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ERNESTO GHERZI
Pontifical Academician

SVMMARIVM — Complura animadvertuntur de radiophonica transmissione undae continuae 80 kHz, quae a statione Defense Research Telecommunications Establishment, prope Ottawa, facta est et in geophysico Collegii Jean de Brébeuf observatorio, prope Montréal, recepta est.

ABSTRACT

One hundred and thirty four 24 hours recordings, made in 1967 at the Geophysical Observatory of Collège J. de Brébeuf, in Montréal, show that at an ultrahorizon distance of 124 statute miles a strong and sudden sunrise fading of a 80 kHz radio transmission is not a regular daily event. At sunset the amplitude, the only element of the transmission considered, increases gradually without any sudden and strong

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transition. The times of the sudden fading at sunrise are variable and not strictly correlated with the astronomical sunrise times, nor with the solar zenith angle. Sixty to seventy per cent of the sudden and strong to moderate sunrise fadings happened at times when the synoptic weather conditions at the receiving station were either frontal (not necessarily stormy) or cyclonic (extratropical depressions).

* * *

The pioneering research work made, years ago, by BUREAU [1] of France, Prof. LUGEON of Switzerland [2], Prof. NORINDER and others on the propagation of low frequency atmospherics is well known to radio scientists. More recently a similar but somewhat more complete technique has developed. Articles on the propagation characteristics of long radio waves (10-100 kHz) have become very numerous. To quote them all would be an impossible task. Our discussion will consider mostly the results published recently in the « Special Issue on « Long Radio Waves Propagation » edited by « Radio Science » [4].

EQUIPMENT

At the Defense Research Telecommunications Establishement near Ottawa, since 1960, a frequency stable transmitter, currently controlled by a rubidium vapor frequency standard, radiating a continuous wave on 80 kHz, has been in action.

Its geographical location is at Lat. 45°36′ N and Long. 75°89′ W and the radiated power is about 400 watts. The transmission antenna is a 135 ft. vertical tower with a radial earth mat.

At the Geophysical Observatory of Collège Brébeuf, where the recordings have been made, the receiving antenna is located at Lat. 45°30′ N and Long. 73°37′ W. The altitude of the station is 112 meters above sea level.

The receiver's antenna is a large vertically crossed-loops BELLINI-TOSI direction finder of the British Admiralty, type A.P.N.W. 5483. It is located on top the roof of the Collège at about 28 meters above the surrounding lawn ground. The horizon in the W to N quadrant is practically unlimited. Some near-by buildings would make unreliable bearings taken in the S and E quadrants. The receiver's circuit is a standard superheterodyne. Since we knew the location of the transmitter no additional vertical aerial was added for eliminating the 180° ambiguity. The vertically crossed-loops were always kept with one loop looking N and S and the other E and W.

We tuned to the maximum intensity output of the transmission received. It compared quite well within 2 or 4 degrees with the bearing of the absolute minimum output, checked with a meter. It gave a bearing of W by N. The accuracy of the BELLINI-TOSI direction finder is of the order of 2-4 degrees in azimuth.

It is well known that the bearings obtained with a vertical loop antenna will be correct if the passing radio waves are also vertically polarized. At night the ionospheric reflexions cause horizontally polarized down coming components of the waves. Polarization errors will be caused in the loops. Such a « night effect », difficult to calculate, has been neglected when we will give some relative values of the night oscillations recorded. At that time the sky wave is apparently stronger than the ground wave, even at the rather short distance of Ottawa to Montreal. Of course the interaction between the sky and the ground wave should be taken into account. We were not sufficiently equipped for trying such a discrimination.

OBSERVATIONS

Owing to a lack of a high precision frequency oscillator for 80 kHz, we have not been able to examine the frequency and the phases shifts and oscillations of the Ottawa transmission. We will consider only the amplitude behaviour during the 134 days of 1967 for which we have good recordings. The fact that, at times, the transmitting station has been silent and that mechanical troubles or dubious timing developed at the receiving station, the number of daily data has been reduced. Nevertheless, notwithstanding these handicaps, the data at hand are worthy a radiometeorological discussion. Most of the articles published on the propagation of long radio waves concern their reception at very great distances from the transmitter. Moreover these radio waves are, most of the time, Morse modulated signals. We prefer the use of a continuous radio wave as the one from Ottawa which interested us.

The reduced documentation available at a private research station made impossible any significant comparison with researches made somewhat sporadically elsewhere [5] between not very distant stations. The Ottawa radiating tower is only about 124 land miles from Montreal but we were pleased to know that this experimenting station was interested also with receptions made at a rather short distance, beyond the horizon.

