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SPECIFICATIONS FOR MODEL 621 COMPARATOR

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W/Motor drive on both "X" & "Y" Screw

1. The Photographic plate to be measured shall be supported horizontally glass side up on a precision turntable which in turn shall be supported as an integral portion of a main carriage assembly. The main carriage assembly shall move along horizontal precision ways in a direction toward and away from the operator seated before the instrument, and with the major portion of its total weight supported by spring loaded rollers, so that only the necessary minimum fraction of its total weight bears on the guiding ways. Provision for the motion of the main carriage along the ways shall be such that, in accordance with the desire of the operator, the motion shall be either (a) free as actuated by the operator, or (b) actuated by means of a "right handed" precision screw to the nut of which the carriage is engaged when desired, by means of a mechanism designed for this purpose. This mechanism shall positively position the carriage with respect to the precision screw to such a degree that on repeated engagements of the carriage, the scale reading on a fixed point (on a plate to be mounted on the turntable) will remain constant within plus or minus 1.0 micron. The precision screw, for actuating motion along the main ways shall be of 1 mm pitch, 1 mm lead, and the overall range of precision motion actuated by screw in direction of main ways shall be 500mm. The coordinate of the main carriage assembly position on the ways shall be readable from the operator's position by means of a circular "least count" dial, rotating directly with the precision screw, and having a "least count" of .001mm, (1 micron), and a gear driven millimeter count dial unit indicating the integral number of millimeters. In accordance with the requirement for 1mm lead screw, the circular "least count" reading dial will be graduated to read through a one millimeter range of carriage motion with the gear driven millimeter count dial always indicating the integral number of millimeters of motion from the point of origin. The millimeter count dial shall have adjustability to permit achieving zero millimeter reading of the millimeter count dial for a desirable position of the carriage near the zero end of the screw travel, and to permit careful adjustment of the millimeter count dial to show exact millimeter coincidence when the least count reading dial indicates an exact millimeter setting. The millimeter count

dial unit shall permit reading of whole millimeter position of the carriage from point of origin corresponding to position of carriage farthest from the operator with readings increasing as carriage moves nearer to operator. The least count reading dial shall have 1000 graduations, i. e., a graduation corresponding to each .001mm (1 micron) of linear motion of the carriage over the 1mm range of lead, and shall have engraved numerals 0, 010, 020 etc. at respective successive one-hundredth millimeter points, the numerals appearing vertical to operator and centrally located with respect to the respective corresponding graduation lines. Graduation lines at one-thousandth millimeter (1 micron) points shall be short; lines at half hundredth (5 micron) points longer, and lines at hundredth (10 microns) points longer yet; the graduation line structure to be arranged by the contractor for maximum operator convenience in reading decimal fractions of millimeters. Index marks for least count dial and for millimeter count dial shall be approximately in same horizontal straight line, and so that operator looks as directly as possible on portion of dials where readings are to be taken.

Hand crank shall be provided for actuating rotary motion of the main screw. In addition, a motor drive for rotary motion of screws shall be provided, with control system, to eliminate excessively tedious hand cranking of the screw in moving the carriage from one end of the run to the other, motor drive to be provided with safety features to prevent accidental jamming of nut at ends of the run, and to automatically disengage when not being used by operator. Motor shall turn screw at maximum rate of approximately three (3) revolutions per second, for limiting undesirable heating of the precision screw nut. Main precision screw shall parallel ways near left hand way (as viewed by operator) so that operator's left hand may be used to operate hand crank.

