II. HISTORY
THE BEGINNINGS AND THE IGY

P. Bencze

The Geophysical Research Laboratory of the Hungarian Academy of Sciences, as one of the predecessors of the Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences was founded in 1955. It was also that time, when the preparations of the International Geophysical Year began in the framework of CSAGI (Comité Special de l'Annee Geophysique International). Thus, the Laboratory was also prompted by these arrangements to establish an observatory for the investigation of the geoelectromagnetic field. The choice fell on the electromagnetic field of the Earth, because at that time the Laboratory was mainly engaged in the establishment of the telluric method used in the geological prospecting for raw materials. As it is known, the telluric method of geophysical prospecting is based on the simultaneous recording of telluric, or earth currents in the field at two different places. The earth currents are recorded at a stationary basic station and at a moving station the situation of which is determined by the given project. Thus, the staff of the Laboratory had already enough experience in the measurement and temporal, as well as spatial variations of two of the six components of the geoelectromagnetic field.

Assignment of the place of the Observatory

In course of the establishment of an observatory, the first and at the same time the most important task is the assignment of the place of the observatory. From the point of view of a geoelectromagnetic observing site, the most important conditions to be fulfilled are the absence of artificial, antropogeneous electromagnetic noises disturbing the natural electromagnetic field. Such disturbing factors can be d.c. railway lines, vagabond currents originating from the 50 Hz electric network. It is to be noted that the intensity of vagabond currents are the larger, the smaller is the thickness of the sedimentary layers covering the bedrock. The currents are concentrated, namely, in the sedimentary layers their electric resistivity being by orders of magnitude less, than that of the bedrock. The increased current density in the sedimentary layers can be observed as the increase of the potential difference between two electrodes on the surface of the ground. Therefore, those places are more suitable for the establishment of a geoelectromagnetic observing site, where the thickness of the sedimentary layers is large enough, i.e. the bedrock is located deep enough. Thus, the location of a geoelectromagnetic observatory depends not only on the electromagnetic conditions, but also on the geological structure of the lithosphere.

At the time of the establishment of the observatory, it was clear that the three magnetic components of the geoelectromagnetic field correspond to the three components of the variation field of the geomagnetic field. However, the situation was not at all as clear in the case of the three electric components, more exactly in case of the vertical electric component, as the situation with the magnetic components. It was assumed that the vertical electric component of the geoelectromagnetic field might be the atmospheric electric field, that is the vertical potential gradient. However, the atmospheric electric field can only be measured at places, where local disturbances as contamination of the air by antropogeneous sources (households, industry, traffic) do not affect the conductivity of the air. Thus, the latter circumstance was also important at the establishment of the observatory.

The assignment of the place of the observatory was also influenced by financial conditions, namely, to establish the observatory at low cost. At that time a border zone existed along the western border of the country, which one could enter only with special permission. In the surroundings of Sopron, there was a formerly well known hostel, which was abandoned because of the proximity of the border. The head of the Laboratory professor Károly Kántás wanted to establish the observatory in and around of this hostel. The control measurements were carried out recording the earth currents and the vertical component of the geomagnetic variation field by a horizontal loop, furthermore mapping the spatial variation of the magnetic field by two Schmidt type magnetometers to reveal a possible magnetic anomaly in the area. Though, it turned out that the thickness of the sedimentary layer is small, the favourable location of the place (far from inhabited area in a woodland, lack of antropogeneous electromagnetic disturbances, building available) induced professor Kántás to try to establish the observatory there. However, to do this, the permission of the ministry for home affairs was needed. The ministry rejected the request because the area was located in the border zone.

It was necessary to find another place in the surroundings of Sopron. Taking the map of this area, such places were selected, which were far from inhabited area and appeared to be undisturbed. For control measurements, places like meadows, woodlands were selected. In this phase of the assignment only earth current measurements indicating the presence of vagabond currents were carried out at the places, which seemed to be suitable to establish a geoelectromagnetic observatory. For this purpose earth current measurements were carried out at least in four places in the surroundings of Sopron. Finally, the present place of the Geophysical Observatory Nagycenk was found suitable to establish a geoelectromagnetic observatory. Though, the area of the Observatory belongs to the territory of the village Fertőboz, it was thought that the centre of the estate of the family Széchenyi, that is the name Nagycenk is more known in the world, than the name of the small village Fertőboz.

