THE WIDE ANGLE LENS CAMERA SHOWS A GREAT DEAL OF PROMISE, NO COMPARISONS CAN BE MADE AT THIS TIME WITH OUR STANDARD EQUIPMENT UNTIL A CAMERA OF THAT TYPE HAS BEEN GIVEN RIGID TESTS IN THE TYPE OF WORK REQUIRED IN HYDROGRAPHIC SURVEYS.

WE MUST NOT OVERLOOK OBLIQUE PHOTOGRAPHY AND ITS MANY ADVANTAGES NOT ONLY IN RECONNAISSANCE SURVEYS BUT IN OBTAINING TOPOGRAPHIC DETAIL BEYOND THE LIMITS OF THE VERTICAL PHOTOGRAPHS. THE MILLER METHOD CAN AND SHOULD BE GIVEN WIDER USE.

GREAT PROGRESS IS BEING MADE IN BETTERING CAMERA EQUIPMENT, SO THE FUTURE WILL DECIDE THE TYPE WHICH WILL EVENTUALLY BE ADOPTED FOR ALL HYDROGRAPHIC WORK.

OUR ENTHUSIASM, OUR ENDORSEMENT OF PHOTOGRAMMETRICAL METHODS AS AN AID IN HYDROGRAPHIC SURVEYS ARE FULLY JUSTIFIED BY THE RESULTS WE HAVE OBTAINED SO FAR. WE FEEL CONFIDENT THAT ANY CHARTING ORGANIZATION, NOT ALREADY UTILIZING THE AIRPLANE AND THE CAMERA FOR THEIR HYDROGRAPHIC WORK, WILL FIND THAT THE APPLICATION OF PHOTOGRAMMETRY TO THEIR SURVEYS WILL PERMIT A MORE DETAILED DELINEATION OF THE TOPOGRAPHIC FEATURES AND, IN ADDITION, EXPEDITE THE COMPLETION OF A PROJECT IN A MORE EFFICIENT AND ECONOMICAL MANNER.

