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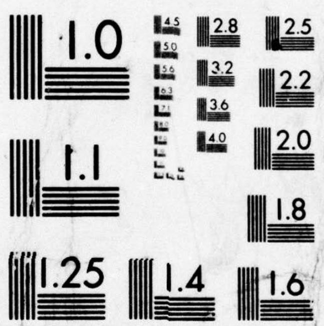

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(Apparatura i metodika issledovaniya elektricheskogo polya v more s ispol'zovaniyem malykh baz)

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INSTRUMENTS AND METHOD FOR INVESTIGATING ELECTRIC FIELDS IN THE SEA USING SMALL BASES

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The article discusses a method of measuring electric field strength using small bases in overseas expeditions. The comparative characteristics of this method are discussed in relation to the method of paravane measurements. Tellurograms obtained by using this new method are presented. /177*

The intensity of the horizontal components of the earth's natural electric field is usually small, measured in a few millivolts or less per kilometer. Therefore, in measurements on dry land, measuring bases of considerable size, i.e., about 1 kilometer or more, are usually required. Large base dimensions are obviously convenient from the standpoint of the relative rise of useful signal level above the level of various types of noise, among which a unique role is played by the instability of the intrinsic electrode emf.

In determining the field vector, two measuring bases are oriented at right angles to each other, while the current-carrying conductors remain fixed relative to the stationary geomagnetic field in the course of the measurements. In measurements on dry land, this requirement is easily met, as is the requirement of large base dimensions. Under open deep sea conditions, considerable technical difficulties arise in setting up a system of mutually perpendicular stationary bases. At any rate, this cannot be done in comprehensive expeditionary studies with serious time limitations.

One of the solutions to the problem is the method of electric field measurement in the ocean, worked out at the MGI (Marine Hydrophysical Institute) using a paravane orientation of the measuring bases, which are afloat and have dimensions /178
of 100-200 m.[1] One of the disadvantages of this method is the impossibility of performing the measurements in the water mass itself at a given depth because the orientation of the bases cannot be determined under water. Moreover, the method of arrangement of the measuring bases with the aid of paravanes has heretofore been characterized by rather large real measuring errors. Analysis shows that the chief contribution to the total measuring error is made by errors in the determination of the direction and size of the bases, which are stretched out by relative flow. One of the key disadvantages of this method is the impossibility of checking the intrinsic electrode emf while the measurements are being made. Such checking is carried out only at the beginning and end of the measurements.

Although the influence of these disadvantages may be eliminated or reduced within the confines of this method, there also exists another way of eliminating

*Numbers in the right margin indicate pagination in the original text.

them, namely, a way of appreciably reducing the dimensions of bases permitting the creation of a geometrically rigid system. Such a system may be in the shape of a cross, for example, forming two mutually perpendicular bases, which is carried by the current away from the drifting ship and may be located either in the water mass or on the bottom. The indeterminacy of the base dimensions is obviously eliminated in this case. The orientation of the bases relative to the points of compass can be determined with a (distant reading) compass. Nor does the orientation stabilization of the bases present any fundamental difficulties, either in the flow of water or on the ground. Incidentally, the possibility of performing deep measurements both in the water mass and on the bottom is apparent in this case.

However, a substantial decrease in the base dimensions is associated with an increase in some of the difficulties noted above; a number of new technical obstacles have thus far prevented the implementation of this simple idea. The difficulties are due to a sharp attenuation of the useful signal in comparison with the noise. Among the most important are:

1) the electric field induced in the conductors, which move in the geomagnetic field in the presence of sea waves;

2) the electric field of the sea waves themselves;

3) the nominal value of the intrinsic electrode emf and its drift.

In addition, other types of noise are also possible: random contact potential differences dependent on temperature gradients at various points of the measuring circuit and apparently, thermal noise in the circuit. Some difficulties are presented by the problem of amplification of weak dc signals and creation of high sensitivity instruments capable of operating while the ship is in motion. /179

Let us examine some ways of overcoming these difficulties.

The problem of amplification of weak signals, constant or slowly changing in time, and the problem of creation of recording equipment does not in itself present any fundamental difficulties and can be solved by using dc amplification circuits based on the modulation principle. Two ways of achieving such modulation are possible: either by continuously varying the parameters of the measuring bases, for example by rotating the bases, or by interrupting the signals in the input circuits of the amplification circuit. The first method has the advantage that it eliminates the influence of the intrinsic electrode emf, since the latter in this case is not modulated and is eliminated from the signal which is amplified and recorded. However, this method involves major design difficulties and should cause difficulties in the operation of the measuring instruments. In addition, this method will apparently give rise to additional noise due to turbulization of the water. The second method is free of these disadvantages, but it requires an additional solution to the problem of intrinsic electrode emf. The optimum compromise appears to be the selection of the second modulation method with sporadic variation of the parameters of the measuring bases to eliminate the intrinsic electrode emf. This can be easily done by using a simple technique. Let the base ℓ change its dimensions by the amount $\Delta\ell$ at some instant. If the recorded voltages before and after the variation are u_1 and u_2, the electrode emf is ε, and the strength of the measured field is E, the latter is determined from the system of equations

$$u_2 = E(\ell + \Delta\ell) + \varepsilon,$$

$$u_1 = E\ell + \varepsilon.$$

Obviously, sporadic changes in base dimensions are structurally simpler to carry out than continuous ones. It is also important to note that the possibility of a definite and sufficiently large variation of the base dimensions arises precisely from the structural transition to small base dimensions.