The conditions, which made the place suitable for the establishment of an observatory for the study of the electromagnetic field of the Earth, were the followings. The area formed a part of a woodland called "Kiscenki fácános". The place was far from inhabited area, on the side of the terrace, a geological, sedimentary formation of Lake Fertő. The nearest settlement, the small village Fertőboz is located at a distance of about 1.6 km to the west. No disturbances were found in course of the control measurements. The road connecting the villages on the shore of Lake Fertő and by which the place can be approached, runs at the foot of the terrace. The railway between Sopron and Győr located at a distance of about 1 km to the south of the selected place, was not electrified at the time of the establishment of the observatory.

Furthermore, for the assurance of the disturbance free state of the observatory, the area around the observatory was declared natural conservation area. This means that no kind of activity may be performed without the permission of the Laboratory. Thus, the illegal activity endangering the function of the observatory could be avoided. However, our observatory could also not avoid the fate threatening the work of many observatories all over the world. The railway between Sopron and Győr was electrified and consequently the increased electromagnetic noise made impossible some of our measurements. The only consolation was the compensation for the limitation of the observation activity of the observatory, which was paid by the railway company to the Institute. The railway line crosses, namely the natural conservation area of the observatory and thus, the railway company violated the law referring to natural conservation areas. However, first it was necessary to prove the fact that the measurements in the observatory are really disturbed by the electrified railway line. As everything has its bright side, the Institute could buy new instruments from the sum of compensation.

The actual establishment of the observatory began just before the revolution of 1956. The conditions for the acquisition of money and the necessary materials changed, but it was necessary to continue the building of the observatory, if we wanted to reach the goal set by us. The director of the Geophysical Research Laboratory professor Kántás left the country in November 1956. Unfortunately, several members of the staff, almost half of the staff left the country, too. The remaining three scientists, Antal Ádám, Pál Bencze and Ákos Wallner had to distribute the work among them. Antal Ádám, who was charged by professor Kántás to be the deputy of him led the workshop of the Factory for Geophysical Instruments founded in Sopron for the production of earth current recording instruments. Ákos Wallner leaved for China to participate in the work of the Hungarian Geophysical Expedition. The author of this paper shouldered the establishment of the Observatory. As it turned out that professor Kántás do not intend to return to Hungary, professor Antal Tárczy Hornoch, the director of the Geodetical Research Laboratory took over the leadership of the Geophysical Research Laboratory.

Establishment of the Observatory

Returning to the establishment of the observatory, first the building plans of the house for the recording of the elements of the geomagnetic field (variation house) and the drawings of the bureau building were prepared. In case of the variation house, the architect wanted to design a building, which fits in with its surroundings, i.e. it looks like a wine cellar (Fig. 1). The surroundings of Sopron and especially

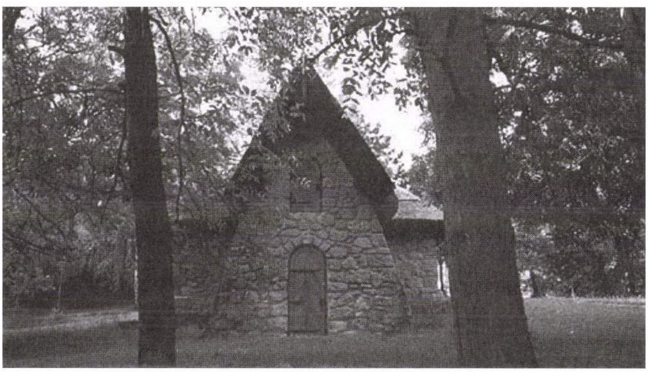

Fig. 1. The house for the recording of the components of the geomagnetic field variations (variation house)

the area around Lake Fertő is a historical winegrower region with many vineyards. The walls of the house were made of limestone from the quarry of Fertőrákos. This limestone is not hard, therefore it can be cut easy. The building had to fulfil also two technical requirements. It was necessary to build it without the use of iron and it had to assure good temperature isolation. This meant that all locks were made from brass, where nails were needed, e.g. for the finishing of windows and doors brass nails were used. The architect designed a roof made from reed, on the one hand for assuring good isolation, on the other hand because of the fitness of the building. The isolation of the building could be increased by the circumstance that the area of the observatory is a hillside. Thus, the variation house was built lowering the structure partly in the hillside. The reed roof was completed by using copper wire for the fastening the sheaves together. According to the technical plans, the variation house consists of two rooms. Entering the house, stairs (staircase) lead to the first room, which was necessary for the light trap, but it can also be used to the installation of other geomagnetic instruments. The solution of the photorecording in the second room necessitated the establishment of the light trap. The variation house was the first building built in the Observatory and it was almost finished in 1956.

