

NESS OF LOCATION OF THE COLLIMATION INDEX POINTS. THE EQUIVALENT FOCAL LENGTH, IN THIS CASE, IS ONE THAT CORRESPONDS TO THE BACK FOCAL LENGTH AS DETERMINED BY THE GUIDES THAT LOCATE THE FILM. THIS COMPLETE TEST IS A VERY USEFUL ONE AND IT APPEARS DESIRABLE THAT ALL CAMERAS MAKING PHOTOGRAPHS TO BE EVALUATED BY MULTIPLEX APPARATUS OR OTHER STEREOSCOPIC PLOTTING DEVICES SHOULD BE TESTED IN THIS MANNER. CAMERAS INTENDED FOR WORK OF THIS CHARACTER SHOULD BE SPECIALLY DESIGNED SO THAT THE CHARACTERISTICS MEASURED IN THIS TEST WILL REMAIN CONSTANT, NOT ONLY DURING USE OF THE CAMERA IN THE FIELD BUT ALSO DURING ANY PROCESS OF DISASSEMBLING AND REASSEMBLING TO WHICH IT IS LIKELY TO BE SUBJECTED. THIS TEST WILL BE DISCUSSED AT GREATER LENGTH AFTER IT BECOMES FURTHER DEVELOPED AND STANDARDIZED.

