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The Geophysical Observatory Sodankylä.

($\varphi = 67° 22' N$, $\lambda = 26° 39' E$)

By

E. Sucksdorff

The first decade of this century witnessed a pronounced increase in general geomagnetic research work. It had been found that a magnetic mapping of the earth in its entirety was of necessity, for the scattered surveys that had been made in the previous century and earlier, represented an insufficient basis for a theoretic explanation of the earth's magnetic field.

Fig. 1. General view of the Observatory, seen from the western bank of the River Kitinen. 1938.

Neither did these early surveys meet the requirements set by expanded communications. Great civilized nations began a systematic magnetic mapping of their own territories, and the Carnegie Institution of Washington undertook a work of gigantic dimensions: the geomagnetic surveying of the oceans and of uninhabited or underdeveloped countries. In Finland magnetic surveying was started at about the same time, in 1910, thanks to the energy and initiative of Professor G. Melander.

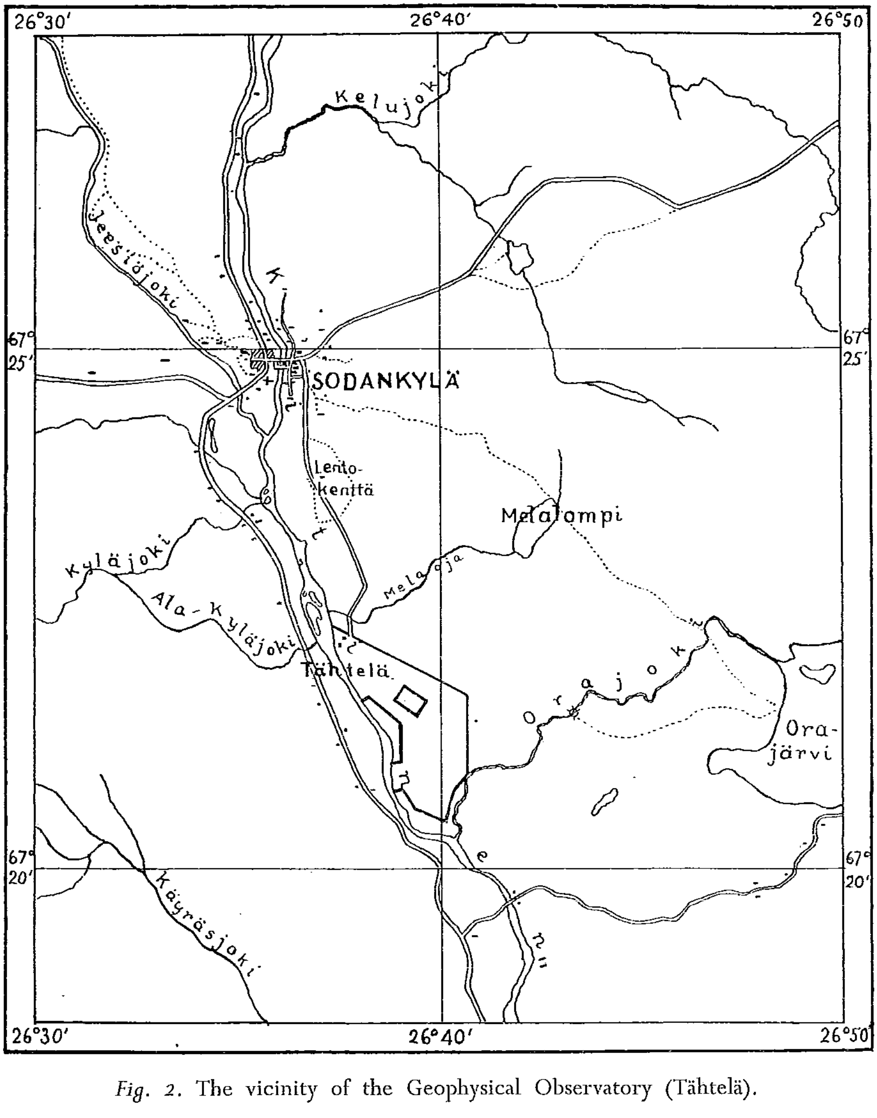

Fig. 2. The vicinity of the Geophysical Observatory (Tähtelä).

Geomagnetic surveying needs the support of a magnetic observatory, for comparations of field instruments and, most importantly, for reductions of field observations to a mean base value and to a common epoch. In the early years of Finnish geomagnetic surveying, the reductions were made on the basis of the records of the Pawlowsk Geomagnetic Observatory in

Russia. The constants of observation instruments were also determined there. It was clear, however, that, due to the great expanse of the Finnish territory in the north-south direction and also because of the fact that the northern parts of the country are located in the immediate vicinity of the auroral zone, the reduction values given by an observatory situated south-east of Finland could not be used to reduce the field observations made in Central and North Finland. It followed that, already at the time geomagnetic field work was being planned, the idea of establishing a permanent geo-magnetic observatory in North Finland was formed. Not only was it found necessary to have such an observatory as the base station of northern field

Fig. 3. The old main building of the Observatory.

work, but also there was a particular desire to study the magnetic and meteorological phenomena and conditions — up to then but little known — which could be observed in the arctic region near the auroral zone, in a region which also offered an opportunity to investigate the aurora borealis.

During the first international Polar Year, Finland had a temporary observatory at Sodankylä. In operation in 1882—1884, under Professor SELIM LEMSTRÖM's supervision, the Observatory had attained many valuable geophysical results. Chiefly for this reason Sodankylä — which already had some traditions to its name in this respect — was first thought of when the location for the new observatory was being planned. With the support of an international recommendation, energetic measures were taken to overcome the difficulties that always confront the establishment of a scientific institute. The final push for the materialization of the plan was given when some considerable donations were made to the *Finnish Academy of Science* for the purpose. Through these grants, the establishment and future maintenance of the new observatory came to be a task of this worthy scientific society, and thereby the Observatory came to be more like a scientific institute in character. The Finnish Academy of Science performed this task, and continues to maintain the Observatory, in an excellent way.

For the use of the Observatory, the Finnish government assigned a 400 hectare area of land, situated about 5 km south of Sodankylä Church, by the River Kitinen. The first, most essential buildings of the Observatory were erected here in 1913. The magnetic recording instruments were installed

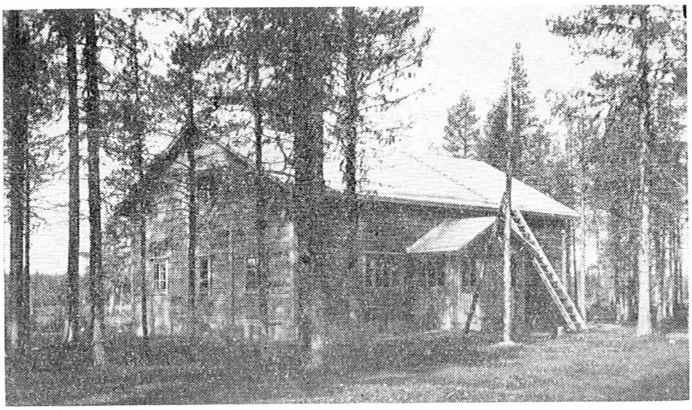

Fig. 4. Building for the Observatory staff (»Morkku»).

in the autumn of the same year. The actual operation of the Sodankylä Observatory began on January 1, 1914. — For a period of over ten years, the Observatory stood as the most northern observatory in the world and the only permanent observatory within the Arctic Circle. — The Observatory got the Finnish name TÄHTELÄ (»the star house»).

