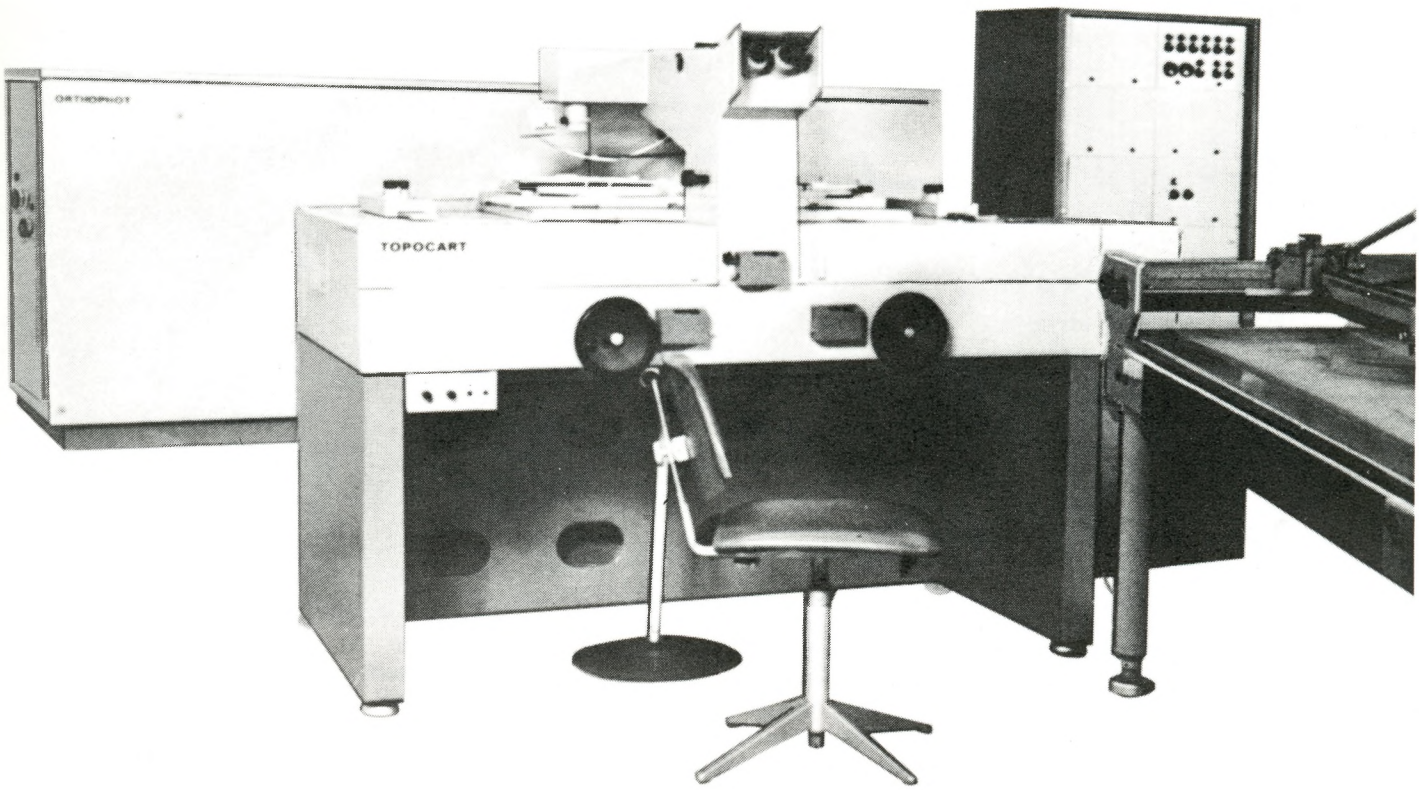
TECHNICAL REPORT

Jena Orthophot Differential Rectifier



The Orthophot C Differential Rectifier is an attachment to the Topocart C Stereoscopic Plotter. The instrument combination is used for stereoplotting, the production of orthophoto maps, dropline representation, and the production of digital terrain models.

It is manufactured by VEB Carl Zeiss Jena of the German Democratic Republic, and is distributed in this country by Jena Instruments (Toronto) Ltd.