CAMERAS AND EQUIPMENT FOR USE IN PHOTOGRAMMETRY

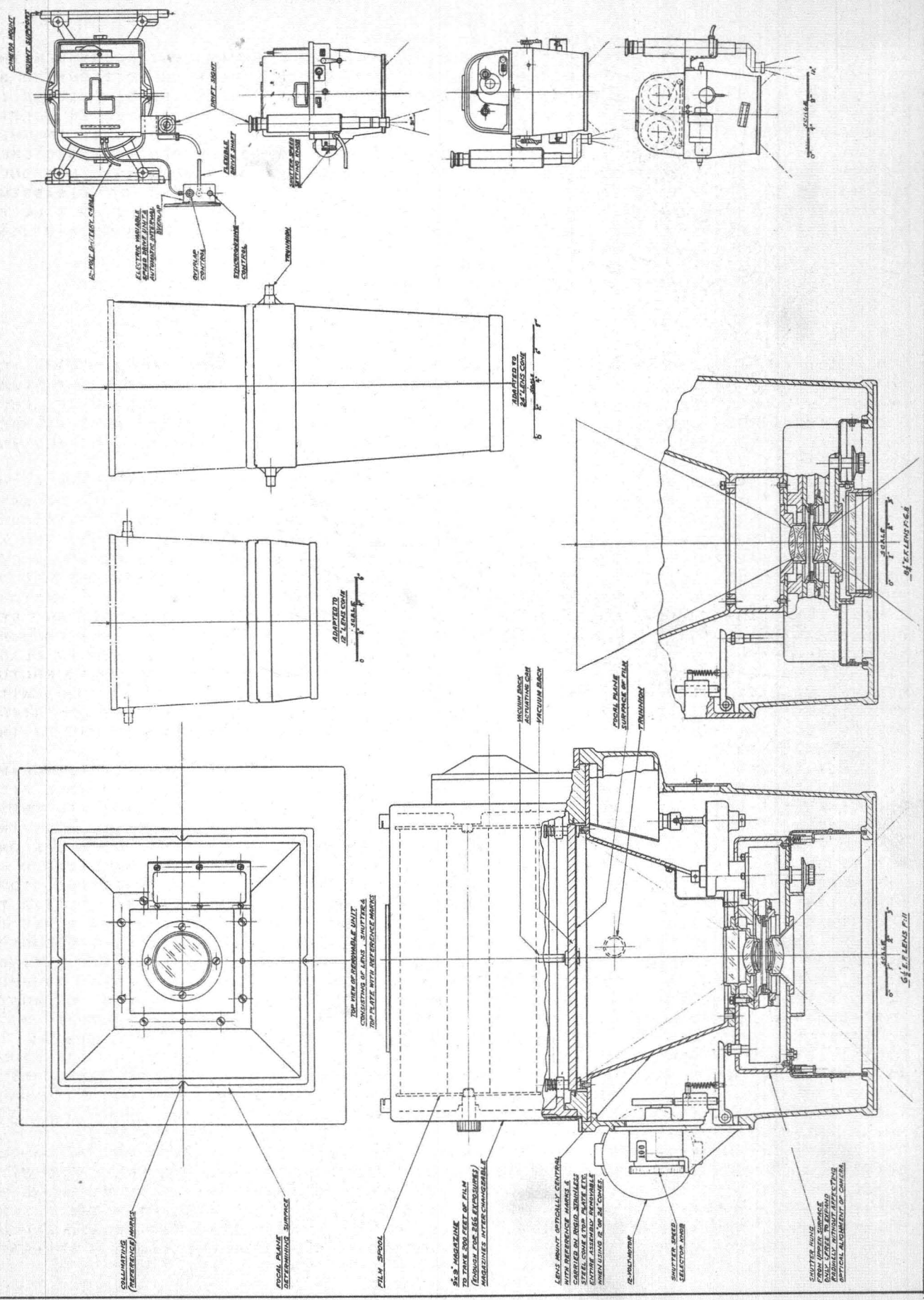
BY
FREDERICK W. LUTZ

BECAUSE OF THE GROWING USE OF AERIAL PHOTOGRAPHY AS A MEANS OF OBTAINING ACCURATE MAPPING RESULTS - RATHER THAN AS AN UNIMPORTANT ACCESSORY TO THE TIME-HONORED GROUND SURVEY METHODS - IT HAS BEEN NECESSARY FOR AMERICAN MANUFACTURERS TO IMPROVE EXISTING EQUIPMENT AND DEVELOP NEW PRODUCTS SO THAT THOSE ENGAGED IN AERIAL PHOTOGRAMMETRIC WORK CAN OBTAIN RESULTS OF THE REQUIRED ACCURACY AND UNIFORMITY.

AERIAL CAMERAS OF THE FAIRCHILD TYPE HAVE BEEN EMPLOYED FOR MANY YEARS WITHOUT RADICAL CHANGES IN DESIGN BY THE MILITARY AND NAVAL FORCES AND OTHER DEPARTMENTS OF THE UNITED STATES GOVERNMENT. THESE AGENCIES HAVE DONE MUCH TO ENCOURAGE PROGRESS IN THE PHOTOGRAMMETRIC APPLICATIONS OF AERIAL PHOTOGRAPHY, AND IT IS ONLY NATURAL THAT THE DEVELOPMENT OF IMPROVED APPARATUS HAS BEEN INFLUENCED GREATLY BY THESE INTERESTS. MUCH VALUABLE WORK HAS BEEN PERFORMED BY THE USE OF THESE ORIGINAL CAMERAS IN CONJUNCTION WITH STEREOPLOTTING MACHINES OF VARIOUS TYPES, ALTHOUGH THE CAMERAS THEMSELVES WERE DESIGNED PRIMARILY FOR MILITARY RECONNAISSANCE AND ROUGH MAPPING WORK. THE RESULTS THUS OBTAINED WERE VERY ENCOURAGING AND GRADUALLY THE REQUIREMENTS FOR SPECIAL CAMERA EQUIPMENT GAINED IN CLARITY AND MOMENTUM WITH THE RESULT THAT IT IS NOW POSSIBLE TO PRESENT A PHOTOGRAPHIC MAPPING INSTRUMENT WORTHY OF THE NAME AND YET DESIGNED TO FIT IN WITH PRESENT METHODS AND APPARATUS. BEFORE DESCRIBING THIS UNIT, IT MAY BE OF INTEREST TO MENTION BRIEFLY A FEW OTHER ITEMS WHICH HAVE BEEN PRODUCED FOR USE BY THE PHOTOGRAMMETRIST.