The bureau building was planned to give place to a bureau room, to a room for the recording of the earth currents, to premises for the developing of recordings and charging of accumulators, to a separate room for the accumulators and a small flat for the keeper of the observatory. The keeper's duty was to look after the instruments, to exchange the films, photosensitive papers and develop them, call up the Laboratory, if he found some irregularity in the functioning of the equipments. The bureau building was built in 1957 (Fig. 2).

The establishment of the Observatory was continued with the building of the house for the magnetic absolute measurements (absolute house). This building was also erected by using limestone as building material, but this time the limestone was transported from Eplény. In this case the locks were also made from brass and where nails were needed, e.g. for the finishing of windows and doors brass nails were used. The absolute house got also a reed roof, for the fastening of the sheaves using copper wire. The building consists of two rooms, of an entrance-hall and a measuring room. The entrance hall was used for the preparation of the measurements. In the measuring room four concrete columns were built for the setting up of the instruments. The absolute house was finished in 1957 (Fig. 3).

Fig. 2. The building in which the earth currents are recorded (bureau building)

Fig. 3. The house for the measurement of the absolute values of the geomagnetic components (absolute house)

A building was allocated also for the placement of atmospheric electric instruments (atmospheric electric house). Originally the recording of all three characteristics of the global atmospheric electric circuit was planned. Thus, the building consists of six rooms. Four rooms open on a corridor, rooms devoted to the placement of the recording instruments of the sensors working in the open air, to the housing of the equipment for the recording of the atmospheric electric conductivity, to the placement of a pendulum clock and an accumulator charger. A small room

Fig. 4. The building erected for the placement of atmospheric electric measurements (atmospheric electric house)

at the end of the room for the atmospheric electric conductivity was planned for the housing of Gerdien condensers. The walls of this room were covered by wire screen for the elimination of electromagnetic noises. Similarly, a small room was formed at the end of the room for the placement of the pendulum clock and the accumulator charger, where accumulators could be kept. The atmospheric electric house was finished in 1957 (Fig. 4). The Observatory was officially opened the 14. 11. 1957.

Instrumentation

The task of the observatories is getting data extending at least to a period of tens of years. The collection of such long series of data can only be warranted, if the probability of the break down of the equipment is minimum. The probability of a break down of the equipment is the less, the simpler is the equipment used for this purpose in the observatory. This principle was also followed in course of the instrumentation.

Earth currents

After the buildings of the Observatory were finished, first the most important task was the installation of the existing instruments. The recording of the earth currents started already at the beginning of the IGY, the 1st July 1957. As the building devoted to the housing of the instruments was at this time not ready,

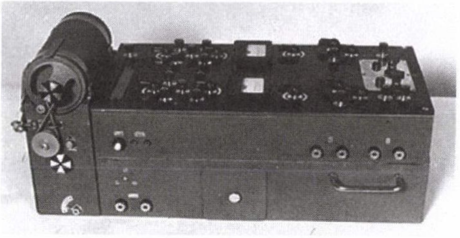

Fig. 5. The instrument by means of which the earth currents are recorded

the scientists József Verő, Cz. Judit Miletits, Lajos Holló carrying out these measurements and providing for the processing, as well as studying the data of these measurements were forced to place the recording instruments in a tent. Without electric network, the instruments could be operated only by means of accumulators. For the charging of the accumulators it was necessary to take them to Sopron. When the bureau building was finished, the recording instruments could be placed in the room devoted for them (Fig. 5).

For the establishment of the recording of the earth currents, electrodes placed at a distance of 500 m from one another were used, one pair of electrode in N-S direction, the other pair in W-E direction. The electrodes were made from lead sheets and were put in a depth of 2 m. The polarisation of the lead electrodes is very small, thus, the compensation of the potential difference between the electrodes must rarely be corrected. The electrode pairs were connected with the recording instruments placed in the bureau house by shielded cables to avoid the picking up of disturbing noises. The recording instruments provide for the compensation of the nearly constant potential difference between the electrodes so that only the variation of the potential difference due to the earth currents can be recorded by means of sensitive galvanometers. The signals of the galvanometers are recorded on photosensitive paper with two different recording speed (2.0 cm/hour and 7 mm/min). The other important part of the recording instruments is the circuit, by means of which the transitional resistance of the electrodes can be measured and then the corresponding resistance is inserted into the scaling circuit. The scaling is made namely by switching off the electrodes from the equipment and thus accurate scaling can only be carried out when the circuit includes also the transitional resistance of the electrodes. The devices can be scaled by a normal cell and the motor operating the convey of the photosensitive paper is supplied from the electrical network. Thus, it was necessary to assure the recording also during that periods, when the electrical network breaks down. The problem is solved by a DC to AC converter, which is supplied from accumulators. In this way the continuous current supply is solved.