A brief description of the Orthophot, some of its ancillary equipment, and their methods of operation follows.

The Jena Topocart is a very clean looking topographic stereoplotter that offers a high degree of sophistication and a broad selection of features.

Photographs up to a maximum size of 230 mm square can be accommodated from all types of cameras with focal lengths between 50 and 215 mm. This permits not only the plotting of normal, wide and superwide photography, but terrestrial photography as well.

It is a mechanical projection instrument. The Topocart utilizes built-in mechanical analog computers to reduce the spacial collimating rays into two planar components by means of plane guide bars rather than the space rods typically used. This innovation has resulted in the reduction of the basic size of the instrument.

An orthophoto, as all members of this Association know, but other readers of this Journal may not know, is an aerial photograph which shows images of objects in positions that are geometrically equivalent to conventional line maps. They can be used to measure distances, angles, areas, etc. This cannot be done with regular aerial photographs, of course.

Aerial photos suffer from image displacements due to photographic tilt and relief. Rectification eliminates the effects of tilt and gives an equivalent vertical photo. Unless the terrain is perfectly flat, however, such a vertical photo will still contain scale variations due to changes in relief.

To illustrate the basic principles of this type of equipment, please refer to Figure 1, which shows a stereomodel projected upon a flat film holder instead of the usual reference table. The film, emulsion side up, is protected from exposure by a cover. The cover can move in both "x" and "y" directions. The film holder, film and cover can be raised and lowered in the "z" direction.

The model is relatively oriented and levelled.

It is unnecessary for the scale of the model to agree absolutely with ground control because scaling may be done later by photographic reduction or enlargement.

