a rectifying medium.



MECHANISM AT $\frac{d_i}{d_o}$ MAGNIFICATION



MECHANISM AT IX MAGNIFICATION