PHOTOGRAMMETRIC MEASUREMENT OF NATURAL SEA-SURFACE

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The article discusses surveys, which are a continuation of measurements of water ripples on hydrotechnic models.
In this case there was created a special technology and equip - ment for surveying of dynamical sea-surface of water.In this aim there were executed synchronously stereogramms of sea-surface - from two planes /AN-2/ using two cameras UMK FF 10/1318. The syn chronous of two photographs creating a stereogram was 1/1000 sec The stereogramms were elaborated by the analytical or analogous method. Finally a graphical map or numerical model was produced.

I.INTRODUCTION

The present report portrays a succeeding example for successful application of photogrammetry in an extrageodesic field of know ledge.
In this instance it concerns the sphere of sea hydraulic, engaged among others:
- in research works,regarding interdependences between sea-surface waving and conform sea-bottom configuration /the so-called wave transformation occurence/,
- in investigation of sea waving occurence in aspect of refraction, wave uprush angle, direction spectrum of waving,
- in investigation of shore dynamic variations,

and so on.
Exactly,the photogrammetry can be useful as a successful research instrument,especially in aspect of possibility to precise designation of sea-surface phisical shape,even at the same time on considerable sea areas.
Photogrammetry surveyors have interest in these problems, both in the sphere of natural sea-surface investigation and in ade - quate model testings. This finds the confirmation in a number of publications: /1/, /3/, /4/, /5/, /7/, /8/, which present photogrammetrical experiments in the last years in the Republic of South Africa, the United States of America, Japan, Holland and Poland.
Following this short introduction we present our attainments and experiences in this sphere.

II. GENERAL NOTICES CONSIDERING RESEARCH METHODICS

Considerations in this field are to be preceded with an ascer - tainment: while photogrammetric measuring of dynamic sea-surface the base principle of photogrammetric measurement technics - execution of stereogramms of investigated sea-surfaces with their instrumental elaboration - is maintained in the whole reach.
For the presented problem, the object's specifity forces a dif - ferent - compared with typical - kind of realization of before

mentioned principle;the necessity to fulfil a number of particular requirements is to be taken into consideration. The leading of them, which results from the dynamic character of investigated sea-surface, is the condition to execute simultaneously the photogramms of sea-surface using two cameras /photogramms,which form the particular stereogramms/.
The kind of solution of these questions depends on the cameras' location; that means, if they will be located on two upraised ground stands at the sea-shore - ie /4/ - or located on two flying apparatuses - for instance two aeroplanes, hellicopters or balloons /5/.
The first variant, which enables to execute photogramms with a side orientation, related to the object, allows a technical relatively easy - by means of a cable - realization of the above mentioned condition to execute simultaneously photogramms,which form a single stereogramm.
The employment of the second variant ie. the execution of stereogramms with cameras located on two flying apparatuses makes the problem of simultaneousness photography more complicated; it demands in consequence the ensurement of a remote and adequate precise synchronization of both photogrammetric cameras, and thus to redesign the cameras /for example cameras of UMK FF 10/1318 type/, and also their connection to special adapted for this aim additional arrangements /ie. radiotelephones of proper technical parameters/.
/Worthy to be noted is, that despite of considerable and resulting from this complications, and thereby higher costs of research works, also their more complicated organization, the last variant of cameras localization enables the obtainment of positively better technical results, than the former one/.
Beside of above described difficulties, another important problem for the research executions is to secure an adequate photogrammetrical base for particular stereogramms. This problem is relatively easier to be soluted if the stereogramms reach includes the sea-shore. On the sea-shore the basic group of base-points can be located. This base should be moderately to possibility - completed with points located at sea in a adequate distance for the reach of the stereogramm, with use for this aim each proper stabile structure - artifical /dolphins/ or natural /rocks/.
The situation in this scope alters considerable to disadvantage when executing photogramms of any sea-surface fragment, thus of photogramms for which no ground base can be formed. A possibility of metric eleboration of such stereogramms form the discernment of photogramms' base, that is to say in the discussed matter, the discernment of distance between the flying apparatuses in the moment of out-working the definite stereogramm. Delimitation of this distance is possible with synchronic execution of