The accuracy of the vertical

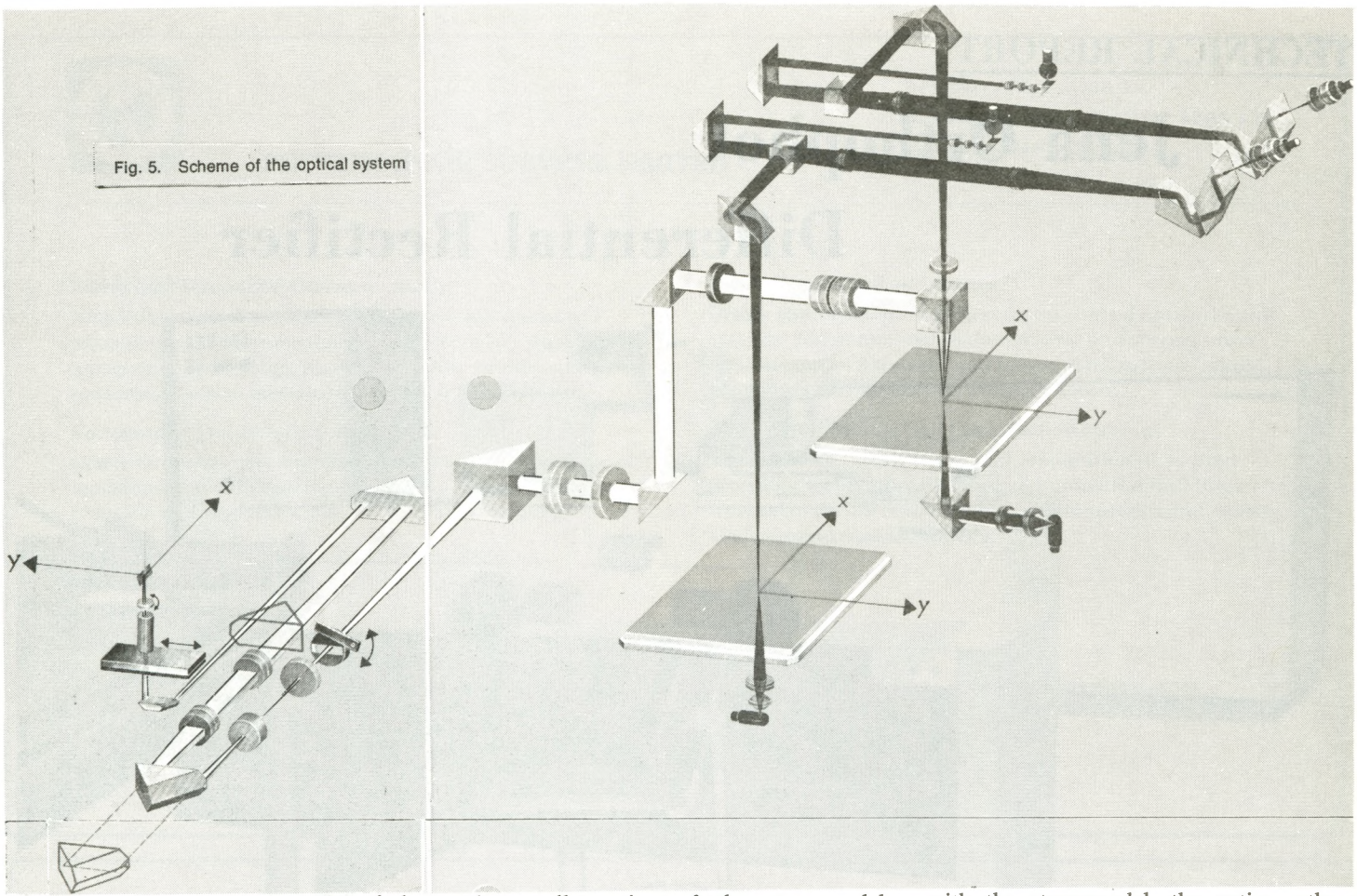


Fig. 5. Scheme of the optical system

ground control and the accuracy of the levelling operation need not be extremely precise, either, because horizontal accuracy of the orthophoto is not appreciably affected by small levelling errors.

A reflecting circular platen with a scanning slit in it is set in the centre of the film cover. The slit may be about 5 mm long, and narrow. At any one time the operator is able to see only the small portion of the stereomodel that is projected onto the platen.

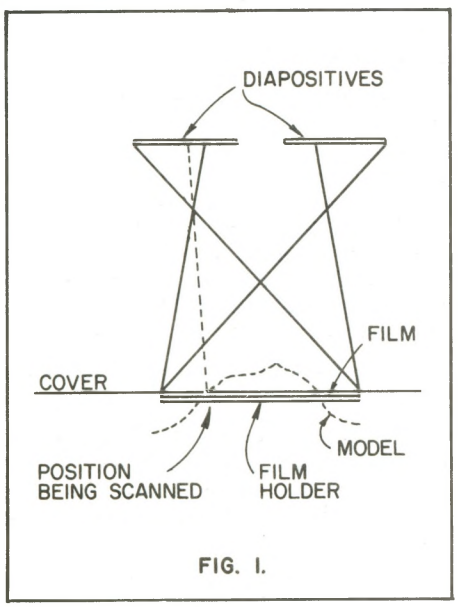


FIG. I.

The platen is moved to one corner of the model. The cover is big enough to still protect the film.

The operator now systematically scans the stereomodel back and forth with the platen, and in doing so exposes the film negative in narrow strips through the thin slit. During the scanning process the film in the film holder remains stationary, at least in the "x" and "y" directions.

Note that light from one diapositive only is used to expose the film.

When a "y" scan is completed, the platen is 'stepped over' or moved sideways in the "x" direction, an amount equal to the width of the scanning slit, and another scan is begun in the opposite direction. Each "y" scan exposes the negative to a narrow strip of terrain.

The slit serves as the operator's reference floating mark.

The film holder and platen can be raised and lowered, and during scanning this is done, so as to keep the scanning slit continually in contact with the surface of the model. As the scale of the stereomodel is uniform throughout, and by keeping the platen continually in contact with the stereomodel, the entire orthonegative is exposed at model scale. The result is a negative of uniform scale throughout, which is, of course, an orthophoto.

The Topocart/Orthophot combination, while conforming generally to the foregoing method of operation, differs from it in several major respects.

By means of a hand wheel the operator maintains the floating mark in contact with the surface of the model as the stereoplotter automatically scans in the "y" direction.

