III

METHODS OF ANALYSIS

3.1 Processing the Raw Data

The raw data for any particular day is obtained by noting down the readings of the mechanical recorder, as registered on the photographic film, at odd hours: 2300 (previous day), 0100, 0300, ..., 2300. Differences between these successive readings then provide the twelve bihourly observations for the day centred at the hours: 0000, 0200, ..., 2200, and these may be termed:

\[ \begin{align*}
    &C_{01}, C_{02}, \ldots, C_{x1}, \ldots, C_{x22} \\
\end{align*} \]  \ ...(3.1)

where subscript 'x' refers to the hour of centering of the particular bihour and the superscript 'i' refers to the identity of the independent units of a detector e.g., two sections of the neutron pile, different meson telescopes having similar geometry, etc.

The independent units of the same detector are expected to show similar pattern of variation. This is tested by grouping the units into pairs and taking the differences

\[ \Delta C_x = C_x^1 - C_x^2 \]

between the bihourly counts recorded by the two units for every bihour for each pair. In ideal case no finite difference should exist between the corresponding bihours outside of the limits of statistical significance i.e.
\[ C_x = 0 \pm 2 \sqrt{2} \sigma_x \text{ for } 95.4\% \text{ of the cases; } \sigma_x \text{ being the standard error for the bihourly counts. However, because of slight difference in geometry, the difference in the sensitivity of the recording arrangement etc., a finite difference will always exist. But then this difference must remain constant within the confidence limits i.e.}

\[ \Delta C_x = d \pm 2 \sqrt{\sigma_1^2 + \sigma_2^2} \]

where 'd' is the constant difference and \( \sigma_1, \sigma_2 \) are the standard errors for the bihourly counts recorded by the two units. The probability for any difference to be greater than \( d \pm 2 \sqrt{\sigma_1^2 + \sigma_2^2} \) is only 4.6%.

Now if \( d_1, d_2, \ldots, d_n \) be the observed differences between the two units for a continuous run of 'n' bihours, then the best estimated value \( \overline{d} \) of the constant difference 'd' in particular case would be given by:

\[ \overline{d} = \frac{d_1 + d_2 + d_3 + \ldots + d_n}{n} = \frac{\sum d_n}{n} \]

The deviations \( \sum (d_n - \overline{d}) \) are then found and plotted on a graph paper. Such deviations are expected to be confined within the boundary lines drawn at a distance of \( +2\sqrt{\sigma_1^2 + \sigma_2^2} \) and \( -2\sqrt{\sigma_1^2 + \sigma_2^2} \) about the mean \( \overline{d} \); the probability for any deviations to exceed the boundary on either positive or
negative side being only 2.3%. So if the plot crosses the boundary lines on either side for a set of consecutive points for more than 2.3% cases then one of the units is suspected of faulty operation. To locate the faulty unit the variance of the same number of bihourly values preceding and following these bihours (36 in all, including these bihours) is calculated. The unit exhibiting the larger variance is the faulty unit. The faulty bihourly observations for this unit are then replaced by values manipulated from the corresponding bihourly observations of the normally working unit by multiplying these values by the averaged ratio of the means obtained on 5 days of the day in question when the two units were showing normal behaviour. The data from the two units is then combined.

The various groups of twos of similar units are then intercompared by the same method and then the data, at corresponding bihours, of all the similar units are added together to give the bihourly counts for the day. This procedure finally gives us raw data in a standard form for the various detectors e.g. neutron monitor, meson telescopes of various geometries etc. The combined bihourly values are then normalised to a mean of one thousand for the whole period by multiplying each bihourly value by thousand and then dividing it by the mean of the entire period.
3.11 Corrections for meteorological effects

3.111 Correction for barometric fluctuations: The values of atmospheric pressure are read out for 0000, 0200, 0400, ........., 2200 hours from daily precision microbarograph charts and these are expressed as deviations from the standard pressure level for the particular station. The standard pressure level for any station was determined from the average pressure over the course of a few years. The standard pressure levels for Gulmarg (λ = +25°, f = +147°, alt. = 2740 m), Ahmedabad (λ = +14°, f = +143°, sea level) and Kodaikanal (λ = +1°, f = +147°, alt. = 2343 m) are respectively, 525 mm, 750 mm, and 570 mm.