2. The precision turntable shall be circular and shall be supported and guided in its rotation by means of a precision friction bearing of approximately the diameter of the turntable. The friction bearing shall be machined as an integral portion of the carriage which rides on the main precision "ways", and shall incorporate a system of spring loaded weight relieving rollers, so that only the minimum necessary fraction of the turntable weight is carried by the friction bearing surfaces. The bearing shall be constructed to such a degree of perfection that on rotation a point (marked on a plate to

be supported by the turntable) shall describe a circle, with allowable deviations not to exceed plus or minus two microns. Turntable shall have an angular scale reading through 360 degrees in either direction inscribed near the periphery, giving vernier least count reading to the nearest 20 seconds of arc. An optical system shall be provided for the convenient reading of the vernier from the position of the operator, regardless of the carriage position. The angular scale shall no where exhibit random graduation errors exceeding 20 seconds of arc, and the accuracy in graduation in centering with respect to the center of rotation of turntable shall be such that eccentricity errors do not exceed 20 seconds of arc. Contractor shall provide smooth working external gear and pinion device for rapid rotation of turntable by operator, and, in addition, means for a precise final rotation adjustment, either in connection with the gear and pinion device, or otherwise. Hand crank arrangement for rapid turntable rotation and device for precise final adjustment shall be conveniently accessible to operators, and should be effectively designed to minimize possibility of turntable alignment being inadvertently disturbed subsequent to adjustment and during course of measurement of a plate.

3. The precision ways which support the turntable - carriage assembly shall be machined as an integral part of a single-casting bed which supports and holds the weight of the entire instrument. The bed shall be designed to provide maximum rigidity and freedom from progressive warping, and the ways shall be essentially parallel and straight. A satisfactory system of illumination, with the source located outside the comparator bed, shall be provided for viewing the portion of the plate within the field of the viewing optical system (to be described).

4. Attached to the comparator bed shall be a bridge designed for maximum rigidity and stiffness, straddling the principal guiding ways, turntable and carriage, and into which are machined essentially straight "horizontal" precision secondary ways. The precision secondary ways shall parallel the plane of the photographic plate and its plane of motion as defined by the principal carriage and guiding ways and shall incorporate means for adjusting the direction of the secondary ways to near-perpendicularity with the direction of the principal guiding ways. The secondary ways shall have suspended from them a secondary carriage moving along the secondary ways, and which shall mount an optical system for viewing the photographic plate.

5. The optical viewing system shall have eye and optic axis inclined approximately 68 degrees from the vertical for operator convenience, and shall, however, view the photographic plate "vertically" from above by means of a pentagon prism arrangement. Optical system shall consist of pentagon prism previously mentioned, followed by an objective system which shall image an area of the photographic plate upon a reticle, the latter of which, along with the optical image of the plate area, shall be viewed by the operator by means of an eyepiece. Design of optical system shall receive careful engineering consideration with respect to location and choice of elements, to achieve excellent quality overall performance. Eyepiece shall be focussable on the reticle (to accommodate eye requirements of various operators) either by friction or focussing adjustment, and shall be mounted so that there is no possibility of eyepiece physically contacting the reticle. Reticle shall consist of two perpendicular fine lines etched or diamond-cut on glass, with intersection in optic axis (approximately). Reticle shall be so mounted as to permit fine rotation adjustment of reticle about the line intersection point (or a point very near this), for purpose of aligning one of the two lines parallel or perpendicular to the direction of motion of the guiding ways, with means for clamping reticle in adjusted position without disturbing the adjustment. Optical system (less prism) shall be focussable with precision on the photographic plate, in order to bring plate emulsion and reticle into conjugate focal point relationship for plates of different thickness, and with means provided to insure rigidity of the optical system to its carriage after focussing. Optical system tube and assembly shall have interior light stops at essential points and shall have mechanical surfaces coated a flat black to the extent required to minimize blurring of imagery by scattered light. Overall visual definition given by the optical system shall be excellent over the entire extent of the field.

6. The secondary carriage (in a manner similar to the main carriage) shall incorporate an appropriate weight relieving mechanism, and shall move either (a) freely by hand, or (b) as actuated by means of a precision secondary screw to the nut of which the carriage is engaged when desired, by means of a mechanism essentially identical to that to be employed in the case of the main carriage assembly and which shall have the same characteristics with respect to functioning and precision.