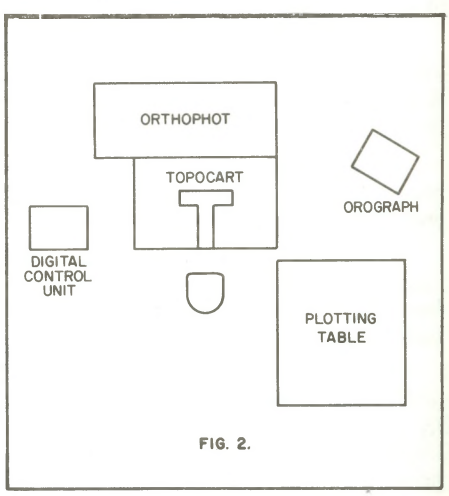


FIG. 2.

Scanning is in forward and backward action to save plotting time. Plotting speed can be varied by either of one of two push buttons. The right one increases the scanning speed, the left one reduces it at a ratio of one to three. Variations in the scanning speed allow the operator to slow down for greater accuracy in rugged terrain while speeding through flat terrain. The push button arrangement activates an automatic computer-controlled diaphragm to ensure that the film is exposed with uniform intensity.

Imagery from the scans is projected via an optical train of lenses and prisms from the right diapositive of the stereopair to a drum in the rear of the instrument which contains the film. White light is used in the instrument.

The optical imaging system of the Orthophot is stationary, except for two inversor prisms for magnification control. Prisms within the train rotate the imagery to account for the photographic tilt.

The projection ratio between image and model scales can be selected as for stereoplotting - the model scale is usually selected to the best plotting conditions, i.e. approximately twice the image scale. The instrument has an independent magnification range between x 0.7 and x 5.0 from model to rectification.

A variable magnification optical unit within the Orthophot constantly corrects for scale variations in accordance with variations in model elevations along the scanned profiles. This is in lieu of the up and down motions of the film holder, etc. in the simpler system previously described.

Exposure is made onto the film through a slit in the drum. Interchangeable slits with widths between 2 mm and 16 mm are used for individual adaption to image scale, scale of rectification, and terrain shapes.

The selected slit shape ensures that bright or dark portions at strip margins can be avoided and that movement in "z" direction does not result in lack of definition.

In order to achieve a theoretically perfect orthophoto, each model point of varying elevation would have to be exposed at the proper height. The procedure followed by these instruments assumes equal model elevation for the width of the strip. Sufficiently narrow strips are chosen so that, for practical purposes, the assumption is met and satisfactory results are achieved. Best results are realised in mountainous terrain by using a narrow strip. In flat country, a wider strip may be scanned, thereby increasing the speed of the operation yet maintaining satisfactory accuracy.

A Cross Slope Corrector may be added to this system when it is being operated in an 'off-line' mode. It is a plug-in unit that fits underneath the Orthophot.

This unit enables rectification to be carried out in mountainous areas using wide slit widths without tolerating gaps, double images, and stair-shaped irregularities between the scanning strips.

It transforms a line element instead of a point. This line element varies the width of the slit so that it does not depend on the cross slope of the terrain but on its lateral curvature.

Movements in "x" and "y" directions are carried out by the picture carriers of the Topocart and the film drum of the Orthophot. The film rotates back and forth in the drum in synchronization with the "y" scanning motion in the stereomodel, while the "x" step-over is done by axial displacement. Motoactuated movement for "x" and "y" is automatic over the entire model without intermediate operation.

Manual intervention, for stopping and re-starting, is possible at any time. An electro-magnetically operated shutter in the optical train interrupts the exposure beam, preventing over-exposure of the film when scanning is stopped temporarily.

Maximum picture size is 600 mm by 900 mm. A daylight magazine for the film and a light-tight housing on the Orthophot permit work to be carried on in normally, and even brightly, illuminated rooms.

Colour photographs can be rectified on colour film within the full range of magnification without additional equipment. The same applies to infra-red film.

Typical map output is an average of four stereo models per day.

An integral component of the Orthopot Differential Rectifier is the Orograph Dropline Drawing Unit.

As the model is scanned in the "y" direction, and the floating mark follows the hills and valleys of the terrain, so the Orograph may draw straight lines on the Topocart plotting table representing each line scanned. As the floating mark crosses predetermined contours, however, the line thickness changes to indicate on the plotting surface the location of the contour.