APPLICATION OF PHOTOGRAMMETRY TO HYDROGRAPHIC CHARTS

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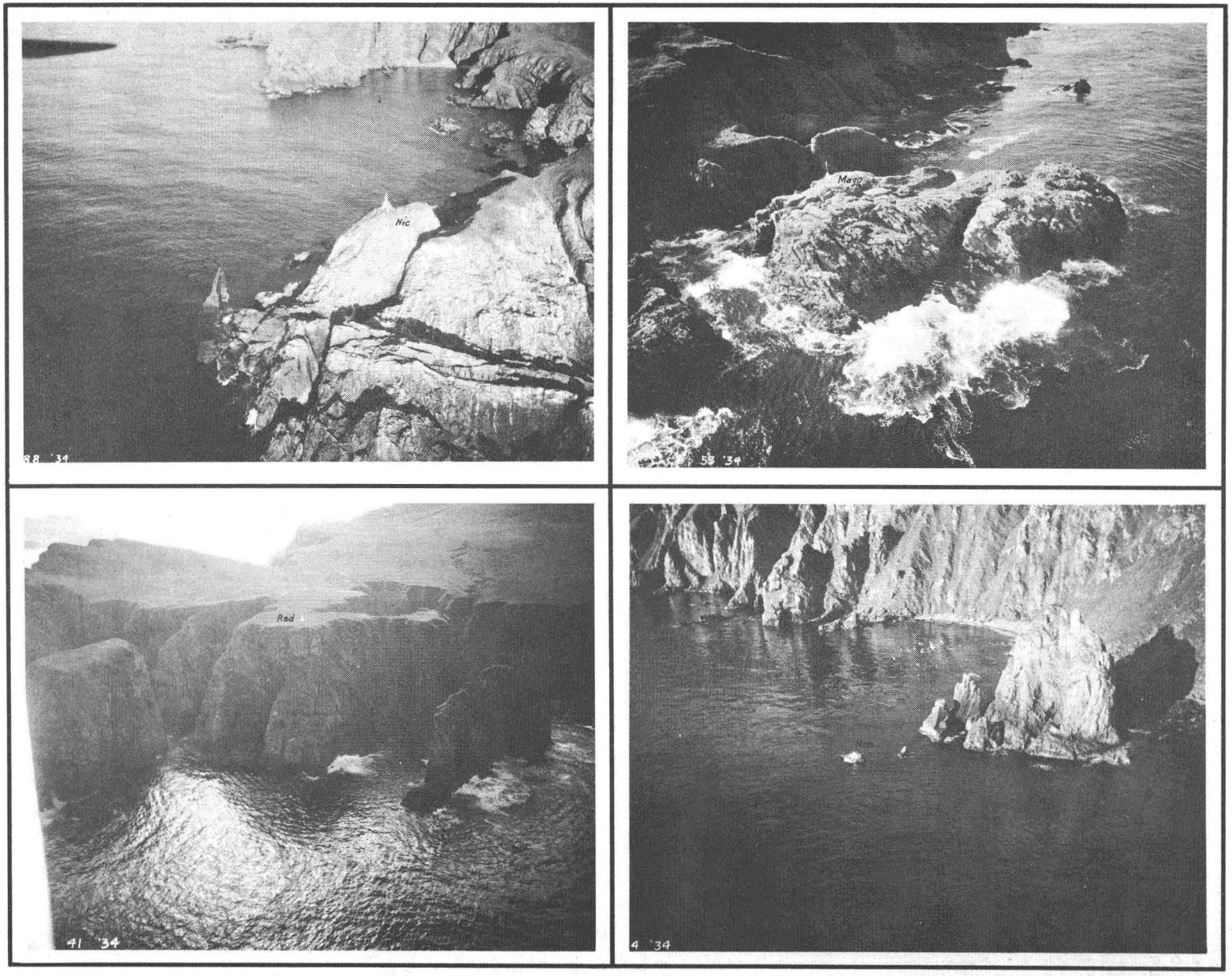
I WOULD LIKE TO FIRST POINT OUT THAT, IN THE COMPILATION OF TOPOGRAPHY FOR HYDROGRAPHIC CHARTS, WE ARE PRIMARILY INTERESTED IN THE CORRECT DELINEATION OF THE SHORE LINE AND THE EXACT POSITION OF ALL OUT-LYING ISLANDS AND ROCKS, SUBMERGED OR OTHERWISE. OUR SECOND INTEREST, OF COURSE, IS IN THE AIDS TO NAVIGATION SUCH AS CHURCH SPIRES, WATER TANKS, HIGH CHIMNEYS, LIGHTHOUSES, PROMINENT PEAKS, AND ALL FEATURES THAT WILL ASSIST THE NAVIGATOR IN DETERMINING HIS POSITION. THESE FEATURES ARE USUALLY CUT IN AND ESTABLISHED BY THE FIELD PARTY; THIRD, THE PLANIMETRIC DETAIL ADJACENT TO THE SHORE LINE.

OUR PHOTOGRAPHS ARE TAKEN AT SCALES RANGING FROM 1:7,000 TO 1:30,000 WITH A K-3B SINGLE LENS 7x9 CAMERA OR A FAIRCHILD T-3A FIVE LENS CAMERA. AS A GENERAL RULE, SINGLE LENS PHOTOGRAPHS ARE TAKEN WHERE THERE IS TO BE A CLOSE DEVELOPMENT OF THE HYDROGRAPHY, AND FIVE LENS PHOTOGRAPHS OF AREAS FOR GENERAL DEVELOPMENT. THESE ARE TAKEN, WHENEVER POSSIBLE, IN ADVANCE OF THE SURVEY.

