Between the Atmospherics

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ABSTRACT.

Examination is made of the residual intensity of energy received between the atmospherics at a frequency of 520 KC.

The nature of the junction between the earth's and sun's atmosphere, and the manner in which an electromagnetic wave travels through an overdense ionosphere are briefly described. The way in which an ionspheric shutter opens and closes is explained plus examples shown and reduced. A celestial component is found at declination -6°, which has a maximum at 2200 RA and a minimum at 0700 RA. The maximum intensity is $4 \cdot 10^{-20}$ jansky per steradian. Unexpected variations at night may be due to auroral particles of low energy. ~~Weak industrial disturbances are dominant during the day.~~ present Manifestations of strong precipitation static and local atmospherics are described. A few observations were made at 143 KC.

INTRODUCTION.

Atmospherics have been studied for more than half a century in a wide variety of manners. However, the short periods of time between the atmospherics seem to have been overlooked. When these are investigated a number of interesting phenomena are encountered.

Consideration was first given to making low frequency observations of cosmic static early in 1953. A considerable number of listening tests were made in Hawaii and it became obvious that if any success were possible it would be necessary to delete the atmospherics and measure only the spaces between the atmospherics. Using high speed instruments this appeared to be hopeful.

The problem of getting a ray of cosmic static through an overdense ionosphere looked much less promising as only one vague suggestion could be found in the literature[1]. In the meantime I ~~had been discovered~~ learned that the values of foF2 ~~got~~ became low and remained low most of the night at Hobart. Thus I ~~was~~ decided to make an initial try at Hobart using ~~only~~ O mode ~~mode~~ propagation, above the critical frequency, as this seemed fairly certain. Success was immediately had at ~~2.13 mc~~ 2130 kc and soon at somewhat lower frequencies[2]. However, the situation at 520 Kc showed that this frequency was below what could be reasonably expected to produce satisfactory results even near solar activity minimum using O mode propagation.

Critical examination of the records made it clear that there was still a smooth background at night below the atmospherics but still far above the day level. This background was controlled by D region absorption at ~~sunrise~~ sunset and ~~sunset~~ sunrise. Further, the background sloped considerable downward during the early morning hours ~~at precisely the time~~ when the ~~2.13 mc~~ 2130 kc records were doing the same thing. The symptoms looked interesting and peculiarly suspicious like cosmic static might be coming through at 520 Kc in some manner other than O mode. One of these recordings, which I took, is shown in figure [redacted] 2g of reference 2. The date is 14 July 1955. [redacted]

On the basis of these hints I decided to come back again to Hobart and have another try. To make significant progress it would be necessary to find a better place and incorporate some direction

SPACE SURROUNDING THE EARTH

Interplanetary space has a material density far greater than interstellar space. Thus the atmosphere of the sun may be thought of as extending throughout the solar system and merging with the zodiacal light. The pressure of light from the sun will exceed that of gravity for molecular size particles. Consequently there is probably a general movement of such material outward from the sun. This tenuous gas is believed to be completely ionized but the number of free electrons is probably a very small part of the total number of ions.

The earth will act as an obstacle to this outward movement and cause the material to flow around it in a shape similar to a rain drop with the tail pointed in the direction of midnight. Figure 1 shows a variety of conditions. The material inside the drop may be considered part of the earths atmosphere, while the material outside the drop belongs to the solar atmosphere.

The size and shape of the drop will depend upon solar activity both on a long and short time basis. When solar activity is low the solar atmosphere becomes more tenuous. The drop will expand and become symmetrical as the earth's atmosphere extends farther from the planet as shown in figure 1a. Increasing solar activity will cause the drop to contract as shown in figure 1b. When the drop becomes small the cross component of the earth's magnetic field becomes effective. This drags some of the material from the sunset side of the earth around to the rear of the earth and causes the drop to become unsymmetrical with the tail pointed toward morning as shown in figure 1c. Figure 1d is an exaggerated example of this condition.

ELECTROMAGNETIC WAVES IN THE IONOSPHERE.

An electromagnetic wave may travel through an ionized medium in a variety of manners. The two of interest here are the ordinary transverse or O mode and the extraordinary longtitudinal or Y mode.* The O wave can travel only in an underdense region where the critical frequency is less than the observing frequency $f_o < f$. The Y wave can travel only in an overdense region where where $f_o > f$. Energy may transfer from one mode to the other at the boundary where $f_o = f$ provided that this region is large enough for the electric fields of the two modes to be coincident over a significant distance. ~~number of wavelengths. A very sharp gradient in electron density will seriously restrict the region. Collisions will increase the size of the coupling region.~~ The lower coupling level will be at the base of the E region by day and ~~may be~~ to just below the F region at night, depending upon the observing frequency. ~~The upper coupling level will depend upon the size and shape of the drop surrounding the earth.~~

An electromagnetic wave travelling though a medium containing free electrons in a magnetic field will cause the electrons to move in curved paths. The magnetic field of the earth becomes weaker farther out. Thus at some level the free electrons will be in resonance with the exciting wave. This level is the gyrolevel where $f_h = f$. Near the gyrolevel the Y wave will encounter a refractive index of infinity[3] and be totally absorbed. On the other hand the gyrolevel will not have any perceptible effect upon an O wave because the free electrons are turning in the wrong direction. Consequently a ~~upper~~ shutter exists which may open or close depending upon whether or not the upper coupling level ~~exists~~ occurs below or above the gyrolevel. At a ~~fixed~~ given observing frequency and ~~fixed~~ location on the earth the gyrolevel will remain fixed both night and day. However, the upper coupling levelmay move higher or lower deperding upon the size and shape of the drop surrounding the earth.

Another door exists in the form of absorption in the D region. This door is closed during the day and open during the night. The effect may easily be seen on the records as rises near sunset and falls near sunrise. Such changes are quite

* NOTE.

The extraordinary longitudinal mode, I denote by the letter Y throughout the discussion. This is in line with the common practice of denoting the ordinary longitudinal mode by the letter Z. In some recent papers the Y mode has been merely called the extraordinary or more poorly the X mode. This is unfortunate as the letter X has, by long usage, been used to denote the extraordinary transverse mode above the gyro frequency. The Y mode ~~can only exist in an overdense medium. It~~ cannot produce an echo on an ionosphere sounding machine because the echo level of ~~gyro~~ zero refractive index occurs above the absorption level of infinite refractive index.

