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An Atlas of Interplanetary Sector Structure 1957-1974

by

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Introduction

Solar magnetic field lines are convected away from the sun by the expanding solar wind. Measurements by spacecraft of the resulting magnetic field in interplanetary space revealed that this field is highly ordered and organized on a large scale. Wilcox and Ness (1965) introduced the concept of Interplanetary Sectors as being extended regions of space where the magnetic field lines are predominantly directed either away from the sun or towards the sun along the basic Archimedes spiral induced by solar rotation (Parker,1958). Because the sector-structure only changes slowly with time it must reflect a similar ordering of the solar magnetic fields. Many interplanetary and solar parameters have been found to vary in an organized way within the magnetic sectors. An increasing number of terrestrial phenomena are being found to respond to the sector-structure as it sweeps past the earth in the course of solar rotation. It is therefore of considerable interest to have a continous record of the sector-structure covering an extended interval of time. The present Atlas has been prepared to meet the need for such a record.

The interval of time covered by the Atlas is 1957 through 1974. Reasonable coverage of in situ measurements by spacecraft is not available before 1965 and even after that substantial data gaps exist from time to time. In order to fill in these gaps and to determine the sector-structure prior to 1965, we have used ground-based magnetograms from stations within the terrestrial polar caps. At such stations the geomagnetic field variations are well correlated with variations of the interplanetary field (e.g. Svalgaard,1974). Several analyses have shown (e.g. Friis-Christensen et al.,1971) that it is possible with fair accuracy to infer the interplanetary sector polarity from these geomagnetic variations. For the purpose of the present Atlas we have investigated the accuracy of these inferred polarities as will be detailed in section 3. It was felt justified to adopt a daily index of (either observed or inferred) sector polarity covering the entire interval 1957-1974. In the following sections details of techniques and procedures will be presented.

Description of techniques for determining or inferring the sector polarity

Polarity determinations are made by utilizing magnetic field data from spacecraft. The spacecraft data is usually averaged over some time interval ranging from seconds to hours. To determine the sector polarity an averaging interval of the order of one hour gives a reasonable time resolution. The data is usually represented by the field magnitude and the field direction given by a latitude angle θ and a longitude angle φ in an appropriate coordinate system. The natural system to use near the earth is the geocentric-solar-equatorial system that has its X-axis pointing towards the sun from the center of the earth. The Z-axis is parallel to the solar rotation axis positive northwards while the Y-axis completes a right-handed coordinate system (positive opposing solar rotation and planetary motion). The longitude angle φ in this system is measured from the X-axis (0° in the direction of the sun) in the solar equatorial plane so that the Y-axis has longitude 90°. This longitude angle of the field direction is used as basis for determination of the field polarity.

It should be appreciated, however, that the field polarity is a physical concept rather distinct from the more formal definition of the instantaneous field direction. The polarity is a large-scale property of the interplanetary magnetic field. This property expresses our knowledge of the intrinsic direction of a field line convected to us from near the sun by the solar wind plasma. Meso-scale and small-scale processes may cause the instantaneous field vector to have any direction whatsoever irrespective of the field polarity. This is illustrated in Figure 1, which shows the distribution of the longitude angle for 12229 hourly averages of the interplanetary field. The Figure, however, also shows the strong tendency for the field to have a longitude close to either 135° (Away polarity) or to 315° (Toward polarity) with very few cases with longitude near 45° or 225°. One could define the polarity to be Away if $45^{\circ} < \varphi \leq 225^{\circ}$ and Toward otherwise. But if during successive hours the longitude were to change slowly trough (say) 110°, 90°, 70°, 50°, 30° and then back: 50°, 70°, etc. to 135° it is clear that the polarity

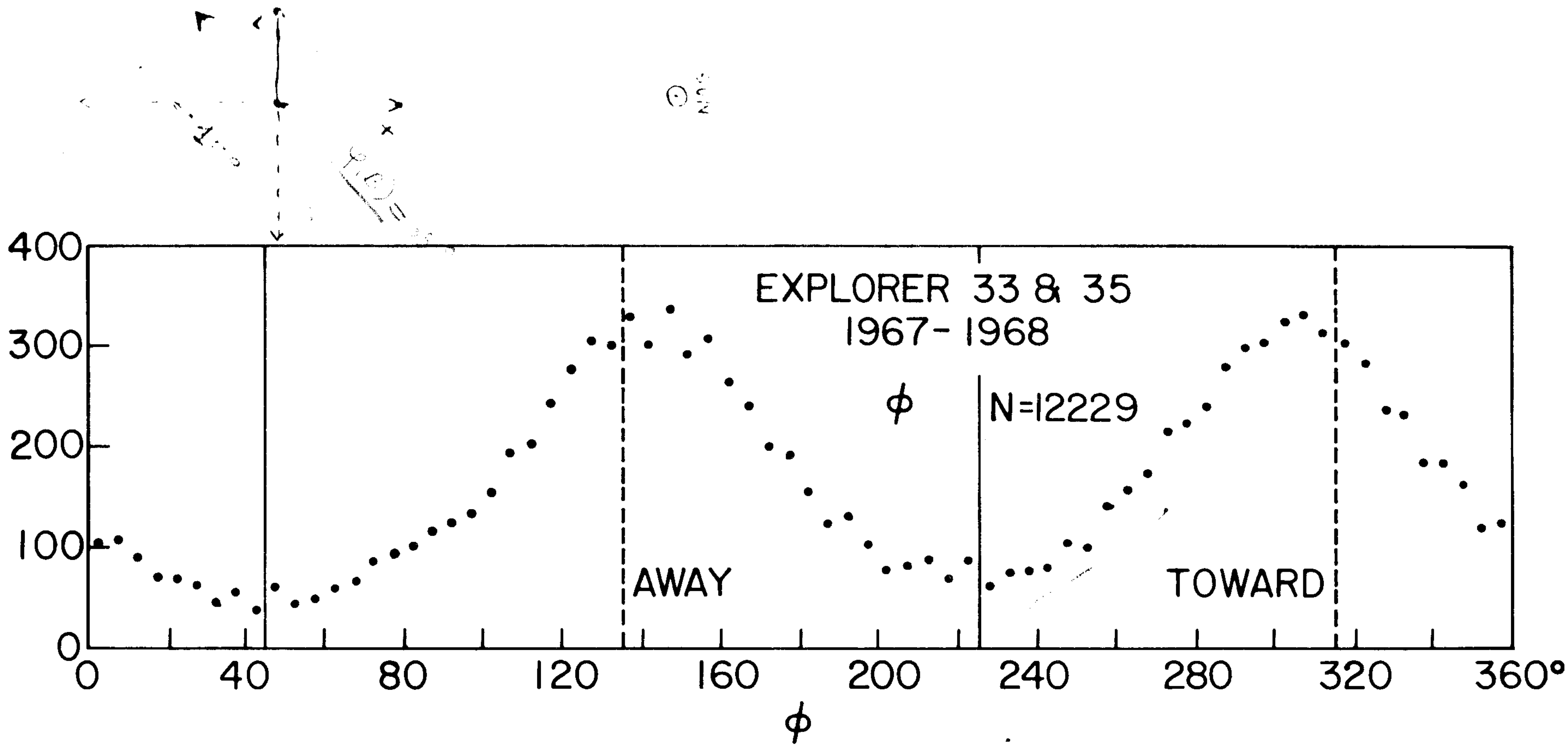


Figure 1. Distribution of longitude angle for 12229 hourly averages of the interplanetary magnetic field measured by spacecraft Explorer 33 and Explorer 35. The theoretical longitudes for Away and Toward polarity along the ideal field spiral are shown by the dashed lines. There is a pronounced tendency for the field direction to lie near the ideal spiral. The ordinate is number of averages in each 5^{o} bin of longitude.

probably did not change, so a more realistic determination of the polarity involves a certain amount of judgement.

Observations clearly indicate that the number of sectors observed during a solar rotation is fairly small (of the order of 4). This justifies trying to minimize the number of sectors by ignoring reversals of the polarity lasting only a few hours even if these reversals are very sharp and clear. A further complication is that the nature of a field reversal - a socalled sector boundary - varies greatly from one reversal to the next. Sometimes the time of the boundary passing can be determined to within a minute, whereas at other times the field direction may change gradually over many hours or a sharp boundary may move back and forth past the spacecraft several times during an interval of up to a day. At such times the field polarity may be designated as "mixed".

A characteristic of the spacecraft data is the frequent occurrence of gaps in the coverage. By employing several spacecraft (when available) this problem may often be replaced by a somewhat less serious difficulty, namely that of combining data from spacecraft in differing orbits and perhaps with different averaging intervals. Intercomparison of simultaneous measurements made by different spacecraft usually show a rather high degree of agreement although disagreements occasionally occur, especially under disturbed conditions. The general procedure adopted here is not to average simultaneous measurements but to select a spacecraft as the primary source for a selected interval, i.e. to define a ranking order among the available spacecraft. This procedure can be generalized to defining a ranking order among already published compilations of interplanetary sector polarities. Several such compilations exist (section 4) and have been utilized heavily in the preparation of the present Atlas.

It is important to stress the fact that the sector structure referred to in the Atlas is the structure observed at the earth. In using data from deep space interplanetary propes, which reach considerable distances from the earth both in radial and azimuthal direction, a correction must be applied to the timing of the observations before they can be compared with near-earth conditions. This correction is made on the assumption that the solar wind velocity is uniform and radial and may introduce errors on the order of a day in determining the time of passage of a sector boundary.

Before comparing the sector-structure with features on the sun it should be realized that the observed sectors refer to conditions near the ecliptic plane about $4\frac{1}{2}$ days after the plasma left the sun. This is the time it takes the solar wind to carry the "frozen-in" magnetic field of the solar corona out to the distance of 1 astronomical unit. Of all the solar wind parameters it seems that the imbedded magnetic field is the critical physical quality that governs the interaction between the solar wind and the magnetized earth. Direct connection or linkage of the interplanetary magnetic field lines and the terrestrial magnetic field provides for transfer of solar wind kinetic energy to the stretched out geomagnetic tail: the magnetic field of the earth is being deformed and bent away from the sun (e.g. reviews edited by Williams and Mead, 1969; also Svalgaard, 1975a). The geomagnetospheric configuration appears to be dependent on the direction of the interplanetary magnetic field; and it was realized some years ago that the different configurations have different magnetic signatures as measured on the ground in the terrestrial polar caps (Svalgaard, 1968, 1972; Mansurov, 1969; Wilcox, 1972).

The important interaction parameter is the interplanetary electric field, $\tilde{E} = \tilde{V} \times \tilde{B}$, in the frame of the magnetosphere, so that actually the components of the magnetic field $\tilde{B}$ that are perpendicular to the solar wind velocity $\tilde{V}$ are important. The ground effects just mentioned allow one to determine the sign (and less reliably also the magnitude) of the azimuthal $\tilde{B}$-component, BYM, in the plane of the geomagnetic equator. Due to the spiral nature of the average interplanetary magnetic field with the field vector directed predominantly along an Archimedes spiral rooted in the sun, and because the geomagnetic equator at the most is about 40° inclined to the average spiral, there is normally a good correlation between the polarity and the sign of the azimuthal component. This correlation improves if the average properties are compared over progressively longer averaging intervals. For an averaging interval of 6 hours the sign of the BYM-component agrees with the sector polarity 88% of the time; for 24 hours the agreement increases to 91% (Russell and Rosenberg, 1974).

Geomagnetic observatories routinely record the variations of the geomagnetic field; usually magnetograms of three vector components are obtained daily. The fluctuations of the field are rather small, very rarely exceeding 1 percent except in the polar regions where disturbances up to 10 percent have been recorded. In the so-called polar cap (within about 15^{o} of the magnetic pole) these disturbances are most pronounced around local noon; they are at first glance erratic, sometimes positive and sometimes negative. The sector structure provides the key to understanding the morphology and possibly the cause of these fluctuations. Figure 2 shows the variation of the vertical component, Z, at Thule and of the horizontal component, H, at Godhavn for several days around the sector boundary passing on July 25, 1968. Thule is located less than 4^{o} from the magnetic pole (more precisely the invariant magnetic pole, cf. Hess (1968) page 59) while Godhavn at $12\overset{o}{.}5$ from the pole is near the polar cap boundary. The undisturbed level of the geomagnetic components is indicated by dashed lines on Figure 2. The azimuthal component of the interplanetary magnetic field changes sign abruptly near 12^{h} UT on July 25 and the perturbances at Thule change from negative to positive. This is the basic change of the geomagnetic field as a response to a change of sector polarity: the irregular daytime deviations change sign. The precise nature of these deviations varies from observatory to observatory depending on distance from the pole, on subsoil conductivity, and on the time difference between solar local noon and so-called magnetic noon (defined analogously to local noon but referring to the invariant magnetic pole).

That the relation between the polar cap magnetic deviations and the azimuthal component of the interplanetary field holds not only on a time-scale of a day (as in Figure 2), but extends even to short-period fluctuations can be seen clearly in Figure 3 , where daily magnetograms of

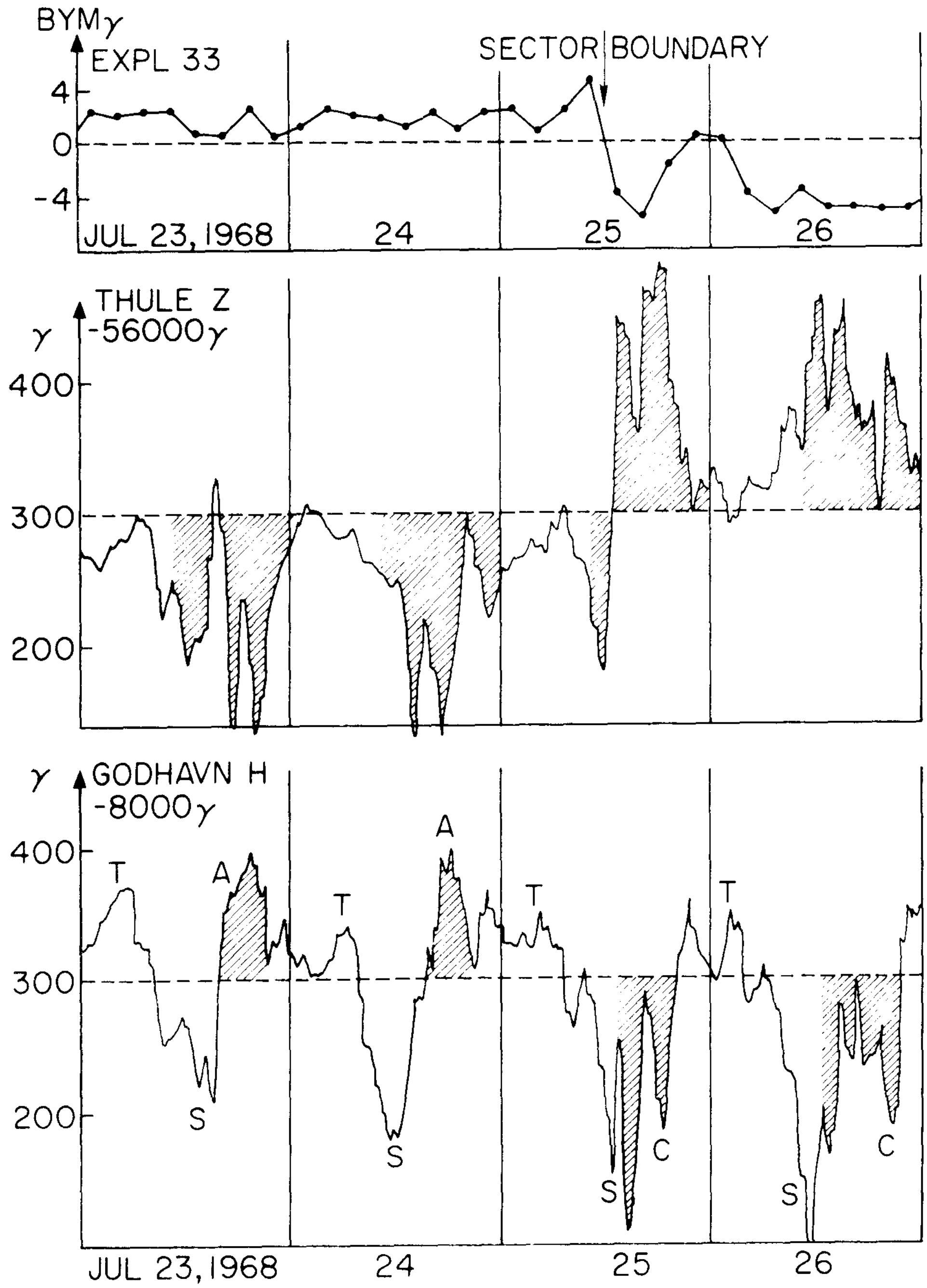


Figure 2. Typical changes of the characteristics of the magnetic variations at Thule and at Godhavn as response to the passage of an interplanetary magnetic sector boundary on July 25, 1968. The upper panel gives the azimuthal component of the interplanetary field in solar magnetospheric coordinates. The lower two panels display Z-magnetograms from Thule and H-magnetograms from Godhavn. The variations related to the sector polarity are shaded (after Svalgaard, 1975).

the vertical component, Z, at Thule are superposed on plots of the azimuthal component observed by the IMP-3 satellite. The records have been

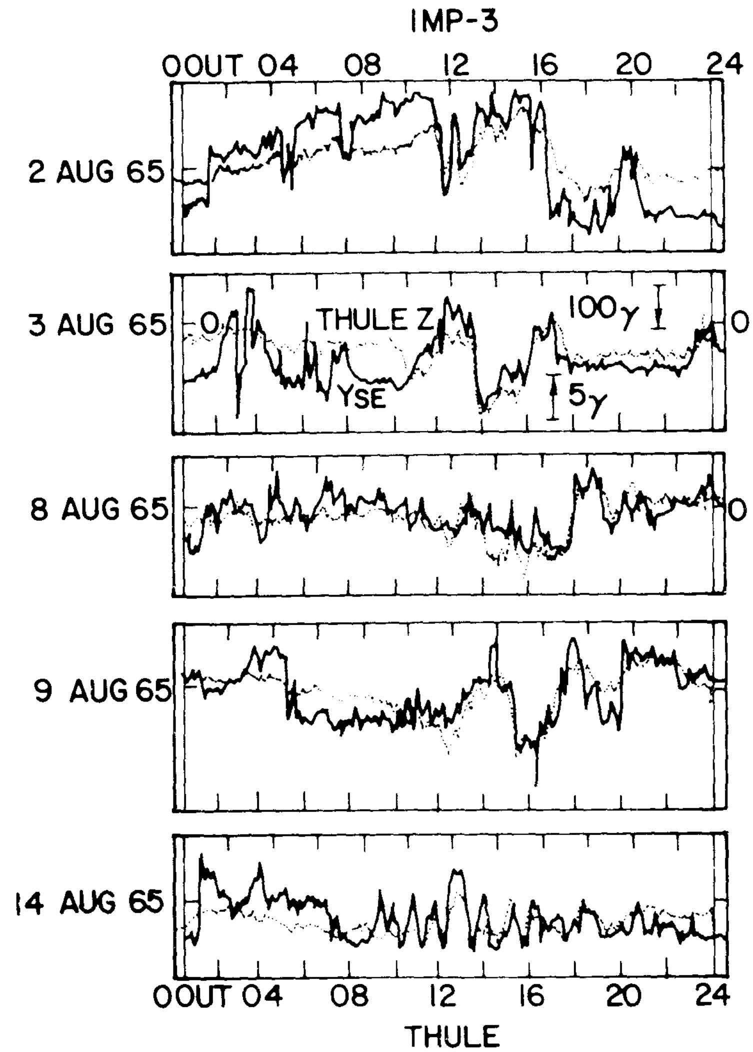


Figure 3. Comparison of Thule Z magnetograms with the azimuthal component (Y) of the interplanetary magnetic field in the solar ecliptic (SE) coordinate system observed by the IMP-3 satellite for several days during northern summer. The Thule Z component (dotted line) is plotted positive downward (Adapted after Kawasaki et al., 1973).

slightly shifted with respect to each other to obtain the best visually observable correlation during the dayhours ($12\text{-}24^h$UT). Even variations on a time-scale of 10-20 minutes appear to be correlated during the day-hours. On the average the variations of Thule Z are delayed about 20 minutes with respect to variations of the interplanetary magnetic field indicative of the typical response time of the magnetosphere to this type of fluctuations.

Quantitative investigations of this relationship show (e.g. Friis-Christensen and Wilhjelm,1975) that the value of the vertical component, Z, in the central polar cap may be written

$$Z(t) = Z_o + Z' - k \cdot BYM(t-20 \text{ min}) \qquad (1)$$

where Z_o is the very slowly varying background field, and the Z' term includes all variations not related to the azimuthal component BYM (in geocentric solar magnetospheric coordinates) of the interplanetary magnetic field. The coefficient k is about 10 on the average but varies greatly with local time, with season and with the sunspot cycle. These regular variations of k by up to a factor of 10 are important for the practical use of the above expression in determining BYM from Z. If k is large enough, the BYM-term will dominate over the Z'-term allowing BYM to be determined.

Much work has been done with hourly averages of Z and of BYM. In this case the 20 minutes delay mentioned above can usually be neglected. To be precise, the coefficient k also depends on the length of the averaging interval; one hour is so short that we usually can neglect this complication too. A final point of interest (and possible confusion) is that the k-coefficient has the same sign in both the northern and the southern hemisphere if the vertical component Z is treated as a signed quantity. Traditionally, Z is considered positive when directed downward, i.e. toward the earth. Hence Z is positive in the northern hemisphere and negative in the southern hemisphere. The effect of positive BYM is then to decrease the numerical magnitude of Z in the northern hemisphere but to increase the magnitude of Z in the southern hemisphere. On magnetograms from the southern hemisphere the "positive" direction of Z is often reversed; caution should be exercized when interpreting such magnetograms. As an aid in this interpretation we show Figure 4 which has been constructed using hourly means and depicts the variation of Z in the two opposite hemispheres for three different ranges of BYM.

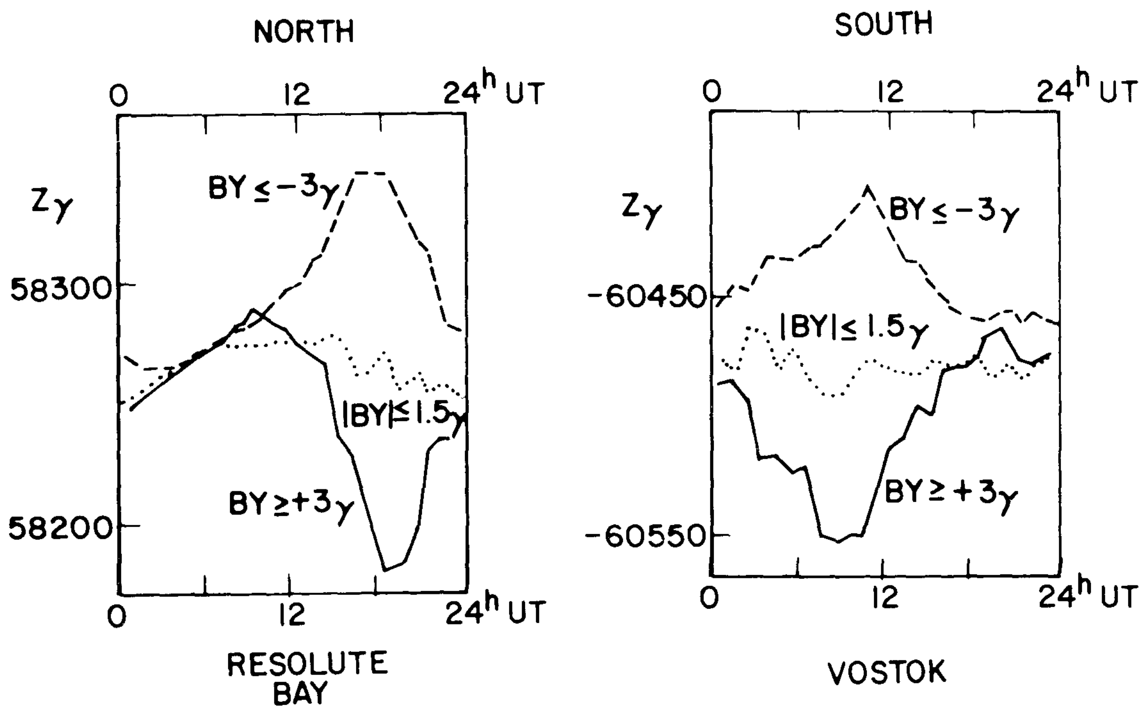


Figure 4. Diurnal variation of the vertical component Z at Resolute Bay and at Vostok during 1967-1968. All hours where the hourly averages of the interplanetary east-west component (BYM) were less than -3 nT were averaged for each UT hourly interval to yield the dashed curves. When BYM is greater than +3 nT, the solid curves result, while the dotted curves were computed for times when BYM was near zero (|BYM| ≤ 1.5 nT). (After Berthelier et al.,1974).

(1 nT = 10^{-9} Tesla = 10^{-5} Gauss = 1 gamma)

A characteristic feature here is that Z depends on BYM during about half of the day. The sensitive interval is about $2\text{-}14^h$UT in the southern hemisphere and about $12\text{-}24^h$UT in the northern hemisphere with most sensitivity near the center of the intervals. These intervals coincide with local daytime at the invariant magnetic poles and do not vary much from station to station within the same polar cap. The maximum k-value is seen to be about 75 nT/$\overline{\text{BYM}\geq 3}$ $\approx$ 15 and is found near 9^hUT at Vostok and near 18^hUT at Resolute Bay. This value is an average over the years 1967-1968. Within a given year the maximum value of k varies from about 1 at Midwinter to about 40 at Midsummer. In addition k varies by more than a factor of 2 during the sunspot cycle, being largest at sunspot maximum. Study of all these variations is still in progress and so far no solid calibration of k exists. It is therefore premature to use eq.(1) to infer the magnitude of the azimuthal component of the interplanetary field. It is worth mentioning that about a decade of spacecraft measurements seems to indicate that the field strength of the interplanetary field does not vary with the sunspot cycle. This somewhat weakens the justification for attempting to determine such a variation using eq.(1).

Determining the sign of the azimuthal component - and thereby the polarity of the field - does not require knowledge of the k-value but only that k is large enough that the BYM-term in eq.(1) can produce a recognizable magnetic signature. Experience (and also the analysis in section 3) shows that this is almost always the case. If BYM were nearly constant during a number of consequetive days the same magnetic signature, determined by the diurnal variation of k and shown in Figure 4, would be observed each day. At a sector boundary passing BYM would change sign and the magnetic signature would similarly reverse as we saw in Figure 2. Various techniques for recognizing the BYM magnetic signature have been discussed in the literature ranging from simple visual inspection and judgement to completely formalized computer algorithms applied to digitized magnetograms. The main difficulty is, of course, separation of the Z'-term and the BYM-term. If the record is sufficiently regular in appearence and resembles one of the two average signatures then one may often assume that the Z' variations are small and insignificant, but cases can be found where this is not true and it is often better to try to identify possible Z' variations on the magnetogram rather than to neglect such variations.

The largest contribution to the Z'-term comes from a nearly sinusoidal diurnal wave that can be discerned on the magnetograms on most of the days. The amplitude of this wave is about 60 nT, but again this may vary by a factor of 10 depending on season and on activity level. Figure 5 shows this regular diurnal variation at Thule and at Resolute Bay.

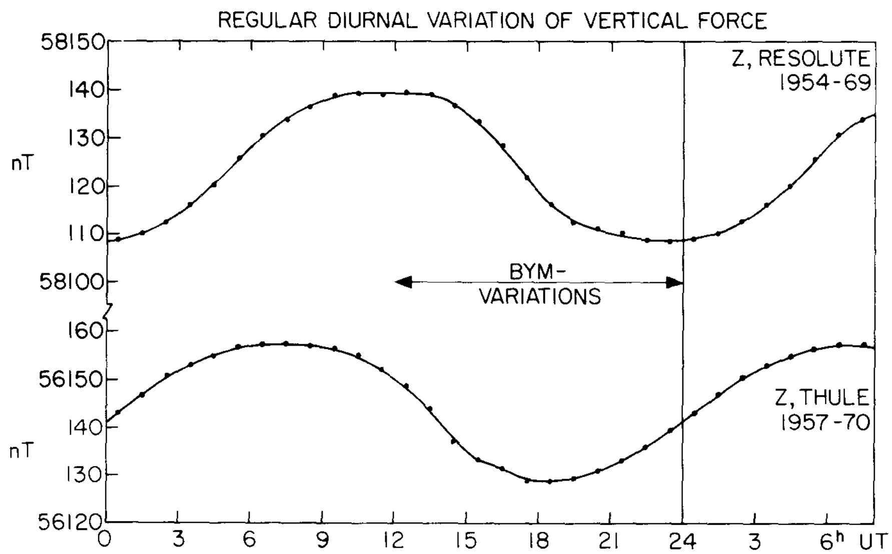


Figure 5. Regular diurnal variation of the vertical component at Thule and at Resolute Bay. Magnetic local noon is at 14^hUT and at 20^hUT respectively.

In terms of local time, ΔZ is positive in the morning and negative in the afternoon, and the sector polarity related perturbations are superposed on the regular variation around local noon. This regular diurnal variation is largest near 75^o magnetic latitude and decreases to insignificance at the invariant pole.

A sequence of magnetograms exemplifying the diurnal variation with superposed perturbations is shown in Figure 6. The regular diurnal wave has been identified on each magnetogram and drawn as a dotted line. As Mayaud (1967) points out, this identification should be done such that it corresponds to a possible form of the diurnal variation. The line should

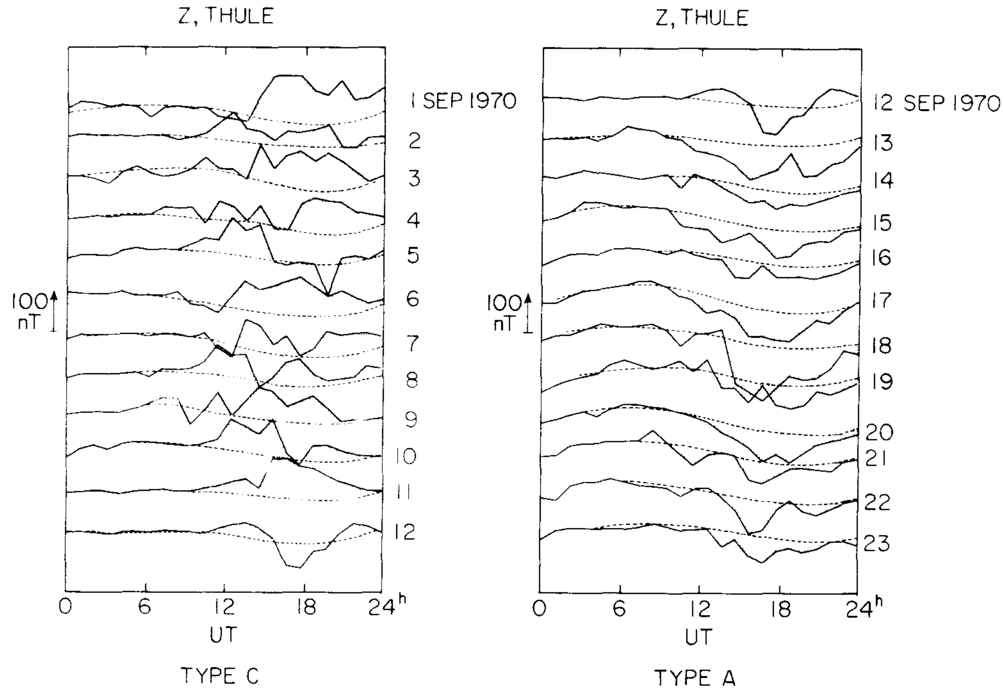


Figure 6. Magnetograms from Thule during the interval 1-23 Sept. 1970. The Z-traces have been redrawn using hourly averages. The dotted lines indicate the regular diurnal wave as identified individually for each day. Perturbations from this regular curve are shaded. The left-hand panel shows a sequence of perturbations classified as type C, while the right-hand panel shows type A. September 12 shows a mixed signature and may be classified as type B.

be drawn by free hand and one should not hesitate too long before making a choice: in doubtful cases, one has to proceed quickly. It would be totally wrong to use an average curve, say over the month in question, to represent the diurnal wave on each individual day. The day-to-day variability of the amplitude and (to a lesser extent) the phase of the diurnal variation is a very important parameter and must be dealt with properly.

It is evident from Figure 6, that positive perturbations dominated the Thule Z-magnetograms throughout the interval 1-11 September. During that time the earth was within a broad Toward sector and we consistently see the geomagnetic signature of Toward polarity (or negative BYM). On September 12 the interplanetary field was fluctuating and the BYM component changed sign at 15^hUT and back again at 20^h before the polarity finally changed to Away at 03^hUT on September 13. After that the polarity was Away until September 28. Correspondingly we observe negative perturbations of Thule Z: the signature of Away polarity (or positive BYM).

When the regular diurnal variation of the day is identified it is very easy to infer the sector polarity for that day simply by noting the sign of the residual deviations during the interval $12\text{-}24^h$UT (in the northern hemisphere). From a purely morphological point of view one can classify each day according to the predominant sign of these deviations into two types called type C (positive deviations) and type A (negative deviations) respectively, with a possibility of a type B denoting days with a mixed signature. The designations A and C are kept for historical reasons (Svalgaard,1968). It is apparent that type A dominantly is observed during Away sectors while type C is dominant in Toward sectors.

During local winter the magnitude of the regular diurnal variation as well as of the sector related perturbations decrease dramatically. But since both decrease, the separation problem becomes no more difficult provided the magnetograms are recorded with sufficient sensitivity. To illustrate this point, Figure 7 shows the average variation of Thule Z during all days of the months of December 1963-1970 where the polarity was known from spacecraft measurements. In Figure 7a we see the now familiar signatures superposed on the sinusoidal diurnal wave. In Figure 7b the diurnal variation has been subtracted out. The important thing to note is that the amplitude of the effects is very small, of the order of ± 5 nT; this corresponds to less than $\frac{1}{2}$ millimeter on the original magnetograms, and shows to what precision and with what care the magnetograms must be scaled or digitized. Alternatively one could employ variometers with a scale value of 1 nT/mm or better; due to the high level of activity during the summer this is, unfortunately, not normal procedure at polar cap observatories.

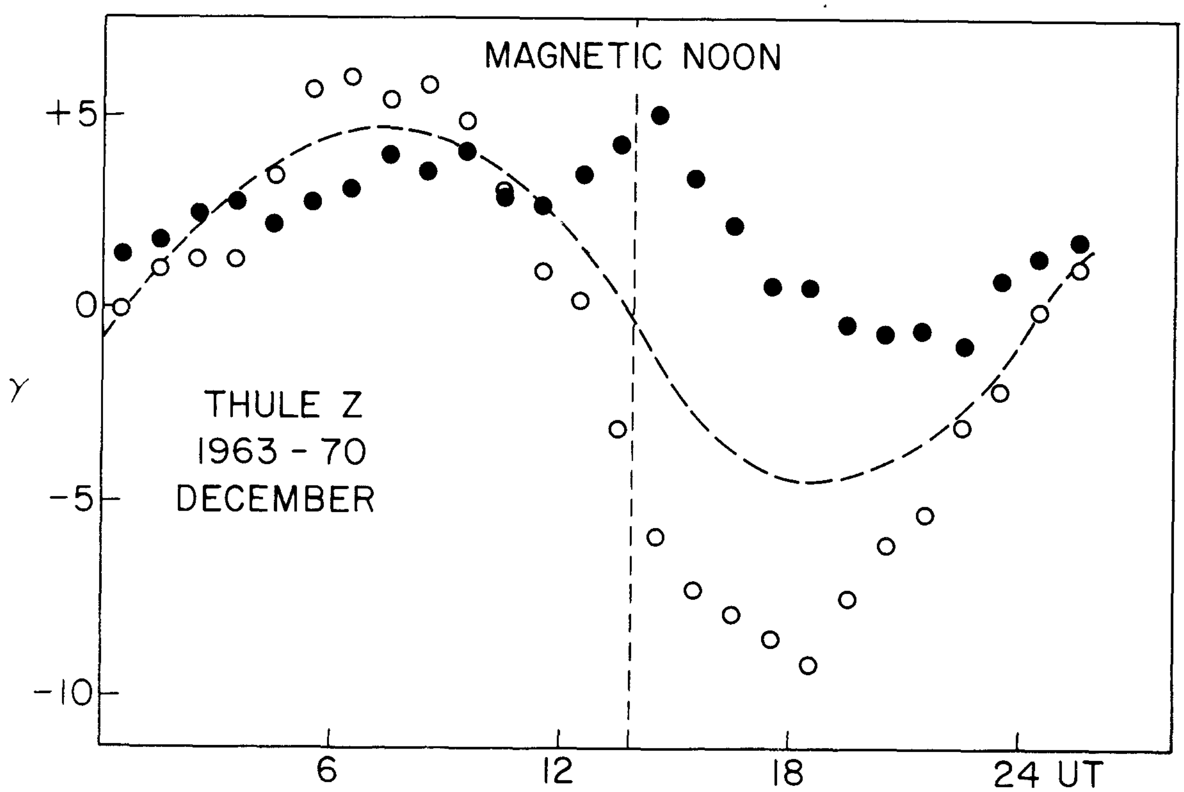


Figure 7a. Average variation of Thule Z during all days of the months of December 1963-1970 (local winter) where the sector polarity was known from spacecraft measurements. Open circles show the variation on days with Away polarity; filled circles show the variation on Toward days. The regular diurnal variation is indicated by a dashed curve. The absolute levels of the curves have been adjusted to agree during the night hours. Secular variation and data gaps cooperate to make these absolute levels slightly different.

Despite the very small effects in Midwinter, it is still possible to infer the sector polarity with fair accuracy (Mansurov et al.,1973; this Atlas: section 3). By employing two stations in opposite hemispheres an even better result can be expected of course. An additional advantage of two antipodal stations is the extended coverage of the UT-day; one station being most sensitive during the first half of the day, the other during the other half.

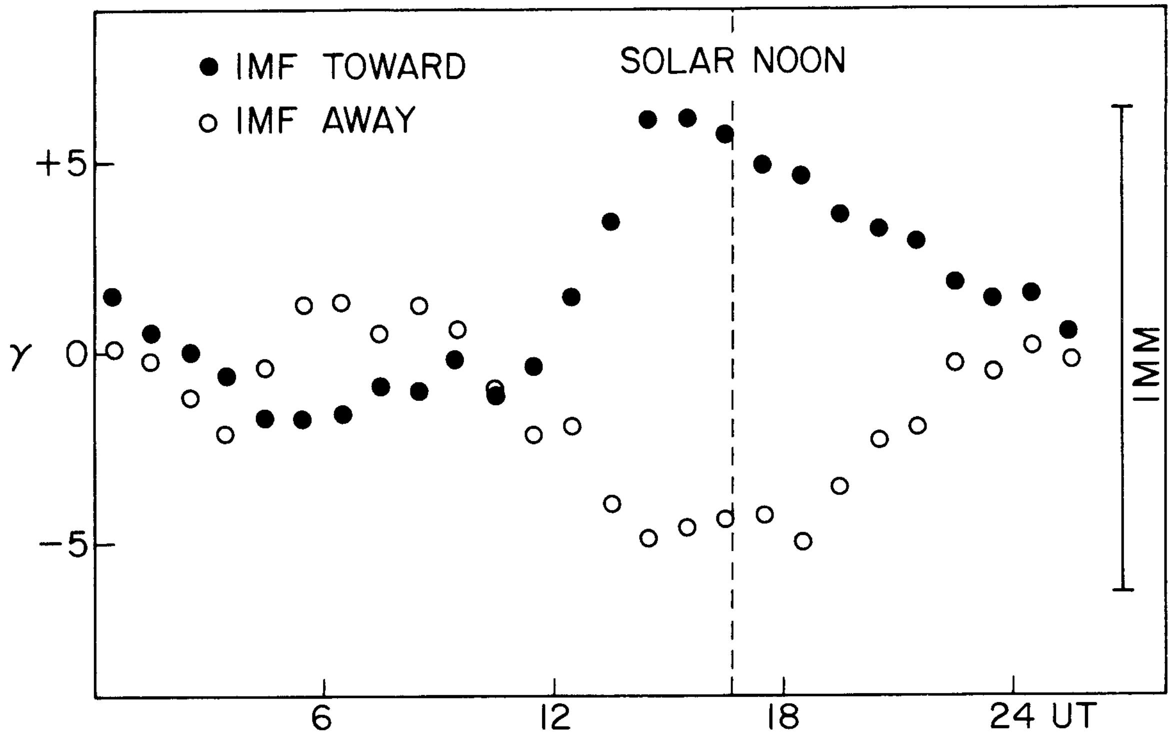
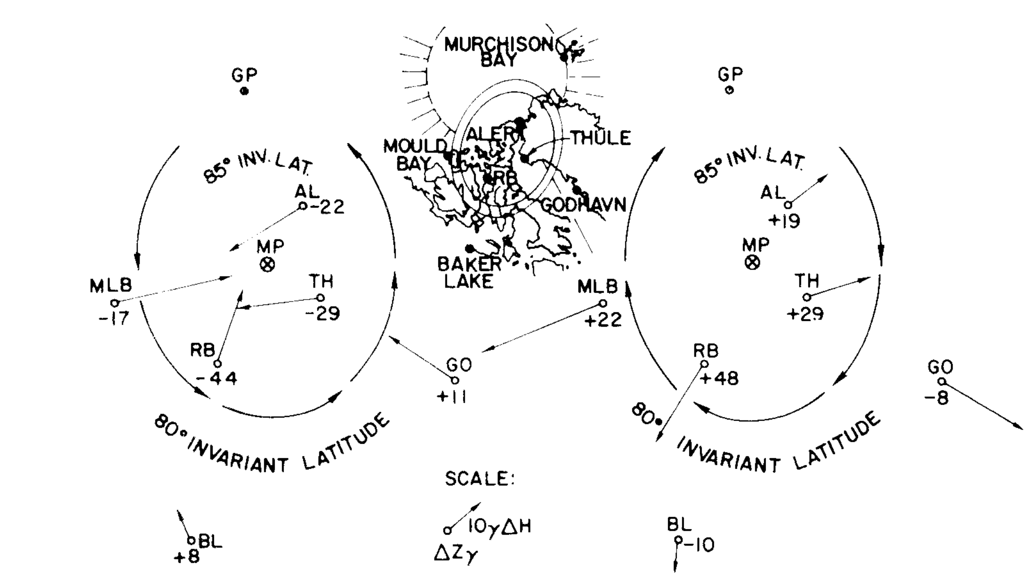


Figure 7b. Same as Figure 7a but with the regular diurnal variation subtracted. The bar at the right shows the scale of one millimeter on the original magnetograms.

We have described the sector polarity effects on the vertical component in some detail to enable the reader to appreciate the intricacies of the method of inferring the polarity from geomagnetic data. At the same time it is anticipated that the reader by understanding some details will be encouraged to use the inferred polarity data with confidence. It should be realized that near the polar cap boundary, sector effects are most prominent in the horizontal components of the geomagnetic field and somewhat different considerations apply. Further details about all these effects and their use for inferring the sector polarity are given by Svalgaard (1973,1975) and the possibility of automating the procedure has been considered by Campbell and Matsushita (1973). So far attempts to automate the procedure of inferring the polarity have met with little success, mostly because of the difficulty of identifying the Z' variations.

As a further aid in interpreting polar cap magnetograms for the purpose of inferring the sector polarity, a synoptic presentation of the polarity-related perturbations as observed at 1800 UT is given in Figure 8. We see the clear and systematic difference in the way the geomagnetic field is influenced during conditions of opposite sector polarities. For Away polarity the horizontal perturbation vectors all converge toward the magnetic pole, and vertical perturbations directed



POLAR CAP DISTURBANCES AT 18^h UT FOUND DURING IMF AWAY POLARITY.

POLAR CAP DISTURBANCES AT 18^h UT FOUND DURING IMF TOWARD POLARITY.

Figure 8. Typical polar cap magnetic variations observed for the two opposite sector polarities. Two synoptic maps are shown with disturbance vectors corresponding to Away polarity and to Toward polarity. An insert shows the geographical location of the six stations used. Signed numbers next to the station circles indicate the Z perturbations. The position of the geographical pole (GP) and of the invariant magnetic pole (MP) are shown.

away from the earth (negative in the northern hemisphere) are observed near the pole while vertical perturbations toward the earth (positive in the northern hemisphere) are seen below about 80° invariant latitude. For Toward polarity the direction of all perturbations is reversed;

horizontal perturbation vectors diverge from the magnetic pole, and vertical perturbations directed toward the earth occur near the pole.

The magnetic effects are what might be produced by a circulating ionospheric current flowing eastward around the northern magnetic pole during Away sectors and flowing westward during Toward sectors. The direction of the current around the southern magnetic pole is opposite to that of the northern. But for an observer on the ground near a magnetic pole, the current direction would be clockwise for Toward polarity and counterclockwise for Away polarity in both hemispheres. This polar cap current is very weak when the magnetic pole is on the nightside of the earth. When the earth's rotation brings the magnetic pole into the dayside, the current develops and intensifies. The current is most concentrated (and its magnetic effects largest) nearest the noon meridian. Physical processes that may be responsible for the polar cap current have been discussed by Stern (1973).

Statistics on the accuracy of the inferred data

In an attempt to evaluate the accuracy of the inferred polarity, the Z-data from Thule was reexamined by the author. The polarity was inferred for each day of the entire interval 1957-1974 completely without any reference to earlier determinations. The reexamination was done in the course of a few weeks and the data was not treated chronologically. A year was selected at random and the polarities were determined for that year; then another year was selected at random, etc.. It is believed - and there is no reason to suspect the contrary - that this re-inferred sector polarity list has a constant calibration throughout the entire interval. By comparing the re-inferred polarities with spacecraft data we shall determine the overall accuracy of the inferred polarity, and in addition investigate how the accuracy varies with the level of geomagnetic activity, with season, and generally with time. It will be particularly important to establish that there is no long-term trend in the accuracy.

As a measure of the accuracy of inferred polarity as an indicator of the actual measured polarity we define the success rate S (over some intervals of time) as follows. First, we consider only days where a definite polarity has been both inferred and measured. That is, all days with mixed polarity or with no data have been excluded from the analysis. Then let A be the number of days where the inferred polarity and the measured polarity agree, and let D be the number of days where the polarities disagree. The success rate is then defined by

$$S = A/(A+D) \qquad (2)$$

A separate success rate may be calculated for each polarity. In defining S, one could have included days with mixed polarity and counted half of them as agreements and half as disagreements. Due to the one-day time resolution of the index, mixed polarity often occurs because a sector boundary passage occurs near the middle of a UT-day, and is thus often artificially introduced in the index. If mixed polarity were taken into account as described above, the success rate would depend on the number of sector boundaries and would not reflect the intrinsic accuracy of the inferred polarity. We realize that a way of incorporating the mixed polarity may lead to success rates that more realistically measure the usefulness of the inferred data. In any case these (and several other possible) various different ways of calculating the success rate give results differing only by a few percent.