Using the pressure deviations calculated as above, the bihourly counts were corrected for pressure fluctuations using a pressure coefficient of -0.94 % mm⁻¹ in case of nucleonic component and -0.30 % mm⁻¹ in case of hard component recorded at Gulmarg.

3.112 Temperature Correction: As shown by Barkow (1917), Dines (1919), Bemmelan (1916), and Venkateswaran & Desai (1953), the amplitude of daily variation of temperature 2 km above ground, hardly amounts to a fraction of 1°C.

* The pressure coefficient for Gulmarg was calculated from the intensity (of hard component) versus altitude curves, given by Neher (1952).
which determination itself is not outside of instrumental error. So view is taken here, following Sarabhai et al (1953), that it is meaningful to correct the daily variation of hard component* only for temperature changes upto 2 km. above ground. Beers (1944) has shown that the temperature variations at 1 km. and at 2 km. above ground have amplitudes 0.22 and 0.11 times the amplitude of variation on ground level respectively.

Dorman and Feinberg (1956) have calculated the global temperature coefficient $K_1$ which should be used in conjunction with temperature variations at specific isobaric levels. These are summarised in the following table.

<table>
<thead>
<tr>
<th>Table of Coefficients $K_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
</tr>
<tr>
<td>Pressure h(mb)</td>
</tr>
<tr>
<td>$K_1 \times 10^{-3}$</td>
</tr>
</tbody>
</table>

Thus if $a_1$ °C be the amplitude of daily variation of temperature at ground level then combining the result of Beers' and of Dorman's, the temperature correction ($dT$) for the daily variation of temperature at Gulmarg between

* As shown in sec.1.52 the temperature correction for nucleonic component is negligible.
ground level (pressure ~ 700 mb.) and 2 km. above it (pressure ~ 500 mb.) amounts to.

\[ \Delta T = (a_T \times 0.024 + 0.22 a_T \times 0.025 + 0.11 a_T \times 0.026) \%
\]

\[ = a_T \times 1.33 \times 0.025 \% \text{ (taking a mean value for } K_1 = 0.025) \]

\[ = a_T \times 0.033 \% \]

\[ \ldots (3.4) \]

The temperature coefficient is thus \(-0.03 \, \% \, ^\circ C^{-1}\) for hard component recorded at Gulmarg.

The ground temperature values for every bihours on different days are read from the daily thermograph charts and these are expressed as deviations from the daily mean temperature. Using the temperature coefficient derived above, the data for the daily variation of hard component were corrected for the daily variation of temperature. No attempt was made to correct the daily mean intensity of the hard component for temperature effect because this requires data of temperature variations in higher isobaric levels which data were not available for Gulmarg. As such, no analysis, whatsoever, has been done for the daily mean intensity of the hard component. Only daily variation of hard component, which can be corrected for temperature effect (as shown above), is studied. It must, however, be noted that the above described method of applying temperature correction to the data of solar daily variation of hard
component is subject to certain uncertainties which become particularly important when the amplitude of solar daily variation is of the same order as the correction (\( \sim 0.05-0.10 \% \), as shown by Maeda, 1953 and Kuzmin, 1955) arising out of the daily variation of temperature. Hence due caution has to be exercised in interpreting the results in such cases.