I hereby suggest that the extraordinary transverse mode below the gyro frequency be denoted by the letter W, because its characteristics are quite different from the common X mode. The cusp frequency is independent of the ordinary transverse or O mode cusp frequency when $f_o > \sqrt{2}\, f_h$. Also in the region $f_h > f > f_h/2$ the f_w cusp is always sharp and clear even on recordings showing great spread on the O and X cusps. Thus the W echo must return from a very small region in the ionosphere, similar to the Z echo. This direction is probably to the south at Hobart. Furthermore, when $f_o < \sqrt{2}\, f_h$ it seems probable that a ray of cosmic static might get through the ionosphere in the frequency range $f_h > f > f_w$. These are both matters worthy of future study.

~~UPPER~~ SHUTTER OPENS AND CLOSES.

Nearly continuous records at a frequency of 520 kilocycles were secured from early August 1956 ~~to June~~ late May 1957. Due to sharply rising solar activity the circumstances of figure 1a were rarely encountered. An example may be seen in figure . Here the ~~upper~~ shutter was open from before sunset to after sunrise. The abrupt rise in base level coincident with the appearance of atmospherics near sunset indicates the removal of D region absorption or the opening of the door at bottom ~~shutter~~. It closes with reverse manifestations near sunrise.

The situation of figure 1b is more common, ~~An example~~ as shown in 2a. Near sunset the D region absroption disappears and atmospherics begin. However, the shutter is closed as day level persists. Gradually the ~~upper~~ shutter opens and lets in celestial energy which reaches a maximum near midnight. Then the ~~upper~~ shutter gradually closes with a fall of the baseline toward sunrise when D region absroption again sets in and the atmospherics disappear. This gradual rise and fall from sunset to sunrise centered on midnight is a fundamental characteristic of the phenomenon, which could be found on the majority of the records secured.

The situation of figure 1c is shown in three different amounts by figures 2b, c, d. The ~~upper~~ shutter stayed closed most of the night and partially opened only a short time after midnight.

The situation in figure 1d is shown in figure 2e where the base line is straight all night. This indicates the ~~upper~~ shutter did not open at all.

The records of figures 2a, b, c, d have been reduced to relative intensity versus time and the results are plotted in figures 3a, b, c, d. ~~and 3e.~~ In all cases there is a rapid, smooth rise and fall of intensity over great ranges which is a sure sign of change in the size of the ~~upper~~ shutter and allows all such records to be deleted from those where the shutter remains open.

~~UPPER~~ SHUTTER REMAINS OPEN.

About three dozen records were secured where the ~~upper~~ shutter remained open for a period of four hours or longer. These all showed a smooth base line which was high compared to the daytime level plus an abrupt rise at sunset or fall at sunrise or both. During the open period the base line usually had a smooth variation over moderate ranges. The data on these records and others was reduced to a common level and plotted against sidereal time. The results are shown in figure 5. Some of the recordings are shown in figure 4.

The major maximum is near 2200 RA. Then a slight fall to 0000 RA; followed by a near flat level to 0200 RA. A second minor maximum probably exists near 0400 RA; followed by a steep fall to a minimum of 0700 RA. Then a slow rise sets in with the intensity gradually building back up to the maximum near 2200 RA.

Both the maximum at 2200 RA and the minimum at 0700 RA are shifted somewhat to the westward compared to similar data[2] taken at 2130 KC. These features of the 2130 KC. data are also somewhat to the westward of similar features on data taken at still higher frequencies. Thus it appears that there is a change in position of the apparant galactic plane which progressively increases as the frequency is decreased.

Current popular ideas suggest that the low frequency radiation originates in a region of the galaxy fairly close to the sun while cosmic static at meter waves ~~probably~~ originates at much greater distances. Thus it seems quite likely that the local region which produces cosmic static at kilometer waves may be at a marked angle to the plane of the entire milkyway system.

The great ratio of intensity from maximum at 2200 RA to minimum at 0700 RA is an unexpected feature when compared to the results at 2130 KC. It is undoubtedly due to the much better resolution at 520 kC in comparison with 2130 KC, ~~compared to 2.13 mc~~ at which frequency the antenna integrated over an area of more than [illegible]

LOCATION AND SIZE OF SHUTTER.

The connections of the various antennas may be changed to produce a variety of nulls. These are shown in figure 6 plotted in terms of amplitude squared. Thus intensity is proportional to the area under the curve. The sharp computed nulls are not available in practice because the various impedances cannot be perfectly equalised. However, by attention to detail, the impedances of the lines can be made to appear at the receiver within three percent or less of one another. Thus minimums of about one tenth percent in power may be achieved. This accuracy is still insufficient to take advantage of the sharpest null. Further limitations are introduced by the large varying component of the energy frequently encountered.

By selecting quiet circumstances it is clear that the radiant, by which the energy is arriving, is definitely between 35° and 40° north of the zenith, with an estimated centre around 37°. This refers to the steady celestial component previously discussed. Figure 2f shows a record taken with the broad null at 37°. It is much the same as one taken when the shutter was closed as in figure 2e. The angle is about what might be expected if the upper coupling level is at 3000 km. with a magnetic dip of 72° at ground level in Hobart.

To suppress the cosmic static by a factor of 10^3 or greater the shutter must be three degrees or less in north-south direction when open. No information is available on the east-west extent of the shutter. It ~~may~~ could be a long slit; but this seems unlikely. Most probably the shutter is nearly circular. Hobart is 43 degrees south so the radiant is in the direction of - 16 degrees declination. How much bending the ray will encounter from space down to the upper coupling level is not known; but is probably only on the order of a few degrees. Increasing the observing frequency will move the radiant further north and vice versa.

INTENSITY.

The maximum intensity at 2200 RA may be estimated in the following manner:-

The antenna extracts energy from the wavefront over an area approximately 3000 ft. east-west by 4000 ft. north-south equal to 1.1 square kilometers. Area, $A = 1.1 \cdot 10^6$ square meters.

Loss in ground, steel antenna wire and tuner box each 1 DB plus 3 DB in buried cable for a total loss is 6 DB. System efficiency, $\mathcal{E} = 0.25$.

The energy arriving in wavefront above antenna is via O mode only, so a correction factor of two is needed to cover the W mode above the upper coupling level ~~in space~~, which cannot penetrate the ionosphere. The antenna is susceptible only to east-west polarized energy, so a further correction factor of two is needed to cover the north south components of a random polarized wavefront. Propagation factor, $F_p = 4.0$.

The receiver bandwidth is six kilocycles, $\Delta f = 6 \cdot 10^3$ cps.

The four buried coaxial lines in parallel present an apparant antenna radiation resistance of 12.5 ohms at input to receiver, which is closely matched for maximum energy transfer giving, $R_a = 12.5$ ohms.

The maximum apparant induced voltage caused by cosmic static at 2200 RA, in series with R_a is 0.65 microvolt, $E_a = 0.65 \cdot 10^{-6}$ volt.