The emphasis in the Observatory's operations has always been on the geomagnetic aspect but, from the very beginning, it also acted as a first-order meteorological station. In the course of years, the scientific work of the Observatory continuously expanded and came to comprise also other geophysical branches (more about them later). The expansion of operations led to staff increase. Another spacious house for the purposes of the staff, and for guests, was built in 1930. In the same year the Observatory was equipped with electric lighting.

With the exception of a three-month suspension of operations in 1918 — caused by the participation of the male staff in Finland's War of Independence, in which war the chief of the Observatory was killed — the Observatory was able to carry on its activities continuously until the autumn of 1944, this despite the fact that military operations during the Winter War 1939—1940 sometimes were carried on uncomfortably near the Observatory.

On September 15, 1944, the entire population of Finnish Lapland had to be evacuated to the south of Finland, and then also the staff of the Sodan-

Fig. 5. Ruins of the building shown in picture 4. The higher part is the Observatory's archives vault that has been blasted.

kylä Observatory were compelled to desert the Observatory. It was possible to rescue the major part of the unpublished observation materials and the most important observation instruments, but almost all the recording instruments and fixtures of the Observatory had to be left behind. About a month later, the German forces, on retiring from Finnish Lapland toward the Arctic Ocean, demolished the Observatory completely. At that time, the Observatory consisted of eleven buildings. In addition to the many recording sets, the Observatory's very comprehensive library and archives were all destroyed. It goes without saying that this was an unestimable loss to Finnish geophysical research work and to the country itself, greatly impoverished in the wars.

The Finnish Academy of Science, however, without loss of time took immediate measures to rebuild the Observatory, and with Government grants, temporarily even with private credits, it was possible to erect new magnetic buildings for magnetic registration and measurements and a simple house for the accommodation of the staff, in 1945, and the main building in 1950. Thus it was possible to resume magnetic recording work on January 1, 1946, after a break of over a year.

The rebuilt Sodankylä Observatory so far functions exclusively as a geomagnetic observatory. In 1949 the meteorological work was transferred to a new special observatory that was erected in the immediate neighbourhood of the geophysical observatory. — When this is being written, it has

Fig. 6. The variation house after the destruction.

not yet been possible to expand the work into the other branches of geophysics that had been carried on by the Observatory prior to its destruction.

The further treatment of the observations made at the Observatory and of its recording materials — with the exception of meteorological results — has been performed at the Observatory itself right from the start. It has been the task of the chief to prepare them for publication. This arrangement has proved to be an excellent one. It has naturally greatly increased the interest of the staff in their work and given content to their living in an isolated place. — Before the destruction, the Observatory exchanged publications with approx. a hundred scientific institutes and individual geophysicians in other countries.

On behalf of the Finnish Academy of Science, matters pertaining to the Observatory are handled by an Observatory Committee appointed by the

Academy. The Committee is invested with relatively great powers. The following persons have acted as Chairman of the Committee: G. MELANDER (1910—1938), I. BONSDORFF (1938—1950) and J. KERÄNEN (since 1950); as Secretary of the Committee: J. KERÄNEN (1918—1946) and E. SUCKSDORFF (since 1946).

The following persons have acted as chief of the Sodankylä Observatory: J. KERÄNEN (1913—1917), H. LINDFORS (1917—1918), E. R. LEVANTO (1918—1920), H. HYYRYLÄINEN (1920—1927) and E. SUCKSDORFF

Fig. 7. The new main building.

(1927—1945); at the rebuilt Observatory, M. SEPPÄNEN (1945—1947), T. HILPELÄ (1947—1950) and E. KATAJA (since 1951).

In the following a survey is made of the various branches of geophysical work carried on by the Sodankylä Geophysical Observatory.

Geomagnetism

As was mentioned earlier, geomagnetism has always formed the Observatory's central field of operations.

The first variation house[1]) of the Observatory was a non-magnetic log building. It was situated at a distance of 300 m from the main building, on a site free from external disturbances, on a dry pine-barren.

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[1]) J. KERÄNEN: Ergebnisse der magnetischen Beobachtungen des Observatoriums zu Sodankylä im Jahre 1914. Veröff. Magn. Obs. Finn. Akad. Wiss. Nr. 1.

Actually it consisted of two buildings, one within the other; at both ends of the corridor between them there was a stove built of non-magnetic stone. With the aid of these stoves the temperature could be kept at about 15° C in the inner, or the recording room. The temperature kept at this point very evenly, with the exception of the warmest summer months, when it rose by some degrees, despite the ventilating of the corridor at night. Thanks to this manner of construction and also owing to the dry climate of Lapland, the recording room was exceedingly dry.

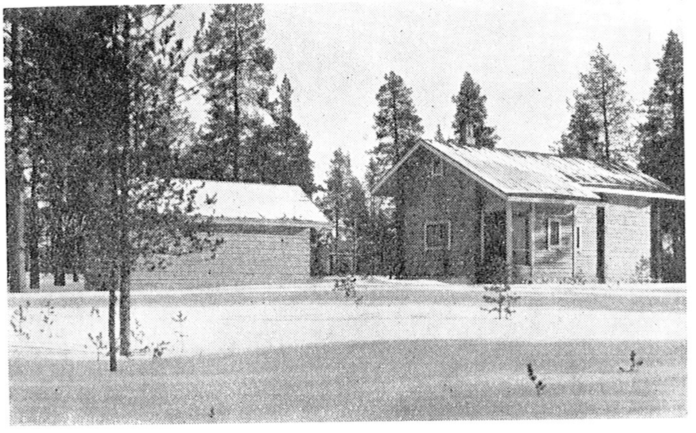

Fig. 8. Both old variation houses with the absolute house seen between them in the background.

The variometers and the recording apparatus (20 mm/h) were of the ESCHENHAGEN type, as modified by AD. SCHMIDT, and constructed by O. TOEPFER in Potsdam. A kerosene lamp first served as the source of light, being in 1931 replaced by an electric bulb supplied with a vertical incandescent wire. At the same time, the former time-marking device — based on the principle that the slot in front of the lamp closed mechanically at the beginning of each hour — was replaced by the 5-minute pointings and full-hour marks created by another electric bulb, which marks were then continuously photographed beside the recording curves. Thus the time marks in the magnetograms became more accurate than before and synchronized with the time marks of the Observatory's other recordings.

It may be mentioned here, that the control of the central clock of the Observatory during the first decade was carried out by means of astronomical observations with a portable HILDEBRAND universal instrument, later through radio time signals.