3.2 Determination of solar daily variation

When bihourly data, normalised as described in Sec. 3.1, are corrected for pressure changes in the case of the nucleonic component and for pressure and temperature changes in the case of the hard component, as described above, they are referred to as normalised bihourly intensities corrected for meteorological effects and may be designated as: \( I_0, I_2, \ldots \ldots, I_x, \ldots \ldots, I_{22} \). The standard error due to statistical fluctuations in each bihourly intensity \( I_x \) is:

\[
\varepsilon I_x = \frac{(I_x^2 + k)^{1/2}}{I_x k} + 100 = \frac{100}{(I_x^2 + k)^{1/2}} \quad \ldots (3.5)
\]

where \( k \) is the scaling factor. The mean intensity (\( \overline{I} \)) for the day is then,

\[
\overline{I} = \frac{I_0 + I_2 + I_x + \ldots + I_{22}}{12} \quad (3.6)
\]
The standard error in $\bar{I}$ is given by

$$\sigma_{\bar{I}} = \frac{\sigma_{I_x}}{(12)^{\frac{1}{2}}} \quad \ldots (3.7)$$

The solar daily variation for any particular day is then represented by the 12 bihourly deviations:

$$(I_0 - \bar{I}), (I_2 - \bar{I}), \ldots, (I_x - \bar{I}), \ldots, (I_{22} - \bar{I}) \quad \ldots (3.8)$$

However, in case of nucleonic component large day to day changes of intensity take place and hence the deviations representing the daily variation curve, in case of nucleonic component, should be further corrected for changes of intensity with period longer than one day. So nucleonic bihourly intensities were, in addition, subjected to the following treatment.

From each normalised and pressure corrected bihourly values the mean of 13 bihours, comprising the particular bihour and 6 bihours on either side of it, is subtracted and this is repeated for each bihour. Let the residual bihourly

* The method of taking moving averages over 13 bihours, to correct the solar daily variation data for day to day changes, was adopted because of convenience in calculating and as can be shown from elementary calculations it is not subject to any appreciable error.
intensities be $i_0, i_2, i_4, \ldots, i_x, \ldots, i_{22}$. Then

$$(i_0 - \bar{I}), (i_2 - \bar{I}), \ldots, (i_x - \bar{I}), \ldots, (i_{22} - \bar{I})$$

$$= U_1 = U_2 = U_k = U_{12}$$

...(3.9)

where

$$\bar{I} = \frac{i_0 + i_2 + i_4 + \ldots + i_x + \ldots + i_{22}}{12}$$

...(3.10)

with

$$\sum_{k=1}^{12} U_k = 0$$

...(3.11)

$U_k$ thus determine the solar daily variation for the day with day to day changes, largely, eliminated.

In general, because of large statistical uncertainties it is difficult to get any information about the genuine variations from the data of a single day. Hence it is customary to derive the average daily variation over a large number of days, selected and grouped according to suitable criteria. The average daily variation for a group of days, selected in this manner, is found by combining the deviations corresponding to the same bihourly interval of all the days in the group and then dividing each bihourly total by the number of days in the group.
3.3 Harmonic analysis

3.31 Expansion into Fourier series

To represent the aggregate of experimental data $U_k (k = 1, 2, \ldots, 2p)$ in a definite interval of time $T$, in the form of a Fourier's series

$$U(t) = \frac{a_0}{2} + \sum_{n=1}^{\infty} \left( a_n \cos \frac{2\pi nt}{T} + b_n \sin \frac{2\pi nt}{T} \right)$$

...(3.12)

we must find the Fourier coefficients $a_0, a_1, b_1, \ldots, \ldots$.

These coefficients are expressed in terms of the integrals (where $T = \frac{2\pi t}{T}$)

$$a_0 = \frac{1}{\pi} \int_0^{2\pi} U(\tau) \, d\tau; \quad a_n = \frac{1}{\pi} \int_0^{2\pi} U(\tau) \cos n\tau \, d\tau;$$

$$b_n = \frac{1}{\pi} \int_0^{2\pi} U(\tau) \sin n\tau \, d\tau \quad \ldots(3.13)$$