The comparison between inferred and directly measured polarities is carried out for all Bartels 27-day rotations for which we have some spacecraft data. On some days within these rotations no spacecraft measurements are available. We therefore have four classes of days: (1) with away polarity, (2) with toward polarity, (3) with mixed polarity, and (4) with no spacecraft data. For each of these four classes we now obtain the number of A, B, and C-type inferences as well as the average values of the Ap-index (Rostoker, 1972) for each type. The result is shown in Table 1. The overall success rate is 85.8%. It is interesting to note that Away-days have a better chance of being inferred correctly while on the other hand Type C inferences are more accurate than Type A.

	Away	Mixed	Toward	No Data	Total	S-rate
Type A	1195 11.2	130 14.9	251 10.4	77 13.8	1653 11.5	82.6
Type B	147 14.8	72 13.4	194 12.3	25 16.0	438 13.5	
Type C	160 14.3	73 17.1	1284 11.9	89 16.0	1606 12.6	88.9
Total	1502 11.9	275 15.1	1729 11.7	191 15.1	3697 12.2	85.8
Success-rate	88.2		83.4		85.8	%

Table 1

Number of days and average Ap-index for each combination of inferred and of observed polarity. The success rates (in percent) are calculated for each polarity separately as well as for all the data.

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Further examination of Table 1 reveals that Type A days on the average have lower Ap-index than Away-days (11.5 vs 11.9) while Type C days have a higher Ap-index than Toward-days (12.6 vs 11.7). While these small differences may be intriguing to the specialist they seem of minor relevance to general users of the Atlas. They must, however, be recognized and proper caution should be exercized in interpreting results involving use of the Atlas.

Table 2 shows the variation of the overall success rate with season. The lowest value is found in January while the highest success is obtained in August. The main result is that the success rate at all times is sufficiently high that its variation with time of year can be neglected for most purposes. There may be a hint of a small increase of

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
77.6	86.2	85.6	90.7	87.2	88.6	89.4	93.3	88.4	84.3	79.5	83.3

Table 2

Seasonal variation of success rate (in percent).

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the success rate near the equinoxes when the diurnal average of the dipole tilt against the solar wind direction is near 90°. In this case the azimuthal component of the average interplanetary magnetic field makes the smallest overall angle with the geomagnetic equator. But again, we are here considering second-order effects of little practical importance.

It is of considerable interest to verify the constancy of the success rate over the years in order to assess the possibility of inferring the polarity for the years before spacecraft measurements began. Table 3 shows yearly success rates from 1962 through 1974.

Year	Number of days		Success rate	
1962	73	235	86.3 %	80.0 %
1963	45		82.2	
1964	117		75.2	
1965	295		75.9	
1966	274		86.1	
1967	272		82.0	
1968	281		89.0	
1969	307		88.3	
1970	279		87.5	
1971	303		85.1	
1972	281		90.7	
1973	268	365	92.9	91.0
1974	97		85.6	

Table 3

Apart from the low success rate in 1964-1965 there seems to be no significant long-term variations of the success rate. It should be noted that spacecraft measurements were only taken during northern winter in 1962-1964, so that a success rate of 80 % (average of 1962-1964) is just what we would expect for these winter months (cf. Table 2). The spacecraft data for the winter 1964-1965 were obtained from the magnetic field experiment onboard Mariner 4 which was on its way to Mars and in the summer of 1965 was as much as 90° in azimuth removed from the earth. We would therefore expect the interplanetary data when referred back to the earth to be of lower quality as is duly reflected in an apparent lower success rate. We conclude that all-year success rates of the order of 85 % or higher could be expected also before the spacecraft era, and we note that this could be achieved by using geomagnetic data from a single station. Using more stations - such as Resolute Bay and even better Vostok in the southern hemisphere further improves the index. Because several stations were indeed used in inferring the polarity for the interval 1957-1964, we conclude that the success rate during that interval should be close to 90 %.

To investigate if the level of geomagnetic activity affects the success rate, we divide the days into six groups with different activity level and compute the success rate for each group. Table 4 shows the result and allows us to state that there is no variation of the overall success rate with activity, but also to note that the difference in accuracy discussed above between type A and type C is largest for quiet geomagnetic conditions. In all cases are the success rates sufficiently

Ap-interval	Average	Number of days	All	Type A	Type C
< 4.5	3.1	622	84.6	80.7	89.6
4.5 - 7.5	5.8	696	85.6	79.5	91.5
7.5 -10.5	8.9	466	87.3	83.9	90.9
10.5 -13.5	11.8	321	88.2	86.2	89.9
13.5 -19.5	16.3	375	85.6	86.9	84.5
>19.5	32.9	410	84.4	83.7	85.0

Table 4

Success rates (in percent) for days with different level of geomagnetic activity as measured by the planetary index Ap.

high that no serious distortions of the inferred sector structure are likely to result from these differences.

Because the sector structure is a large scale property of the solar wind and because many sources of errors in the inferred polarities are of short-term nature, it is to be expected that a slight smoothing of the inferred data will improve the success rate. This is indeed found to be the case. A very simple smoothing procedure that computes an n-day running mean of the inferred polarity (with Away = +1, Toward = -1, and Mixed = 0) has been tested for various values of n. After the smoothing the data set was again rectified in the sense that positive values were assumed to represent Away polarity and negative values were assumed to represent Toward polarity while zeroes were assumed to represent Mixed polarity. Table 5 shows the success rate for different values of the smoothing interval. It seems that a 3-day running mean provides an

Interval (days)	1	3	5	7	9	11	13
Success rate (%)	85.8	87.8	87.5	85.6	83.3	80.2	77.7

Table 5

Success rate for smoothed inferred polarity as function of the length of the averaging interval.

optimum representation of the sector structure. It is remarkable that the success rate drops off so slowly with increasing averaging interval, which shows the prevalence of large-scale structures in the interplanetary magnetic field. The increase of 2% of the success rate turns out on closer examination to be caused by a 4% increase during northern winter while there is no change during the summer months. This suggests that the smoothing helps to reduce the random noise arising from trying to infer the polarity at times when the magnitude of the geomagnetic response is at a minimum. Finally it must be stressed that although the smoothing does seem to work, no smoothing of any kind has been applied to the data presented in this Atlas.

Data Sources: References and Comments

Following the guidelines set forth in the previous sections or applying similar procedures, compilations of estimated sector polarities have been published by many authors. The time resolution of the compilations varies; typically it is three hours for spacecraft data and one day for lists of inferred polarity. We have chosen one day (the UT day) as the time resolution for the Atlas in order that data from various sources may be combined and also because of the economy of a 1-day index to describe the large-scale sector structure. This choice leads to adoption of the following "majority-rule": if more than about 2/3 of the data-values (maybe represented as hourly averages) measured by spacecraft during the day corresponds to a definite polarity that polarity is adopted for the day. Again some judgement must be exercised in pathological cases so the rule cannot always be strictly enforced. If data exists for the day but no majority polarity can be assigned the polarity is designated as "mixed".

For each day of the entire interval 1957-74 a polarity was adopted from each source of data. Most often there are about three sources including the recent re-examination of Thule Z described in section 3, so that a Data Compilation Sheet was designed with three entries per day organized in three rows covering one Bartels solar rotation at a time. Figure 9 shows a section of the Data Sheet for 1968; six rotations are shown in a 27-day recurrence diagram. Each day is represented by a vertical column of three symbols: large and small dots, a cross or a blank space. The data source is indicated for each row on the extreme right of the Sheet by a letter corresponding to the source as detailed below. Occasionally the source is changed during a rotation. In this case the dominant source is indicated and the previous (or following) rotation will indicate the other source. Finally the serial number of the Bartels solar rotation and its starting date are indicated. The following table explains the data source code letters.

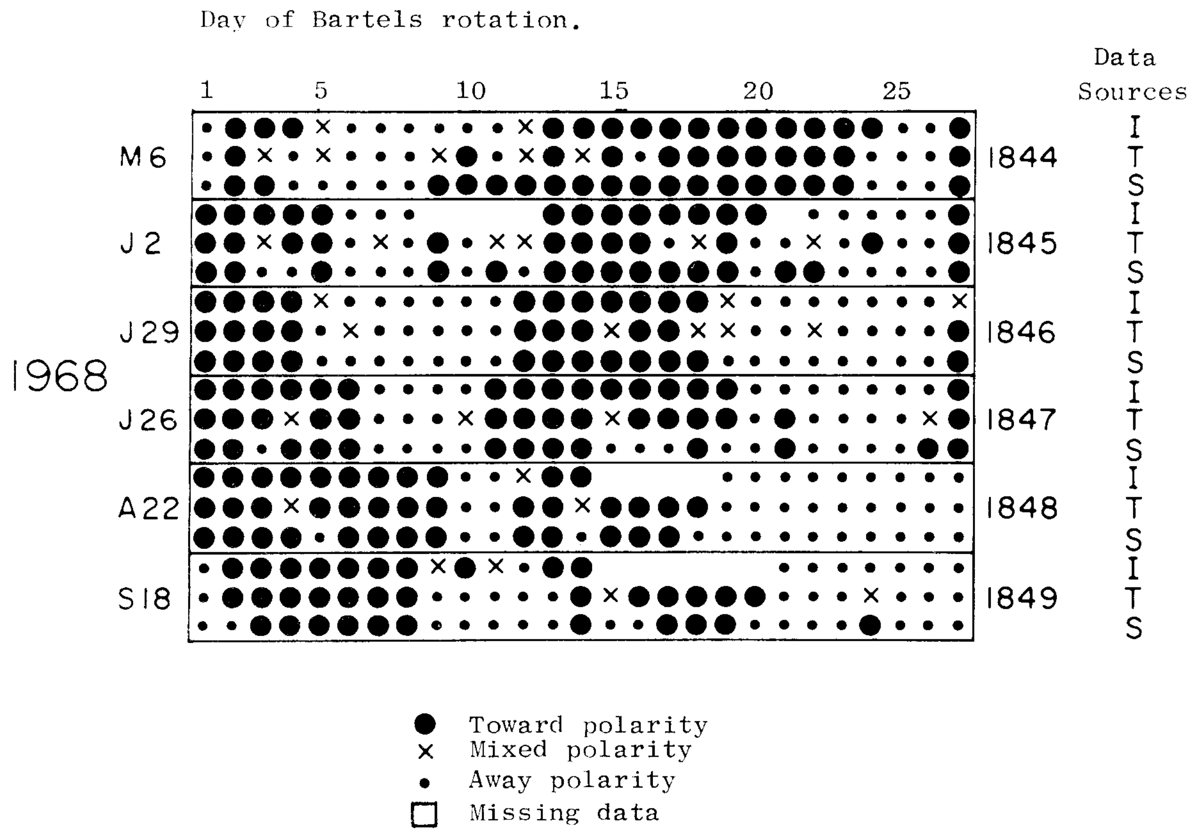


Figure 9. Section of Data Compilation Sheet (see text).

--

Code letter	Legend
R	Inferred using Resolute Bay Z
T	Inferred using Thule (Qanaq) Z
S	Inferred using various stations (Svalgaard,1972)
M	Inferred using many stations (Mansurovs, 1973)
A	Inferred using Alert Z
I	Observed by various spacecraft
V	Inferred using Vostok Z
P	Observed by Pioneer 10
X	Observed by Mariner 10

Table 6. Data source code letters used on Data Compilation Sheets.

--

The many geomagnetic observatories used by the author and by Mansurov and Mansurova are listed below. For each observatory is given its location in geographic and in invariant magnetic coordinates as well as an indication of which geomagnetic component (Z=vertical, H=horizontal) is most sensitive to the sector polarity effects.

Station	Geographic		Magnetic		Max effect	
	Lat.	Long.	Lat.	Long.	in	at
Alert	82°.5	297°.5	86°.8	123°.8	Z	14^h UT
Charcot	-69.4	139.0	-83.4	238.5	Z	06
Dumont d'Urville	-66.7	140.0	-80.6	231.9	H	06
Godhavn	69.2	306.5	77.6	41.6	H	15
Mirny	-66.6	93.0	-76.9	122.9	H	09
Mould Bay	76.2	240.6	80.6	263.5	H,Z	20
Pionerskaya	-69.7	95.5	-79.7	114.8	H	08
Resolute Bay	74.7	265.1	84.1	304.3	Z	18
Scott Base	-77.9	166.8	-80.1	325.6	H	06
Thule (Qanaq)	77.5	290.8	86.8	36.3	Z	16
Thule AFB	76.5	291.2	86.0	33.0	Z	16
Vostok	-78.5	106.9	-85.4	69.0	Z	09

The times of maximum effect are very approximate and vary seasonally by more than ±3 hours for some stations (noticably Alert and Vostok).

We offer the following comments on the data sources over the years.

R: Inferred by the author from Resolute Bay Z which has a scale value of about 4.5 nT/mm. Up to 1958 the Z-variometer was very temperature sensitive and changes in temperature (as shown by the T trace on the magnetograms) sometimes produces large perturbations of Z which should not be confused with BYM-effects.

T: Inferred by the author from Thule (Qanaq) Z which has a scale value of about 12.5 nT/mm (i.e. three times less sensitive than Resolute Bay Z). The polarity was inferred for the entire interval 1957-1974 in the course of a few weeks (see section 3) and is believed to be of uniform quality.

S: From Svalgaard (1972). Inferred from various stations and components.

Godhavn H and Thule Z was used most of the time (except during 1964-1965 where Resolute Bay Z, Alert Z and Mould Bay H and Z were used). The dataset is quite inhomogenous: the station which was believed to show the effect the strongest at any given time was used for that time. A few clerical errors in the published lists have been corrected.

M: From Mansurov and Mansurova (1973) who used data from several observatories in both hemispheres and describe their inferences as follows: "Determination of the prevalent sector polarity from geomagnetic data comes down to determination of the type of daily geomagnetic variation. We used data of those stations at which the most distinct appearance of all morphological characteristics inherent in one type of variation or the other can be expected at a given season". The Mansurovs have used a rather different technique than the present author. Instead of identifying the diurnal variation on each day and then considering deviations from this as indicators of the polarity, they used the total overall morphology of the daily magnetograms as basis for the inference. It is worth noting that the two data sources M and T are completely independent as they are derived by different observers using (very often) different stations and (always) different approach and technique. Examination of the Data Sheets shows that the two sources agree 85 % of the time. This is very encouraging because no spacecraft data is available for the epoch of the M list: 1957-1961.

A: Inferred by the author from Alert Z which has a scale value of 6.5 nT/mm. The sector polarity effect at Alert is peculiar in the sense that the local time variation of k (see page 9) is small, so that the entire level of the Z-record is changed troughout the day rather than just for a few hours near noon (e.g. Figures 2 and 3 in Langel and Svalgaard, 1974).

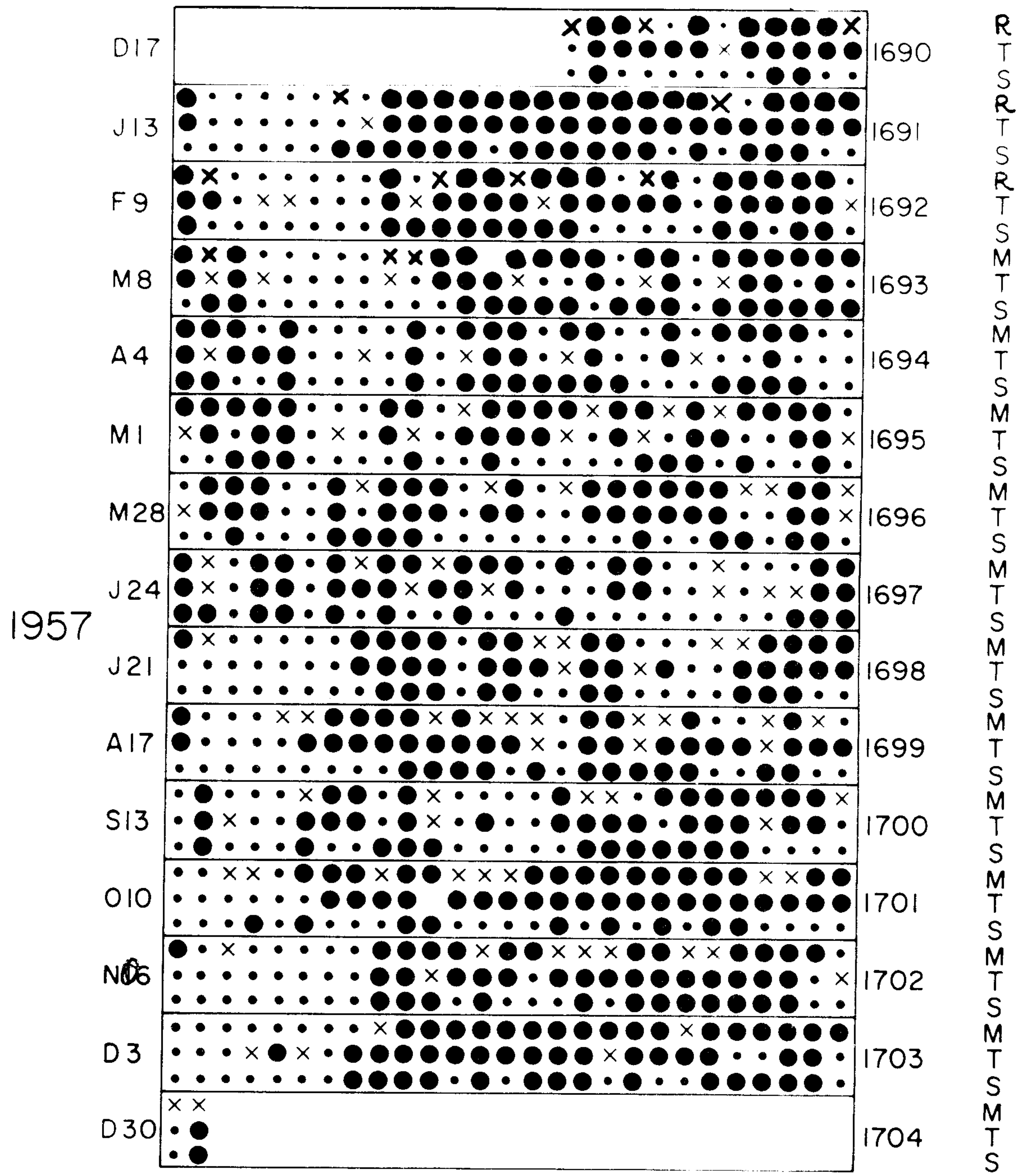
I: Interplanetary sector polarity observed by spacecraft. The following compilations were used: Wilcox and Colburn (1972) for the interval 1962-1969, Fairfield and Ness (1974) for the interval 1970-1972, and Hedgecock (1975) for the interval 1969-1974. Additional data from spacecraft not utilized by the above workers have been obtained from the National Space Science Data Center and used to fill in gaps in the compiled data and to check the accuracy of the compilations. A few errors have been found and corrected (most of them in 1965). A most valuable source of interplanetary magnetic field data is a recent Data Book by King (1975).

V: Inferred from Vostok Z by Mansurov and the author. A combined index is shown where most weight has (arbitrarily) been given to the author's own inference. Mansurov's values are given in Solar Geophysical Data (Prompt Reports), NOAA, Asheville.

P: Observed by Pioneer 10 (enroute to Jupiter) while it was still near the earth. The data has been discussed by Rosenberg (1975).

X: Observed by Mariner 10 enroute to Mercury and corrected for radial distance and azimuth difference in order to reduce the data to near-earth conditions, (Behannon *et al.*, 1974).

Data Compilation Sheets for each of the years 1957 through 1974 are presented on the following pages.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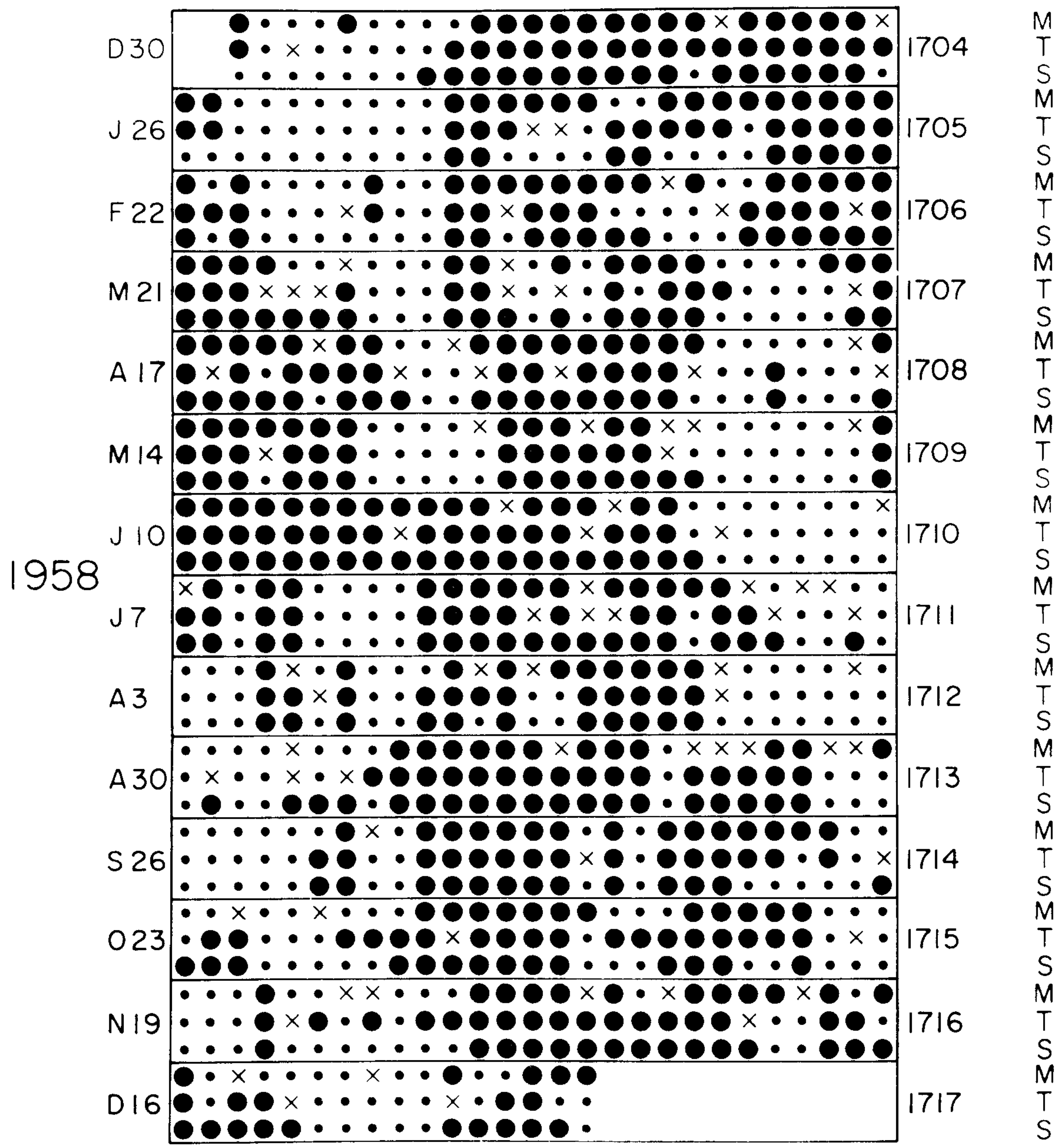
F9
M8
A4
M1
M28
J24
J21
A17
S13
O10
N06
D3
D30
1957
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
R T S R T S R T S M T S M T S M T S M T S M T S M T S M T S M T S M T S M T S M T S M T S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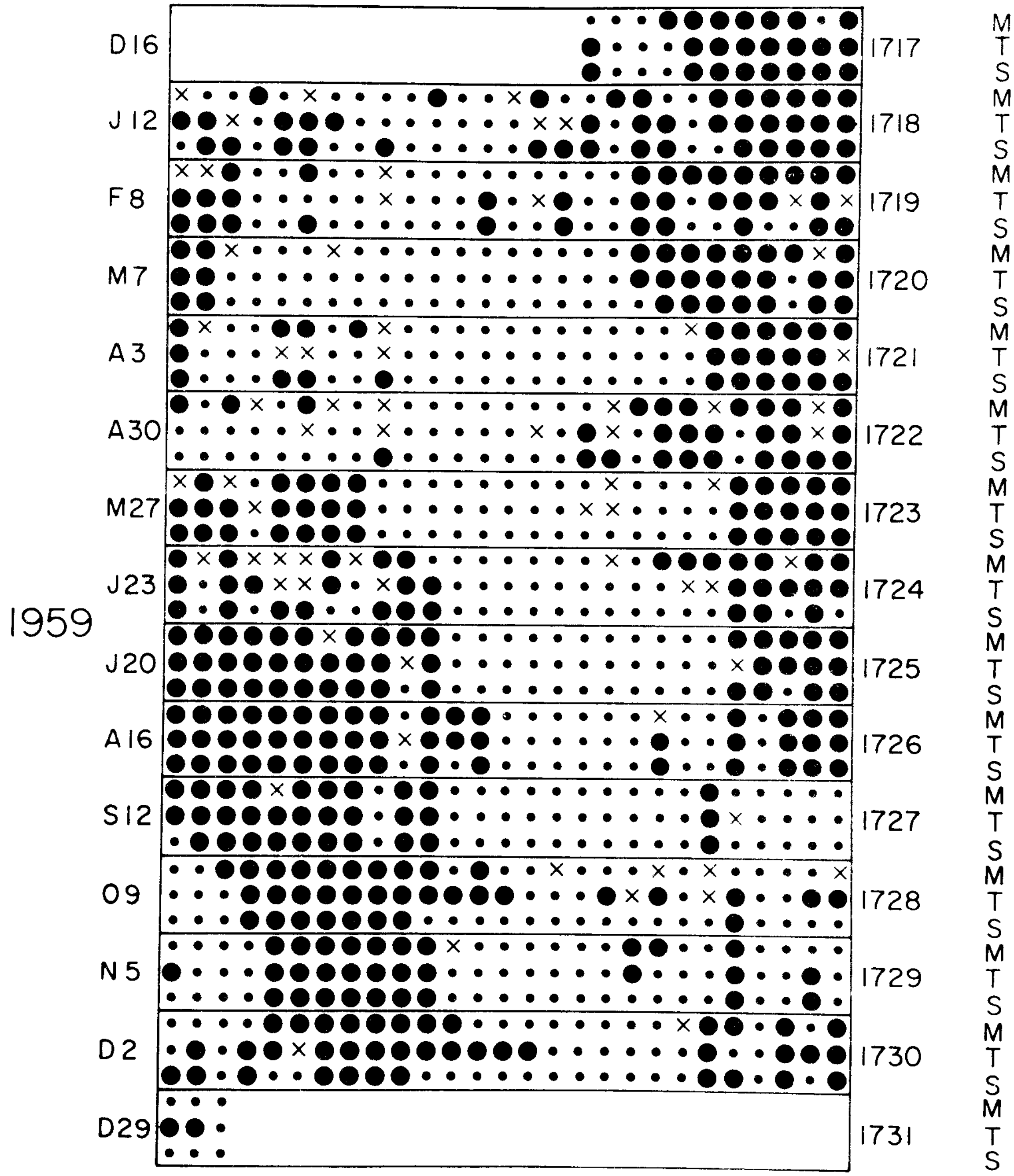
D30
J 26
F 22
M 21
A 17
M 14
J 10
J 7
A 3
A 30
S 26
O23
N 19
D 16
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
M T S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D16
J12
F8
M7
A3
A30
M27
J23
J20
A16
S12
O9
N5
D2
D29
1717
1718
1719
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1727
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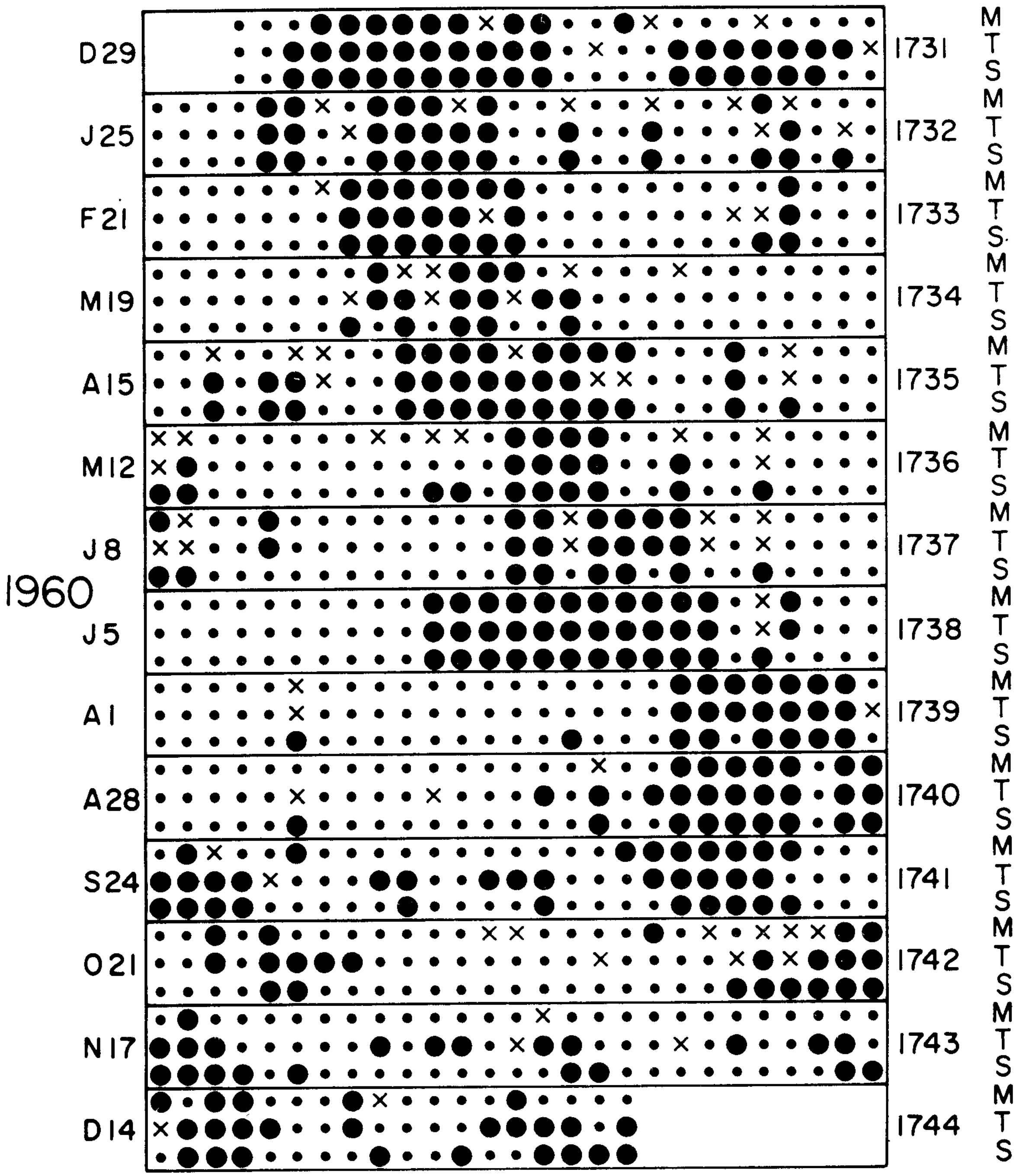
1729
1730
1731
M
T
S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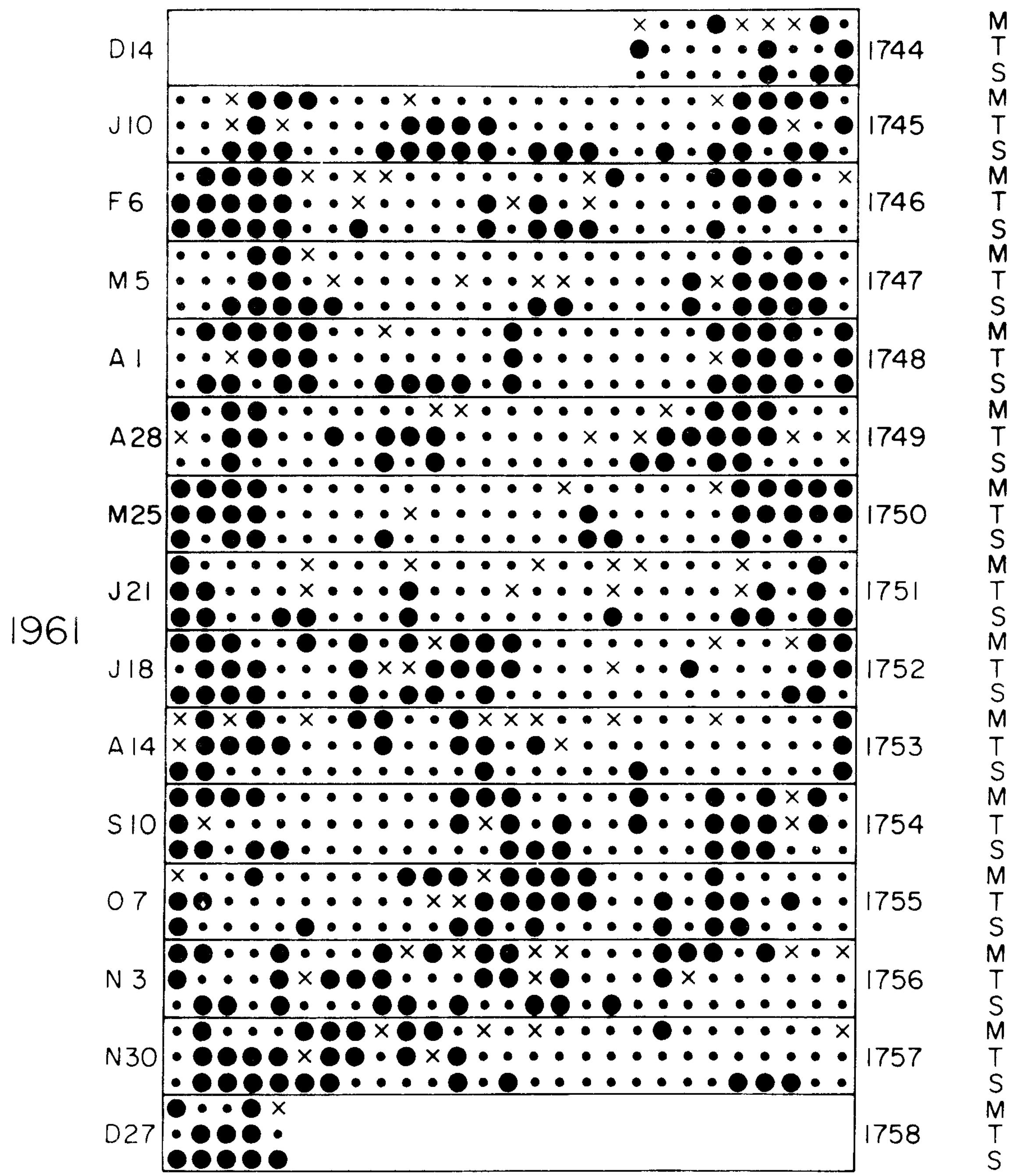
J25
F21
M19
A15
M12
J8
J5
A1
A28
S24
O21
N17
D14
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
M
T
S


1961
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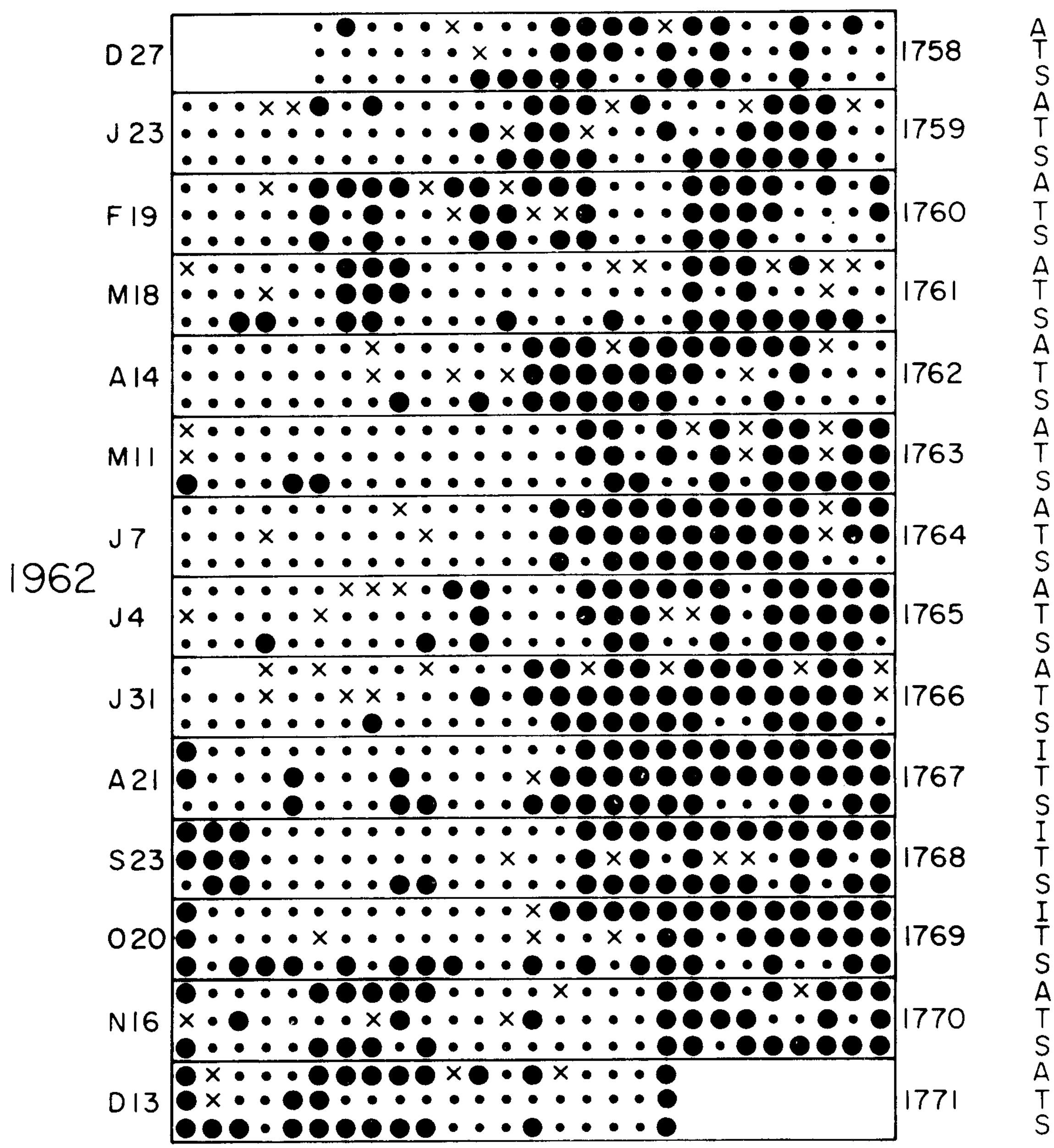
J10
F6
M5
A1
A28
M25
J21
J18
A14
S10
O7
N3
N30
D27
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
M
T
S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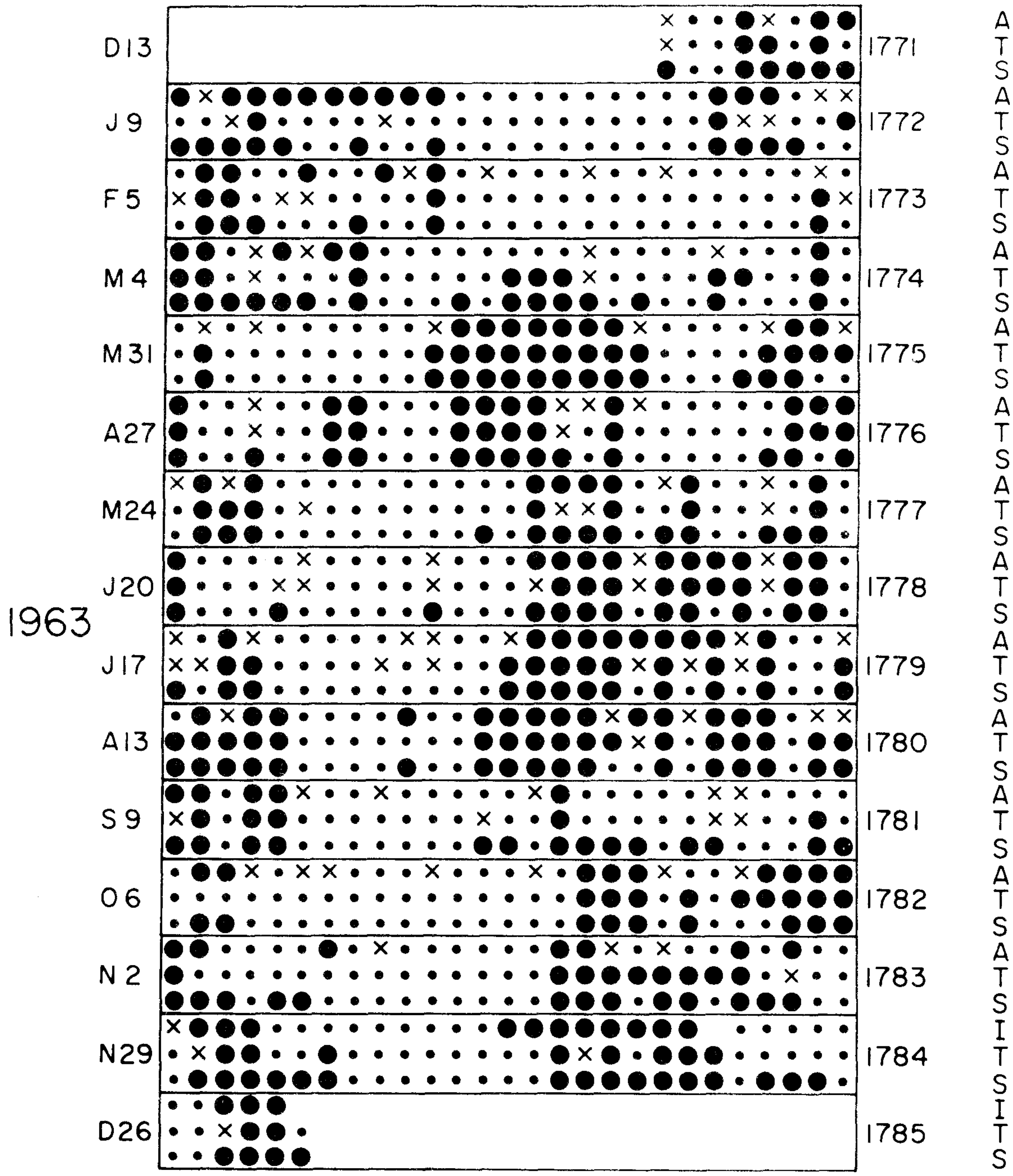
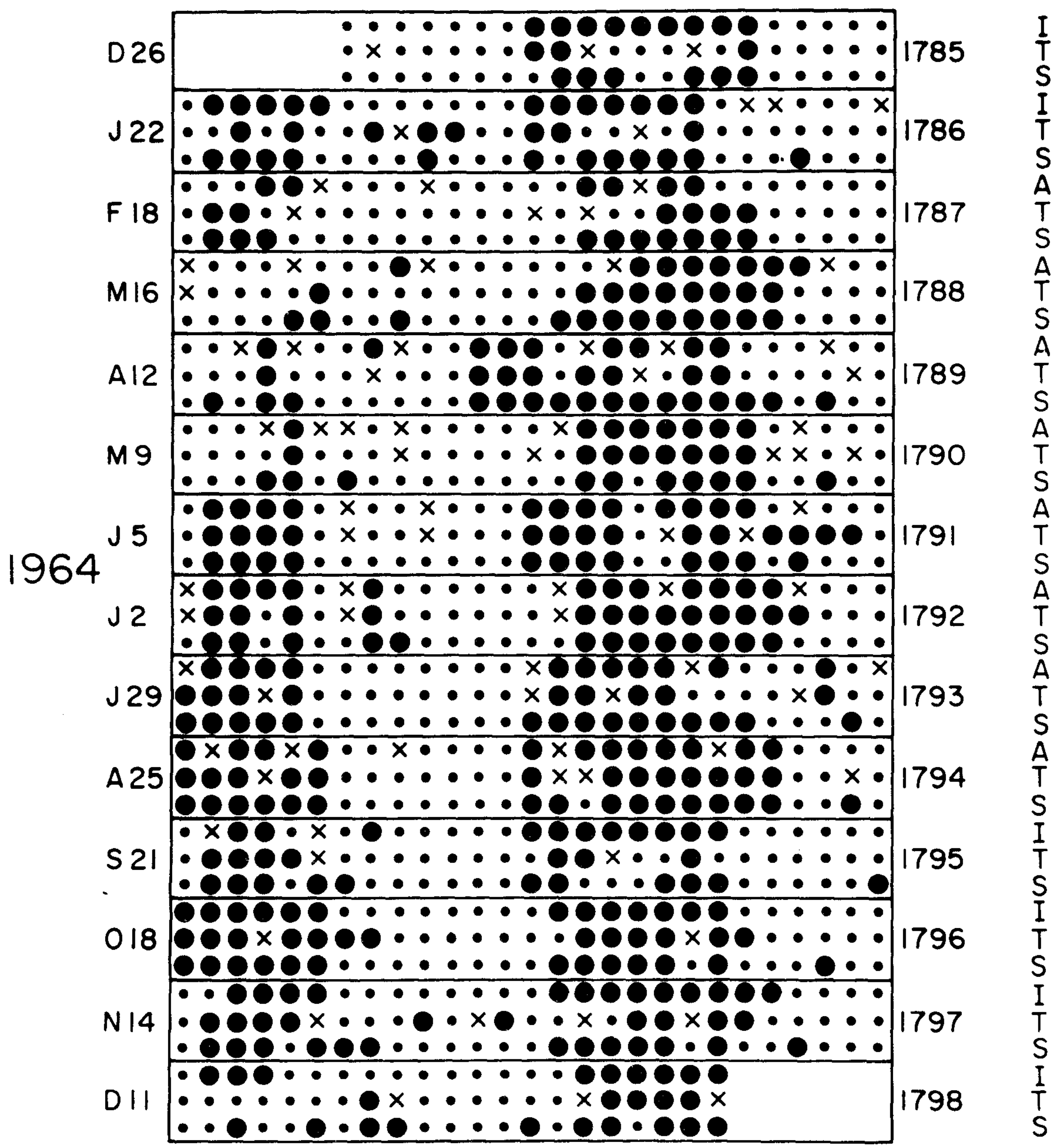
D27
J23
F19
M18
A14
M11
J7
J4
J31
A21
S23
O20
N16
D13
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
A T S
A T S
A T S
A T S
A T S
A T S
A T S
A T S
A T S
I T S
I T S
I T S
A T S
A T S