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7. The precision secondary screw shall be "right handed" with thread of 1mm lead, 1mm pitch, and entirely similar to that which actuates the motion of the main carriage assembly, except the overall range for precision motion of the secondary carriage as actuated by precision screw shall be 360mm. The precision screws for the principal and secondary motions shall be of the highest precision quality developed by [redacted] and in each case with any systematic errors detectable through careful study by the manufacturer being to a large extent eliminated through compensator rotation of the nut, induced through the medium of a "corrector bar". The screws shall be manufactured essentially free from periodic errors, and shall be mounted by means of highest precision ball bearings with end play entirely eliminated by means of "pre-loading". The precision screw nuts shall be of "Mechanite" (unless otherwise elected by contractor) and shall be so accurately fitted and adjusted to the respective screws as to reduce backlash to a minimum. In the case of either the principal or secondary motions, coordinate values of image points on a photographic negative or other test object attached to the turntable, as measured by the respective screw motions and reading dials, shall nowhere deviate from exact linearity by more than plus or minus 2.5 microns due to uncompensated defects of manufacture. The coordinate of the secondary carriage assembly position along its ways shall be readable from the operator's position by means of a circular dial and associated millimeter count dial essentially the same in functioning, adjustability to zero, dial graduations, and least count, as specified for reading the position of the main carriage assembly, except least count dial and millimeter count dial shall indicate coordinate position from point of origin corresponding to extreme left position of secondary carriage, with readings increasing in magnitude as carriage is moved from origin in right (as seen by the operator) direction, carriage being driven in right direction by right hand rotation of screw as readings are increasing. (For actual plate measures operator approaches desired setting by right hand motion of secondary screw, dial reading increasing in magnitude during this process - after setting is achieved, corresponding dial reading is recorded) Secondary screw shall be provided with operator hand-crank. (as principal screw) Both screws shall incorporate flexible stops or their equivalent to prevent operator from hand-cranking screw nuts too near mechanical end of run.

8. The comparator as a whole shall be designed to be effective in appearance and all non-machined surfaces shall have an attractive and durable gray lacquer finish. The overall design and arrangement of controls shall be such as to afford maximum convenience and ease of operation.

9. Filters will be provided either between light source and objective or between objective and eyepiece. Types of filters to be specified at a later date.

10. Illumination sources to be situated so that both transparent and opaque objects can be illuminated.

11. The comparator shall have provisions for measuring 9" x 18" format continuous roll film; and shall accommodate spools for the following film widths: 9.5", 70mm, 6.7", and 5.0". Controls for rolling and unrolling of film to be conveniently located near operator, i. e., operator should not have to leave his seat to manipulate rollers. There is to be a minimum amount of backlash or coasting off film-spool supports.

12. The comparator will be fitted with an electronic or a mechanical readout of x and y coordinate values. The readout will be fed into a "Flexowriter" for printed output and simultaneous tape punching.

The contract will include the "Flexowriter". The "Flexowriter" is manufactured by:



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13. The turntable will accommodate two planar plates of glass between which film will be clamped during measurements. The bottom plate of glass to be semi-permanently located and cut in such a manner that it will support 14" x 14" film and 9" x 18" film. Both surfaces of the bottom plate will be made accessible for occasional cleaning. The top plate will have an area such that it will apply pressure to both a 14" x 14" and 9" x 18"; or there will be two separate top plates, one for the 14" x 14"

area and one for the 9" x 18" area. Provisions for lifting the top plate will be included, either in the form of knobs or by a mechanical lift. The top plate will be removable for cleaning.

When film is advanced rapidly it will not touch any surface that will damage the emulsion.

14. Instrument will have variable magnification for 12 to 28 power.

15. The comparator will have a binocular eyepiece arrangement for plate viewing. The exit pupil of the eyepieces shall be large enough to permit slight head movement by the operator. The binocular eyepiece will have a screw type arrangement to change interpupillary distance instead of a sliding design.

It is realized that no comparator to date has been designed with a binocular viewing system and it is appreciated that unforeseen difficulties may prohibit their use. If, after analyzing the problem, it is found that binocular eyepieces cannot be utilized then the monocular eyepiece as used in the present Model 621 will be acceptable.

16. In addition, a table and chair on rails especially constructed for operator convenience and with table extension for recorder shall be provided.