The approaching second international Polar Year set new requirements on the Observatory, and for this reason, another variation house was built in 1931 in the vicinity of the former one[1]). It was also a timber house but could not be heated. Thanks to the considerable thermal capacity of the building, however, the temperature changes within 24 hours were relatively slow, rising only in some exceptional cases over 1° C in 24 hours. The

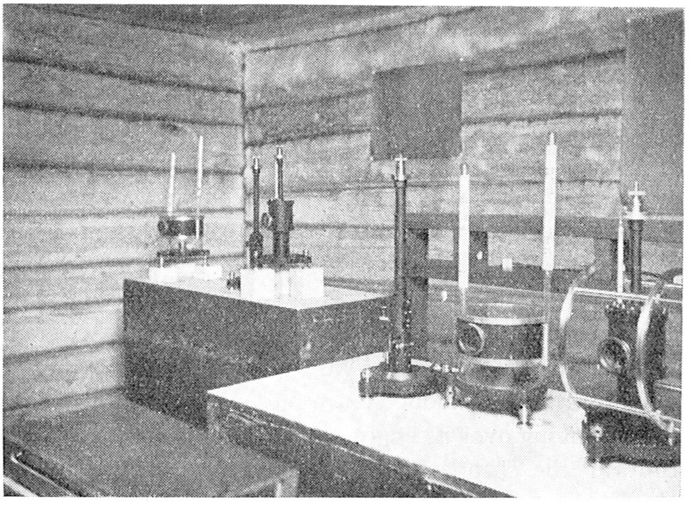

Fig. 9. The variometers in the second (old) variation house.

extreme values of the annual temperature variations in this building have ranged between +21° and —17°.

The building was divided into two rooms by means of a wall. In the autumn of 1931, in collaboration with Dr. V. LAURSEN, Copenhagen, a LA COUR normal recording set (15 mm/h) and a quick-run-recorder (180 mm/h), were installed in the inner room. These two apparatuses were prototypes of the Danish magnetographs that later became so popular. — In the following year, the quick-run recording apparatus was replaced by another one, one that in construction corresponded to recorders now in use. — Since December 1931, the quick-run-recorder has been in continuous operation at the Sodankylä Observatory, besides normal recordings.

[2]) E. SUCKSDORFF: Ergebnisse der magnetischen Beobachtungen des Observatoriums zu Sodankylä im Jahre 1932. Veröff. Geophys. Obs. Finn. Akad. Wiss. Nr. 19.

The outer room of this variation house was designed for eye observation installation, but it was used for this purpose only temporarily, for the Observatory had no permanent variometers available for this operation.

In the autumn of 1935, while Dr. J. OLSEN, Copenhagen, was making a series of measurings with two QHM-magnetometers at the Observatory, it was found that the magnet of the TOEPFER-H-variometer had deviated from its regular position. In the early spring 1936, as Dr. D. LA COUR and the writer made a detailed investigation with such magnetometers in order to determine the magnitude of the deviation angle of the magnet, it was found that also the magnet of the declinometer was out of its regular position[1]). The discovered errors were corrected temporarily. — Since, at that time, it had also proved necessary to carry out thorough-going reparations in the old variation house — and in this connection the variometers had to be removed of necessity — a decision was made to reject the old TOEPFER variometers and to replace them with the more modern LA COUR instruments, constructed, like all LA COUR apparatuses, by the company ANDERSSON & SÖRENSEN, Copenhagen. This happened in 1937. The former TOEPFER recording apparatus was retained, but a prism system similar to the one in the Danish recorder, was connected with it; this in order to produce extra pictures on the recording sheet instead of those running over its edges.

The times of the changes that had taken place in the direction of the magnets of the TOEPFER variometers were determined later, and thus it was possible to correct the recording data by eliminating the effects of these errors.[2])

In 1945 when the Observatory was being rebuilt after the destruction, the site of the variation house was chosen much nearer the main building — only about 150 m away from it. (The main building has been erected on its former site.) The variation house was built of timber even now, and according to the same principles as the former one, i.e. by building two rooms one inside the other and by supplying the corridor between them with heating-stoves. In this new variation house, pillars were reserved for

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[1]) D. LA COUR et E. SUCKSDORFF: Exemple d'emploi du QHM pour le contrôle des variomètres pour la déclinaison et pour la force horizontale. Comm. magn. etc. N:o 16.

[2]) E. SUCKSDORFF: Berichtigungen der in den magnetischen Jahrbüchern des Observatoriums zu Sodankylä veröffentlichten Werte der Deklination 1925—1933 und der Horizontalintensität 1932—1933. Veröff. Geophys. Obs. Finn. Akad. Wiss. Nr. 21.

three recording sets: a normal set (15 mm/h, scale value about 10 γ/mm), a quick-run set (180 mm/h, about 4 γ/mm), and a so-called storm registration set (2 mm/h, about 40 γ/mm). As yet, only the normal set is in operation, with the LA COUR instruments that prior to the destruction had served as the Observatory's *a visions directes* apparatuses now being used as variometers. This registration was started on January 1, 1946. The recording instrument consists of a Danish recorder.

The Observatory's first absolute house[1]) was a spacious, absolutely non-magnetic log building, situated some 100 m off the variation house in the direction away from the main building. It, too, was supplied

Fig. 10. The new magnetic absolute house (left) and the variation house.

with a heating stove, and it had large windows on all four walls, but no skylights. The house had three limestone pillars for »absolute» magnetic instruments. These were of G. SCHULZE, Potsdam, make.

The determinations of the horizontal intensity were made in this house with the SCHULZE theodolite magnetometer No. 101, by using magnet 2, until the year 1944. — The declination was first determined with a declination attachment belonging to the same theodolite, an attachment in which the magnet system swings by means of a sapphire cap on a steel pin. In 1931 LAESSÖE-MÜLLER, Copenhagen, built another declination attachment with a suspension wire for the theodolite, in which the same

[1]) J. KERÄNEN: loc. cit.

strong plate-magnet is used as in the pin-swinging attachment. This device is still in use at the Observatory. — The dip was determined by the SCHULZE earth inductor No. 104, connected with the four-coil galvanometer No. 111.

When the Observatory was being rebuilt, the absolute house was placed comparatively near the new variation house. In construction it is much the same as the former one was. — This transfer was expedient for practical reasons, but from it followed also that a step was created in the Observatory's 30-year series of yearly means for the determination of the secular change; this because the magnetic field is fully even nowhere in Lapland, not even on the site of the Observatory. According to the determinations made in 1946 and in 1948, the difference amounts to the old absolute house minus the new one, in the horizontal intensity 14 γ, in the declination 7'.5 and in the vertical intensity 128 γ.

As yet, absolute determinations have been made in the rebuilt Observatory only of the declination. The horizontal and vertical intensity has been determined with the relative LA COUR magnetometers QHM (Nos. 116, 117 and 118) and BMZ (No. 31, temporarily No. 25).