1963
D13 1771
J9 1772
F5 1773
M4 1774
M31 1775
A27 1776
M24 1777
J20 1778
J17 1779
A13 1780
S9 1781
O6 1782
N2 1783
N29 1784
D26 1785
A T S A T S A T S A T S A T S A T S A T S A T S A T S A T S A T S A T S A T S I T S I T S


1964
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J22
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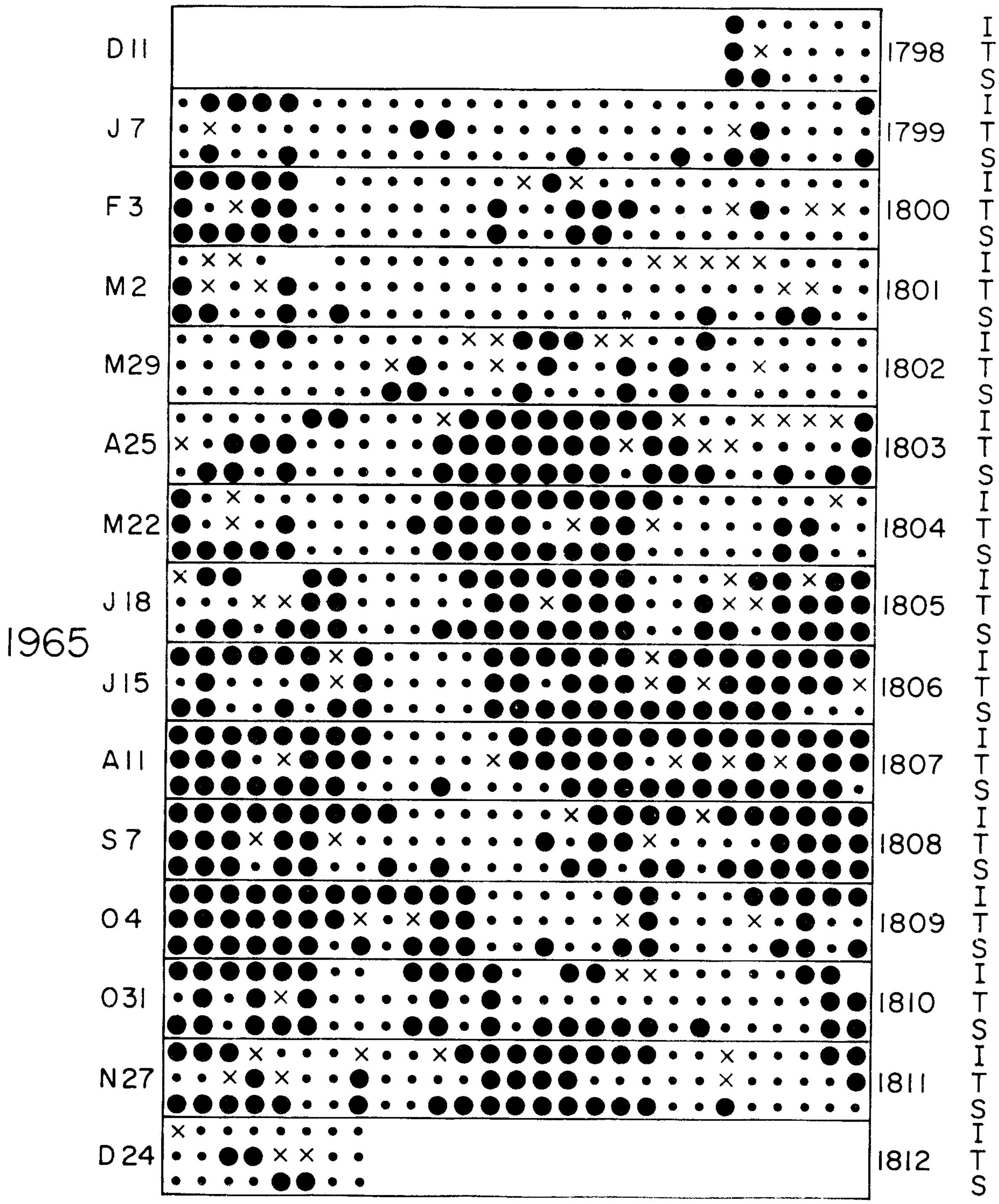
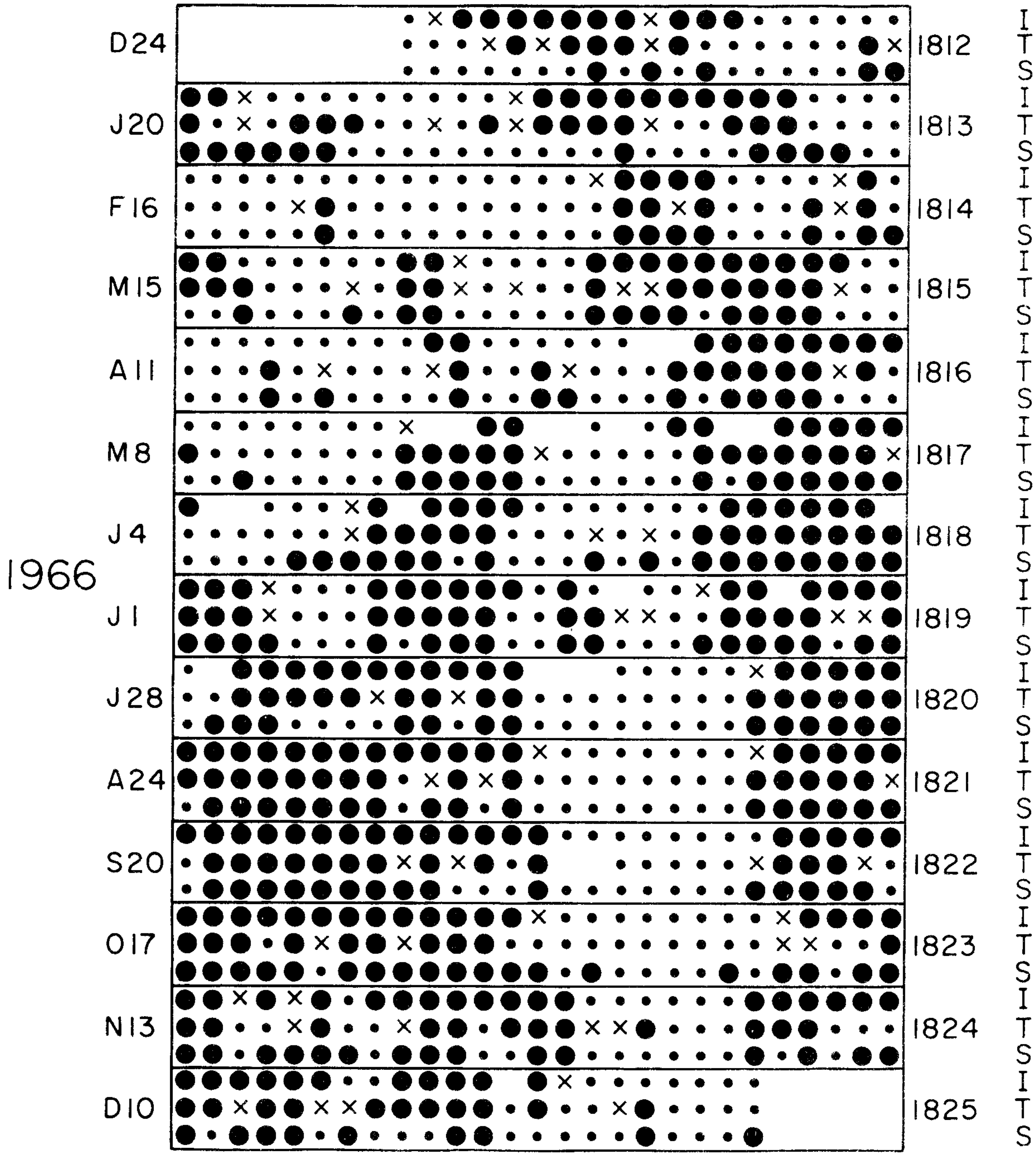
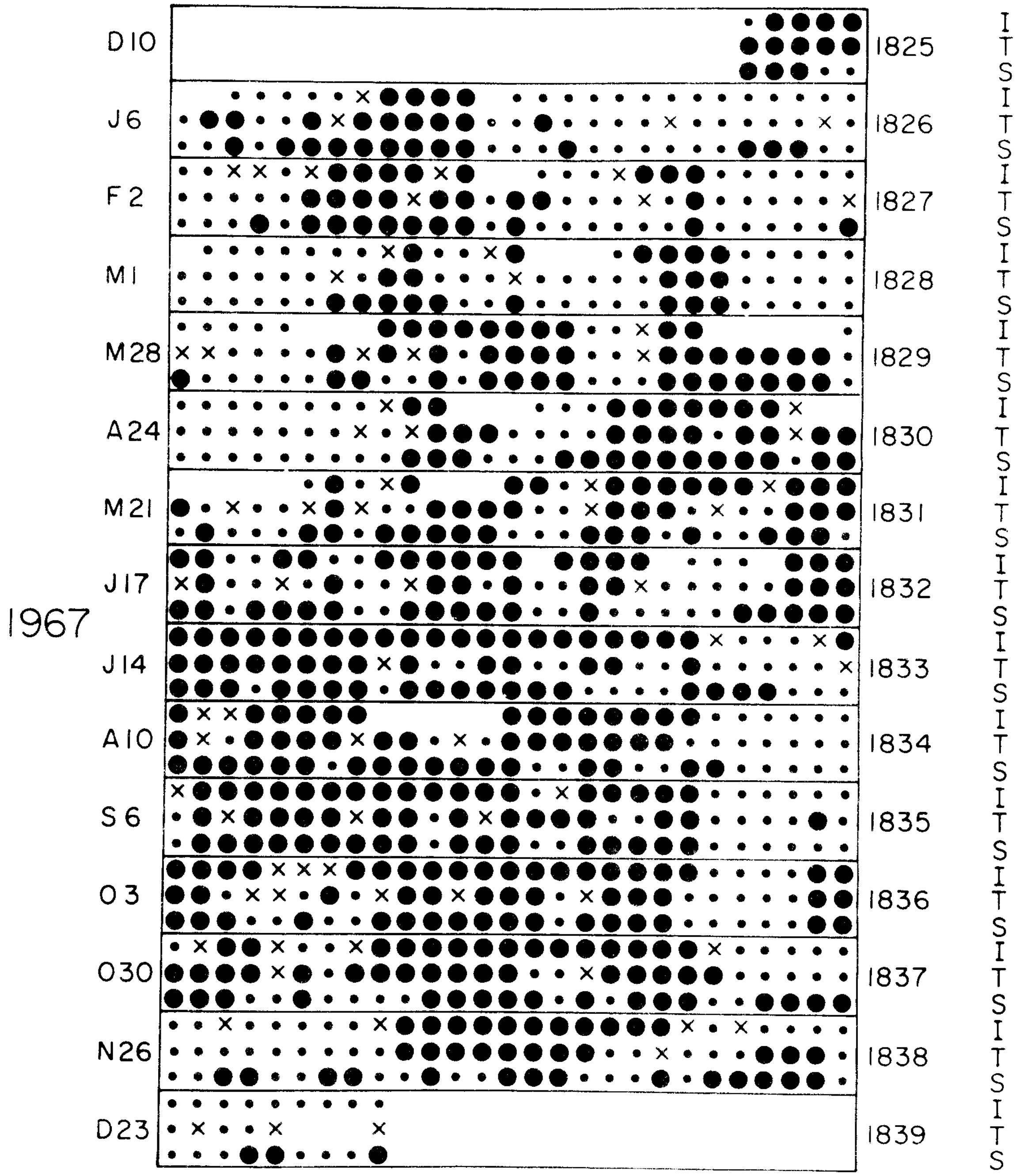
M9
J5
J2
J29
A25
S21
O18
N14
D11
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
I T S I T S A T S A T S A T S A T S A T S A T S A T S A T S I T S I T S I T S I T S


1965
D11
J7
F3
M2
M29
A25
M22
J18
J15
A11
S7
O4
O31
N27
D24
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
I
T
S


1966
D24
J20
F16
M15
A11
M8
J4
J1
J28
A24
S20
O17
N13
D10
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
I
T
S


1967
D10
J6
F2
M1
M28
A24
M21
J17
J14
A10
S6
O3
O30
N26
D23
1825
1826
1827
1828
1829
1830
1831
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1833
1834
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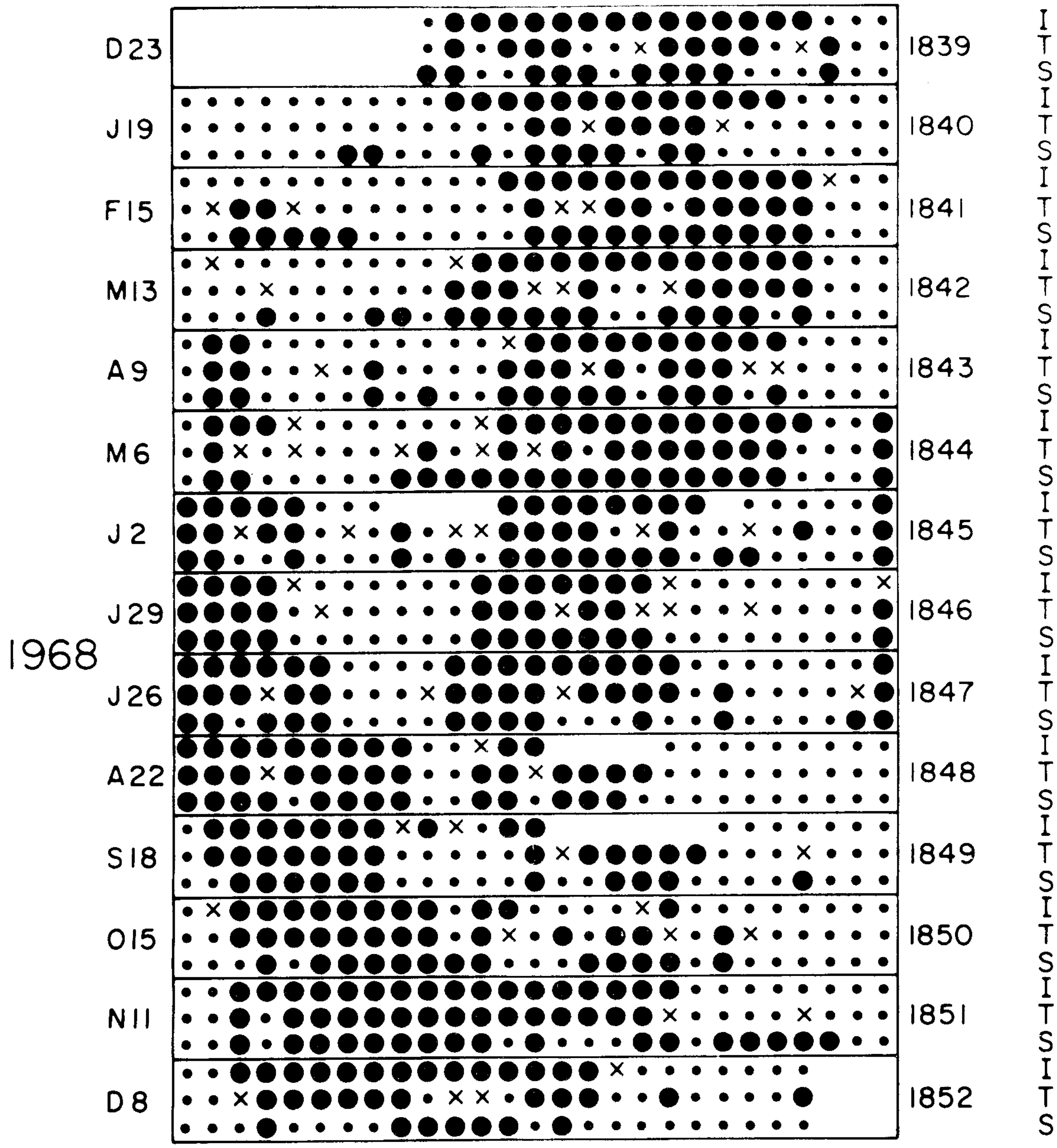
1836
1837
1838
1839
I
T
S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D23
J19
F15
M13
A9
M6
J2
J29
J26
A22
S18
O15
N11
D8
1839
1840
1841
1842
1843
1844
1845
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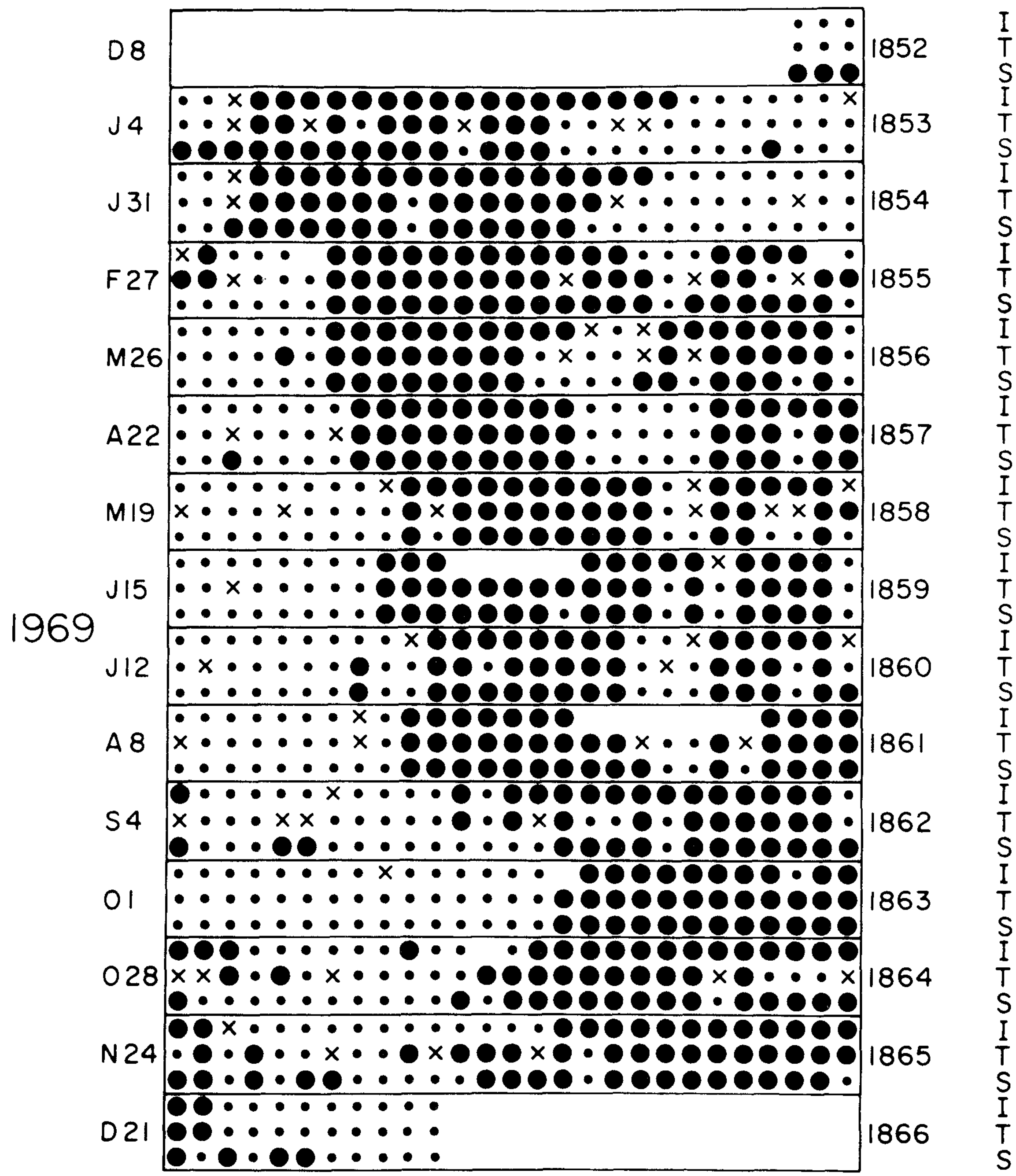
1847
1848
1849
1850
1851
1852
I T S


1969
D8
J4
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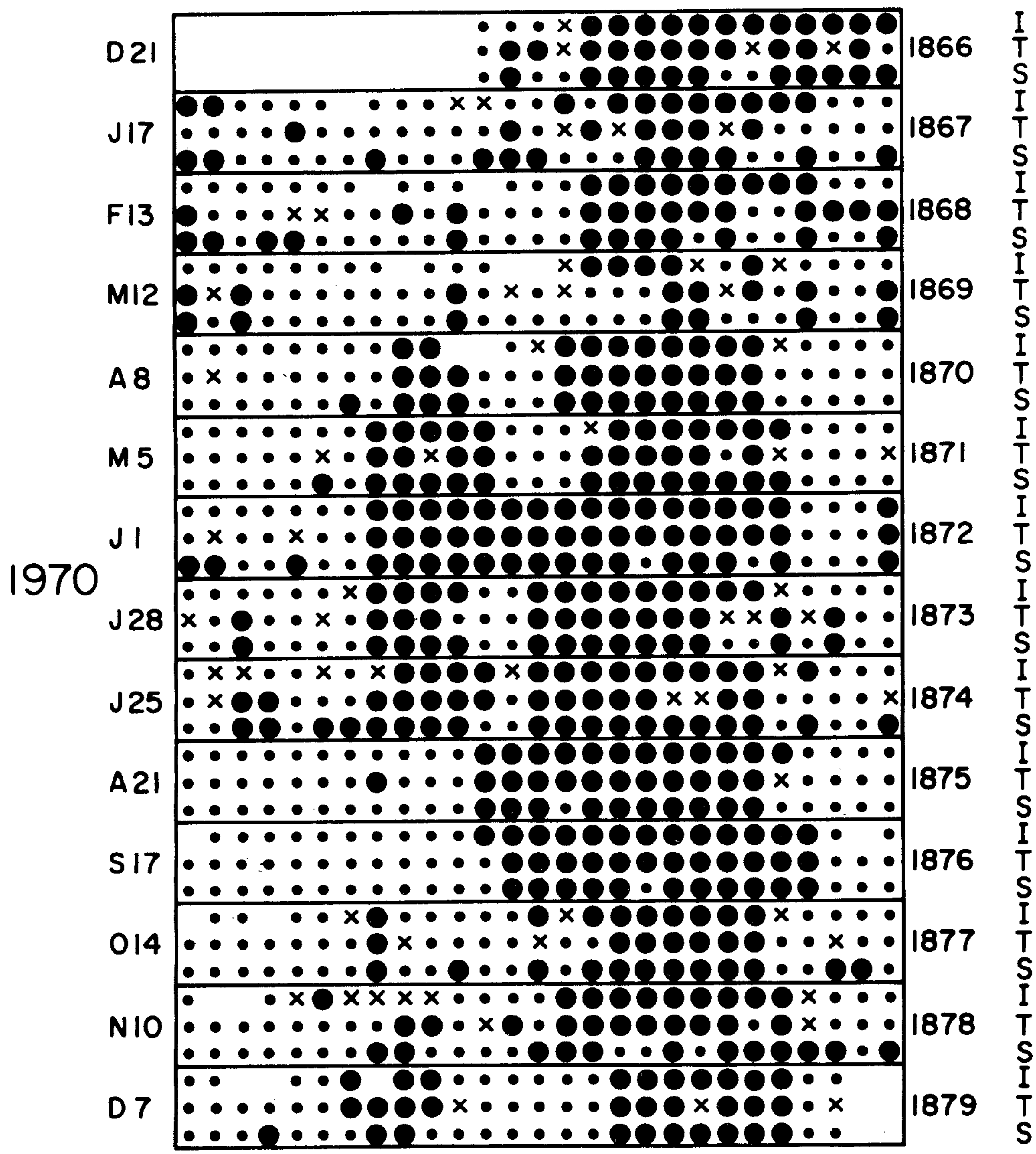
F27
M26
A22
M19
J15
J12
A8
S4
O1
O28
N24
D21
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
I T S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F13
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M5
J1
J28
J25
A21
S17
O14
N10
D7
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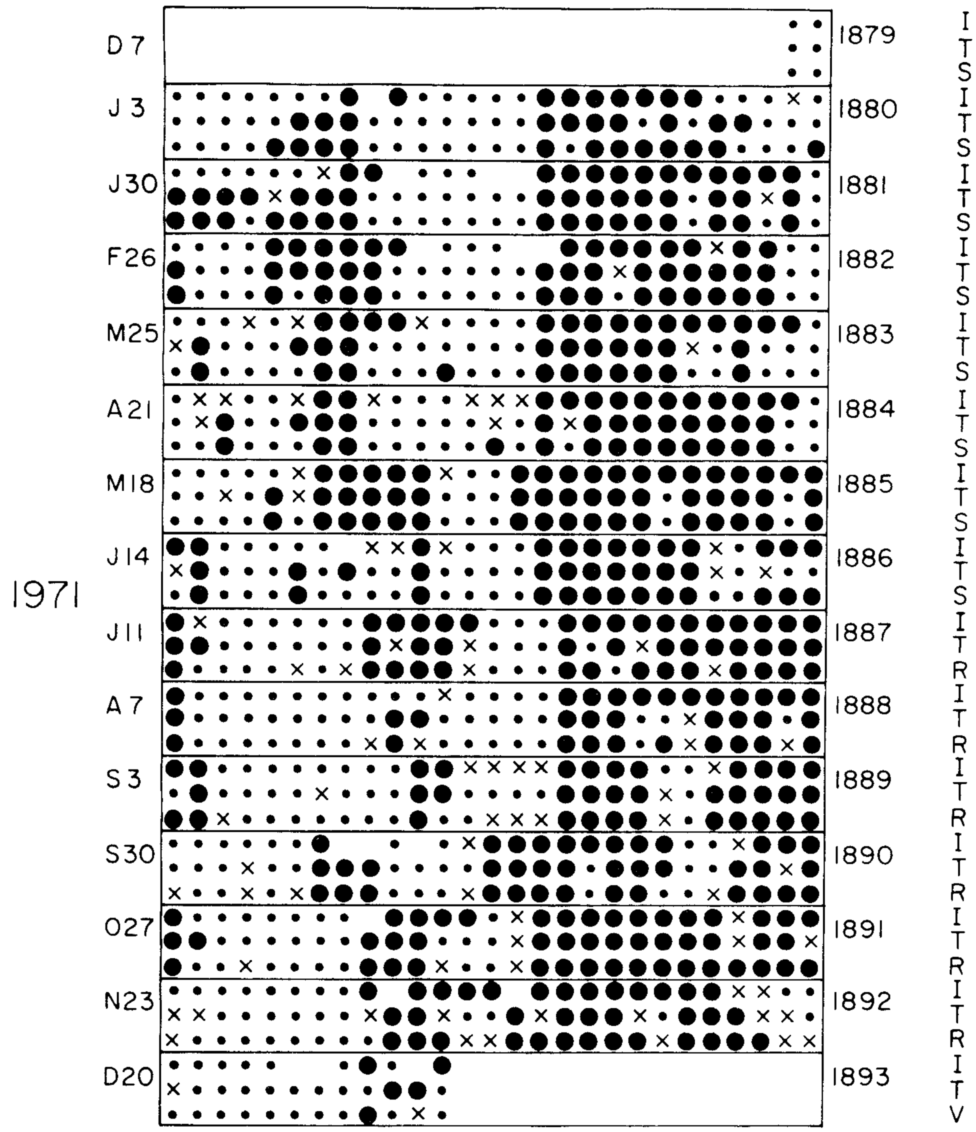
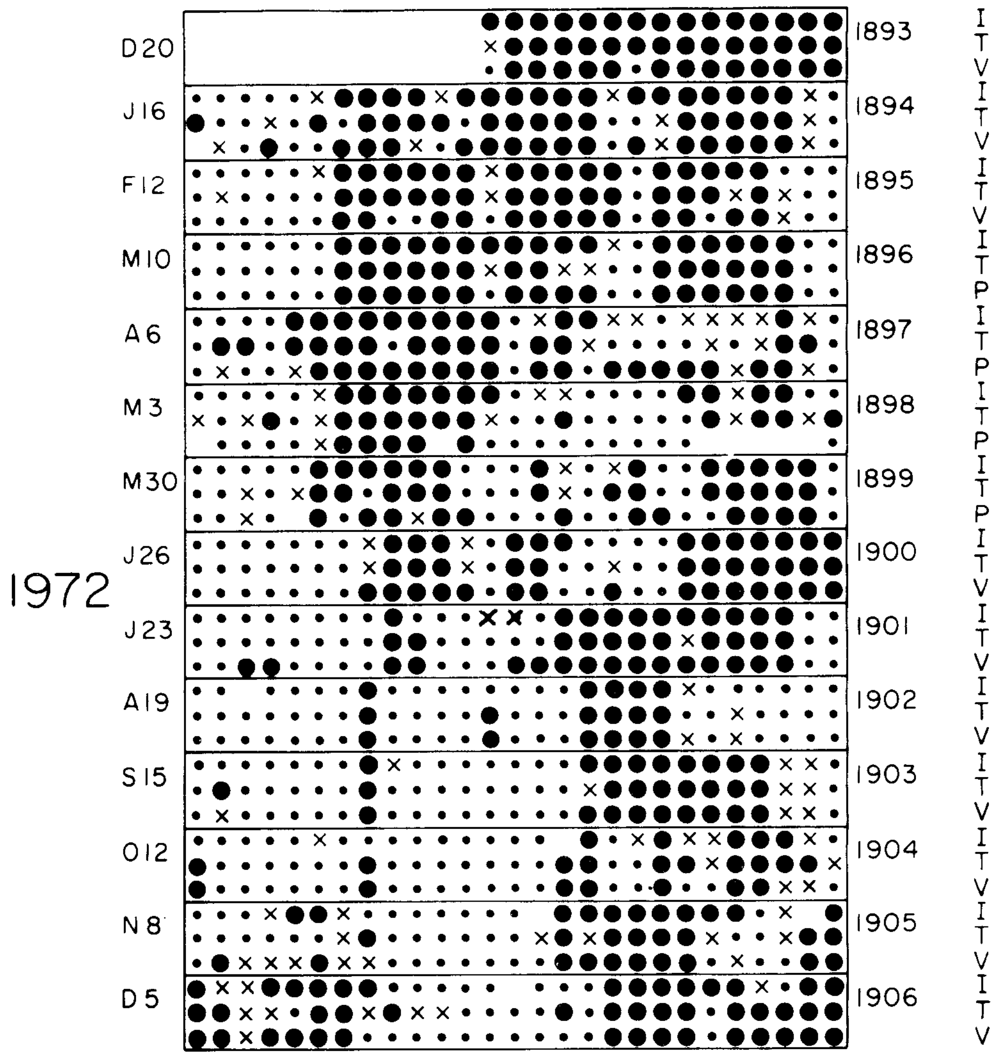
1877
1878
1879
I T S


1971
D 7
J 3
J30
F26
M25
A21
M18
J14
J11
A 7
S 3
S30
O27
N23
D20
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
I T S I T S I T S I T S I T S I T S I T S I T S I T R I T R I T R I T R I T R I T R I T V


1972
D20
J16
F12
M10
A6
M3
M30
J26
J23
A19
S15
O12
N8
D5
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
I T V
I T V
I T V
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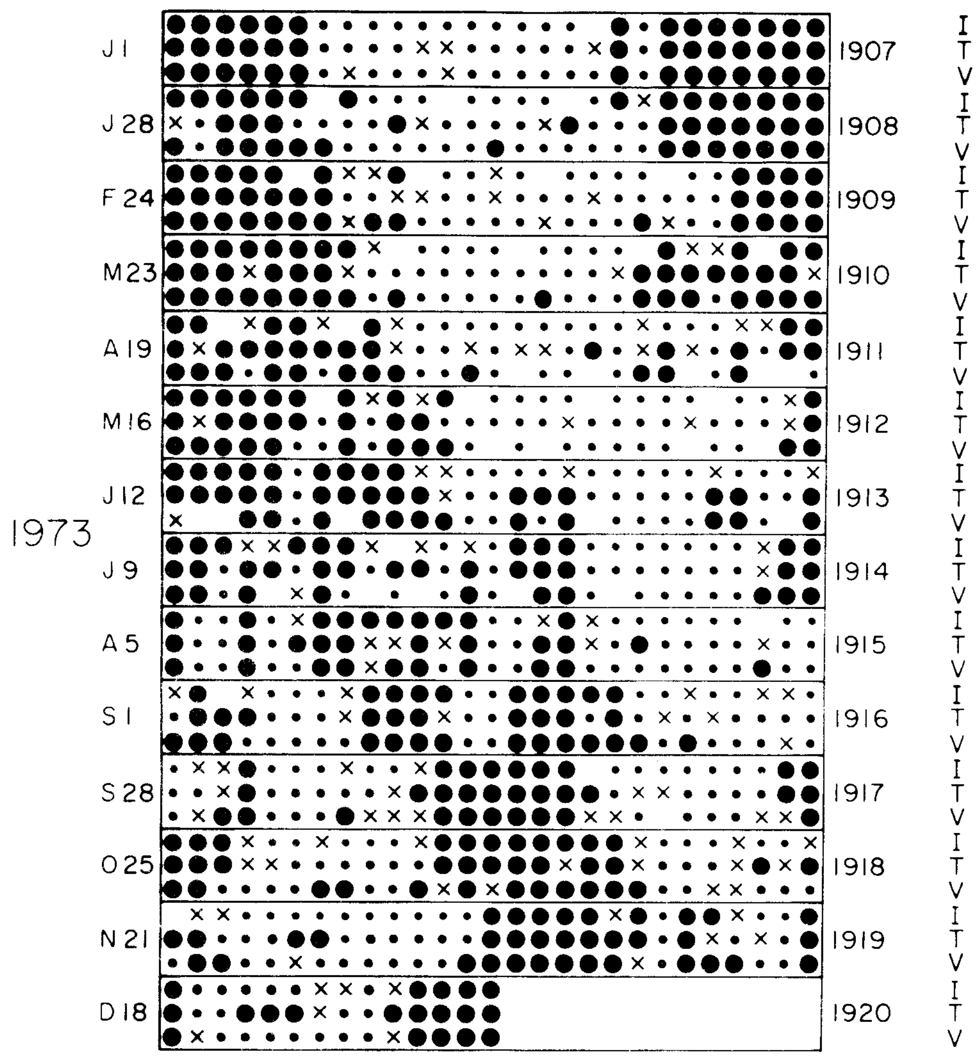
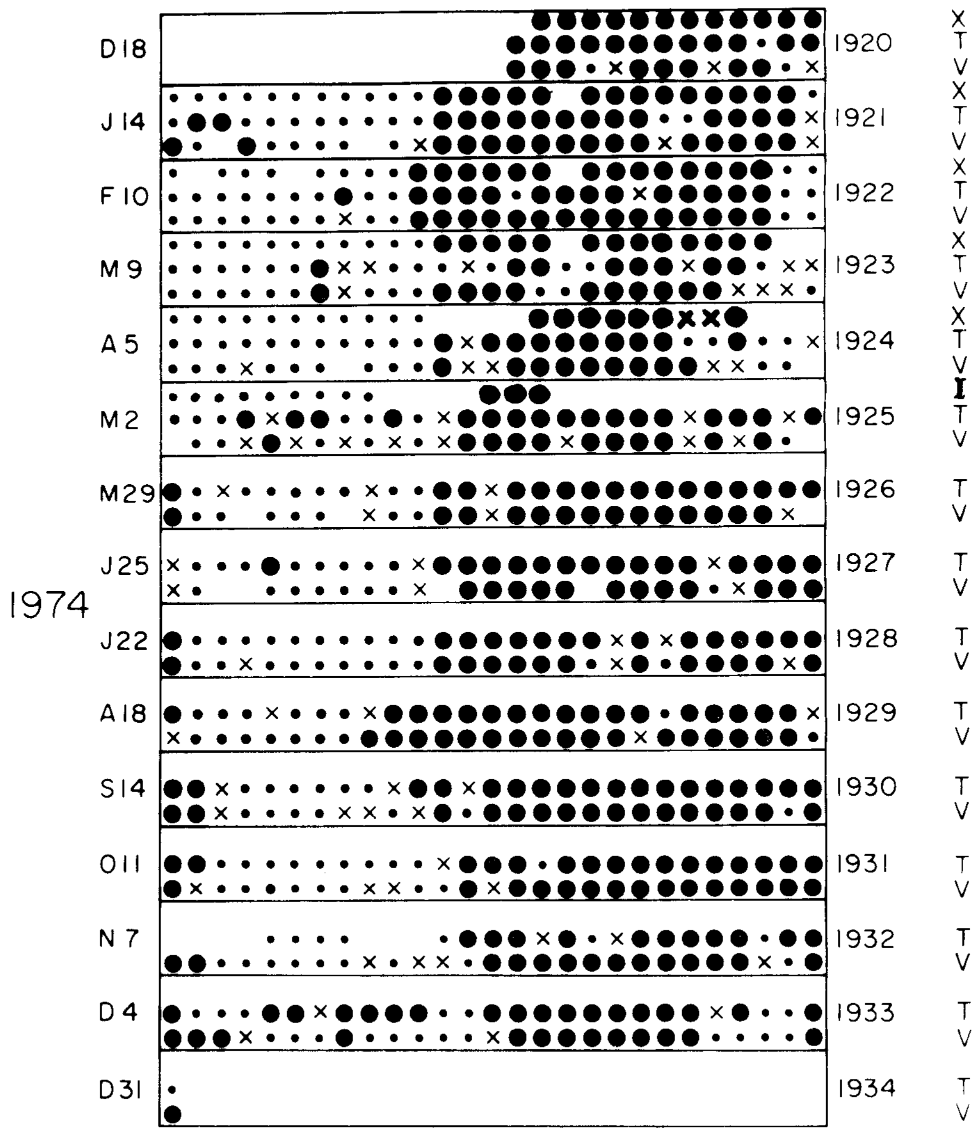
I T V
I T V


1973
J1
J28
F24
M23
A19
M16
J12
J9
A5
S1
S28
O25
N21
D18
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
I
T
V


1974
D18 1920 X T V
J14 1921 X T V
F10 1922 X T V
M9 1923 X T V
A5 1924 X T V
M2 1925 I T V
M29 1926 T V
J25 1927 T V
J22 1928 T V
A18 1929 T V
S14 1930 T V
O11 1931 T V
N7 1932 T V
D4 1933 T V
D31 1934 T V

Adopted sector structure

Using the data compilation sheets a polarity is adopted for each day. If all sources agree there is no problem in adopting the polarity. In all other cases, the adopted polarity reflects the influence of the following factors:

(1) Available interplanetary data,

(2) Majority agreement among data sources,

(3) Stability and recurrence tendency of the sector structure,

(4) The sector structure is a large-scale phenomenon with only a few sector boundaries per rotation.

No single factor was allowed to dominate. As far as possible they were all applied with the goal of obtaining a sensibly weighted estimate of the sector polarity. Occasionally, mixed polarity was adopted. Realizing that personal judgement has entered into the polarity determination for <u>all</u> data sources, it was felt resaonable to retain that element of judgement in the final adopted values.

The adopted sector polarity is displayed in the following Bartels rotation diagrams. Each day is represented by a rectangle with the polarity indicated as follows

	Toward polarity	(negative)
	Mixed polarity	
	Away polarity	(positive)

The rotation number and the starting date are given to the left of each row of 27 days; the year is indicated to the right.

In addition to the Bartels rotation diagrams, Table 7 gives the adopted polarity for each day arranged by month of year. The data has been grouped in groups of 5 days for easier reference. The coding is

C	Toward polarity
B	Mixed polarity
A	Away polarity.

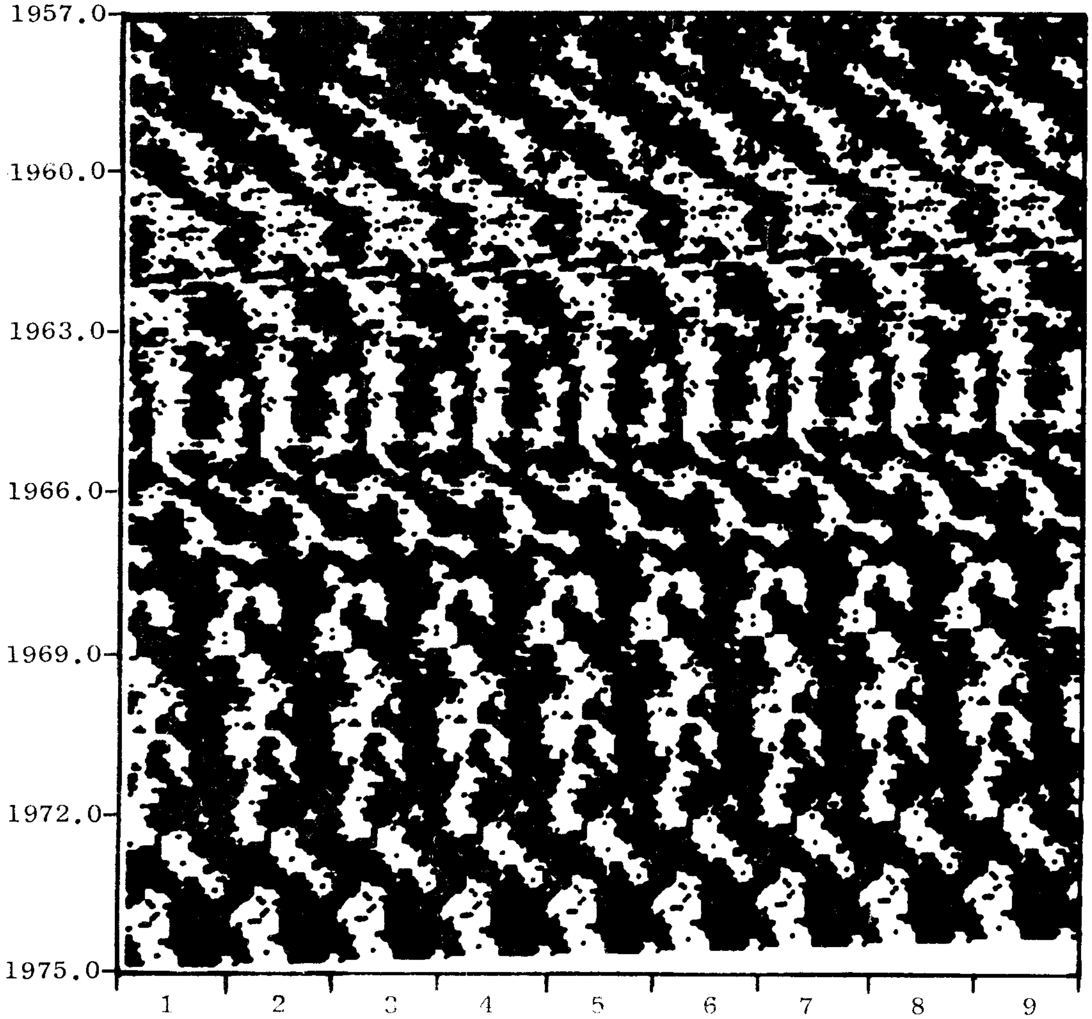
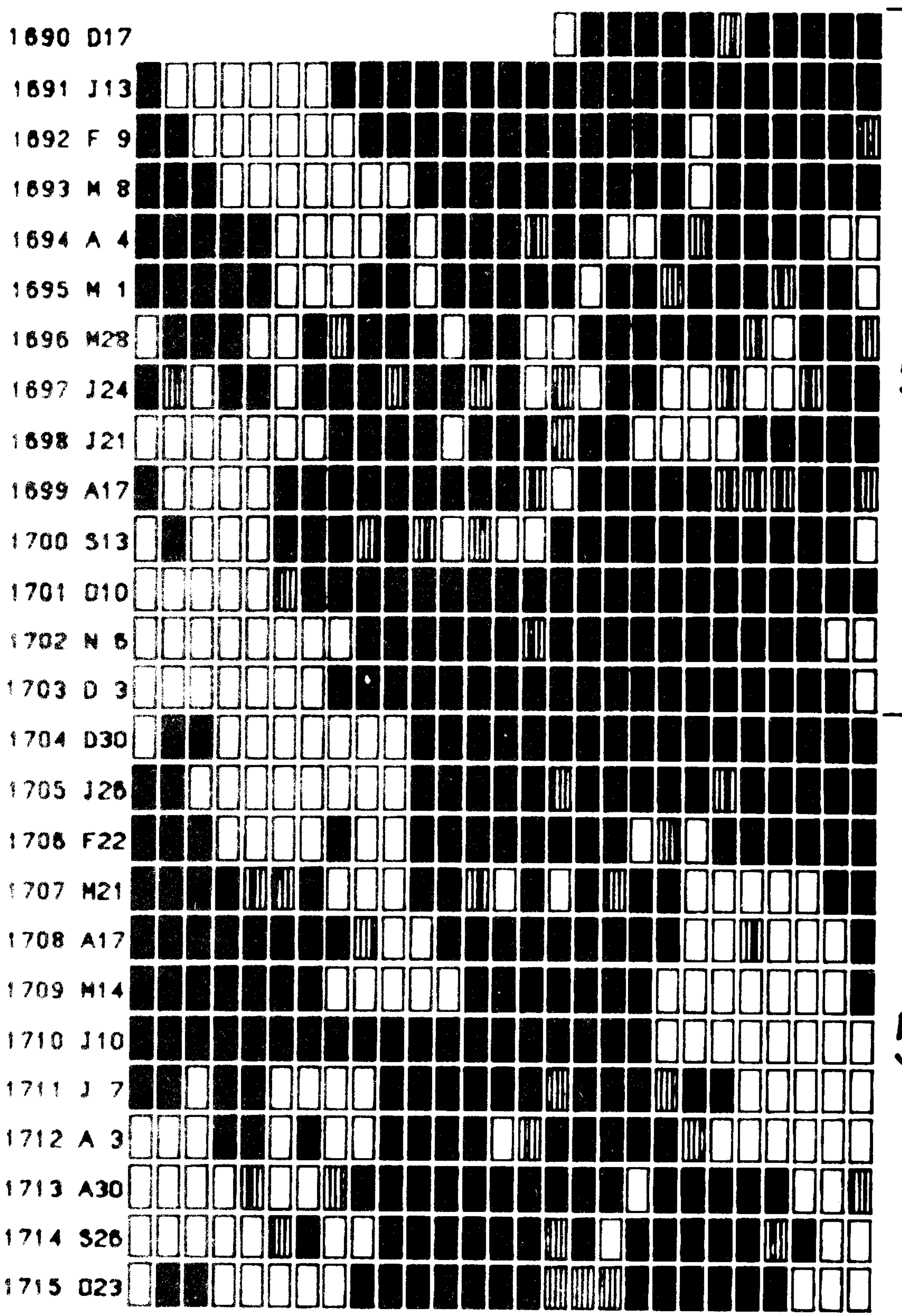