GETTING SUFFICIENT GROUND CONTROL ACCURATELY SPOTTED ON THE PHOTOGRAPHS BECOMES QUITE A PROBLEM AT TIMES, AS MOST OF OUR SURVEYS ARE MADE IN WHAT MIGHT BE TERMED VIRGIN TERRITORY. THEREFORE, WE DO NOT HAVE THE NUMEROUS MAN-MADE FEATURES SUCH AS ROAD-INTERSECTIONS, FENCE CORNERS, HOUSES, BARNS, ETC., TO USE AS CONTROL POINTS EXCEPT ON RARE OCCASIONS. EVEN THOUGH WE ARE WORKING IN AREAS THAT HAVE SOME OR ALL THESE FEATURES, THEY GENERALLY LIE SO FAR BACK FROM THE SHORE LINE THAT THE LIMITED PERSONNEL AND TIME DO NOT PERMIT THEIR ACCURATE LOCATION. IT IS, THEREFORE, NECESSARY TO USE NATURAL FEATURES AND THE SIGNALS ESTABLISHED BY THE FIELD PARTY. SUFFICIENT NATURAL FEATURES ALONG THE SHORE LINE ARE SOMETIMES DIFFICULT TO FIND, AND THE SPOTTING ON THE PHOTOGRAPHS OF THE EXACT LOCATION OF THE SIGNALS IS, AT TIMES, EXTREMELY DIFFICULT.

THE HYDROGRAPHIC OFFICE DOES NOT BELIEVE IT PRACTICABLE TO LAY DOWN A SPECIFIC RULE FOR SPOTTING THE SIGNALS ON THE PHOTOGRAPHS THAT WOULD MEET ALL CONDITIONS. IT IS LEFT TO THE DISCRETION OF THE SENIOR HYDROGRAPHIC ENGINEER OF THE SURVEY EXPEDITION TO SEE THAT SUFFICIENT INFORMATION IS OBTAINED TO ACCURATELY TIE THE PHOTOGRAPHS TO THE GROUND CONTROL BEFORE LEAVING THE SURVEY AREA. (FIGURE 1.)

A METHOD OF IDENTIFYING THESE SIGNALS, USED ON NAVAL SURVEYS WHERE CONDITIONS PERMIT, THAT MIGHT BE OF INTEREST TO THE SOCIETY, IS THE USE OF LOW ALTITUDE, NEARLY VERTICAL PHOTOGRAPHS OF ALL SIGNALS. THIS NOT ONLY ASSURES AN ACCURATE SPOTTING OF AT LEAST 75% OF ALL SIGNALS ON THE SMALL SCALE MAPPING



Low altitude oblique photographs of hydrographic signals, from which signal positions are transferred, by comparison, to vertical prints.

Fig. 1

PRINTS, WHICH IS AMPLE TO CONTROL THE RADIAL PLOT, BUT ALSO IS A COMPLETE RECORD OF THESE SIGNALS TO BE RETAINED IN THE FILES OF THE OFFICE. THESE LOW ALTITUDE PHOTOGRAPHS ARE GENERALLY TAKEN WITH A K-3B CAMERA BY HOLDING IT OVER THE SIDE OF THE PLANE AND AS NEARLY VERTICAL AS POSSIBLE. THESE PHOTOGRAPHS ARE TAKEN AT ALTITUDES RANGING FROM 1,000 TO 2,000 FEET, DEPENDING ON THE RELIEF OF THE TERRAIN, SO AS TO GIVE A RECOGNIZABLE RECORD OF THE SIGNAL AND ADJACENT FEATURES.