FOR GENERAL PURPOSES, IT IS NOW USUALLY RECOGNIZED THAT A SQUARE PHOTOGRAPH IS DESIRABLE AS SECURING OPTIMUM EFFICIENCY IN COVERAGE, SO 9 X 9 INCH ROLL FILM MAGAZINES ARE NOW AVAILABLE FOR USE ON STANDARD 7 X 9 INCH K-3B CAMERAS, THESE UNITS BEING FULLY INTERCHANGEABLE WITH THE ORIGINAL FILM UNITS. PARTICULARLY INTENDED FOR WIDE ANGLE WORK WITH 6 INCH TO $8\frac{1}{4}$ INCH LENSES, THE MAGAZINE HAS A CAPACITY OF OVER 250 EXPOSURES AT ONE LOADING AND USES FILM OF THE SAME WIDTH AS ITS PREDECESSOR. HOWEVER, ITS SIMILARITY TO THE ORIGINAL 7 X 9 MAGAZINE STOPS HERE. IN PLACE OF THE FOCAL PLANE GLASS, A VACUUM SUCTION PLATE IS UTILIZED TO SECURE ABSOLUTE FLATNESS OF THE FILM IN THE FOCAL PLANE. THE SUCTION PLATE IS AUTOMATICALLY RAISED BEFORE FRESH FILM IS BEING WOUND INTO PLACE, DESCENDING AGAIN, AFTER THIS MOTION CEASES, TO PRESS THE FILM ONCE MORE AGAINST A FIXED METAL FRAME SURROUNDING THE PICTURE AREA. THIS FRAME SERVES AS A SEAL TO PREVENT INGRESS OF UNWANTED AIR AS THE VACUUM LINE TO A SMALL VENTURI TUBE EXHAUSTS THE REMAINING SURPLUS BETWEEN FILM AND VACUUM PLATE. THE FRAME IS PROVIDED WITH COLLIMATING NOTCHES WHICH INDICATE THE PRINCIPAL POINT OF THE PHOTOGRAPH. A SIMPLIFIED AND ENTIRELY FOOLPROOF MECHANISM AUTOMATICALLY SYNCHRONIZES THE WINDING, METERING AND VALVE-OPERATING FUNCTIONS OF THE MAGAZINE WHICH CAN BE USED EITHER ON HAND OR ELECTRICALLY-OPERATED CAMERAS. IT IS POSSIBLE TO COLLIMATE THESE MAGAZINES WITHIN FAIRLY CLOSE LIMITS WITH REGARD TO THE LENS CONES ON WHICH THEY ARE EMPLOYED.

AMONG RECENT PRODUCTS, MENTION SHOULD BE MADE OF THE 9 LENS AERIAL CAMERA DEVELOPED IN COLLABORATION WITH THE U. S. COAST AND GEODETIC SURVEY, AND WITH WHICH THE MEMBERS OF THE AMERICAN SOCIETY OF PHOTOGRAMMETRY ARE MORE OR LESS FAMILIAR. THIS CAMERA PRODUCES ON A SINGLE FILM, 9 NEGATIVES WHICH ARE TRANSFORMED IN A SPECIAL PRINTER, TO PRODUCE A PRINT ABOUT THREE FEET SQUARE OF THE 130° AREA PHOTOGRAPHED. ALTHOUGH THIS PHOTOGRAPH IS MADE BY USING 9 SEPARATE



LENSES IN THE CAMERA, THE PRINTING APPARATUS AND THE CAMERA ARE DESIGNED TO HAVE THE OPTICAL ELEMENTS ADJUSTED AND COLLIMATED WITH EXTREME ACCURACY SO THAT THE RESULTING PRINT IS FREE FROM THE ERRORS ASSOCIATED WITH COMPOSITES MADE WITH OTHER FORMS OF MULTIPLE LENS EQUIPMENT USED IN THE PAST.

STAINLESS STEEL OF A SPECIAL TYPE HAS BEEN FREELY EMPLOYED IN THE CONSTRUCTION OF THE CAMERA ELEMENTS TO MINIMIZE THE EFFECTS OF TEMPERATURE CHANGE ON THE CAMERA CALIBRATION. THE 9 SEPARATE SHUTTERS INVOLVED ARE OPERATED IN ABSOLUTE SYNCHRONISM THROUGH THE MEDIUM OF AN ELECTRICAL SURGE SYSTEM IN WHICH THE EXPOSURE IS VARIED BY CHANGING THE TUNING OF THE CIRCUIT VERY MUCH AS IN A RADIO RECEIVER. ALL SHUTTERS OPERATE ON ONE IMPULSE.

THE TYPE OF DRIFT SIGHT-INTERVALOMETER PRODUCED FOR USE WITH THIS CAMERA IS INTERESTING INASMUCH AS IT ELIMINATES SOME OF THE TROUBLES FACING THE AERIAL PHOTOGRAPHER. THIS UNIT CONSISTS OF TWO PARTS, ONE OF WHICH IS THE TELESCOPIC SIGHT ATTACHED RIGIDLY TO THE CAMERA BODY, AND HAVING AN ANGULAR FIELD OF ABOUT 30° . IN THE FIELD OF VIEW BESIDES THE GROUND IMAGE, APPEAR A SERIES OF FIXED STRAIGHT LINES PARALLEL TO FORE AND AFT CENTER LINE OF THE CAMERA. BY ROTATING THE CAMERA IN AZIMUTH, CORRECTION IS MADE FOR DRIFT BY OBSERVING THE MOTION OF THE GROUND IMAGE IN RELATION TO THESE LINES.