The apparant antenna power is thus

$$P_a = \frac{E_a^2 F_p}{R_a \mathcal{E}} = 0.54 \cdot 10^{-12} \text{ watts.}$$

The size of the shutter ~~propagation hole in region of upper shutter~~ is probably about three degrees in diameter. Sky area, $\psi = 2.1 \cdot 10^{-3}$ steradian.

The maximum surface brightness of the galaxy at 520 Kc near 2200 RA and -6° declination averaged over $2.1 \cdot 10^{-3}$ steradian becomes $I_s = \frac{P_a}{A \Delta f \psi} = 3.9 \cdot 10^{-20}$ jansky/steradian. The error may easily be a factor of two but rather unlikely a factor of ten.

If the surface brightness is averaged over a large area, such as a steradian, the value of I_s will probably drop by a factor of two or more.

Recent examination of the data taken at 2130 Kc during winter of 1955 indicates that a better value of maximum intensity is $1.5 \pm 0.3 \cdot 10^{-19}$ jansky per steradian, when averaged over an area of 1.2 steradians near 1900 RA and -43° declination. While this position is somewhat different from that quoted for 520 Kc it seems ~~is obvious~~ that the surface brightness of the galaxy is decreasing with frequency.

(X)

Direction finding tests show the sky to be fairly evenly illuminated during the day and often a bit brighter high in the south. The sounds are characteristic of a thermal continuum with occasional feeble man made disturbances of sparking type. Some of this interference may be of industrial origin in Hobart and propagated by tropospheric refraction over the intervening hills. Perhaps once a month the morning minimum drops to about 300° abs. for an hour or less so that one time mark may disappear.

DAYTIME BACKGROUND

The daytime level is ~~at all time~~ considerably above the amount expected from D region absorption. A characteristic dailyvariation is present which begins as a minimum about an hour after sunrise. Then a gradual smooth increase sets in which reaches a maximum in the afternoon. This is followed by a slow decline all night long to the next minimum after sunrise. The minimum follows the sunrise time closely throughout the year. However the maximum changes its position with the seasons. In winter the maximum occurs after sunset and can only be seen on occasional records where the ~~upper~~ shutter remains closed and ~~auroral~~ disturbances are absent. With the coming of spring the maximum moves forward in time and about the vernal equinox it may be usually seen an hour or so before sunset. It continues to move forward and reaches about 2 p.m. at the summer solstice. There after it moves backward and merges with the night record shortly after the autumnal equinox.

Direction finding tests ~~invariably~~ show this energy to be arriving from the south at an angle of 15 degrees or less from the horizon. The southern end of the valley is blocked by a ridge about 9 degrees high. Listening discloses the sounds to be rough grinding and sparking noises with strong 50 and 100 cycle components. Obviously this background is industrial disturbances generated in Hobart about 30 miles away. It is propagated by tropospheric refraction over the many intervening hills. The hot afternoon air of the country highlands provides better propagation conditions than the uniform temperature conditions reached near dawn. ~~A rather exaggerated example of the daily maximum is shown in figure 4h. The nighttime decline may be seen in figures 2d and 4d.~~

Fortunately, when the antennas look upward there is very small response at low angles. Thus even at the galactic minimum near 0700 RA the level of cosmic static is well above the ~~industrial~~ background; see figure 4-. ~~Obviously, more refined and delicate observations at 520 Kc will require~~

PRECIPITATION STATIC and atmospherics.

Tasmania has a maritime climate. Thus violent thunderstorms with blinding displays of lightning are unknown. The prevailing winds are from the ~~north~~ south west and sharp cold fronts bring intense examples of precipitation static, particularly in the winter. This energy does not seem to radiate many miles out of the front but is exceedingly intense when directly overhead. In a few instances enough radio frequency energy on a bandwidth of 30Kc was extracted to cause the input tuning condenser at the receiver to flash over. Such displays only last ten minutes or less; however, they are quite new to me. I suggest that some similar disturbances in the atmosphere of Jupiter may account for the peculiar transients emitted from time to time on that planet. Listening to more moderate examples discloses a slowly varying frying noise, often having squeals and screeches of several seconds duration. These sounds usually ascend in pitch and may rise from below audible pitch in the general frying up to above audible pitch. Often they gain coherence and become purer as they persist and end as a whistle. Perhaps they are due to sheets of rain intersecting.

Four recordings were secured similar to figures 3g. In all cases a moderate local thunder storm was found to be in progress somewhere over Tasmania. Examination of figure 3 g shows that even during local electrical storms there occur short intervals when the snapping momentarily abates and the pen finds its way to the celestial background level. A statistical investigation of these matters might provide new information about electrical storms. The apparatus seems well able to cope with normal distant atmospherics.

FLUCTUATIONS, SWELLS AND RIPPLES.

The majority of the recordings show different amounts of high variable background. This is an unexpected and disconcerting discovery compared to the situation during winter of 1955 when the recordings were mainly quite smooth. About half of the records with high background showed more or less coherence varying from long swells to short ripples. Selected samples are shown in figure 7.

It has been suggested [4, 5] that auroral ~~and cosmic ray~~ particles might produce radio frequency radiation by the Cherenkov effect when travelling through regions of high refractive index. ~~The cosmic rays may be eliminated since they have very small changes in number over a solar activity cycle.~~ No visible aurora occurred in Tasmania or Australia on any of the nights shown in figure 7.

The 520 KC records taken during several minor displays showed the usual weak to moderate irregular swells, but nothing to distingiush these nights particularly.

One 24th February, 2nd and 10th March 1957 great auroral displays occured with bright arcs and rays high overhead and to the north of Tasmania. These displays were also seen in Victoria and South Australia. On all three nights the 520 KC equipment recorded steady smooth day time level until the auroral display was over. Apparently intense displays in the direction of the lower coupling level cause abnormal D region absroption at night.

It is clear that the auroral particles which produce the visible displays are not important in producing 520 KC radiation. This is probably because their number is too small, ~~flux is of too low density.~~

It may well be that the earth is flooded with low energy particles incapable of producing a visible aurora. During 1955 the upper coupling level was far below the gyro level so that no regions of high refractive index were effective. During 1956 and 1957 the increase in solar activity seems to now cause the upper coupling level to hover around the gyro level and its associated very high index of refraction. Thus, these low energy particles, which may always be present, are now effective in producing 520 KC radiation. Such was not so in 1955. It ~~seems~~ appears as if these unknown particles get bunched by a process similar to that in a klystron tube. This may account for the regular features of figure 7. The fourth trace is particularly interesting as the amplitude builds up over several hours until cutoff at dawn.

