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A preliminary survey of the distribution of micropulsations in the magnetosphere from OGO's-3 and 5

by

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Contents

ABSTRACT

REFERENCES

FIGURE CAPTIONS

ABSTRACT

Magnetic field data from the OGO-3 and 5 satellites is being systematically scanned to determine the magnetospheric distribution of micropulsations in 7 bands (periods: 0.8 to 2^s, $2\text{-}5^s$, $5\text{-}10^s$, $10\text{-}25^s$, $25\text{-}45^s$, $45\text{-}120^s$, and $120\text{-}240^s$) and incoherent irregularities in two categories (time constants: $T < 5^s$ and $5^s < T < 45^s$). Although incomplete at this date, the principal features of the distributions are sufficiently evident near the equatorial plane to make preliminary results significant. The characteristics and distribution of Pc-3 waves ($10 - 45^s$) with a broad dayside maximum roughly independent of distance agrees exceptionally well with well known Pc-3 properties at the earth's surface. Pc-4 ($45\text{-}150^s$) distributions are similar to Pc-3 but some difference appears in detail. Waves with Pc-2 periods ($5\text{-}10^s$) are statistically distributed in close coincidence with the distributions of waves with Pc-1 periods ($0.2\text{-}5^s$). Comparitively minor differences occur between the bands $0.8\text{-}2^s$, $2\text{-}5^s$, and $5\text{-}10^s$. The magnetospheric distribution of periods 0.8^s to 10^s is however completely different than that for periods $10^s\text{-}120^s$. The percentage of time signals appear in the $0.8\text{-}10^s$ range has a pronounced maximum within the magnetosphere near the magnetopause and the 6^h LT meridian with high percentages extending tailward near the magnetopause. This distribution is similar in many respects to the magnetospheric distribution of incoherent irregularities which statistically supports the observation that 0.8 to 10^s waves are most generally, but not always, closely associated with other field irregularities, suggesting a plasma instability origin. Statistically it would probably be incorrect to label these waves as being Pc (i.e., continuous pulsations) in the satellite data.

Waves and recurrent pulses with Pc-3 periodicities frequently constitute the dominant large amplitude fluctuations in the magnetosheath sunward from the dayside magnetopause. It is believed that these waves and recurrent pulses are closely related to the Pc-3 oscillations within the dayside magnetosphere. Support is given to the suggestion that a Pc-3 activity index based on surface observations should be derived and be made available as an international service.

INTRODUCTION

The use of micropulsations observed at the earth's surface as a tool for diagnosing conditions in the magnetosphere and solar wind parameters that influence the solar wind-magnetosphere interaction has been strongly advocated by Troitskaya [1967]. Specific characteristics of surface micropulsations have already been related to solar wind velocity, interplanetary field directions, magnetopause location, outer magnetosphere electron densities, etc, and an even greater number of investigations treat problems involving cause and propagation, ionospheric effects, global, local, and time distributions, associations with other disturbances, etc. The number of published papers involving surface observations of micropulsations in the Pc (continuous pulsation) bands 1-5 and Pi (irregular pulsation) bands is somewhat overwhelming to those that do not specialize in pulsation studies. In marked contrast to this great body of information the number of publications involving direct satellite observations of micropulsations in the magnetosphere is extremely small and devoted almost entirely to the Pc 4 and 5 bands and still lower frequencies.

In analyses of magnetic field data from the OGO-3 and OGO-5 satellites and associated analyses of OGO-5 electric field data with T. L. Aggson and N. C. Maynard it has been apparent for some time that small amplitude coherent oscillations with Pc periods occur frequently with observable amplitudes within the magnetosphere. There has, however, been a tendency to neglect these waves relative to the usually greater amplitude and more prevalent waves observed in the magnetosheath and bow shock regions. More recently, relative to problems involving instabilities in the magnetosphere, and especially instabilities at the magnetopause, a need for knowing more about Pc and Pi oscillations became apparent. It was also apparent from the great variety of pulsation data available that a statistical framework was needed to assist in deciding whether occurrences were spatially confined or events in time or likely to be confined in both space and time.

The statistics presented here are very preliminary in that they involve only a small fraction of the data to be examined in achieving the final statistics on space-time distributions and their relationships to other activity parameters. However, the gross properties of the distributions are sufficiently pronounced to make these preliminary results significant.

DATA EXAMINED

Decisions as to how to proceed in compiling statistics involved: use of power spectra or alternatively visual examination, and use of fluxgate magnetometer data or rubidium vapor magnetometer data or both. Power spectra techniques were ruled out from operational considerations involving the volume of data to be handled relative to the frequency vs. time discrimination required for the intermittent occurrences that characterize the higher frequencies. Thus visual scanning was adopted. Initially both the 3-axis fluxgate and rubidium magnetometer, total field, data were scanned by the procedure described below. However, it was soon obvious that one could not statistically mix the two because of the lower sensitivity of the fluxgates (± 0.12^{γ} increments) which is effectively poorer in terms of total field or visually when the wave is divided into components, and the variable sampling of the fluxgates (1.7, 7, 55, and 111 samples/sec/axis). It was also apparent that the rubidium magnetometer detected virtually all waves that could be seen in the fluxgate data. This interesting fact can be correctly interpreted as implying that a pure (i.e., 100%) transverse wave is extremely rare at Pc frequencies in the magnetosphere. For these reasons we have confined our statistics to visual scans of the routine microfilm plots of the rubidium magnetometer data and the 7 bands of frequencies that can be visually detected in a consistent manner.

Figure 1 illustrates a typical 2 minute microfilm frame of rubidium magnetometer data in which the total field, B, and the measured m computed reference field, ΔB, is plotted. The Larmor frequency ($\approx$ 7 Hz/gamma) from the Rb-magnetometer is transmitted directly and routinely digitized at 7 samples/second with a theoretical precision of ± 1 part in $5 \times 10^6/7$. In practice, from examining digital repeatability during quiet times, the precision is such that the scatter is < 0.02 gammas. Thus, the principal sensitivity limitation is simply the plotting scale. As an example, in Figure 1 the 2.5 sec. and 30 second oscillations have peak to peak amplitudes of 0.4 and 0.3^γ, respectively. Inasmuch as the plot scales are such that the grid increments vary with the magnitude of B and ΔB, independently, some control on the threshold of detection is imposed by rejecting all plots where the most sensitive grid interval exceeds 15^γ. 6^γ and 10^γ grid intervals are most common. With this variability the estimated thresholds for detection range from 0.1 to 0.3^γ, peak to peak, at Pc-1 frequencies, 0.2 to 0.6^γ, pp at Pc-3, 0.3 to 1.0^γ, pp near 120 sec. periods, and roughly (see later discussion) 0.5 to 2.0^γ for periods between 120 and 240 sec. Particularly for the long period, Pc-3 to 5, waves the wave period seldom remains constant. This quasi-periodicity in general does not destroy the "coherence" of the wave but when a number of frequencies are simultaneously present, and particularly when incoherent irregularities are present together with waves, qualitative judgments enter the statistics. The effects of these qualitative aspects of the scanning are believed to be small in the overall statistics. The factor of 2.5 variability in the plot scale, however, means that the statistics have greater relative meaning (i.e., for comparisons of distributions) than absolute accuracy.

For recording occurrences, the magnetosphere was divided into volume elements determined by: 10° magnetic latitude intervals, eight 3^h local time segments, and 14 intervals of the main field L parameter. The frequency spectrum for coherent waves was divided into seven bands with periods: $< 2^s$, $2-5^s$, $5-10^s$, $10-25^s$, $25-45^s$, $45-120^s$, and $120-240^s$. The quantities recorded are the total number of minutes within a volume element and the number of minutes containing coherent waves in each of the 7 bands. The number of minutes during which incoherent irregularities are present is also recorded separately for irregularities having a time constant, T, $< 5^s$ and $5^s < T < 45^s$. The scanning is also used to spot other features in the data outside the scope of this presentation.

OCCURRENCE STATISTICS

To date, only 4×10^4 minutes of rubidium magnetometer data have been tabulated. When broken down into several hundred volume elements and further classified relative to Kp this is not adequate to show statistical significance for many detailed questions (e.g., latitude and Kp dependence at different local times). Thus, for this preliminary presentation volume elements are grouped and the statistics are not sub-divided relative to Kp, but times when Kp exceeded 5 are excluded. Within 20° of the magnetic equator this gives a quantity of data, about one-half the total tabulated, that has reasonable statistical significance in the blocks containing numbers in Figures 2-5.