If the $U_k$ are given at equal intervals of time, then the Fourier's coefficients for $n < p$ are calculated from the following expressions (Bessel, 1815, formulas)

$$a_0 = \frac{1}{p} \sum_{k=1}^{2p} U_k; \quad a_n = \frac{1}{p} \sum_{k=1}^{2p} U_k \cos \frac{nk\pi}{p};$$

$$b_n = \frac{1}{p} \sum_{k=1}^{2p} U_k \sin \frac{nk\pi}{p} \quad \ldots(3.14)$$
If eqs. (3.14) be substituted in eqs. (3.12), then the resultant series at \( t = \frac{KT}{2p} \) takes exactly the values of the \( U_k \), thereby satisfying the principle of least squares. Further if \( p = 6 \) i.e. \( U_k \) represent the twelve bihourly deviations characterising the solar daily variation on any particular day, then

\[
a_0 = 0 \quad (\therefore \sum_{k=1}^{12} U_k = 0 \text{ from eq.3.11}) \quad (3.15)
\]

Many authors e.g. Thompson (1911), Whittaker and Robinson (1937), Henny (1941), Serebrennikov (1948), and Kane (1954), have suggested diverse methods for evaluating the Fourier's coefficients. Author has followed Kane's 12-ordinate calculation scheme, which is illustrated in the appended chart.

Eq. (3.12) can also be written in the form of the sum of individual harmonics (combining the terms of the same periods):

\[
U(t) = \sum_{n=1}^{\infty} r_n \sin \left( \frac{2\pi nt}{T} + \gamma_n \right), \quad (a_0 = 0, \text{ from eq.3.15})
\]

\[
(3.16)
\]

It follows from eq. (3.16) that the amplitude of the \( n \)th harmonic is

\[
r_n = \sqrt{\frac{2}{2a_n + b_n^2}} \quad (3.17)
\]
while the phase $\gamma_n$ is determined from

$$\tan \gamma_n = \frac{a_n}{b_n} \quad \text{or} \quad \gamma_n = \arctan \left( \frac{a_n}{b_n} \right) \quad \ldots (3.18)$$

If we denote

$$|\gamma_n| = \arctan \left| \frac{a_n}{b_n} \right| \quad \ldots (3.19)$$

then the phase $\gamma_n$ is defined in terms of $|\gamma_n|$, depending upon the sign of $a_n$ and $b_n$ by means of the following Table:

<table>
<thead>
<tr>
<th>$a_n$</th>
<th>$b_n$</th>
<th>$\gamma_n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
<td>$</td>
</tr>
<tr>
<td>+</td>
<td>-</td>
<td>$\pi -</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>$\pi +</td>
</tr>
<tr>
<td>-</td>
<td>+</td>
<td>$2\pi -</td>
</tr>
</tbody>
</table>

Again the $n$th harmonic given by $r_n \sin \left( \frac{2\pi t}{T} \cdot n + \gamma_n \right)$ will have the maximum amplitude $r_n$, when

$$\frac{2\pi t}{T} \cdot n = n \cdot \theta_n \quad \ldots (3.20)$$

where $\theta_n$ is the time of maximum of $n$th harmonic in degrees.

Thus we have
\[ n \cdot \phi_n + \gamma_n = 90^\circ \text{ or } n \cdot \phi_n = 90^\circ - \gamma_n \quad \cdots (3.21) \]

The above table therefore, be modified to give \( n \cdot \phi_n \) directly in terms of \( |\gamma_n| \) by subtracting \( \gamma_n \) values from \( 90^\circ \).

Modified table is given below:

<table>
<thead>
<tr>
<th>( a_n )</th>
<th>( b_n )</th>
<th>( n \cdot \phi_n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma_n )</td>
<td>+</td>
<td>( 90^\circ - \gamma_n )</td>
</tr>
<tr>
<td>+</td>
<td>-</td>
<td>( -(90^\circ - \gamma_n) )</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>( \pi + (90^\circ - \gamma_n) )</td>
</tr>
<tr>
<td>-</td>
<td>+</td>
<td>( 90^\circ + \gamma_n )</td>
</tr>
</tbody>
</table>

To get the time of maximum of \( n \)th harmonic in hours one has to divide the value of \( \phi_n \) (in degrees) by 15.