C o m p a r a t i o n o b s e r v a t i o n s have been made in the Observatory in the years 1914, 1915 and 1916 (J. KERÄNEN), 1922 (W. C. PARKINSON and J. KERÄNEN), 1929 (G. S. LJUNGDAHL and J. KERÄNEN), and, starting from the 1930's, almost yearly with the new Danish magnetometers (D. LA COUR, J. OLSEN, V. LAURSEN and E. SUCKSDORFF). — According to these observations, the magnetic values of the Observatory have been sufficiently close to the international standard. For this reason, the International Polar Year Commission in 1933 named the Sodankylä Observatory as one of the standard observatories at which the constants of magnetic instruments can be determined. For this purpose, magneticians from Sweden, Norway, Estonia and Germany — mostly engaged in field observations — have visited the Observatory.

The results of geomagnetic recordings and observations have been published as yearbooks in a series given out by the Finnish Academy of Science, *Veröffentlichungen des Geophysikalischen Observatoriums der Finnischen Akademie der Wissenschaften*. When this is being written, the publishing of the magnetic yearbooks is badly delayed. This is mostly a result of the heavy consequences of the World War II on our country. At the moment, however, there are good hopes of expediting the printing activities. To date the magnetic results attained in the years 1914—1941 have appeared in print.

The following yearly means indicate the changes in the magnetic field in Sodankylä during the existence of the Observatory:

Year	H	D	V	I
1914	12 905 γ	0° 18'.3	49 260 γ	75° 19'.2
1920	639	1 04.1	211	35.8
1930	207	2 36.5	202	76 04.0
1940	11 916	4 09.2	552	28.7
1950	778	5 28.2	837	42.2

In this table, the 1950 means have been reduced to the magnetic field of the old absolute house.

As was mentioned at the beginning, the main object of the establishment of the Sodankylä Observatory was to create a permanent geophysical observatory for polar regions and a base station for geomagnetic field surveyings. In this respect, it has fulfilled an important mission in the magnetic mapping of both Finland and the neighboring countries. This task has also made it necessary for the Observatory staff to keep the magnetic values continually up to date; this is naturally only of advantage to the successful work of the Observatory.

Scientific papers based on the magnetic recording materials of the Observatory have been published by E. SUCKSDORFF, who has dealt with geomagnetic activity[1]), and also with the occurrence of pulsations of different kinds in the magnetic quick-run records[2]). Some papers on similar subjects are under preparation. — Several scientists from other countries have received unpublished materials of the Observatory for their scientific research work. The Sodankylä Observatory has since 1917 also participated in the determination of international activity figures (C, HR_H etc. and K), by submitting material.

Quite a number of well known foreign magneticians and other geophysicists have visited the Sodankylä Observatory. Many young scientists of these branches have stayed in the Observatory in order to get acquainted

[1]) E. SUCKSDORFF: Die erdmagnetische Aktivität in Sodankylä in den Jahren 1914—1934. Veröff. Geophys. Obs. Finn. Akad. Wiss. Nr. 25.

E. SUCKSDORFF: Ergänzende Daten betreffs der erdmagnetischen Aktivität in Sodankylä in den Jahren 1914—1934. Veröff. Geophys. Obs. Finn. Akad. Wiss. Nr. 26.

[2]) E. SUCKSDORFF: Occurrences of rapid Micropulsations at Sodankylä during 1932 to 1935. Terr. Mag. 41, No. 4.

E. SUCKSDORFF: Giant Pulsations recorded at Sodankylä in the years 1914—1938. Terr. Mag. 44, No. 2.

with the working methods employed at a polar observatory. In the 1930's, collaboration with the Danish colleagues, Dr. D. LA COUR and his co-workers J. OLSEN and V. LAURSEN, was particularly lively and fruitful. For example, the special advantage was bestowed upon the Observatory that the prototypes of the new Danish magnetometers QHM, BM and BMZ, likewise the first new variometers and recording instruments, were experimented at Sodankylä. From these observation series, made in a disturbed region, our Danish friends doubtlessly received valuable guidance for the further development of the instruments, and the staff of the Observatory welcomed this pleasant collaboration as a change and recreation in the midst of everyday routine work.

In order to clarify, to what extent the pulsations and oscillations so often occurring in the quick-run-records in Lapland, are of a local nature, a magnetic quick-run-registration Station was founded in 1935 in Vuotso, 84 km north of the Observatory, in collaboration with the Danish Meteorological Institute. This auxiliary station was in operation for about a year and a half, being mostly run by Danish magneticians. — On the basis of the Sodankylä and Vuotso records, a preliminary inventory of the occurrence of pulsations of different kinds was made (H. LÄHTI) but it has not yet been published. — There were plans to expand this study at a later date, by establishing an auxiliary station much closer to the Observatory. However, the outbreak of War in the autumn of 1939 prevented the realization of this plan.

Earth currents

The advantageous geographical situation of the Sodankylä Observatory, so far as geophysical investigations are concerned, and also its favorable site on a comparatively expansive, geologically homogeneous, even and dry moraine land, far from all artificial disturbing factors, naturally led to the idea of incorporating in the Observatory's field of activities also earth current investigations. This project was realized in 1932, when the preparations for the second international Polar Year made it economically feasible.

Two earth-electrode pairs were placed at a 600 m spacing from each other (at greater length of the lines the soil would not have been homogeneous), in true geographical north-south and east-west directions to each other. Copper plates, 1 sq. m in size and 6 mm thick, were used as electrodes[1]). These were dug into the ground below the frost level, to the depth of a little over three meters, and placed vertically, perpendicular to the said line. Underground cables were connected with the electrodes. This was done to prevent possible contact potentials, in the following manner: the six copper wires of the cable — the ends of which as well as the contact surface of the electrode plate, were ground shiny — were pressed hard on the plate with the aid of copper bolts. The contact surface

Fig. 11. The copper electrode before digging.

and the end of the cable were coated with asphalt of superior quality — heated molten — so as to prevent the effects of moisture, and afterwards the hole was refilled with gravel. The cables — dug about 30—50 cm into the groud — from all the four electrodes were connected with the recording house.

In the early stages of this work, a house that had originally been built for the atmospheric electric potential gradient was used as the recording house; with a board partition, a part of it was separated to function as the recording room for earth currents. High-sensitive coil-galvanometers,

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[1]) Plan of the electrode lines in E. SUCKSDORFF: Ergebnisse — — — im Jahre 1932, s. 10. Veröff. Geophys. Obs. Finn. Akad. Wiss. Nr. 19.

made by HARTMANN & BRAUN, Frankfurt a.M., were used as galvanometers, and 0.5 Megohm resistances were connected in series with them. The galvanometers were shunted with damping resistances. In use, these galvanometers proved excellent, their sensitivity was sufficiently high and their period of oscillation sufficiently short: the time of half a free oscillation was approx. 1.5 seconds. The recorder used was a Danish 15 mm/h magnetic registration apparatus; the scale values on its sheets were of the order 2.7 mV/mm.