Pc-3 (and Pi): 10-45^s Periods

As illustrated in Figure 2 the Pc band (10-45^s) was split into 2 bands 10-25^s and 25-45^s for scanning. The spatial distributions of the 2 sub-bards are, however, very similar indicating that this sub-grouping is not very meaningful, although there could be some significance in the ratio 10-25^s/25-45^s increasing toward the noon meridian in the outer regions.

Treated as a whole (i.e., 10^s-45^s) the dayside maximum in occurrence is quite striking and closely resembles the diurnal distribution of occurrences found for Pc-3 at the earth's surface by various investigators (e.g., Jacobs and Sinno, 1960; Saito, 1964a; reviews by Campbell, 1967, and Troitskaya, 1967, etc.). The agreement with surface observations appears to exist also for more detailed considerations. For example, comparison with percentage occurrences given for surface stations and corrected to similar thresholds (e.g., 0.2^γ Jacobs and Sinno, 1960; 0.5^γ, Saito, 1964a) indicate such close agreement that it appears safe to assume that the satellite distribution below L = 5 extends to the earth's surface with very little modification. Similarly, although amplitudes have not been statistically treated in this survey it appears highly likely that a frequency of occurrence vs. amplitude distribution would closely resemble those found for surface observatories (e.g., Jacobs and Sinno's 1964, results for Fredericksburg).

Here, as in surface studies, the definition of "an occurrence" depends on the detection threshold. Thus at this stage of our survey we are inclined to believe that the maximum in the occurrence of $10\text{-}45^s$ waves between L = 5 and 8 (Figure 2) represents an amplification, rather than source, effect whose cause remains to be determined. Viewed in this manner agreement with surface observations is again indicated in that Kato (1962) finds that amplitudes in this band are roughly a factor of two greater at the corresponding surface latitudes (near 65^o) than at lower latitudes.

There is not an obvious definitive way to distinguish between Pc and Pi oscillations in the satellite data. However two aspects of the data make it likely that the high percentages for dayside occurrences of $10\text{-}45^s$ waves come from Pc oscillations. One is the agreement with surface observations; the other is that these waves frequently appear almost continuously for extended periods of time (e.g., several tens of minutes) on the dayside even though the satellite is rapidly changing location. It also appears likely from the brief appearances of $10\text{-}45^s$ waves on the nightside that the small percentages there come largely from oscillations that might be called Pi. Elimination of Pi oscillations, if possible, would thus have the effect of making the dayside distribution even more distinct. Also, in this regard, the large numbers in the zone 3^h - 6^h between L = 5 and 8 are somewhat deceiving in that the observations in this zone are more concentrated near 6^h than near 3^h.

The distribution and high occurrence percentages for the dayside Pc-3 should give statistical significance to examining occurrence percentages as a function of 3^h Kp. This has been done with the result that there does not appear to be a strong correlation. In fact, a small maximum in the percentages occurred for Kp = 3 and percentages for Kp ≥ 4 were less than a factor of two higher than for Kp ≤ 2.

Pc-4, 5 (and Pi): 45^s-240^s periods

Distributions for wave periods 45-120^s and 120-240^s are shown in Figure 3. This division differs from the usual designation of Pc-4 as 45-150^s and Pc-5 as 150-600^s. The following factors affected this choice: (a) the form of data presentation (i.e., 2 minute frames) introduces greater uncertainty in visually detecting waves with periods > 120^s than for waves of period < 120^s, (b) no evidence has been found that 150^s is particularly significant as a break between two bands, and (c) limiting the visual scans to maximum periods of 240^s is not only influenced by the greater uncertainty in maintaining continuity beyond 2 frames but also other evidence indicates that a phenomenological break may occur near 240^s. The latter point--the possibility that a change in wave properties may take place near 240^s rather than either 150^s or 600^s---is suggested by some unpublished analyses that are incomplete at this writing. These analyses for which 30^s averages are more quantitative should also provide better information on the 120-240^s band. In this paper figures for the 120-240^s band should be taken to be only indicative of the probable distribution.

Considering only the $45\text{-}120^s$ band in Figure 3, it is apparent that the distribution is similar to that of Pc-3 in terms of having maximum occurrence on the dayside. The percentage of time is, however, lower; it appears doubtful that this is entirely a consequence of the slightly higher threshold for detecting $45\text{-}120^s$ than for Pc-3 but this possibility is not ruled out. Noting that the percentages for $45\text{-}120^s$ decrease greatly as distance from the earth decreases, it also appears possible that the propagation and/or the source of the Pc-4 waves may differ from that of Pc-3 waves. Similarity to surface observations appears with respect to Kato's (1962) observation that the increase in Pc-4 amplitude with increasing latitude is considerably more pronounced than for Pc-3. If such comparison is valid, Kato's (1962) results would suggest that the decrease in percentages toward the earth from the dayside magnetopause simply reflects the greater amplitude on the more distant shells. In future analyses it will be desirable to examine the relative amplitudes of the transverse and compressional components of the Pc-3 and Pc-4 waves as a function of distance on the dayside to see if the different locations of maximum percentages (i.e., L = 5-8 for Pc-3 and L = 8-12 for Pc-4) are related to differences in these ratios.

The statistical significance of the isolated 6% between 0^h - 3^h beyond L = 15 is not obvious at this writing. Considerations of the relative contributions of Pc and Pi waves are analogous to those for Pc-3 but involve greater uncertainty as a consequence of the smaller percentages involved.

Pc-1, 2 (and Pi): periods $< 10^s$

Distributions for wave periods, $< 2^s$, $2\text{-}5^s$, and $5\text{-}10^s$ are shown in Figure 4. In general the category $< 2^s$ can be taken to be 0.8^s to 2.0^s but a small number of cases where wave periods were 0.6 - 0.7^s have probably been included. The usual designation of Pc-1 as 0.2-5^s and Pc-2 as 5-10^s has thus been followed except for splitting the Pc-1 band and cutting the shortest period band near 0.8^s rather than 0.2^s.

Pc-2 has frequently been grouped with Pc-3 in surface investigations. It is obvious from Figures 2 and 4 that the satellite statistics are markedly different for the 5-10^s and 10-45^s bands. Unlike the Pc-3 band, the 5-10^s waves are statistically concentrated toward the magnetopause and away from the sub-solar region with a pronounced maximum near the dawn meridian. Thus to find similarities between Pc-2 and Pc-3 one has to look at special cases rather than statistics. Such cases are found in the form of wave periods very close to 10^s and suggest that they represent times when the waves characteristic of Pc-3 have exceptionally short periods. Statistically this appears in the form of the isolated 2% in the L = 5-8, 9^h - 12^h local time block. Figure 6 illustrates a case of this type in which the quasi-periodicity ranges from roughly 8^s to 14^s. It is probably significant that on this inbound pass similar periods were observed in the magnetosheath (discussed later) and that the magnetopause was unusually close to the earth, 8.3 R_e. The satellite data thus suggest that groupings of Pc-2 and 3 should only be used when overlapping periods are indicated. It might also be worthwhile to see how a division near 8^s instead of 10^s would affect the distribution.

As indicated by the percentages in Figure 4 waves in the 2-5^s band are more prevalent than waves in the adjacent bands and a pronounced maximum occurs near the dawn meridian magnetopause. The distribution for periods

0.8 to 2^s differs slightly from that of the $2\text{-}5^s$ and $5\text{-}10^s$ bands in that a smaller maximum is reached near the magnetopause and this is displaced tailward from the dawn meridian.

For all 3 bands of Figure 4 the occurrences which contribute the most to the statistics are highly intermittent and it would probably be incorrect to refer to them as Pc waves without some clear definition of Pc which would distinguish between a sequence of intermittent occurrences and an unbroken continuous wave.

The most characteristic feature of waves in these bands, $0.8\text{-}2^s$, $2\text{-}5^s$, and $5\text{-}10^s$ is that in the majority of cases they are associated with other irregularities in the magnetic field. This association is statistically apparent in comparing Figures 4 and 5. In many individual cases the waves are superimposed on the irregularities but more generally the waves appear adjacent in time or between irregularities. This suggests that many of the waves originate from local plasma instabilities and makes it unlikely that statistical comparisons with surface observations can be very meaningful. A curious point for future study is that the ratio of wave occurrences ($2^s\text{-}10^s$ bands) to irregularity occurrences is a maximum near the dawn meridian magnetopause. This indicates either a boundary influence on the instabilities or additional wave penetration from the magnetosheath.