Since the polarization of the transmitted waves was vertical as that of the BELLINI-TOSI receiving crossed-loops antenna, the « night effect », already mentioned, should have been only slightly felt. Not knowing the threshold sensitivity of the Montreal receiver no *d*B variations of the amplitude can be given; only relative values were calculated on the trace of the Angus recorder.

RESULTS

In the « Radio Science Special Issue on Long Radio Waves Propagation » some phenomena are commented upon which were also present in the 80 kHz transmission under review. Nevertheless we noticed that in the numerous articles of this symposium no mention is made of the meteorological conditions at the receiving station. The behaviour of the different modes of the propagation is thoroughly discussed, models of the ionosphere are proposed and seasonal intensities described.

In our research we paid also attention to the local synoptic distribution and quality of the atmospheric air masses at the times of strong and sudden « sunrise fadings ». We call strong and sudden this « sunrise effect » when the actual amplitude of the reception is at least twice that of the daylight hours and when the drop requires only 2 to 5 minutes of time (Plate I).

This so called « solar sunrise effect » has been known since many years. Nevertheless one gets the impression, in reading many articles, that a strong and sudden fading at sunrise is a daily occurence. The research made on 80 kHz shows that such is not the case. Many times the fading is quite gradual and relatively slow. Such a lack of regularity of the « solar effect » induced the writer to examine a meteorological approach of the problem.

As a matter of fact out of the 82 sudden and strong to moderate fadings recorded in 134 days, 59 were found to be contemporary with local disturbed weather conditions; fronts (not necessarily very stormy) or extratropical cyclones. The remaining 23 days without atmospheric disturbances happened mostly with very cold arctic air. We had at our disposal the daily weather maps for 1h a.m. E.S.T. published by the Washington Weather Bureau, the meteorological data of the Dorval Air field and our local own.

Such a more than partial correlation of the strong and sudden amplitude fadings at sunrise with unsettled weather conditions at the receiving site might be another case of a surprising statement we made many years ago and even more recently [6] of a possible transient interaction between the ionosphere and the lower atmosphere. We still regret that such an interesting item, found very useful for forecasting weather and storm centres, extratropical or tropical, has been up to now almost overlooked by meteorologists. Nevertheless we note that our old statement that internal gravity waves of the troposphere could reach the ionospheric layers has been tacitly admitted and that such a dynamic aspect of the lower atmosphere is now a days on the « crest », so to say, of many researches.

The seasonal variation of the strong and sudden fadings at sunrise is somewhat shown by the fact that 19 cases were recorded from April to September and 48 from January to April and September to December. Several very small cases were neglected. These belong to the total list of 82 cases of « solar effect » already mentioned. Nevertheless we have to note that we had only 47 recordings available from April to September while for the cold season (January to April and September to December) their number was up to 87.

The sharply defined « solar effect » (Plate I) is commonly attributed to a rapid transition of the ionospheric reflecting conditions caused by the first solar rays (solar zenith angle) reaching the ionosphere night and daylight layers. RIEKER [7] and others have noticed that at times, after the first sudden decrease of amplitude of the transmission received there is a delayed increase of amplitude which lasts for a few minutes and which has been called « satellite ». This happened also in our recordings and sometimes it was a « double satellite ». Exceptions are numerous and when the « satellite » showed up the « solar effect » had been strong (Plate II).

RIEKER found this « satellite » while recording thunder atmospherics from distant centers. We were recording the Ottawa transmission. It would be very difficult to state if the « satellites » of our registrations were not due to the Ottawa radio wave but to atmospherics from great distances.

No correlation between the local weather conditions and the appearance of « satellites » was found, even partially.

Another point open to discussion is the proper definition of « sunrise ». Of course there are the well known times of the astronomical and of the civil sunrise. They are all listed in the official Nautical Almanach. These values are practically constant all over the world according to the different latitudes.

If we consider the times when the « solar effect » happens, even for two succeeding days, we find that the times recorded, even granted a possible but not probable error of 5 minutes, are at random when related to the astronomical times. The difference reached one hour. It happens here what happens to the « solar effect » on the recordings of the electric gradient of the atmosphere. The « effect » does exist strong or weak, but its timing appears to be variable and, as far as the data at hand would show, is erratic. STEELE and CROMBIE seem to agree [8].

In the « Radio Science Special Issue » already quoted great stress is made on the different modes of the radio transmission. While at very great distances from the transmitter the first mode is considered as prevailing at a short distance, as in our case, the secondary modes and even the electrostatic field, which at the transmitter is one half of the electric energy countained in the wave, should be acting. The more so if it is true that is is only at over 100 miles distance that the radiation energy is acting alone.