The precise time-signal is very important for every observatory. The time-signal was originally provided by a pendulum clock, which gave time-signals hourly, or each minute according to the requirement of the recording speed. Later, the time-signals were provided by a central time marking system, which is controlled by the time-signals of a time-signal transmitter. Hourly, each minute and even each second time-signals can be provided by this system for every building of the Observatory.

Geomagnetism

For the recording of the variations of the geomagnetic field, the generally observed declination (D) and the horizontal (H), as well as vertical (V) components of the geomagnetic field, the well known La-Cour type variometers were bought from Denmark (Fig. 6). Two systems of these variometers were obtained differing only in the sensitivity of the H variometer. The systems placed in the variation house on two tables made from artificial stone began to work in 1961. However, besides the running of the variometers, it was also necessary to carry out absolute measurements. The absolute values of the recorded field components were measured by an old magnetic theodolith obtained from the Geomagnetic Observatory

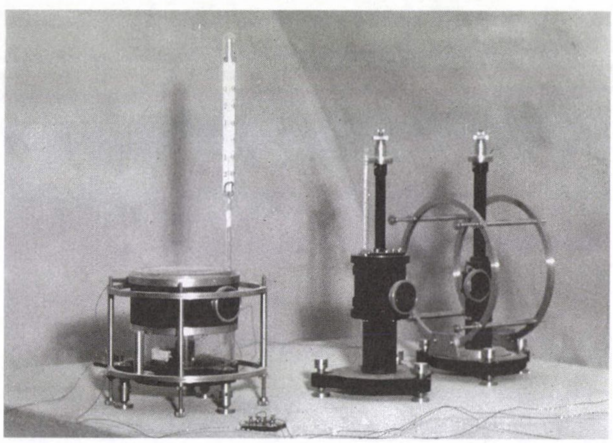

Fig. 6. The La-Cour type variometers, from left to right the Z, the H and the D variomters

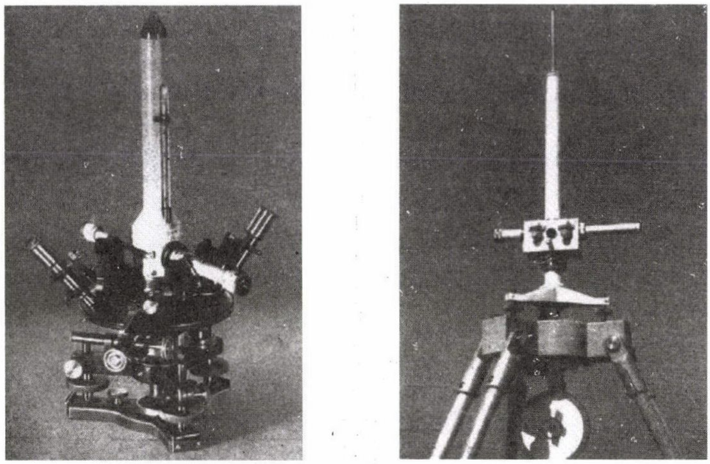

Fig. 7. The instruments for the measurement of the absolute values of the geomagnetic components

Tihany, two QHM and a BMZ instruments bought from Denmark (Fig. 7). The calibration of this devices was made in the Geomagnetic Observatory Tihany comparing our instruments with the instruments of that place. This was temporarily a sufficient solution, since the equipments of Tihany were earlier compared with the instruments of Niemegk (Potsdam). The measurements of the absolute value of the declination could only be determined by a magnetic theodolith, if the azimuth of a geographical direction was known. The azimuth of a geographical direction can be calculated, if the geographical co-ordinates of two points determining the direction are known. For this purpose, on the one hand the geographical co-ordinates of the Observatory had to be determined. On the other hand it was necessary to select a distant point (mira), which is far enough, it can be seen from the window of the absolute house with the magnetic theodolith and the geographical co-ordinates of which are available. In our case the tower of the church in Balf built at the hillside was used as a mira.

Atmospheric electricity

The measurement of the characteristics of the atmospheric electric circuit could be started only after the construction of the instruments needed for this purpose. From the atmospheric electric measurements operated in the Observatory the recording of the point discharge currents was the first because of its simplicity.