Incoherent Irregularities

Incoherent irregularities were simultaneously tabulated to detect, if present, any tendency for them to occur with similar time constants to the waves being tabulated. For this purpose an original distinction, based on expectations from surface investigations grouping Pc-2 and 3, was made for time constants $T < 5^s$ and $5^s < T < 45^s$. Although the Pc-2 and 3 grouping has since been shown to be contrary to the wave observations (see previous discussion) the grouping for irregularities appears to be without consequence. In fact, as shown by Figure 5 there is very little difference between the statistical distributions for $T < 5^s$ and $5^s < T < 45^s$. In scanning data it is obvious that this is the consequence of abrupt, $T < 5^s$, irregularities generally occurring in association with less abrupt $5^s < T < 45^s$ field changes.

The fact that the irregularities are most prevalent near the dawn meridian and along the flanks of the cavity toward the magnetopause is to be expected in this equatorial zone from previous studies which showed that β (the ratio of plasma energy density to field energy density) must be ≥ 1 in this region (Heppner, et al., 1967). The somewhat smaller, but still relatively high percentages in the central tail region are also expected. The slightly smaller ratio of $T < 5^s$ to $5^s < T < 45^s$ irregularities in the central tail, compared to regions near the magnetopause, may be indicative of penetration of magnetosheath fluctuations similar to that noted for 2-10^s waves. On the dayside the irregularities are obviously concentrated toward the magnetopause.

MAGNETOSHEATH Pc-3 FLUCTUATIONS

The rapid sampling of the OGO-3 and 5 fluxgate and rubidium magnetometers reveals the variety of waves, irregularities, impulses, and quasi-periodic pulses that contribute to the complexity of magnetosheath field fluctuations. Within a given traverse and between traverses on successive orbits markedly different behaviors and combinations of principal fluctuations occur. A simple technique for classifying the most characteristic behaviors is needed for correlations with micropulsations and other phenomena in the magnetosphere as well as interplanetary conditions. This is a goal for the future.

For the present, one characteristic is visually obvious and that is that quasi-periodic waves at Pc-3 frequencies and recurrent pulses separated in time by Pc-3 periods frequently dominate the large amplitude fluctuations in the magnetosheath on the sunward side of the cavity. Figures 7 and 8, respectively, illustrate what is meant by quasi-periodic waves and recurrent pulses for simple small amplitude, weak field conditions. In both these examples, as in most but not all similar cases, the 3 components measured by the fluxgates simultaneously decrease and increase in intensity approximately in phase. This suggests that these waves and pulses are primarily compressional (i.e., magneto-acoustic mode) although transverse components appear to varying degrees. Despite this compressional wave appearance, study of simultaneous plasma measurements with appropriate time and energy resolution is essential for final identification. If compressional the plasma energy density should also increase and decrease in phase with the magnetic field. Our present reservation in identification stems partly from the fact that more isolated pulses similar in duration and symmetry to those in the magnetosheath have been observed within the magnetosphere (Sugiura, et al., 1969 and these are accompanied by a large increase, rather than decrease, in plasma flux. Finding similar correlation in the magnetosheath would suggest that the pulses, and perhaps the waves, are really recurrent blobs of diamagnetic plasma.

The belief, implied in the above, that the recurrent pulses and waves are closely related stems from numerous examples of two types: (a) examples which show the waves apparently turn into pulses (and vice versa) with time, and (b) examples where it is difficult to decide whether the fluctuations are waves or pulses. Figure 9 illustrates this related behavior: the first minute contains pulses and the second minute has the appearance of waves. Noting the in-phase decreases in the components also illustrates the compressional wave appearance mentioned previously. The field components are shown in spacecraft coordinates. Transformed to earth magnetic coordinates the magnetosheath field is almost parallel to the magnetic field in the nearby magnetosphere in this case.

Figures 9, 10 and 6, in sequence, are samples along the inbound portion of one orbit chosen to illustrate that the magnetospheric and magnetosheath Pc-3 fluctuations may be closely related, as well as illustrating other features previously discussed. Figure 10, 14 minutes after Figure 9, shows the magnetopause crossing which precedes Figure 6 by about 2 hours. Quasi-periodic oscillations of approximately 2^{γ} peak to peak amplitude are apparent within the magnetosphere (right side of Figure 10) near the magnetopause. In phase fluxgate magnetometer fluctuations show that these waves are also primarily compressional. The waves continue, but intermittently disappear (or alternatively the varying amplitude temporarily falls below the detection threshold), as the satellite moves inward to Figure 6 and beyond. In general, one cannot assume continuity of behavior in the magnetosheath over the span of several hours. In this particular case intermittent continuity appears probable from the similarity of wave periods near the magnetopause and regions much closer to the earth and the fact that the wave periods are shorter than usually observed. As noted under the Pc-2 discussion the fact that the magnetopause was closer to the earth (approximately 8.3 R_e at 11^h LT) than usual may be related to the occurrence of the shorter periods. There are thus some grounds for thinking that this may be a case where the waves observed within the magnetosphere can be related to a type of magnetosheath behavior observed earlier.

Whether or not there is validity to interpreting specific cases like the above should be readily resolved in the future using simultaneous data from several satellites. However, on more general grounds it is attractive to relate the frequent occurrence of large amplitude dayside magnetosheath fluctuations at Pc-3 periods to the prevalence of Pc-3 oscillations in the dayside magnetosphere. This implies that the magnetopause acts as a source for the Pc-3 waves observed within the magnetosphere. Whether the magnetopause is reacting to the waves in the magnetosheath or acting to create them is an open question that we are attempting to understand. This is the same as seeking an explanation for the Pc-3 magnetosheath waves and the phenomena that gives the recurrent pulses.

Pc-3 INDICES

Saito (1964b) proposed that an index of surface Pc-3 pulsations be used as an indicator of solar wind velocity. This was based in part on his finding that Pc-3 had a higher correlation with Mariner-II solar wind velocities than Kp. Bolshakova and Troitskaya (1968), comparing surface observations with Pioneer-6 and IMP-1 magnetic field observations, concluded that the direction of the interplanetary magnetic field in the ecliptic plane was the parameter which determined the excitation or attenuation mechanisms for the Pc-3 waves. The present study does not bear on these conclusions but does illustrate that Pc-3 waves have a well defined magnetospheric distribution and other characteristics that agree with surface observations. This lends credence to the use of surface Pc-3 observations as an indicator of activity taking place at the dayside magnetopause. The statistics also indicate that dayside Pc-3 activity does not have any direct relationship with K_p and D_{st} indices and thus a Pc-3 index would not be providing duplicate information.

We thus agree that an index of dayside surface Pc-3 activity would be a valuable parameter for future studies. We do not believe that it should be labelled as an index of any particular phenomena or space parameter until the mechanism for wave generation is better understood. The <u>initial</u> value of a surface Pc-3 activity index would be that its availability would promote more extensive study of satellite data pertaining to pulsations.

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FIGURE CAPTIONS

Figure 1: Typical microfilm plot of rubidium magnetometer data. Horizontal Scale: 2 min/frame. Left Vertical Scale: Total B, thick line, 10^{γ} grid lines. Right Vertical Scale: $\Delta B = B$ (measured) - B (reference field), thin line, 6^{γ} grid lines. Center grid is $\Delta B = 0$.

Figure 2: Distribution of occurrences of wave periods $10\text{-}25^{s}$ (top number) and $25\text{-}45^{s}$ (bottom number) in terms of percentage of time.

Figure 3: Distribution of occurrences of wave periods $45\text{-}120^{s}$ (top number) and $120\text{-}240^{s}$ (bottom number) in terms of percentage of time.

Figure 4: Distribution of occurrences of wave periods $< 2^{s}$ (approx. 0.8 to 2^{s}) (top number), $2\text{-}5^{s}$ (middle number), and $5\text{-}10^{s}$ (bottom number) in terms of percentage of time.

Figure 5: Distribution of incoherent irregularities in the magnetic field for field changes having time constants $T < 5^{s}$ (top number) and $5^{s} < T < 45^{s}$ (bottom number) in terms of percentage of minutes containing irregularities.