photogramms by means of three cameras, two of which take pictures of the sea-surface, while the third photographs the neighbouring aeroplane /8/; /an additional inspection element can be formed, for example by a ship of known dimensions photographed on both stereogramms./.
An esentional problem, however of another type, are high costs of photogramms, when two aeroplanes have been used /or two helicopters/, as well as their small organizational disposals.A way out of this situation makes the replacing of aeroplanes by balloons /5/ or better by a pair of minicrafts /2/ or minihelicopters /6/.
It is necessary - as well known - to use in this instance adequate light photocameras. These can be - just wide used in the photogrammetric practise - the so-called non-metric cameras of Hasselblad MK 70 or Rolleiflex SLX Reseau type /6/.
Beside of considerable economic- and organizational adventages, if balloons or minihelicopters are used for execution of photogramms, and also in smaller degree minicrafts, it additional allows to execute - in the technical view-point more interesting- photography of the same sea-surface - in cyclic way.
Regardless of matter of photography, in accordance with measuring method principles, the photogramms are successively subjected to instrumental elaboration. If photogrammetric cameras have been used for these picture make, and if their indicatory elements are contained in the operation range of stereoplotters, / what in spite of the attained technics' value in this discussed instance is not easy to be achieved, mainly considering the fact that the most favourable - in view-point of technical usability of elaborated results - season for research-works and at the same time for execution of photogramms, is the season of hard weather conditions/ exactly then the photo-pictures are to be elaborated on them.
Otherwise stereocomparator is to be used for observation of the photogramm, and an analytic method for its elaboration.
According to necessity, this phase can effect in:
- a contour chart of sea-surface
- a numerical model of this surface
- optionally led vertical sections
- spherical diagramms of sea-surface

and so on.

III. SHORT DESCRIPTION OF REALIZED RESEARCH-WORKS

It is proposeful to begin with a statement, that surveys of natural sea-surfaces have been preceded by successful laboratory measurements of water surfaces on hydraulic models /7/. Of course the achieved experiences have been utilized for transfer the technology to a macroscale object. In the described work, after disregarding - as few useful - the method to take pictures of

sea-surfaces from ground stands /their faults: a great number of dead fields and heterogeneous accouracy of elaborations,which decrease with the growth of distance/, the method to photograph from air-crafts came into consideration.
Considering the approchable means and possibilities, the method to photograph by means of UMK FF 10/1318 type cameras, located in hatches of two aeroplanes of AN-2 type, have been resolved. A special arrangement for remote and synchronized cameras excitation has been of course designed. This arrangement has to operate in hard conditions, inside a small plane, with appreciable vibrations; it has also to secure a constant and precise synchronization of both cameras operation.
A number of trials has proved, that the arrangement, composed of two radiotelephones fulfils the preset requirements.Special test of a whole set of equipment /two cameras of UMK FF type with complete instrumentation including the additional equipment - drg 1/ has effected in synchronization exactitude of both cameras' shutters opening down to 1/1000 second.
A so prepared apparatus set, with a film of 27 DIN film speed has allowed to execute shore-zone stereogramms from a height of 300 m; the photogramms'scale amounts to 1:3000.
The quality of the pictures, sufficient for subsequent instrumental elaboration, found the expression, among others, in a distinctly visible stereoscopic effect on the sea-surface; this is confirmed by a fragment of a stereogramm shown on the drg N° 2, included to the present report.
For these stereogramms have been previously set, along the sea-side, points of photogrammetric base, completed with single ones located on artifical marine arrangements; in this instance these have been dolphins contained in the reach of stereogramms.A photogrammetrical material of technical standard value has been in this way attained, suitable for subsequent instrumental elaboration, which enables the geometric description of dynamic sea-surfaces.
Within the cameral elaboration of pictures, both manners, possible for employment in this range have been tested. One of them was the typical elaboration of stereograms on the stereoplotter /in the described instance it was a stereometrograph of F type / in consequence of which a contour chart of the sea-surface in a 1:250 scale has been prepared /its reduction is shown on drg 3./ and also the vertical sections of the sea-surface in a scale of 1:10/100 /drg N° 4/.
A more interesting, but more stiff in realization is the second, analytic mean of picture elaboration, within which the stereogramms have been observed on a precise stereocompactor of "Stecometr F " type. Then, as an effect of adequate calculations on a digital computer of Odra 1305 type /according to OWT, MOD and TPO programms of W.Mizerski authorship/, a numerical of a chosen

