survey where the amount of levelling required to control the photogrammetric survey is almost equal to that required to provide a grid of spot levels dense enough to permit the interpolation of contours by eye.

(3) Again ground survey is essential for small-scale mapping of dense areas of forest or bush where trails, drainage, and even small villages may often be screened entirely from the aerial view and can only be supplied by running a traverse on the ground.

(4) As the scale of the plan becomes large so the work of the ground surveyor becomes increasingly important. At very large scales, say in excess of 30 ft. to the inch, it is usually advisable to do the whole survey on the ground, for the sake of both accuracy and economy.

(5) Ground survey is also preferred for the preparation of large-scale plans of very small areas where the cost of aerial photography is disproportionately high to the size of the job. The undisputed field of the ground surveyor must lie however in practically all work which involves setting out, including the running of lines of precise engineering levels.

(6) As regards the reference to $\frac{1}{4}$ inch accuracy becoming "meaningless" this does not, of course, refer to the many cases where levels are referred to precise ground marks, but to level information read off a plan and of which the accuracy is dependent on the scale of the plan. For instance, the nearest one can re-establish a given point on the ground from measurements taken on a 1/2,500 plan is ± 3–4 feet. Within this circle of location on uneven or sloping ground it is possible for the level to vary by an amount far in excess of the precision with which it is surveyed and its value marked on the plan.

*Considerations for the Design of a Projection Plotter**

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The advantage of the projection plotter compared with the more complicated binocular instruments is its extreme simplicity.

Having examined a number of projection plotters of different makes, I am convinced that a cheap projection plotter could be built for plotting individual models with better performance and facilities than any existing projection plotters and with a working accuracy as good, if not better than any existing first-order plotter, except of course, the instrument would not measure machine coordinates or be convenient for air triangulation.

The design should feature the following points:

(1) Rotating shutter viewing should be employed. Compared with anaglyph viewing this system presents enormous advantages with regard to model clarity and definition, and obviates the necessity for spectacles.

(2) The instrument should be nominally distortion free and utilise full size $9'' \times 9''$ diapositives. Optimum projection should be between $\times 5$ and $\times 6$. The working table should be large enough to accommodate the whole of a $\times 6$ projection. Allowing margins at front and back to accommodate the tracing table supports when working close to the model edge, the table width would need to be 62 inches. This is not too large to be conveniently worked from both sides.

(3) The projectors should be mounted so that the diapositives are held in an approximately vertical plane, and prisms should be provided in front of each lens to reflect the projections down vertically onto the horizontal working table. The advantage of this

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would be to obtain a model without mirror reversal. In all existing instruments this is only achieved by one of the following methods, each of which tends to introduce errors, or presents special difficulties:

(i) By placing the diapositives upside down in the projectors so that the glass of the diapositive plant is interposed between the emulsion and the lens. This calls for an impossibly high quality of glass diapositive plate with both surfaces flat and of equal thickness and without optical blemishes, if errors are to be avoided.

(ii) By contact printing with point source light with the thickness of the negative film interposed between the emulsion surfaces. This reduces resolution by scatter and multiple reflections in the film thickness.

(iii) By projection printing with a transforming printer which introduces possible errors from the transforming printer and involves expenditure on this accessory.

The above systems would be avoided if the method proposed was adopted, and diapositives could be made by direct contact printing, emulsion to emulsion, preferably in an electronic printer.

(4) The lamp houses, and their connection by a rod, or rods, to the tracing table should be supported by arrangements quite separate from the arrangements for supporting the projectors so there could be no possibility of the movement of the tracing table disturbing the projectors.

(5) The projectors should be supported in a rigid frame, avoiding any cantilevering principle. This frame should be adjustable on three, and not four screws to provide facilities for absolute levelling. These three screws should bear on a second frame of particularly rigid construction which should bridge firmly between the main supports. Consideration should be given to the idea of casting the main supports in concrete, and it is suggested that manufacturers might provide shuttering so that customers could cast their own supports. The supporting arrangements of all existing instruments are considered to be nothing like rigid enough.