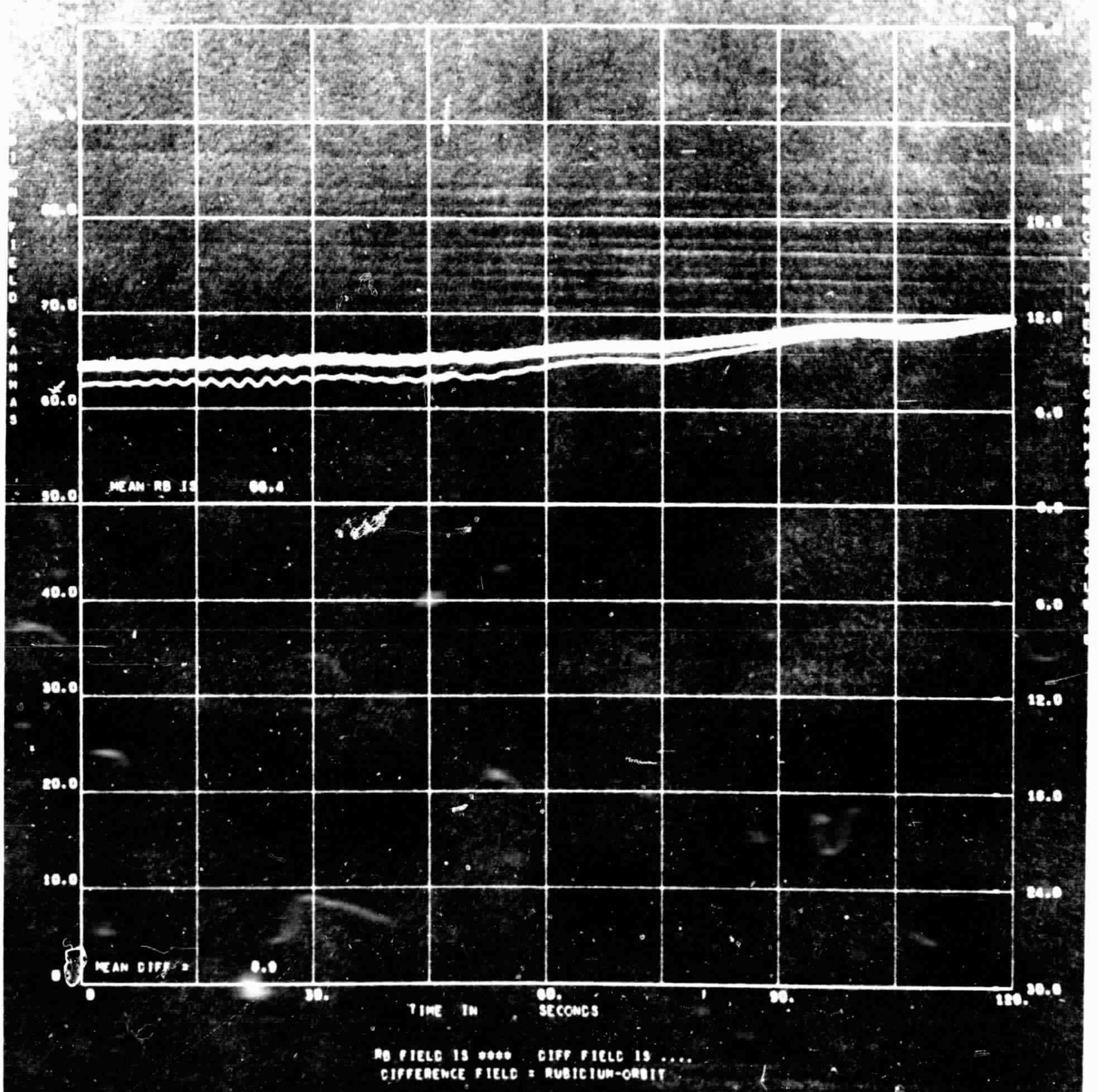
Figure 6: Quasi-periodic waves near L=4, $22^{h}36^{m}$ to $22^{h}38^{m}$, March 14, 1968. Left Scale: total B, thick line, 90^{γ} grid lines. Right Scale: ΔB, thin line, 6^{γ} grid lines.

Figure 7: Quasi-periodic waves in the magnetosheath. Left Scale: total B, thick line, 5^{γ} grid lines. Right Scale: ΔB, thin line, 6^{γ} grid lines.

Figure 8: Recurrent pulses in the magnetosheath. Left Scale: total B, thick line, 5^{γ} grid lines. Right Scale: ΔB, thin line, 10^{γ} grid lines.

Figure 9: Large amplitude pulses and/or waves in the magnetosheath (see text).