sea-surface area has been achieved. The model was composed of a point-net of 1.2 m long sides; in general about 5000 points have been observed on an area of 200x60 m. Next this model has been subjected to a further transformation on a digital computer of EMR 6135 type; in effect basing on a plotter of Benson 421 type a contour chart of the investigated surface /drg N° 5/ has been created - similarly as with photogramms elaborated on the stereoplotter. An additional effect of this mean of picture elaboration can also be the vertical surface sections, also its spatial diagrams /drg N° 6/.
Within further research-works, accuracy testings have also been worked-out; theyhave proved, that the most interesting error of the point height amount to $m_z = \pm 7$ cm /for 1:3000 picture scale/. In this phase of elaboration this size is completely sufficient.

IV. RECAPITULATION

A technology of photogrammetric sea-surface measurement has been elaborated as the effect of executed trials and investigations.
This technology has to its disposal a verificated set of photo apparatuses, and also the possibility of double kind of the stereogramm elaboration. The last feature takes on the technology an universal character, and makes it independent of probable great elements of photogramms orientation. At the same time, the analytic manner of picture elaboration takes into account the possibility to elaborate stereogramms, which have been made by using non-metric cameras /ie. above mentioned cameras of Hasselblad MK 70 or Rolleiflex SLX Reseau types/,located for example on a miniparaglider /3/.
The last possibility, reduced to execution of cyclic photogramms of the same sea-surface fragment, with two flying mini apparatuses utilized as platforms for non-metric cameras,lays out the direction of our further operation for improvement and first of all for simplification and cheapen the technology.
We hope, at least, that the portrayed reflections in connection with various documentations /drawings and photogramms /, will be helpful in realization of similar intentions in other centrums.