Although the dispersion of the maxima and the minima of the oscillating amplitude is attributed at least partially to changes in height of the reflecting ionospheric layers, the well known travelling disturbances and consequent turbulence of the ionosphere are not mentioned.

In our case one should also consider, during the night, a possible erratic behaviour of the azimuth bearing at the receiving station. The BELLINI-TOSI antenna is strongly fixed and the wind's action should be nil; moreover the windings being enclosed in a tube (electrostatic shield) are not affected by snow or rain.

The « sunset effect » is quote by different authors. (Plate III). Usually it is not analyzed. How to interpret its behaviour so different from that of the « sunrise effect »? In our recordings a sudden and strong transition has never been noticed; only a gradual increase of amplitude is shown. RIEKERT has tried to explain [9, 10].

This fact is strangely contrary to what we have found when recording a Loran ultrahorizon station, on the Atlantic coast, radiating on 1.950 MHz [11]. At sunset this transmission has shown a rapid increase of amplitude while at sunrise its decrease was very slow. As if at sunset the D layer were dissolving or decaying more rapidly than it was forming again at sunrise. Of course different frequencies show different behaviour. (Plate IV).

This is the reason why we cannot compare the results obtained on 80 kHz with those obtained on the 16 kHz (Rugby, England) and so well analyzed by HULTQVIST [12].

In the different articles of the « Radio Science Special Issue » the behaviour of the amplitude fluctuations, during the night hours after sunset is most of the time overlooked. These night fluctuations of the amplitude of the 80 kHz signals, or more exactly continuous wave, of the Ottawa station show often oscillations of 5-10 minutes period forming at times successive groups of similar amplitude. Nevertheless we failed to find recurrent repetition of the same pattern in the successive nights. Interractions of the sky and ground waves together with the turbulence of the reflecting ionosphere seems to be the prevailing causes of this at random fluctuations. (Plates I and II). At times a kind of scintillation is apparent on the peaks of the main oscillation.

The mean amplitude value of the night oscillations, on the Easterline Angus milliammeter recorder reached 0.4 mA rms; with maxima of 0.7 mA rms. The receiver's noise without the antenna remained steady at 0.15 mA rms. The reception input, during the day light hours raised this value to 0.3 mA rms. Of course most of the radiation recorded during the day, even with a crossed-loops antenna, not very distant from the transmitting station, was due to the ground wave. At 80 kHz the scattering should have been small.

We examined the dates of magnetically disturbed days, listed in the « Preliminary Reports and Forecasts of Solar-Geophysical Activity » issued by the High Altitude Observatory in Boulder, Colorado. By an extraordinary lack of « chance » those were days for which we had had no recordings. We cannot state if, as it happened for the Loran transmission on 1.950 MHz, the amplitude of the night oscillation had been affected.

CROMBIE reports that « the day time signal level variations were very stable compared with the night level » even at a distance of 19,420 km from the transmitter [13]. But the frequencies considered were lower than the 80 kHz one from Ottawa.

BELROSE [14] has given graphs of the same 80 kHz transmission from Ottawa, received at several moderately distant stations. The amplitude during day time does not appear to be as quiet as in our case. Of course the stations quoted are located in more northern latitudes than Montreal, and in the real auroral region. If the sensitivity of our receiver had been greater we would have probably recorded some variations of amplitude at least during polar absorption conditions.

As a concluding remark of our study we think that owing to the dependence on frequency and range of the received transmission, no general and strict rule can yet be formulated concerning the distant reception of long radio waves.

The more so that BELROSE reports that in high latitude, namely for the transmission of 77 kHz waves between Thule and Churchill « there is practically no signal fading at night. The daily variation (except in summer when the path is always sunlit) is large and regular ».

Radio scientists have stated that in any radio transmission research the physical characteristics of the receiving antenna should be considered. We made series of two simultaneous recordings of the Ottawa 80 kHz transmission by means of the BELLINI-TOSI vertically crossed-loops and of a large (300 ft) Delta system. The shape and the important details of the amplitude variations are quite similar in both registrations. Only the amplitude are quite similar differs owing to the different threshold sensitivity of the two receivers. Both antennas were vertically polarized.