This high variable background also arrives from north of the zenith. The radiant is quite difficult to measure. However, the best estimate indicates a patch 10° to 15° in diameter with a center somewhere around ~~above~~ 30° north of the zenith. The intensity ~~xx~~ rarely exceeds ten times that of the cosmic static near 2200 RA as measured on the recordings. Listening discloses sounds which are typical of a smooth continuum.

Another type of fluctuation exists which at first was confused with examples of figure 7. This second type however, is much smoother along the base and tends toward pointed instead of rounded tops. Most important, it passes across a sunset or sunrise time with no discontinuity whatever. It exists in an attenuated form during the day, even at noon, a couple of long term examples show it gradually weaken from dawn to noon and then strengthen from noon to dusk. Listening discloses a ~~smooth hiss sound quite similar to thermal sounds.~~ steady continuous low frying sound about half way between a thermal continuum and precipitation static. The few cases tested all showed the source to be high, ~~perhaps~~ on the order of 45° up, in the south. ~~Apparently~~ Perhaps this disturbance is associated with intense examples of moderately distant precipitation static. It ~~is~~ seems to be generated well below the D region ~~and~~ as it is only weakly influenced by such absorption during its travel to the observer.

Other Observations

During June, July + August 1957 ~~a small number of~~ records were secured at 143KC. The results confirm the above in a general way. D region absorption is markedly less and fluctuations more rare and weaker. No better correllation between fluctuations and the visible aurora could be found. Precipitation static is stronger and effective at greater distances. When this phenomenon is absent the recordings invariably show a broad maximum between midnight and dawn. Usually only a feeble discontinuity exists at sunrise and nearly always the daytime level persists ~~for~~ several hours after sunset. Only a few of the daytime records are flat. Most show a pronounced minimum between noon and 2PM. This is always for sun excess of 30°. The daytime sky is ~~not~~ bright all over but usually ~~much~~ brightest north of the zenith. Thus some of the night time energy is probably leaking thru during the day. The sounds are the characteristic smooth thermal hiss. Man made interference appears weaker, probably because of the poorer radiating ability of the various electrical appliances.

It ~~appears~~ well worthwhile to continue these studies at higher and lower frequencies and two or more frequencies simultaneously and at other places such as Port Davey, Tasmania; Sawyer Creek, Macquarie Island and someplace in South Australia. Probably the celestial component can be traced down to markedly lower frequencies near solar activity minimum.

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OTHER OBSERVATIONS

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Observations at 143KC

During --- less. Fluctuations have a wider range of intensities which varies rapidly in an irregular fashion. The cyclic character frequently found at 520KC is only occasionally recognizable at 143KC. The fluctuations come and go in an irregular manner, ~~over several days~~. Several days of strong fluctuations may be followed by a couple of days with a complete absence of the phenomenon. No better correllation between fluctuations and the visible aurora could be found.

During quiet periods the background level shows a characteristic diurnal pattern which begins as a minimum in the early afternoon. This is always far in excess of 300° abs. The level then rises very slowly and steadily until a couple of hours after sunset. Thereafter rapid increase in an hour or two brings the background up to over a hundred times the daytime level. This high level persists all night to near dawn after which a slow and steady decline brings the background level down to a minimum the next afternoon. The only feature of the high nighttime background which might be construed as of celestial origin is a small minimum near 2100RA which moved forward in mean solar time during the above limited collection of records. This nighttime energy comes in from 25° or 30° north of the zenith.

The daytime ---- high. No significant discontinuities exists in the background level at either sunset or sunrise. ~~However~~ Fluctuations are nearly always limited to the period of high nighttime background. Man ---- appliances.

The substantial lag between sunset and beginning of the nighttime rise in background may be due to the proposed jet of gas streaming off the sunset side of the earth.

No cosmic static could be seen by the observer until ~~[illegible]~~ his radiant ~~the~~ passes out from under the jet. Perhaps by by making simultaneous measurements at several frequencies (both higher + lower) from a variety of latitudes over the entire year it ~~[illegible]~~ would be possible to deduce the physical size, shape and density throughout ~~[illegible]~~ the stream to even beyond the counterglow, a few likely places which suggest themselves are Port Davey, Tasmania; -next page.

Recent extensive tests have demonstrated that all perceptible ~~dis~~ electrical manmade disturbances originate within a radius of 15 miles from Keystone at 143KC

INSTALLATION.

A north-south valley containing very few trees was selected about 30 miles north of Hobart. Four steel wires each about 3/4 mile long were strung across the valley ~~in an east-west direction. The wires are spaced~~ about 1000 ~~[illegible]~~ feet apart ~~[illegible] north-[illegible] direction~~. The antennas consist of the near centre 2200 feet of each wire. This working part is 300 feet above the bottom of the valley at the centre and about 200 feet at the ends. ~~The 2200 feet section is broken at the centre and~~ A tuned down lead ~~with a characteristic impedance of 520 ohms~~ goes from the center of antenna ~~top insulator~~ to a tuning box on a post directly below. A 50 ohm coaxial line from each tuner box to the building, which is in the centre of the array, is buried a few inches in the ground for protection from sheep and cattle. ~~This configuration of wires plus a suitable transformer gives a system which resonates at both 170 Kc and 520Kc; and provides a 50 ohm output to the coaxial line at both frequencies. Thus it is possible to make simultaneous recordings at frequencies having a ratio of 1 to 3. Unfortunately~~

Phase adjustment between the various antennas is made with a variety of patch cords.

The electronic equipment uses entirely 1.4 volt tubes. ~~These are operated from a group of lead-acid storage batteries which last a week. The only particular refinement is a double tuned circuit between antennas and first grid to eliminate crossmodulation from broadcast stations; plus a good filter in the intermediate frequency amplifier. A Brush high speed inserting~~ A minimum reading circuit between the receiver and the recorder ~~Most of the observations described below were taken using~~ provides a downward time of 0.05 second from full to zero scale and an upward time of 50 seconds from zero to full scale. Thus the height of the marks above the minimum are a measure of the persistence and not the strength of the atmospherics. ~~The observations~~

The Brush recorder is clock driven by the works of an Esterline-Angus instrument. A speed of 2-3/8" of chart paper per hour has been

Horizontal dipole antennas are much more desirable than loop antennas because a well balanced dipole is ~~greatly suppressive~~ quite insensitive to vertical polarized energy such as precipitation static, atmospherics, radio transmitters and power line radiation. Investigation has shown that nearly all the spurious radiation from faults in the power system is vertically polarized. The entire grid system acts as an immense multiple tuned Beverage antenna. The power line wires form the capacity flat top, a vertical down lead in form of ground wire exists at each distribution transformer. Each small fault is an oscillator. Thus the whole grid is driven by innumerable small incoherent oscillators all synchronously modulated in a three phase manner.