Figure 10. The adopted sector structure 1957-1974. Toward (and Mixed) polarity is shown in black. The format is a Bartels rotation diagram repeated nine times and extending from 1957 (top) through 1974 (bottom). Structures that are recurrent with a 27-day period can be seen as vertical features, e.g. during 1963-1965 and 1970-1972. At other times, e.g. 1958-1962, 1967-1969 and 1973, the features are slanting downward to the right indicating a recurrence period near $28\frac{1}{2}$ days. For a discussion of these and other properties of the solar sector structure on time scales of sunspot cycles or longer, see Svalgaard and Wilcox (1975).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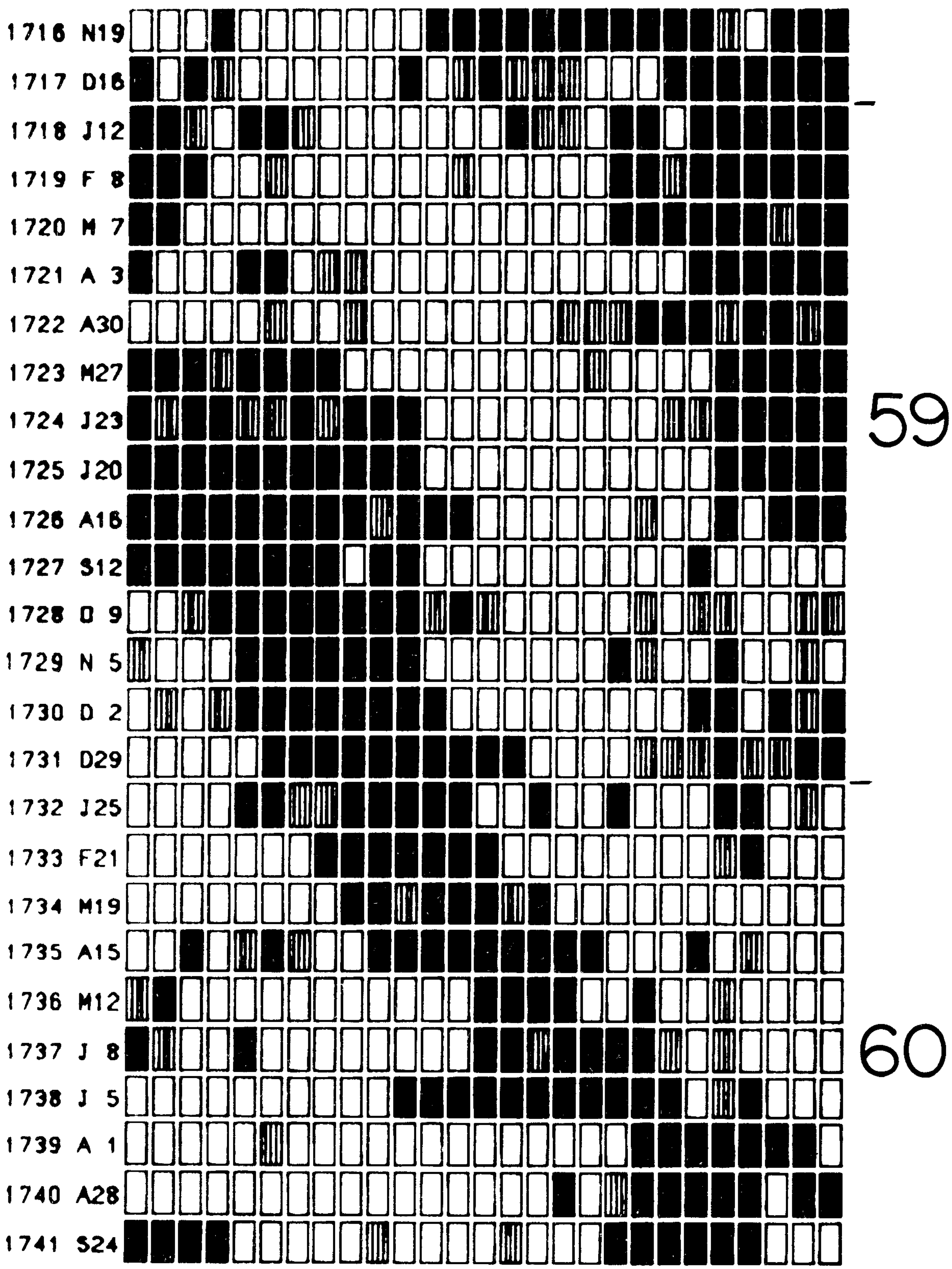
1692 F 9
1693 M 8
1694 A 4
1695 M 1
1696 M28
1697 J24
1698 J21
1699 A17
1700 S13
1701 O10
1702 N 6
1703 D 3
1704 D30
1705 J26
1706 F22
1707 M21
1708 A17
1709 M14
1710 J10
1711 J 7
1712 A 3
1713 A30
1714 S26
1715 O23

57

58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1727 S12
1728 O 9
1729 N 5
1730 D 2
1731 D29
1732 J25
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1738 J 5
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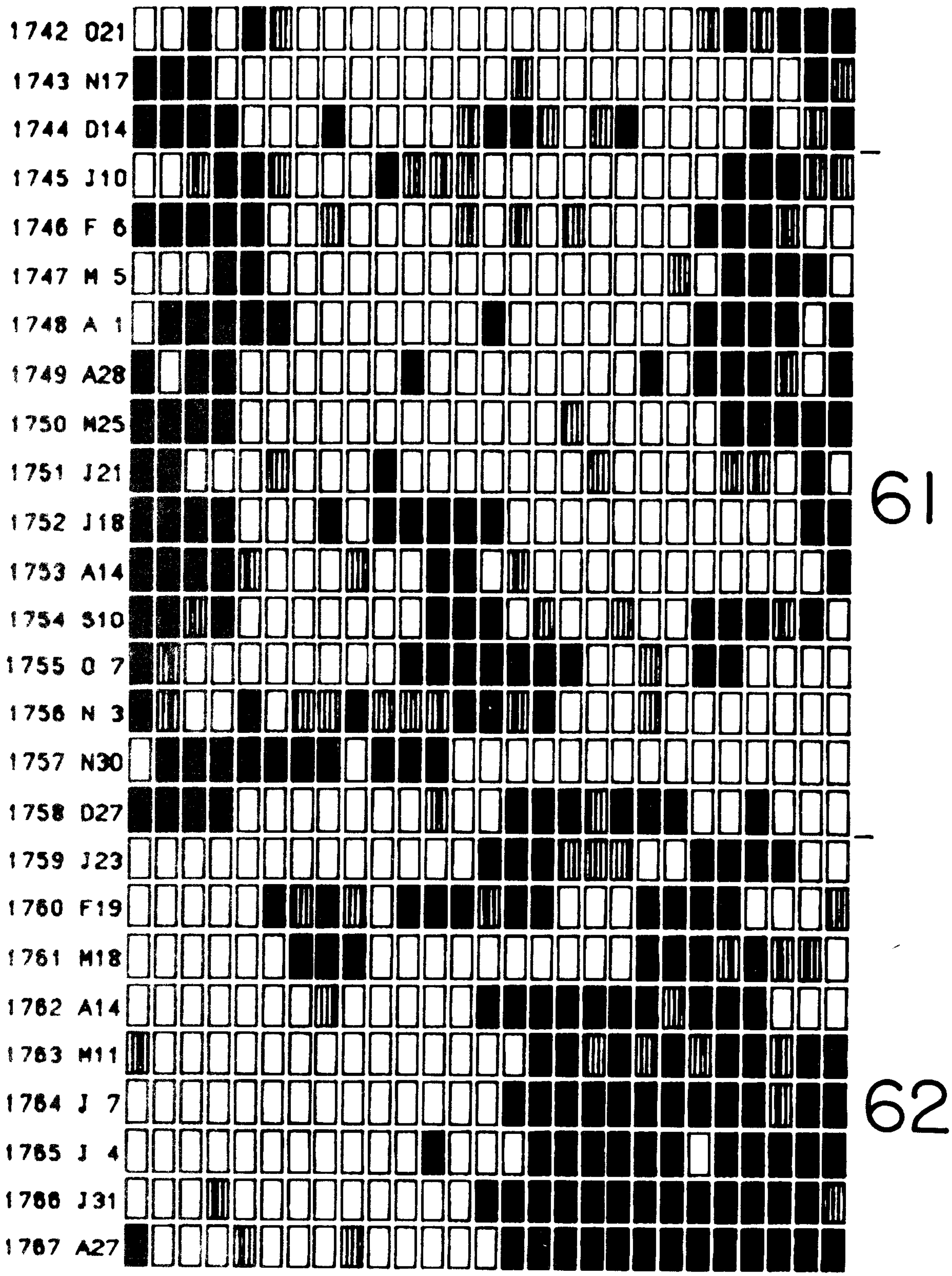
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1753 A14
1754 S10
1755 O 7
1756 N 3
1757 N30
1758 D27
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1764 J 7
1765 J 4
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1767 A27
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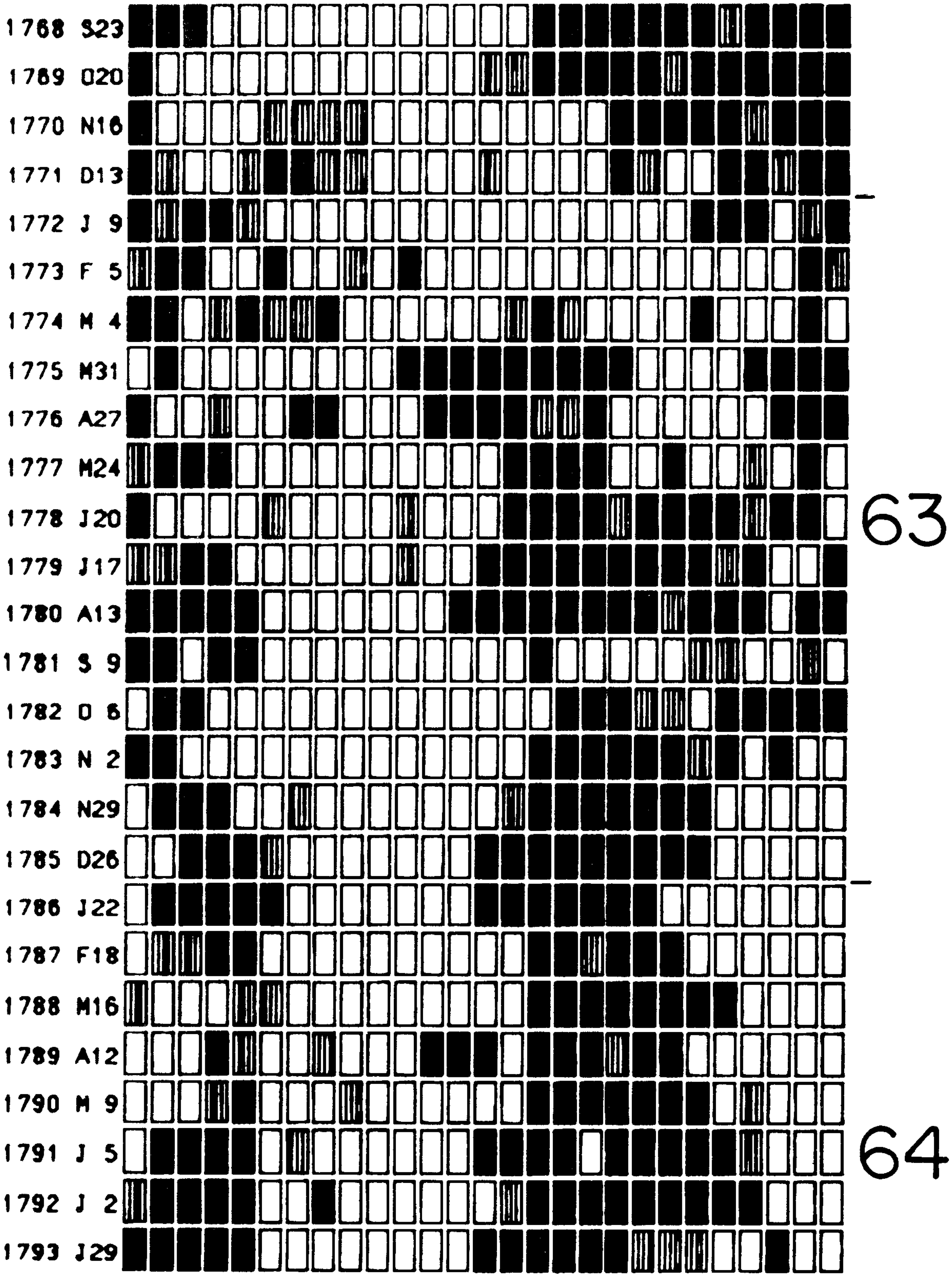
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1773 F 5
1774 M 4
1775 M31
1776 A27
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1778 J20
1779 J17
1780 A13
1781 S 9
1782 O 6
1783 N 2
1784 N29
1785 D26
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1787 F18
1788 M16
1789 A12
1790 M 9
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1793 J29
63
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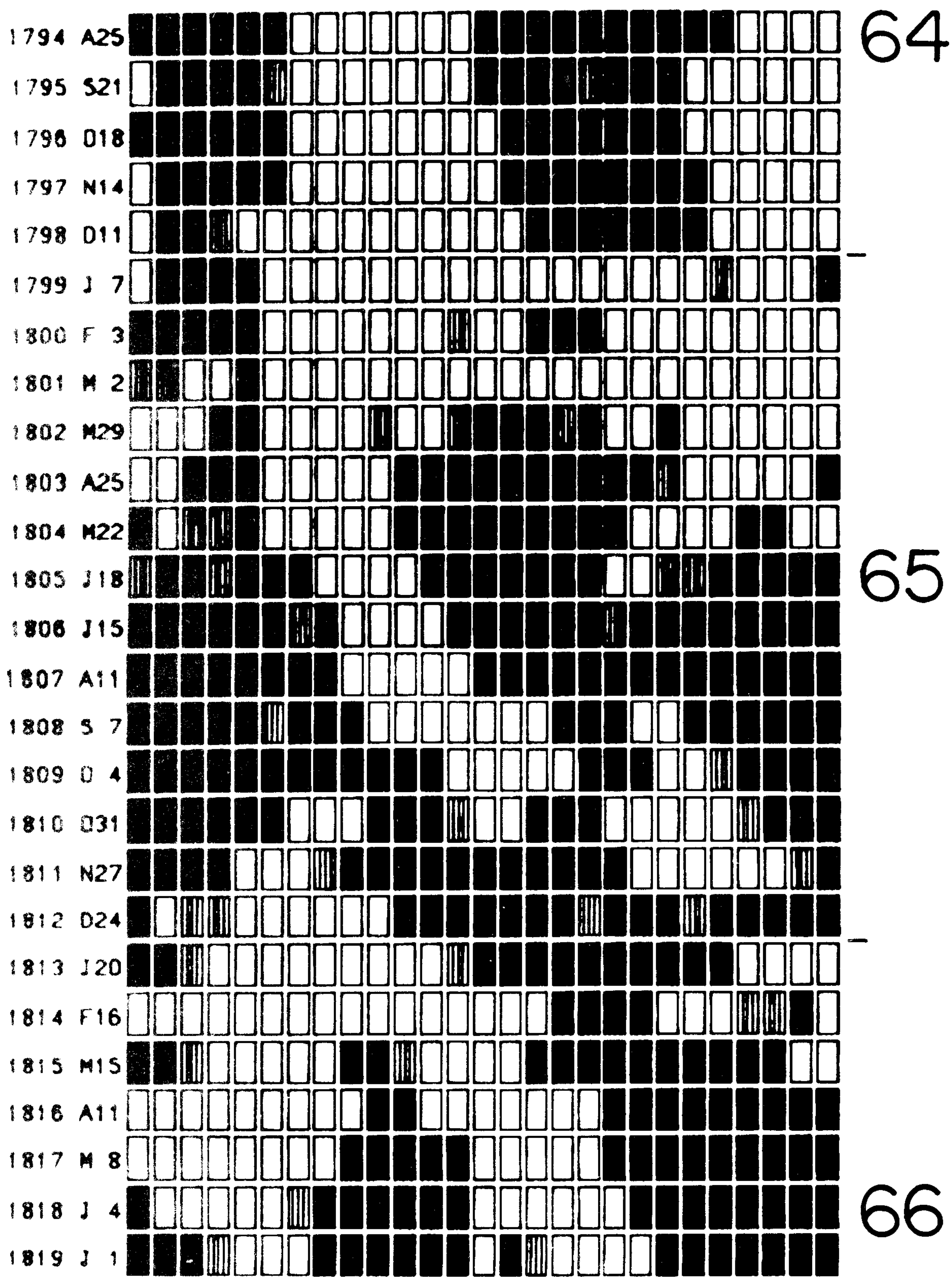
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1799 J 7
1800 F 3
1801 M 2
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1805 J18
1806 J15
1807 A11
1808 S 7
1809 O 4
1810 O31
1811 N27
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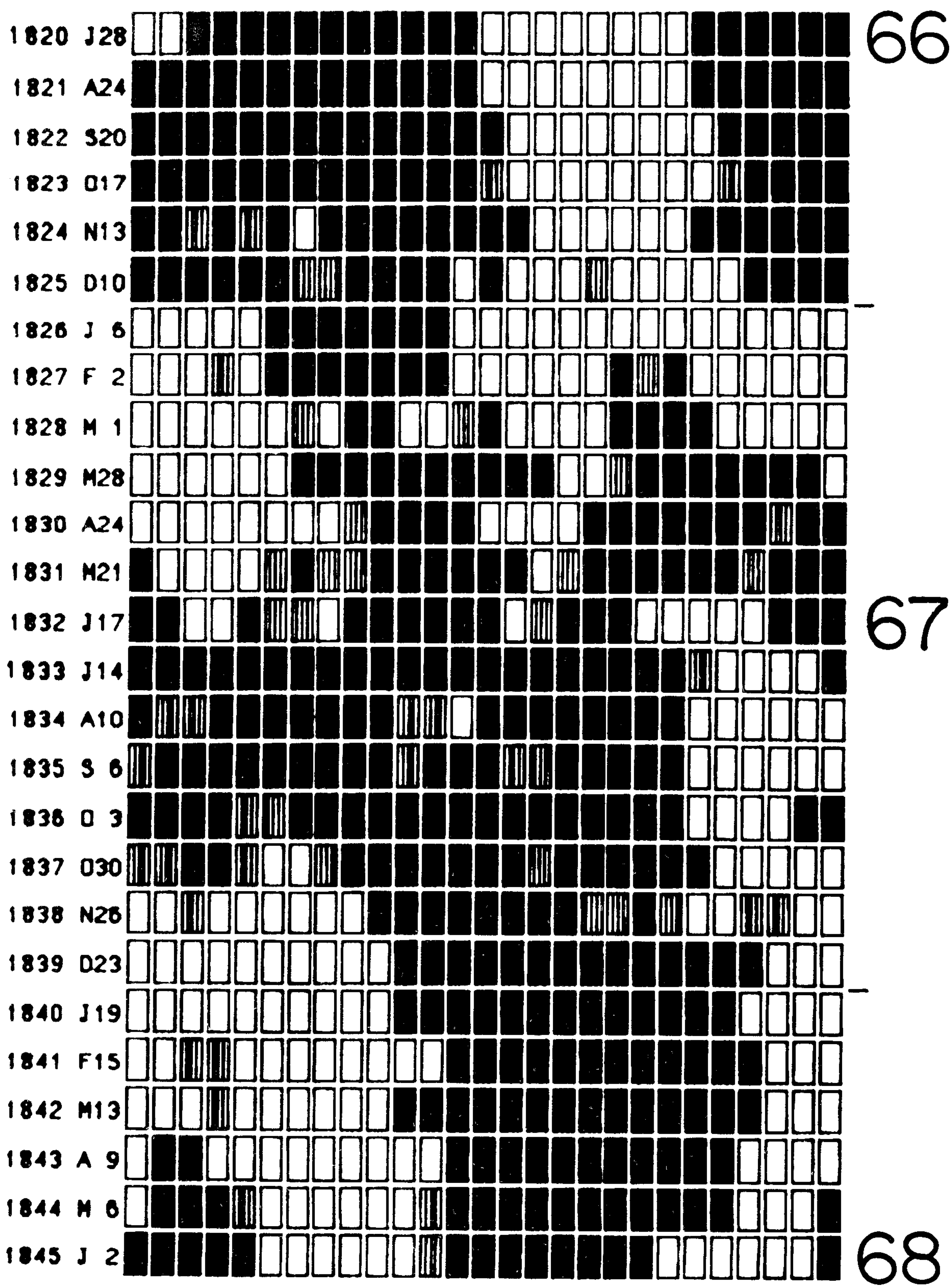
1819 J 1
64
65
66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1826 J 6
1827 F 2
1828 M 1
1829 M28
1830 A24
1831 M21
1832 J17
1833 J14
1834 A10
1835 S 6
1836 O 3
1837 O30
1838 N26
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1840 J19
1841 F15
1842 M13
1843 A 9
1844 M 6
1845 J 2
66
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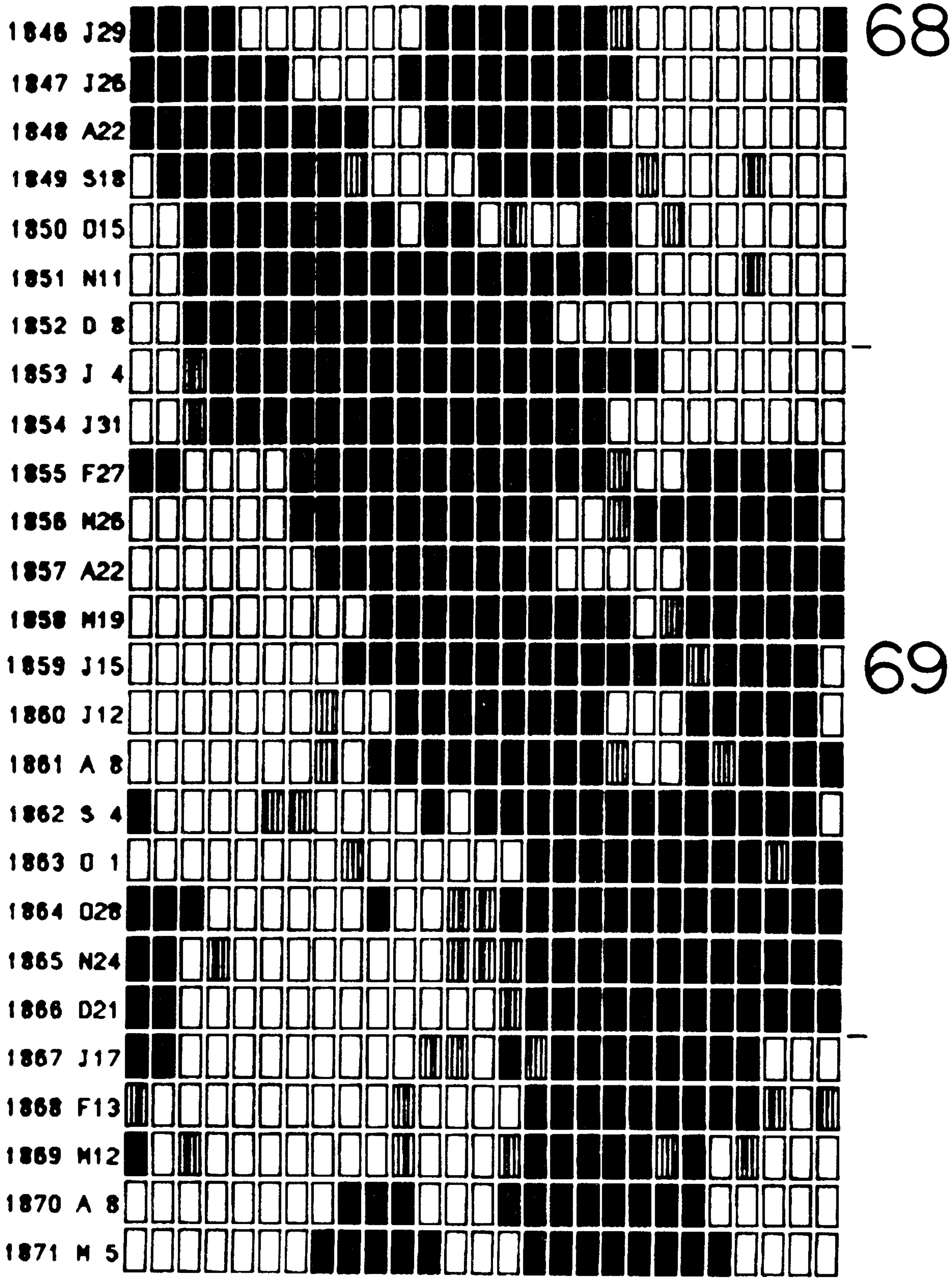
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1852 D 8
1853 J 4
1854 J31
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1857 A22
1858 M19
1859 J15
1860 J12
1861 A 8
1862 S 4
1863 O 1
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1865 N24
1866 D21
1867 J17
1868 F13
1869 M12
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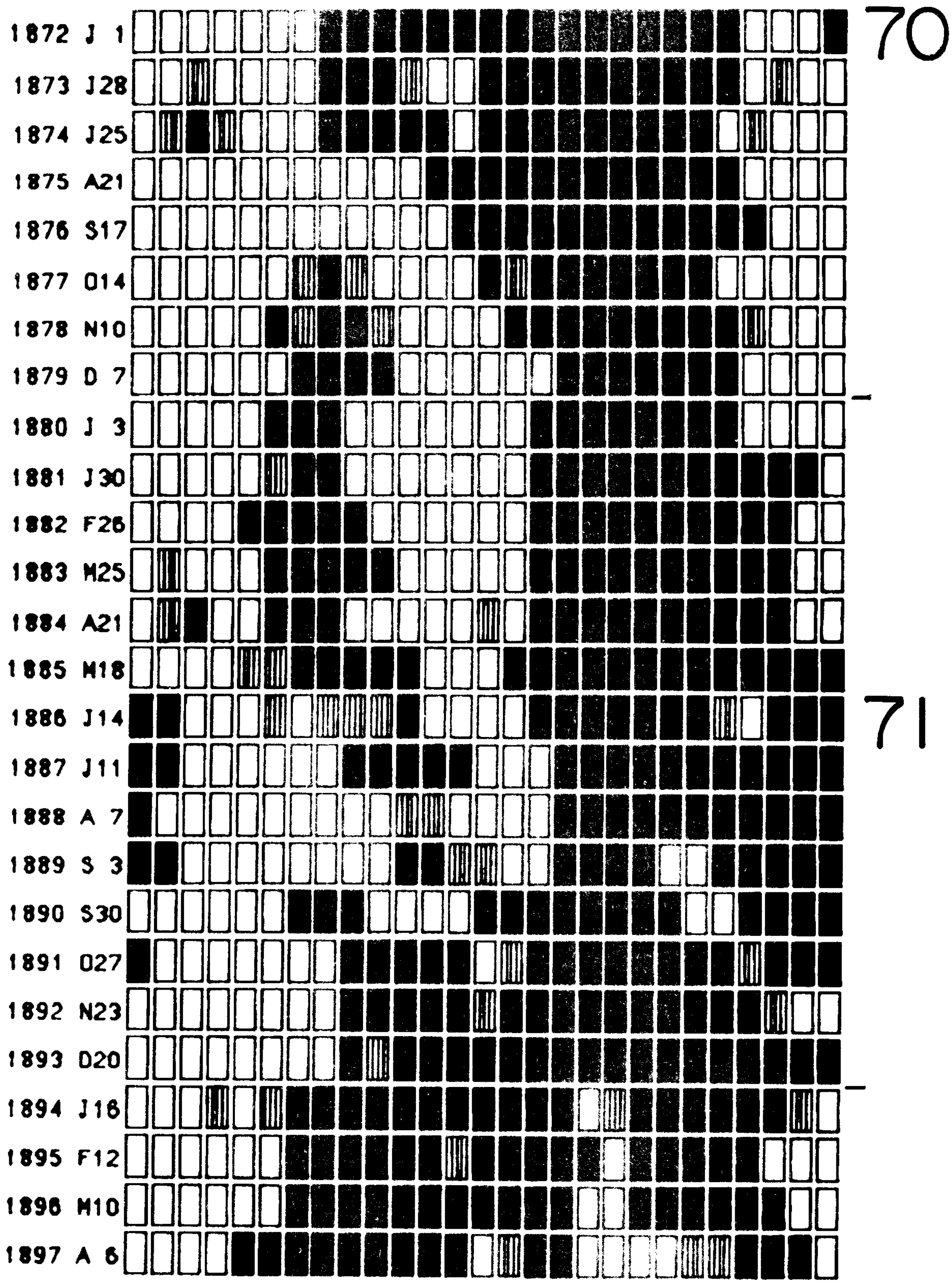
1871 M 5
68
69



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1874 J25
1875 A21
1876 S17
1877 O14
1878 N10
1879 D 7
1880 J 3
1881 J30
1882 F26
1883 M25
1884 A21
1885 M18
1886 J14
1887 J11
1888 A 7
1889 S 3
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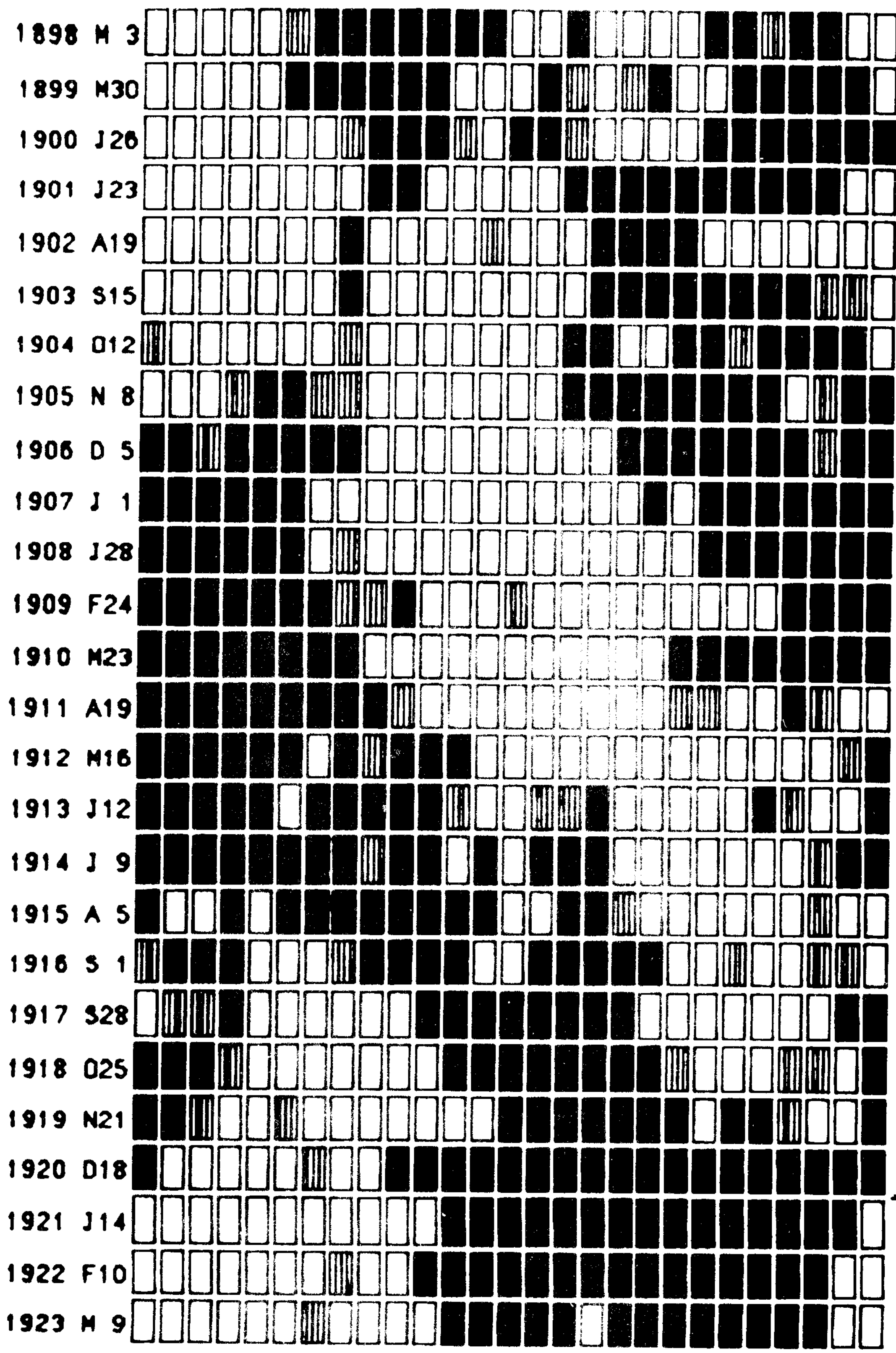
1893 D20
1894 J16
1895 F12
1896 M10
1897 A 6
70
71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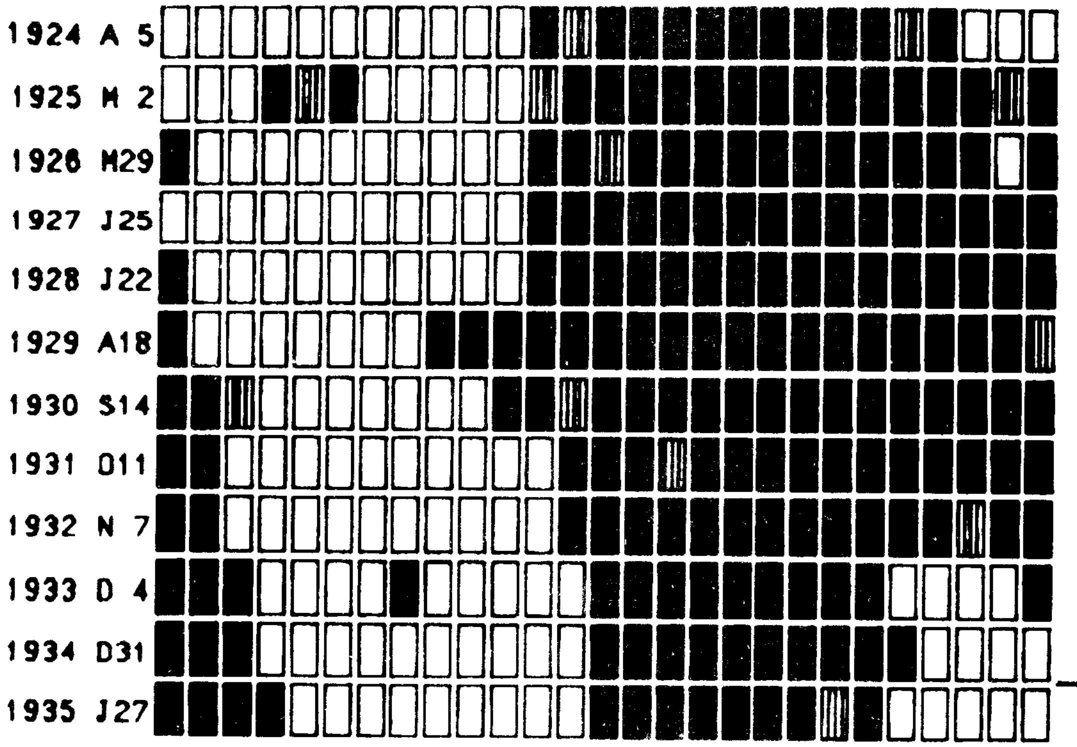
1902 A19
1903 S15
1904 O12
1905 N 8
1906 D 5
1907 J 1
1908 J28
1909 F24
1910 M23
1911 A19
1912 M16
1913 J12
1914 J 9
1915 A 5
1916 S 1
1917 S28
1918 O25
1919 N21
1920 D18
1921 J14
1922 F10
1923 M 9

72

73


1924 A 5
1925 M 2
1926 M29
1927 J25
1928 J22
1929 A18
1930 S14
1931 O11
1932 N 7
1933 D 4
1934 D31
1935 J27

74

Table 7.

1957

1	ACCCC	CACCC	CCCAA	AAAAC	CCCCC	CCCCC	C
2	CCCCC	CCCCC	AAAAA	ACCCC	CCCCC	CCC	
3	ACCCC	CACCC	AAAAA	AACCC	CCCCC	CCACC	C
4	CCCCC	CCCAA	AACAC	CCBCC	AACBC	CCCAA	
5	CCCCC	AAACC	ACCCC	CACCB	CCCBC	CAACC	C
6	AACBC	CCACC	AACCC	CCCBA	CCBCB	ACCAC	
7	CCBCC	BCABA	CCAAB	AABCC	AAAAA	AACCC	C
8	ACCCB	CCAAA	ACCCC	CCAAA	ACCCC	CCCCC	B
9	ACCCC	CBBBC	CBACA	AACCC	BCBAB	AACCC	
10	CCCCC	CCCAA	AAAAB	CCCCC	CCCCC	CCCCC	C
11	CCCCC	AAAAA	AAACC	CCCCB	CCCCC	CCCCC	
12	AAAAA	AAAAC	CCCCC	CCCCC	CCCCC	CCCAA	C

1958

1	CAAAA	AAACC	CCCCC	CCCCC	CCCCC	CCAAA	A
2	AAAAC	CCCCB	CCCCC	BCCCC	CCCCA	AAA	
3	CAACC	CCCCC	CABAC	CCCCC	CCCCB	BCAAA	C
4	CBACA	CBCCA	AAAAC	CCCCC	CCCCB	AACCC	
5	CCCCC	CAABA	AACCC	CCCCC	AAAAA	CCCCC	C
6	CAAAA	AAACC	CCCCC	CCCCC	CCCCC	CCCAA	
7	AAAAA	ACCAC	CAAAA	CCCCC	CBCCC	BCCAA	A
8	AAAAA	CCACA	ACCCC	ABCCC	CCBAA	AAAAA	A
9	AABAA	BCCCC	CCCCC	CACCC	CCAAB	AAAAA	
10	BCAAC	CCCCC	BCACC	CCCBC	AAACC	AAAAA	C
11	CCCCC	CBBBC	CCCCC	AAAAA	ACAAA	AAAAC	
12	CCCCC	CCCCC	BACCC	CACBA	AAAAA	CABCB	B

1959

1	BAAAC	CCCCC	CCCBA	CCBAA	AAAAA	CBBAC	C
2	ACCCC	CCCCC	AABAA	AAAAB	AAAAA	CCB	
3	CCCCC	CCCAA	AAAAA	AAAAA	AAAAC	CCCCC	B
4	CCCAA	ACCAB	BAAAA	AAAAA	AAACC	CCCCA	
5	AAAAB	AABAA	AAAAA	BBBCC	CBCCB	CCCCB	C
6	CCCAA	AAAAA	AABAA	AACCC	CCCBC	CBBCB	
7	CCCAA	AAAAA	AABBC	CCCCC	CCCCC	CCCCC	A
8	AAAAA	AAAAA	CCCCC	CCCCC	CCCCB	CCCAA	A
9	AAABA	ACACC	CCCCC	CCCCA	CCAAA	AAAAA	
10	AACAA	AAAAA	BCCCC	CCCCB	CBAAA	AABAB	B
11	AABBB	AAACC	CCCCC	AAAAA	AACBA	ACAAB	
12	AABAB	CCCCC	CCCAA	AAAAA	AACCA	CBCAA	A

1960

1	AACCC	CCCCC	CCAAA	ABBBC	BBCCA	AAACC	B
2	BCCCC	CAACA	ACAAA	CCABA	AAAAA	AACC	
3	CCCCC	AAAAA	AAABC	AAAAA	AAAAA	ACCBC	C
4	CBCAA	AAAAA	AAAAA	ACABC	BAACC	CCCCC	
5	CCAAA	CABAA	ABCAA	AAAAA	AAAAC	CCCAA	C
6	AABAA	AACBA	ACAAA	AAAAA	CCBCC	CCBAB	
7	AAAAA	AAAAA	AAAAC	CCCCC	CCCCC	ABCAA	A
8	AAAAA	BAAAA	AAAAA	AAAAC	CCCCC	CAAAA	A
9	AAAAA	AAAAA	AACAB	CCCCC	ACCCC	CCAAA	
10	AABAA	AABAA	ACCCC	CCAAA	AACAC	BAAAA	A
11	AAAAA	AAAAA	BCBCC	CCCCA	AAAAA	AAAAA	
12	BAAAA	AAAAA	ACBCC	CCAAA	CAAAA	BCCBA	B

1961

1	CAAAA	CABCA	ABCCB	AAACB	BBAAA	AAAAA	A
2	CCCBB	CCCCC	AABAA	AABAB	ABAAA	ACC	
3	CBAAA	AACCA	AAAAA	AAAAA	AAAAB	ACCCC	A
4	ACCCC	CAAAA	AAACA	AAAAA	ACCCC	ACCAC	
5	CAAAA	AACAA	AAAAA	ACACC	CBACC	CCCAA	A
6	AAAAA	AAAAB	AAAAA	CCCCC	CCAAA	BAAAC	
7	AAAAA	AABAA	AABBA	CACCC	CAAAC	ACCCC	C
8	AAAAA	AAAAA	ACCCC	CCBAA	ABAAC	CABAA	A
9	AAAAA	AAACC	CBCAA	AAAAA	CCCAB	AABAA	
10	CCCBC	ACBAA	AAAAA	ACCCC	CCCAA	BACCA	A
11	AACBA	ACABB	CBBBC	CBCAA	ABAAA	AAAAA	
12	CCCCC	CCACC	CAAAA	AAAAA	AAAAA	ACCCC	A

1962

1	AAAAA	ABAAC	CCBCC	CAACA	AAAAA	AAAAA	A
2	AAAAC	CCBBB	AACCC	CAAAA	AAACB	CBA	
3	CCCBC	CAAAC	CCCAA	ABAAA	AAACC	CAAAA	A
4	AAAAA	CCCBC	BBAAA	AAAAA	BAAAA	ACCCC	
5	CCCBC	CCAAA	BAAAA	AAAAA	AAAAA	CCBCB	C
6	BCCBC	CAAAA	AAAAA	AAAAA	CCCCC	CCCCC	
7	BCCAA	AAAAA	AAAAC	AAACC	CCCCA	CCCCC	A
8	AABAA	AAAAA	AACCC	CCCCC	CCCCC	BCAAA	B
9	AAABA	AAAAC	CCCCC	CCCCC	CCCCC	AAAAA	
10	AAAAA	AACCC	CCCCB	CCCCC	AAAAA	AAAAA	A
11	ABBCC	CCCBC	CCCCC	CAAAA	BBBBA	AAAAA	
12	AAACC	CCCBC	CCCBA	ABCCB	BAAAA	BAAAA	C

1963

1	BAACC	BCCCB	CCBAA	AAAAA	AAAAA	AAAAC	C
2	CABCB	CCAAC	AABAC	AAAAA	AAAAA	AAA	
3	ACBCC	ABCBB	CAAAA	AABCB	AAAAC	AAACA	A
4	CAAAA	AAAAC	CCCCC	CCCAA	AACCC	CCAAB	
5	AACCA	AACCC	CBBCA	AAAAA	CCCBC	CCAAA	A
6	AAAAA	ACCCC	AACAA	BACAC	AAAAB	AAAAB	
7	AAACC	CCBCC	CCBCC	ABBCC	AAAAA	ABAAC	C
8	CCCCC	CCBCA	ACCCC	CCAAA	AAAAC	CCCCC	C
9	CBCCC	ACCCC	ACCAA	AAAAA	AAACA	AAAAB	
10	BAABA	ACCAA	AAAAA	AAAAA	ACCCB	BACCC	C
11	CCCAA	AAAAA	AAAAA	ACCCC	CCBCA	CAAAC	
12	CCAAB	AAAAA	AABCC	CCCCC	AAAAA	AACCC	B

1964

1	AAAAA	AACCC	CCCCC	CAAAA	AACCC	CCAAA	A
2	AAACC	CCCCC	AAAAA	AAABB	CCAAA	AAAA	
3	AAACC	BCCCA	AAAAA	BAAAB	BAAAA	AAAAA	C
4	CCCCC	CCAAA	AAAAC	BAABA	AACCC	ACCCB	
5	CCAAA	AAAAA	ABCAA	ABAAA	AAACC	CCCCC	A
6	BAAAA	CCCCA	BAAAA	AACCC	CACCC	CCBAA	
7	ABCCC	CAACA	AAAAA	BCCCC	CCCCC	AAACC	C
8	CCAAA	AAAAA	CCCCC	CBBBA	ACAAC	CCCCC	A
9	AAAAA	ACCCC	CCCCC	CAAAA	ACCCC	BAAAA	
10	AAACC	CCBCC	CAAAA	AACCC	CCCAA	AAAAA	A
11	CCCCC	CCAAA	AAAAC	CCCCA	AAAAA	AACCC	
12	CCCCC	AAAAA	ACCBA	AAAAA	AAAAA	CCCCC	C

1965

1	CAAAA	AACCC	CAAAA	AAAAA	AAAAA	AAABA	A
2	ACCCC	CCAAA	AAAAB	AABCC	AAAAA	AAA	
3	ABBAA	CAAAA	AAAAA	AAAAA	AAAAA	AAAAA	A
4	CCAAA	ABAAB	CCCBC	AACAA	AAAAA	ACCCA	
5	AAAAC	CCCCC	CCCCB	AAAAA	CCABB	CAAAA	A
6	CCCCC	CCCCA	AAACC	AABCC	BCCCA	AAACC	
7	CCCCC	AABBC	CCCCC	CCCCC	BCAAA	ACCCC	C
8	CBCCC	CCCCC	CCCCC	CCCAA	AAACC	CCCCC	C
9	CCCCC	CCCCC	CCCCC	AAAAA	ABCCC	CAACC	
10	CCCCC	CCCCC	CCCCC	AAAAA	CCAAA	CCCCC	C
11	CCCCC	AAACC	CCAAC	CBBAA	AAAAC	CCCCC	
12	AAACA	AACCC	CCCCC	AABAA	ACCBA	AAAAA	A

1966

```
 1    ABCCC CCCCB CCCAA AAAAC CCAAB AAAAA A
 2    BCCCC CCCCC CAAAA AAAAA AAAAA AAA
 3    AAACC CCAAA BBCAC CBAAA AACCB AAAAC C
 4    CCCCC CCCAA AAAAA AAAAC CAAAA AAACC
 5    CCCCC CCAAA AAAAA CCCCC AAAAA CCCCC C
 6    CCCCA AAAAB CCCCC CAAAA AACCC CCCCC
 7    CCCBA AACCC CCCAC BAAAA CCCCC CCAAC C
 8    CCCCC CCCCA AAAAA AACCC CCCCC CCCCC C
 9    CCCCC AAAAA AAACC CCCCC CCCCC CCCCC
10    CCCAA AAAAA ACCCC CCCCC CCCCC CCCCB A
11    AAAAA AABCC CCCCB CBCAC CCCCC CCAAA
12    AAACC CCCCC CCCCC BBCCC CACAA ABAAA A
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1967