Three different line thicknesses are available.

Upon completion of scanning, the changes in line thickness marking corresponding points of equal elevation can be joined to form continuous contours. To assist in the identification of points of equal elevation, which can be difficult in some circumstances, the instrument will put in a small cross line at certain contour locations. These are apparent in the example shown in Figure 3.

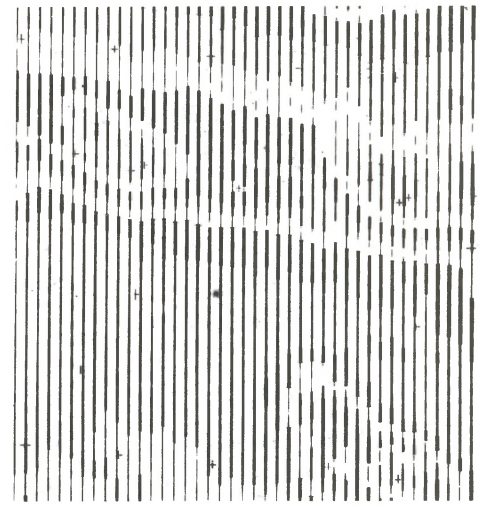


FIG. 3 DROPLINE CHART

Because the drawing on the plotting table is related to the model in the Topocart, even when the exposure of the orthonegative has been completed, it is possible to transfer to it by normal plotting methods any of the following that may be required:- control points, spot elevations, ridge lines, streams, edge of water, etc. Contours can be added in difficult areas in which the drop line technique may not have worked too well.

Contour maps prepared in this manner may be used as an overlay to the orthophoto map. While they are satisfactory for some work, they will not be as accurate as contour maps compiled in the conventional manner with the Topocart stereoscopic plotter.

The rectifier can be operated "on-line", as discussed, or "off-line", with the addition of the Digital Control Unit.

This is a supplementary module for the Topocart/Orthophot Differential Rectifying System. It permits the technology of differential rectification to be combined with the technology of the digital terrain model.

Input data required for the digital control unit are "z" co-ordinates of the model arranged in a regular rectangular screen. These digital values can be generated in various ways.

Profiles can be recorded with the

Topocart/Orthophot and the control unit during on-line orthophoto map production. Also off-line, using the Topocart only, with the control unit. A stereoplotter-coordinatograph combination can also generate similar data. Contour information and control profiles can be derived from existing topographic maps and data banks.

Once the data has been recorded, then it can be transmitted through the proper interface to various recording and storage devices for future processing.

The uses to which such data can be put are practically limitless and include absolute orientation, angular rotation in "x" and "y", area and volume computation, digital contour line plotting, and, of course, the automatic, or off-line, control of the Orthophot.

Several significant advantages can accrue through the use of off-line techniques.

Greater accuracy generally results because any errors can be immediately corrected, and spot checks can be made before the model is removed from the stereoplotter.

Also, the efficiency of orthophoto production can be improved because the rate of exposure can be increased. Profiles can be read from several stereoplotters and fed to one off-line orthoprojector.

Profiles of a particular area can be stored for a long time, and then re-used for map revisions. Although planimetric details of an area may change significantly, these rarely affect terrain profiles.

The foregoing was prepared with the cooperation of George Annis and Don Porter of "Photomap Air Surveys Ltd." and Klaus Ulbrich of "Jena Instruments Ltd." Diagrams 1 and 2 are by Rodger Grant, City Hall, Ottawa. Their assistance is appreciated.