THE TELESCOPE ALSO CONTAINS A TRAVELING GRID SYSTEM WHICH MOVES ACROSS THE FIELD OF VIEW PARALLEL TO THE DRIFT LINES REFERRED TO. THE SPEED AT WHICH THIS GRID MOVES IS CONTROLLED BY THE SECOND ELEMENT OF THE SYSTEM, THE TWO BEING CONNECTED TOGETHER THROUGH THE MEDIUM OF A FLEXIBLE SHAFT. THE SPEED CHANGE IS ACCOMPLISHED DURING OBSERVATION BY TURNING A KNOB ON THIS DRIVE UNIT. THE SECOND KNOB CARRIES A SCALE GRADUATED TO REPRESENT PERCENTAGE OVERLAPS RANGING FROM 15% TO 75%. BY SELECTING THE OVERLAP DESIRED, AND SYNCHRONIZING THE MOVABLE GRID WITH THE GROUND AS DESCRIBED, THE CAMERA OPERATES AUTOMATICALLY, TAKING PICTURES AT PROPER INTERVALS WITHOUT ATTENTION FROM THE OPERATOR BEYOND THE NECESSARY LEVELING. IT WILL BE NOTED THAT IT IS NOT NECESSARY TO MAKE ANY MEASUREMENT OF TIME BY MEANS OF A STOP WATCH. IT IS BELIEVED THAT THIS FORM OF SIGHT WILL FIND WIDE APPLICATION IN AERIAL PHOTOGRAPHY IN WHICH IT IS NECESSARY TO TAKE A LONG SERIES OF OVERLAPPING EXPOSURES.

COMPANIES ENGAGED IN AERIAL SURVEY WORK FIND IT INCREASINGLY IMPORTANT TO KNOW AT WHAT TIME OF DAY THE SUN WILL BE AT A CERTAIN ALTITUDE INASMUCH AS MANY CONTRACTS ARE DRAWN UP IN WHICH THE MINIMUM ALTITUDE OF THE SUN IS SPECIFIED TO SECURE THE BEST PHOTOGRAPHIC RESULTS. THIS CAN BE DETERMINED IN A NUMBER OF WAYS BY USING SUCH INSTRUMENTS AS THE HAGNER POSITION FINDER, THE MAXSON LINE OF POSITION COMPUTER, OR BY THE LONGER AND MORE CONVENTIONAL TABULAR METHODS. ANOTHER ALTERNATIVE, EXTREMELY CONVENIENT FOR USE BY NON-TECHNICAL PERSONNEL, IS THE TIME ALTITUDE COMPUTING CHART, NOW AVAILABLE WHICH WAS DESIGNED FOR THIS SPECIFIC PURPOSE. IT HAS THE ADVANTAGES OF BEING INEXPENSIVE AND ACCURATE.

DURING THE PAST 12 MONTHS, DEVELOPMENT HAS BEEN SUCCESSFULLY CARRIED OUT ON THE TALLEY STEREO-COMPARAGRAPH, A FULL DESCRIPTION OF WHICH HAS ALREADY APPEARED IN THE NEWS NOTES. THIS DEVICE REPRESENTS THE SIMPLEST FORM OF STEREO-PLOTTING MACHINE THAT CAN BE PRODUCED FOR THE PURPOSE OF OBTAINING PLANIMETRIC AND OTHER DATA FROM STEREO PHOTOGRAPHS.

THE NEW PHOTOGRAMMETRY CAMERA NOW BEING INTRODUCED HAS A NEGATIVE SIZE OF 9 x 9 INCHES. AT THE PRESENT TIME, THE MOST SUITABLE AVAILABLE LENSES WHICH COVER THIS SIZE OF NEGATIVE ARE OF $6\frac{1}{2}$ INCH AND $8\frac{1}{4}$ INCH FOCAL LENGTH; HOWEVER, WHEN LENSES OF SHORTER EQUIVALENT FOCUS BECOME AVAILABLE, THESE WILL PROVIDE THE INCREASED ADVANTAGES ASSOCIATED WITH A WIDER ANGLE OF COVERAGE. IN DESIGNING THIS EQUIPMENT, CARE HAS BEEN TAKEN TO INCLUDE EVERY FEATURE EXPERIENCE INDICATES AS DESIRABLE IN A PHOTOGRAMMETRY CAMERA.