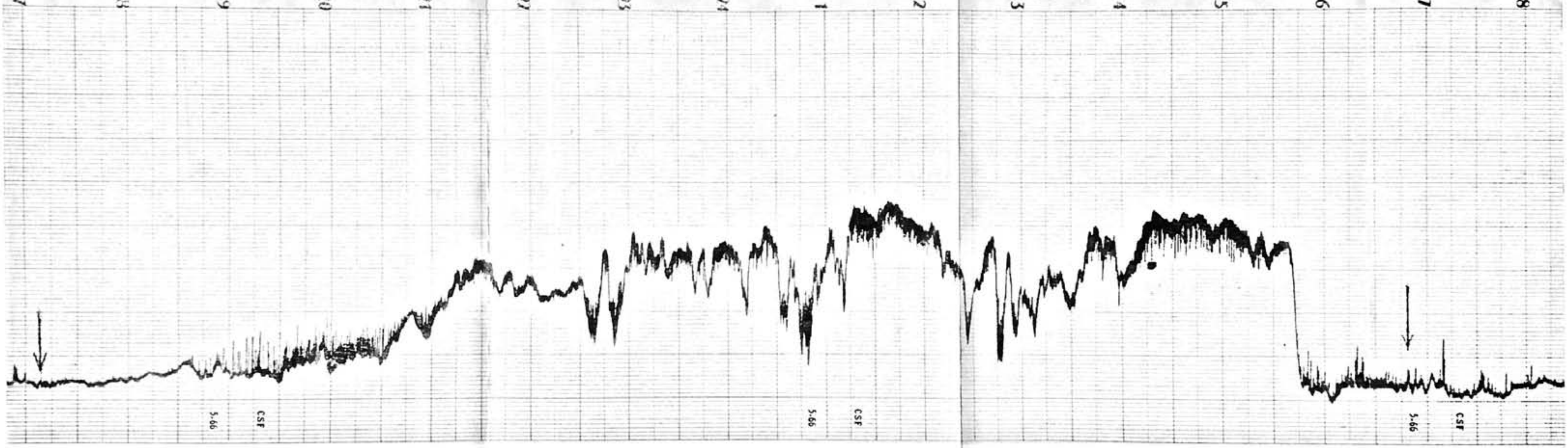

PLATE I — Recording of the 80 kHz c.w. radio transmission from Ottawa. - 10 Nov. 1967. - E.S. Time (5 hours ahead of Greenwich time). - The arrows indicate the local astronomical sunset and sunrise times.

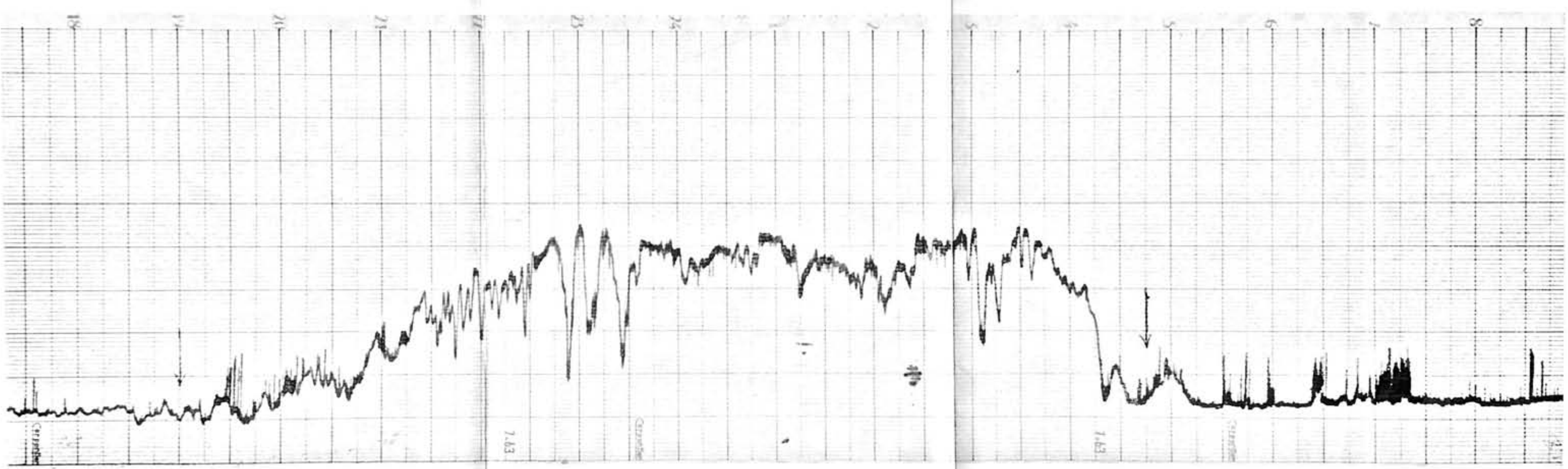

PLATE II — Recording of the 80 kHz c.w. radio transmission from Ottawa. - 29 April 1967. - E.S. Time (5 hours ahead of Greenwich time). - The arrows indicate the local astronomical sunset and sunrise times. - Two « satellites ».