3.32 Harmonic diagram

For a clear representation and convenient study of the results obtained by harmonic analysis, wide use is made of their representation by the aid of vectors on a harmonic diagram. Such diagrams may be constructed both for the first harmonic and higher harmonics; for \( n \)th harmonic, the period of diagram would be \( \frac{T}{n} \) as shown in Fig.18.
The radius vector of the points \((a_n, b_n)\) on such a dial will be \(r_n = (a_n^2 + b_n^2)^{\frac{1}{2}}\) while the angle between the \(b\)-axis and radius vector, measured counter clockwise will be the phase, \(\gamma_n\) of the \(n\)th harmonic (eq. 3.18). The angle between \(a\)-axis and the radius vector, measured clockwise, gives the time of maximum, \(\phi_n\), of the \(n\)th harmonic.

Thus if this representation be used to denote the harmonic components of the solar daily variation, then \(T = 24\) hrs. For first harmonic or diurnal component of solar daily variation \(n = 1\); for second harmonic or semidiurnal component of solar daily variation \(n = 2\) and so on.
3.33 Errors in the Fourier coefficients

The standard error \( \sigma \) of a function \( F(m_1, m_2, m_3, \ldots, m_n) \) of \( m_1, m_2, m_3, \ldots, m_n \) corresponding errors of which are \( \sigma_1, \sigma_2, \sigma_3, \ldots, \sigma_n \) is given by (e.g., see Topping, 1955):

\[
\sigma^2 = \left( \frac{dF}{dm_1} \right)^2 \sigma_1^2 + \left( \frac{dF}{dm_2} \right)^2 \sigma_2^2 + \ldots + \left( \frac{dF}{dm_n} \right)^2 \sigma_n^2
\]

or \( \sigma^2 = \left\{ \sum \left( \frac{dF}{dm_n} \right)^2 \frac{2}{\sigma_n^2} \right\}^{\frac{1}{2}} \) \hspace{1cm} \ldots(3.22)

where \( \frac{dF}{dm_1}, \frac{dF}{dm_2}, \ldots, \frac{dF}{dm_n} \), are the partial differential coefficients of \( F \) with respect to \( m_1, m_2, \ldots, m_n \).

Since the Fourier's coefficients are expressed by certain linear functions of \( U_k \) of the form \( \sum \lambda_k U_k \), where \( \lambda_k \) are the corresponding factors of the grouping (for instance, refer to the chart showing analysis scheme), the errors of the coefficients will be determined by the quantity (using eq.3.22):

\[
(\sum \lambda_k^2 \cdot \sigma_k^2)^{\frac{1}{2}} = \left( \sum \lambda_k^2 \right)^{\frac{1}{2}} \cdot \sigma \triangleq \sigma \hspace{1cm} \ldots(3.23)
\]

taking

\[
\sigma_1 = \sigma_2 = \ldots = \sigma_k = \sigma \hspace{1cm} \ldots(3.24)
\]
where $\sigma_k$ is the standard error in $U_k$. An elementary calculation shows that, in the scheme for 12 ordinates, we have

$$\sigma_{a_n} = \sigma_{b_n} = \frac{\sigma}{(6)^{\frac{1}{2}}} = 0.41 \sigma \quad \ldots (3.25)$$

Hence taking account of eqs. (3.17) and (3.18) in conjunction with eq. (3.22) we have

$$\sigma_{r_n} = \left( \frac{a_n^2}{a_n^2 + b_n^2} \cdot \sigma_{a_n}^2 + \frac{b_n^2}{a_n^2 + b_n^2} \cdot \sigma_{b_n}^2 \right)^{\frac{1}{2}}$$

$$= 0.41 \sigma \quad \ldots (3.26)$$

and

$$\sigma_{\psi_n} = \frac{1}{\left(1 + \left(\frac{a_n}{b_n}\right)^2\right)^{\frac{1}{2}}} \left( \frac{a_n^2}{b_n^2} \cdot \sigma_{a_n}^2 + \frac{b_n^2}{b_n^4} \cdot \sigma_{b_n}^2 \right)^{\frac{1}{2}}$$