AN OUTSTANDING IMPROVEMENT IS THAT THE LENS IS MOUNTED IN A VERY RIGID HOUSING OF STAINLESS STEEL, THE UPPER END OF THE HOUSING PROJECTING INTO THE FILM MAGAZINE AND FORMING THE FOCAL PLANE FRAME AGAINST WHICH THE FILM IS PRESSED PRIOR TO MAKING AN EXPOSURE. THIS PRESSURE IS APPLIED THROUGH THE MEDIUM OF AN ACCURATE BACKING PLATE CONTAINING SMALL APERTURES THROUGH WHICH ANY AIR REMAINING BEHIND THE FILM IS EVACUATED TO SECURE PERFECT FLATNESS OF THE SENSITIZED SURFACE. THE APPLICATION OF THIS VACUUM IS CONTROLLED AUTOMATICALLY BY THE FILM METERING MECHANISM CONTAINED IN THE MAGAZINE. THE FOCAL PLANE FRAME CONTAINS FOUR COLLIMATING MARKS IN THE FORM OF NARROW SLITS CARRIED ON SMALL PLATES WHICH ARE CAREFULLY ADJUSTED DURING COLLIMATION OF THE CAMERA TO CORRESPOND TO THE PRINCIPAL POINT OF THE PICTURE. THESE PLATES ARE THEN DOWELED IN PLACE. SMALL ROUND HOLES

IN THE PLATES CARRYING THE SLITS PROVIDE AN EASY MEANS OF MEASURING NEGATIVES FOR SHRINKAGE. THE CONSTRUCTION OF THE COLLIMATING MARK PLATE HAS BEEN ARRANGED TO FACILITATE CALIBRATION BY THE UNITED STATES BUREAU OF STANDARDS. ANOTHER POINT OF INTEREST IS THE METHOD USED TO MOUNT THE LENS. SO MUCH TROUBLE HAS BEEN EXPERIENCED IN THE PAST IN OBTAINING ACCURATELY FITTING THREADS ON LENS AND SHUTTER BARRELS THAT THIS FEATURE HAS BEEN ELIMINATED AND CENTERING IS OBTAINED WITH EXTREME ACCURACY BY MEANS OF A CYLINDRICAL SHOULDER ON THE FRONT AND REAR CELL ASSEMBLIES. THE LOWER PART OF THE CAMERA BODY IS PROVIDED WITH FLANGES AT THE PROPER DISTANCE APART TO SECURE THE NECESSARY SEPARATION OF THE TWO CELLS AND THESE FLANGES ARE BORED OUT SO AS TO BE PERFECTLY CONCENTRIC WITH THE MECHANICAL AXIS OF THE BODY. THE CYLINDRICAL SHOULDERS ON THE LENSES ARE TRUED UP BY TAKING A LIGHT CUT OFF THE LOCATING SURFACES AFTER THESE ELEMENTS HAVE BEEN OPTICALLY CENTERED BY WELL KNOWN MEANS. THE FRONT AND REAR ASSEMBLIES ARE HELD IN PLACE BY ORDINARY SCREWS PASSING THROUGH A FLANGE ADJACENT TO THE LOCATING DIAMETERS, THIS FLANGE BEING MACHINED SQUARE AT THE TIME OF TRUING UP.

THE SHUTTER MECHANISM IS CONTAINED IN A CAST ALUMINUM HOUSING INSERTED BETWEEN THE TWO FLANGES AT THE LOWER PART OF THE CAMERA BODY. THE HOUSING IS ATTACHED ONLY TO ONE OF THESE FLANGES AND IN SUCH A WAY AS TO PERMIT RADIAL EXPANSION OF THE DISSIMILAR MATERIALS WITHOUT DISTORTION BEING TRANSMITTED TO THE BODY FROM THIS CAUSE OR AS A RESULT OF SHOCKS INCIDENT TO THE OPERATION OF A HIGH SPEED SHUTTER, ETC. PROVISION IS MADE TO ACCOMMODATE THE USUAL LIGHT FILTERS ON BAYONET PINS ON THE LOWER FLANGE.