Literature

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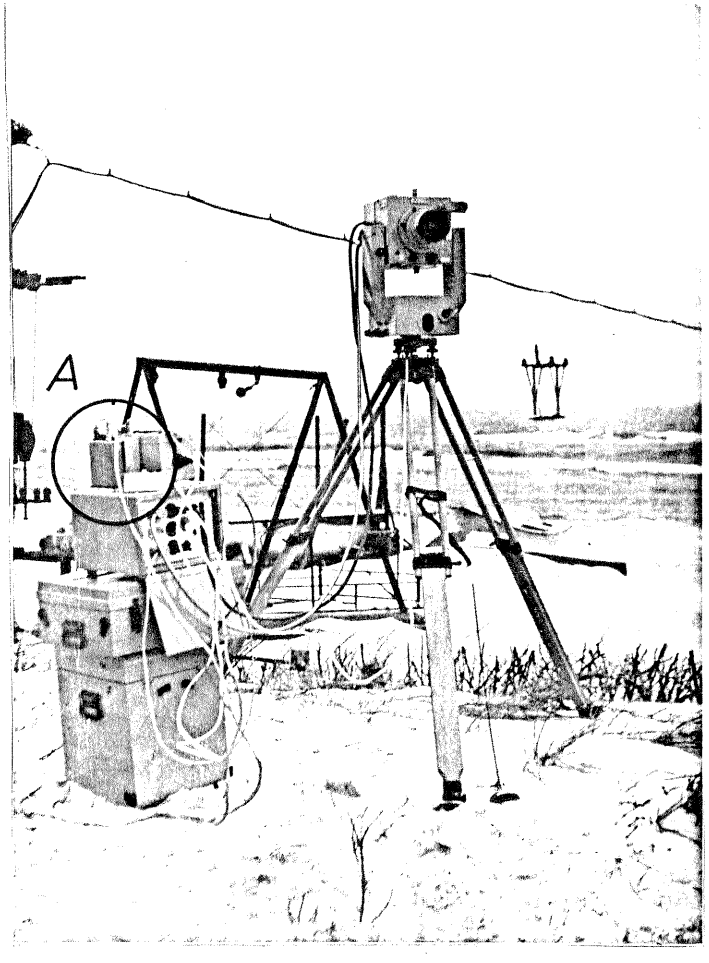