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15/4/57

$4.2 \cdot 10^3$ circular degrees per steradian

Hole diameter 3 degrees = 9 circular degrees.

Bandwidth $= 6 \cdot 10^3$ cycles, $= \Delta f$

antenna height = $.132 \lambda$

antenna efficiency = 80% (20% ground loss) estimated (= 1 DB) Pawsey, JATP, Vol 1 p 267

antenna pickup area 3000' EW × 4000' NS = $1.2 \cdot 10^7$ sq ft = $1.1 \cdot 10^6$ sq meters = 1.1 sq km ≐ A

See Terman page 786

Steel wire loss = 1 DB = 20%

Cable loss = 3 DB = 50%

Tuner box loss = 1 DB = 20%

antenna radiation resistance 12.5 Ω

Maximum input at RA 2100 = 0.65 μv.

Total loss = 3 + 1 + 1 + 1 = 6 DB or ℰ = 25%

Energy in wave front (Y mode only)

$P = \frac{E^2}{R} = \frac{.65^2 \cdot 10^{-12}}{12.5} = .034 \cdot 10^{-12} = 3.4 \cdot 10^{-14}$ watts in one plane only

$P = 6.8 \cdot 10^{-14}$ watts for both planes only.

$P_w = 27.2 \cdot 10^{-14}$ watts for both planes in wavefront above antennas
× 2 = 54.4×10^{-14} for both Y + O modes.

$\phi = \frac{9}{4.2 \cdot 10^3} = 2.1 \cdot 10^{-3}$ steradian,

$I = \frac{P_w}{A \phi \Delta f} = \frac{\overset{54.4}{\cancel{27.2}} \cdot 10^{-14}}{1.1 \cdot 10^6 \cdot 2.1 \cdot 10^{-3} \cdot 6 \cdot 10^3} = \frac{\overset{54.4}{\cancel{27.2}}}{1.1 \cdot 2.1 \cdot 6} 10^{-20} = \overset{3.9}{\cancel{1.95}} \cdot 10^{-20}$ watts / sq m / cycle / steradian

$= \overset{3.9}{\cancel{2}} \cdot 10^{-20}$ Jansky / steradian.

in space at 2100 RA at 520 KC.

If averaged over an area of a steradian the intensity will probably drop by a factor of $\cancel{10}\,^3$ which will put it far below the 2130 KC average level.

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4. "Radiation emitted by a Uniformly Moving Electron in an Electron Plasma and a Magnetic Field", A.A. Kolomenski, Compt. Rend. Acad. Sci. USSR, 21 February 1956, Vol 106, pp 982-985.
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6. "The Earth's Exterior Atmosphere and the Counterglow", E.R. Hope, Third edition April 1957, Defense Research Board of Canada T65R, particularly figure opposite page XVI.

Titles

~~1. 520 KC record August 1955. Severe atmospherics before midnight and smooth slope to dawn. D region absorption causes sunrise drop to low day level and abrupt rise near sunset.~~

1. Symbolic representation of extent of earths atmosphere during low, weak, medium and strong solar activity. Solar atmosphere is outside the drop.

2. a, b, c, d shutter opens after sunset, near 10 p, MN and 3 AM respectively; e, shutter remains closed all night; f, antenna null 37° north of zenith; g, persistent atmospherics most of night; h, typical day record with gradual rise all day; i, day record with peak in afternoon; j, unusual flat day record.

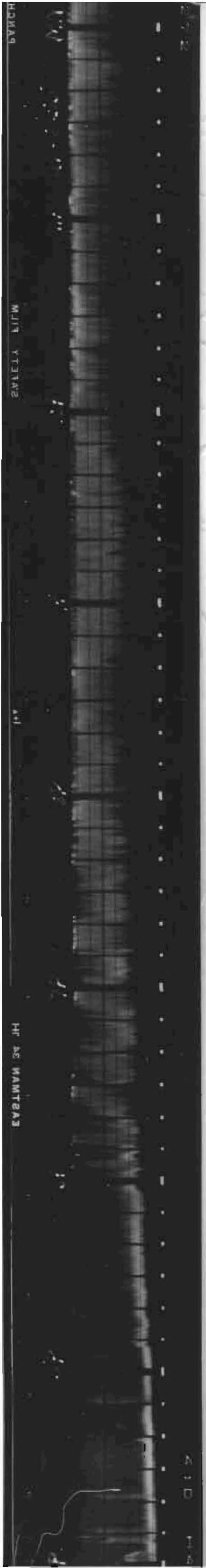
3. Relative intensity versus time as shutter opens and closes. Data taken from recordings 2a, b, c, d.

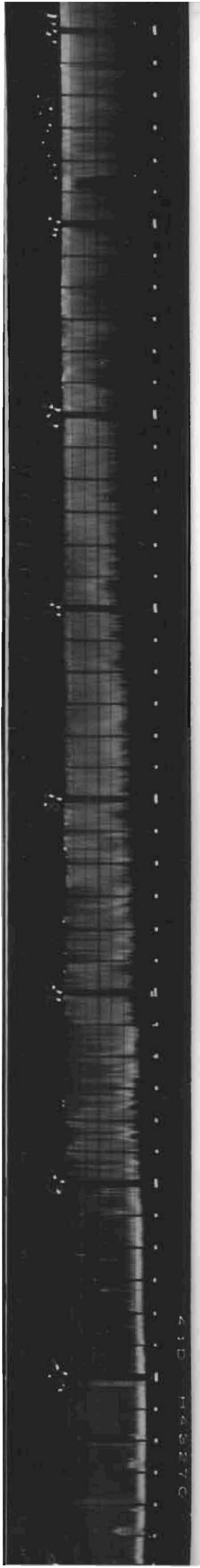
4. Smooth slow variations of intensity when shutter remains open several hours.

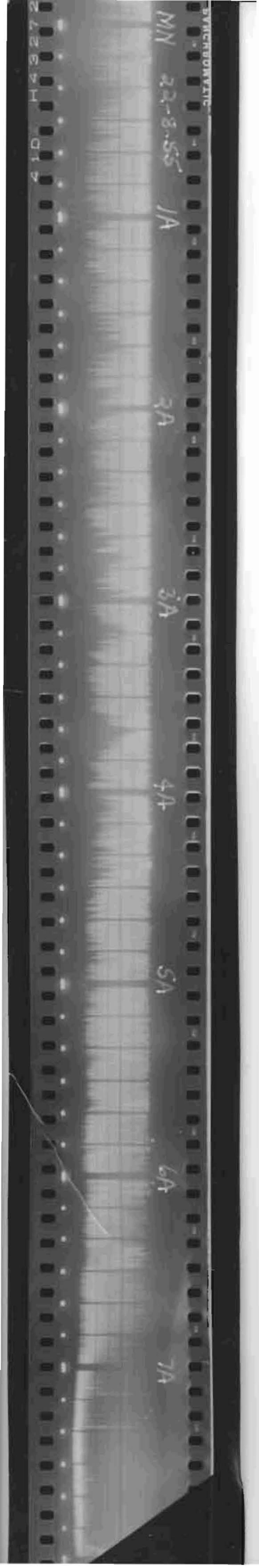
5. Relative intensity versus Right Ascension for records of figure 4 and others. Declination about −6 degrees.