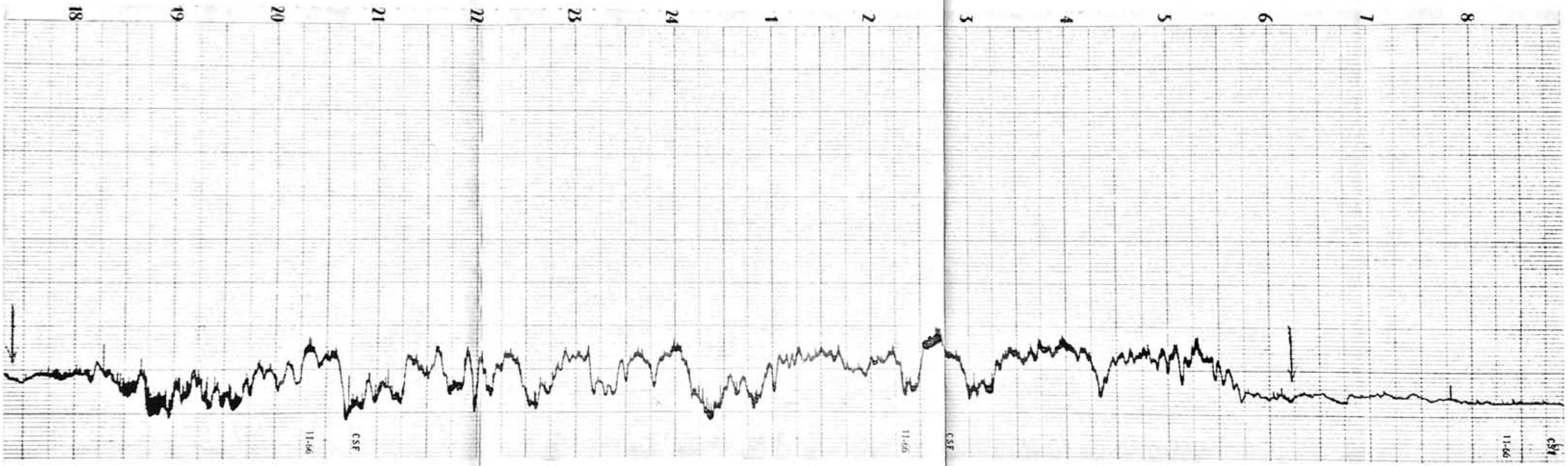

PLATE III — Recording of the 80 kHz c.w. radio transmission from Ottawa. - 13 October 1967. - E.S. Times (5 hours ahead of Greenwich time). - The arrows indicate the local astronomical sunset and sunrise times. No sudden sunrise fading.

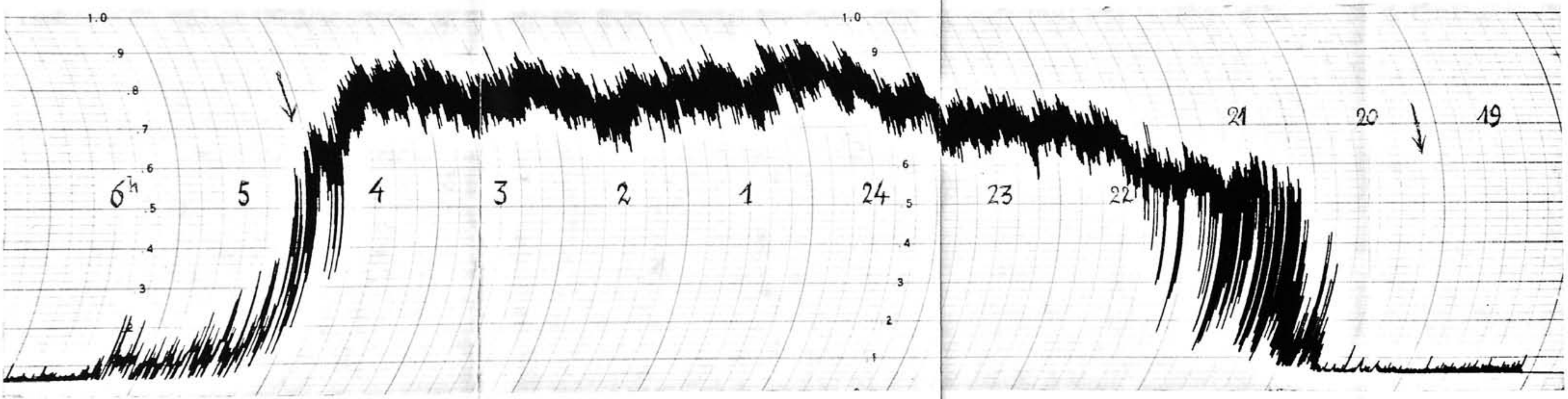

PLATE IV — Recording of an ultrahorizon Loran station on 1.950 MHz. - 20 August 1965. - E.S. Time (5 hours ahead of Greenwich time). - The arrows indicate the local astronomical sunset and sunrise times.

