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# A CONTRIBUTION TOWARDS SOLVING THE QUESTION OF THE OCCURRENCE OF CHROMOSPHERIC FLARES BEFORE GEOMAGNETIC STORMS.

by Bohumila Bednářová-Nováková

Geophysical Institute,
Czecosl. Acad. Sci., Prague

ABSTRACT

The incorectness of the hypothesis according to which flares should be the source of corpuscular solar radiation, which is responsible for the origin of geomagnetic storms, is proved on the basis of determining the number of geomagnetic storms not preceded by any flares. Using the list of guaranteed large flares from the IGY of C.S. Warwick [14] and making an analysis of the solar situations occuring simultaneously with flares but on the CM or in the centre of the solar disc, it was shown why some flares were followed by a geomagnetic storm while after others, on the contrary, a period of absolute geomagnetic quiet set in.

Since it was shown that geomagnetic storms are preceded by changes in the magnetic fields in the solar chromosphere and because flares also occur during such changes, the question arises, what role do flares play here? Are they the cause of such changes or are they their product ? It is deduced, and observations confirm this, that olthough flares are produced as a sort of consequence of changes in the photospheric fields, they can simultaneously be regarded to a certain degree as the cause of substantial changes in the chromosphere which lead to the annulling of the field at least in that component which is represented by chromospheric structure and filaments. Their relationship to geophysical effects of a solar corpuscular origin is, however, quite indirect and very limited.

The fact that after the first historically recorded observation of a flare on September 1, 1859, by Carrington and Hodson and also after the two consecutive flares on August 3 and 5, 1872, which were observed by Young , a strong geomagnetic storm always followed , led to the hypothesis of a connection between flares and geomagnetic storms. This hypothesis was also supported by the classical observations of G.E. Hale, carried out from 1892, using the new instruments developed by him : a spectroheliograph and later by means of a spectrohelioscope. After the discovery of the radiotelescope and after it was found by means of it that in the period when a flare occurs on the Sun, radiation is sometimes magnified on some wave-lengths (much longer than the optical), it was hoped that this meant an indicator of an effusion of corpuscular radiation had been found, i.e. such radiation which is responsible for the origin of geomagnetic disturbances. It was only later that it was discovered that not even this fact can be used for example for prognoses etc.

From the hypothesis on the connection between flares and geomagnetic storms the opinion gradually developed that flares were the direct source of geoactive corpuscular radiation. However, flares in themselves are not high formations [1] and than they are observed on the edge of the solar disc, they do not exhibit any marked rise of matter to any great height [2]. They are often accompanied by rising prominences which, as will be seen later, may be conceived as the consequence of changes in the local magnetic field which occur often without flares and sotimes during a flare. It is this random simultaneity of the two effects which is the cause of frequent mistakes so that there are some authors who speak of flares but obviously have in mind rising prominences. That these are two quite different effects, which probably have no direct physical inter-relationship, is borne out by the fact that disappearing filaments-rising prominences occur ~~[illegible]~~ very often in absence of flares. It seems that the two phenomena are likely the consequences of one and the same cause. Sometimes they occur simultaneously and other times only one of them appears.

Flares occur almost universally in active centres and are thus only one part of a complex of events which occur shortly after one another or at absolutely the same time. From the consequences occurring after either a shorter or a longer interval it is impossible to deduce a connection with the different effects separately. This is even more difficult with geomagnetic storms which exhibit a longer time lag after sudden changes occurring on the Sun. If, however, the mechanism of the effusion of corpuscular radiation and its propagation towards the Earth is to be found, it must first be determined whether such a phenomenon can be found among the known expressions of solar activity which, in each period and during the whole cycle of solar activity, would be reliable indicator of geomagnetic storms. It is also necessary to give physical reasons for each connection found. One must also take into consideration an explanation of the fact that sometimes no connection was found. As is clear from the many papers already published, it was found in the Geophysical Institute of the Czechoslovak Academy of Sciences that of all the known expressions of solar activity studied by optical methods the best indicators of the origin of geomagnetic storms are filaments and the fine chromospheric structure under certain circumstances. As will be seen below, in the period of greater solar activity, i.e. in the period of flare occurence, these are eruptive and disappearing filaments, denoted in the Geophysical Institute by the one term - unstable filaments - which, only if they are in a suitable position, safely indicate when a geomagnetic storm with ssc will occur [3]. This is because such phenomena, as will be seen later, provide direct information on changes in the magnetic field of the Sun. And it is then only these changes which are actually the direct indicators of changes in the corona and thus also of the origin of geomagnetic storms.