6. Types of nulls available by adjusting antenna connections.

7. High variable background with periods of 5, 4, 3, 2, 1 hour, 30, 10, 5 minutes. Also samples of shutter opening briefly near midnight with abrupt onset of fluctuations near 2 AM and 3 AM.



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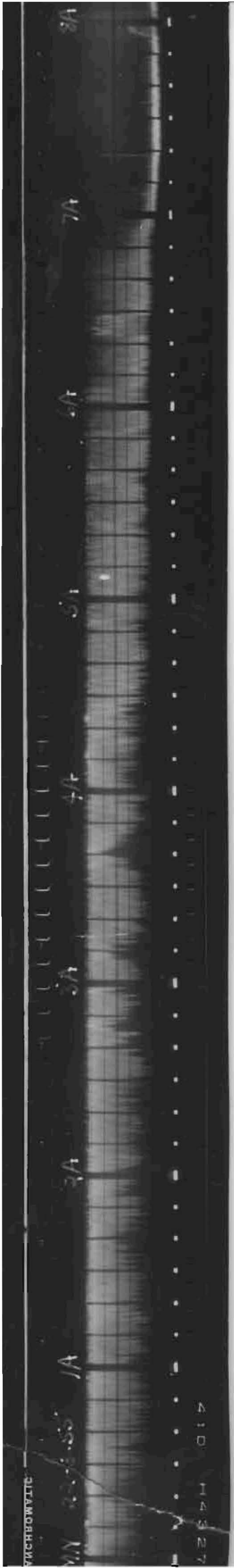
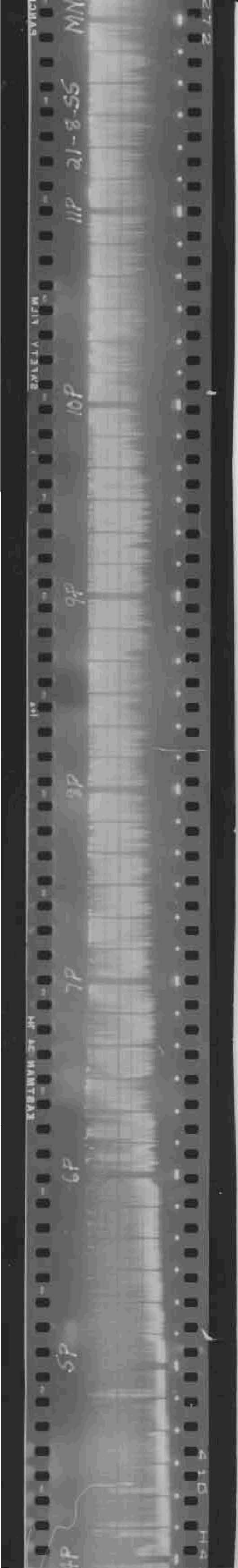
2A
3A
4A
5A
6A
7A