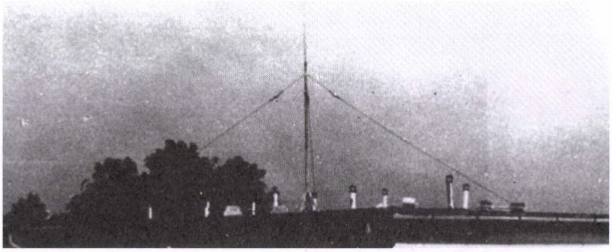

Fig. 8. The vertical mast enabling the observation of point discharge currents on the roof of the atmospheric electric house

For the observation of these currents, namely, an electrically insulated point made from stainless steel was put to the end of a vertical mast, which was placed on the roof of the atmospheric electric house (Fig. 8). It was fastened to the roof by means of three wire ropes to secure its position in case of strong wind. The insulated point establishes the conditions of point discharge, since the distance of equipotential surfaces decreases in the vicinity of curved surfaces (points, edges, peaks) depending on their radius of curvature. The smaller is the radius of curvature, the smaller the distance between the equipotential surfaces and thus the greater the field strength accelerating the ambient ions. At a certain field strength the ambient ions gain enough energy in the electric field between two collisions, that they can ionise the neutral molecules at the next collision. The field strength is above flat surfaces relatively small, when this process can already start in the vicinity of curved surfaces. From the arising ions those, which have a charge of sign opposite to that of the ground, flow through a cable — placed inside the mast and connected to a galvanometer — to the ground. The currents originating in this process are called point discharge currents. In our case these currents are recorded photographically by a high sensitivity galvanometer, the sensitivity of which can be changed by resistances connected in series and parallel with the galvanometer. For this purpose one of the recorder instruments was applied, which was originally used in the first earth current measurements in the field. The ions of sign corresponding to the sign of the charge of the ground remain in the vicinity of the point decreasing the field strength, till the wind does not transport them. Then the process starts again. In this manner, the point discharge is a successive process. The recording of point discharge currents began in 1961.

The first experiment for the recording of the atmospheric electric potential gra-

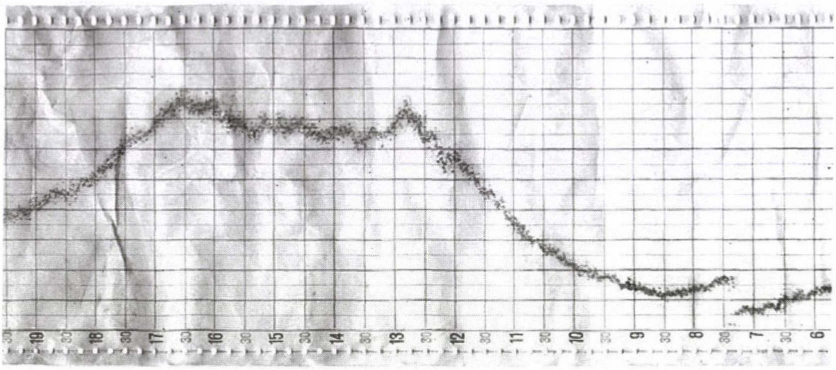

Fig. 9. The first record of the atmospheric electric potential gradient

dient by means of a simple device using a radioactive (polonium) collector and a point recorder was made in the garden of the family house of the author (Fig. 9). However, for the continuous recording of the potential gradient a radioactive collector is needed, which is prepared with an alpha radiating radioactive isotope having a long half-period. Such radioactive isotope is the radium, the half-period of which is 1680 years. Another important characteristic of the radioactive isotope used in the radioactive collector must be its activity. If the activity of the radioactive material is too high, then the collector becomes sensitive to the wind. However, if the activity is too low, then the transitional resistance of the collector is high and an appreciable part of the atmospheric electric potential difference between the collector and the ground gets to the transitional resistance reducing the measured value. Therefore, the radioactive collector could only be obtained from abroad. The large insulation resistance was secured by a double-walled cylindrical holder, the inside of which is connected with the outer space through diffusive channels formed by the lower side of the holder. The insulator separating the radioactive collector from the ground is placed in the inner part of the holder. This space is heated to assure the same high insulation resistance in any weather conditions. The radioactive collector, actually the radioactive preparation is put into a small cylindrical box, which is attached to the end of a rod. The rod is fixed to the top of the holder and they keep the radioactive preparation in a height of 1 m above the ground (Fig. 10). Beside the high insolation resistance, an instrument of high input resistance is needed because of the appreciable transitional resistance of the radioactive collector. The atmospheric electric potential difference between the potential in 1 m height and the ground is