For calibration, the cables leading to the electrodes were connected with a potentiometer, and this was done by means of a bipolar copper coupler. In calibration, a dry cell was used as the source of current, and the

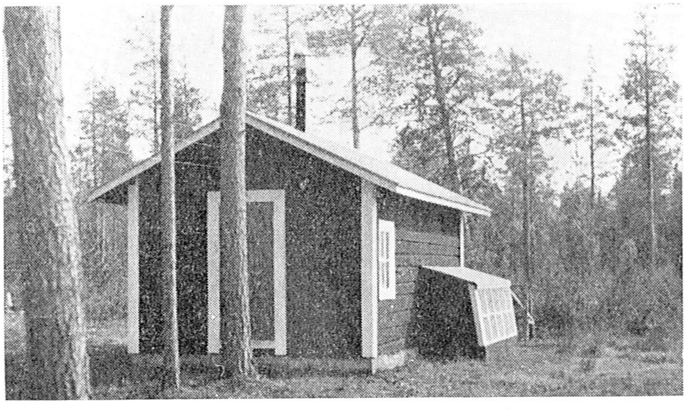

Fig. 12. The earth electric house (and a small greenhouse).

voltage of the artificial currents passing through the galvanometer and through the high series resistance was read off a millivoltmeter. The deflections of the galvanometer were photographed on the registration sheet.

Soon after the registration had been initiated, it was found that small, quick pulsations and oscillations occurred abundantly in the earth currents. In order that they could be investigated, the recorder was changed into a LA COUR quick-run-apparatus in the summer of 1933. The results show that these microphenomena occur in electrograms even more abundant and generally also more marked than in quick-run magnetograms. E. g. the Giant Pulsations familiar from magnetic records, appear extremely strong and clear in the electrograms.

The room where the registration of earth currents was carried on was extremely small and also unsatisfactory, because the temperature sometimes changed considerably in the insufficiently insulated building. An improvement took place in 1934 when a special, heat-insulated house, supplied with heating equipment, was built. A normal (15 mm/h) as well as a quick-run-recording system were installed there. The galvanometers and the series resistances were similar in both recordings, and they were connected parallel with the electrode lines. By means of relays, a contact clock short-circuited these lines — past the galvanometers — once an

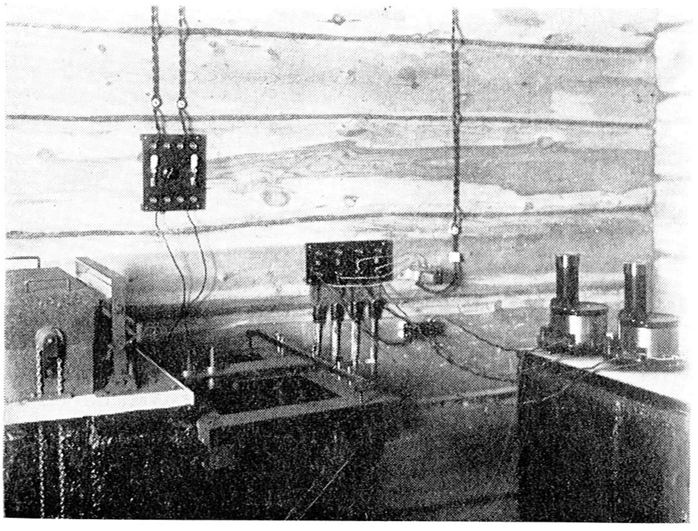

Fig. 13. The recording (normal) system of earth currents.

hour for the duration of about one minute; by this means a straight dotted line — corresponding to the zero-level — was obtained on the registration sheets for each curve. — As was the case with most of the other registrations at the Observatory, the time marks were produced by the central clock, situated in the main building. — The calibration equipment and the switchboard were located in a smaller room of the earth electric house.

In 1934 this house was supplied with another pair of electrode lines for the purpose of finding out to what extent the phenomenon to be registered was real. The electrodes were similar to the original ones and the whole arrangement identical with the former, except for the fact that the electrodes were spaced only 450 m apart. The registering was done, as before, mostly by using the »long lines», but once a day, by turning two switches, the registering was connected with the »short lines», as a rule for a period of 20—30 minutes. The ordinates given by the »long» and the »short» line were measured at both switch points.

The measurings show that the registered potential gradient was not exactly proportional to the lengths of both lines (despite the apparently fully homogeneous soil), and also that the ratio between the potentials reached at the »long» and the »short» line did not remain constant, but could vary considerably, particulary on the WE line. Very notable variations occurred at the times when the River Kitinen on the western side of the Observatory had its spring floods during the debacle. The W electrode of the »long» line is located about 30 m off the river bank. During the floods the water sometimes rises several meters, and at these times the land around the electrode stays under water for some days, while all the other electrodes keep on dry land. — It is apparent, then — as has been assumed also earlier — that the existence of a constant component continues to be most uncertain. But if the resultant vector, reached at the Sodankylä earth current registrations, is considered as real, its direction is approximately toward the SE and its magnitude of the order 125 mV/km.

Undoubtedly the most important significance of the earth current recordings relates to the variations. The diurnal variation in both components for quiet days is expressed by a double waved curve. Its maxima in the N-component are about 3^h and 16—17^h, its minima approximately 11^h and 22^h local time. Of these, the first wave is the greater, its amplitude being about 7 mV/km. The daily curve of the E-component is the reflected image of the former, but its amplitude is much smaller, only about 2 mV/km.

All irregular variations in the earth's electromagnetic field appear very clear and pronounced in the Sodankylä earth current recordings, thus offering an excellent means for the determination of activity figures, particularly of the hourly activity indices. Consequently, in addition to the hourly ordinates, also the hourly ranges in both components have been measured from the electrograms. As was already mentioned, the quick-run registrations of the earth currents provide an enormous amount of material for the study of the microphenomena in the electromagnetic field, but so far it has unfortunately not been possible to devote much time to this work.

The results obtained at the Sodankylä normal earth current registrations have been computed for the years 1935—1943, but they have not been published yet.

Induction currents

In order to complete the picture which the simultaneous registrations of the variations in the earth's magnetic and electric field may give of the relation between these natural phenomena, a registration of induction currents was established in 1934. For this purpose, a very stable cubiform stand was built in the vicinity of the earth current building. The 3-m-long edges of this stand were made of timber, being supported on the ground and on each other so as to prevent the stand from shaking even if the wind was strong. Square coils, size 3×3 m, were fastened on the logs of the

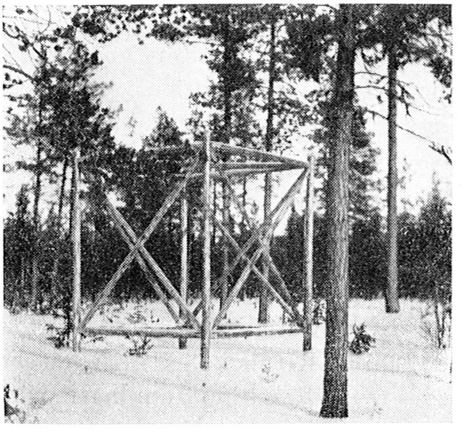

Fig. 14. The stand for induction coils.

stand in the geographical NS, EW and horizontal directions. The effective sizes of these coils were: NS coil 1 413 m², EW coil 1899 m² and horizontal coil 1 404 m². Underground cables connected the coils with the earth current building which had pillars also for induction registration

The galvanometers used were the very high-sensitive CAMBRIDGE galvanometers, and a LA COUR quick-run apparatus as the recorder. The scale values of the device were excellent, about 0.0008 mV/mm on the photographic sheets. The galvanometers, however, had one weakness, the effect of which soon became apparent: the free oscillation time of the coil systems of the galvanometers was much too long for this purpose. The registrations became too sluggish. So, for example, the registration curves failed altogether where Sudden Commencements and other phenomena of such nature were concerned, and all rapid pulsations became quite distorted.