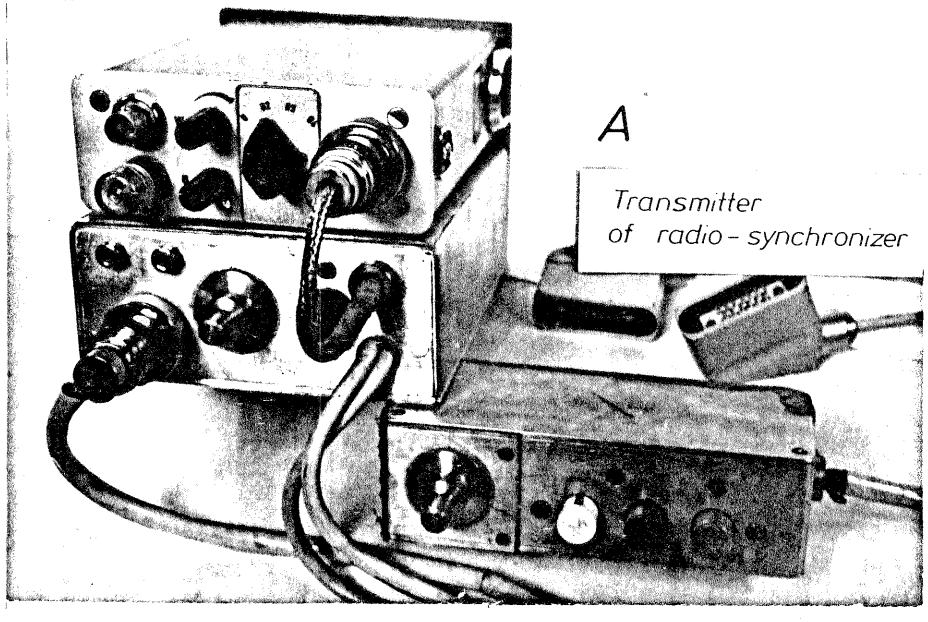
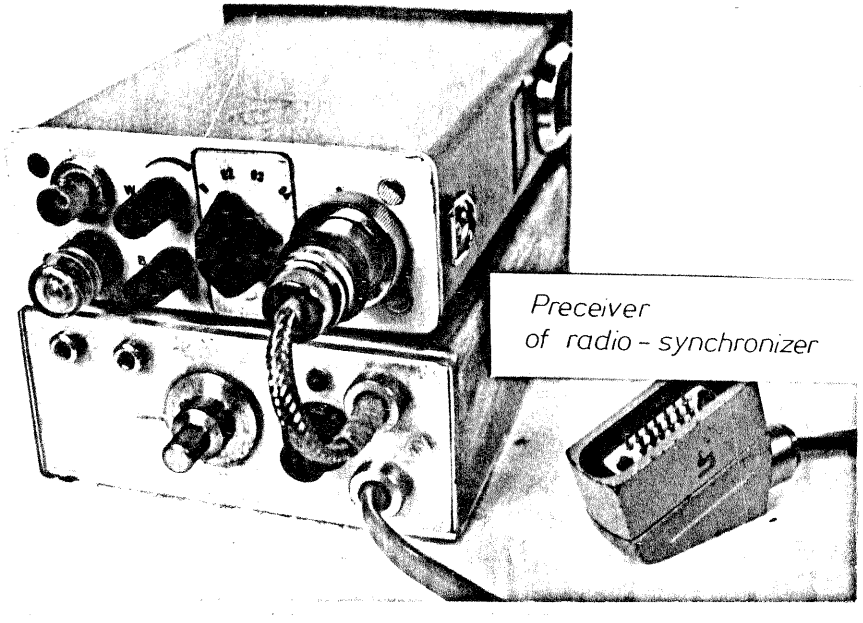
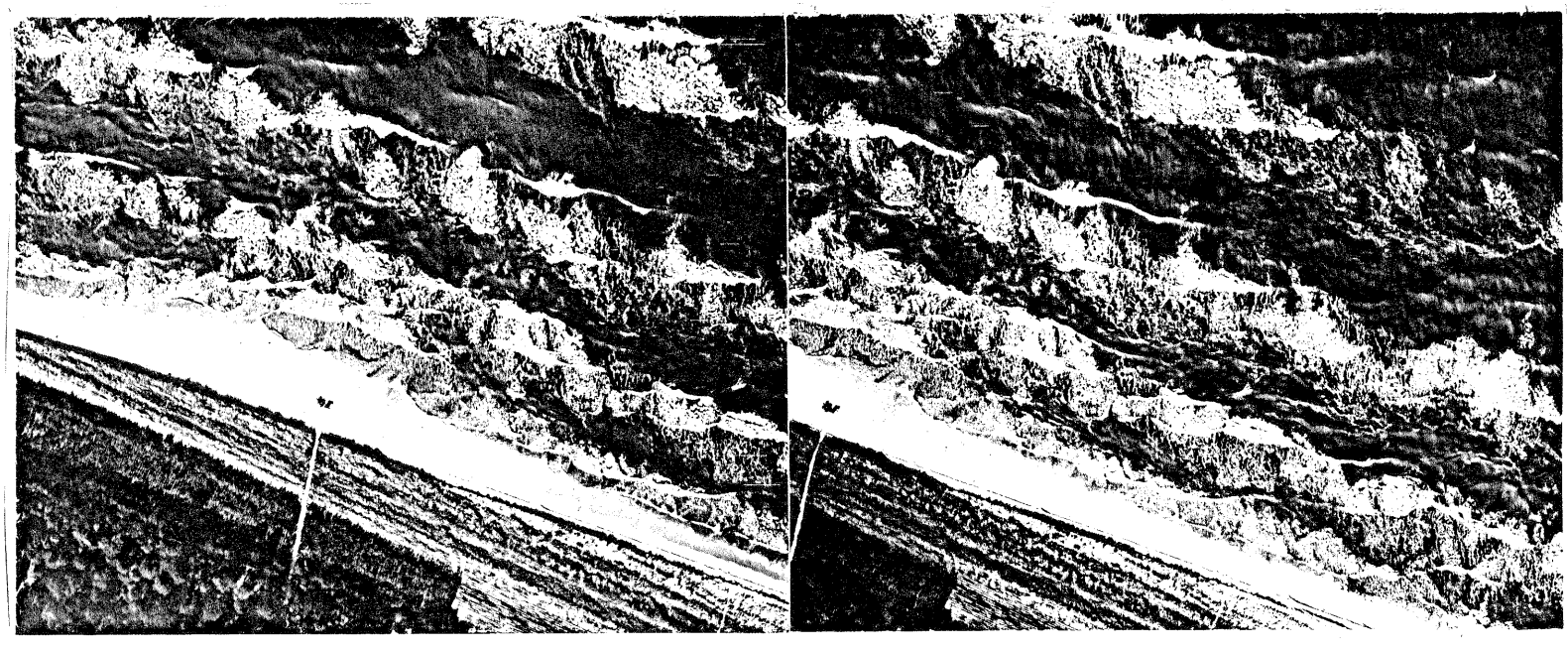