Doubts as to flares being the source of corpuscular radiation were raised by D.Van Sabben [4], R.A.Watson [5] and O.M. Barsukov [6]. The statistical paper by C.S. Warwick and R.T. Hansen [7] shows the not very high ma-xima of the Ap-indices after flares in the period of greater solar activity for flares nearer to the CM but does not give positive results for the period before the minimum. It can easily be supposed, and later this will be quite clearly proved, that the circumstance can regarded as merely a statistical phenomen, as is also clear from the table given in [8]: the more elements contained by the two series compared, the more frequently two of them are found which are either simultaneous or follow one another in a certain time interval. The effect is the same although one series is much more numerous than the other, as is the case when the number of flares greatly exceeds, particularly in periods of greater activity, the number of geomagnetic storms. It is seen from Tab. I. and even better from Fig.1 that a decrease in the number of flares after the maximum (1959-60) is followed not by decrease but by an increase in the number of geomagnetic storms whether flares of greater importance or whether ~~of~~ all, including those with the smallest importance, are used for the comparison. No connection can be observed even if one takes the number of ssc or the greatest storms which, according to accepted world opinion, should be connected with flares but which, as will be seen later, indicate no pronouced connection.

Table I Comparison between number of flares and number of geomagnetic storms.

| Year | number of flares Imp. 3,3+ | 2 | 1 | 1- | total ≧2 | total ≧1- | number of geomag. storms all Kp≧5+ | ssc |
|---|---|---|---|---|---|---|---|---|
| 1957, 2nd half | 25 | 203 | – | – | 228 | 5189 | 27 | 17 |
| 1958 | 24 | 327 | – | – | 351 | 9668 | 42 | 24 |
| 1959 | 30 | 239 | 2208 | 910 | 269 | 3387 | 50 | 22 |
| 1960 | 19 | 118 | 1490 | 541 | 137 | 2168 | 72 | 32 |
| 1961 | 10 | 38 | 787 | 294 | 48 | 1129 | 35 | 17 |

The results in the paper by J. Halenka [9], [10] also give rise to doubts as to the direct connection between chromospheric flares and geomagnetic storms,