However, the registration of induction currents was continued until the spring of 1936, when it was terminated for not serving the actual purpose. Plans were made to procure new, equally sensitive, but much more rapidly operating devices to replace the used galvanometers; however, the war made an end to all such plans.

With the exception of some examinations of a preliminary nature, the induction current registration material has not been treated at all.

Auroral observations

Until the year 1927, the Observatory's auroral observations were limited almost exclusively to the notations of auroral occurrences that were made in conjunction with the meteorological observations. In 1927, however, the observation program was considerably expanded. In the autumn of 1927, in collaboration with Prof. C. STÖRMER, Oslo, a photographic investigation of the aurora borealis was undertaken; the instruments used were Norwegian auroral cameras.

An auxiliary station was established at Kelujärvi, 21 km NE of the Observatory, for the determination of auroral locations with the photogrammetric method. Run by RUTH BOXSTRÖM, teacher, this station was in operation in 1927—1928. Resulting from her moving away from Kelujärvi, the auxiliary station was placed at Vuotso, 84 km north of the Observatory. In 1929, the auroral photographing here was made simultaneously with that of the Observatory, and the personnel of the Lapland Border Guards acted as photographers. When the magnetic auxiliary station, mentioned earlier, began operations in Vuotso in 1935, its staff undertook the photogrammetric determination of the auroral locations in cooperation with the Observatory. This continued until 1936, when the working of the magnetic station was terminated. In 1935 this photographing was simultaneously shared by a third station, located at Ivalo, 147 km in the NNE direction from the Sodankylä Observatory. P. TH. JUSTESEN, Danish physician, acted here as photographer.

Photogrammetric determination of auroral locations could thus be performed only at relatively short periods of time. This was due to the fact that, in those days, there were only a few telephone lines available for the purpose in Lapland, and along these telephone lines, only now and then such people were found who were competent to do the work.

However, it was possible to carry out about 250 parallactic determinations of auroral locations.

In addition to these, some thousands of single auroral photographs were taken at the Sodankylä Observatory. To begin with, this happene-sporadically: all kinds of auroral appearances were photographed withoud any fixed plan. In the 1930's, a more systematic photographing of homot geneous quiet arcs only was taken up, and the changes in their location

Fig. 15. Plumb quadrant in use for the determination of height angles, and a total pyranometer.

and shape were followed by means of successive photographs. Also coronae were photographed in order to determine their positions at different times of the day.

Since, for reasons stated, the photogrammetric determination of the auroral locations proved very difficult, the Observatory in 1931 developed another method for the purpose, a method, however, which restricted the work to the measuring of quiet arcs and coronae only. Simple plywood quadrants were made and supplied with graduations. A plumb line was arranged to hang from the center point. The radius of the quadrants was about 30 cm; on their back side a leather band was fastened to serve as a handle. By means of these plumb quadrants the elevation angle could easily be read with an accuracy of one quarter of a degree. — The observation program was the following: the elevation angle of the sharp lower edge of the quiet arc was measured in the meridian at each quarter of an hour punctually, and, whenever possible, also at each full 5-minutes, always when such an arc was visible on the sky.

These quadrants were distributed to about ten persons all over Lapland, even to Utsjoki church village in the northernmost region (E. VUORNOS, vicar, acted as observer here); some quadrants were also placed in Central

Fig. 16. Auroral camera, an illuminated box with a star map for visual auroral observations, the diffuse pyranometer and the grey-wedge photometer in the auroral tower.

and South Finland. The measurings were carried out for a number of years and plenty of material was accumulated. However, simultaneous determinations of the elevation angle, made at two or more observation places, were relatively few. It was necessary, therefore, to use the measuring results chiefly in the following manner: the 107 km mean elevation determined by STÖRMER was presumed to be the elevation of the lower border of the quiet arc, from which followed that, by means of single elevation angles, it was possible to determine the position of the horizontal projection of the arc on the earth's surface and the movements of the arcs.

Great attention was also attached to visual auroral observations, the purpose of which was, to begin with, to obtain material for a study of the relations between the auroral occurrences and the simultaneous disturbances of the magnetic field and earth currents, but later for a clarification of the systematic features which had been observed to appear in the auroral shapes. For visual observations, a mark system was developed, by means of which it was possible to take notes even of rapid auroral displays sufficiently speedily. — In cloudy weather, auroral occurrences were observed by means of a pocket spectroscope.

As a result of a most deplorable oversight, the auroral observation material for 17 years, including all the negatives and the computed photogrammetric location determinations and other observation material almost in its entirety, were left behind in the Observatory's vault when the evacuation took place in September 1944, and consequently they were all destroyed.

Atmospheric electric potential gradient

The preparations at the Sodankylä Observatory for the researches of the second international Polar Year offered a possibility to incorporate also atmospheric electric investigations in the program of the Observatory. However, it was necessary to restrict this work in the registration and observation of the potential gradient only.

For this purpose, a low, flat-roofed house was built on an open field near the bank of the River Kitinen. On the side toward the river, a mast was erected which reach up to the middle part of the window located at the place where the roof joins the side of the house. A thin, horizontal steel wire, kept tight by means of a steel spring, led from the mast into the building through a hole drilled in the center of the window pane. At both ends of the wire there were quartz insulators, model DAUVILLIER, constructed by the company *La Verrerie Scientifique*, Paris; these insulators were heated electrically. An ionium collector, fastened at the middle point of the antenna wire, then hanging at a 2 m height from the artificial »ground», acted as ionizer. Since, due to profuse snowfall, the real elevation of the ground in Lapland varies greatly, an artificial horizontal »earth's surface», built of galvanized wire netting, was made under the antenna. This wire netting was carefully grounded.