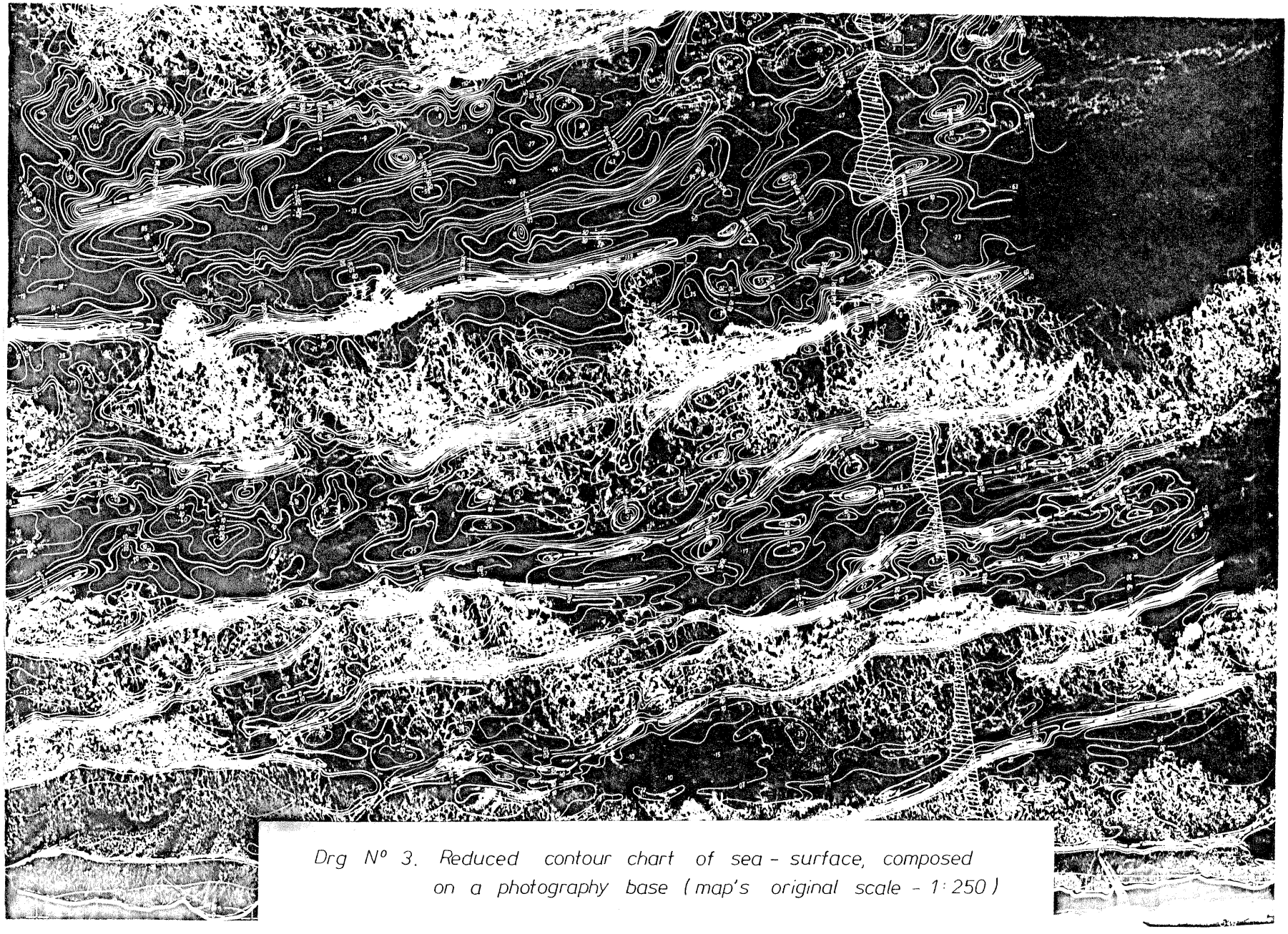
Drg N° 1. Camera UMK FF 10/1318 type with special arrangement for remote operational synchronization.