```
 1    ACCCC AAAAA CCCCC CCAAA AAAAA AAAAA A
 2    AAAAB ACCCC CCCAA AAAAC BCAAA AAA
 3    AAAAA ABACC AABCA AAACC CCAAA AAAAA A
 4    AACCC CCCCC CCAAB CCCCC CCAAA AAAAA
 5    ABCCC CAAAA CCCCC CCBCC CAAAA BCBBC C
 6    CCCCA BCCCC CCBCC CCCAA CBBAC CCCCC
 7    ABCCC AAAAA CCCCC CCCCC CCCCC CCCCC C
 8    CCCBA AAACC BBCCC CCCCB BACCC CCCCC A
 9    AAAAA BCCCC CCCCC BCCCB BCCCC CAAAA
10    AACCC CBBCC CCCCC CCCCC CCCAA AACCB B
11    CCBAA BCCCC CCCBC CCCCC AAAAA AABAA
12    AAAAC CCCCC CCBBC BAABB AAAAA AAAAA A
```

1968

```
 1    ACCCC CCCCC CCCCC AAAAA AAAAA AAACC C
 2    CCCCC CCCCC AAAAA ABBAA AAAAA ACCC
 3    CCCCC CCCCA AAAAA BAAAA AACCC CCCCC C
 4    CCCCC AAAAC CAAAA AAAAA CCCCC CCCCC
 5    CAAAA ACCCB AAAAA ABCCC CCCCC CCCAA A
 6    CCCCC CAAAA AABCC CCCCC CAAAA AACCC
 7    CCAAA AAAAC CCCCC CBAAA AAAAC CCCCC C
 8    AAAAC CCCCC CCCAA AAAAA CCCCC CCCCC A
 9    ACCCC CCCAA AAAAA AAACC CCCCC BAAAA
10    CCCCC CBAAA BAAAA ACCCC CCCCA CCABA A
11    CCABA AAAAA AACCC CCCCC CCCCC CCCCA
12    AAABA AAAAC CCCCC CCCCC CCCAA AAAAA A
```

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1969

 1    AAAAA BCCCC CCCCC CCCCC CCCAA AAAAA A
 2    ABCCC CCCCC CCCCC CCAAA AAAAA ACC
 3    AAAAC CCCCC CCCCC CBAAC CCCCA AAAAA A
 4    CCCCC CCCCC AABCC CCCCC AAAAA AAACC
 5    CCCCC CCAAA AACCC CCCAA AAAAA AACCC C
 6    CCCCC CABCC CCCCA AAAAA AACCC CCCCC
 7    CCCCC BCCCC AAAAA AAABA ACCCC CCCCA A
 8    ACCCC CAAAA AAAAB ACCCC CCCCC BAACB C
 9    CCCCA AAABB AAAAC ACCCC CCCCC CCCCA
10    AAAAA AAABA AAAAA CCCCC CCCCB CCCCC A
11    AAAAA CAABB CCCCC CCCCC CCCCC ABAAA
12    AAAAA BBBCC CCCCC CCCCC CCAAA AAAAA A

1970

 1    AAABC CCCCC CCCCC CCCAA AAAAA AABBA C
 2    BCCCC CCCCA AABAA AAAAA AABAA AAC
 3    CCCCC CCCBA BCABA AAAAA ABAAA BCCCC C
 4    BCABA AAAAA AAAAA CCCAA ACCCC CCCCA
 5    AAAAA AAAAA ACCCC CAAAC CCCCC CCAAA A
 6    AAAAA AACCC CCCCC CCCCC CCCAA ACAAB
 7    AAAAC CCBAA CCCCC CCCCC ABAAA BCBAA A
 8    CCCCC ACCCC CCCCC ABAAA AAAAA AAAAA A
 9    CCCCC CCCCC CCAAA AAAAA AAAAA AAACC
10    CCCCC CCCCC AAAAA AAAAB CBAAA ACBCC C
11    CCCCA AAAAA AAAAC BCCBA AAACC CCCCC
12    CCBAA AAAAA AACCC CAAAA AACCC CCCCA A

1971

 1    AAAAA AACCC AAAAA AACCC CCCCC AAAAA A
 2    AAABC CAAAA AAACC CCCCC CCCCA AAA
 3    ACCCC CAAAA AACCC CCCCC CCAAA BAAAC C
 4    CCCAA AAACC CCCCC CCCAA ABCAA CCCAA
 5    AAABA CCCCC CCCCC AAAAA ABBCC CCCAA A
 6    CCCCC CCCCC CCCCC AAABA BBBCA AAACC
 7    CCCCC BACCC CCAAA AAACC CCCAA ACCCC C
 8    CCCCC CCAAA AAAAA ABBAA AACCC CCCCC C
 9    CCCCA AAAAA AACCB BAACC CCAAC CCCCA
10    AAAAA CCCAA AACCC CCCCC AACCC CCAAA A
11    AAACC CCCAB CCCCC CCCBC CCAAA AAAAA
12    CCCCC BCCCC CCCCC CBAAA AAAAA AACBC C
```

1972

1	CCCCC	CCCCC	CCCCC	AAABA	BCCCC	CCCCC	C
2	CABCC	CCCCB	AAAAA	AACCC	CCCBC	CCCC	
3	ACCCC	CAAAA	AAAAA	CCCCC	CCCCC	CAACC	C
4	CCCAA	AAAAC	CCCCC	CCCAB	CCAAA	ABBCC	
5	CAAAA	AABCC	CCCCC	AACAA	AACCB	CCAAA	A
6	AAACC	CCCCA	AACBA	BCAAC	CCCCA	AAAAA	
7	AABCC	CBACC	BAAAA	CCCCC	CCAAA	AAAAA	C
8	CAAAA	ACCCC	CCCCC	CAAAA	AAAAA	CAAAA	B
9	AAACC	CCAAA	AAAAA	AAAAA	ACAAA	AAAAA	
10	CCCCC	CCCBB	ABAAA	AAABA	AAAAA	ACCAA	C
11	CBCCC	CAAAA	BCCBB	AAAAA	AACCC	CCCCC	
12	ABCCC	CBCCC	CCAAA	AAAAA	ACCCC	CCCBC	C

1973

1	CCCCC	CAAAA	AAAAA	AAACA	CCCCC	CCCCC	C
2	CCABA	AAAAA	AAAAA	ACCCC	CCCCC	CCC	
3	CCBBC	AAABA	AAAAA	AAACC	CCCCC	CCCCC	A
4	AAAAA	AAAAA	CCCCC	CCCCC	CCCCC	CCBAA	
5	AAAAA	AABBA	ACBAA	CCCCC	CACBC	CCAAA	A
6	AAAAA	AAAAB	CCCCC	CACCC	CCBAA	BBCAA	
7	AAACB	AACCC	CCCCC	CBCCA	CACCC	AAAAA	A
8	ABCCC	AACAC	CCCCC	CCAAC	CBAAA	AAABA	A
9	BCCCA	AABCC	CCAAC	CCCCA	ABAAB	BAABB	
10	CAAAA	AACCC	CCCCC	AAAAA	AACCC	CCBAA	A
11	AAAAC	CCCCC	CCBAA	ABBAC	CCBAA	BAAAA	
12	AAACC	CCCCC	ACCBA	ACCAA	AAABA	ACCCC	C

1974

1	CCCCC	CCCCC	CCCAA	AAAAA	AAAAC	CCCCC	C
2	CCCCC	CCCAA	AAAAA	ABAAC	CCCCC	CCC	
3	CCCCC	CAAAA	AAAAB	AAAAC	CCCCA	CCCCC	C
4	CCAAA	AAAAA	AAAAA	CBCCC	CCCCC	CBCAA	
5	AAAAC	BCAAA	AABCC	CCCCC	CCCCC	CCCCA	A
6	AAAAA	AAACC	BCCCC	CCCCC	CCACA	AAAAA	
7	AAAAA	CCCCC	CCCCC	CCCCC	CCAAA	AAAAA	A
8	ACCCC	CCCCC	CCCCC	CCCAA	AAAAA	CCCCC	C
9	CCCCC	CCCCC	CCBCC	BAAAA	AAACC	BCCCC	
10	CCCCC	CCCCC	CCAAA	AAAAA	AACCC	BCCCC	C
11	CCCCC	CCCAA	AAAAA	AAACC	CCCCC	CCCCC	
12	BCCCC	CAAAA	CAAAA	ACCCC	CCCCC	AAAAC	C

Sector boundary list

For a field reversal to be classified as a sector boundary we shall generally require that the polarity be the same for at least four days before the reversal and that it remains reversed for at least four days following the reversal. We thereby distinguish between the large-scale sector structure and finer scale filaments and reversals. Most of the large-scale features are recurrent, while most of the small-scale features are not. Occasionally a four day wide sector may recur as a sector only three days wide and then later again become four or more days wide. In such cases the four day criterion described above is relaxed in order not to miss what obviously is a bona fide sector boundary rather than just a transient reversal. A list of such well-defined sector boundary passings can now be prepared from the Bartels rotation plots of the adopted sector polarities. In the list given as Table 8, the time of day of the boundary passing is always given as nominally 0^hUT because of the one-day time resolution of the polarity list. It is then understood that the most probable time of the boundary passage is within ±12 hours of the UT time given. The list includes an indication of the polarity change across the boundary, (+,-) or (-,+) where "+" is Away and "-" is Toward polarity. Finally the Bartels rotation number and the day within that rotation of the first day of the new sector are given.

We will emphasize that Table 8 gives an almost complete account of sector boundaries passing by the earth. A total of 545 boundaries are listed during the interval 1957-1974 covering 245 rotations; this corresponds to an average number of boundaries per rotation of 2.2. The number of sector boundaries per month seems to have a semi-annual variation as was first pointed out by Sawyer (1974). The following table gives the number of boundaries per month (normalized to 30 days length) as deduced from Table 8.

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
47	43	38	45	51	48	47	44	43	44	40	48

The maximum number of boundaries occurs near the solar equatorial plane.

Table 8.

SB #	Date	UT	change	B.rot#	day
1	JAN 14 1957	00:00:00.0	−, +	1691	2
2	JAN 20 1957	00:00:00.0	+, −	1691	8
3	FEB 11 1957	00:00:00.0	−, +	1692	3
4	FEB 17 1957	00:00:00.0	+, −	1692	9
5	MARCH 11 1957	00:00:00.0	−, +	1693	4
6	MARCH 18 1957	00:00:00.0	+, −	1693	11
7	APRIL 9 1957	00:00:00.0	−, +	1694	6
8	APRIL 15 1957	00:00:00.0	+, −	1694	12
9	MAY 6 1957	00:00:00.0	−, +	1695	6
10	JULY 13 1957	00:00:00.0	−, +	1697	20
11	JULY 28 1957	00:00:00.0	+, −	1698	8
12	AUG 8 1957	00:00:00.0	−, +	1698	19
13	AUG 12 1957	00:00:00.0	+, −	1698	23
14	AUG 18 1957	00:00:00.0	−, +	1699	2
15	AUG 22 1957	00:00:00.0	+, −	1699	6
16	SEPT 12 1957	00:00:00.0	−, +	1699	27
17	SEPT 18 1957	00:00:00.0	+, −	1700	6
18	SEPT 24 1957	00:00:00.0	−, +	1700	12
19	SEPT 28 1957	00:00:00.0	+, −	1700	16
20	OCT 9 1957	00:00:00.0	−, +	1700	27
21	OCT 16 1957	00:00:00.0	+, −	1701	7
22	NOV 6 1957	00:00:00.0	−, +	1702	1
23	NOV 14 1957	00:00:00.0	+, −	1702	9
24	DEC 1 1957	00:00:00.0	−, +	1702	26
25	DEC 10 1957	00:00:00.0	+, −	1703	8
26	DEC 29 1957	00:00:00.0	−, +	1703	27
27	JAN 9 1958	00:00:00.0	+, −	1704	11
28	JAN 28 1958	00:00:00.0	−, +	1705	3
29	FEB 5 1958	00:00:00.0	+, −	1705	11
30	FEB 25 1958	00:00:00.0	−, +	1706	4
31	MARCH 4 1958	00:00:00.0	+, −	1706	11
32	MARCH 26 1958	00:00:00.0	−, +	1707	6
33	MARCH 31 1958	00:00:00.0	+, −	1707	11
34	APRIL 10 1958	00:00:00.0	−, +	1707	21
35	APRIL 15 1958	00:00:00.0	+, −	1707	26
36	APRIL 28 1958	00:00:00.0	+, −	1708	12
37	MAY 7 1958	00:00:00.0	−, +	1708	21
38	MAY 13 1958	00:00:00.0	+, −	1708	27
39	MAY 21 1958	00:00:00.0	−, +	1709	8
40	MAY 26 1958	00:00:00.0	+, −	1709	13
41	JUNE 2 1958	00:00:00.0	−, +	1709	20
42	JUNE 9 1958	00:00:00.0	+, −	1709	27
43	JUNE 29 1958	00:00:00.0	−, +	1710	20
44	JULY 12 1958	00:00:00.0	−, +	1711	6
45	JULY 16 1958	00:00:00.0	+, −	1711	10
46	JULY 29 1958	00:00:00.0	−, +	1711	23
47	AUG 12 1958	00:00:00.0	+, −	1712	10
48	AUG 23 1958	00:00:00.0	−, +	1712	21
49	SEPT 7 1958	00:00:00.0	+, −	1713	9
50	SEPT 23 1958	00:00:00.0	−, +	1713	25

51	OCT	5	1958	00:00:00.0	+, −	1714	10
52	OCT	21	1958	00:00:00.0	−, +	1714	26
53	OCT	31	1958	00:00:00.0	+, −	1715	9
54	NOV	16	1958	00:00:00.0	−, +	1715	25
55	NOV	30	1958	00:00:00.0	+, −	1716	12
56	DEC	17	1958	00:00:00.0	−, +	1717	2
57	JAN	15	1959	00:00:00.0	−, +	1718	4
58	JAN	30	1959	00:00:00.0	+, −	1718	19
59	FEB	11	1959	00:00:00.0	−, +	1719	4
60	FEB	26	1959	00:00:00.0	+, −	1719	19
61	MARCH	9	1959	00:00:00.0	−, +	1720	3
62	MARCH	25	1959	00:00:00.0	+, −	1720	19
63	APRIL	4	1959	00:00:00.0	−, +	1721	2
64	APRIL	24	1959	00:00:00.0	+, −	1721	22
65	APRIL	30	1959	00:00:00.0	−, +	1722	1
66	MAY	17	1959	00:00:00.0	+, −	1722	18
67	JUNE	4	1959	00:00:00.0	−, +	1723	9
68	JUNE	18	1959	00:00:00.0	+, −	1723	23
69	JULY	4	1959	00:00:00.0	−, +	1724	12
70	JULY	14	1959	00:00:00.0	+, −	1724	22
71	JULY	31	1959	00:00:00.0	−, +	1725	12
72	AUG	11	1959	00:00:00.0	+, −	1725	23
73	AUG	29	1959	00:00:00.0	−, +	1726	14
74	SEPT	7	1959	00:00:00.0	+, −	1726	23
75	SEPT	23	1959	00:00:00.0	−, +	1727	12
76	OCT	12	1959	00:00:00.0	+, −	1728	4
77	OCT	20	1959	00:00:00.0	−, +	1728	12
78	NOV	9	1959	00:00:00.0	+, −	1729	5
79	NOV	16	1959	00:00:00.0	−, +	1729	12
80	DEC	6	1959	00:00:00.0	+, −	1730	5
81	DEC	14	1959	00:00:00.0	−, +	1730	13
82	DEC	23	1959	00:00:00.0	+, −	1730	22
83	DEC	29	1959	00:00:00.0	−, +	1731	1
84	JAN	3	1960	00:00:00.0	+, −	1731	6
85	JAN	13	1960	00:00:00.0	−, +	1731	16
86	JAN	29	1960	00:00:00.0	+, −	1732	5
87	FEB	7	1960	00:00:00.0	−, +	1732	14
88	FEB	28	1960	00:00:00.0	+, −	1733	8
89	MARCH	6	1960	00:00:00.0	−, +	1733	15
90	MARCH	27	1960	00:00:00.0	+, −	1734	9
91	APRIL	4	1960	00:00:00.0	−, +	1734	17
92	APRIL	24	1960	00:00:00.0	+, −	1735	10
93	MAY	3	1960	00:00:00.0	−, +	1735	19
94	MAY	25	1960	00:00:00.0	+, −	1736	14
95	MAY	29	1960	00:00:00.0	−, +	1736	18
96	JUNE	21	1960	00:00:00.0	+, −	1737	14
97	JUNE	28	1960	00:00:00.0	−, +	1737	21
98	JULY	15	1960	00:00:00.0	+, −	1738	11
99	JULY	26	1960	00:00:00.0	−, +	1738	22
100	AUG	20	1960	00:00:00.0	+, −	1739	20

101	AUG	27	1960	00:00:00.0	-,+	1739	27
102	SEPT	16	1960	00:00:00.0	+,-	1740	20
103	SEPT	28	1960	00:00:00.0	-,+	1741	5
104	OCT	12	1960	00:00:00.0	+,-	1741	19
105	OCT	18	1960	00:00:00.0	-,+	1741	25
106	NOV	11	1960	00:00:00.0	+,-	1742	22
107	NOV	20	1960	00:00:00.0	-,+	1743	4
108	DEC	12	1960	00:00:00.0	+,-	1743	26
109	DEC	18	1960	00:00:00.0	-,+	1744	5
110	JAN	16	1961	00:00:00.0	-,+	1745	7
111	FEB	1	1961	00:00:00.0	+,-	1745	23
112	FEB	11	1961	00:00:00.0	-,+	1746	6
113	FEB	27	1961	00:00:00.0	+,-	1746	22
114	MARCH	27	1961	00:00:00.0	+,-	1747	23
115	APRIL	7	1961	00:00:00.0	-,+	1748	7
116	APRIL	22	1961	00:00:00.0	+,-	1748	22
117	MAY	2	1961	00:00:00.0	-,+	1749	5
118	MAY	19	1961	00:00:00.0	+,-	1749	22
119	MAY	29	1961	00:00:00.0	-,+	1750	5
120	JUNE	16	1961	00:00:00.0	+,-	1750	23
121	JUNE	23	1961	00:00:00.0	-,+	1751	3
122	JULY	22	1961	00:00:00.0	-,+	1752	5
123	JULY	27	1961	00:00:00.0	+,-	1752	10
124	AUG	1	1961	00:00:00.0	-,+	1752	15
125	AUG	12	1961	00:00:00.0	+,-	1752	26
126	AUG	18	1961	00:00:00.0	-,+	1753	5
127	SEPT	9	1961	00:00:00.0	+,-	1753	27
128	SEPT	14	1961	00:00:00.0	-,+	1754	5
129	OCT	1	1961	00:00:00.0	+,-	1754	22
130	OCT	9	1961	00:00:00.0	-,+	1755	3
131	OCT	17	1961	00:00:00.0	+,-	1755	11
132	OCT	24	1961	00:00:00.0	-,+	1755	18
133	NOV	11	1961	00:00:00.0	+,-	1756	9
134	NOV	19	1961	00:00:00.0	-,+	1756	17
135	DEC	1	1961	00:00:00.0	+,-	1757	2
136	DEC	12	1961	00:00:00.0	-,+	1757	13
137	DEC	27	1961	00:00:00.0	+,-	1758	1
138	DEC	31	1961	00:00:00.0	-,+	1758	5
139	JAN	10	1962	00:00:00.0	+,-	1758	15
140	FEB	5	1962	00:00:00.0	+,-	1759	14
141	FEB	17	1962	00:00:00.0	-,+	1759	26
142	FEB	24	1962	00:00:00.0	+,-	1760	6
143	MARCH	14	1962	00:00:00.0	-,+	1760	24
144	APRIL	6	1962	00:00:00.0	+,-	1761	20
145	APRIL	13	1962	00:00:00.0	-,+	1761	27
146	APRIL	27	1962	00:00:00.0	+,-	1762	14
147	MAY	8	1962	00:00:00.0	-,+	1762	25
148	MAY	26	1962	00:00:00.0	+,-	1763	16
149	JUNE	7	1962	00:00:00.0	-,+	1764	1
150	JUNE	21	1962	00:00:00.0	+,-	1764	15

151	JULY	4 1962	00:00:00.0	-,+	1765	1
152	JULY	19 1962	00:00:00.0	+,-	1765	16
153	JULY	31 1962	00:00:00.0	-,+	1766	1
154	AUG	13 1962	00:00:00.0	+,-	1766	14
155	AUG	28 1962	00:00:00.0	-,+	1767	2
156	SEPT	10 1962	00:00:00.0	+,-	1767	15
157	SEPT	26 1962	00:00:00.0	-,+	1768	4
158	OCT	8 1962	00:00:00.0	+,-	1768	16
159	OCT	21 1962	00:00:00.0	-,+	1769	2
160	NOV	3 1962	00:00:00.0	+,-	1769	15
161	NOV	17 1962	00:00:00.0	-,+	1770	2
162	DEC	4 1962	00:00:00.0	+,-	1770	19
163	DEC	14 1962	00:00:00.0	-,+	1771	2
164	DEC	31 1962	00:00:00.0	+,-	1771	19
165	JAN	13 1963	00:00:00.0	-,+	1772	5
166	JAN	30 1963	00:00:00.0	+,-	1772	22
167	MARCH	2 1963	00:00:00.0	+,-	1773	26
168	MARCH	12 1963	00:00:00.0	-,+	1774	9
169	APRIL	10 1963	00:00:00.0	+,-	1775	11
170	APRIL	19 1963	00:00:00.0	-,+	1775	20
171	APRIL	23 1963	00:00:00.0	+,-	1775	24
172	APRIL	28 1963	00:00:00.0	-,+	1776	2
173	MAY	8 1963	00:00:00.0	+,-	1776	12
174	MAY	15 1963	00:00:00.0	-,+	1776	19
175	MAY	21 1963	00:00:00.0	+,-	1776	25
176	MAY	28 1963	00:00:00.0	-,+	1777	5
177	JUNE	7 1963	00:00:00.0	+,-	1777	15
178	JUNE	21 1963	00:00:00.0	-,+	1778	2
179	JULY	4 1963	00:00:00.0	+,-	1778	15
180	JULY	21 1963	00:00:00.0	-,+	1779	5
181	JULY	30 1963	00:00:00.0	+,-	1779	14
182	AUG	18 1963	00:00:00.0	-,+	1780	6
183	AUG	25 1963	00:00:00.0	+,-	1780	13
184	SEPT	14 1963	00:00:00.0	-,+	1781	6
185	OCT	22 1963	00:00:00.0	+,-	1782	17
186	NOV	4 1963	00:00:00.0	-,+	1783	3
187	NOV	17 1963	00:00:00.0	+,-	1783	16
188	DEC	3 1963	00:00:00.0	-,+	1784	5
189	DEC	13 1963	00:00:00.0	+,-	1784	15
190	DEC	21 1963	00:00:00.0	-,+	1784	23
191	DEC	28 1963	00:00:00.0	+,-	1785	3
192	JAN	1 1964	00:00:00.0	-,+	1785	7
193	JAN	8 1964	00:00:00.0	+,-	1785	14
194	JAN	17 1964	00:00:00.0	-,+	1785	23
195	JAN	23 1964	00:00:00.0	+,-	1786	2
196	JAN	28 1964	00:00:00.0	-,+	1786	7
197	FEB	4 1964	00:00:00.0	+,-	1786	14
198	FEB	11 1964	00:00:00.0	-,+	1786	21
199	FEB	19 1964	00:00:00.0	+,-	1787	2
200	FEB	23 1964	00:00:00.0	-,+	1787	6

201	MARCH	4	1964	00:00:00.0	+, −	1787	16
202	MARCH	10	1964	00:00:00.0	−, +	1787	22
203	MARCH	31	1964	00:00:00.0	+, −	1788	16
204	APRIL	8	1964	00:00:00.0	−, +	1788	24
205	APRIL	23	1964	00:00:00.0	+, −	1789	12
206	MAY	3	1964	00:00:00.0	−, +	1789	22
207	MAY	24	1964	00:00:00.0	+, −	1790	16
208	MAY	31	1964	00:00:00.0	−, +	1790	23
209	JUNE	6	1964	00:00:00.0	+, −	1791	2
210	JUNE	10	1964	00:00:00.0	−, +	1791	6
211	JUNE	18	1964	00:00:00.0	+, −	1791	14
212	JUNE	28	1964	00:00:00.0	−, +	1791	24
213	JULY	3	1964	00:00:00.0	+, −	1792	2
214	JULY	7	1964	00:00:00.0	−, +	1792	6
215	JULY	17	1964	00:00:00.0	+, −	1792	16
216	JULY	26	1964	00:00:00.0	−, +	1792	25
217	JULY	29	1964	00:00:00.0	+, −	1793	1
218	AUG	3	1964	00:00:00.0	−, +	1793	6
219	AUG	11	1964	00:00:00.0	+, −	1793	14
220	AUG	20	1964	00:00:00.0	−, +	1793	23
221	AUG	25	1964	00:00:00.0	+, −	1794	1
222	AUG	31	1964	00:00:00.0	−, +	1794	7
223	SEPT	7	1964	00:00:00.0	+, −	1794	14
224	SEPT	17	1964	00:00:00.0	−, +	1794	24
225	SEPT	22	1964	00:00:00.0	+, −	1795	2
226	SEPT	27	1964	00:00:00.0	−, +	1795	7
227	OCT	4	1964	00:00:00.0	+, −	1795	14
228	OCT	12	1964	00:00:00.0	−, +	1795	22
229	OCT	18	1964	00:00:00.0	+, −	1796	1
230	OCT	24	1964	00:00:00.0	−, +	1796	7
231	NOV	1	1964	00:00:00.0	+, −	1796	15
232	NOV	8	1964	00:00:00.0	−, +	1796	22
233	NOV	15	1964	00:00:00.0	+, −	1797	2
234	NOV	20	1964	00:00:00.0	−, +	1797	7
235	NOV	28	1964	00:00:00.0	+, −	1797	15
236	DEC	6	1964	00:00:00.0	−, +	1797	23
237	DEC	26	1964	00:00:00.0	+, −	1798	16
238	JAN	2	1965	00:00:00.0	−, +	1798	23
239	JAN	8	1965	00:00:00.0	+, −	1799	2
240	JAN	12	1965	00:00:00.0	−, +	1799	6
241	FEB	2	1965	00:00:00.0	+, −	1799	27
242	FEB	8	1965	00:00:00.0	−, +	1800	6
243	APRIL	10	1965	00:00:00.0	+, −	1802	13
244	APRIL	16	1965	00:00:00.0	−, +	1802	19
245	MAY	5	1965	00:00:00.0	+, −	1803	11
246	MAY	15	1965	00:00:00.0	−, +	1803	21
247	JUNE	1	1965	00:00:00.0	+, −	1804	11
248	JUNE	10	1965	00:00:00.0	−, +	1804	20
249	JUNE	18	1965	00:00:00.0	+, −	1805	1
250	JUNE	25	1965	00:00:00.0	−, +	1805	8

251	JUNE	29	1965	00:00:00.0	+,-	1805	12
252	JULY	6	1965	00:00:00.0	-,+	1805	19
253	JULY	10	1965	00:00:00.0	+,-	1805	23
254	JULY	23	1965	00:00:00.0	-,+	1806	9
255	JULY	27	1965	00:00:00.0	+,-	1806	13
256	AUG	19	1965	00:00:00.0	-,+	1807	9
257	AUG	24	1965	00:00:00.0	+,-	1807	14
258	SEPT	16	1965	00:00:00.0	-,+	1808	10
259	SEPT	23	1965	00:00:00.0	+,-	1808	17
260	OCT	16	1965	00:00:00.0	-,+	1809	13
261	OCT	26	1965	00:00:00.0	+,-	1809	23
262	NOV	6	1965	00:00:00.0	-,+	1810	7
263	NOV	25	1965	00:00:00.0	+,-	1810	26
264	DEC	1	1965	00:00:00.0	-,+	1811	5
265	DEC	8	1965	00:00:00.0	+,-	1811	12
266	DEC	16	1965	00:00:00.0	-,+	1811	20
267	JAN	3	1966	00:00:00.0	+,-	1812	11
268	JAN	14	1966	00:00:00.0	-,+	1812	22
269	JAN	23	1966	00:00:00.0	-,+	1813	4
270	FEB	1	1966	00:00:00.0	+,-	1813	13
271	FEB	12	1966	00:00:00.0	-,+	1813	24
272	MARCH	4	1966	00:00:00.0	+,-	1814	17
273	MARCH	8	1966	00:00:00.0	-,+	1814	21
274	MARCH	30	1966	00:00:00.0	+,-	1815	16
275	APRIL	9	1966	00:00:00.0	-,+	1815	26
276	APRIL	29	1966	00:00:00.0	+,-	1816	19
277	MAY	8	1966	00:00:00.0	-,+	1817	1
278	MAY	16	1966	00:00:00.0	+,-	1817	9
279	MAY	21	1966	00:00:00.0	-,+	1817	14
280	MAY	26	1966	00:00:00.0	+,-	1817	19
281	JUNE	5	1966	00:00:00.0	-,+	1818	2
282	JUNE	10	1966	00:00:00.0	+,-	1818	7
283	JUNE	17	1966	00:00:00.0	-,+	1818	14
284	JUNE	23	1966	00:00:00.0	+,-	1818	20
285	JULY	4	1966	00:00:00.0	-,+	1819	4
286	JULY	8	1966	00:00:00.0	+,-	1819	8
287	JULY	14	1966	00:00:00.0	-,+	1819	14
288	JULY	21	1966	00:00:00.0	+,-	1819	21
289	AUG	10	1966	00:00:00.0	-,+	1820	14
290	AUG	18	1966	00:00:00.0	+,-	1820	22
291	SEPT	6	1966	00:00:00.0	-,+	1821	14
292	SEPT	14	1966	00:00:00.0	+,-	1821	22
293	OCT	4	1966	00:00:00.0	-,+	1822	15
294	OCT	12	1966	00:00:00.0	+,-	1822	23
295	OCT	30	1966	00:00:00.0	-,+	1823	14
296	NOV	8	1966	00:00:00.0	+,-	1823	23
297	NOV	28	1966	00:00:00.0	-,+	1824	16
298	DEC	4	1966	00:00:00.0	+,-	1824	22
299	DEC	22	1966	00:00:00.0	-,+	1825	13
300	JAN	2	1967	00:00:00.0	+,-	1825	24

301	JAN	6	1967	00:00:00.0	-,+	1826	1
302	JAN	11	1967	00:00:00.0	+,-	1826	6
303	JAN	18	1967	00:00:00.0	-,+	1826	13
304	FEB	7	1967	00:00:00.0	+,-	1827	6
305	FEB	14	1967	00:00:00.0	-,+	1827	13
306	MARCH	19	1967	00:00:00.0	+,-	1828	19
307	MARCH	23	1967	00:00:00.0	-,+	1828	23
308	APRIL	3	1967	00:00:00.0	+,-	1829	7
309	APRIL	23	1967	00:00:00.0	-,+	1829	27
310	MAY	11	1967	00:00:00.0	+,-	1830	18
311	MAY	22	1967	00:00:00.0	-,+	1831	2
312	MAY	27	1967	00:00:00.0	+,-	1831	7
313	JULY	6	1967	00:00:00.0	-,+	1832	20
314	JULY	11	1967	00:00:00.0	+,-	1832	25
315	AUG	4	1967	00:00:00.0	-,+	1833	22
316	AUG	9	1967	00:00:00.0	+,-	1833	27
317	AUG	31	1967	00:00:00.0	-,+	1834	22
318	SEPT	6	1967	00:00:00.0	+,-	1835	1
319	SEPT	27	1967	00:00:00.0	-,+	1835	22
320	OCT	3	1967	00:00:00.0	+,-	1836	1
321	OCT	24	1967	00:00:00.0	-,+	1836	22
322	OCT	28	1967	00:00:00.0	+,-	1836	26
323	NOV	21	1967	00:00:00.0	-,+	1837	23
324	DEC	5	1967	00:00:00.0	+,-	1838	10
325	DEC	17	1967	00:00:00.0	-,+	1838	22
326	JAN	2	1968	00:00:00.0	+,-	1839	11
327	JAN	16	1968	00:00:00.0	-,+	1839	25
328	JAN	29	1968	00:00:00.0	+,-	1840	11
329	FEB	11	1968	00:00:00.0	-,+	1840	24
330	FEB	27	1968	00:00:00.0	+,-	1841	13
331	MARCH	10	1968	00:00:00.0	-,+	1841	25
332	MARCH	23	1968	00:00:00.0	+,-	1842	11
333	APRIL	6	1968	00:00:00.0	-,+	1842	25
334	APRIL	21	1968	00:00:00.0	+,-	1843	13
335	MAY	2	1968	00:00:00.0	-,+	1843	24
336	MAY	17	1968	00:00:00.0	+,-	1844	12
337	MAY	29	1968	00:00:00.0	-,+	1844	24
338	JUNE	7	1968	00:00:00.0	-,+	1845	6
339	JUNE	13	1968	00:00:00.0	+,-	1845	12
340	JUNE	22	1968	00:00:00.0	-,+	1845	21
341	JUNE	28	1968	00:00:00.0	+,-	1845	27
342	JULY	3	1968	00:00:00.0	-,+	1846	5
343	JULY	10	1968	00:00:00.0	+,-	1846	12
344	JULY	17	1968	00:00:00.0	-,+	1846	19
345	JULY	25	1968	00:00:00.0	+,-	1846	27
346	AUG	1	1968	00:00:00.0	-,+	1847	7
347	AUG	5	1968	00:00:00.0	+,-	1847	11
348	AUG	14	1968	00:00:00.0	-,+	1847	20
349	AUG	21	1968	00:00:00.0	+,-	1847	27
350	SEPT	9	1968	00:00:00.0	-,+	1848	19

351	SEPT	19	1968	00:00:00.0	+, −	1849	2
352	SEPT	26	1968	00:00:00.0	−, +	1849	9
353	OCT	1	1968	00:00:00.0	+, −	1849	14
354	OCT	7	1968	00:00:00.0	−, +	1849	20
355	OCT	17	1968	00:00:00.0	+, −	1850	3
356	NOV	3	1968	00:00:00.0	−, +	1850	20
357	NOV	17	1968	00:00:00.0	+, −	1851	3
358	NOV	30	1968	00:00:00.0	−, +	1851	20
359	DEC	10	1968	00:00:00.0	+, −	1852	3
360	DEC	24	1968	00:00:00.0	−, +	1852	17
361	JAN	6	1969	00:00:00.0	+, −	1853	3
362	JAN	24	1969	00:00:00.0	−, +	1853	21
363	FEB	2	1969	00:00:00.0	+, −	1854	3
364	FEB	18	1969	00:00:00.0	−, +	1854	19
365	MARCH	5	1969	00:00:00.0	+, −	1855	7
366	MARCH	25	1969	00:00:00.0	−, +	1855	27
367	APRIL	1	1969	00:00:00.0	+, −	1856	7
368	APRIL	21	1969	00:00:00.0	−, +	1856	27
369	APRIL	29	1969	00:00:00.0	+, −	1857	8
370	MAY	8	1969	00:00:00.0	−, +	1857	17
371	MAY	13	1969	00:00:00.0	+, −	1857	22
372	MAY	19	1969	00:00:00.0	−, +	1858	1
373	MAY	23	1969	00:00:00.0	+, −	1858	10
374	JUNE	15	1969	00:00:00.0	−, +	1859	1
375	JUNE	23	1969	00:00:00.0	+, −	1859	9
376	JULY	11	1969	00:00:00.0	−, +	1859	27
377	JULY	22	1969	00:00:00.0	+, −	1860	11
378	AUG	7	1969	00:00:00.0	−, +	1860	27
379	AUG	17	1969	00:00:00.0	+, −	1861	10
380	SEPT	5	1969	00:00:00.0	−, +	1862	2
381	SEPT	17	1969	00:00:00.0	+, −	1862	14
382	SEPT	30	1969	00:00:00.0	−, +	1862	27
383	OCT	16	1969	00:00:00.0	+, −	1863	16
384	OCT	31	1969	00:00:00.0	−, +	1864	4
385	NOV	10	1969	00:00:00.0	+, −	1864	14
386	NOV	26	1969	00:00:00.0	−, +	1865	3
387	DEC	8	1969	00:00:00.0	+, −	1865	15
388	DEC	23	1969	00:00:00.0	−, +	1866	3
389	JAN	4	1970	00:00:00.0	+, −	1866	15
390	JAN	19	1970	00:00:00.0	−, +	1867	3
391	JAN	31	1970	00:00:00.0	+, −	1867	15
392	FEB	10	1970	00:00:00.0	−, +	1867	25
393	FEB	28	1970	00:00:00.0	+, −	1868	16
394	MARCH	9	1970	00:00:00.0	−, +	1868	25
395	MARCH	27	1970	00:00:00.0	+, −	1869	16
396	APRIL	3	1970	00:00:00.0	−, +	1869	23
397	APRIL	22	1970	00:00:00.0	+, −	1870	15
398	APRIL	30	1970	00:00:00.0	−, +	1870	23
399	MAY	12	1970	00:00:00.0	+, −	1871	8
400	MAY	28	1970	00:00:00.0	−, +	1871	24

401	JUNE	9	1970	00:00:00.0	+, -	1872	8
402	JUNE	24	1970	00:00:00.0	-, +	1872	24
403	JULY	5	1970	00:00:00.0	+, -	1873	8
404	JULY	21	1970	00:00:00.0	-, +	1873	24
405	AUG	1	1970	00:00:00.0	+, -	1874	8
406	AUG	16	1970	00:00:00.0	-, +	1874	23
407	SEPT	1	1970	00:00:00.0	+, -	1875	12
408	SEPT	13	1970	00:00:00.0	-, +	1875	24
409	SEPT	29	1970	00:00:00.0	+, -	1876	13
410	OCT	11	1970	00:00:00.0	-, +	1876	25
411	OCT	27	1970	00:00:00.0	+, -	1877	14
412	NOV	5	1970	00:00:00.0	-, +	1877	23
413	NOV	24	1970	00:00:00.0	+, -	1878	15
414	DEC	4	1970	00:00:00.0	-, +	1878	25
415	DEC	13	1970	00:00:00.0	+, -	1879	7
416	DEC	17	1970	00:00:00.0	-, +	1879	11
417	DEC	23	1970	00:00:00.0	+, -	1879	17
418	DEC	30	1970	00:00:00.0	-, +	1879	24
419	JAN	18	1971	00:00:00.0	+, -	1880	16
420	JAN	26	1971	00:00:00.0	-, +	1880	24
421	FEB	14	1971	00:00:00.0	+, -	1881	16
422	FEB	25	1971	00:00:00.0	-, +	1881	27
423	MARCH	2	1971	00:00:00.0	+, -	1882	5
424	MARCH	7	1971	00:00:00.0	-, +	1882	10
425	MARCH	13	1971	00:00:00.0	+, -	1882	16
426	MARCH	23	1971	00:00:00.0	-, +	1882	26
427	MARCH	30	1971	00:00:00.0	+, -	1883	6
428	APRIL	4	1971	00:00:00.0	-, +	1883	11
429	APRIL	9	1971	00:00:00.0	+, -	1883	16
430	APRIL	19	1971	00:00:00.0	-, +	1883	26
431	MAY	6	1971	00:00:00.0	+, -	1884	16
432	MAY	16	1971	00:00:00.0	-, +	1884	26
433	MAY	23	1971	00:00:00.0	+, -	1885	6
434	MAY	29	1971	00:00:00.0	-, +	1885	12
435	JUNE	1	1971	00:00:00.0	+, -	1885	15
436	JUNE	16	1971	00:00:00.0	-, +	1886	3
437	JUNE	29	1971	00:00:00.0	+, -	1886	16
438	JULY	13	1971	00:00:00.0	-, +	1887	3
439	JULY	19	1971	00:00:00.0	+, -	1887	9
440	JULY	24	1971	00:00:00.0	-, +	1887	14
441	JULY	27	1971	00:00:00.0	+, -	1887	17
442	AUG	8	1971	00:00:00.0	-, +	1888	2
443	AUG	23	1971	00:00:00.0	+, -	1888	17
444	SEPT	5	1971	00:00:00.0	-, +	1889	3
445	SEPT	19	1971	00:00:00.0	+, -	1889	17
446	SEPT	30	1971	00:00:00.0	-, +	1890	1
447	OCT	13	1971	00:00:00.0	+, -	1890	14
448	OCT	20	1971	00:00:00.0	-, +	1891	2
449	NOV	4	1971	00:00:00.0	+, -	1891	9
450	NOV	23	1971	00:00:00.0	-, +	1892	1

451	DEC	1	1971	00:00:00.0	+,-	1892	9
452	DEC	18	1971	00:00:00.0	-,+	1892	26
453	DEC	28	1971	00:00:00.0	+,-	1893	9
454	JAN	16	1972	00:00:00.0	-,+	1894	1
455	JAN	22	1972	00:00:00.0	+,-	1894	7
456	FEB	11	1972	00:00:00.0	-,+	1894	27
457	FEB	18	1972	00:00:00.0	+,-	1895	7
458	MARCH	7	1972	00:00:00.0	-,+	1895	25
459	MARCH	16	1972	00:00:00.0	+,-	1896	7
460	APRIL	4	1972	00:00:00.0	-,+	1896	26
461	APRIL	10	1972	00:00:00.0	+,-	1897	5
462	MAY	2	1972	00:00:00.0	-,+	1897	27
463	MAY	8	1972	00:00:00.0	+,-	1898	6
464	MAY	16	1972	00:00:00.0	-,+	1898	14
465	MAY	23	1972	00:00:00.0	+,-	1898	21
466	MAY	28	1972	00:00:00.0	-,+	1898	26
467	JUNE	4	1972	00:00:00.0	+,-	1899	6
468	JUNE	10	1972	00:00:00.0	-,+	1899	12
469	JUNE	20	1972	00:00:00.0	+,-	1899	22
470	JUNE	25	1972	00:00:00.0	-,+	1899	27
471	JULY	3	1972	00:00:00.0	+,-	1900	8
472	JULY	12	1972	00:00:00.0	-,+	1900	17
473	JULY	16	1972	00:00:00.0	+,-	1900	21
474	JULY	23	1972	00:00:00.0	-,+	1901	1
475	AUG	7	1972	00:00:00.0	+,-	1901	16
476	AUG	17	1972	00:00:00.0	-,+	1901	26
477	SEPT	4	1972	00:00:00.0	+,-	1902	17
478	SEPT	8	1972	00:00:00.0	-,+	1902	21
479	OCT	1	1972	00:00:00.0	+,-	1903	17
480	OCT	10	1972	00:00:00.0	-,+	1903	26
481	OCT	31	1972	00:00:00.0	+,-	1904	20
482	NOV	7	1972	00:00:00.0	-,+	1904	27
483	NOV	23	1972	00:00:00.0	+,-	1905	16
484	DEC	13	1972	00:00:00.0	-,+	1906	9
485	DEC	22	1972	00:00:00.0	+,-	1906	18
486	JAN	7	1973	00:00:00.0	-,+	1907	7
487	JAN	21	1973	00:00:00.0	+,-	1907	21
488	FEB	3	1973	00:00:00.0	-,+	1908	7
489	FEB	17	1973	00:00:00.0	+,-	1908	21
490	MARCH	6	1973	00:00:00.0	-,+	1909	11
491	MARCH	19	1973	00:00:00.0	+,-	1909	24
492	MARCH	31	1973	00:00:00.0	-,+	1910	9
493	APRIL	11	1973	00:00:00.0	+,-	1910	20
494	APRIL	29	1973	00:00:00.0	-,+	1911	11
495	MAY	12	1973	00:00:00.0	+,-	1911	24
496	MAY	28	1973	00:00:00.0	-,+	1912	13
497	JUNE	10	1973	00:00:00.0	+,-	1912	26
498	JUNE	24	1973	00:00:00.0	-,+	1913	13
499	JULY	8	1973	00:00:00.0	+,-	1913	27
500	AUG	2	1973	00:00:00.0	+,-	1914	25

501	SEPT	9	1973	00:00:00.0	+, −	1916	9
502	SEPT	20	1973	00:00:00.0	−, +	1916	20
503	OCT	8	1973	00:00:00.0	+, −	1917	11
504	OCT	16	1973	00:00:00.0	−, +	1917	19
505	OCT	23	1973	00:00:00.0	+, −	1917	26
506	OCT	29	1973	00:00:00.0	−, +	1918	5
507	NOV	5	1973	00:00:00.0	+, −	1918	12
508	NOV	14	1973	00:00:00.0	−, +	1918	21
509	DEC	4	1973	00:00:00.0	+, −	1919	14
510	DEC	27	1973	00:00:00.0	+, −	1920	10
511	JAN	14	1974	00:00:00.0	−, +	1921	1
512	JAN	25	1974	00:00:00.0	+, −	1921	12
513	FEB	9	1974	00:00:00.0	−, +	1921	27
514	FEB	20	1974	00:00:00.0	+, −	1922	11
515	MARCH	7	1974	00:00:00.0	−, +	1922	26
516	MARCH	20	1974	00:00:00.0	+, −	1923	12
517	APRIL	3	1974	00:00:00.0	−, +	1923	26
518	APRIL	16	1974	00:00:00.0	+, −	1924	17
519	APRIL	29	1974	00:00:00.0	−, +	1924	25
520	MAY	13	1974	00:00:00.0	+, −	1925	17
521	MAY	30	1974	00:00:00.0	−, +	1926	[illegible]
522	JUNE	9	1974	00:00:00.0	+, −	1926	12
523	JUNE	25	1974	00:00:00.0	−, +	1927	1
524	JULY	6	1974	00:00:00.0	+, −	1927	12
525	JULY	23	1974	00:00:00.0	−, +	1928	2
526	AUG	2	1974	00:00:00.0	+, −	1928	12
527	AUG	19	1974	00:00:00.0	−, +	1929	2
528	AUG	26	1974	00:00:00.0	+, −	1929	9
529	SEPT	16	1974	00:00:00.0	−, +	1930	3
530	SEPT	24	1974	00:00:00.0	+, −	1930	11
531	OCT	13	1974	00:00:00.0	−, +	1931	3
532	OCT	23	1974	00:00:00.0	+, −	1931	17
533	NOV	9	1974	00:00:00.0	−, +	1932	3
534	NOV	19	1974	00:00:00.0	+, −	1932	17
535	DEC	7	1974	00:00:00.0	−, +	1933	4
536	DEC	17	1974	00:00:00.0	+, −	1933	14
537	DEC	26	1974	00:00:00.0	−, +	1933	23
538	DEC	30	1974	00:00:00.0	+, −	1933	27
539	JAN	3	1975	00:00:00.0	−, +	1934	4
540	JAN	13	1975	00:00:00.0	+, −	1934	14
541	JAN	23	1975	00:00:00.0	−, +	1934	24
542	JAN	27	1975	00:00:00.0	+, −	1935	1
543	JAN	31	1975	00:00:00.0	−, +	1935	5
544	FEB	9	1975	00:00:00.0	+, −	1935	14
545	FEB	18	1975	00:00:00.0	−, +	1935	23

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An atlas of interplanetary sector polarities as observed near the earth is presented. The atlas has been compiled using all available sources: spacecraft measurements and polar cap geomagnetic data. The interval 1957-74 is covered with a time resolution of one polarity value per day. The accuracy of the polarity inferred from geomagnetic data has been investigated and found to be about 85%. A list of well-defined sector boundaries has been derived from the adopted sector structure.