WHENEVER THE PHOTOGRAPHS ARE AVAILABLE AND BEFORE THE SHIPS LEAVE FOR THE SURVEY AREA, A RADIAL PLOT IS MADE ON CELLULOSE SHEETS FROM THE MAPPING PRINTS WITHOUT REFERENCE TO ANY GROUND CONTROL, WHICH NATURALLY IS NOT AVAILABLE. ALL INFORMATION IS THEN TRACED ON TO THE CELLULOSE SHEETS FROM THE PHOTOGRAPHS. THESE SHEETS AND THE PHOTOGRAPHS ARE TURNED OVER TO THE FIELD PARTY, TO BE USED FOR RECONNAISSANCE PURPOSES AND THE MAKING OF FIELD SOUNDING SHEETS. IN CASE THE PHOTOGRAPHS ARE OF THE FIVE LENS TYPE, THE COMPOSITE PRINTS ARE TRIMMED TO 8 INCHES IN WIDTH ACROSS THE LINE OF FLIGHT. THESE PRINTS, SO TRIMMED, ARE AS EASILY CARRIED AND AS PRACTICAL FOR FIELD USE AS THE SINGLE LENS PRINTS. CONTROL POINTS ARE SPOTTED ON THESE PHOTOGRAPHS TOGETHER WITH ALL INFORMATION NECESSARY FOR THE CORRECT INTERPRETATION OF THE CULTURE. A SPECIAL FIELD PARTY IS ASSIGNED TO COMPARE PHOTOGRAPHS WITH THE ACTUAL GROUND FEATURES. NOTES ARE MADE ON THE PHOTOGRAPHS WHICH WILL BRING OUT THESE FEATURES, SUCH AS THE HIGH WATER LINE OF THE SHORE, SAND BARS, SUBMERGED AND EXPOSED ROCKS, BUILDINGS, DOCKS, FERRIES, RIVERS, RAILROADS, FLYING FIELDS, NAMES OF TOWNS, AND ALL LANDMARKS, WHICH SHOULD APPEAR ON THE COMPLETED CHARTS, WHENEVER THESE POINTS ARE NOT CLEARLY DISTINGUISHABLE ON THE PHOTOGRAPHS. EACH TYPE OF CULTURE OR VEGETATION AS MANGROVES, BRUSH, OR HIGH TREES, ETC., IS NOTED ON THE PHOTOGRAPHS, WITH SUFFICIENT FREQUENCY TO MAKE CERTAIN THAT IT MAY BE INTERPRETED CORRECTLY IN THE OFFICE.

ON RECEIPT OF THE FIELD DATA, INCLUSIVE OF THE PHOTOGRAPHS USED IN THE FIELD, THE CONTROL POINTS ARE CHECKED AND TRANSFERRED TO AN ENTIRELY NEW SET OF PRINTS, BEING CAREFUL IN TRANSFERRING THE CONTROL POINTS TO ALL PRINTS ON WHICH THEY FALL. A MINIMUM NUMBER OF PICTURE CONTROL POINTS IS THEN SELECTED USING ONLY POINTS THAT ARE EASILY IDENTIFIABLE. A PROJECTION IS THEN DRAWN ON CELLULOSE TO THE AVERAGE SCALE OF THE PHOTOGRAPHS AND ALL CONTROL STATIONS PLOTTED ON THESE SHEETS. THIS SHEET IS KNOWN AS THE MASTER SHEET AND WILL BE SO DESIGNATED THROUGHOUT THIS DISCUSSION. AN ORDINARY CONTROLLED RADIAL PLOT IS THEN MADE OF THE ENTIRE AREA. THIS PLOT IS GENERALLY MADE WITH A CHISEL POINTED RED "SCRIPTO" PENCIL. VERY FINE LINES MAY BE MADE IN THIS WAY, YET THEY SHOW CLEARLY ON THE CELLULOSE AND MAY BE WASHED OFF WITH WATER QUITE EASILY, NOT AFFECTING ANY OTHER WORK ON THE SHEET. AFTER THE RADIAL PLOT IS COMPLETED, ALL ADJUSTMENTS ARE MADE, AND, IN THE CASE OF FIVE LENS PHOTOGRAPHS, THE COLLIMATING MARKS OF ALL PICTURES ARE TRANSFERRED TO THE MASTER SHEET. THE CELLULOSE SHEET IS THEN TURNED OVER AND A SMALL BLUE CIRCLE IS MADE AT THE RADIAL INTERSECTIONS. A DUPLICATE SET OF THE MASTER SHEETS IS THEN MADE IN INDIA INK. THE MASTER SHEETS ARE LAID ASIDE AND THE DUPLICATE SET NOW BECOMES THE WORK SHEET. AFTER BEING SATISFIED THAT THE RADIAL PLOT HAS THE PROPER ADJUSTMENT, FIVE LENS PRINTS, IF USED, ARE TRIMMED TO 8 INCHES IN WIDTH ACROSS THE LINE OF FLIGHT. THIS ALLOWS US TO CAREFULLY STUDY ALL DETAIL UNDER THE STEREOSCOPE AND TO SELECT POINTS NECESSARY TO PROPERLY CONTROL THE DETAILS WHICH WE ARE DESIROUS OF OBTAINING FROM THE PRINTS. THE PRINTS ARE THEN RESECTED IN THEIR PROPER POSITION UNDER THE WORK SHEETS AND RADIALS DRAWN THROUGH THE NEW POINTS. ALL NECESSARY INFORMATION IS THEN TRANSFERRED FROM THE PHOTOGRAPHS TO THE WORK SHEET, USING INDIA INK IN THE OPERATION. WHEN COMPLETED, THIS INFORMATION IS TRACED ON THE MASTER SHEET.