IN ORDER TO ELIMINATE THE POSSIBILITY OF STRAINS BEING APPLIED TO THE CAMERA BODY ABOVE MENTIONED, THE ENTIRE ASSEMBLY IS SUSPENDED BY MEANS OF A FLANGE NEAR ITS UPPER EXTREMITY INSIDE A SECONDARY CASING IN WHICH ALL REMAINING CAMERA MECHANISM IS ASSEMBLED. THIS MECHANISM CONSISTS OF THE WINDING MOTOR, SHUTTER RETARD AND DRIVE COUPLINGS, MAGAZINE DRIVE ASSEMBLY, ETC. SUITABLE BAFFLES ARE PROVIDED FOR THE EXCLUSION OF UNWANTED ILLUMINATION AND DIRT. A SPECIAL MAGAZINE CONTAINING ENOUGH FILM FOR 250 EXPOSURES FITS INTO A RECESS ON TOP OF THIS SECONDARY BODY IN SUCH A WAY THAT ITS MOVABLE VACUUM BACK WILL FUNCTION IN THE MANNER PREVIOUSLY DESCRIBED. THE MAGAZINE IS EASILY REMOVABLE AND THUS PERMITS THE USE OF AN EXTRA SUPPLY OF FILM WHENEVER DESIRED. THE OUTER BODY IS PROVIDED WITH FITTINGS TO PERMIT INSTALLATION IN STANDARD MAPPING MOUNTS. PROVISION IS ALSO MADE FOR THE ATTACHMENT OF THE TELESCOPIC VIEW FINDER MENTIONED EARLIER IN THIS ARTICLE SO THAT THE ENTIRE ASSEMBLY PROVIDES AN AERIAL PHOTOGRAMMETRY UNIT OF ADEQUATE ACCURACY AND HAVING THE NECESSARY ADVANTAGES OF FULLY AUTOMATIC OPERATION AND RUGGED DEPENDABILITY, FREE FROM DAMAGE DUE TO THE HANDLING TO WHICH AERIAL PHOTOGRAPHIC EQUIPMENT IS UNAVOIDABLY SUBJECTED.

THE BOULDER RESERVOIR SURVEY

BY

LEON T. ELIEL

(PAPER PRESENTED AT THE ANNUAL MEETING OF THE AMERICAN SOCIETY OF PHOTOGRAMMETRY
JANUARY 18, 1937)

AT EIGHT O'CLOCK ONE SATURDAY MORNING, TELEGRAPHIC NOTIFICATION TO PROCEED WITH MAPPING LAKE MEAD (BOULDER RESERVOIR) WAS RECEIVED IN LOS ANGELES. THE CONTRACTOR WAS FURTHER INFORMED THAT WATER WAS BACKING UP BEHIND THE CLOSED GATES OF THE DAM AT THE RATE OF TWO MILES A DAY. IT WAS IMPERATIVE TO GET THE PICTURES TAKEN AND THE CONTROL IN BEFORE ANY SUBSTANTIAL AREA OF THE RESERVOIR WAS SUBMERGED. PICTURES OF THE CRITICAL AREA WERE SAFELY RECORDED ON THE AERIAL FILM FIVE HOURS AFTER RECEIVING NOTICE OF AWARD, NEEDLESS TO SAY THE PHOTOGRAPHIC CREW HAD BEEN HELD ON THEIR MARKS AND SET, READY FOR THE CRACK OF THE GUN -- "JUST IN CASE."

TO BEGIN WITH, THE RESERVOIR BACKED UP BETWEEN FAIRLY STEEP SLOPING BANKS, CONFINING THE GROWING LAKE SO THAT IT LENGTHENED WITHOUT GETTING VERY WIDE. FOR THIS REASON IT WAS POSSIBLE TO CONTROL THE PICTURES WHICH COVERED MUCH MORE THAN THE WIDTH OF THE RAPIDLY EXTENDING LAKE LONG AFTER THE RIBBON OF WATER EXTENDED ACROSS THEM. THUS ALL OF THE AREA WHICH WAS ABOVE THE FLOOD LINE AT THE TIME OF PHOTOGRAPHY WAS CONTROLLED AND MAPPED.

THE SOIL CONSERVATION SERVICE, FOR WHOM THE MAP WAS MADE, ARRANGED FOR THE