Figure 10: Magnetopause crossing between Figures 9 and 6, $20^h 26^m$ - $20^h 28^m$, March 14, 1968. Left Scale: total B, thick line, 20^γ grid lines. Right Scale: ΔB, thin line, 20^γ grid lines. Center line is $\Delta B=0$.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50.0
40.0
30.0
20.0
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18.0
12.0
6.0
0.0
6.0
12.0
18.0
24.0
30.0
MEAN RB IS 60.4
MEAN DIFF = 0.0
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30.
60.
90.
120.
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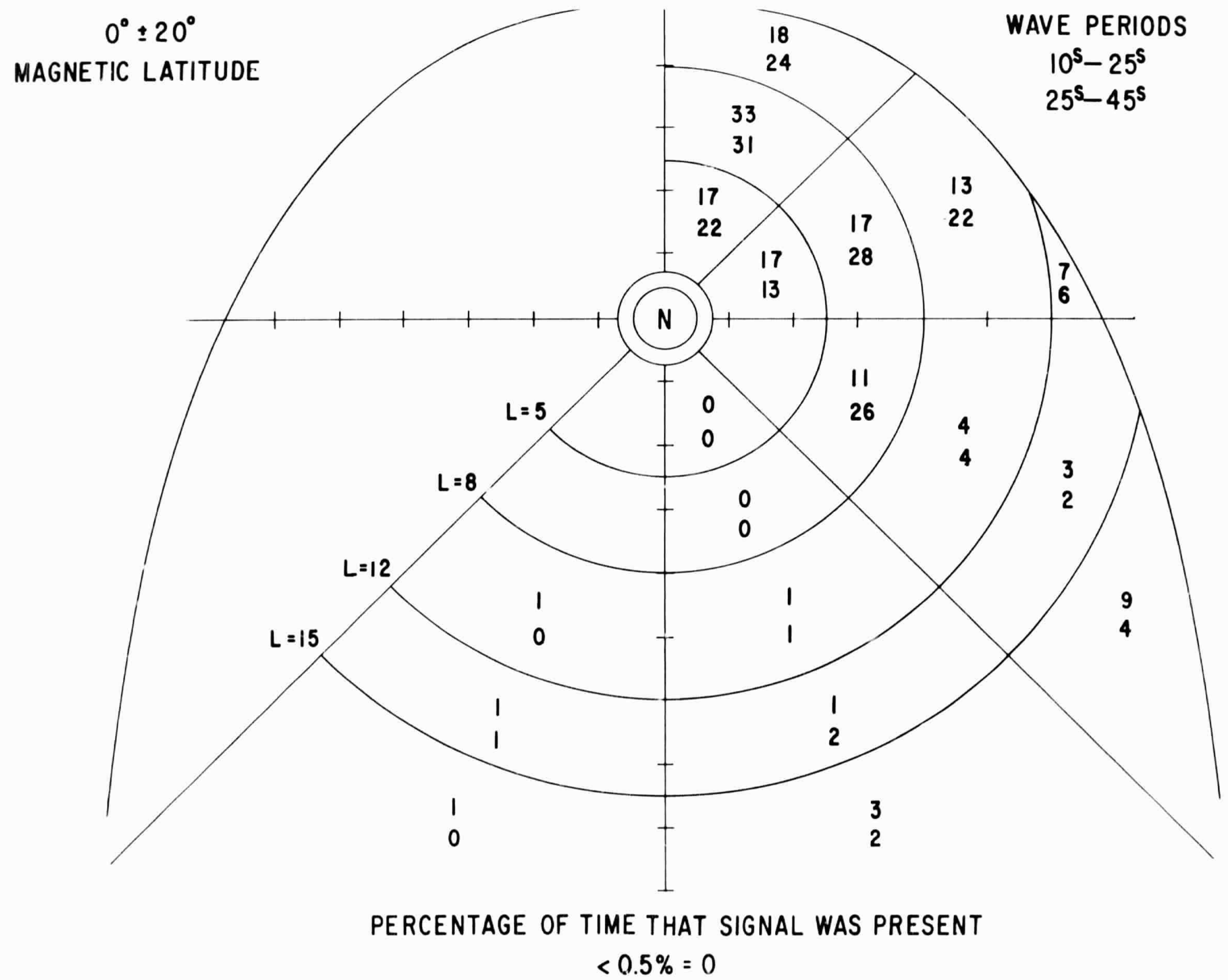
0° ± 20°
MAGNETIC LATITUDE
WAVE PERIODS
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25^s—45^s
N
L=5
L=8
L=12
L=15
18
24
33
31
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22
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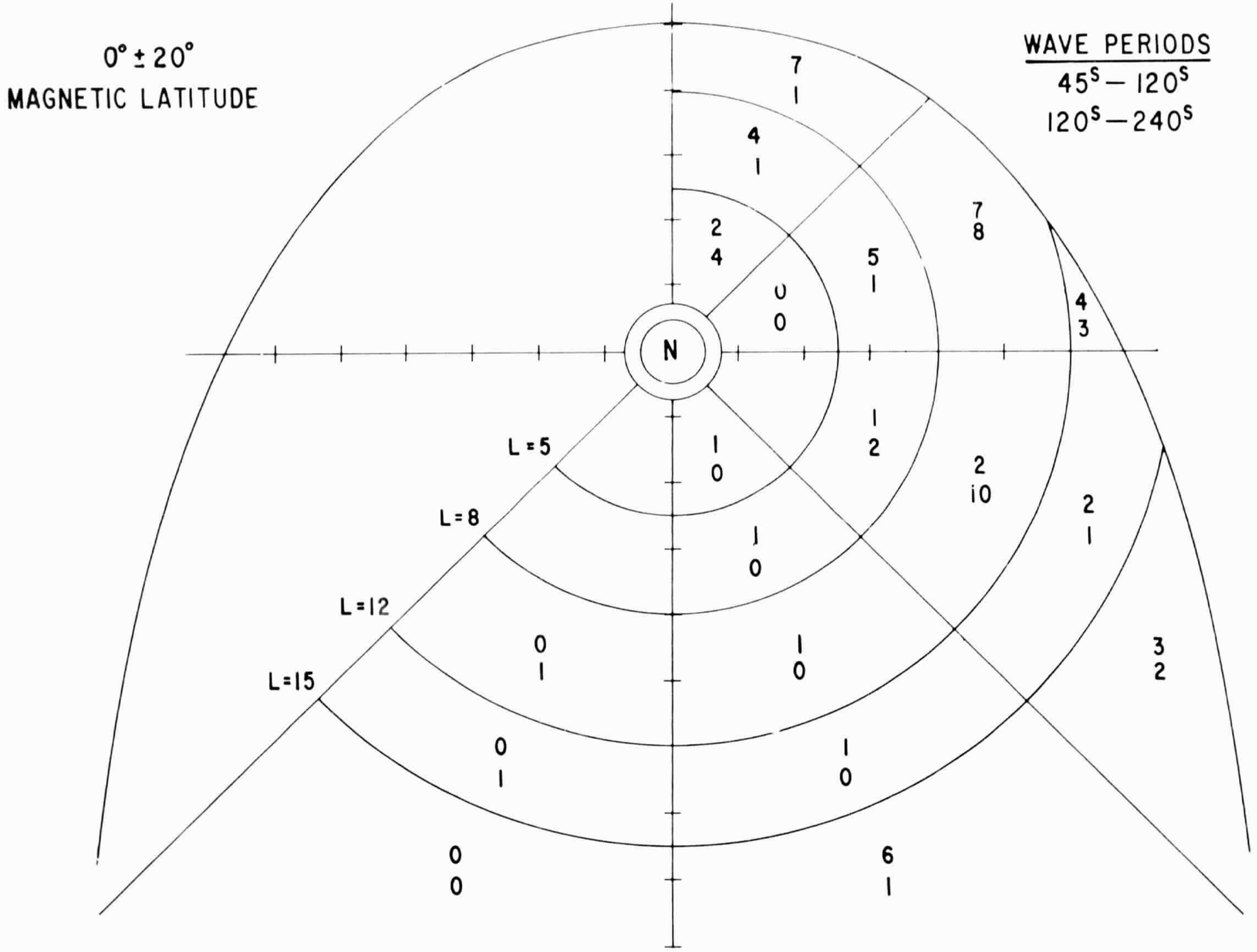
PERCENTAGE OF TIME THAT SIGNAL WAS PRESENT
< 0.5% = 0