FOR ALL INK WORKS ON THE MASTER SHEET "CRAFTINT" CELLULOSE INK IS USED; BLACK FOR ALL DETAIL AND THE PROJECTION; RED CIRCLES FOR GROUND CONTROL POINTS AND BLUE CIRCLES FOR THE PICTURE CONTROL POINTS.

TWO SETS OF SHEETS ARE USED IN ORDER TO MAKE THE FINAL RESULTS NEAT AS WELL AS ACCURATE. BY USING INDIA INK ON THE WORK SHEET, IT MAY BE WASHED AND THE SHEET USED AGAIN. DUE TO THE TRANSPARENCY OF THE CELLULOSE SHEETS, A SHEET OF VELLUM TRACING PAPER IS PLACED BETWEEN THE WORK SHEET AND THE MASTER SHEET. THIS REDUCES THE TRANSPARENCY AND ALLOWS THE DRAFTSMAN TO JUDGE THE WEIGHT OF THE LINES.

FORM LINES OF THE TOPOGRAPHY ARE DRAWN IN THE SAME MANNER AS DESCRIBED ABOVE. IT WILL BE NOTED THAT THE TERM "FORM LINES" AND NOT CONTOURS IS USED. ALTHOUGH WE TRY TO DRAW THE FORM LINES OF EQUAL ELEVATIONS, THEY ARE IN NO SENSE AS ACCURATE AS CONTOURS DEVELOPED BY PLOTTING INSTRUMENTS. WE ARE NOT INTERESTED IN THAT DEGREE OF ACCURACY. THE ONLY REASON FOR PUTTING FORM LINES ON OUR CHARTS IS TO AID THE NAVIGATOR IN IDENTIFYING PEAKS ON WHICH BEARINGS MAY BE TAKEN AND TO FACILITATE THE OPERATIONS OF LANDING PARTIES.

THE FIELD PARTIES GET ELEVATIONS TO ALL PROMINENT PEAKS IN THE SURVEY AREA, BUT AS THE ELEVATION POINTS ARE NOT SUFFICIENT TO DRAW FORM LINES, ADDITIONAL POINTS ARE COMPUTED. THIS IS BEING DONE AT PRESENT WITH A ZEISS-STEREOMETER, A PARALLAX MEASURING INSTRUMENT. BEFORE RECEIVING THE ZEISS STEREOSCOPE AND STEREOMETER, WE WERE COMPUTING ADDITIONAL ELEVATIONS FROM THE PARALLAX DISPLACEMENT. AS I UNDERSTAND SOME MEMBERS OF THE SOCIETY ARE INTERESTED IN THIS METHOD, I WILL DISCUSS IT FIRST.

BEFORE TAKING UP THIS METHOD, I SHOULD LIKE TO POINT OUT THAT PRACTICALLY EVERY PICTURE WITH WHICH WE ARE WORKING MAY BE REFERRED TO A DEFINITE DATUM PLANE OF SEA LEVEL, AS THIS PLANE APPEARS IN NEARLY ALL OUR PHOTOGRAPHS.

WE FIRST GO OVER THE PHOTOGRAPHS WITH THE STEREOSCOPE AND SELECT POINTS ALONG RIDGES, ALONG ALL DRAINAGE, AND AT OTHER PLACES WHERE WE BELIEVE ADDITIONAL CONTROL FOR THE FORM LINES IS NEEDED. THESE POINTS ARE NUMBERED SO THERE WILL BE NO TROUBLE IN IDENTIFYING THEM. AFTER THESE POINTS HAVE BEEN ESTABLISHED ON THE CELLULOSE SHEETS BY RADIAL INTERSECTIONS, WE ARE READY TO COMPUTE THEIR ELEVATIONS. (FIGURE 2.)