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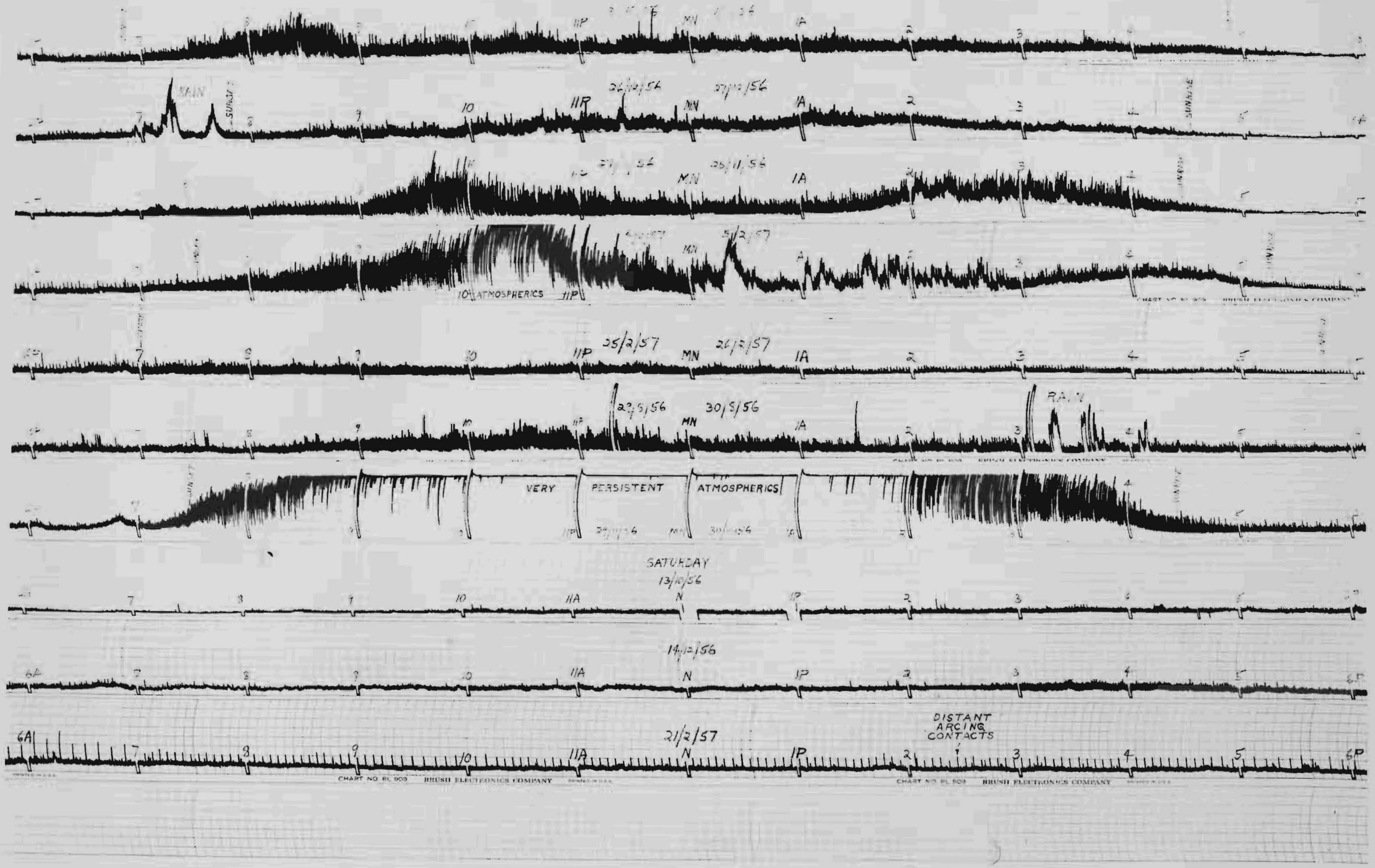
10P
9P
8P
7P
6P
5P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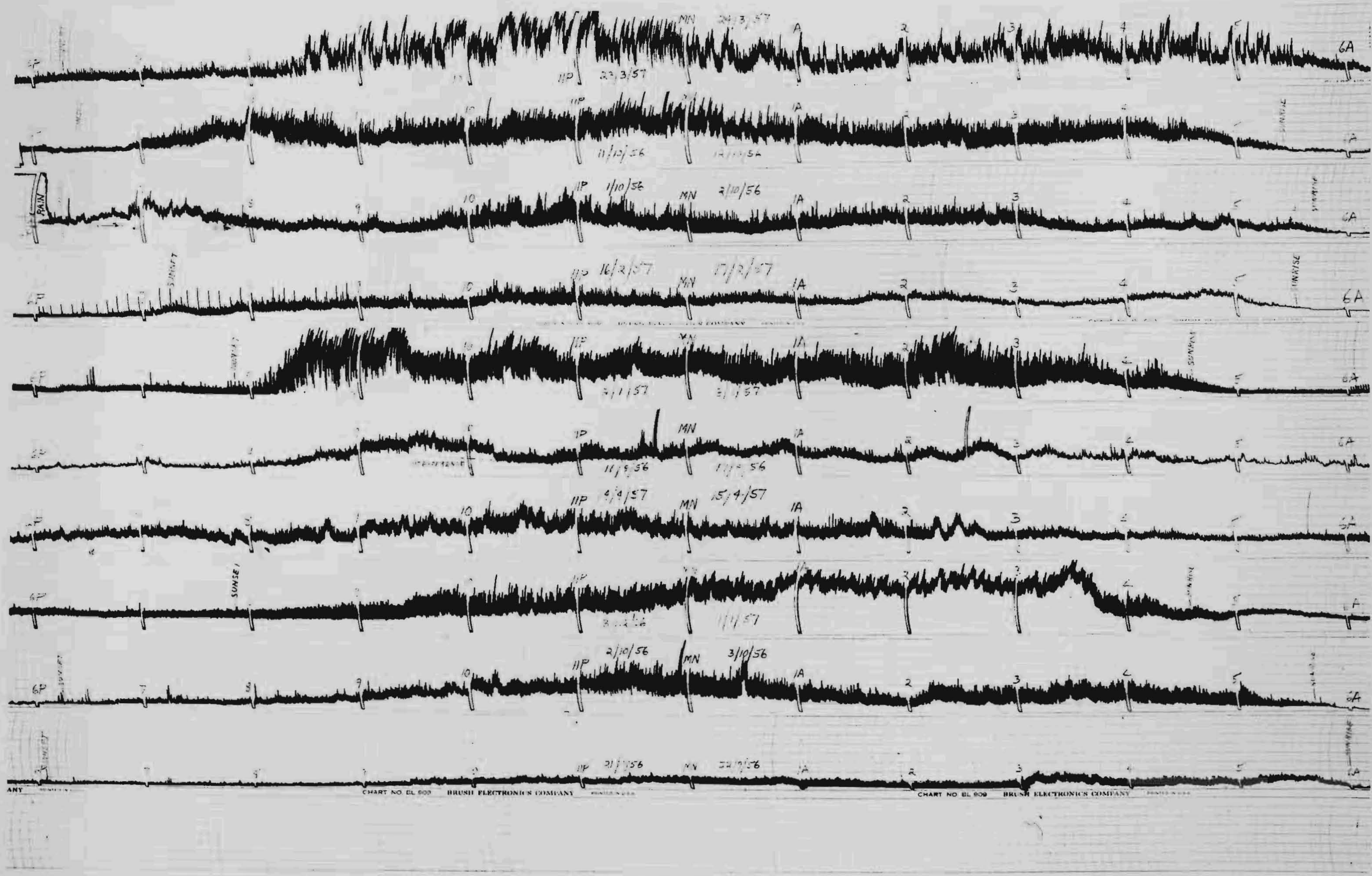
SUNSET
26/12/56
27/12/56
25/11/56
10 ATMOSPHERICS 11P
5/2/57
25/2/57
26/2/57
23/5/56
30/5/56
RAIN
VERY PERSISTENT ATMOSPHERICS
SATURDAY
13/10/56
14/12/56
DISTANT
ARCING
CONTACTS
21/2/57
CHART NO. BL 909 BRUSH ELECTRONICS COMPANY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SUNRISE