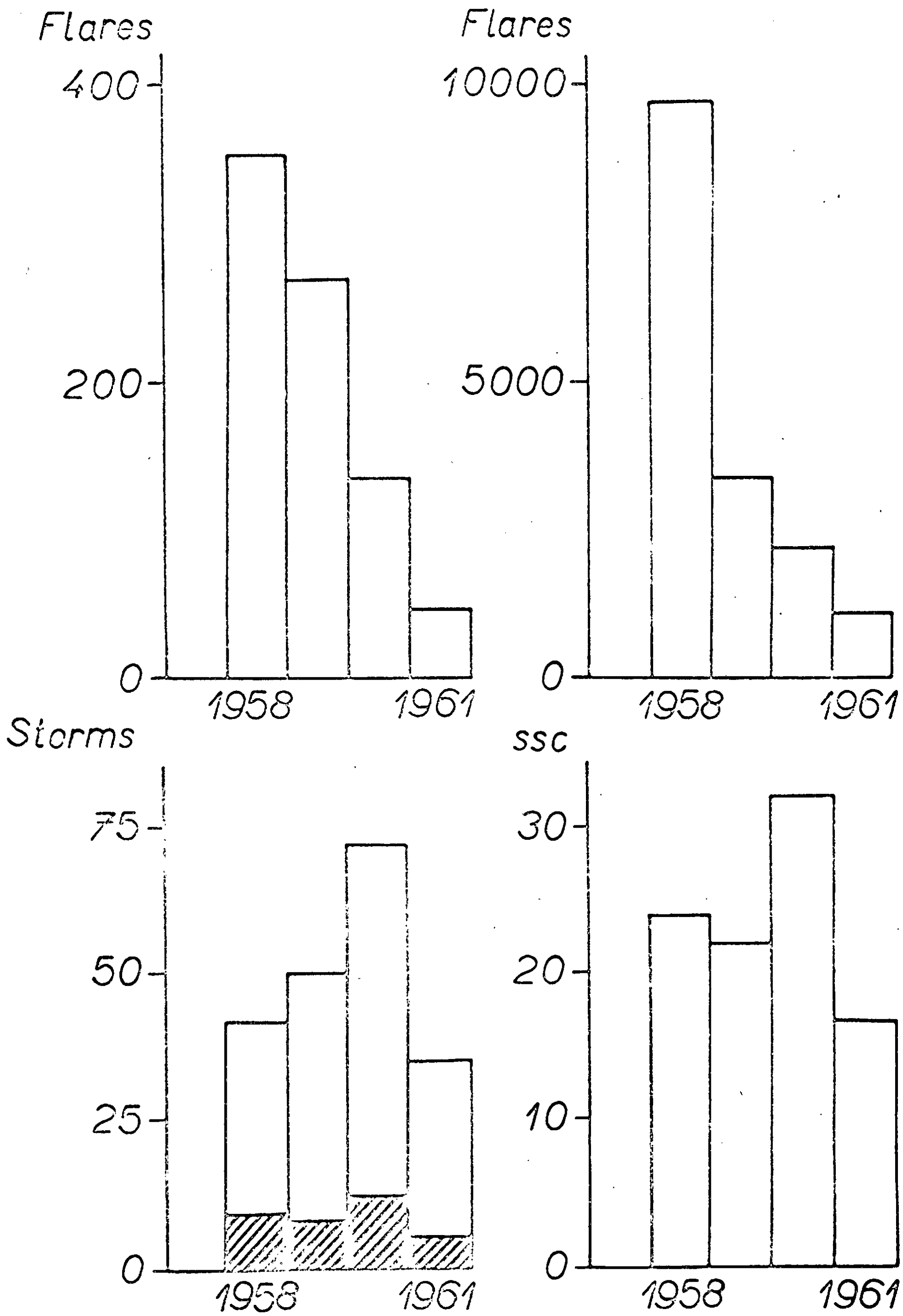


Fig. 1. Comparison of number of flares with number of geomagnetic storms in 1958-61 ; top left: flare $\geqq$ 2, top right: flare $\geqq$ 1-, bottom left: geomagnetic storm Kpmax. $\geqq$ 5+ , dashed line - large geomagnetic storm Kpmax. $\geqq$ 7+, Kpmin. = 5-, bottom right: ssc.

as given in [11]. The author of the present paper showed [12] that when studying the flare activity of different active centres during the whole period of passage over the solar disc a geomagnetic storm occurred only after the CMP of the active centre in which flares occurred throughout the period. This means that flares outside the CM fell flat. This is in complete agreement with the results of O.M. Barsukov [6].

In 1961 a paper was published by B. Bell [13] from which it is clear that the connection between flares and geomagnetic storms is doubtful if it is guaranteed, and then only in the relatively long interval of three days, only to 50%. Not even a distribution according to the magnetic types of spots, in the neighbourhood of which the flares occured, gives satisfactory results. Despite these facts flares are continually given in di-relation with geomagnetic storms. But the question of theoretical opinions, in the same way as the question of prognoses, necessitates a detailed investigation. For this reason the author decided to supplement the work of B.Bell and to find, on the contrary, how great a percentage of geomagnetic storms is preceded by flares. This kind of research is part of the work of the heliogeophysical group of the geomagnetic department of the Geophysical Institute which aims at leaving no geomagnetic storm unexplained.

For this purpose the material from 30.VI. 1957 to the end of 1962 was investigated. Only material from these years, thanks to the IGY and IGC, can be regarded as practically complete as regards flares. The work was divided into several stages.