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Interplanetary Sector Structure 1947-1975

by

Leif Svalgaard

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Interplanetary Sector Structure 1947-1975

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Abstract

This report is an extension of "An Atlas of Interplanetary Sector Structure 1957-1974" to include earlier years back to 1947 and also the years 1932-1933 and 1975.

Interplanetary Sector Structure 1947-1975

by

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The present report is an extension of "An Atlas of Interplanetary Sector Structure 1957-1974" (Svalgaard, 1975a). Using ground-based magnetograms from high-latitude stations, the polarity of the interplanetary magnetic field has been inferred for each day in the time period 1947-1956. During this interval stations within the polar caps were operating most of the time making reliable determination of the sector polarity possible. We refer to the "Atlas" for details about the determinations and about the representation of the data.

Except for about a year (August 1952 - September 1953) at least one central polar cap station was always available. This means that the accuracy of the inferred polarities is high (≈85% correct) and that for many statistical investigations the inferred polarity is an adequate substitute for in-situ spacecraft observations (Wilcox et al., 1975; Russell et al., 1975). During the time when only the polar cap boundary station Godhavn was operating, the sector structure was simple and stable. We therefore believe that also during that interval the inferred polarity is of sufficiently high accuracy.

The data sources are shown on the data complilation sheets by code letters as detailed in the "Atlas". A few additional data sources are given below.

G: Inferred by the author from Godhavn H which has a scale value of 9.5 nT/mm. The inference has been carried out recently with no reference to earlier inferences.

D: Inferred by the author from Dumont D'Urville X. These inferences agree with the simultaneous Godhavn inferences 75% of the time. If the probability that Godhavn and Dumont D'Urville both agree is called q and if p denotes the probability that Godhavn (or Dumont D'Urville) agrees with the interplanetary sector polarity, then we have $q = 1 - 2p(1-p)$. This gives $p = 0.85$ for $q = 0.75$ attesting to the high accuracy of the Godhavn and Dumont D'Urville inferences.

J: Objective determination of the polarity using Godhavn H. The method is described in Svalgaard (1975b).

N: Yet another subjective inference by the author using Godhavn H and published by Antonucci (1974).

Sources J and N were only available for periods of a year each and were included in the complilation to show how stable the inferences are when repeated.

We present in this report the following tables and data compilations:

1) Daily classification of sector polarity 1947-1975.
2) Sector boundary list 1947-1975.
3) Bartels rotation plots of adopted sector structure 1947-1975.
4) Data compilation sheets 1932-1933, 1947-1974.

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1947

```
 1    ACCCC CCAAA AAAAA BCCCC CBABC CCCCB B
 2    CCCBA AABCA AAAAA BCCCC AAAAA AAA
 3    BCBAA AABAA ACCCC BCCCC CAACA BCBCC A
 4    CACAB ABAAC CCCCC CCBAA AAAAA AAAAA
 5    AAAAA AAAAC CCCCC CCCCC AAACA ABABA A
 6    AAAAC CCCCC CCCAA BAABA AAAAA AABAA
 7    ABAAC CCCCC CCCCC BBCAA BAAAA AACAA B
 8    CCCCC CCCCC CCAAB BBAAA AACAC ABCCC C
 9    CCACB CCCCB ACAAB AAACA ABCCC CCCCC
10    CBCCC CBAAA AAAAA AAAAA ACBAC CCBCC C
11    CBAAC BAAAB CCCBA AAAAA BACAB CCCCC
12    CCBAA BCABB CBAAB BAAAA BACCC BCCBA A
```

1948

```
 1    CBCCC CAAAB AAAAA ACCCC CCCBC AAABB A
 2    BBCCA ABAAA AAAAC CCCCB AAACB AACC
 3    ABAAA AAAAB BACCC CCAAA CAAAC BCCCC C
 4    AAAAA ACACC CCAAA ABAAA CCBAC CCCCA
 5    AAACC CBCBA AAABA ABCCC CCCCC CAAAB A
 6    ACCCA ACAAA AABAA ACBCC CBCCC AAAAA
 7    CCACC ACCAA AACCB CCCCC AAAAA CCBAA A
 8    AAAAA ABCCC CCCCC CCCBC CCCCC CAAAA A
 9    AACCC ACCCC BCCCC CCCCC CCCAB AABAA
10    ABBAC CCCCC CCCCB BCCCB BCAAA AABAA A
11    ABCCC BCCBC BAABC CBAAC CCCCC CCABA
12    CACAA CCCCC BABBA CCBAA CBCCC AAAAB C
```

1949

```
 1    CCBCC CCBAA CCCBA ABCBB AAABC CCBCC C
 2    CCACC CCBCA CCCBB CBAAB AACAA BCC
 3    AAAAC AAAAA AACCC CBCCC CBABC AACCA B
 4    ACABC AACCB CACCA CCCCC BAAAA AAAAA
 5    CAACC CCCCA ABCCC CCBAA AAAAA AAAAA C
 6    CCCCC ABAAA CCCAC CCAAA ABAAC CCCCC
 7    BCCBB AAAAA AAACC AAAAA ACCCC BCCBA A
 8    AABCC CBAAA AAAAA ACCCC CCCCA AAAAA C
 9    BCCBA AAAAA ACCCC BCBCC AABAA ABBCA
10    AAABB AACCC CCCCC CCAAA AAAAA ACCAA B
11    CAAAC CCCBC BCAAA ABACB BCCAA BACCC
12    ACCCC AAACA AAACC CAAAA BAAAA BCCCC C
```

1950

```
 1    CCCCA AABCC CCCBC CAAAA AAACC CCCCC C
 2    CBAAA BCCCB CAAAA BCACC BABAB CCA
 3    AAAAA BCBAC CCCAA AAACC CCABC AABCC C
 4    BBCBA CCCAA AAAAC CCCCC AAAAA ACCCB
 5    CCCCC CABAA BACCC CAABA AACCC CCCCC C
 6    CCACC CACCC CCCAA ABAAA ACCCC CCABC
 7    BAACC BAAAA CAABA AAAAC CCCCA ACCCC C
 8    CCCCC CAAAA AAACB CCCAA AAAAA AACCC C
 9    CAAAA AAAAA ABCCC BAAAA AACCC CCABA
10    CCBAA AAAAC CCACA AAAAC CCCCC CCCCA A
11    BAAAA AACCC AABAA CCCCC CCCCC CCAAA
12    AABCC CABAA ACCCC CCCCC CCCCA AAAAA C
```

1951

```
 1    CCCCC BAAAC CCCCB CBAAC CBAAA CCCCC C
 2    CAAAC AAACC CCCAA BAAAA AABBB BCC
 3    AAAAB CCCCC BCBAC AACAA ACCCC CCCCA A
 4    ACBCC CCCCC AAAAA AACCC CCCCC CAAAA
 5    CCCCC CCCCB AAACC CCACC CBCAA ACBAB A
 6    CCCCA BABAB CCCCC BAAAB AAAAB AACCC
 7    AAAAB CCCCC CCCCB AAAAA AAAAA AAAAA C
 8    CCCCC CCCCC AAAAA ABCAA AAAAA AAABC C
 9    CCCCC CCCAA AAAAA AACCA AAAAA CCCCA
10    CCCCC CAAAA AAAAA AAAAA AAACC CCCCC C
11    BAAAA AABCC ABCAA ABCCC CCCCB CBAAA
12    AAACB AAABA AAABC CCCCC CCBCC AAAAA B
```

1952

```
 1    CCCCC CCACC CCCCC CACAA CCCCA ACCCA B
 2    AAAAB CCCCC CCBCA AAAAA AAACC CBAA
 3    AACCC CCCCC CCCCC AAABA CCCCA AAAAC C
 4    CCCCC CCCCA AAAAA AACCC CBAAA AACCC
 5    CCCCC CCCCC AAAAA AABCA AACCC CCCCA C
 6    CCCCC ACBBB AAAAA ABAAA ACCCC CCACC
 7    CCAAB AAAAA AAAAB AACBC CCCCB CCCCC A
 8    AAABA AAAAA AAAAA CCCCC CBCAA AAACA A
 9    AAAAC AABAA CCCCC CCCCC CAAAC CCCCA
10    AAAAA AACCC CCCCC BAAAA CCCBC CAAAA B
11    AAAAA CCCCC CAAAA ACCCC CCAAA AAAAA
12    CCCCC BAAAB AAABB AAAAA ABAAA AACCC C
```

1953

1	CCCBA	BAAAA	AACBA	AAAAA	AAACC	CCCCC	A
2	AAAAA	AAABC	AAAAA	CBAAA	CCCCC	CCC	
3	ACCBC	CCCCC	ABAAA	AAACC	CCCCC	CACCC	C
4	CBCCC	CCAAA	AAAAA	AABCC	CCAAA	BAAAC	
5	AAAAA	AAAAA	AAAAC	CCCBC	CCAAA	AACAA	C
6	AAAAA	AAAAA	AAACA	CBBAC	ACCCC	ACAAB	
7	AAAAA	ACCAA	ACCCA	AAAAC	CCCCB	AAAAA	A
8	AAAAA	AAACB	CCCAA	ABAAA	ACAAA	ABCCC	C
9	AACCC	AAAAA	CCAAC	AABCC	ACCAA	AAACA	
10	AACAA	AAABC	BCBCC	CCCCC	CAAAA	AAACC	C
11	AAABC	CCBBB	CCCCC	AABCC	AAACC	CCBAA	
12	ABBCC	CCCCB	CCAAA	AACCC	BCCCB	BCCCC	A

1954

1	BCAAC	ABAAA	BBAAC	CCCCC	CCBAB	CCAAA	C
2	CCCCA	ACCCC	CAACC	CCCAA	CBCCC	CCC	
3	BCBAC	CCCCC	CCCCC	CCCCC	ACCCA	CBABC	C
4	CCCCA	ACACC	CCCBC	CCCCC	CACCC	CCABA	
5	AAABC	AABCB	BCCAC	BCBAC	CAAAA	BABAA	C
6	BCACC	BAAAA	ACCAA	AAAAA	ACBAA	AAAAA	
7	AAAAA	AAAAA	AAABA	CCAAA	AAAAA	AAAAA	A
8	AABAA	AAABA	AAAAA	AAAAA	AAAAA	AABBB	A
9	CACBC	CBBCA	AAACB	CABAB	AAACB	AABCC	
10	BABAA	CBBAA	AAAAA	BACCC	ACCCC	AAAAA	C
11	CCCAA	ABCAA	ACACB	AAACC	CACCA	ACACC	
12	AAABC	CCCCA	BCCAA	ACCCA	AACAB	AAAAA	A

1955

1	BBACB	ABACA	CABAA	CCCCC	CBCCC	ABBCC	A
2	AACCB	CCCCA	CCCCA	CABAC	AACCC	AAB	
3	AAAAA	BCCCC	CCCCC	CACCA	ABCCC	AAAAA	C
4	ACCCC	CCCAC	ABAAA	AACAB	CAACC	CCCCC	
5	CBBAA	ACABA	ACAAA	AAAAA	AAAAC	CCCCC	B
6	CAACC	CBAAB	AAAAA	AAAAA	BACCC	CCBCA	
7	BCBAA	AAAAA	BCAAA	AAAAA	ABBAA	AABAA	A
8	AABCA	CCAAA	AAACA	ABAAA	AAAAA	CBCAA	A
9	CAABA	ACAAA	AAAAA	BBAAC	BCACA	BAABC	
10	CABCC	CBBCA	AAAAA	ACCCA	ACCCC	BABAA	C
11	CCBAA	AACCB	CCCCC	BBCCC	AAAAA	AAAAB	
12	CBCCC	BCCCC	CCCBA	AAAAB	CAABC	CCCAA	B

1956

```
 1    CCCCC CCCCC CCCAA AACCA ABBBA ACCCC C
 2    CCAAB CCCCC CCAAC ABAAB CCCCC CCBC
 3    CCACC CAAAA CBAAA AAAAC CCACC CCCBC C
 4    CCCCA AAAAA AAAAA ACCCC CCABA CCCAA
 5    AAAAA AAAAA ACBAC CCBCC CCCCC CCAAA A
 6    BAAAA AAAAC CCCCC CCCCC CCCCA AAAAA
 7    AAAAA AACCC CCCCA ACCCC CBCAA AABAA B
 8    AACAA CCCBA CCCCC CCCCC CAABB AAAAA B
 9    CAAAA ACBCC CBCCC CCACA ABAAA AABAA
10    AAACC CCCCC CCCCC BCAAA AAAAC CAAAA A
11    CCCCC CCCCB CCCAA AAAAA ACCCC CCCAC
12    CCCCB CBBBC BCAAA AABCC CCCCC CCCCC C
```

1974

1	CCCCC	CCCCC	CCCAA	AAAAA	AAAAC	CCCCC	C
2	CCCCC	CCCAA	AAAAA	ABAAC	CCCCC	CCC	
3	CCCCC	CAAAA	AAAAB	AAAAC	CCCCA	CCCCC	C
4	CCAAA	AAAAA	AAAAA	CBCCC	CCCCC	CBCAA	
5	AAAAC	BCAAA	AABCC	CCCCC	CCCCC	CAACA	A
6	AAAAA	AAACC	BCCCC	CCCCC	CCACA	AAAAA	
7	AAAAA	CCCCC	CCCCC	CCCCC	CCAAA	AAAAA	A
8	ACCCC	CCCCC	CCCCC	CCCAA	AAAAA	CCCCC	C
9	CCCCC	CCCCC	CCBCC	BAAAA	AAACC	BCCCC	
10	CCCCC	CCCCC	CCAAA	AAAAA	AACCC	BCCCC	C
11	CCCCC	CCCAA	AAAAA	AAACC	CCCCC	CCCCC	
12	BCCCC	CAAAA	CAAAA	ACCCC	CCCCC	AAAAC	C

1975

1	CCBBB	AACAA	AACCC	CCCCC	CCAAA	ACCBC	A
2	AAAAA	AACCC	CCBBC	BBBCC	AAAAA	AAA	
3	AABCA	AACCB	CCCBC	CCCCC	AAAAC	BBAAA	C
4	BCCCC	CCCCC	BAABC	CAAAA	BCBAA	AAABA	
5	ACCCC	CCCCC	CCCCC	AABBC	CBAAA	AABCC	B
6	CCCCC	CCCCA	AAAAA	BCCAA	ABAAA	ACCCA	
7	AACCC	CCAAA	AAABA	BAAAA	AAAAC	CBCCC	C
8	BAAAA	BACCA	AAAAA	ACBBC	CCCCC	CCCAA	A
9	ABCAA	ABAAA	AAAAA	ACCCB	CCCCC	AABAA	
10	CBBAA	AAAAB	CAAAC	CBCCC	CBBCC	CCCAA	A
11	AAAAA	BAACC	CCCCB	ACCCC	BCCAA	BAAAA	
12	AABAA	AACCC	BCBCC	CBBCC	CCAAB	AAAAB	A

1	JAN	8	1947	00:00:00.0	-,+	1555	15
2	JAN	17	1947	00:00:00.0	+,-	1555	24
3	FEB	4	1947	00:00:00.0	-,+	1556	15
4	FEB	16	1947	00:00:00.0	+,-	1556	27
5	FEB	21	1947	00:00:00.0	-,+	1557	5
6	MARCH	12	1947	00:00:00.0	+,-	1557	24
7	APRIL	10	1947	00:00:00.0	+,-	1558	26
8	APRIL	19	1947	00:00:00.0	-,+	1559	8
9	MAY	10	1947	00:00:00.0	+,-	1560	2
10	MAY	21	1947	00:00:00.0	-,+	1560	13
11	JUNE	5	1947	00:00:00.0	+,-	1561	1
12	JUNE	14	1947	00:00:00.0	-,+	1561	10
13	JULY	5	1947	00:00:00.0	+,-	1562	4
14	JULY	19	1947	00:00:00.0	-,+	1562	18
15	AUG	1	1947	00:00:00.0	+,-	1563	4
16	AUG	13	1947	00:00:00.0	-,+	1563	16
17	AUG	28	1947	00:00:00.0	+,-	1564	4
18	SEPT	10	1947	00:00:00.0	-,+	1564	17
19	SEPT	22	1947	00:00:00.0	+,-	1565	2
20	OCT	8	1947	00:00:00.0	-,+	1565	18
21	OCT	22	1947	00:00:00.0	+,-	1566	5
22	NOV	3	1947	00:00:00.0	-,+	1566	17
23	NOV	10	1947	00:00:00.0	+,-	1566	24
24	NOV	15	1947	00:00:00.0	-,+	1567	2
25	NOV	26	1947	00:00:00.0	+,-	1567	13
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29	JAN	17	1948	00:00:00.0	+,-	1569	11
30	JAN	26	1948	00:00:00.0	-,+	1569	20
31	FEB	15	1948	00:00:00.0	+,-	1570	13
32	FEB	21	1948	00:00:00.0	-,+	1570	19
33	MARCH	13	1948	00:00:00.0	+,-	1571	13
34	MARCH	18	1948	00:00:00.0	-,+	1571	18
35	MARCH	25	1948	00:00:00.0	+,-	1571	25
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37	APRIL	7	1948	00:00:00.0	+,-	1572	11
38	APRIL	13	1948	00:00:00.0	-,+	1572	17
39	APRIL	21	1948	00:00:00.0	+,-	1572	25
40	APRIL	30	1948	00:00:00.0	-,+	1573	7
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43	MAY	18	1948	00:00:00.0	+,-	1573	25
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50	AUG	27	1948	00:00:00.0	-,+	1577	18

51	SEPT	3	1948	00:00:00.0	+,-	1577	25
52	SEPT	24	1948	00:00:00.0	-,+	1578	19
53	OCT	5	1948	00:00:00.0	+,-	1579	3
54	OCT	23	1948	00:00:00.0	-,+	1579	21
55	NOV	2	1948	00:00:00.0	+,-	1580	4
56	NOV	28	1948	00:00:00.0	-,+	1581	3
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58	DEC	30	1948	00:00:00.0	+,-	1582	8
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62	MARCH	23	1949	00:00:00.0	-,+	1585	10
63	APRIL	8	1949	00:00:00.0	+,-	1585	26
64	APRIL	21	1949	00:00:00.0	-,+	1586	12
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66	MAY	18	1949	00:00:00.0	-,+	1587	12
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68	JUNE	6	1949	00:00:00.0	-,+	1588	4
69	JUNE	11	1949	00:00:00.0	+,-	1588	9
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71	JUNE	25	1949	00:00:00.0	+,-	1588	23
72	JULY	5	1949	00:00:00.0	-,+	1589	6
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78	AUG	25	1949	00:00:00.0	-,+	1591	3
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81	OCT	8	1949	00:00:00.0	+,-	1592	20
82	OCT	18	1949	00:00:00.0	-,+	1593	3
83	NOV	5	1949	00:00:00.0	+,-	1593	21
84	NOV	13	1949	00:00:00.0	-,+	1594	2
85	DEC	6	1949	00:00:00.0	-,+	1594	25
86	DEC	27	1949	00:00:00.0	+,-	1595	19
87	JAN	5	1950	00:00:00.0	-,+	1596	1
88	JAN	9	1950	00:00:00.0	+,-	1596	5
89	JAN	17	1950	00:00:00.0	-,+	1596	13
90	JAN	24	1950	00:00:00.0	+,-	1596	20
91	FEB	3	1950	00:00:00.0	-,+	1597	3
92	FEB	7	1950	00:00:00.0	+,-	1597	7
93	FEB	12	1950	00:00:00.0	-,+	1597	12
94	FEB	28	1950	00:00:00.0	-,+	1598	1
95	MARCH	14	1950	00:00:00.0	-,+	1598	15
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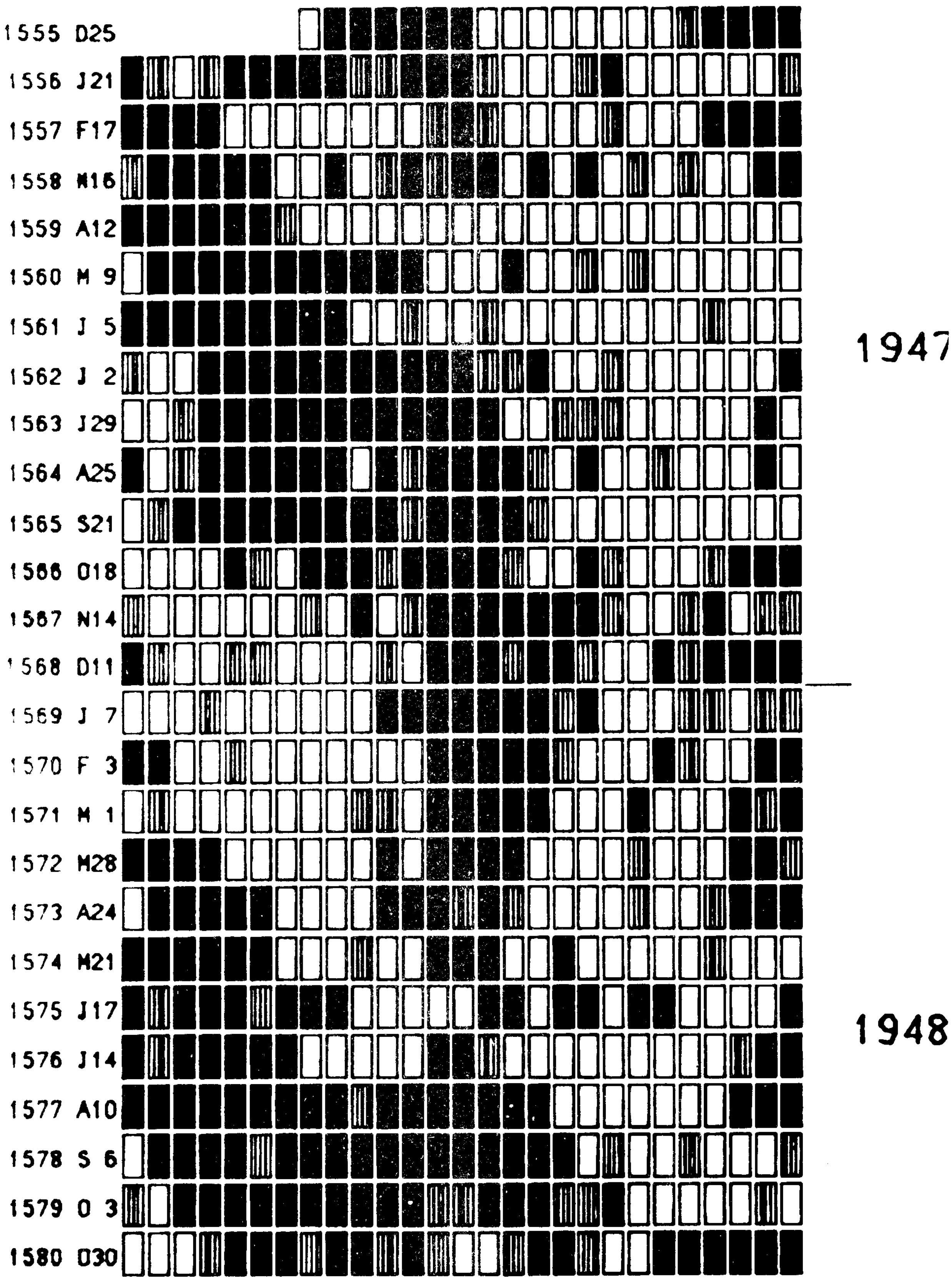
103	MAY	17	1950	00:00:00.0	−, +	1600	25
104	MAY	23	1950	00:00:00.0	+, −	1601	4
105	JUNE	14	1950	00:00:00.0	−, +	1601	26
106	JUNE	22	1950	00:00:00.0	+, −	1602	7
107	JULY	20	1950	00:00:00.0	+, −	1603	8
108	AUG	7	1950	00:00:00.0	−, +	1603	26
109	AUG	14	1950	00:00:00.0	+, −	1604	6
110	AUG	19	1950	00:00:00.0	−, +	1604	11
111	AUG	28	1950	00:00:00.0	+, −	1604	20
112	SEPT	2	1950	00:00:00.0	−, +	1604	25
113	SEPT	12	1950	00:00:00.0	+, −	1605	8
114	SEPT	16	1950	00:00:00.0	−, +	1605	12
115	SEPT	23	1950	00:00:00.0	+, −	1605	19
116	SEPT	28	1950	00:00:00.0	−, +	1605	24
117	OCT	10	1950	00:00:00.0	+, −	1606	9
118	OCT	15	1950	00:00:00.0	−, +	1606	14
119	OCT	20	1950	00:00:00.0	+, −	1606	19
120	OCT	30	1950	00:00:00.0	−, +	1607	2
121	NOV	8	1950	00:00:00.0	+, −	1607	11
122	NOV	11	1950	00:00:00.0	−, +	1607	14
123	NOV	16	1950	00:00:00.0	+, −	1607	19
124	NOV	28	1950	00:00:00.0	−, +	1608	4
125	DEC	3	1950	00:00:00.0	+, −	1608	9
126	DEC	7	1950	00:00:00.0	−, +	1608	13
127	DEC	12	1950	00:00:00.0	+, −	1608	18
128	DEC	25	1950	00:00:00.0	−, +	1609	4
129	DEC	31	1950	00:00:00.0	+, −	1609	10
130	JAN	6	1951	00:00:00.0	−, +	1609	16
131	JAN	10	1951	00:00:00.0	+, −	1609	20
132	JAN	17	1951	00:00:00.0	−, +	1609	27
133	JAN	26	1951	00:00:00.0	+, −	1610	9
134	FEB	2	1951	00:00:00.0	−, +	1610	16
135	FEB	9	1951	00:00:00.0	+, −	1610	23
136	FEB	14	1951	00:00:00.0	−, +	1611	1
137	FEB	23	1951	00:00:00.0	+, −	1611	10
138	MARCH	1	1951	00:00:00.0	−, +	1611	16
139	MARCH	6	1951	00:00:00.0	+, −	1611	21
140	MARCH	14	1951	00:00:00.0	−, +	1612	2
141	MARCH	22	1951	00:00:00.0	+, −	1612	10
142	MARCH	30	1951	00:00:00.0	−, +	1612	18
143	APRIL	2	1951	00:00:00.0	+, −	1612	21
144	APRIL	11	1951	00:00:00.0	−, +	1613	3
145	APRIL	18	1951	00:00:00.0	+, −	1613	10
146	APRIL	27	1951	00:00:00.0	−, +	1613	19
147	MAY	1	1951	00:00:00.0	+, −	1613	23
148	MAY	10	1951	00:00:00.0	−, +	1614	5
149	MAY	14	1951	00:00:00.0	+, −	1614	9
150	MAY	24	1951	00:00:00.0	−, +	1614	19

151	JUNE	11	1951	00:00:00.0	+, -	1615	10
152	JUNE	17	1951	00:00:00.0	-, +	1615	16
153	JULY	6	1951	00:00:00.0	+, -	1616	8
154	JULY	15	1951	00:00:00.0	-, +	1616	17
155	JULY	31	1951	00:00:00.0	+, -	1617	6
156	AUG	11	1951	00:00:00.0	-, +	1617	17
157	AUG	29	1951	00:00:00.0	+, -	1618	8
158	SEPT	9	1951	00:00:00.0	-, +	1618	19
159	SEPT	26	1951	00:00:00.0	+, -	1619	9
160	OCT	7	1951	00:00:00.0	-, +	1619	20
161	OCT	24	1951	00:00:00.0	+, -	1620	10
162	NOV	1	1951	00:00:00.0	-, +	1620	18
163	NOV	18	1951	00:00:00.0	+, -	1621	8
164	NOV	27	1951	00:00:00.0	-, +	1621	17
165	DEC	15	1951	00:00:00.0	+, -	1622	8
166	DEC	26	1951	00:00:00.0	-, +	1622	19
167	JAN	1	1952	00:00:00.0	+, -	1622	25
168	JAN	17	1952	00:00:00.0	-, +	1623	14
169	JAN	30	1952	00:00:00.0	-, +	1623	27
170	FEB	5	1952	00:00:00.0	+, -	1624	6
171	FEB	15	1952	00:00:00.0	-, +	1624	16
172	FEB	24	1952	00:00:00.0	+, -	1624	25
173	FEB	28	1952	00:00:00.0	-, +	1625	2
174	MARCH	3	1952	00:00:00.0	+, -	1625	6
175	MARCH	16	1952	00:00:00.0	-, +	1625	19
176	MARCH	21	1952	00:00:00.0	+, -	1625	24
177	MARCH	25	1952	00:00:00.0	-, +	1626	1
178	MARCH	30	1952	00:00:00.0	+, -	1626	6
179	APRIL	10	1952	00:00:00.0	-, +	1626	17
180	APRIL	18	1952	00:00:00.0	+, -	1626	25
181	APRIL	22	1952	00:00:00.0	-, +	1627	2
182	APRIL	28	1952	00:00:00.0	+, -	1627	8
183	MAY	11	1952	00:00:00.0	-, +	1627	21
184	MAY	23	1952	00:00:00.0	+, -	1628	6
185	JUNE	6	1952	00:00:00.0	-, +	1628	20
186	JUNE	22	1952	00:00:00.0	+, -	1629	9
187	JULY	3	1952	00:00:00.0	-, +	1629	20
188	JULY	18	1952	00:00:00.0	+, -	1630	8
189	JULY	31	1952	00:00:00.0	-, +	1630	21
190	AUG	16	1952	00:00:00.0	+, -	1631	10
191	AUG	24	1952	00:00:00.0	-, +	1631	18
192	SEPT	11	1952	00:00:00.0	+, -	1632	9
193	SEPT	22	1952	00:00:00.0	-, +	1632	20
194	SEPT	25	1952	00:00:00.0	+, -	1632	23
195	SEPT	30	1952	00:00:00.0	-, +	1633	1
196	OCT	8	1952	00:00:00.0	+, -	1633	9
197	OCT	17	1952	00:00:00.0	-, +	1633	18
198	OCT	21	1952	00:00:00.0	+, -	1633	22
199	OCT	27	1952	00:00:00.0	-, +	1634	1
200	NOV	6	1952	00:00:00.0	+, -	1634	11

201	NOV	12	1952	00:00:00.0	-,+	1634	17
202	NOV	17	1952	00:00:00.0	+,-	1634	22
203	NOV	23	1952	00:00:00.0	-,+	1635	1
204	DEC	1	1952	00:00:00.0	+,-	1635	9
205	DEC	7	1952	00:00:00.0	-,+	1635	15
206	DEC	28	1952	00:00:00.0	+,-	1636	9
207	JAN	4	1953	00:00:00.0	-,+	1636	16
208	JAN	24	1953	00:00:00.0	+,-	1637	9
209	JAN	31	1953	00:00:00.0	-,+	1637	16
210	FEB	21	1953	00:00:00.0	+,-	1638	10
211	MARCH	11	1953	00:00:00.0	-,+	1639	1
212	MARCH	19	1953	00:00:00.0	+,-	1639	9
213	APRIL	8	1953	00:00:00.0	-,+	1640	2
214	APRIL	18	1953	00:00:00.0	+,-	1640	12
215	APRIL	23	1953	00:00:00.0	-,+	1640	17
216	MAY	15	1953	00:00:00.0	+,-	1641	12
217	MAY	23	1953	00:00:00.0	-,+	1641	20
218	JULY	20	1953	00:00:00.0	+,-	1643	24
219	JULY	25	1953	00:00:00.0	-,+	1644	2
220	AUG	9	1953	00:00:00.0	+,-	1644	17
221	AUG	14	1953	00:00:00.0	-,+	1644	22
222	AUG	28	1953	00:00:00.0	+,-	1645	9
223	OCT	10	1953	00:00:00.0	+,-	1646	25
224	OCT	22	1953	00:00:00.0	-,+	1647	10
225	NOV	5	1953	00:00:00.0	+,-	1647	24
226	NOV	16	1953	00:00:00.0	-,+	1648	8
227	NOV	24	1953	00:00:00.0	+,-	1648	16
228	NOV	29	1953	00:00:00.0	-,+	1648	21
229	DEC	3	1953	00:00:00.0	+,-	1648	25
230	DEC	13	1953	00:00:00.0	-,+	1649	8
231	DEC	18	1953	00:00:00.0	+,-	1649	13
232	JAN	15	1954	00:00:00.0	+,-	1650	14
233	APRIL	28	1954	00:00:00.0	-,+	1654	9
234	MAY	22	1954	00:00:00.0	-,+	1655	6
235	SEPT	10	1954	00:00:00.0	-,+	1659	9
236	OCT	18	1954	00:00:00.0	+,-	1660	20
237	OCT	26	1954	00:00:00.0	-,+	1661	1
238	OCT	31	1954	00:00:00.0	+,-	1661	6
239	NOV	4	1954	00:00:00.0	-,+	1661	10
240	NOV	19	1954	00:00:00.0	+,-	1661	25
241	FEB	3	1955	00:00:00.0	+,-	1664	20
242	FEB	15	1955	00:00:00.0	-,+	1665	5
243	MARCH	6	1955	00:00:00.0	+,-	1665	24
244	MARCH	17	1955	00:00:00.0	-,+	1666	8
245	MARCH	31	1955	00:00:00.0	+,-	1666	22
246	APRIL	9	1955	00:00:00.0	-,+	1667	4
247	APRIL	24	1955	00:00:00.0	+,-	1667	19
248	MAY	4	1955	00:00:00.0	-,+	1668	2
249	MAY	26	1955	00:00:00.0	+,-	1668	24
250	JUNE	23	1955	00:00:00.0	+,-	1669	25

251	JUNE	28	1955	00:00:00.0	−, +	1670	3
252	OCT	10	1955	00:00:00.0	−, +	1673	26
253	NOV	4	1955	00:00:00.0	−, +	1674	24
254	NOV	8	1955	00:00:00.0	+, −	1675	1
255	NOV	21	1955	00:00:00.0	−, +	1675	14
256	DEC	1	1955	00:00:00.0	+, −	1675	24
257	DEC	15	1955	00:00:00.0	−, +	1676	11
258	JAN	14	1956	00:00:00.0	−, +	1677	14
259	JAN	27	1956	00:00:00.0	+, −	1677	27
260	FEB	13	1956	00:00:00.0	−, +	1678	17
261	FEB	20	1956	00:00:00.0	+, −	1678	24
262	MARCH	7	1956	00:00:00.0	−, +	1679	13
263	MARCH	20	1956	00:00:00.0	+, −	1679	26
264	APRIL	5	1956	00:00:00.0	−, +	1680	15
265	APRIL	17	1956	00:00:00.0	+, −	1680	27
266	APRIL	29	1956	00:00:00.0	−, +	1681	12
267	MAY	12	1956	00:00:00.0	+, −	1681	25
268	MAY	28	1956	00:00:00.0	−, +	1682	14
269	JUNE	10	1956	00:00:00.0	+, −	1682	27
270	JUNE	25	1956	00:00:00.0	−, +	1683	15
271	JULY	8	1956	00:00:00.0	+, −	1684	1
272	JULY	24	1956	00:00:00.0	−, +	1684	17
273	AUG	6	1956	00:00:00.0	+, −	1685	3
274	AUG	22	1956	00:00:00.0	−, +	1685	19
275	SEPT	7	1956	00:00:00.0	+, −	1686	8
276	SEPT	18	1956	00:00:00.0	−, +	1686	19
277	OCT	4	1956	00:00:00.0	+, −	1687	8
278	OCT	18	1956	00:00:00.0	−, +	1687	22
279	NOV	1	1956	00:00:00.0	+, −	1688	9
280	NOV	14	1956	00:00:00.0	−, +	1688	22
281	NOV	22	1956	00.00:00.0	+, −	1689	3
282	DEC	13	1956	00:00:00.0	−, +	1689	24
283	DEC	18	1956	00:00:00.0	+, −	1690	2
284	JAN	14	1957	00:00:00.0	−, +	1691	2
285	JAN	20	1957	00:00:00.0	+, −	1691	8
286	FEB	11	1957	00:00:00.0	−, +	1692	3
287	FEB	17	1957	00:00:00.0	+, −	1692	9
288	MARCH	11	1957	00:00:00.0	−, +	1693	4
289	MARCH	18	1957	00:00:00.0	+, −	1693	11
290	APRIL	9	1957	00:00:00.0	−, +	1694	6
291	APRIL	15	1957	00:00:00.0	+, −	1694	12
292	MAY	6	1957	00:00:00.0	−, +	1695	6
293	JULY	13	1957	00:00:00.0	−, +	1697	20
294	JULY	28	1957	00:00:00.0	+, −	1698	8
295	AUG	8	1957	00:00:00.0	−, +	1698	19
296	AUG	12	1957	00:00:00.0	+, −	1698	23
297	AUG	18	1957	00:00:00.0	−, +	1699	2
298	AUG	22	1957	00:00:00.0	+, −	1699	6
299	SEPT	12	1957	00:00:00.0	−, +	1699	27
300	SEPT	18	1957	00:00:00.0	+, −	1700	6

801	APRIL	16	1974	00:00:00.0	+, −	1924	12
802	APRIL	29	1974	00:00:00.0	−, +	1924	25
803	MAY	13	1974	00:00:00.0	+, −	1925	12
804	MAY	30	1974	00:00:00.0	−, +	1926	2
805	JUNE	9	1974	00:00:00.0	+, −	1926	12
806	JUNE	25	1974	00:00:00.0	−, +	1927	1
807	JULY	6	1974	00:00:00.0	+, −	1927	12
808	JULY	23	1974	00:00:00.0	−, +	1928	2
809	AUG	2	1974	00:00:00.0	+, −	1928	12
810	AUG	19	1974	00:00:00.0	−, +	1929	2
811	AUG	26	1974	00:00:00.0	+, −	1929	9
812	SEPT	16	1974	00:00:00.0	−, +	1930	3
813	SEPT	24	1974	00:00:00.0	+, −	1930	11
814	OCT	13	1974	00:00:00.0	−, +	1931	3
815	OCT	23	1974	00:00:00.0	+, −	1931	13
816	NOV	9	1974	00:00:00.0	−, +	1932	3
817	NOV	19	1974	00:00:00.0	+, −	1932	13
818	DEC	7	1974	00:00:00.0	−, +	1933	4
819	DEC	17	1974	00:00:00.0	+, −	1933	14
820	DEC	26	1974	00:00:00.0	−, +	1933	23
821	DEC	30	1974	00:00:00.0	+, −	1933	27
822	JAN	4	1975	00:00:00.0	−, +	1934	5
823	JAN	13	1975	00:00:00.0	+, −	1934	14
824	JAN	23	1975	00:00:00.0	−, +	1934	24
825	JAN	27	1975	00:00:00.0	+, −	1935	1
826	JAN	31	1975	00:00:00.0	−, +	1935	5
827	FEB	8	1975	00:00:00.0	+, −	1935	13
828	FEB	21	1975	00:00:00.0	−, +	1935	26
829	MARCH	8	1975	00:00:00.0	+, −	1936	14
830	MARCH	21	1975	00:00:00.0	−, +	1936	27
831	MARCH	31	1975	00:00:00.0	+, −	1937	10
832	APRIL	17	1975	00:00:00.0	−, +	1937	27
833	MAY	2	1975	00:00:00.0	+, −	1938	15
834	MAY	16	1975	00:00:00.0	−, +	1939	2
835	MAY	19	1975	00:00:00.0	+, −	1939	5
836	MAY	23	1975	00:00:00.0	−, +	1939	9
837	MAY	29	1975	00:00:00.0	+, −	1939	15
838	JUNE	10	1975	00:00:00.0	−, +	1939	27
839	JUNE	27	1975	00:00:00.0	+, −	1940	17
840	JULY	8	1975	00:00:00.0	−, +	1941	1
841	JULY	25	1975	00:00:00.0	+, −	1941	18
842	AUG	2	1975	00:00:00.0	−, +	1941	26
843	AUG	17	1975	00:00:00.0	+, −	1942	14
844	AUG	29	1975	00:00:00.0	−, +	1942	26
845	SEPT	17	1975	00:00:00.0	+, −	1943	18
846	SEPT	26	1975	00:00:00.0	−, +	1943	27
847	OCT	15	1975	00:00:00.0	+, −	1944	19
848	OCT	29	1975	00:00:00.0	−, +	1945	6