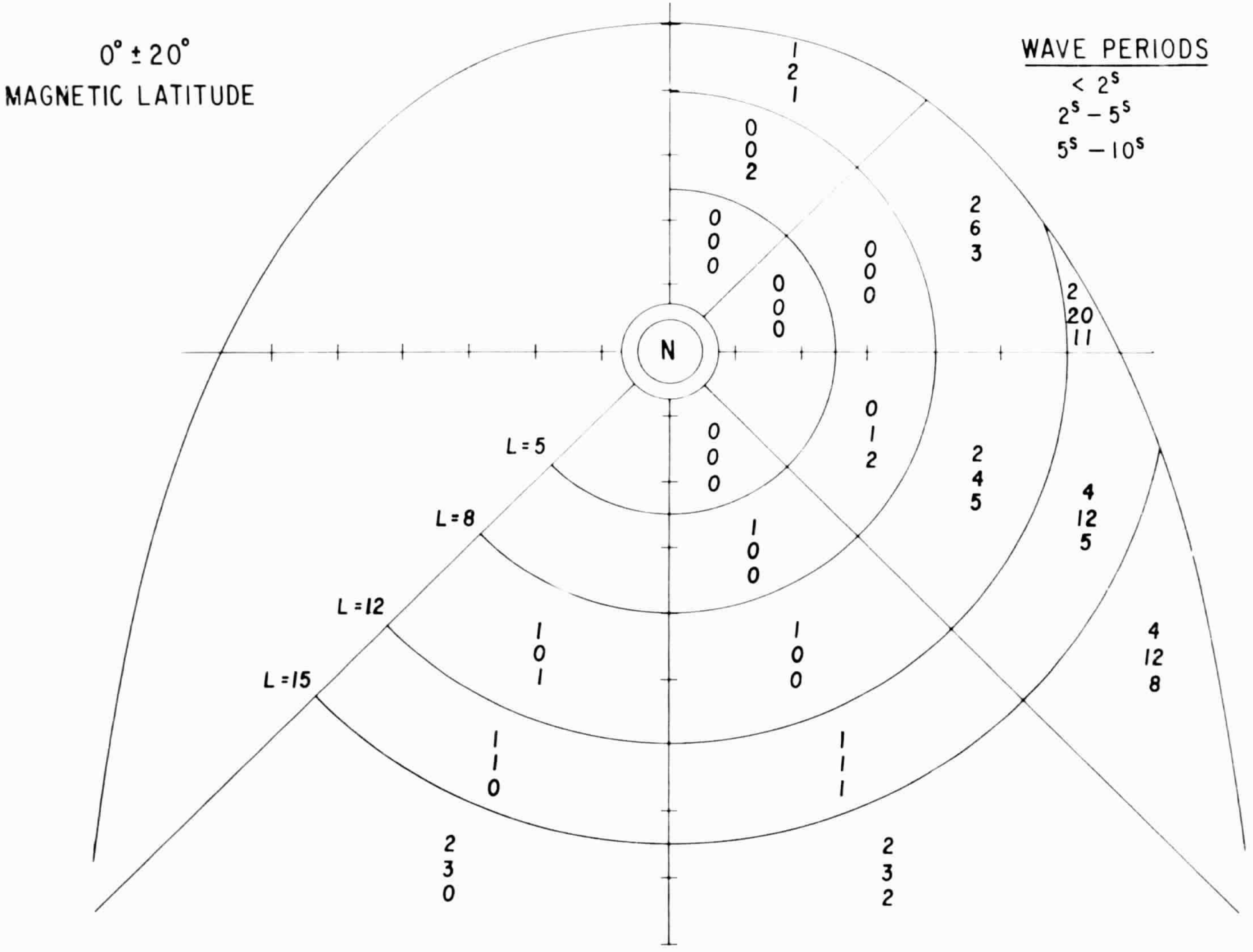
FIGURE 2



PERCENTAGE OF TIME THAT SIGNAL WAS PRESENT

< 0.5% = 0

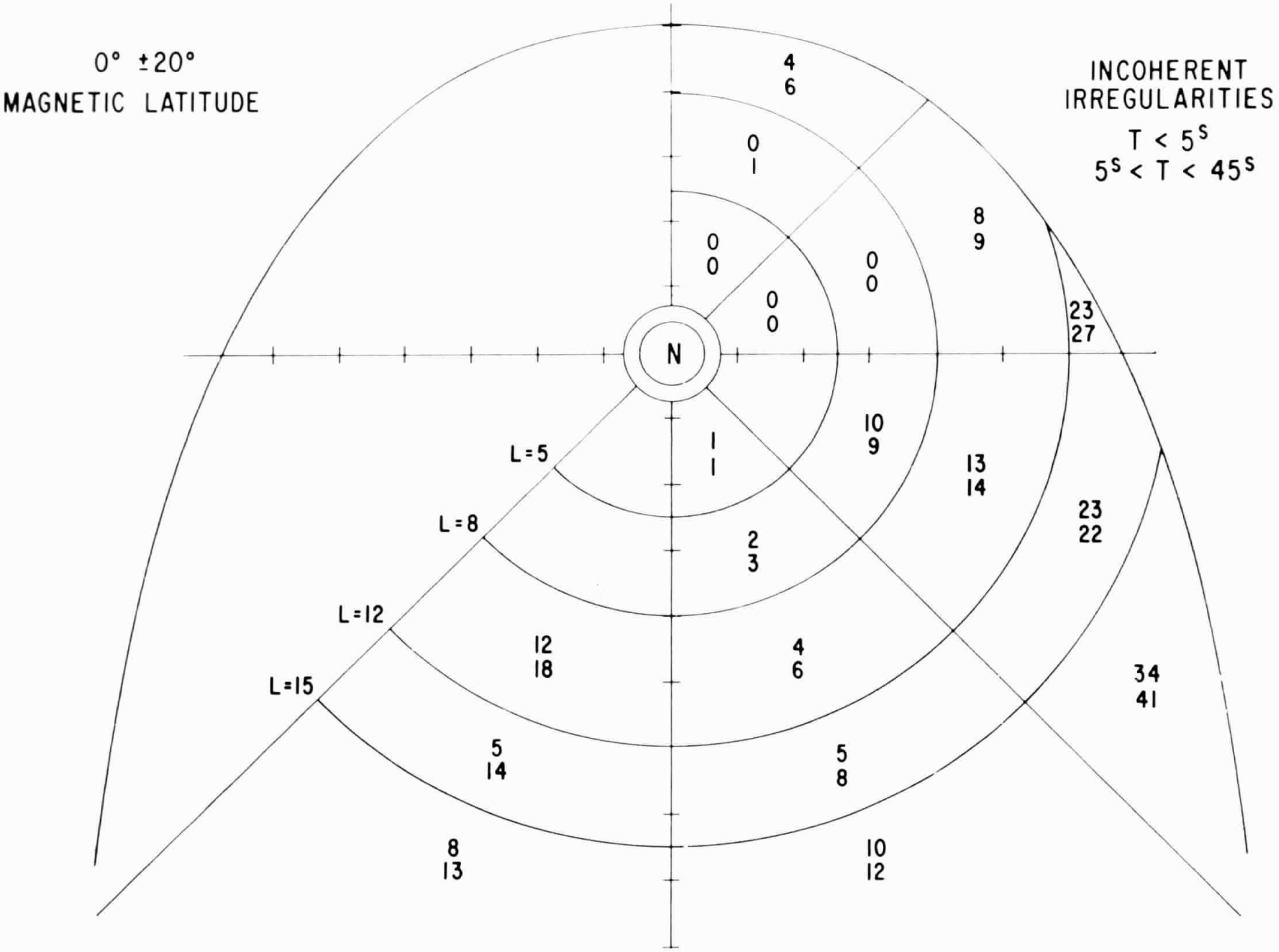
FIGURE 3



PERCENTAGE OF TIME THAT SIGNAL WAS PRESENT

< 0.5% = 0

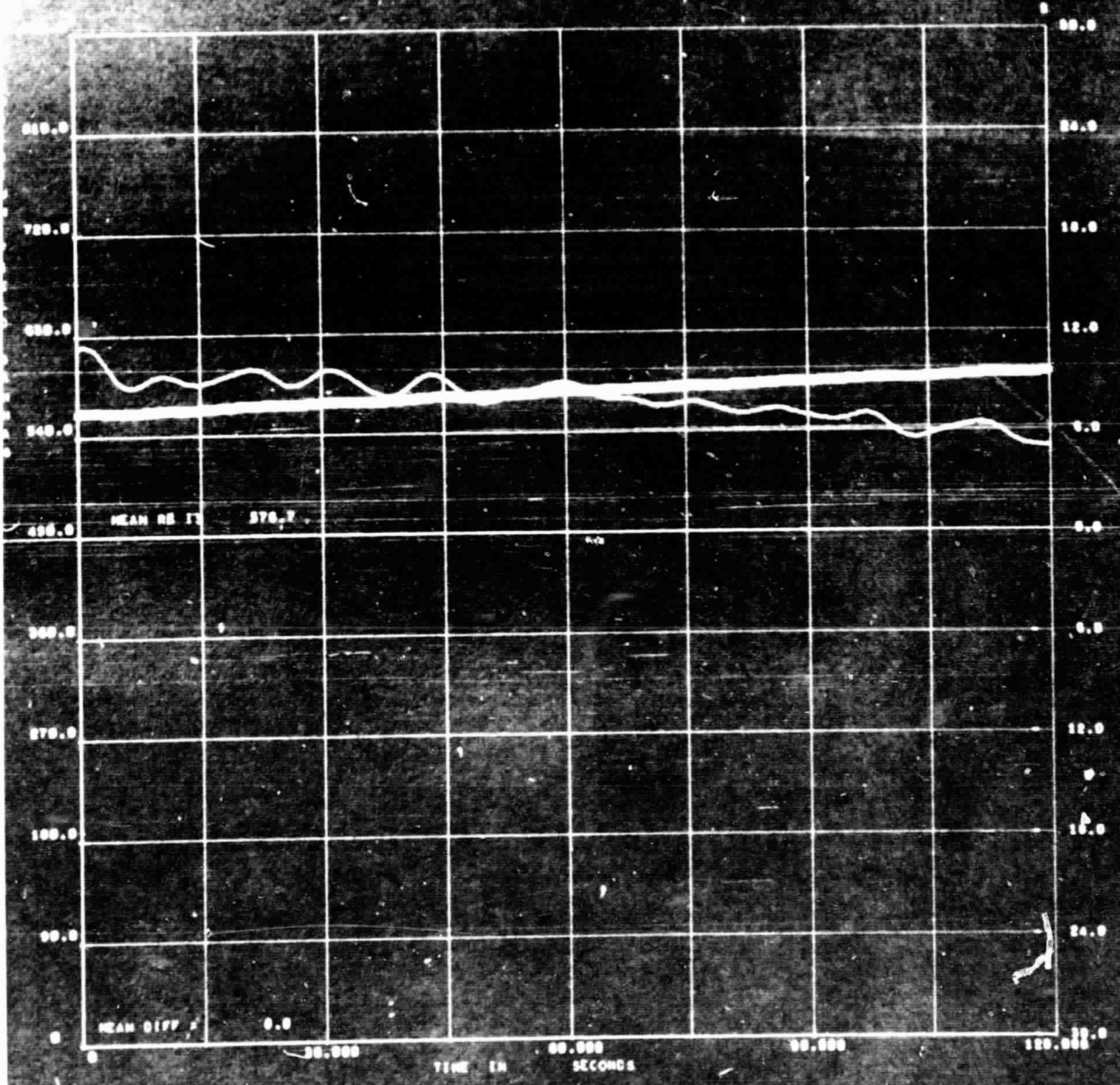
FIGURE 4



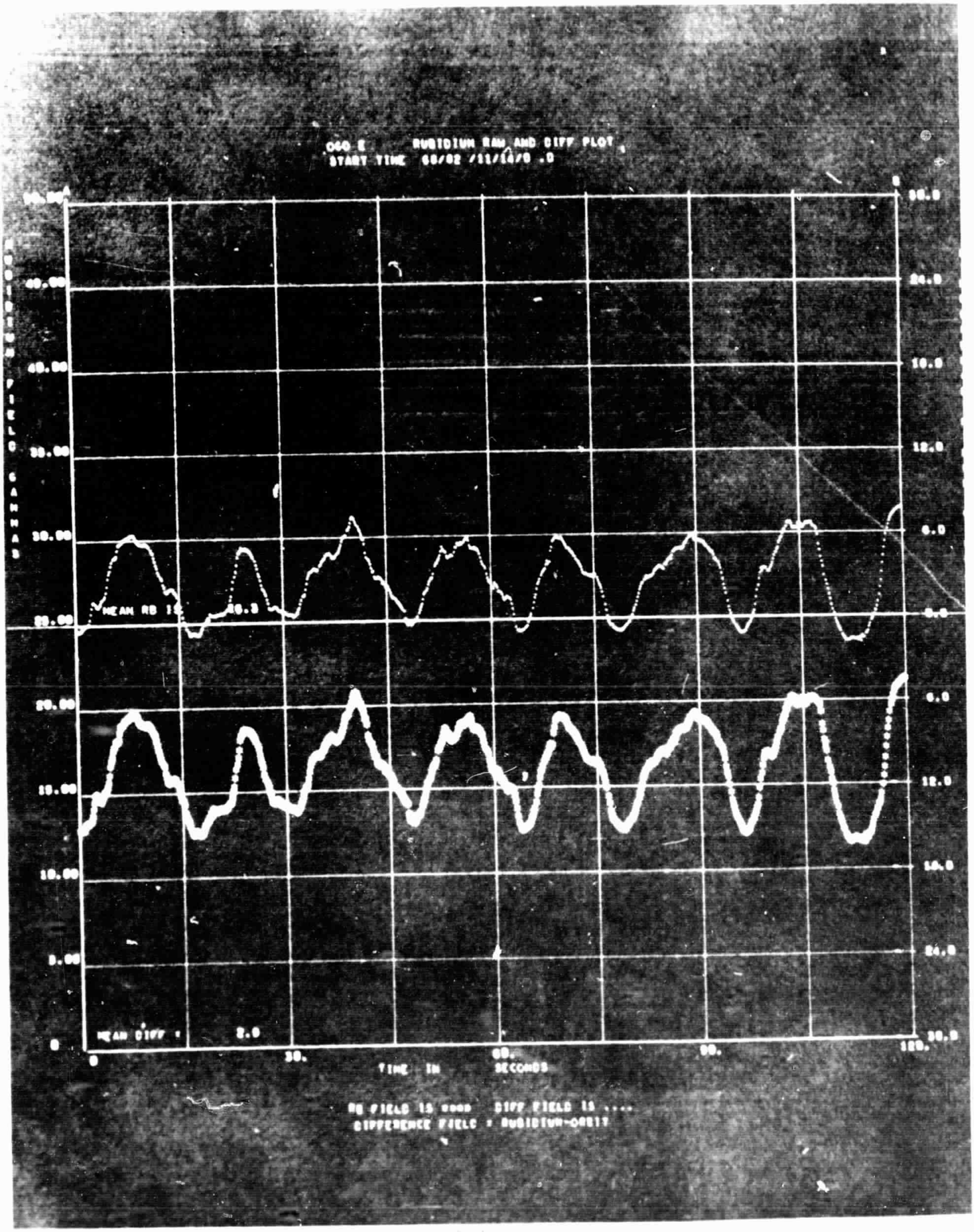
PERCENTAGE OF TIME THAT SIGNAL WAS PRESENT
<0.5% = 0

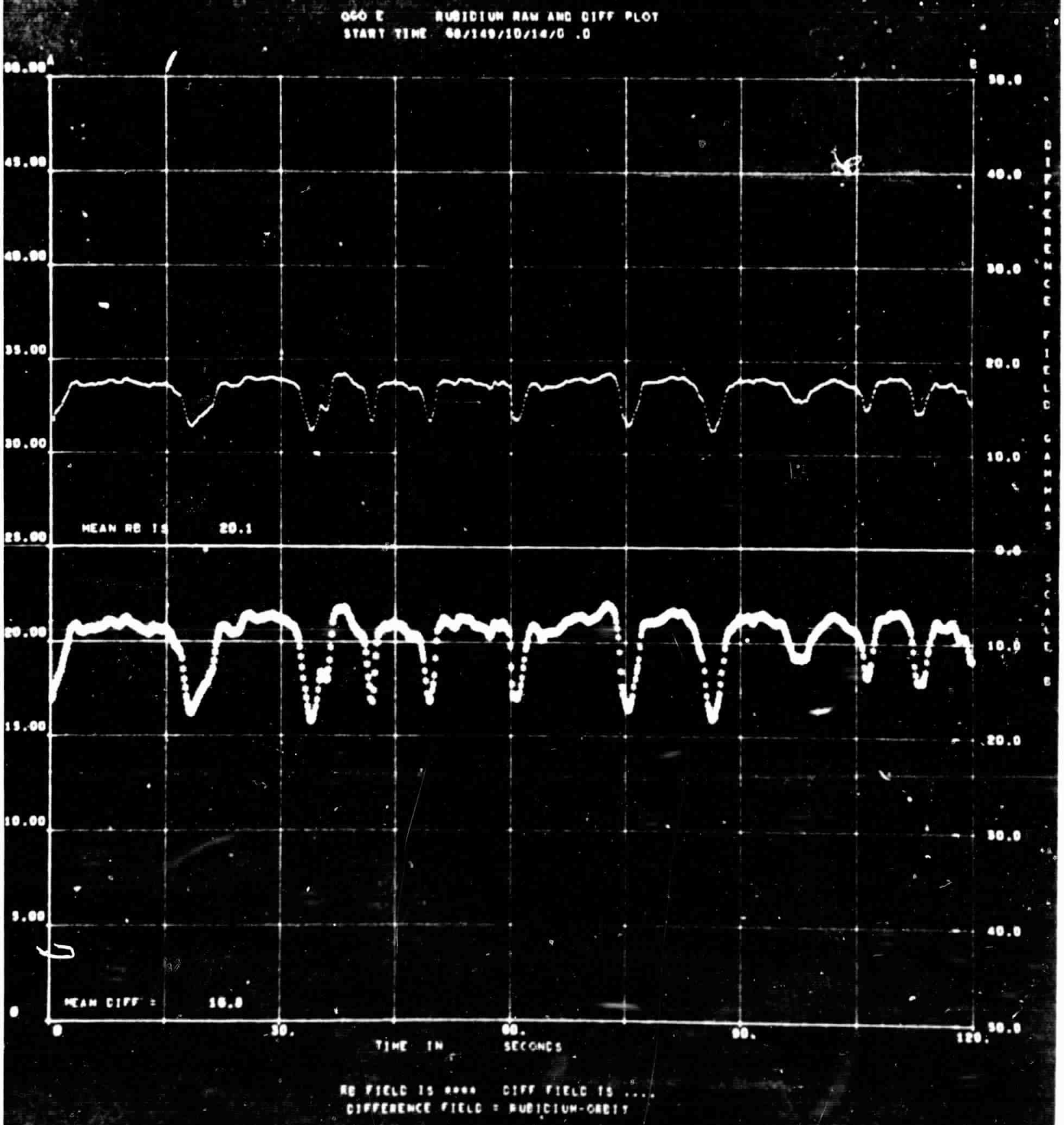
FIGURE 5

OGO E RUBIDIUM RAW AND DIFF PLOT
START TIME 68/74 /22/36/0 .0



RB FIELD IS oooo DIFF FIELD IS ....
DIFFERENCE FIELD = RUBIDIUM-ORBIT


OGO E RUBIDIUM RAW AND DIFF PLOT
START TIME 68/02 /11/14/0 .0
RUBIDIUM FIELD GAMMAS
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0
30.0
24.0
18.0
12.0
6.0
0.0
6.0
12.0
18.0
24.0
30.0
MEAN RB IS 26.3
MEAN DIFF = 2.0
0
30.
60.
90.
120.
TIME IN SECONDS
RB FIELD IS oooo DIFF FIELD IS ....
DIFFERENCE FIELD = RUBIDIUM-ORBIT


OGO E RUBIDIUM RAW AND DIFF PLOT
START TIME 68/149/10/14/0 .0
A
B
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0
50.0
40.0
30.0
20.0
10.0
0.0
10.0
20.0
30.0
40.0
50.0
DIFFERENCE FIELD GAMMAS
SCALE B
MEAN RB IS 20.1
MEAN DIFF = 10.8
0
30.
60.
90.
120.
TIME IN SECONDS
RB FIELD IS **** DIFF FIELD IS ....
DIFFERENCE FIELD = RUBIDIUM-ORBIT