1) The percentage of geomagnetic storms for Kpmax $\geqq$ 5+ was found which were not preceded by any flares $\geqq$ 2 in intervals of 10-48 hours, 10-60 hours, 10-72 hours. These are relatively long intervals. In an earlier paper the present author found shorter intervals, valid for disappearing filaments, i.e. 28-38 hours. Since, however on account of the small number of observations from which these values were derived they must be regarded as provisional. Since an interval of three days was used in the work of B.Bell, such longer time intervals were left in the present paper as well. Indeed

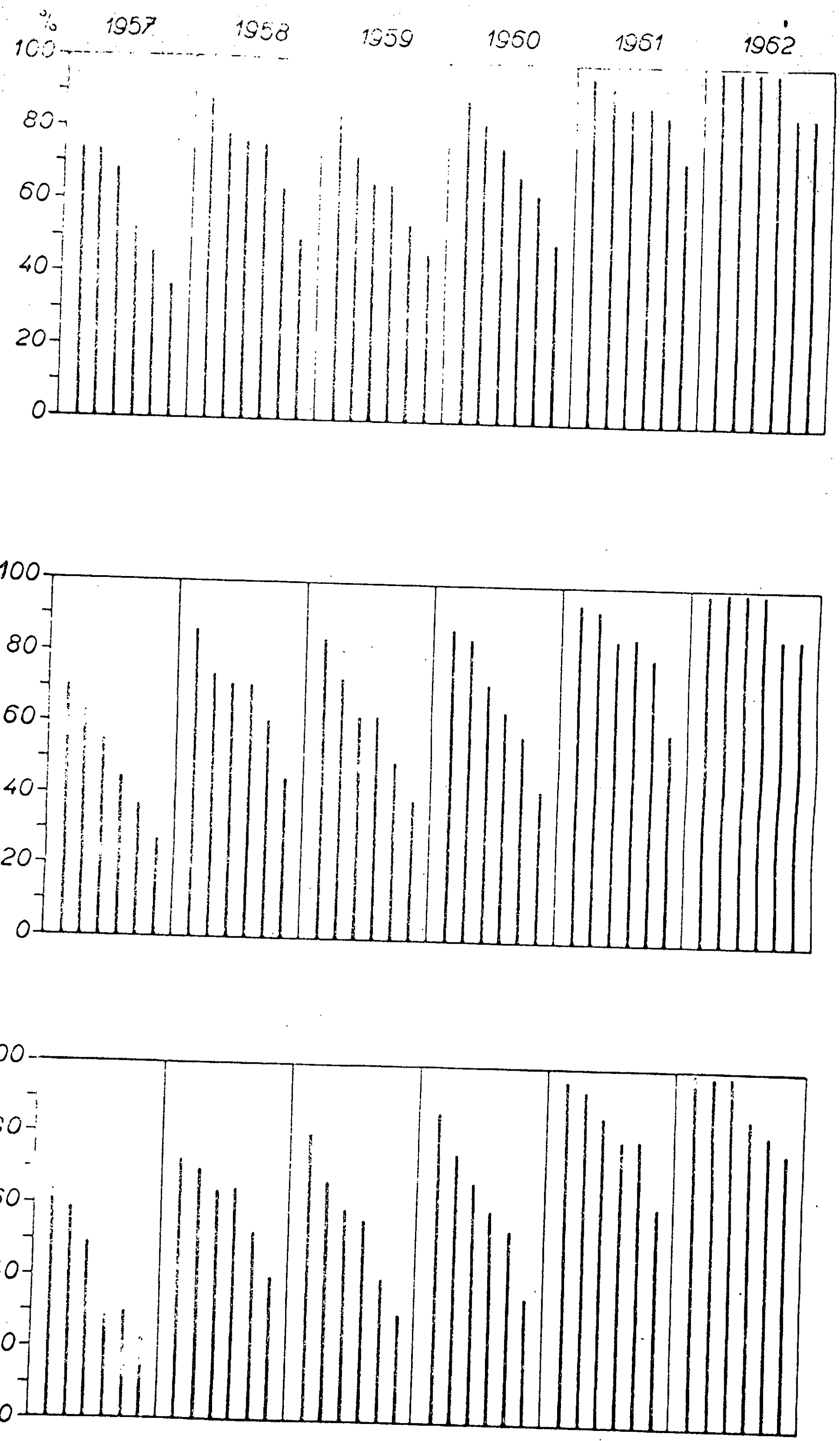


Fig. 2. Percentage of geomagnetic storms Kpmax. ≥5+ from 1957 (2nd half), 1958, 1959, 1960, 1961 and 1962. Vertical abscissae denote, from left right, magnitude of percentage for flares from spaces (with respect to CM) : $0^\circ - 10^\circ$ , $0^\circ - 20^\circ$ , $0^\circ - 30^\circ$ , $0^\circ - 45^\circ$ , $0^\circ - 60^\circ$, $0^\circ - 90^\circ$. From top to bottom with respect to commencement of geomagnetic storm for inte...

if it is proved for such intervals, that there is no connection between flares and geomagnetic storms, this is even more likely to be for shorter intervals.