(6) Each projector should be provided with adjustments for tip, tilt and swing, the former about the nodes of the projector lenses and the latter about the optical axes. Adjustments of the projectors in (bz) and (by) are not necessary and should not be provided. A (bx) adjustment should be provided, either to move both projectors towards or away from a central point, or alternatively only to move one projector. Controls for all these adjustments should be situated so that they can be worked easily by the operator whilst he is actually inspecting the model in any part of the model area. They should move smoothly and firmly without backlash.*

(7) The working table should be a completely rigid block of material which should be machined flat. It should be rigidly supported on levelling screws which would not be adjusted after initial installation of the instrument.

(8) The grid model when projected onto the plotting table should be as free as possible from plan and height errors which should not exceed 0.10 mm. and 0.17 mm. respectively. This requirement calls for projecting lenses with distortions smaller than 16 microns at negative scale.

(9) It is suggested that residual errors of this order might then be removed in the plane of the projection by raising or lowering the tracing table platen. This could be accomplished in a manner somewhat similar to that employed in the Kelsh instrument for raising or lowering the projector lenses except that the correction would be accomplished at the tracing table (instead of at the lens) where the errors would be larger and more easily handled. It is suggested that the correcting arm which would raise or lower the table top should be motivated by a feeler bearing on a miniature surface which would be flat in the absence of distortion but would depart from flatness where corrections were desired by amounts equal to the required corrections multiplied by an enlarging factor. This factor would depend on the leverage employed. The shape of such a surface would be easy to determine by empirical methods, and would not be difficult to manufacture.

(10) The tracing table should be operable from both front and back of the instrument without the necessity for rotating the table or disconnecting and re-attaching the lamp house guide rods. This is already possible on the Williamson and Kelsh instruments and the only necessity to rotate the tracing table on these instruments seems to be because the height scale can only be read from one side.

* Mr. Eden has called attention to a minor error in paragraph 6. Clearly the adjustments for tip and tilt would need to be about the images of the nodes of the projectors and not about the nodes themselves. He is also now of the opinion that it would be necessary to employ mirrors, and not prisms, in front of the lenses.—EDITOR

It should be easy to arrange for the height scale to be readable from both sides.

(11) The depth of focus should be as large as possible without very adversely affecting the model resolution. This is probably best achieved by employing small apertures and very bright lighting, with, if necessary, silent running fans to effect cooling.

(12) Resolution should be as high as possible. With rotating shutter viewing the considerable loss of resolution which is the worst feature of most projection plotters employing anaglyph viewing would be very substantially avoided. It is considered that a resolution performance should be obtainable which approaches closely that of binocular instruments provided the instrument is worked close to its level of optimum projection. The depth of focus provided should thus be used for accommodating the model relief and not as a means of changing model scale.

(13) An accessory should be provided as an optional extra in the form of a pantograph, or coordinatograph for the purpose of adjusting the plotting scale without introducing plottable error.

*Automatic Stereo Plotting**†

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ABSTRACT: *The mechanical function of detecting and removing X and Y parallax from the stereo model is performed automatically by the instrument described.*

The clearing of parallax between two images requires that corresponding points in the images be identified and located with respect to each other. In the Stereomat, a small area is scanned by a spot of light moving in a random pattern. Fluctuations in the light produced by the scanning spots crossing image boundaries are sensed by a separate photo electric cell for each photograph. Signals from the two photo electric cells are processed electronically and X and Y parallax information is obtained therefrom in the form of separate X and Y error voltages. The "Y error" is used to orient the projectors in the relative orientation operation, and "X error" is used to actuate a Z motion so as to bring the platen or floating mark to the surface of the model.

INTEREST in automation of the tedious process of stereo plotting has increased steadily over the past decade, following the development of electronics computation, information theory and servo techniques.

As a result, various co-ordinate read-out systems have been devised for plotting instruments, and direct coupling to computers has been used to achieve rapid data reduction for highway planning and other engineering applications of photogrammetry.

Two years ago Mr. D. N. Kendall, the president of the Photographic Survey Corporation, Toronto, Canada, gave support to, and provided funds for, a research project aimed at automatizing the basic stereo operations of clearing parallax, and driving the floating mark to produce profiles or contours automatically.

The essential sensing operation to be performed by a stereo perception system (human or mechanical) is that of relating corresponding points in two similar images. In general a fiducial mark or optical axis defines a point in one image; another mark or axis is then positioned by the system to the corresponding point in the other image.

It is essential that the operation of locating

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