REFERENCES

[1] R. Bureau, *Les foyers d'atmosphériques*, Mémorial de l'Office National Météorologique de France, No. 25 (1936).

[2] J. Lugeon, *Courbes mensuelles des parasites atmosphériques à Zurich de 1939 à 1947*, Annales de la Station centrale suisse de météorologie (1947).

[3] H.A. Thomas, *Survey of existing information and data on radio noise over the frequency range 1-30 MHz*, Radio Research - Department of scientific and industrial research, London (1947).

[4] *Radio Science Special Issue on Propagation of Long Radio Wawes*, Vol. 2, Number 6, June. ESSA Washington (1967).

[5] R.N. Bracewell R.N., *The ionospheric propagation of radio waves of frequency 16 kc/s over distances of about 200 km*, « Proc. IEE » Pt IV, 99, pp. 217-228 (1952).

D.D. Crombie and H.I. Rath, *Reversal of the diurnal phase variations of GBR (16 kc/s) observed over a path of 750 km*, « J. Geophysics. Res. », *69*, No. 23, pp. 5023-5027 (1964).

[6] E. Gherzi, *Typhoon forecasting at the ZiKaWei Observatory in Shanghai, China*, Seventh Pacific Science Congress, Vol. III, pp. 1-3 (1952).

— *Ionosphere and weather*, Lisbon Academia das Ciencias, Ann. T. IX (1966).

[7] J. Rieker, *Le lever du soleil dans l'ionosphère et ses repercutions sur la propagation des ondes longues*, Ecole Polytechnique, Zurich. Prom. 3036 (1960).

[8] F.K. Steele and D.D. Crombie, *Frequency dependance of VLF fading at sunrise*, « Radio Science Special Issue », p. 548 (1967).

[9] J. Rieker, *Sunset and sunrise in the ionosphere. Effect on the propagation of long waves*, « Journal of Research. NBS. Radio propagation », Vol. 67 D., No. 2 (1962).

[10] D. E. Rugg, *Theoretical investigations of the diurnal phase and amplitude variation of VLF signals*, « Radio Science Special Issue », p. 553 (1967).

[11] E. Gherzi, *Note on the reception at Brébeuf College, in Montreal, of pulses from distant Loran stations on the Atlantic coast*, « Commentarii », Vol. II, No. 1. Pontifical Academy of Sciences - Vatican City. (1966).

[12] B. Hultqvist et alii, *The influence of solar disturbances on very Low frequency radio waves propagation on long high latitude path*. Kiruna Geophysical Observatory, Sweden (1962).

low frequency radio waves propagation on long high latitude path, during sunrise and sunset, « Radio Science J. Res. NBS », 68 D, No 1, pp. 47-51 (1964).

[14] J.B. Belrose, *The oblique reflexion of low frequency radio waves from the ionosphere*, AGARDograph 74. Propagation of radio waves at frequencies below 300 kilocycles. « Pergamon Press », p. 153 (1963). J.B. Belrose, *Some remarks on ionization changes in the lower ionosphere inferred from the propagation of long radio waves*. Conference Digest Program. Radio Physics Lab. Defense Board, Ottawa, p. 122 (1966).