6P
MN
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17/2/57
11/9/56
4/4/57
15/4/57
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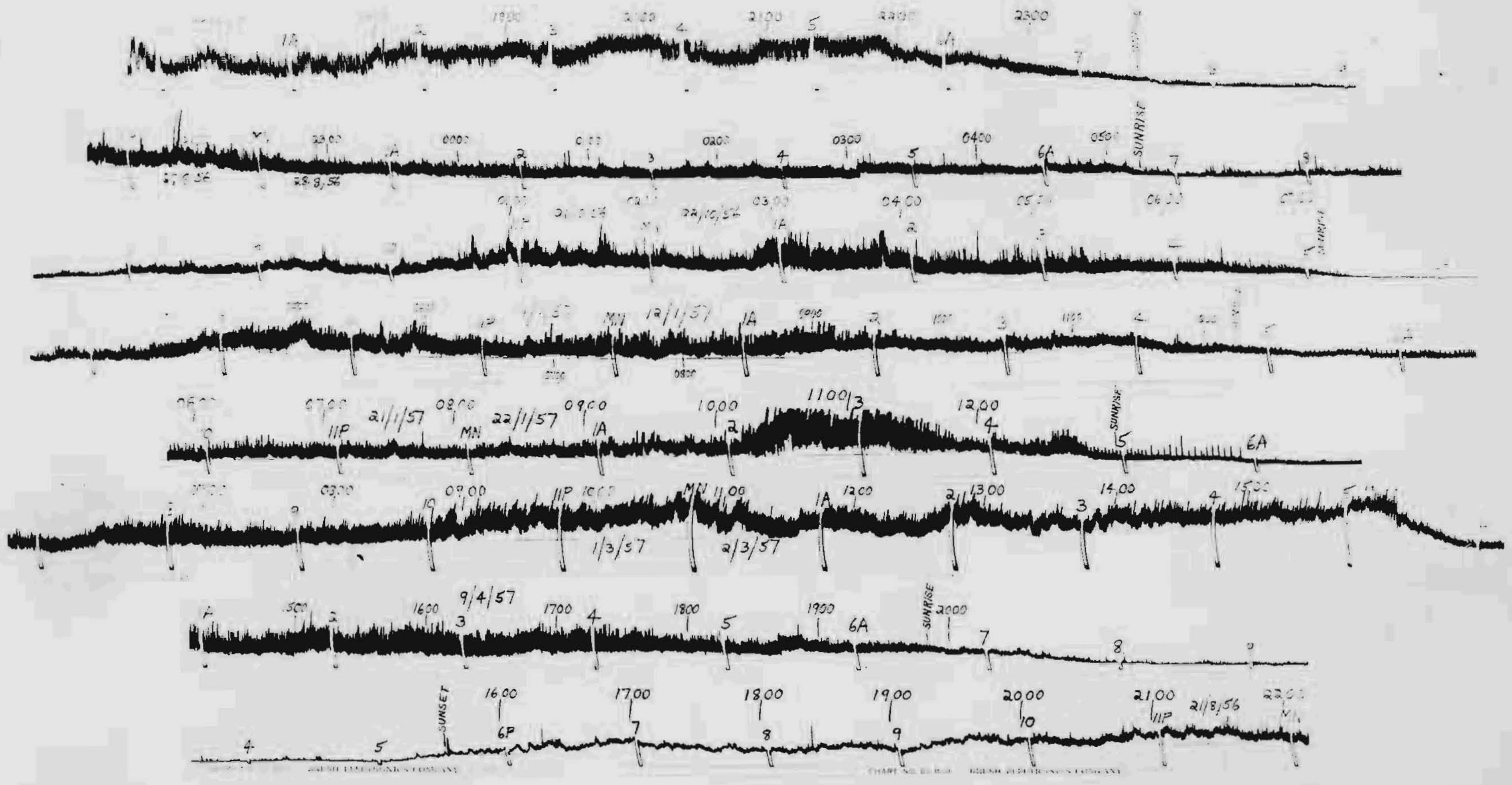
CHART NO. EL 509 BRUSH ELECTRONICS COMPANY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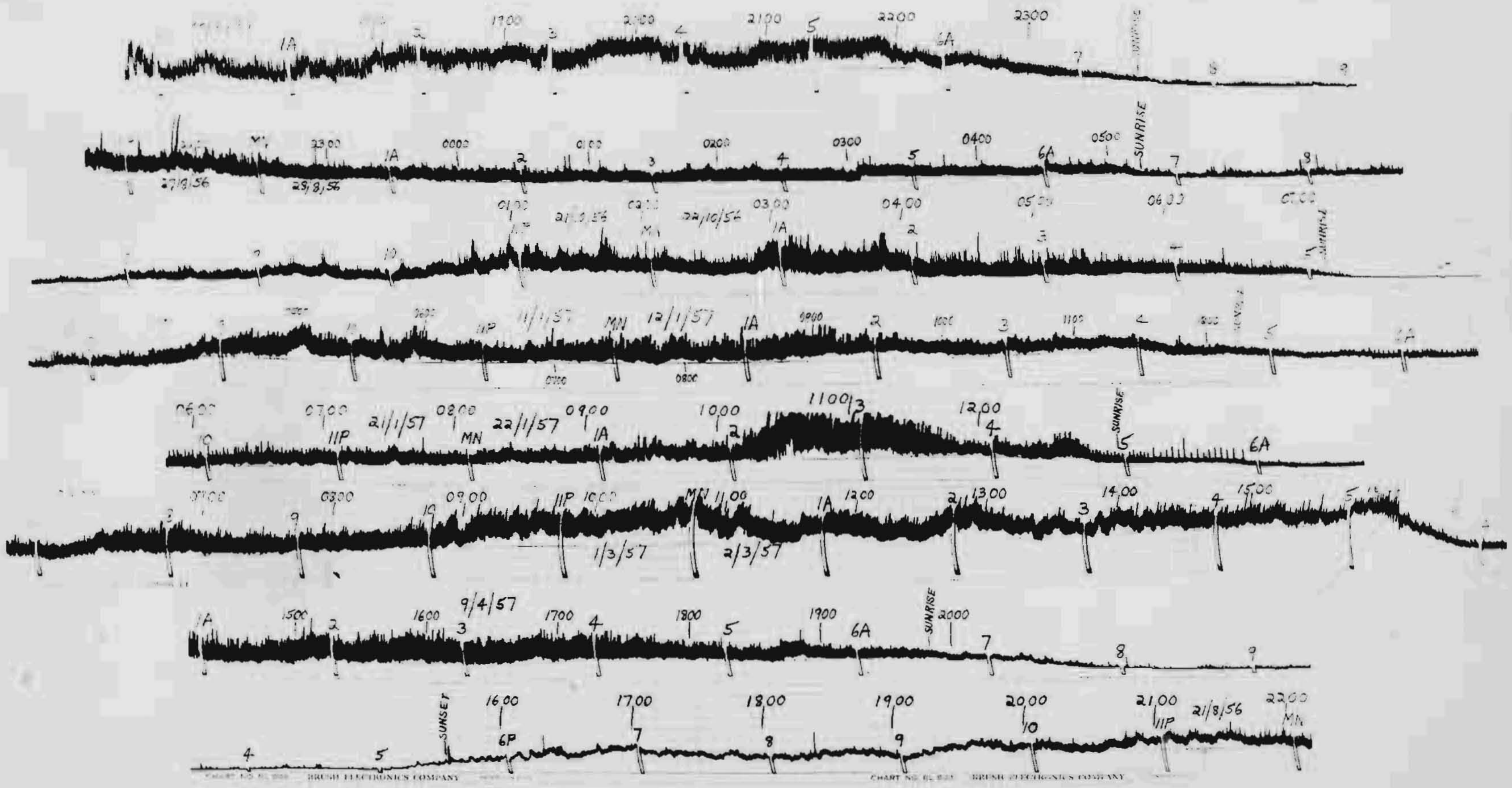
SUNSET
21/8/56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2/3/57
9/4/57
SUNSET
21/8/56