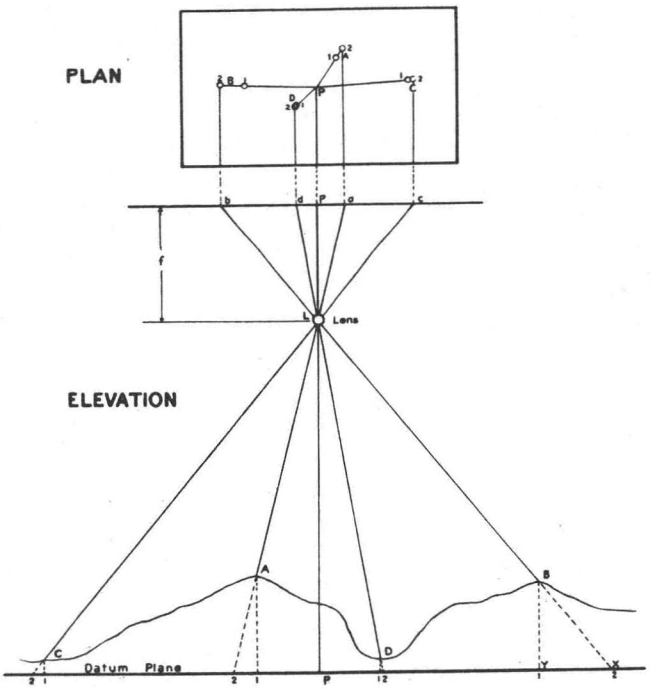


Illustration showing Displacement due to Relief
1 Shows Map position
2 Shows Photograph position

Figure 2

"Y" SHOWS THE MAP POSITION (POSITION ON THE CELLULOSE SHEET AFTER THE RADIAL PLOT IS FINISHED). X SHOWS THE PHOTOGRAPHIC POSITION OF THE POINT WHEN THE POINT IS HIGHER THAN THE DATUM PLANE. IT WILL BE SEEN FROM THIS ILLUSTRATION THAT THE DISPLACEMENT INCREASES AS THE HEIGHT OF THE OBJECT INCREASES

ABOVE THE DATUM PLANE AND ITS DISTANCE FROM THE PRINCIPAL POINT "P". THE DISPLACEMENT IS ALSO PROPORTIONAL TO THE HEIGHT OF LENS ABOVE THE DATUM PLANE.

IN THE RIGHT-ANGLE TRIANGLES LPX AND BYX, THE ANGLES LPX AND BYX ARE EQUAL AND THE ANGLE X COMMON TO BOTH TRIANGLES. THE TWO TRIANGLES ARE, THEREFORE, SIMILAR AND PX:YX :: LP:BY; THEREFORE, BY = (YX) (LP) / (PX). LP = ALTITUDE OF AIRPLANE IN FEET; PX = DISTANCE FROM THE PRINCIPAL POINT TO THE OBJECT ON PHOTOGRAPH. PY = DISTANCE FROM THE PRINCIPAL POINT TO THE OBJECT AS LOCATED ON THE CELLULOSE SHEET; THAT IS, THE DIFFERENCE IN THE DISTANCE AS MEASURED ON THE PHOTOGRAPH AND THE DISTANCE AS MEASURED ON THE CELLULOSE SHEET, MULTIPLIED BY THE ALTITUDE OF THE AIRPLANE (IN FEET) DIVIDED BY THE DISTANCE AS MEASURED ON THE PHOTOGRAPH EQUALS THE HEIGHT OF OBJECT ABOVE THE DATUM PLANE.

THIS IS TRUE ONLY IN PHOTOGRAPHS THAT HAVE ABSOLUTELY NO TILT IN ANY DIRECTION. IN PHOTOGRAPHS THAT ARE TILTED, THIS DISPLACEMENT IS EITHER LENGTHENED OR SHORTENED ACCORDING TO THE AMOUNT AND DIRECTION OF TILT. AS THERE IS SOME TILT PRESENT IN NEARLY ALL PHOTOGRAPHS, THIS DISPLACEMENT, DUE TO RELIEF, CANNOT BE ACCURATELY MEASURED. THEREFORE, DUE TO THIS AND OTHER CAUSES, NO GREAT ACCURACY IS CLAIMED FOR THIS COMPUTATION.