$$= \frac{0.41 \sigma}{r_n} = \frac{\sigma_{r_n}}{r_n} \quad \ldots (3.27)$$

$\sigma_{r_n}$, $\sigma_{\psi_n}$, being the errors in the amplitude and phase of the $n$th harmonic, respectively. Thus, on the harmonic dial, when plotting the results of the harmonic analysis of the data $U_k$ each having error $\sigma$, a circle of radius $\sigma_{r_n} = 0.41 \sigma$ (for 12-ordinate Scheme) characterising the accuracy of the given harmonic must be drawn about the point $(a_n, b_n)$. 
3.4 Method of separation of quasi-periodic variation

Small quasi-periodic variations in cosmic rays which are masked by the statistical fluctuations of individual measurements can be detected by the aid of a special averaging method, first used in the studies of geomagnetic variations by Chree (1913) and known after him as Chree's method of superposed epochs.

Suppose we single out 'n' epochs on a certain criterion and we wish to study the association of such epochs with the intensity changes in cosmic rays. To do this the values of cosmic ray intensity corresponding to the times of onset of these epochs are entered in a vertical column numbered 0. The values of the intensity for the times following the times so chosen are then entered in a sequence of columns arranged to the right of the column marked 0 and are numbered +1, +2, +3, .... etc. The data for times preceding the time 0 are entered in columns arranged to the left of the column 0 and are numbered -1, -2, -3, .... etc. In the table so obtained consisting of n rows, the mean value of the cosmic ray intensity for each column is then found and plotted on a graph against the corresponding column number. The curve so obtained very clearly brings out the relationship, if any, between the epochs used and cosmic ray intensity and at the same time, it gives the recurrence period if any recurrence tendency is present in the cosmic ray effect.
3.5 Correlation analysis

The method of correlation is a mathematical process for determining the degree of relationship between two variables, say, \( x \) and \( y \). The relationship is characterised by a coefficient called, 'correlation coefficient'. If \( \Delta x, \Delta y \) represent the deviations from the mean of \( x \) and \( y \) over a common interval of time and if \( 'n' \) is the number of pairs, the correlation coefficient \( r_{x,y} \) between \( x \) and \( y \) is given by:

\[
y = \frac{n \sum xy - \left( \frac{n}{n} \sum x \sum y \right)}{\sqrt{\left[ \left( \frac{n}{n} \sum x^2 - \left( \frac{n}{n} \sum x \right)^2 \right) \left( \frac{n}{n} \sum y^2 - \left( \frac{n}{n} \sum y \right)^2 \right) \right]}} \quad \ldots(3.23)
\]

\[
y = \frac{n \sum \Delta x \sum \Delta y}{\sqrt{\left[ \left( \frac{n}{n} \sum (\Delta x)^2 \right) \left( \frac{n}{n} \sum (\Delta y)^2 \right) \right]}} \quad \ldots(3.29)
\]

Any of the above two equations can be used to determine the correlation coefficient. \( r_{x,y} \) can be positive or negative which respectively indicates whether \( x \) and \( y \) vary in the same or in the opposite manner. \( r_{x,y} = 0 \) would indicate that there is no relationship between \( x \) and \( y \) whatsoever.

The standard error \( (\sigma_y) \) in \( r_{x,y} \) is given by:
\[ \frac{1}{\sqrt{\frac{2}{n} \left( \sum_{x,y} x^2 \right)}} \]  

which shows that the larger the number of pairs \( n \) and the larger the value of \( \sqrt{N} \), the smaller would be \( \sigma_y \).