It is also obvious that discrete determinations of intrinsic electrode emf require the use of high-quality electrodes and their selection when the emf drift is small. /180

The influence of the electric field of sea waves can be substantially reduced by immersing the measuring bases to a sufficient depth, where a decrease in the amplitudes of cyclic motion of the liquid is known to take place. The higher spectral components of waves are the ones attenuated the most. As for the lower components of the spectrum of ocean waves, even though the corresponding low-period motion of the liquid does reach depths of the order of several hundred meters, none the less its perturbing influence can be eliminated by placing the bases at a certain depth in the seawater mass. Actually, a rigid electrical base of neutral buoyancy and a small size in comparison with the wavelength will, as a first approximation, execute in the geomagnetic field the same cyclic motions as the conducting liquid. The emf induced in the base will in this case be approximately equal to the voltage applied by the liquid, and this will cause the absence of a current in the measuring circuit. In this case, it is necessary also to impart neutral buoyancy to a certain portion of the cable tie directly adjacent to the rigid structure of the bases. When this tie is sufficiently long, there is a simultaneous damping of the periodic motion of the bases, due to oscillations of the point of support of the cable on the ship in the presence of sea waves. Experiment shows that the electromotive force generated in the conductors of the cable during its oscillations is not detected in the measuring circuits (within the sensitivity of the instruments, limited by other factors) when each pair of conductors of one base is located in the same cable and thus moves as a whole. This fact is very significant. It is easy to show that the differential oscillatory motion of the conductors is inadmissible. To estimate the order of magnitude of the emf induced in the conductors during their motion on a sea wave, allowing for the geomagnetic field, it suffices to assume that certain portions of the conductors can move from time to time at the phase velocity of the waves v. Then the emf induced in each meter of conductor is given by

$$\mathcal{E} = [\bar{v} \cdot \bar{B}] \leq vB = \sqrt{\frac{g\lambda}{2\pi}}\, B .$$

For a wavelength of, say, 20-30 m, which is very modest for ocean conditions, and a cable length of 5 m transported at the velocity of the wave, the corresponding emf value will be on the order of 1 mV. This is at least one order of magnitude greater than the useful signal on a base also with dimensions of about 5 m. /181

The above orders of magnitude show how important it is to eliminate the transfer of oscillatory motion of the cable (at the point of support on the ship) to the measuring base.

We will also examine the influence of induced effects and thermal noise. It is well known that the level of the internal thermal noise in the input circuits of the amplifier is proportional to the root of the absolute value of the passband of the measuring circuit. Since the absolute interval of natural electric field frequencies measured for geophysical purposes is very small and amounts to approximately a few hertz, as is shown by simple calculations, the level of such noise will, for all practical purposes, lie beyond the range of accuracy of, say, one meter. On the contrary, under the conditions in question, external noise, particularly the industrial and ship frequency of 50 Hz, assumes a major importance. Although this frequency lies outside the range of measured frequencies, the presence of 50 Hz induction effects creates difficulties in the use of standard electronic recording instruments, in which 50 Hz is the working frequency. It thus becomes necessary to have a measuring system with a different modulation frequency.

The arguments presented here were verified experimentally. During the first voyage of the research ship AKADEMIK VERNADSKIY, tests of the method and model of the equipment with base dimensions of 5 m were carried out. The bases were formed by using a rigid T-shaped cross made of vinyl plastic tubes. The experiment was conducted at a "stop" during a wind drift of the ship. The cross had a neutral buoyancy thanks to a system of deep liquid floats 1, situated in a balanced arrangement relative to the cross (Fig. 1). One of the liquid floats 2 was attached by means of a symmetric strap on a base transverse relative to the water flow, thus imparting a stable horizontal position to this base. The horizontal position of the cross in a longitudinal direction relative to the flow and the stability of its azimuthal orientation were ensured by tail stabilizer 3. The cable tie of the cross to load 4, by means of which the system was lowered to a given depth, had a length of 30 m and was also balanced to neutral buoyancy by means of liquid floats 5. A distant reading compass of special construction was attached to the cross.