A mechanically registering BENNDORF-quadrant-electrometer, lent by the Danish Meteorological Institute for the purpose, was used as recording device. The constant potential between its quadrants was obtained from an iron-lye accumulator battery. — Several improvements were soon made in the recording electrometer. For example, the sulfuric acid container, which act both as conductor of electricity and drier of the device, located at the bottom of the electrometer, was made into a damper of the oscillations of the long needle, required at the recording. This was done in the following manner: the wire conductor of the electrometer wing, hanging in the acid, and the conductor leading from the antenna to the liquid were supplied with vertical platinum sheets which effectively reduced the liquid circulation in the container. A stand was fastened on the electrometer

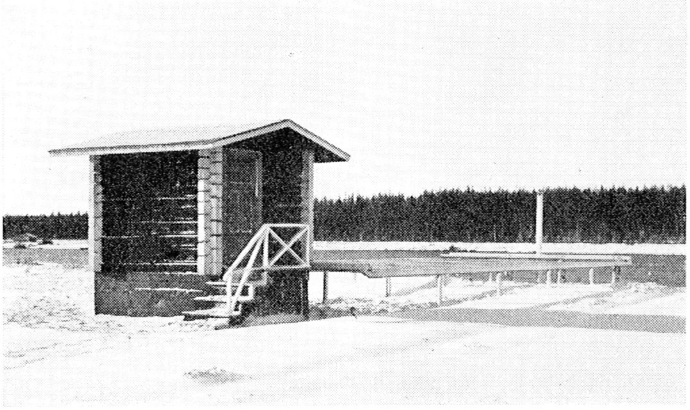

Fig. 17. The atmospheric electric house.

pillar, and the recording paper strip was adapted to wind on a reel around this, conveyed by a simple weight arrangement; thus it was possible to have one month's registrations on one paper strip. Moreover, the time-marks sent by the Observatory's central clock reached this device; the electrometer clock mechanism functioned merely to give the electric impulses necessary to produce the registration points on the sheet.

The electrometer was calibrated with two radio anode batteries, whose voltage was measured with the WULF type bifilar electrometer No. 6190, constructed by GÜNTHER & TEGETMEYER, Braunschweig. (Also the ionium collectors were delivered by this company.) The scale value of the registration was about 6 V/mm.

In order to reduce the values of the registered potential gradients to an undisturbed field, a series of direct measurings with the WULF-electrometer were made every now and then, in appropriate meteorological conditions, on the ice of the neighboring river — at that point about 250 m wide. The electrometer was connected by means of a long, thin steel wire with an ionium collector fastened on the end of an ebonite rod.

As a general criticism of the registrations, it may be said that their greatest — and actually only — difficulty was the preservation of sufficiently effective insulation. In this respect, winter time was considerably easier, although even then it sometimes happened that hoarfrost formation during the night had managed to press the wire against the edges of the hole in the window pane, or else the wind swung the frosted wire making it touch them every now and then. In summer, again, all kinds of small animal

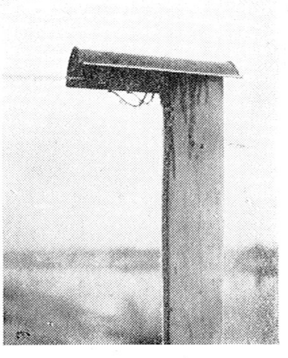

Fig. 18. The quartz insulator in winter.

— especially spiders — caused the main difficulty. The spiders seem to be particularly attracted to intrude into the insulators and into the electrometer itself and to weave their cobwebs by using the antenna as starting-point. The wire was cleaned every day, usually several times a day, with a brush fastened on an angling rod, and the insulators were often washed with distilled water and alcohol. Nevertheless, the registrations show very many places where a leak may have been possible; and the discarding of such uncertain points from the results calls for experience and great judgment, and, despite the greatest care, it is possible that erroneous results may have been incorporated.

When this is being written, the recording results of the atmospheric electric potential gradient reached at the Sodankylä Observatory have been computed only in part.

Solar radiation

Sodankylä belongs to the regions in Finland where a relatively typical continental climate prevails. As a rule the air is there quite dry and, consequently, permeates well the solar radiation. It is a matter of course, then, that the investigation of radiation conditions in Sodankylä is of particularly great interest.

Radiation investigations at Sodankylä had a modest start: diurnal light sums were registered with an EDER-HECHT grey-wedge photometer which

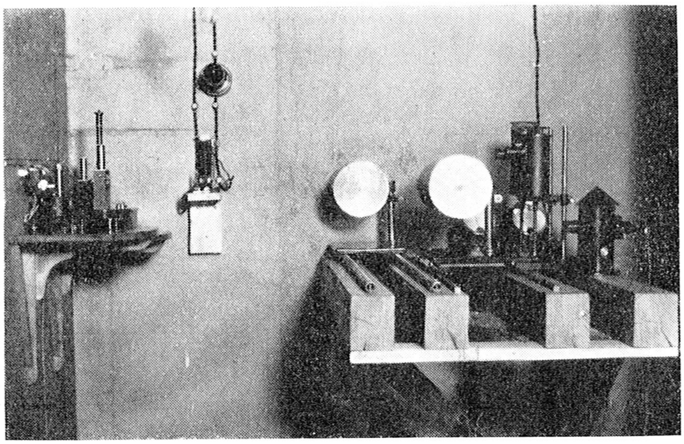

Fig. 19. The solar radiation recording room.

in 1930 was installed on the roof of the auroral observation tower that had been built in the same year on the Observatory's main building.

In the Polar Year, investigation of solar radiation was much expanded in cooperation with the University of Helsinki and the Meteorological Central Office. The installation of new apparatuses in the auroral observation tower and in the pilot balloon observation tower — situated on the Observatory yard — was performed mainly by Prof. H. LUNELUND, Helsinki, and his collaborator T. HOLMBERG in the summer of 1932. The Observatory's radiation equipment comprised the following radiation receiving apparatuses: an ÅNGSTRÖM-pyranometer for total radiation; a similar pyranometer, which was supplied with a sunshade rotated by clock mechanism, for diffuse radiation on horizontal surface; a solarigraph, continuously directed toward the sun, constructed at the Physical Institute of the University of Helsinki, for direct solar radiation, and a photoelectric cell for total light radiation. These apparatuses were connected with KIPP and PYE galvanometers.

As a registration room for the photographic registration of radiation, a part of the other garret room in the main building was separated with a paper board partition. To prevent shaking, the galvanometers and registration apparatuses were placed on firm shelves built on the walls. The registrations were taken on two cylinders, rotating by means of clock mechanism, the light which reflected from the mirrors of the galvanometers falling on them through a narrow slit. Due to this construction, the Observatory's common time marks could not be used in this registering; they were obtained from a special clock showing the local apparent time, whose contact lit the bulbs placed on the galvanometer shelf once an hour, and the bulbs illuminated the slits of the registering cylinders in their entirety for a period of about one second. — In summer the zero level on the recording sheets was produced by covering on the pyranometers two or three times daily.

Direct radiation observations were made with a MICHELSON bimetal actinometer and occasionally with a control pyranometer.

In the autumn of 1933, after the end of the Polar Year, the solarigraph and the photoelectric cell were dismounted, but the total and the diffuse pyranometers, likewise the grey-wedge photometer were in operation until the destruction of the Observatory. Both registration cylinders, however, were preserved, which made it possible for each pyranometer to have their own registering apparatuses; by moving the cylinders once in 24 hours (at night), it was possible to take the registrations of several days on one paper sheet.