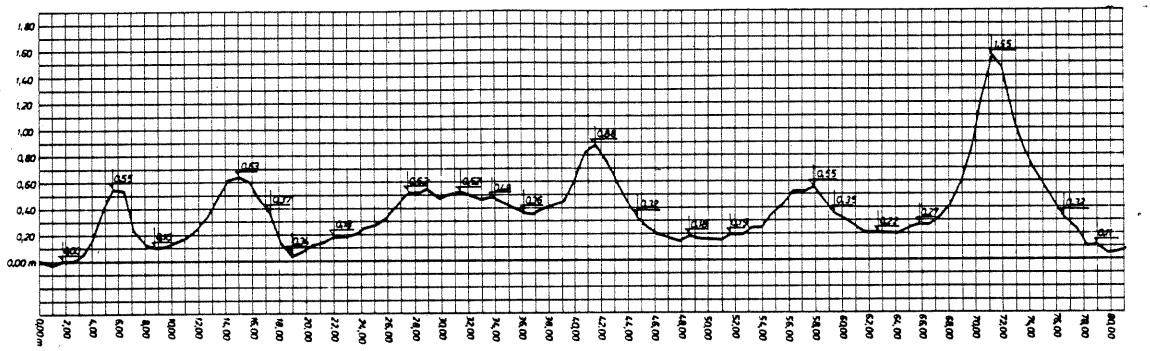




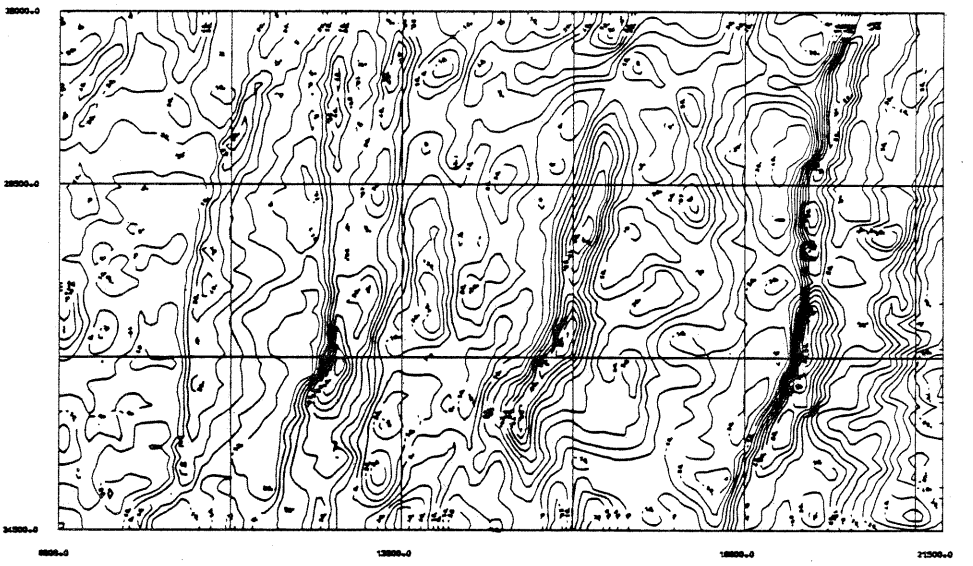
Drg N° 2. Stereogramm of sea - surface.



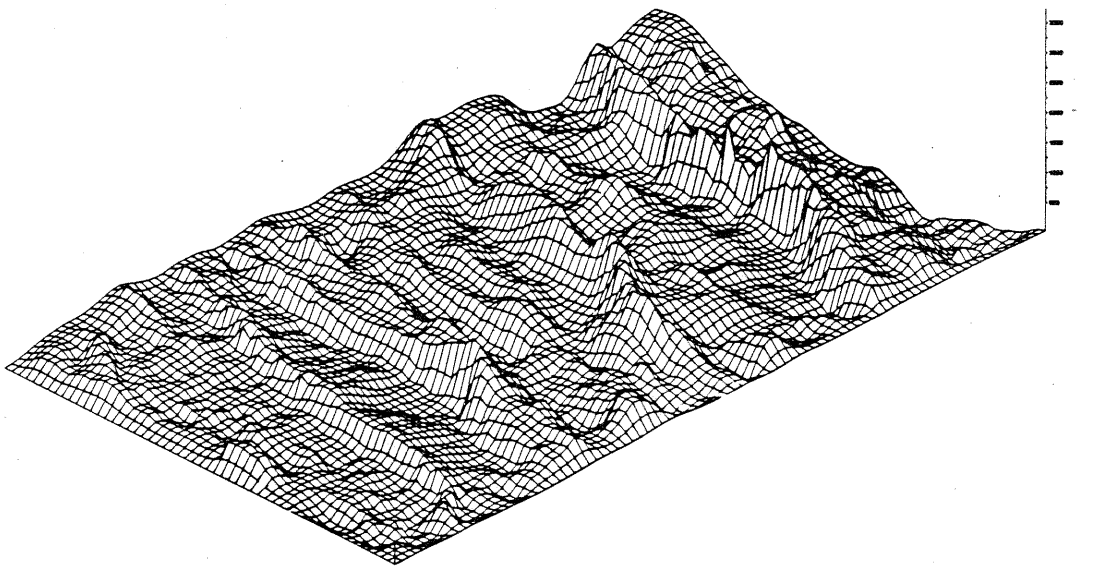
Drg N° 3. Reduced contour chart of sea - surface, composed on a photography base (map's original scale - 1 : 250)



Drg N° 4. Vertical section of a sea surface (fragment).



Drg N° 5. Reduced sea-surface contour-chart elaborated by a digital computer of EMR 6135 type and plotter Benson 421 type.



Drg N° 6. Reduced and spatial diagram of sea-surface, elaborated by a digital computer EMR 6135 type and plotter Benson 421 type.