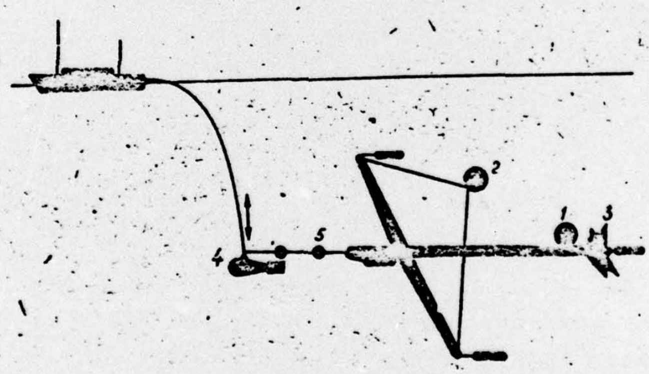
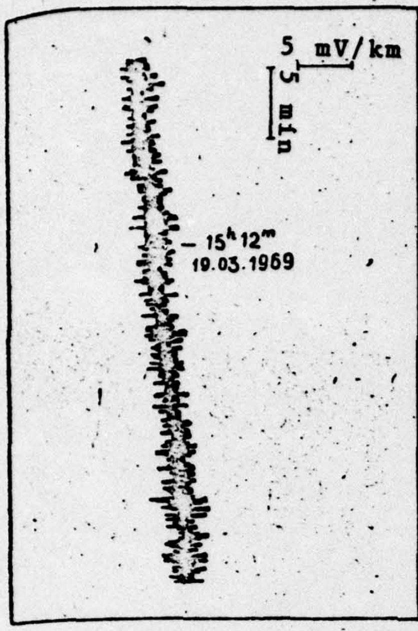


FIGURE 1. Diagram of electric field measurements in the seawater mass.

The experiment showed that for a definite sea state, there is an optimum immersion of the cross for a significant reduction of the noise due to waves. For example, for a sea state of about 4, the optimum cross immersion depth is 150-200 m. Increasing the depth further does not affect the noise level, since this noise is due to an incomplete extinction of the motion of the cross during the ship's motion, as could be readily ascertained by observation. The stability of the compass readings confirmed that of the orientation of the cross in space within the limits of moderate drift velocities (up to one grid point). Figures 2 and 3 reproduce the tellurograms obtained for a rough sea (about 4) and a slack sea (about 2). The first tellurogram does not show any telluric oscillations within the accuracy of measurement, which because of the wave noise decreases to 2-3 mV/km /182



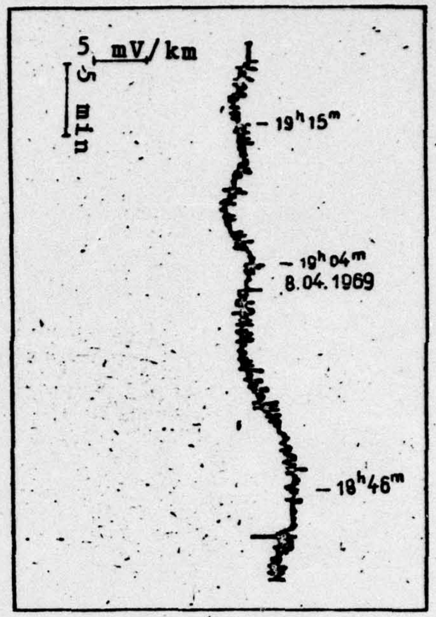


FIGURE 2. Tellurogram with induction of electrical noise caused by irregular displacement of bases during the ship's motion.

FIGURE 3. Tellurogram of electro-telluric field oscillations, obtained with a base of small dimensions.

in this case. A tellurogram was obtained in the deep-water area of the Gulf of Guinea, and according to our other measurements, expresses a marked *attenuation of* the telluric field strength in this region. A second tellurogram, obtained in the Mediterranean, clearly shows telluric oscillations.

The recording equipment used consisted of strip chart recorders using modulation of the measured signal by a mechanical transducer. The selected modulation frequency was 58 Hz, which was due to the high level of the 50 Hz network noise aboard the ship. The recorders were made with type PS 1 standard circuits. The input part of the recorder amplifier was modified. The power supply circuits and input circuits were separated and shielded. In order to improve the S/N ratio, an additional amplification stage supplied from an independent dc source was introduced. In order to obtain a significant increase in the scale sensitivity of the recorder, a constant voltage much lower than in the standard circuits was supplied to the input bridge. These steps made it possible to achieve a scale sensitivity /183 of about 100 µV. The actual sensitivity was limited by the wave noise, instability of the intrinsic electrode emf, and other random noise associated with the conditions of marine experiments. A scale sensitivity of 300 µV was selected for the tests. The complete achievement of such sensitivity requires additional steps involving the damping of motions of the cross during the ship's motion, as is evident from the tellurogram of Fig. 2.

On the whole, the tests performed lead to the definitive conclusion that small rigid bases can be used for measuring the natural electric field in the sea.

In conclusion, let us note several important advantages of measuring an electric field in the sea by means of small rigid bases in comparison with the method of paravane orientation of bases of considerable dimensions:

1. Elimination of errors due to the determination of base dimensions, and reduction of errors due to the determination of base orientation relative to the points of compass.

2. Possibility of checking the intrinsic electrode emf and consequent possibility of measuring the constant component of the telluric field. /184

3. Possibility of measurements at any given depth.

REFERENCES

1. Lopatnikov, V. I., R. V. Smirnov, and B. I. Novikov, Method of measuring the electrotelluric field in the sea. In: Hydrophysical and Hydrochemical Studies in the Atlantic Ocean and Black Sea (Gidrofizicheskiye i gidrokhimicheskiye issledovaniya v Atlanticheskom okeane i Chernom more), Vol. 38. "Naukova dumka" Publishing House, 1967.