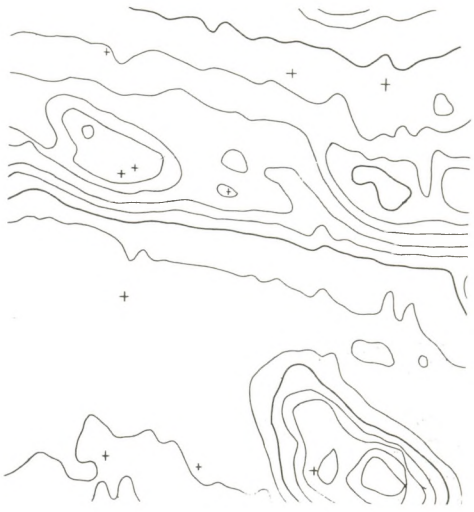
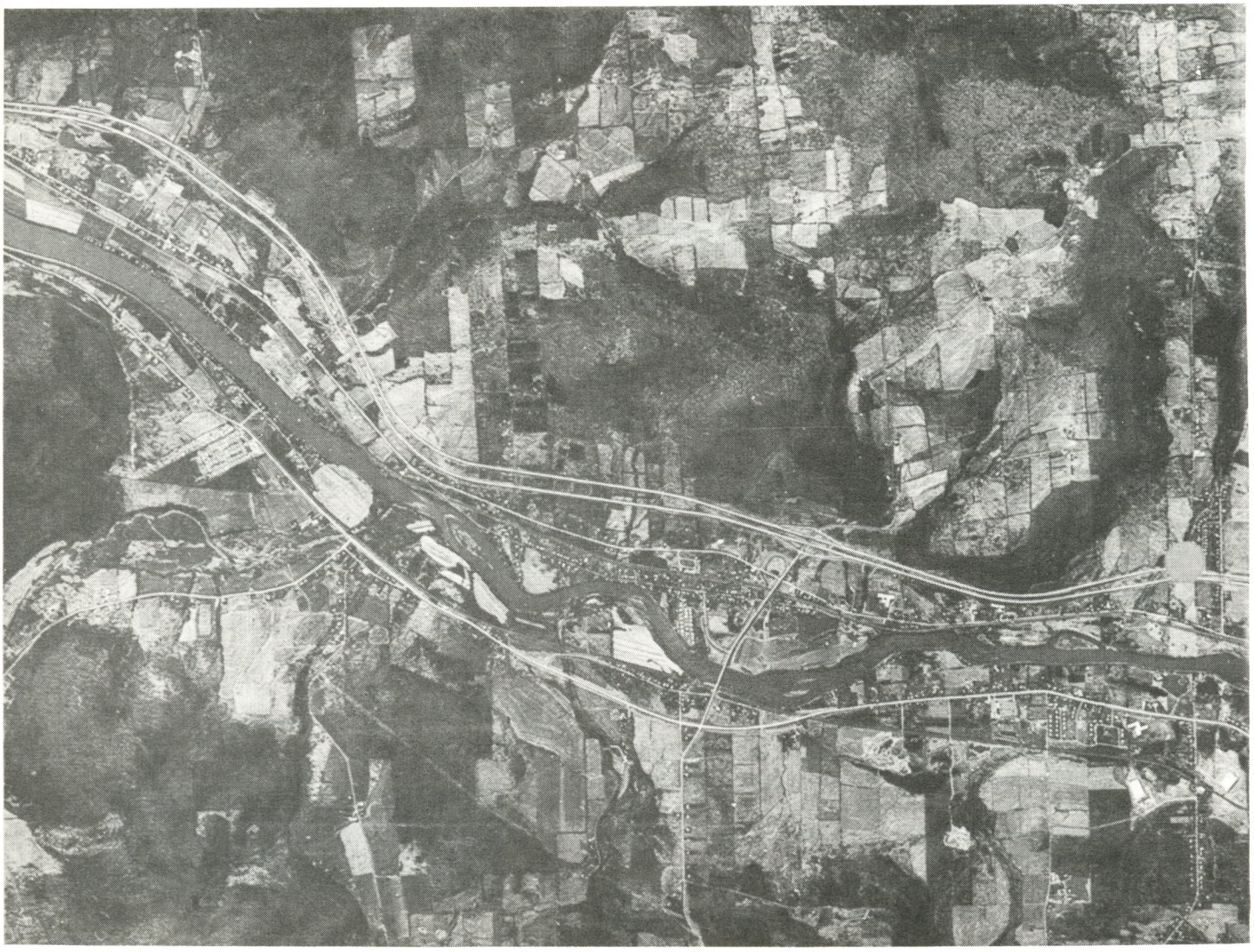


FIG. 4 CONTOUR LINES



Orthophotograph made with the Topocart-Orthoplot Instrument