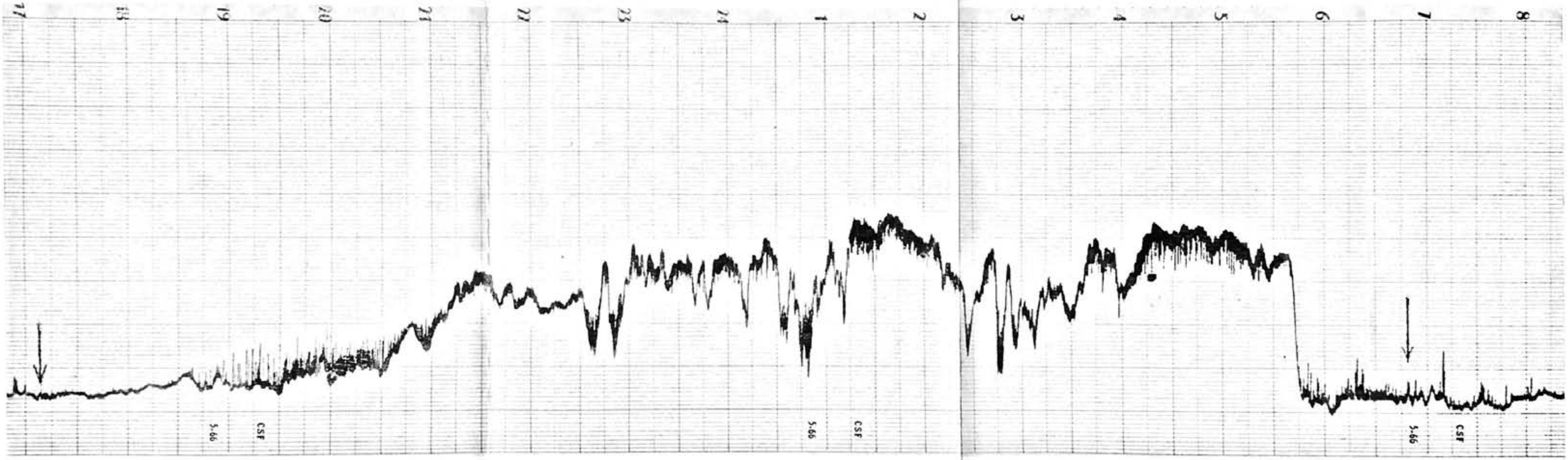

PLATE I — Recording of the 80 kHz c.w. radio transmission from Ottawa. - 10 Nov. 1967. - E.S. Time (5 hours ahead of Greenwich time). - The arrows indicate the local astronomical sunset and sunrise times.

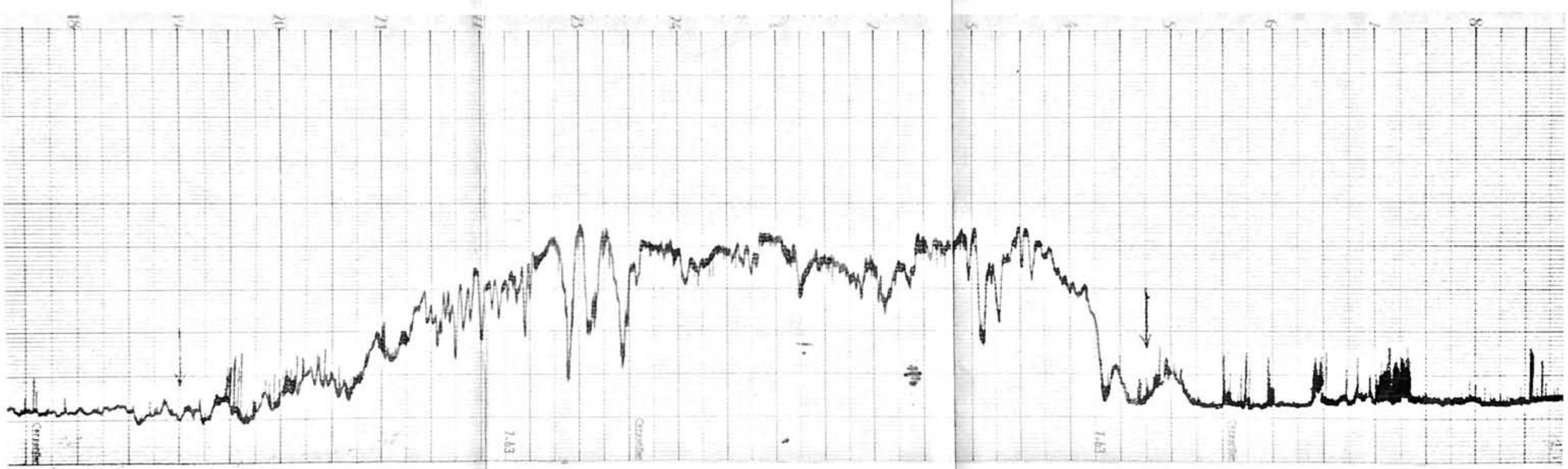

PLATE II — Recording of the 80 kHz c.w. radio transmission from Ottawa. - 29 April 1967. - E.S. Time (5 hours ahead of Greenwich time). - The arrows indicate the local astronomical sunset and sunrise times. - Two « satellites ».