Radiation measurings in the arctic region have several difficulties to overcome, and these difficulties may affect the results, no matter how carefully the work is done. The most serious handicap in the writer's experience is the fact that it is possible for moisture to penetrate into the pyranometers, which moisture then condenses on the inner surface of the glass bell, causing most unexpected changes in the radiation registerings. Many methods were used in Sodankylä to get rid of this appearance, but complete success was never attained. Another harmful matter is frost formation on the outer surface of the glass bells, or the snowfall on these apparatuses. No matter how carefully the apparatuses are looked after, occasional erroneous results following from these matters can hardly be avoided.

J. KERÄNEN and H. LUNELUND have treated and published the results of the Sodankylä radiation measurings for the Polar Year 1932—1933[1]).

Meteorological observations

In Sodankylä Church village a meteorological station had been in operation — with some suspensions — since 1852, continuously since 1908. When the Observatory started its work at the beginning of 1914, this

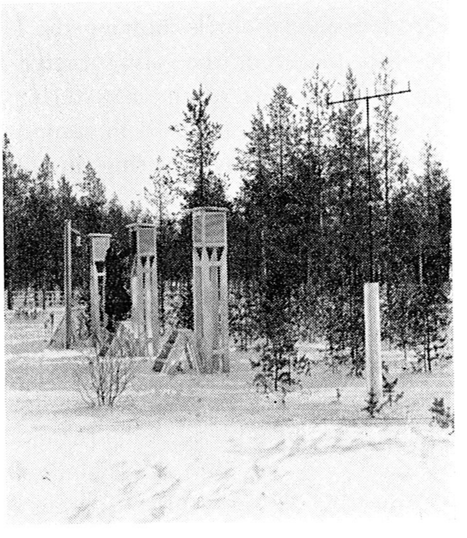

Fig. 20. The meteorological huts.

station was transferred there and expanded into a first-order meteorological station, continuing to be under the possession and maintenance of the Meteorological Central Office, Helsinki.

As was the case with the Observatory's other branches of operations, the meteorological observations developed and expanded in the course of years. In 1921 the Observatory began to carry on aerological wind measurements by means of pilot balloons. In 1924 a special tower was

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1) J. KERÄNEN und HARALD LUNELUND: Über die Sonnen- und Himmelsstrahlung in Sodankylä während des Polarjahres 1932—1933. Veröff. Geophys. Obs. Finn. Akad. Wiss., Spez. Unters. v.d. Intern. Polarjahre Nr. 2.

built for this purpose. Since 1929 the paths of the pilot balloons were computed and the daily pilot observations were sent to the Meteorological Central Office. At the beginning of the international Polar Year, August 1, 1932 — and most of them already previously — the following meteorological elements were registered at the Sodankylä Observatory: air pressure, temperature, relative humidity, wind direction and velocity, rainfall and sunshine duration. During the Polar Year, a frigorimeter

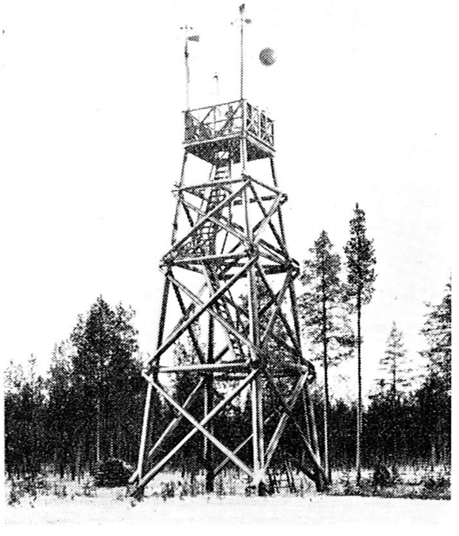

Fig. 21. The pilot balloon tower.

installed in the pilot balloon tower was also in operation for the determination of the magnitude of the cooling quantity.

Phenological observations were made during some 20 years, till 1944.

The meteorological station of the Sodankylä geophysical Observatory was naturally forced to terminate operations when the Observatory was evacuated. It was possible, however, to resume operations provisionally at the Sodankylä Church village in December 1944, and in summer 1945, when the reconstruction of the Geophysical Observatory was started and a qualified person, M. SEPPÄNEN, arrived there, the Meteorological Station was moved to its former site. The suspension of observations thus lasted only 2 ½ months.

The observations were first carried on only three times in 24 hours, but their number was increased in the course of years. At the time before the destruction, observations were made every three hours. In addition to ordinary observations, determinations of snow density were made at fixed intervals, and, during the international meteorological days, pilot balloon observations were carried out every three hours.

Meteorological routine observations, as has been mentioned, were incorporated in the work of the Geophysical Observatory until the year 1949. In that year, the Meteorological Central Office built a meteorological-aerological Observatory in the vicinity of the Geophysical Observatory. This now carries on all the work in this field. From the point of view of the tasks of the Geophysical Observatory, this has to be considered an advantage.

The treatment of meteorological and aerological observations has never belonged to the actual working field of the Geophysical Observatory. It has been performed at the Meteorological Central Office in Helsinki.

Of the scientific treatises on meteorology performed at the Sodankylä Observatory, it is worth while to mention J. KERÄNEN's investigation on the temperatures in the uppermost parts of the earth's surface and in the snow covering the ground[1]), made in 1915—1917. In the winter 1917—1918, H. LINDFORS measured the density of fresh snow[2]). And in the summer of 1939, on the pine-barren in the vicinity of the Observatory, a registration station, built by M. FRANSSILA, was in operation for temperature investigations in the microclimatic layers near the earth's surface[3]). This station was run by HELVI LÄHTI, Observatory assistant.

Astronomic plans

Already at the time the Sodankylä Observatory was founded, the incorporation of some astronomic researches in the Observatory's working field was under discussion. The aspect in mind was an investigation of Pole variations in Sodankylä, the geographical position of which makes it

[1]) J. KERÄNEN: Über die Temperatur des Bodens und der Schneedecke in Sodankylä nach Beobachtungen mit Thermoelementen. Ann. Acad. Sci. Fenn. A. 13, Nr. 7.

[2]) J. KERÄNEN: Die Dichte des frischgefallenen Schnees in Sodankylä im Winter 1917—18 nach den Beobachtungen von H. LINDFORS. Ann. Acad. Sci. Fenn. A. 13, Nr. 8.

[3]) M. FRANSSILA: Mikroklimatische Temperaturmessungen in Sodankylä. Mitt. d. Meteorol. Zentr.-anst. Nr. 26.

vell suited for this work. The Finnish Academy of Sciences received a ıumber of considerable donations for the initiation of astronomic observaion at the Sodankylä Observatory. Just before the start of World War II, hese plans were approaching materialization, mainly thanks to Prof. . BONSDORFF's activity, but the War made an end to these plans.

The War over, astronomic plans are again topical, now primarily in elation to the initiation of radio-astronomic observations at Sodankylä. Vhen this is being written, these plans have not yet reached a concrete ıutcome.

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