1) Altogether 248 geomagnetic storms, obtained from the graphs of Kp-indices from Göttingen, were investigated in the manner indicated. As regards flares, American catalogues [14], [15], [16], [17] were used. Only for 1962 was the Quarterly Bulletin from Zürich [18] used. The results are plotted in Fig.1, where the magnitude of the number of percentages is denoted by the vertical abscissa successively from left to right for the individual years and for flares considered in the areas defined by the distances from the CM: $0^{\circ}$–$10^{\circ}$, $0^{\circ}$–$20^{\circ}$, $0^{\circ}$–$30^{\circ}$, $0^{\circ}$–$45^{\circ}$, $0^{\circ}$–$60^{\circ}$ and $0^{\circ}\div 90^{\circ}$, and from the top downwards for the different time intervals, beginning with the shortest and ending with the longest, as given above.

It is seen that the height of the percentages of geomagnetic storms not preceded by a flare is considerable in all cases. Of the large number of flares e.g. in the period of sunspot maximum, there are less geomagnetic storms without flares than in other years when there were less flares (see Tab.I and Fig.1). The percentages of geomagnetic storms continually decrease with a gradual increase in flares as the distance from the CM grows. They also decrease gradually and disproportionately as the length of the time interval increased which is again connected with a rise in the number of flares, the more likely one is to occur in the critical interval before a geomagnetic storm. However, such an occurrence need not indicate an interdependence. It is merely a statistical matter. If this fact is taken into consideration, it must be deduced from the graph in Fig.2 that the connection between flares and geomagnetic storms can be only random. Later this this conception will be made somewhat more exact and supplemented.

2) Since it might be objected that it is actually only large geomagnetic storms which are connected with flares, it was necessary to investigate the percentage of the number of geomagnetic storms with $Kp_{max} \geq 7+$ and $Kp_{min} \geq 5-$. In this part of work the Quarterly Bulletins [18] were used in