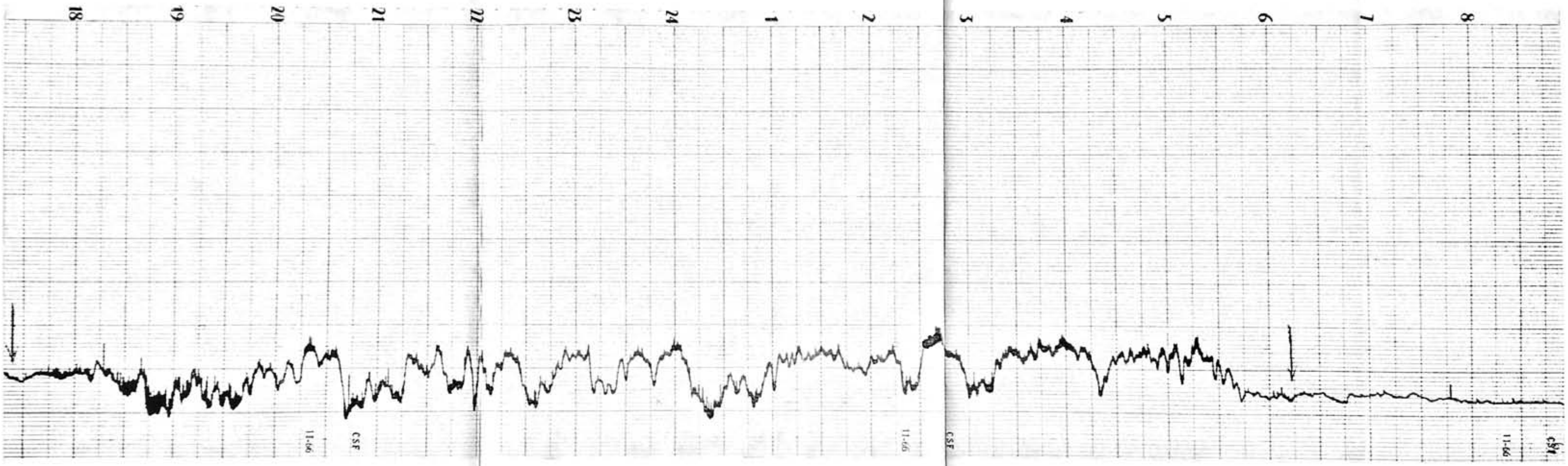

PLATE III — Recording of the 80 kHz c.w. radio transmission from Ottawa. - 13 October 1967. - E.S. Times (5 hours ahead of Greenwich time). - The arrows indicate the local astronomical sunset and sunrise times. No sudden sunrise fading.

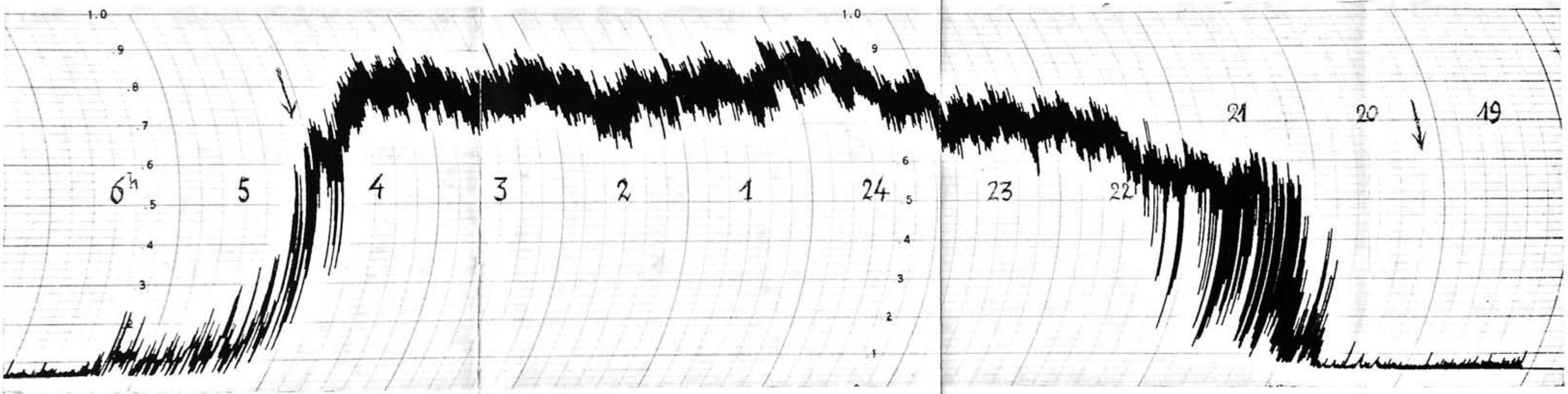

PLATE IV — Recording of an ultrahorizon Loran station on 1.950 MHz. - 20 August 1965. - E.S. Time (5 hours ahead of Greenwich time). - The arrows indicate the local astronomical sunset and sunrise times.