### 3.6 The \( X^2 \) test

To test the conformance of a series of \( n \) values of \( I_n \) to the Poisson law, where the interval length is the same for all the determinations we compute,

\[ X^2 = \frac{n}{\bar{I}} (\bar{I} - I_n)^2 \]  

where,

\[ \bar{I} = \frac{1}{n} \sum_{i=1}^{n} I_i \]

Elderton (Elderton's tables of goodness of fit) has prepared a table of \( X^2 \) from which, knowing the number of degrees of freedom of \( n \) measurements, one can find out the proportion of the cases \( P \) in which a particular value of \( X^2 \) will be exceeded. Applying this to the case of solar daily variation where we have 12 bihourly measurements, and so the degree of freedom is 11, the probability \( P \) that \( X^2 \) will exceed any specified value is given in the following Table.
Thus in 99.9% of the cases $X^2$ should have a value $\leq 26.22$, if daily variation were to be due to purely statistical fluctuations. The more the value of $X^2$ the greater would be the dispersion of bihourly intensities about the daily mean intensity and hence the greater would be the amplitude of the daily variation.

3.7 Punch card system of tabulation of data

A detailed study of the various aspects of the daily variation of cosmic rays involves the determination of frequency distributions, the sorting out of days according to different criteria, evaluating the parameters of the average daily variation on groups of days thus sorted out and the determination of the time series of different parameters.

In analyses of this nature, it is convenient to use the punch card system of tabulation of data so that the

* which would be given by eq. 3.22, where $I_n$ is the bihourly intensity centred at the hour 'n'.

\[ P = 0.5, 0.1, 0.05, 0.01, 0.001 \]

\[ X^2 = 12.90, 17.23, 19.68, 24.73, 26.22 \]
standard electrical sorting and tabulating machines can be used to perform these various computational operations. In the present investigation, Hollerith cards having eighty columns and ten rows were used for tabulating the primary data corrected for meteorological effects. The following information is punched on the cards:

<table>
<thead>
<tr>
<th>Column No.</th>
<th>Information punched</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2</td>
<td>Identity numbers of the recording instrument.</td>
</tr>
<tr>
<td>3, 4</td>
<td>Year.</td>
</tr>
<tr>
<td>5, 6, 7</td>
<td>Day of the year.</td>
</tr>
<tr>
<td>8, 9</td>
<td>$c_p$</td>
</tr>
<tr>
<td>10</td>
<td>Number indicating whether any bihourly deviation in percent is greater than 5.0% or less than -5.0% for the day.</td>
</tr>
<tr>
<td>11, 12, 13</td>
<td>Blank.</td>
</tr>
<tr>
<td>14 to 37</td>
<td>The 12 bihourly deviations in percent to which 5.0% has been added to make them all positive.</td>
</tr>
<tr>
<td>38, 39</td>
<td>Residue in percent to which 5.0% has been added to make it positive.</td>
</tr>
<tr>
<td>40</td>
<td>Number characterising any manipulations made in bihourly intensities.</td>
</tr>
<tr>
<td>41</td>
<td>Number of similar units running for the day.</td>
</tr>
<tr>
<td>42</td>
<td>Scaling factor of the recorder.</td>
</tr>
<tr>
<td>Column No.</td>
<td>Information punched</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------</td>
</tr>
<tr>
<td>43 to 46</td>
<td>Pressure corrected mean intensity for the day.</td>
</tr>
<tr>
<td>47 to 50</td>
<td>Blank.</td>
</tr>
<tr>
<td>51 to 58</td>
<td>(a_1, b_1, a_2, b_2) the Fourier coefficients for the day in percent to which 5.0 % has been added to make them all positive.</td>
</tr>
<tr>
<td>59 to 66</td>
<td>(r_1, \phi_1; r_2, \phi_2) the harmonic parameters characterising the diurnal and semidiurnal variation for the day.</td>
</tr>
<tr>
<td>67, 68</td>
<td>Ratio (r_1/r_2).</td>
</tr>
<tr>
<td>69, 70</td>
<td>(X^2) for the day.</td>
</tr>
<tr>
<td>71 to 80</td>
<td>Blank.</td>
</tr>
</tbody>
</table>