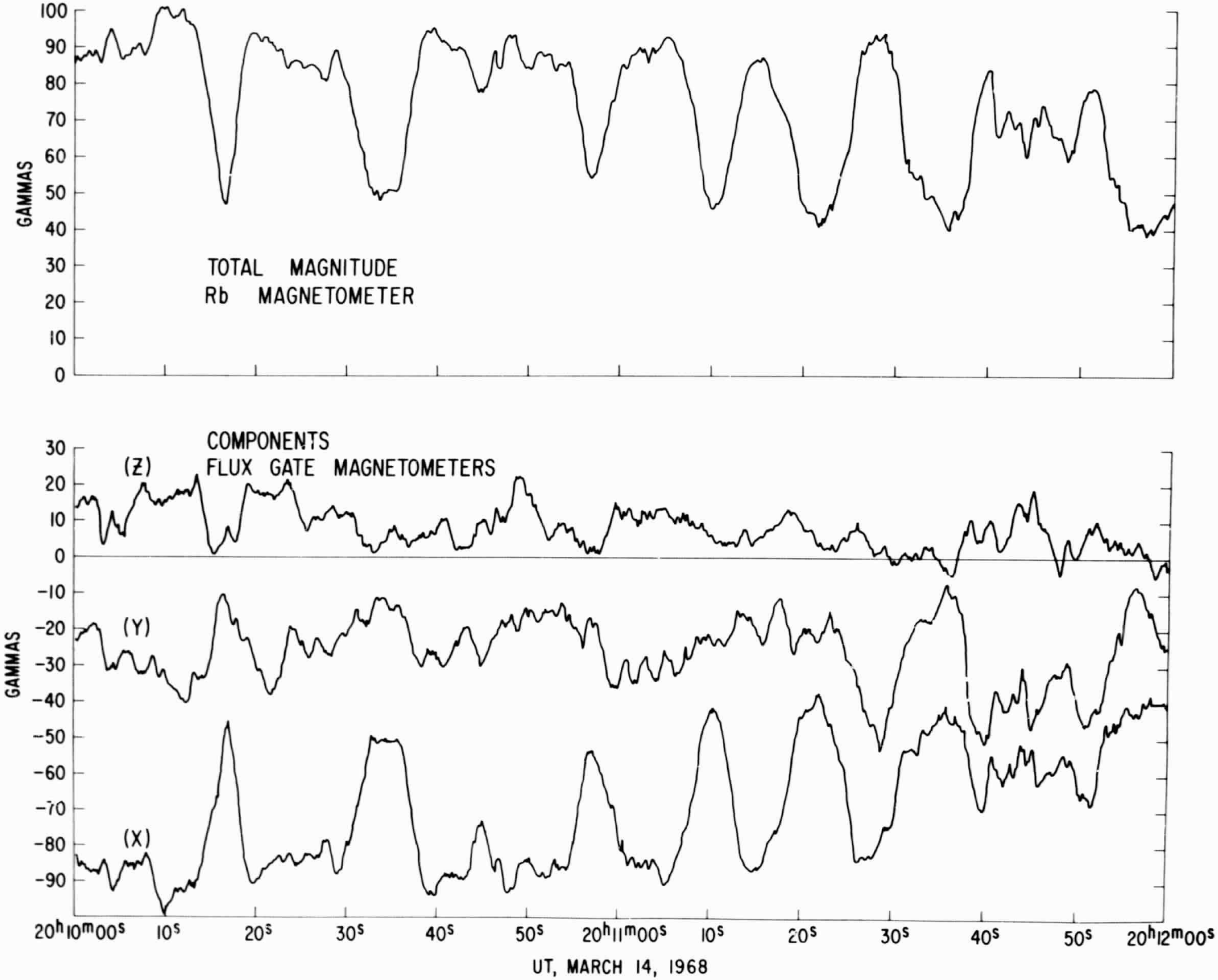
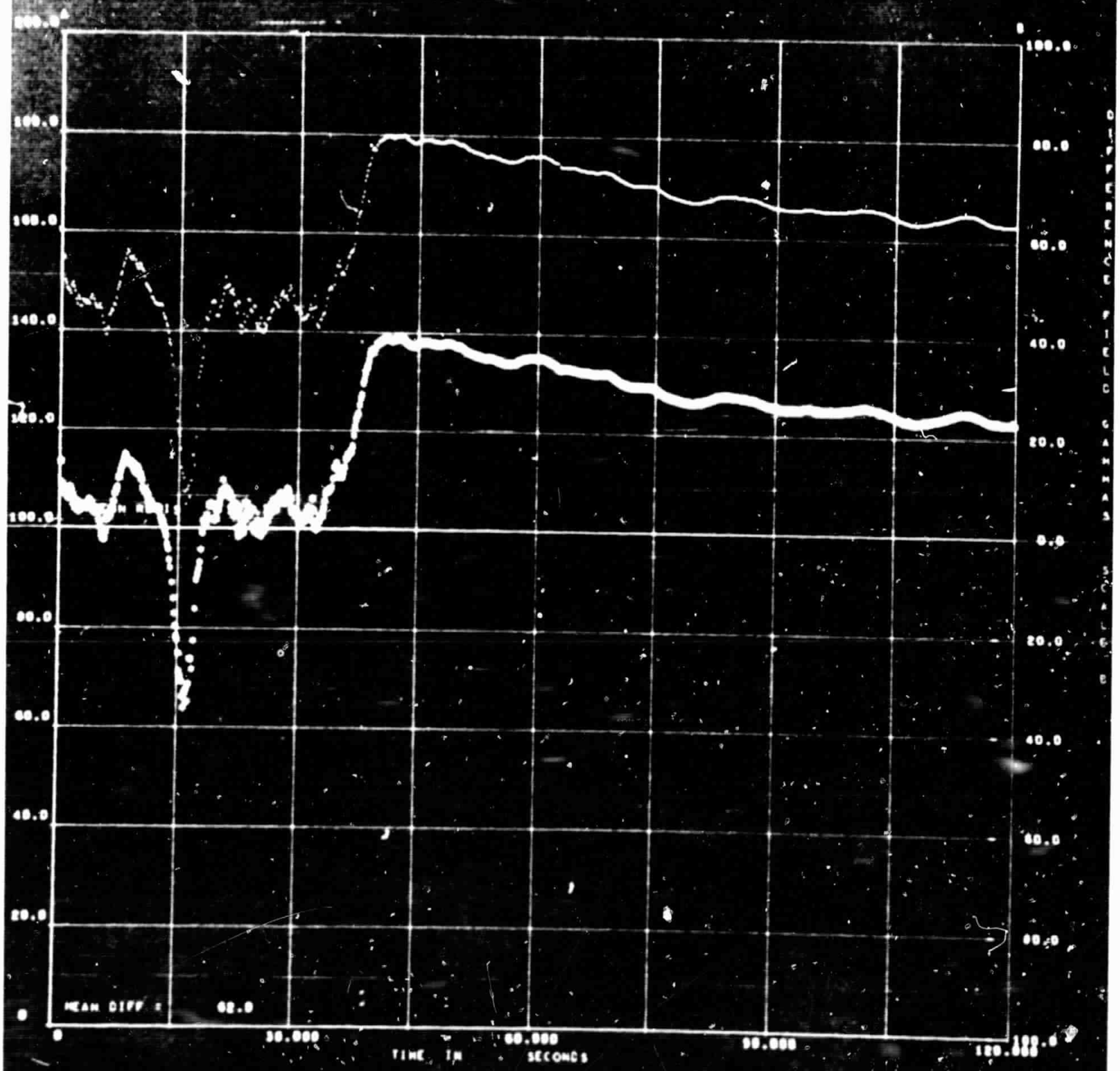

GAMMAS
100
90
80
70
60
50
40
30
20
10
0
TOTAL MAGNITUDE
Rb MAGNETOMETER
GAMMAS
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
COMPONENTS
FLUX GATE MAGNETOMETERS
(Z)
(Y)
(X)
20h10m00s
10s
20s
30s
40s
50s
20h11m00s
10s
20s
30s
40s
50s
20h12m00s
UT, MARCH 14, 1968

FIGURE 9

OGO E RUBIDIUM RAW AND DIFF PLOT
START TIME 68/74 /20/26/0 .0



RB FIELD IS **** DIFF FIELD IS ....
DIFFERENCE FIELD = RUBIDIUM-ORBIT