1555 D25
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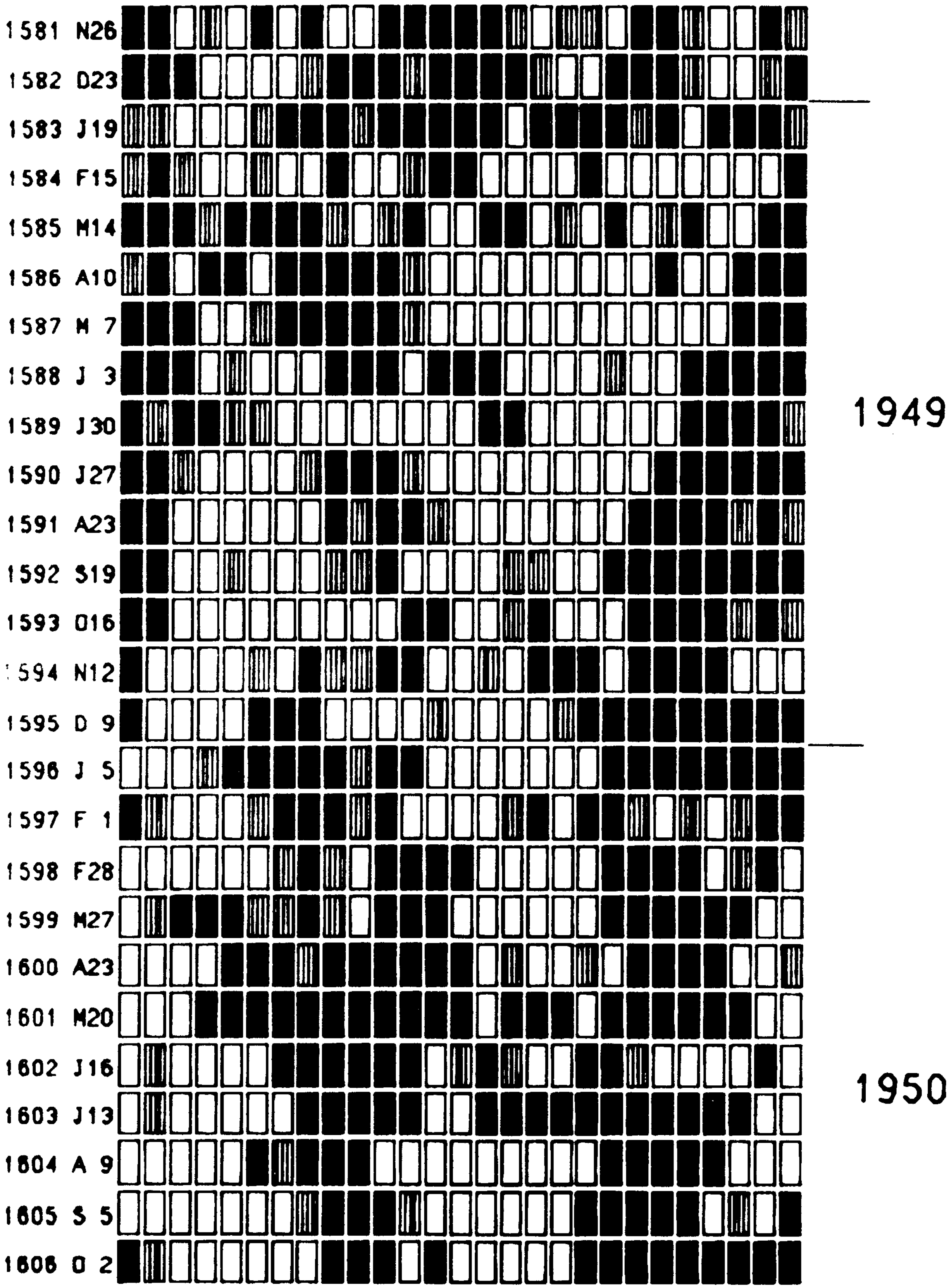
1557 F17
1558 M16
1559 A12
1560 M 9
1561 J 5
1562 J 2
1563 J29
1564 A25
1565 S21
1566 O18
1567 N14
1568 D11
1569 J 7
1570 F 3
1571 M 1
1572 M28
1573 A24
1574 M21
1575 J17
1576 J14
1577 A10
1578 S 6
1579 O 3
1580 O30
1947
1948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1589 J30
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1591 A23
1592 S19
1593 O16
1594 N12
1595 D 9
1596 J 5
1597 F 1
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1600 A23
1601 M20
1602 J16
1603 J13
1604 A 9
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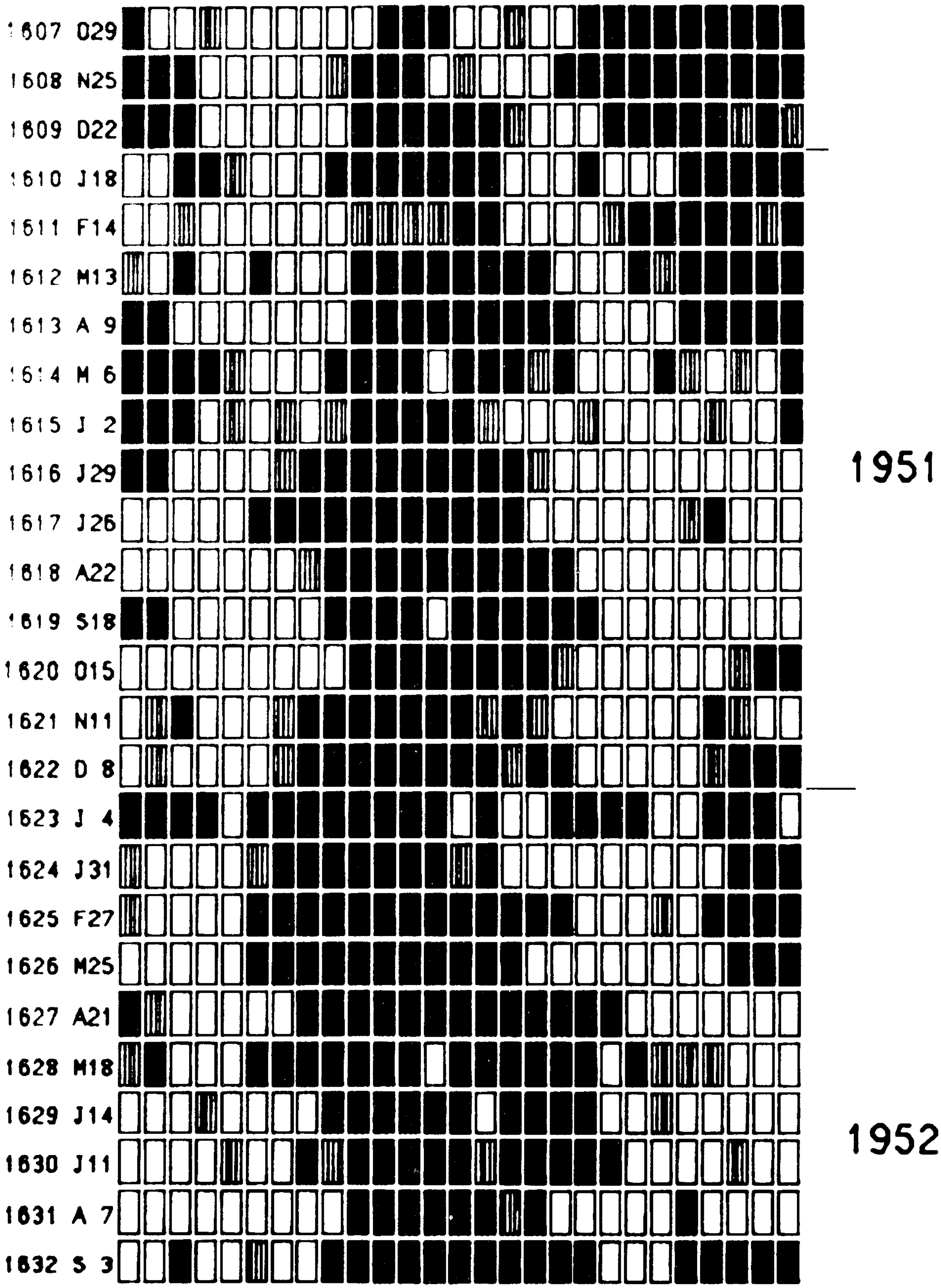
1606 O 2
1949
1950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1609 D22
1610 J18
1611 F14
1612 M13
1613 A 9
1614 M 6
1615 J 2
1616 J29
1617 J26
1618 A22
1619 S18
1620 O15
1621 N11
1622 D 8
1623 J 4
1624 J31
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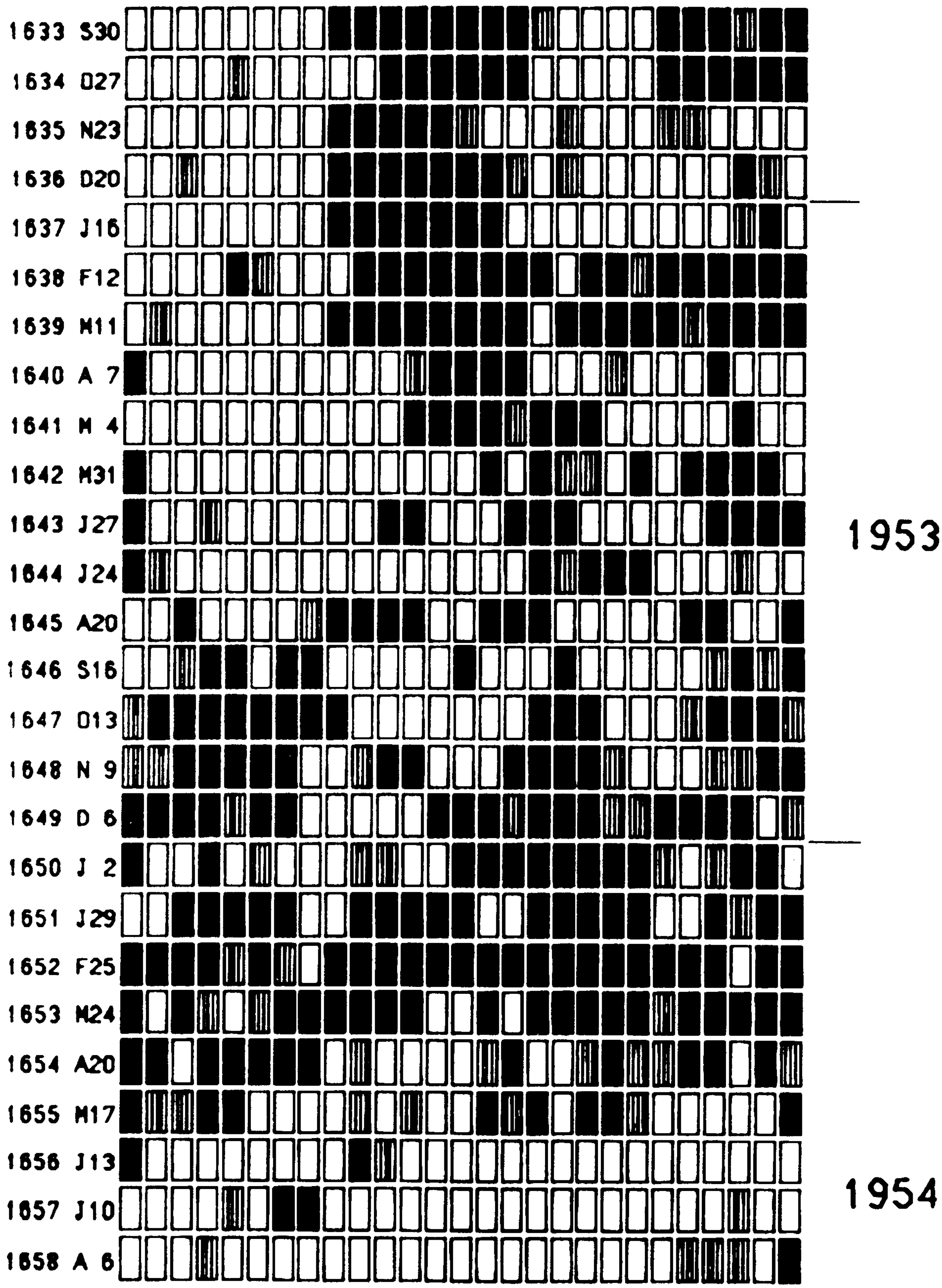
1626 M25
1627 A21
1628 M18
1629 J14
1630 J11
1631 A 7
1632 S 3
1951
1952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1635 N23
1636 D20
1637 J16
1638 F12
1639 M11
1640 A 7
1641 M 4
1642 M31
1643 J27
1644 J24
1645 A20
1646 S16
1647 O13
1648 N 9
1649 D 6
1650 J 2
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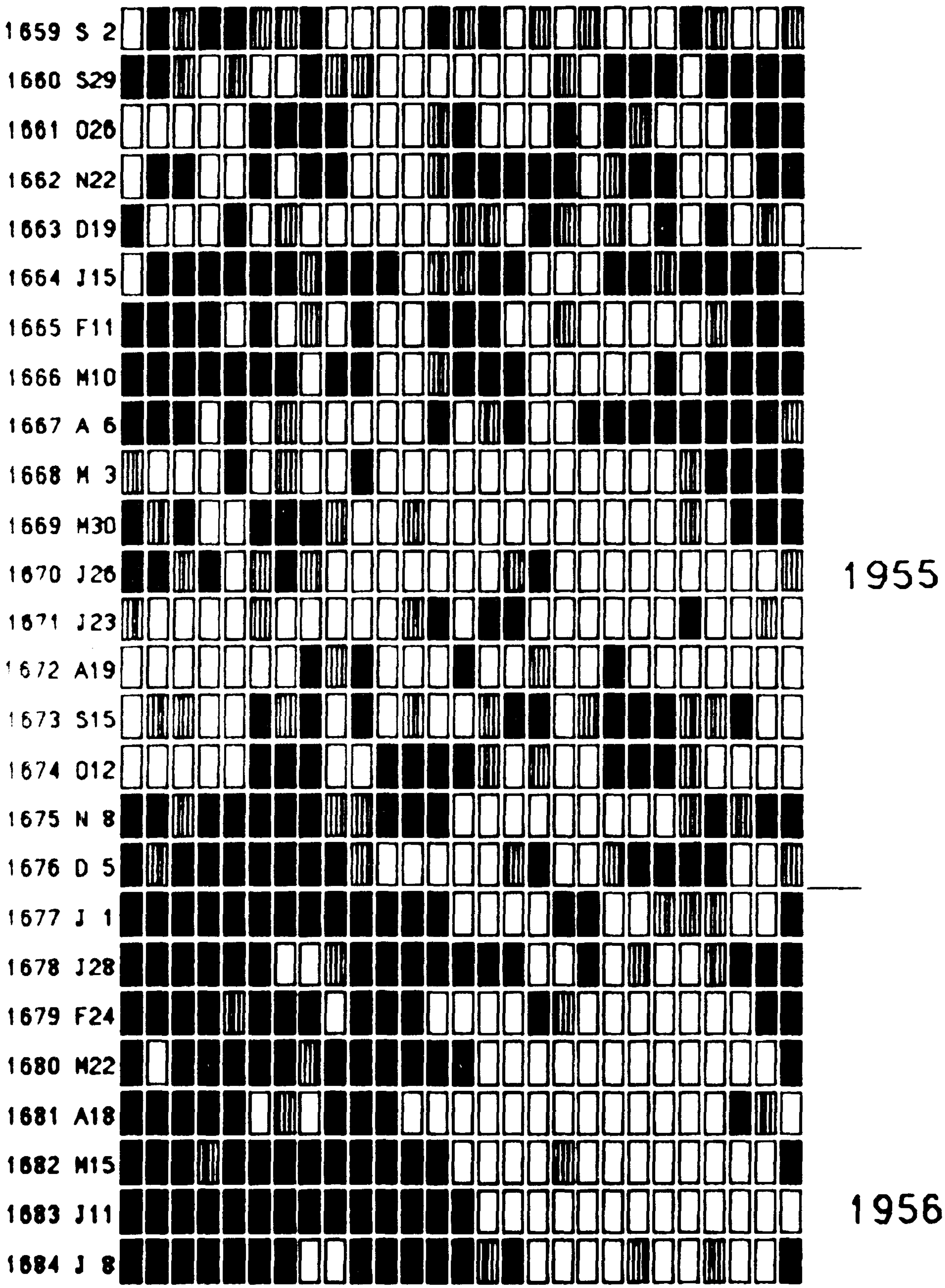
1652 F25
1653 M24
1654 A20
1655 M17
1656 J13
1657 J10
1658 A 6
1953
1954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1667 A 6
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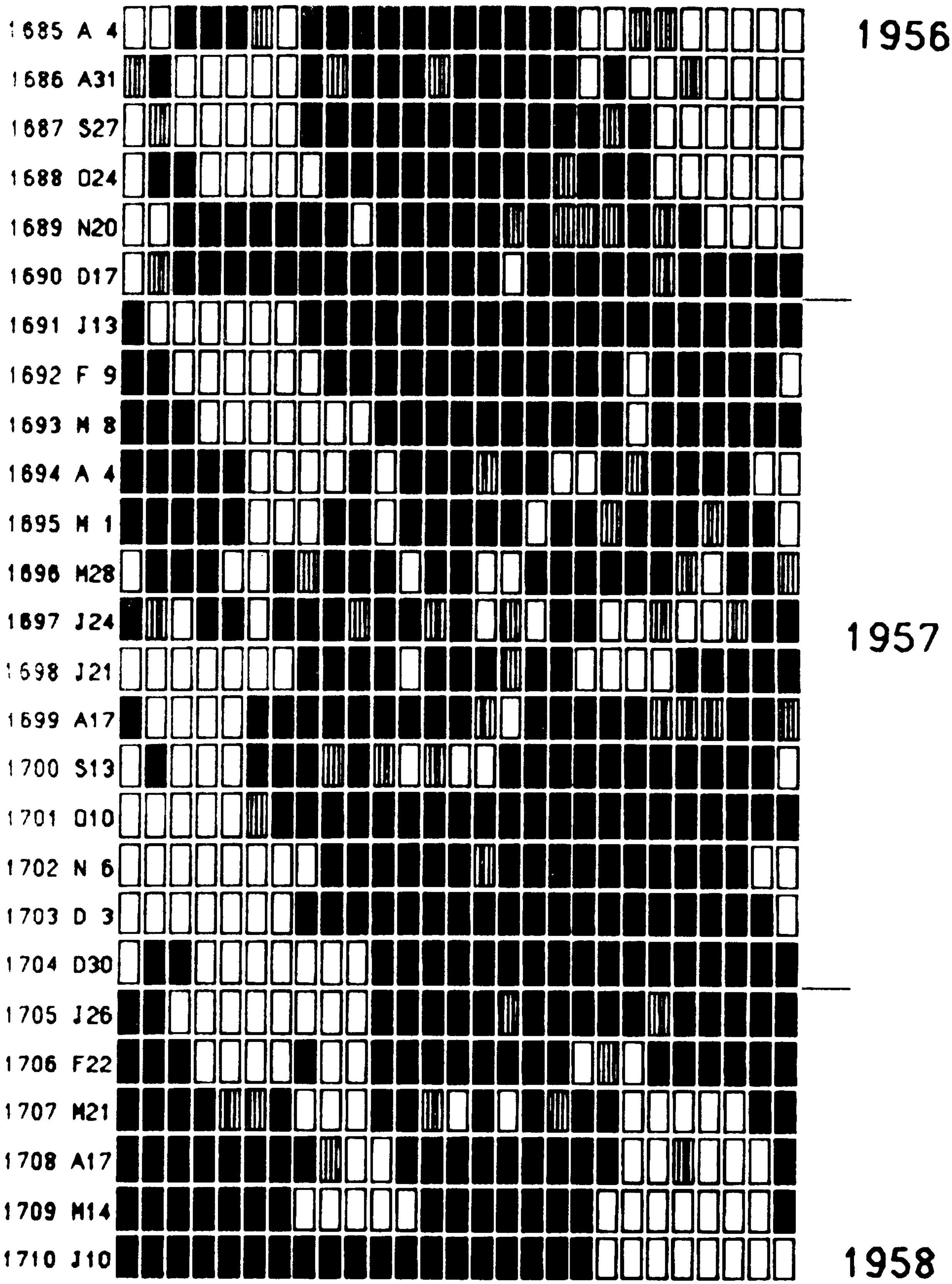
1670 J26
1671 J23
1672 A19
1673 S15
1674 O12
1675 N 8
1676 D 5
1677 J 1
1678 J28
1679 F24
1680 M22
1681 A18
1682 M15
1683 J11
1684 J 8
1955
1956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1693 M 8
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1696 M28
1697 J24
1698 J21
1699 A17
1700 S13
1701 O10
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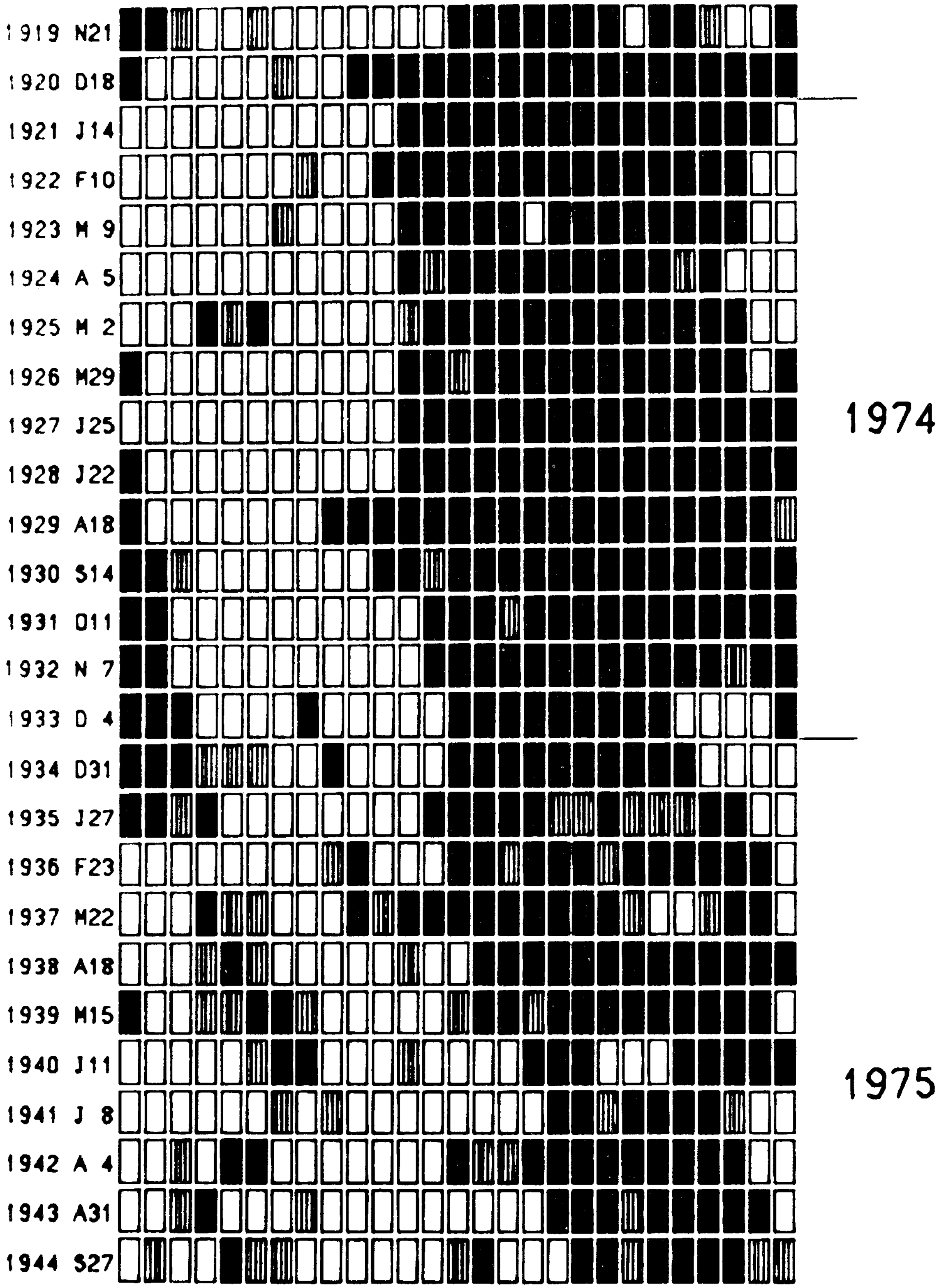
1710 J10
1956
1957
1958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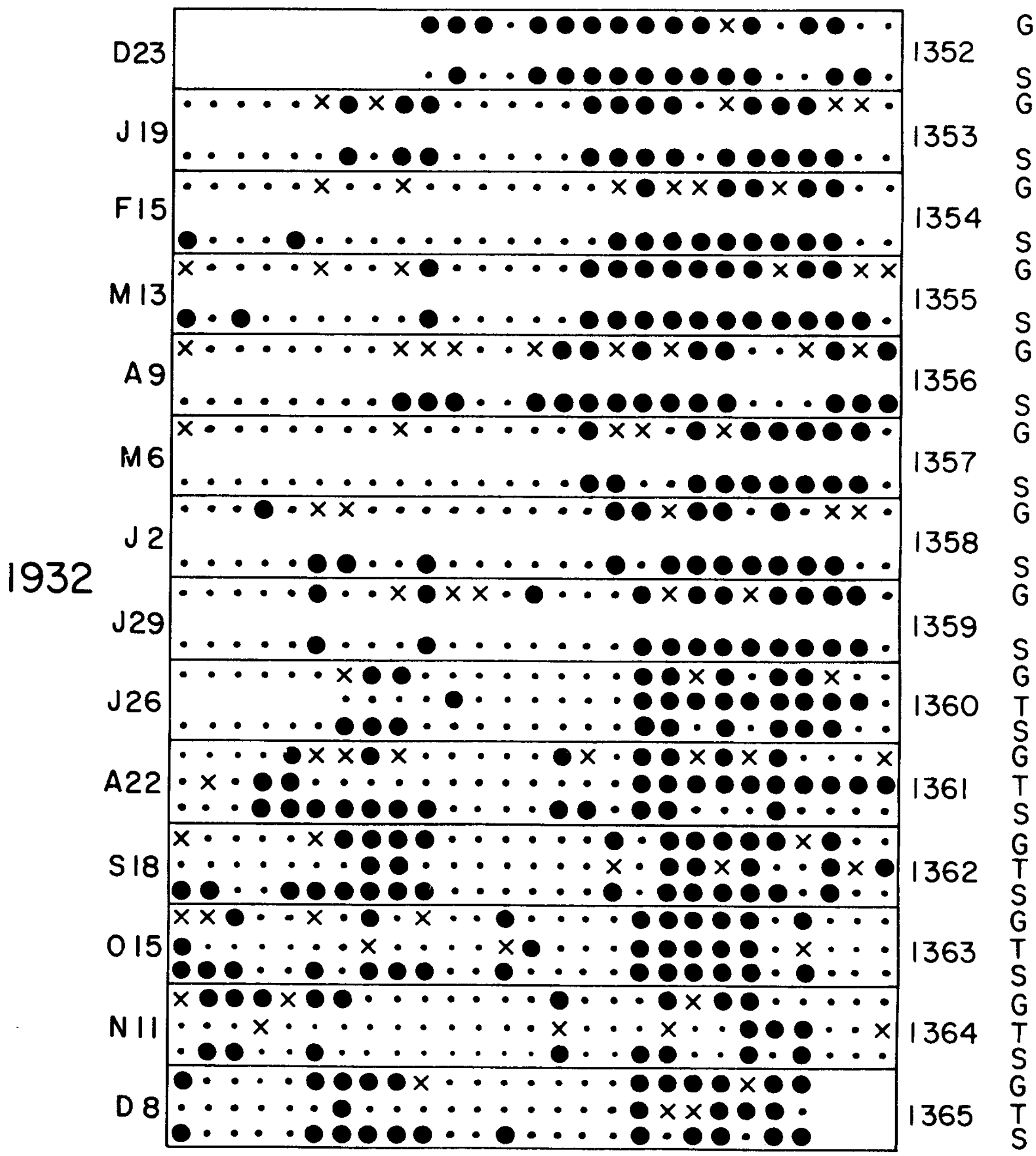
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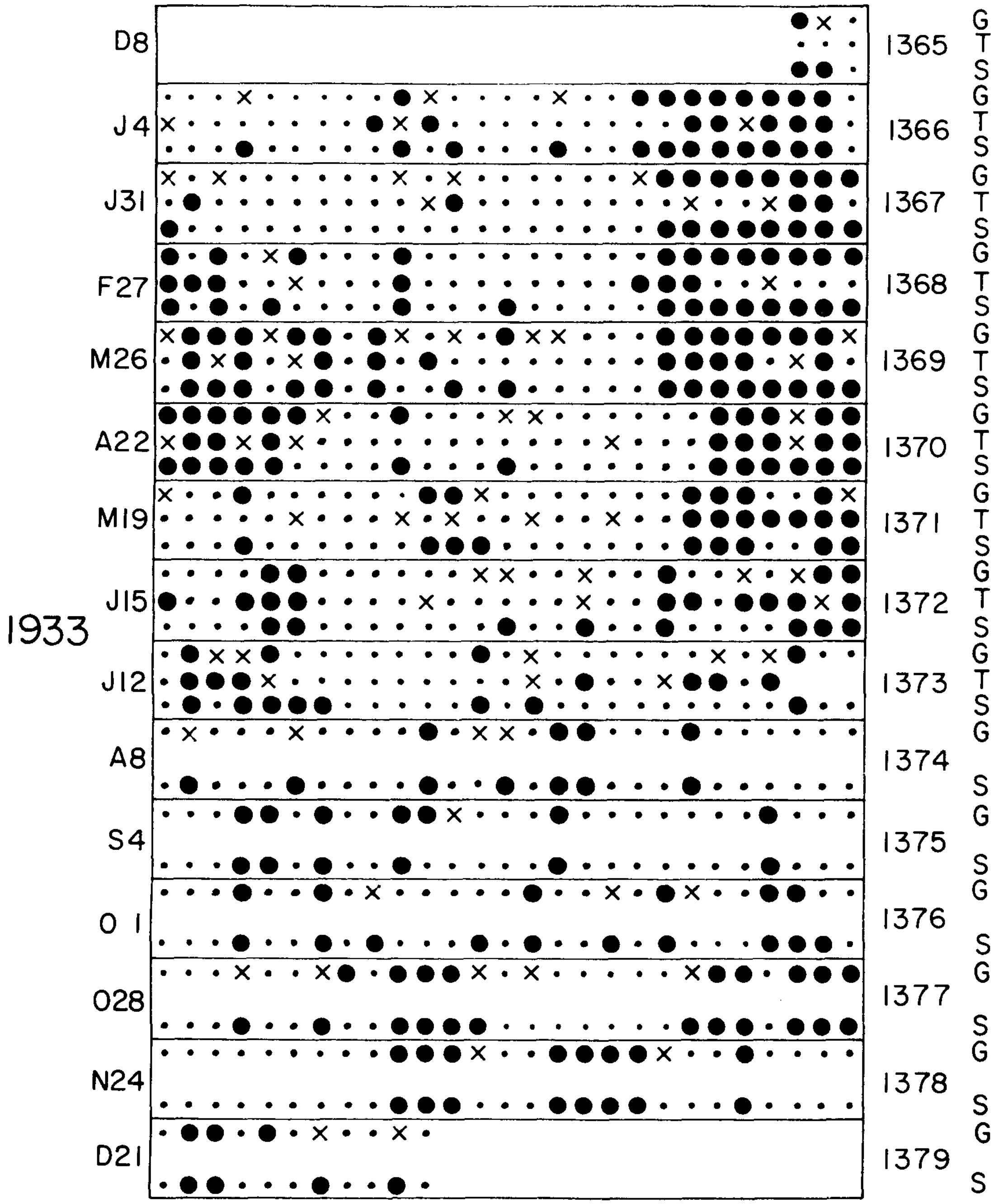
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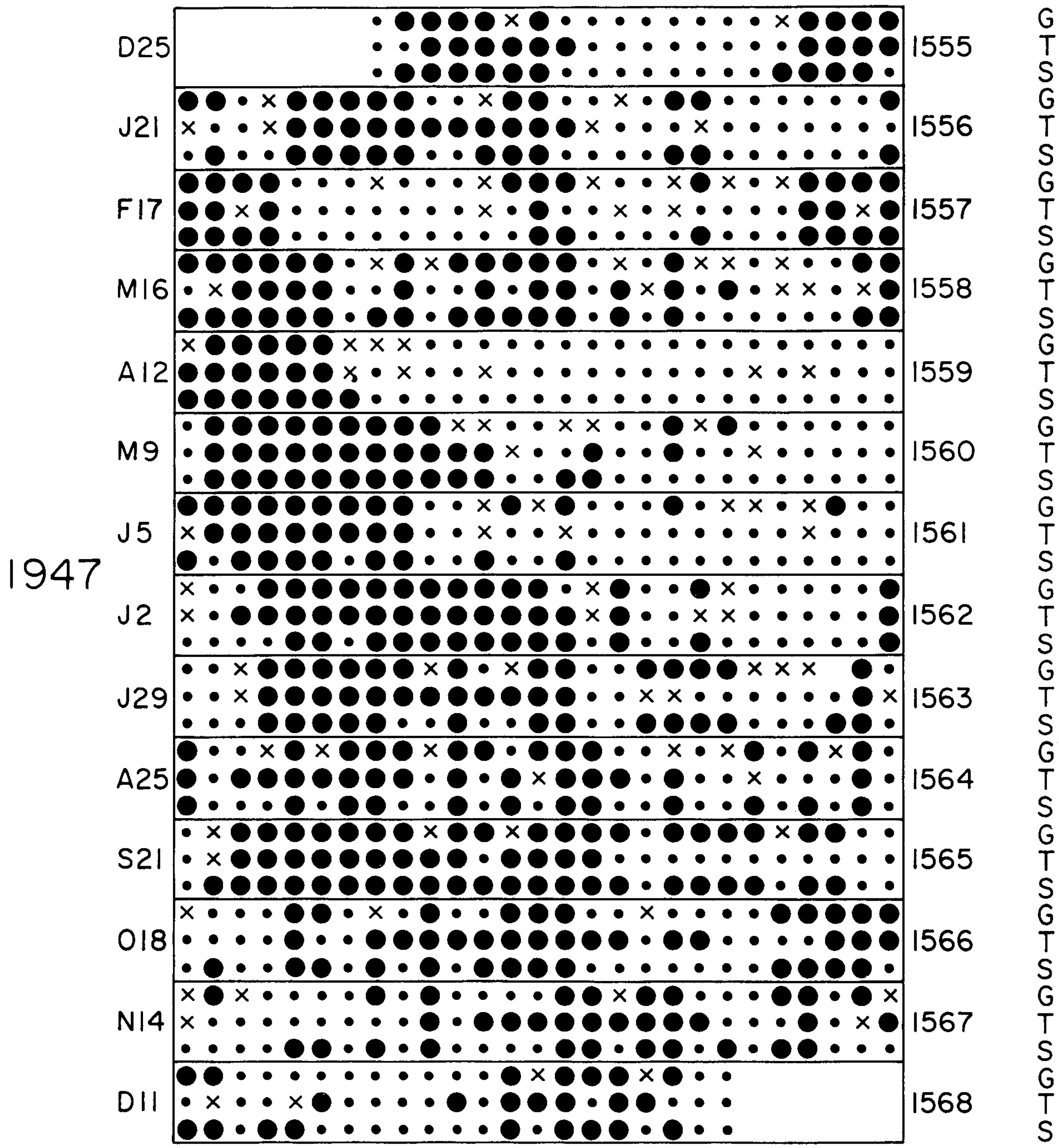
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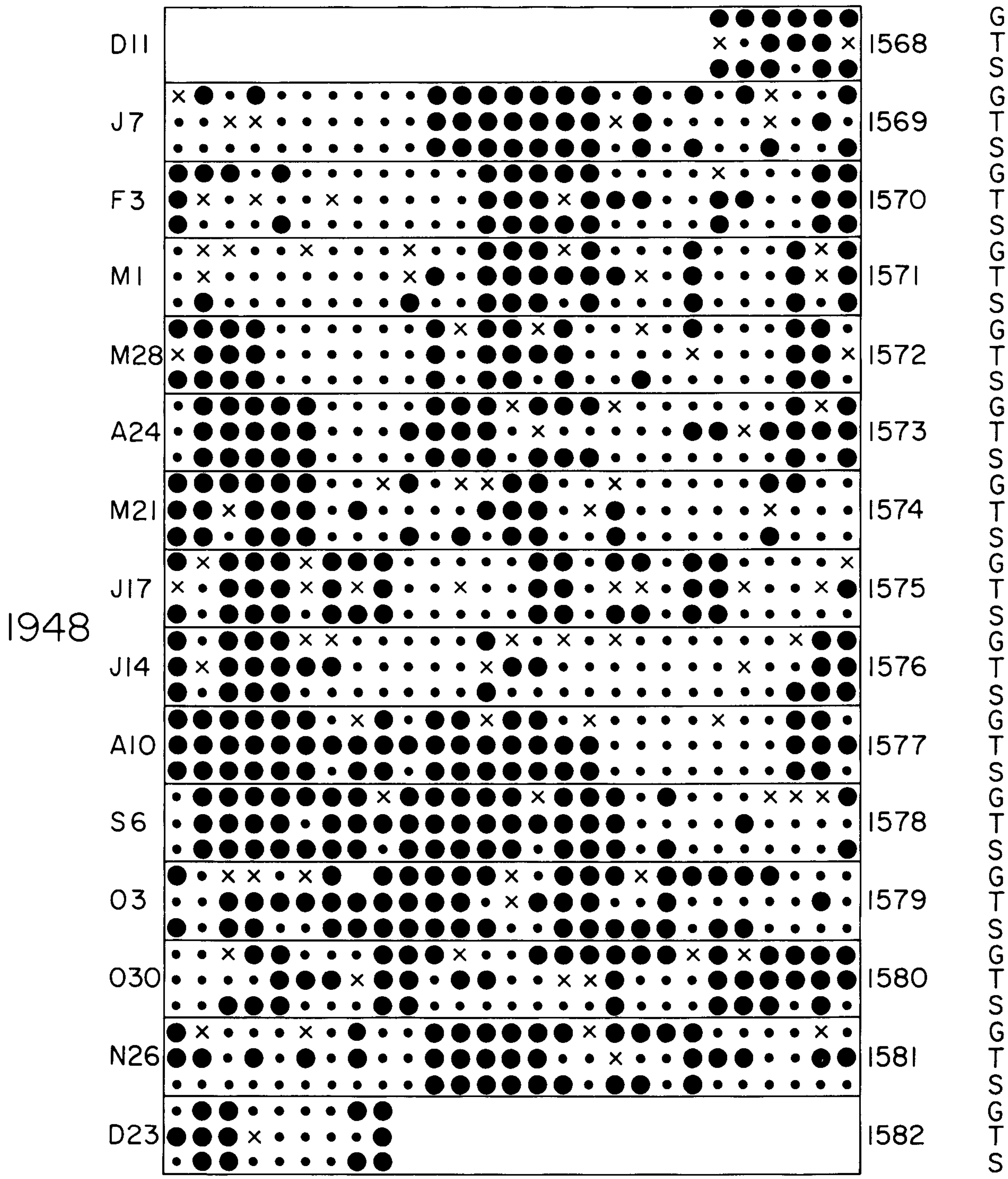
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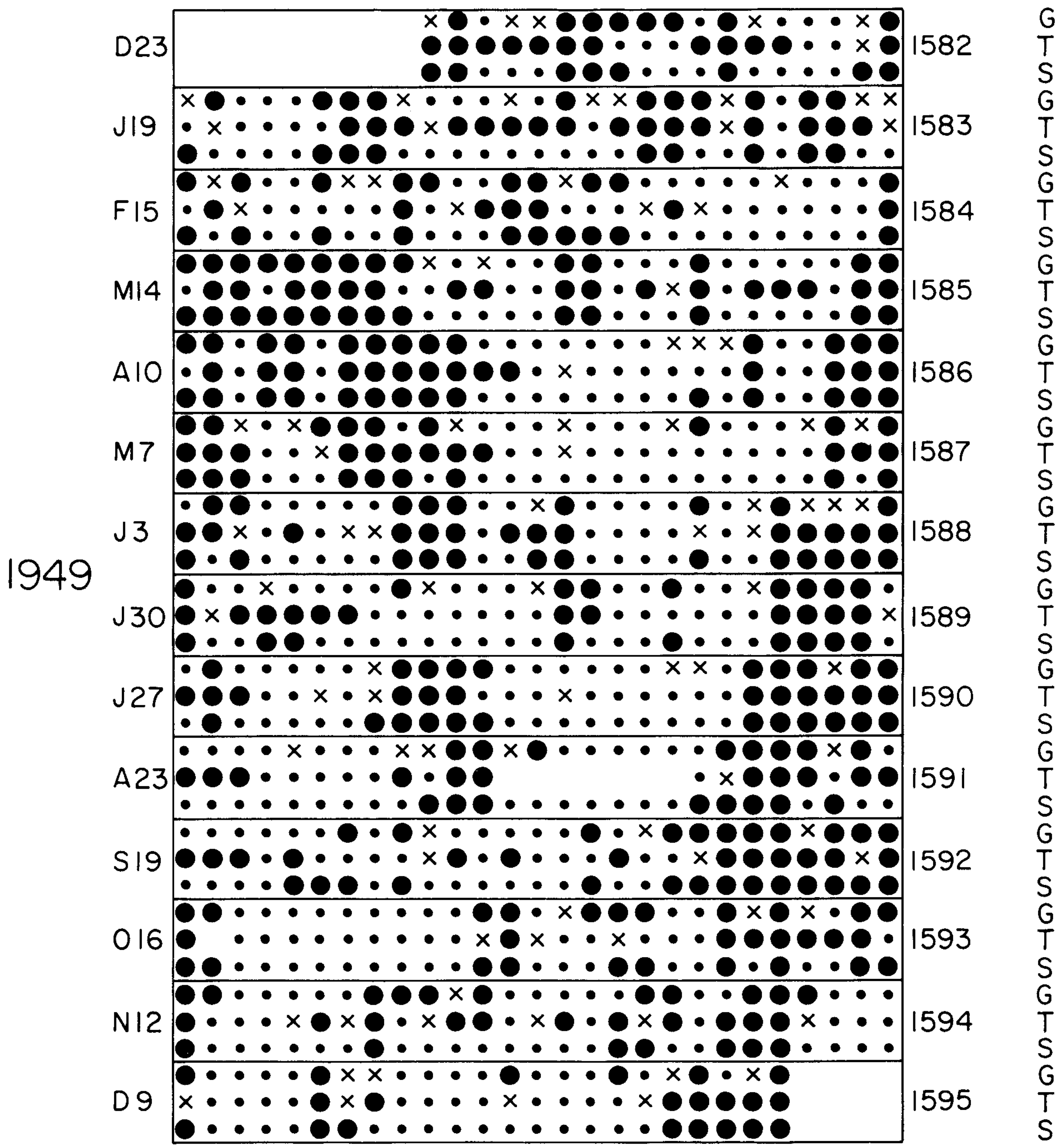
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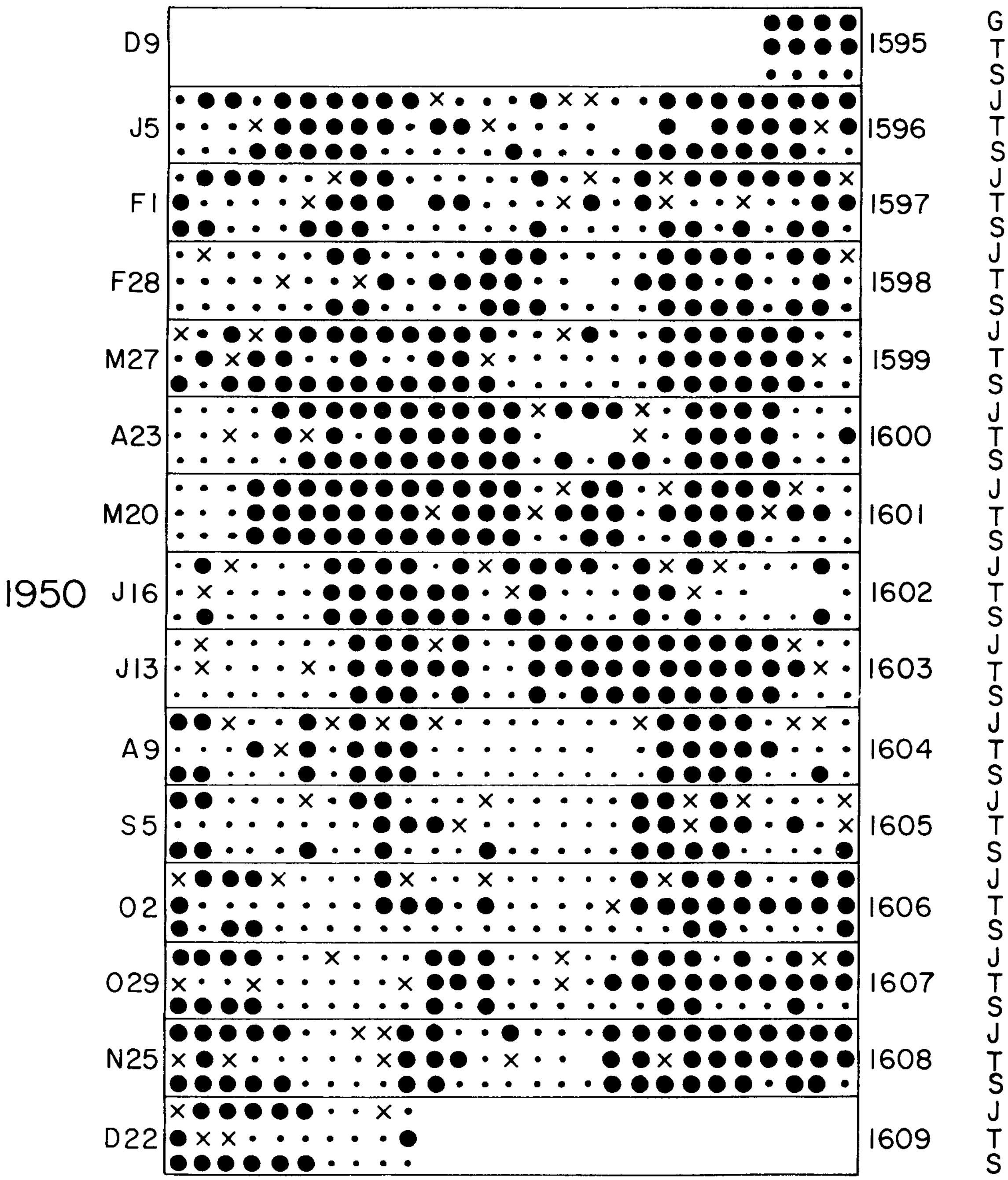
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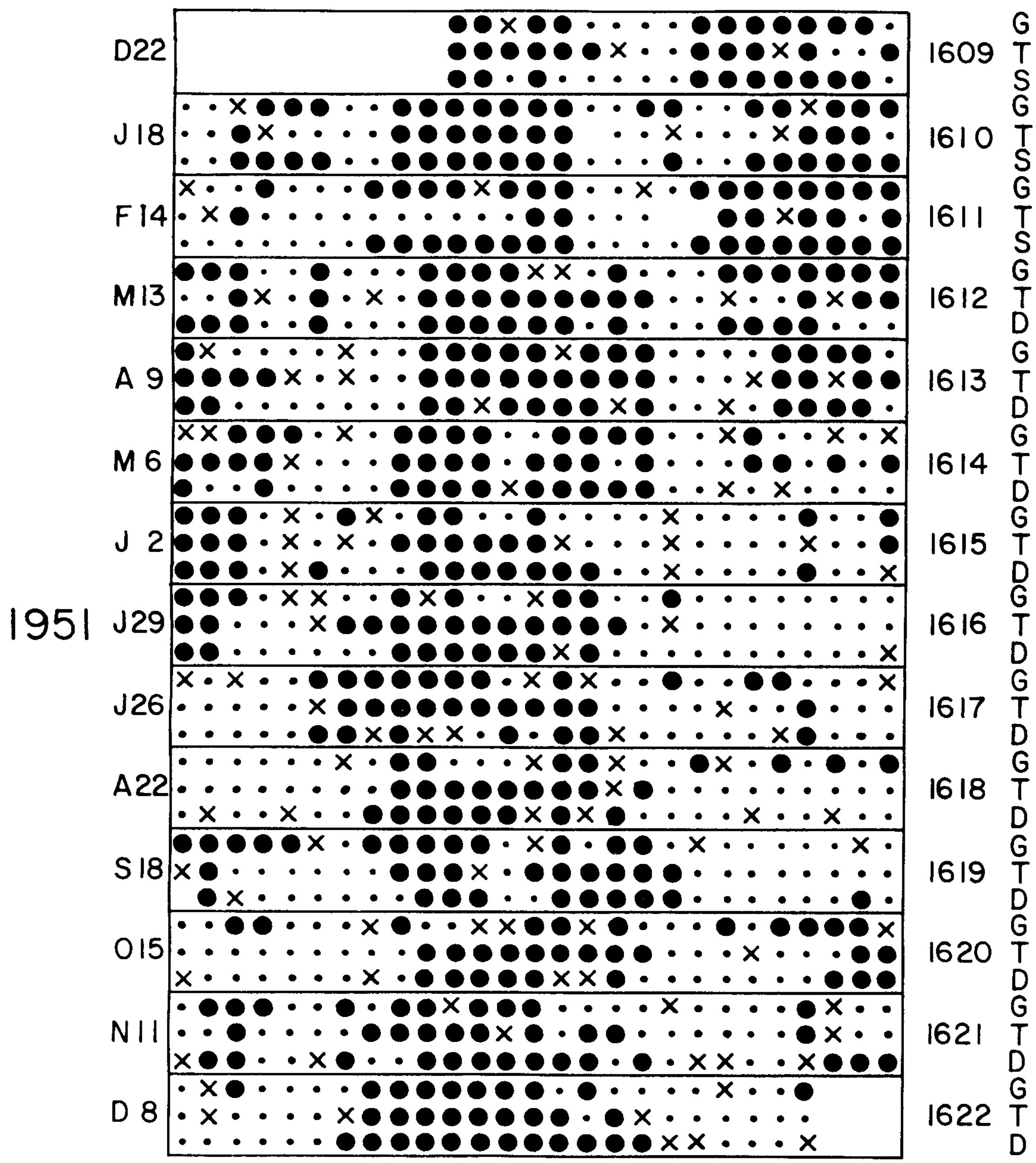
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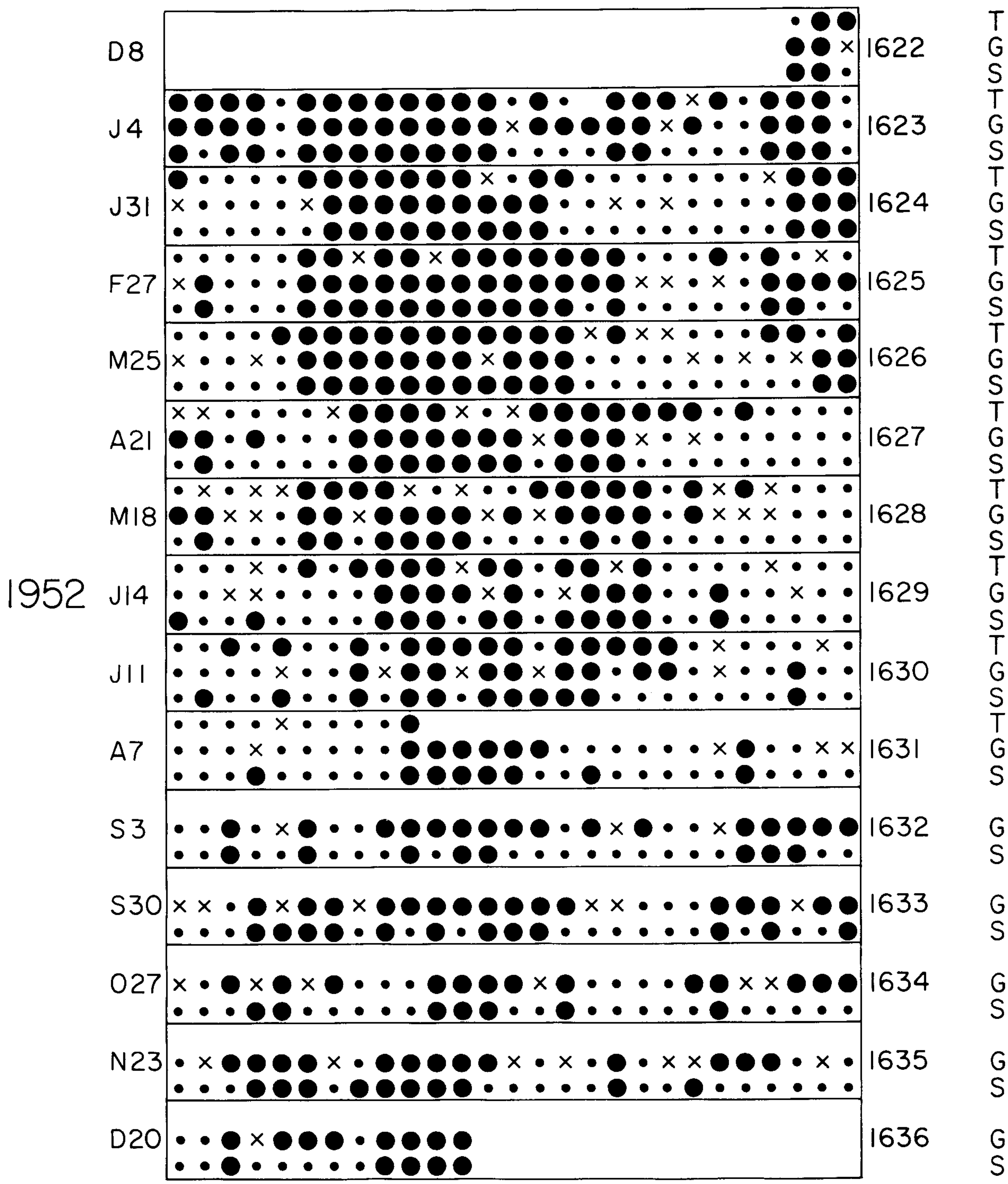
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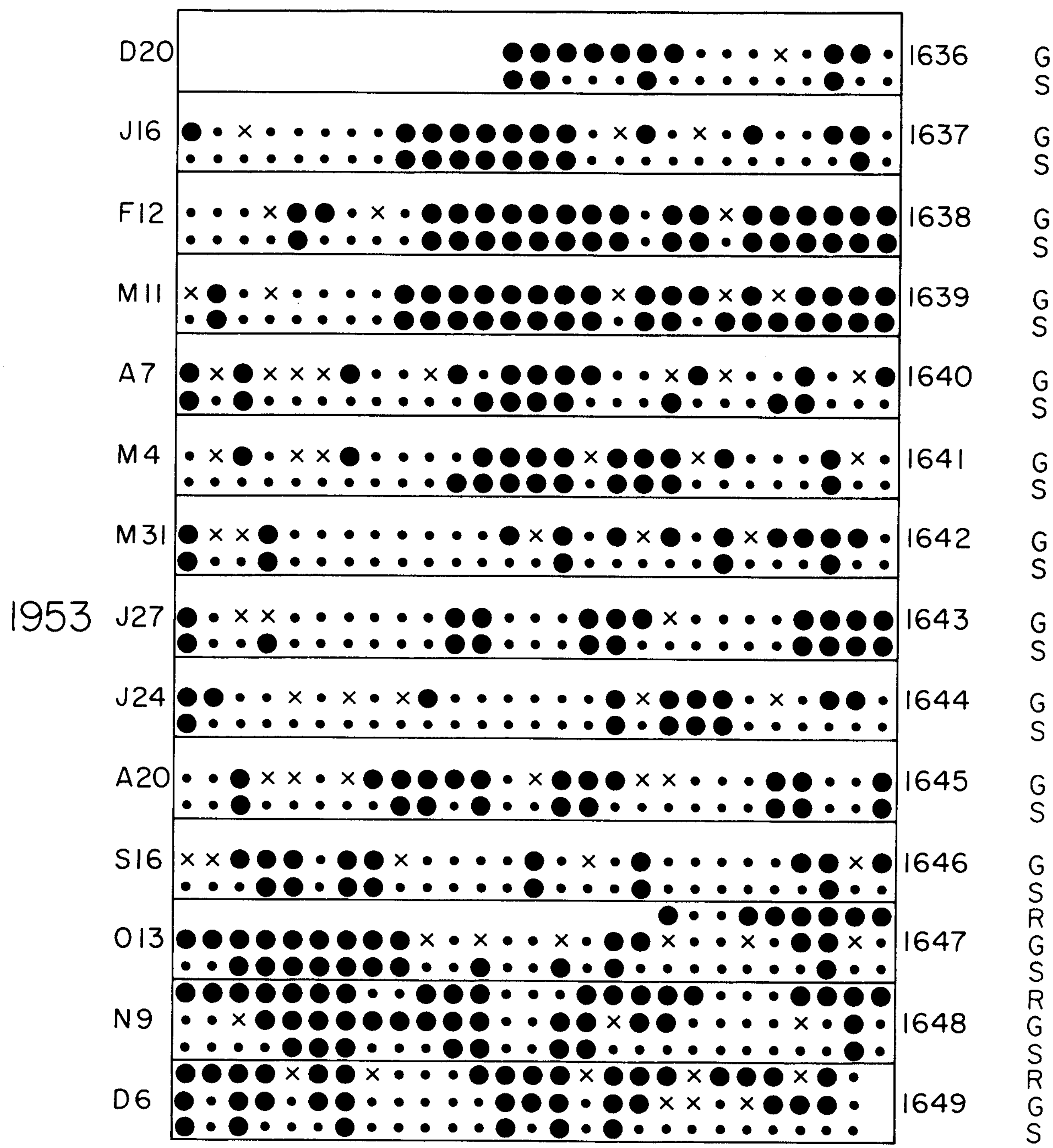
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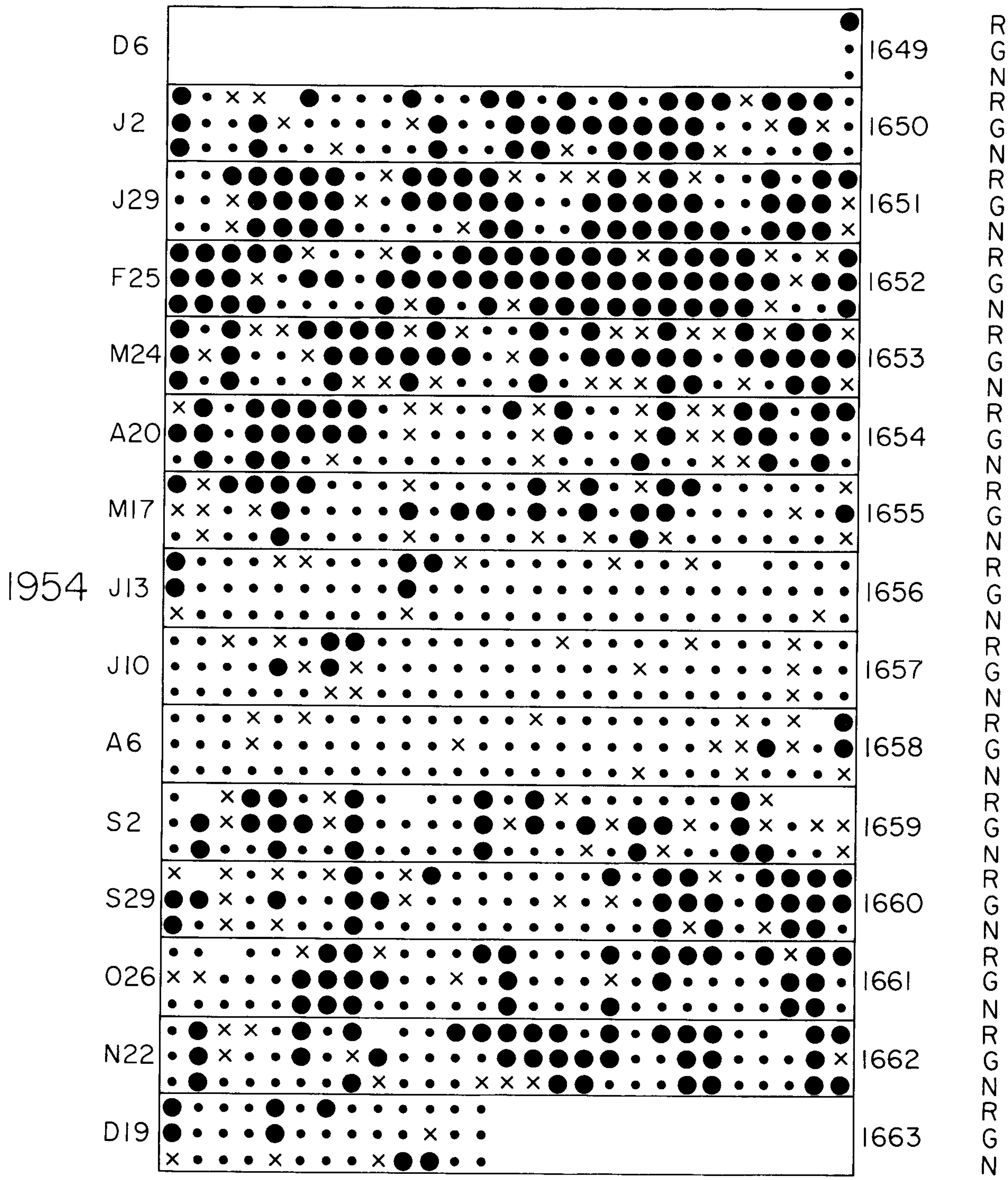
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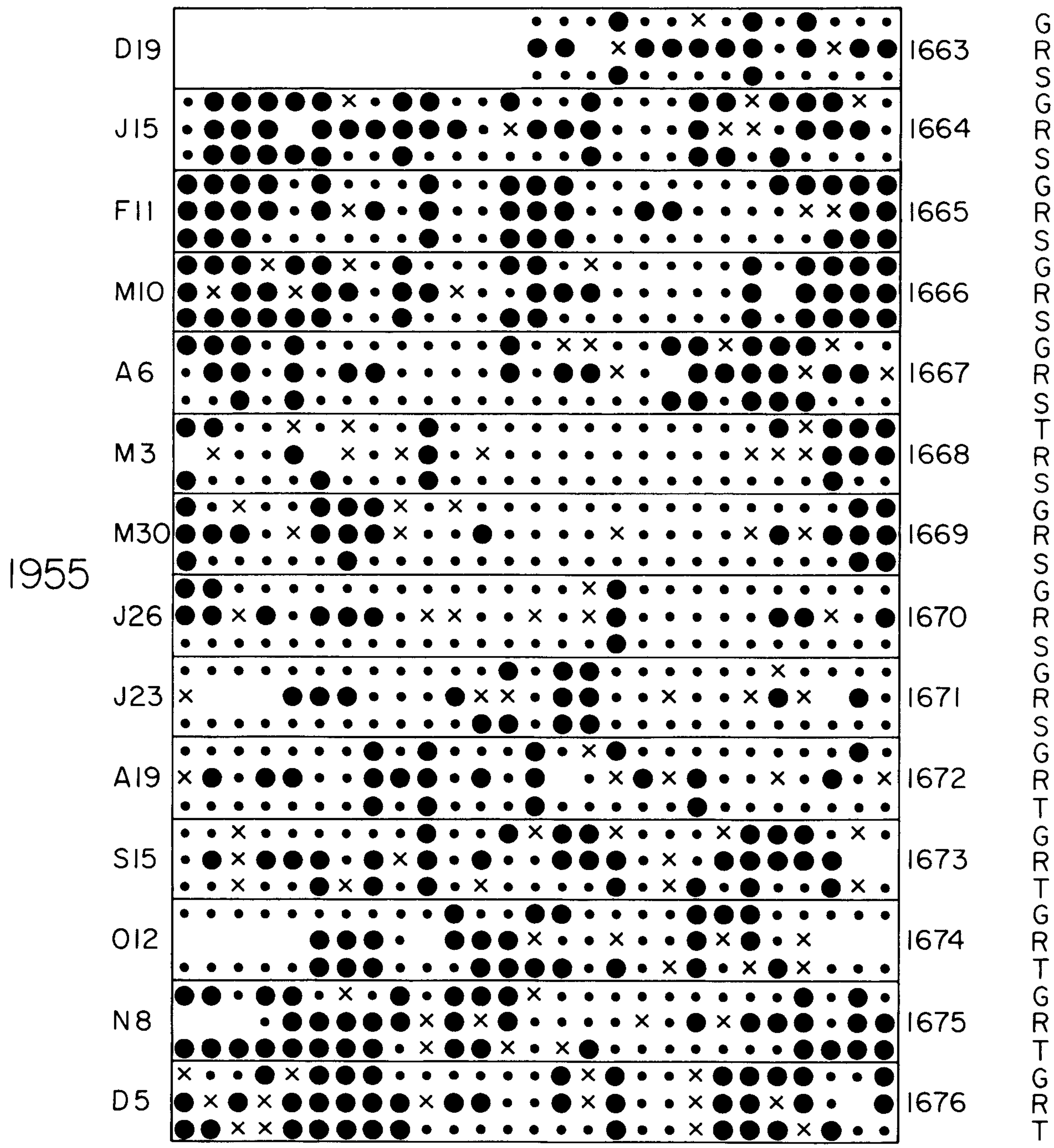
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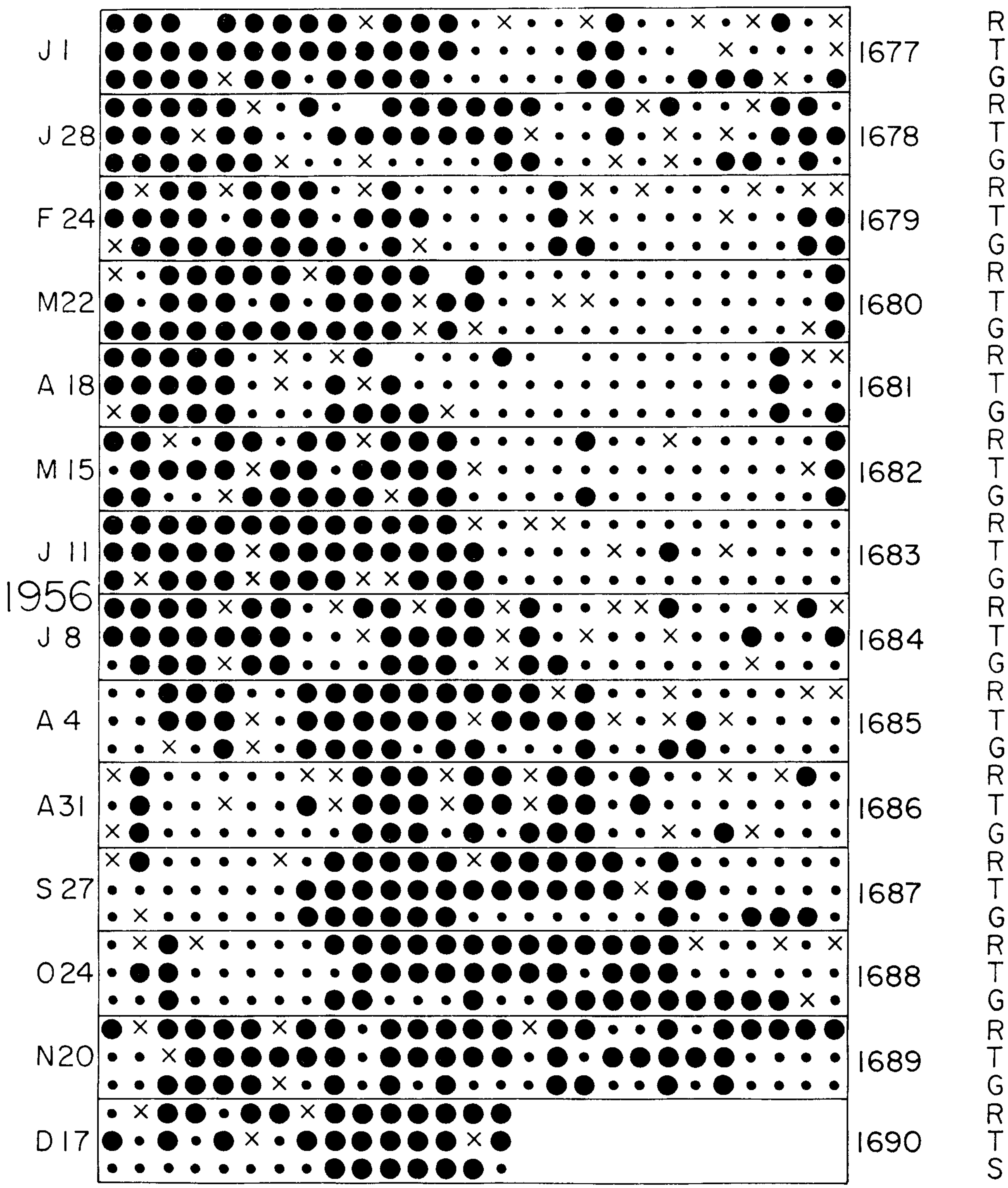
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This report is an extension of "An Atlas of Interplanetary Sector Structure 1957-1974" to include earlier years back to 1947 and also the years 1932-1933 and 1975.