IF ONLY THE PHOTOGRAPHS THAT SHOW VERY LITTLE TILT ARE USED, FAIL RESULTS MAY BE OBTAINED. AT LEAST IT WILL BE SUFFICIENT TO ASSIST IN CONTROLLING FORM LINES BETWEEN POINTS OF KNOWN ELEVATION OBTAINED BY THE FIELD PARTY.

AS PHOTOGRAPHS ARE SELDOM AT THE SCALE OF THE PROJECTION SHEETS, IT BECOMES NECESSARY TO MAKE A CORRECTION FOR THIS DISCREPANCY. WE THEN REFER EACH PHOTOGRAPH TO SEA LEVEL. THAT IS, MEASUREMENTS ARE TAKEN FROM THE CENTER OF THE PHOTOGRAPH TO AT LEAST THREE POINTS ALONG THE HIGH WATER LINE. WE THEN TAKE MEASUREMENTS TO THE SAME POINTS ON THE CELLULOSE SHEET. THE AVERAGE OF THESE DIFFERENCES IS EITHER ADDED TO OR SUBTRACTED FROM THE PX DISTANCE - WHICH GIVES A CORRECTION DUE TO THE DIFFERENCES OF SCALE.

THIS PROCEDURE OF COMPUTING ELEVATIONS HAS NOW BEEN REPLACED BY THE USE OF THE ZEISS STEREOMETER, ALTHOUGH I CANNOT SAY THAT WE GET ANY GREATER ACCURACY WITH THIS INSTRUMENT OVER THE OTHER METHOD. THE ONE ADVANTAGE, HOWEVER, IS THAT IT IS QUICKER.

THIS STEREOMETER IS SIMILAR TO THE TALLEY STEREO-COMPARATOR WITH THE EXCEPTION THAT IT IS NOT MOUNTED ON A UNIVERSAL DRAFTING MACHINE; IT WAS PURCHASED BY THE HYDROGRAPHIC OFFICE BEFORE THE TALLEY INSTRUMENT WAS DEVELOPED. AS YOU ARE FAMILIAR WITH THE WORKING PROCEDURE OF THIS TYPE OF PARALLAX MEASURING INSTRUMENT, I WILL NOT DISCUSS IT EXCEPT TO SAY THAT WE USE THIS INSTRUMENT FOR SPOTTING ELEVATIONS AND NOT FOR DRAWING CONTOURS.

AFTER THE ELEVATIONS OF ALL POINTS THAT ARE DESIRED TO CONTROL THE FORM LINES HAVE BEEN COMPUTED, WE NOTE THESE ELEVATIONS BESIDE THEIR PROPER POINTS ON THE PHOTOGRAPHS AND ALSO THE CORRESPONDING POINTS ON THE WORK SHEETS. WE THEN GO OVER THE ENTIRE SET OF PRINTS UNDER THE STEREOSCOPE AND SKETCH THE FORM LINES ON THE PRINTS WITH A COLORED PENCIL, USING THE ELEVATIONS AS SPOTTED ON THE PRINTS AS A GUIDE, TRYING TO HOLD THEM AT SOME SET INTERVAL, GENERALLY 50 TO 100 FEET.

THESE PRINTS ARE THEN PLACED UNDER THE WORK SHEETS AND THE FORM LINES RECTIFIED BACK TO THEIR PROPER POSITION. THESE LINES ARE PUT ON THE WORK SHEETS IN RED PENCIL OR INK. WE THEN GO OVER THIS WITH BLACK INK, DRAWING THE CONTOURS SO AS TO HOLD THE SHAPE OF THE TERRAIN AND THE ELEVATIONS AS COMPUTED, SO THAT WHEN COMPLETED WE HAVE FORM LINES DRAWN ON THE MASTER SHEETS AT A SET INTERVAL.

THE EASE AND ACCURACY OF THIS METHOD IS DEPENDENT UPON THE QUANTITY AND THOROUGHNESS OF FIELD DATA.