Fig. 10. The radioactive collector of the equipment by means of which the atmospheric electric potential gradient is measured

namely divided between the transitional resistance of the radioactive collector and the input resistance of the instrument. The potential difference appearing at the input resistance of the instrument approximates the better the potential difference between 1 m height and the ground, the larger the input resistance. The problem was solved by using a hot-cathode tube applied in battery receivers. If the role of the anode and that of the grid is inverted, the input resistance increases and the dynamic range of the tube widens. The recording of the atmospheric electric potential gradient began in 1961. The processing of the atmospheric electric measurements was supervised by Ferenc Märcz.

Ionosphere

After the beginning of the recording of the quantities listed above, it turned out that the atmospheric electric field can not be considered as the vertical electric component of the electromagnetic field. However, the electromagnetic field of the Earth depends on the state of the ionosphere, first of all on the state of the lower ionosphere. The author of this paper participated in a summer school on the lower ionosphere in Kühlungsborn/Heiligendamm in 1964. Here methods for the investigation of the lower ionosphere were also reviewed and demonstrated in the

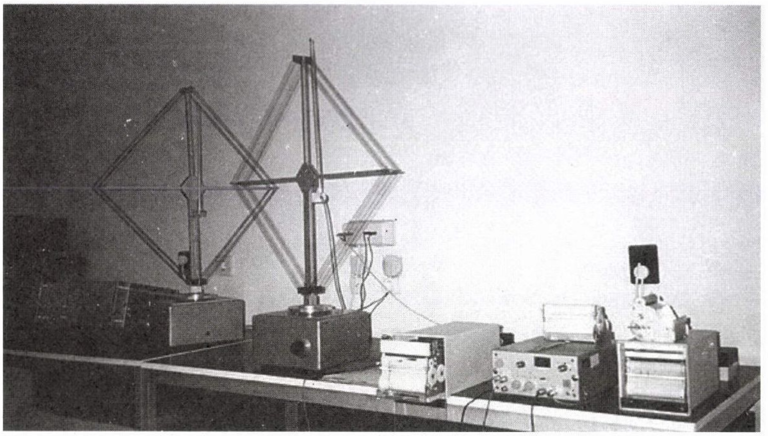

Fig. 11. The frame antenna used for the measurement of the ionospheric absorption of radio waves

Observatory Kühlungsborn. As a consequence of this meeting, the experimental measurements of the ionospheric absorption of radio waves of transmitters working in the long and middle wavelength bands were started in 1966. For the measurement of the ionospheric absorption the transmitters Ceskoslovensko (272 kHz) and Budapest (539 kHz) were selected, the sky waves of the carrier frequency of which were received by means of frame antennas and wide-band receivers (Fig. 11). The use of frame antennas is necessary for the separation of the sky wave from the surface wave. The received signal corresponds to the total field strength, if the plane of the frame antenna is parallel with the direction connecting the place of the transmitter with the receiving site. It is to be noted that the share of the sky wave in the total field strength is negligible small as compared to the surface wave in this position of the antenna. Moving the antenna from this position and approaching the position perpendicular to the direction mentioned above, the surface wave is gradually eliminated. In the position of the frame antenna perpendicular to the transmitter-receiver direction, it is only the sky (reflected) wave, with a component perpendicular to the plane of the antenna, which induces voltage in the coil of the antenna. The rectified signals of the output of the receivers were recorded by point-recorders. The recording speed is 6.0 cm/hour. However, wide-band receivers are not suitable for the accurate measurement of ionospheric absorption, because they do not have enough frequency stability in case of the reception of a single station's carrier frequency for longer time. Therefore, it is necessary to construct a heterodyne receiver with a crystal controlled oscillator, the frequency of which mixed with the carrier frequency of the selected transmitter produces a medium frequency. Thus, the stability of the frequency of the oscillator and also that of the medium frequency is of the same order of magnitude as the frequency stability of the transmitter. The mistuning of the receiver can be avoided. The receiver is scaled by turning the frame antenna from its position perpendicular to the direction connecting the place of the transmitter with the receiving site gradually by 90° both to the left and to the right first in steps of 5° (to 30°) and then in steps of 10°. This method of the measurement of the ionospheric absorption is namely a relative method, the magnitude of the absorption is determined in units of the surface wave.