On the Use of Godhavn *H* Component as an Indicator of the Interplanetary Sector Polarity

LEIF SVALGAARD

Journal of Geophysical Research, vol. 80, no. 19, July 1, 1975

On the Use of Godhavn *H* Component as an Indicator of the Interplanetary Sector Polarity

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An objective method of inferring the polarity of the interplanetary magnetic field using the *H* component at Godhavn is presented. The objectively inferred polarities are compared with a subjective index inferred earlier (Svalgaard, 1972*b*). It is concluded that no significant difference exists between the two methods. The inferred polarities derived from Godhavn *H* are biased by the $S_q{}^p$ signature in the sense that during summer, prolonged intervals of geomagnetic calm will result in inferred away polarity regardless of the actual sector polarity. This bias does not significantly alter the large-scale structure of the inferred sector structure.

Fougere and Russell [1974] suggest that evaluation of the accuracy of the inferred interplanetary sector polarity [*Svalgaard,* 1972*a*] is difficult due to the subjective nature of the inferred index and also due to the apparent lack of a detailed recipe on how to infer the sector polarity from polar cap magnetograms. It is the purpose of this note to provide such a recipe and also to show that the quality of the published list of inferred polarities going back to 1926 [*Svalgaard,* 1972*b*] is not seriously affected by the fact that for most years before 1964 only one station (Godhavn, 77.5° invariant latitude) was used in deriving the list.

The above statements should be qualified by noting that the recipe which will be presented is certainly not the perfect recipe, but it has the virtue of belonging to a class of recipes which are very simple yet still useful. Furthermore, the extent to which the inferred index (the so-called A/C index) is useful depends somewhat on the purpose of the analysis. Just as the *Kp* index does not give meaningful results when used for deriving the diurnal variation of geomagnetic activity, there may well be (and apparently are [*Fougere,* 1974]) limitations inherent in the present A/C index, which may preclude its application to certain problems without affecting its usefulness in other areas.

In the original A/C classification a day was classified as type C (associated with toward sector polarity) if the *Z* magnetograms from near-polar stations showed a broad positive perturbation around local noon; a negative perturbation would classify the day as a type A day (associated with away polarity). It was found that the amplitude of these perturbations of the vertical *Z* component decreased with increasing distance from the invariant poles. Instead, perturbations are found in the horizontal *H* component. The sense of the *H* perturbations is opposite to the sense of the near-pole *Z* perturbations. Figure 1 shows the average diurnal variation of the *H* component at Godhavn for 1950. The curves labeled A and C are the average variations during days classified by *Svalgaard* [1972*b*] as being of type A and of type C, respectively. The all-day average variation is also shown in the figure. A 6-hour interval around 1800 UT is delineated by the two dashed lines. In this interval the largest differences between the A- and the C-type variation occurs.

If a Godhavn *H* magnetogram for a given day shows a definite local maximum within the interval 1500–2100 UT, the day is classified as type A, while a definite local minimum or depression will classify the day as type C. This recipe leaves room for a type B, when the variation is irregular during the interval of interest. It turns out that type B occurs rarely enough (≈10% of the time) to make the A/C type classification meaningful. Originally, a choice was made such that every day was classified only in terms of A or C.

The local maxima and minima (or enhancements and depressions) used to determine the type of the daily variation appear to be superposed on the normal diurnal variation, which is roughly sinusoidal. The amplitude of this background curve varies greatly with season and with disturbance level. To a certain degree the quality of the A/C index is then dependent upon how well the background can be discerned and removed. This in turn demands some familiarity with the Godhavn magnetograms. The situation is analogous to the problem of determining Bartels' *K* index. This index is basically a subjective index, because its determination requires recognition and subsequent removal of the normal undisturbed diurnal *Sq* variation, which itself varies from day to day or even may change character during the day. In the case of an isolated *K* disturbance the background reference level can normally be interpolated on the magnetogram by using the quieter intervals before and after the disturbance. Similar considerations apply for the determination of the A/C index, and, as is true for the *K* index, the difficulty in removing the background becomes most important when small disturbances are scaled.

A simple approach to the problem of removing the background level is as follows: In Figure 2, data for May 1968 are plotted such that during the interval 1500–2100 UT the actual variation of the horizontal component at Godhavn is shown for each day, while for all other times only the monthly mean value of *H* is shown. The figure is then composed of a straight line interrupted each day by the (very time compressed) actual *H* trace. If *H* has a local enhancement within the interval of interest (1500–2100 UT), a positive spike will result for that day on Figure 2, while a depression will show as a negative spike. Figure 2 displays just a series of such spikes. The sector polarity as measured by spacecraft [*Wilcox and Colburn,* 1970] is indicated for each day on Figure 2 with a plus sign (away) or a minus sign (toward), placed near the spike for that day. Generally, we see the familiar pattern, that a positive spike is associated with away polarity and a negative spike with toward polarity. In a few cases a mixed signature is seen, but the data in Figure 2 as well as similar plots for other months of 1968 are in good accordance with the result of *Friis-Christensen et al.* [1971], that the A/C signature may be used

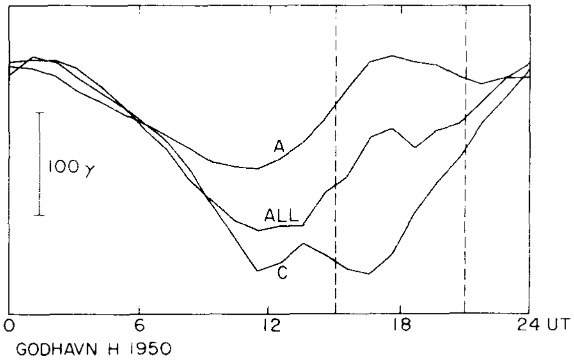

Fig. 1. Diurnal variation of the horizontal component at Godhavn during 1950. The curves labeled A and C are the average variations on days classified as being of type A and of type C, respectively. In the interval, shown by the dashed lines, the largest difference between the two types occurs.

to infer the second polarity with an accuracy exceeding 85%. Part of the remaining uncertainty is related to the observation [*Friis-Christensen et al.,* 1972] that the sign of the azimuthal component of the interplanetary magnetic field rather than its polarity seems to determine the sign of the A/C perturbation.

The apparent success of the very simple procedure used in preparing Figure 2 in producing features (spikes) which correlate well with the interplanetary sector polárities as measured by spacecraft suggests the following formal recipe for assigning a character (A, B, or C) to a UT day characterizing the inferred IMF polarity.

1. Use the horizontal H component at Godhavn.
2. For each day within a given month, subtract the monthly mean value of H from the hourly means of H.
3. Set the reduced values of H equal to zero for all hours outside the interval 1500–2200 UT, thus simulating the base line on Figure 2.
4. Determine the maximum value HA and the minimum value HC for each day. Due to the previous step we will generally have $HA \geq 0$ and $HC \leq 0$.
5. If $HA > -HC/2$, then classify the day as type A, and if $HC < -HA/2$, then classify the day as type C; otherwise classify the day as type B.

By using this recipe the A/C index has been redetermined for an interval in 1968 and compared with spacecraft measurements of the interplanetary magnetic field polarity. The result is shown in Figure 3. Even with this very crude recipe, which

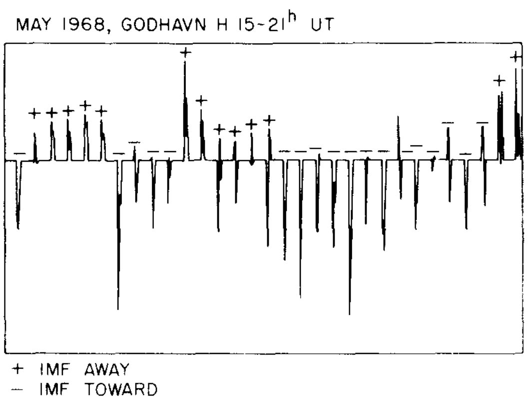

Fig. 2. Data for May 1968 plotted such that during the interval 1500–2100 UT the actual variation of the horizontal component at Godhavn is shown for each day, while for all other times the monthly mean value is shown as straight line segments (see text).

certainly is inferior to the visual judgement of the experienced observer, we obtain almost 80% agreement between the A/C index and the sector polarity. The larger-scale features of the sector structure are well defined by the A/C index, and this seems to be the case independent of season. The point we are trying to make is that as long as we concentrate on the interval of the day where the A/C effects are largest, we obtain very reasonable agreement between the A/C index and the sector polarity, even if the classification procedure is as rough as the one discussed above.

We shall not at this point discuss how much better one could do by using other stations at even higher latitudes, such as Thule or Resolute Bay, or by using more elaborate (and possibly more subjective or shrewd) techniques for removing the background level. Instead, we will note that if only the Godhavn station and the simple recipe described above are used, it seems possible to determine the large-scale features of the sector structure exhibited by the interplanetary magnetic field.

Figure 4 shows Godhavn H plotted in the same format as used in Figure 2 but for April 1950, when no spacecraft measurements of the interplanetary medium were available. Unless we assume that the response of the magnetosphere to the interplanetary magnetic field has changed between 1968 and 1950, we may again associate positive spikes with away polarity and negative spikes with toward polarity. Also shown in Figure 4 are the original visual estimates of the A/C index by *Svalgaard* [1972*b*]. Generally, we find that inferred away polarity is dominant on type A days, while inferred toward polarity is predominant on type C days, as was originally suggested by *Svalgaard* [1968]. This correspondence is further

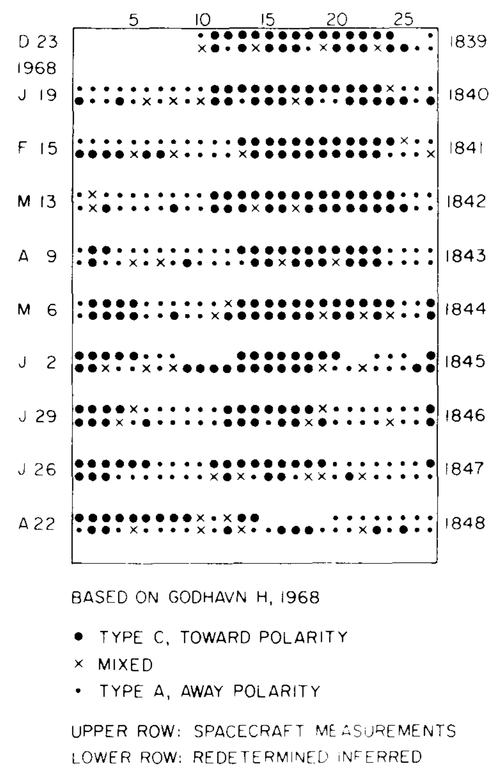

Fig. 3. Comparison between the polarity of the interplanetary magnetic field (toward the sun or away from the sun) as measured by spacecraft [*Wilcox and Colburn,* 1970] and the polarity inferred by using the recipe described in the text. The data are displayed in 27-day Bartels' rotations, with the date of the starting day of each rotation shown at the left.

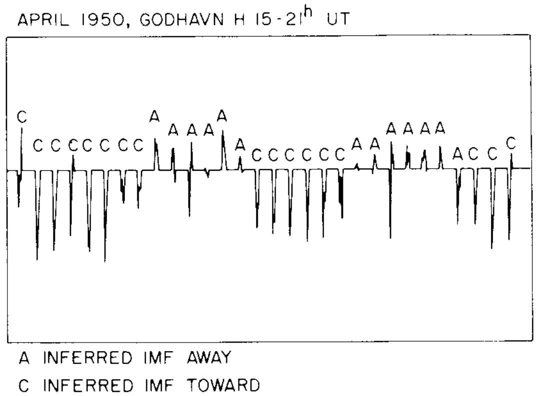

Fig. 4. Data for April 1950 plotted in the same format as used in Figure 2.

evidenced by Figure 5, where the original visual estimates are compared with the inferred polarities determined by using the algorithm given above for each day of 1950. In all the cases we have examined here, the agreement between the various estimates and determinations is of the order of 80% or better.

After it has been established that the A/C index is well correlated with the polarity of the interplanetary magnetic field most of the time, the few cases with obvious disagreements command particular attention. If the disagreements depend systematically on other properties of the disturbance pattern, which is a very reasonable assumption, it may have a strong influence on some of the statistical properties of the A/C index. Let us assume that the five international quiet days in a month (for some reason) are always classified as being of type A, while the five disturbed days are always classified as being of type C. The remaining twenty days are classified correctly. If geomagnetic activity were independent of the sector polarity, 2½ international quiet days and 2½ international disturbed days would be classified wrongly, meaning that out of the 30-day month, 25 days were classified correctly, corresponding to 83% agreement. We now assume that the quiet days have a C_i character figure of 0, that the disturbed days have a C_i character figure of 2, and that the remaining days are moderately active with a C_i character figure of 1. The average C_i figure for type A days then becomes $(10 * 1 + 5 * 0)/15 = 0.67$, while the average C_i figure for type C days becomes $(10 * 1 + 5 * 2)/15 = 1.33$, or twice as high.

This idealized example shows that the A/C index can well have a high information content (83% agreement) yet can be systematically contaminated such that C days appear much more active than A days. How serious this particular systematic error will be depends of course on what research problem the A/C index is applied to. One such application was the confirmation by *Wilcox and Scherrer* [1972] of a finding by *Rosenberg and Coleman* [1969] that the polarity of the interplanetary magnetic field measured out of the solar equatorial plane should be biased by the polarity of the magnetic pole of the sun, which is on the same side of the equator as the interplanetary probe.

When the interplanetary sector structure was first discovered [*Wilcox and Ness*, 1965] during the descending phase of sunspot cycle 19, there were four stable sectors. Analyses of the inferred field using the A/C index [*Svalgaard*, 1973] show that this four-sector pattern is a persistent feature of at least the last five sunspot cycles. The main conclusion from the analysis of the A/C index was that the solar sector structure evolves through rather similar patterns in each sunspot cycle. During most of the cycle a four-sector structure with synodic recurrence period near 27 days is apparent. Near sunspot maximum there emerges a superposed structure having polarity into the sun with a width of about 100° in longitude and a synodic recurrence period between 28 and 29 days. This '28½-day feature' coexists with the basic underlying four sectors for extended periods of time. At these times it may be difficult to discern the four-sector structure clearly, but when the 28½-day structure disappears or weakens some time after sunspot maximum, the four-sector structure becomes very prominent as the cycle progresses toward sunspot minimum. This evolutionary scheme has been observed directly by spacecraft during the present cycle, and the A/C index seems to indicate that the sunspot cycle variation of the sector structure is rather similar also in the previous four cycles.

It would seem that the A/C index, even in its present form, can be used to study the large-scale evolution of the sector structure through the sunspot cycle. For other kinds of study, such as the study of the average disturbance level for the two polarities separately, it seems equally certain that a revised A/C index will be needed. A dilemma arises between conflicting views on how this index should be constructed. Should it be a homogeneous index derived from the Godhavn station only but covering the full interval from 1926 to the present? Or should it be the 'best possible' index in the sense that whenever additional stations are available, they should be utilized to im-

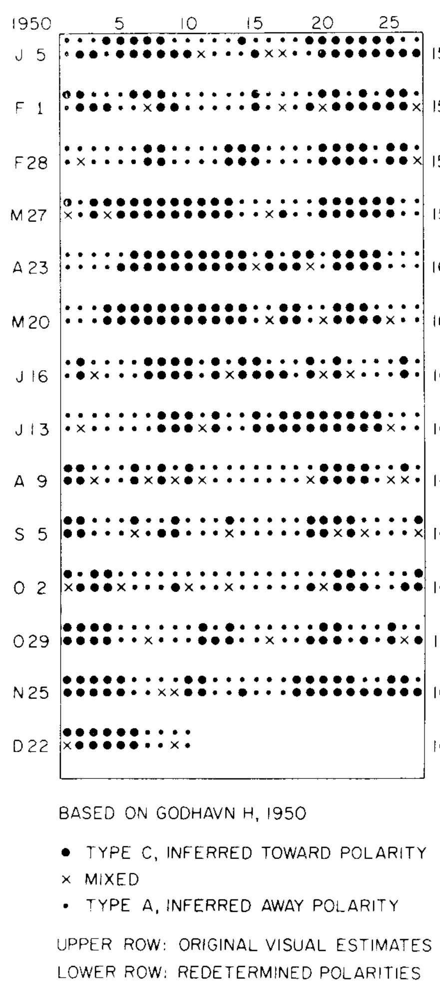

Fig. 5. Comparison between the polarity of the interplanetary magnetic field inferred by using the method described in the text and as originally classified by *Svalgaard* [1972*b*].

prove the index? A case can be made for both points of view. The list published by *Svalgaard* [1972*b*] is not a homogeneous list because additional data from other polar cap stations (mostly Thule) were used when available (mostly after 1963).

By using published yearbooks from the Godhavn Geophysical Observatory and the recipe given above a homogeneous A/C index could be produced. Analysis of statistical properties of this index may show various differences between polarities, seasons, and sunspot cycles. It would not be possible to establish which of these differences were due to artifacts in the index or due to real physical changes. A more constructive approach would be to intensify the study of polar cap geomagnetic variations, because it seems to this author that a purely mechanical recipe based on a few initial observations is not the proper solution to the very important problem of inferring the interplanetary magnetic field.

As *Rostoker* [1974] points out, the study of polar cap disturbances is still on unsure ground, and large arrays of observatories need to be set up to allow researchers to separate out the magnetic effects of many contributing current systems. The observed magnetic perturbation pattern in the polar cap may stem from (1) the distant effect of the auroral electrojets, (2) the high-latitude *Sq* current flow, (3) cross-polar cap ionosphere currents associated with magnetospheric convection, (4) the effects of distant field-aligned currents penetrating the auroral oval, and (5) the special vortexlike currents associated with variations in the azimuthal component of the interplanetary magnetic field. Varying degrees of activity produce dramatically different mixtures of all these effects, and much work remains to be done before these possible contributions can be separated out. A mechanical procedure which is not based on physical understanding can only provide a crude first approximation to the physical reality under study. But even an approximation can be very useful if it is applied within its limitations.

Returning to the discussion of interplanetary signatures in the geomagnetic field, we shall study the reason why some quiet days appear to show the A signature at Godhavn irrespective of the actual sign of the azimuthal component of the interplanetary field. Figure 6 shows the typical variation of Thule *Z* and Godhavn *H* for a few days around the sector boundary passing on July 25, 1968. These days are moderately to weakly disturbed. At Godhavn we note the normal night maximum, indicated by *T* on the figure, and the morning minimum, indicated by *S*. These features occur regularly every day independent of sector polarity. Both features invariably appear enhanced during magnetically active intervals. In addition, we note the characteristic signatures associated with the interplanetary field. A noon and afternoon positive perturbation, indicated by A, is correlated with eastward-pointing interplanetary magnetic field, and the negative perturbation, indicated by C, is associated with a westward interplanetary field. The Thule records also show dramatic change of the diurnal variation as the sector boundary passes. We emphasize that the typical signatures are reversed at the two stations, maximum at one corresponds to minimum at the other and vice versa.

However, this is not always the case. During intervals of prolonged geomagnetic calm, Thule *Z* still shows the correct signature corresponding to the interplanetary field, while Godhavn *H* develops a peculiar perturbation resembling very much the A signature. This happens even if the interplanetary magnetic field is westward, which should produce a C signature. Figure 7 shows a good example of this

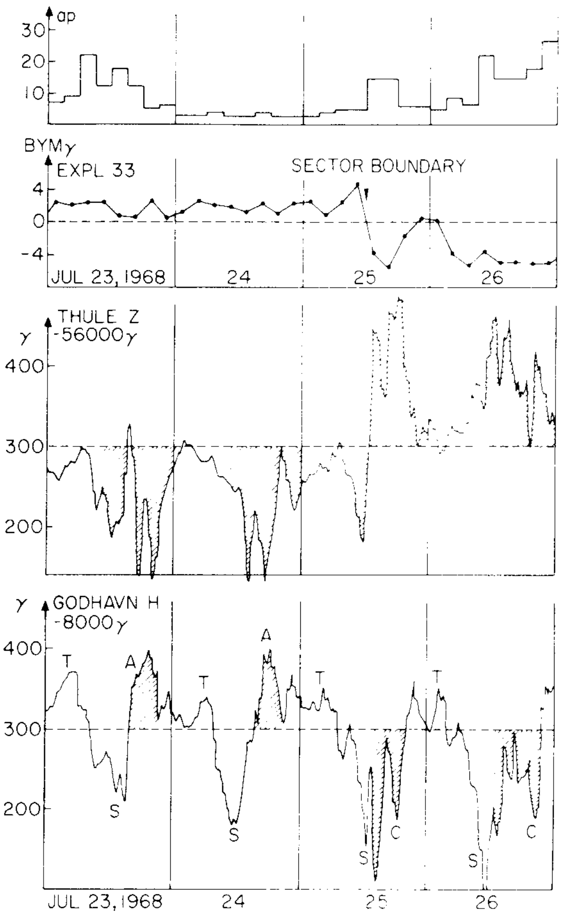

Fig. 6. Typical changes of the characteristics of the magnetic variations at Thule and at Godhavn as response to the passage of an interplanetary magnetic sector boundary on July 25, 1968. The upper panel shows the 3-hour planetary activity index *ap*. The next panel gives the azimuthal component of the interplanetary field in solar magnetospheric coordinates. The lower two panels display *Z* magnetograms from Thule and *H* magnetograms from Godhavn. The variations related to the sector polarity are shared.

phenomenon. During four consecutive days the interplanetary magnetic field is steady westward, and geomagnetic activity is very low. Thule *Z* shows a clear C signature on each day. All of what is left of a C signature in Godhavn *H* is a minor depression around 2100 UT. Otherwise a positive perturbation, denoted by a *P* on the records, in the afternoon is prominent in the diurnal variation. Without knowledge of the Thule magnetograms these four days would be classified as being of type A because the *P* perturbation has a strong resemblance to the A signature. In fact, Figure 3 shows that these four days actually are classified as type A.

What we are seeing here are examples of the $S_q{}^P$ variation, which may be observed on quiet days in the polar regions [e.g., *Kawasaki and Akasofu*, 1973]. Figure 8 shows the average $S_q{}^P$ variation at Godhavn, and it is now clear that many quiet days may have been classified as type A due to the similarity of the A signature to the $S_q{}^P$ variation. With increasing activity the *P* maximum in Figure 8 decreases, and the *S* minimum gets deeper, which may cause the day to be classified as a type C day. The $S_q{}^P$ variation thus introduces a bias in the A/C classification (when based on Godhavn *H*) in the sense that quiet days have a greater possibility of being classified as type A, while disturbed days have a greater possibility of being classified as type C. This systematic bias is expected to be most

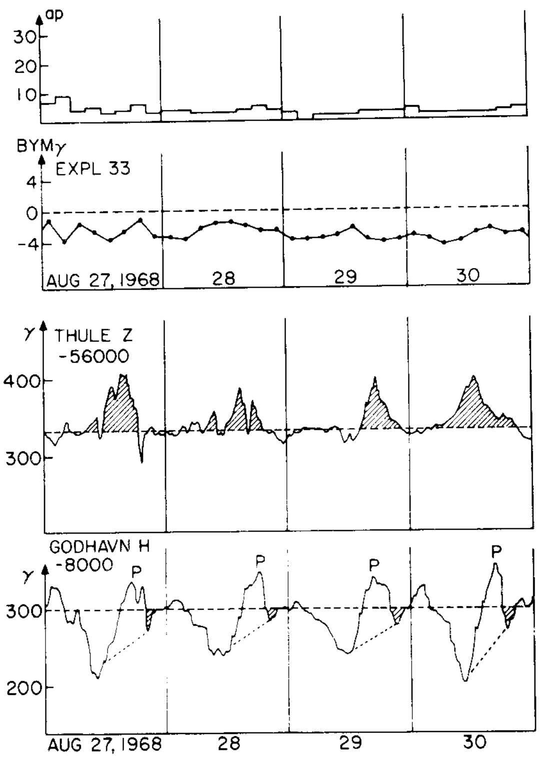

Fig. 7. Same format as used in Figure 6 but showing an atypical response at Godhavn as discussed in the text.

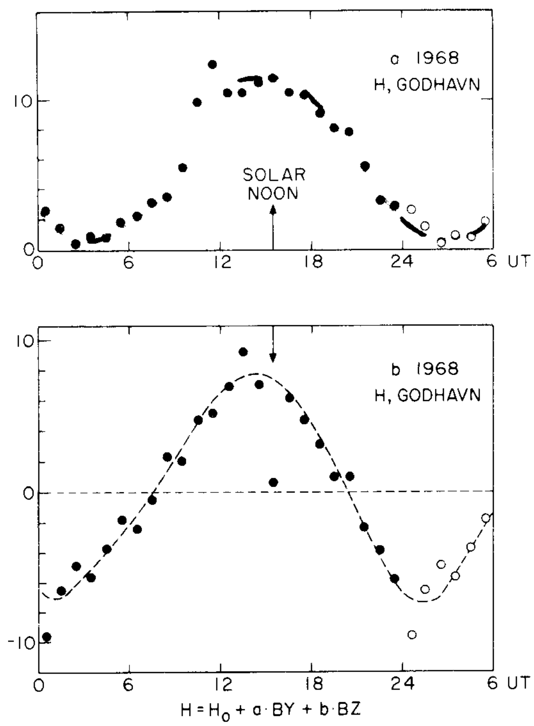

Fig. 9. Diurnal variation of the coefficients (*a* and *b*) of a fit $H = H_0 + a \cdot BY + b \cdot BZ$ of the horizontal *H* component at Godhavn to the east-west component *BY* and the north-south component *BZ* of the interplanetary magnetic field.

effective if the interplanetary signature is weak, i.e., if the interplanetary magnetic field strength is small. Furthermore, the bias reflects the changing size of the polar cap. On an internationally quiet day the polar cap is small, and Godhavn is heavily influenced by the $S_q{}^p$ currents flowing near the day side polar cap boundary. With increasing activity the polar cap expands, and Godhavn becomes a true polar cap station situated well within the polar cap boundary, and the influence of the $S_q{}^p$ currents is weaker. Since the size of the polar cap is determined by the north-south component of the interplanetary magnetic field [*Akasofu et al.*, 1973], it seems reasonable to fit the observed values of *H* to an expression of the form

$$H = H_0 + a \cdot BY + b \cdot BZ \qquad (1)$$

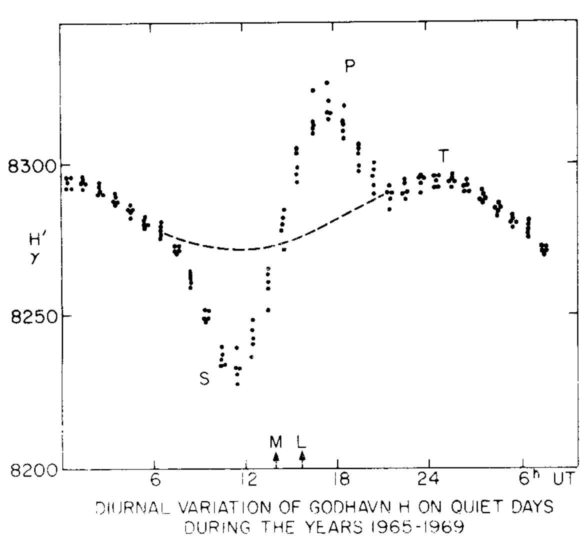

Fig. 8. Diurnal variation of the horizontal *H* component at Godhavn on internationally quiet days during 1965–1969.

where *BY* and *BZ* are the east-west and the north-south components of the interplanetary magnetic field and H_0 is a slowly varying background field. It is well known that H_0 has a yearly variation of the order of 30 γ. It is not known why. Further-

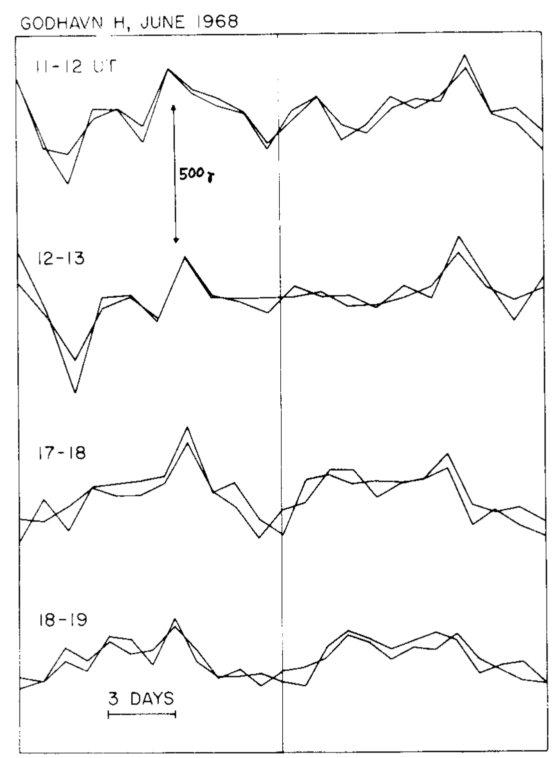

Fig. 10. Comparison between the observed values of *H* at Godhavn and the values computed from $H = H_0 + a \cdot BY + b \cdot BZ$ for four hourly intervals as indicated on the left side of each curve. The figure shows the values for each day during June 1968 for which interplanetary data were available.

more, H_0 has a roughly sinusoidal daily variation of the order of 80 γ. The coefficients a and b change during the day as shown in Figure 9 and also change with the seasons, being larger during summer. The values plotted are averages of the 12 monthly values obtained by fitting (1) separately for each month of 1968. Figure 10 gives some indication of the kind of fit which may be obtained by using the very simple expression (1). In computing the least squares fits, hourly averages were used. Since on time scales of an hour or more BY is generally greater than BZ and since $a > b$, we see that the effects of BY are generally greater than those of BZ during the day hours, whereas the opposite is true during the night hours, where a approaches zero. Roughly speaking then we might say that normally BY-related variations dominate during the day, while BZ-related variations dominate during the night. The same conclusion was also reached by *Kawasaki et al.* [1973].

Then, to the extent that fluctuations of BZ average out over a time scale of a few hours, Godhavn H is a fair indicator of the east-west component of the interplanetary magnetic field. Only when BZ has a constant sign for extended time intervals do its influences dominate over the influence of BY, and systematic errors are introduced into an index of sector polarity based exclusively on Godhavn H. These systematic errors will be of great importance in a study of the average disturbance properties of the two different polarities but will be of minor or no importance in a study of the long-term evolution of the interplanetary sector structure.

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