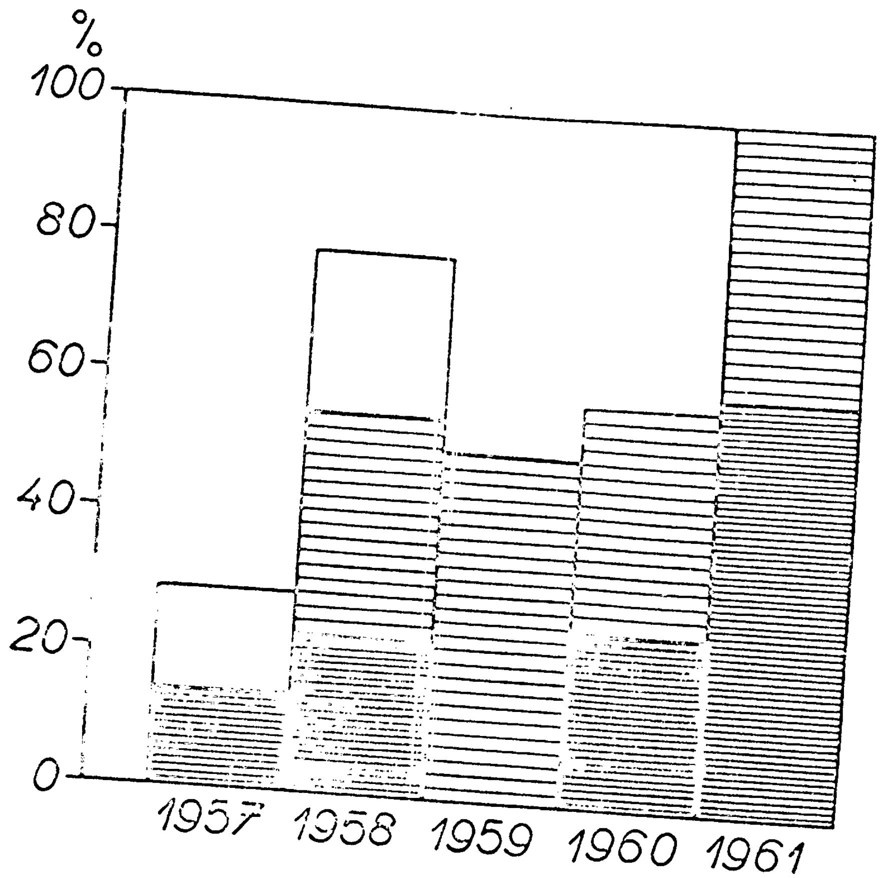


Fig. 3. Percentage of large geomagnetic storms ( Kpmax. ≧ 7+, Kpmin.≧5-) not preceded by flare at distances from 0° to 10° from CM. White strip : importance ≧ 3 ; lightly dashed strip : ≧ 2 ; dashed strip : ≧ 1-. For 1959-61 white strip coincides with lightly dashed strip.

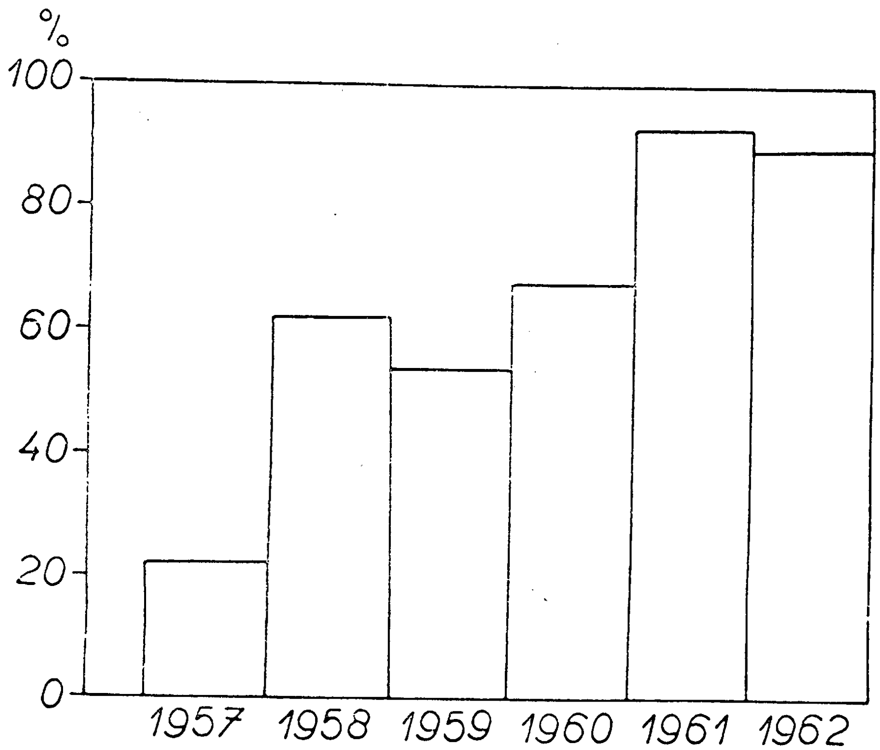


Fig.4. Percentage of geomagnetic storms with sudden commencement not preceded by flare ( imp. $\geq$ 2) at distances from $0^{\circ}$ to $10^{\circ}$ from CM.

the hope that the number of flares would be as complete as possible and importances $\geqq 3$, $\geqq 2$ and $\geqq 1-$ occurring between $0^\circ$ to $10^\circ$ from the CM in intervals of -3 days to -1 day with respect to the commencement of the geomagnetic storm ( first part of Tab. II ) were considered separately. The results are plotted in Fig.2. Since there were no large geomagnetic storms in 1962, only material up to the end of 1961 was treated. It is seen that even for large geomagnetic storms the percentages of cases without preceding flares were considerable in 1958-61 not only for the largest flares but also when using flares $\geqq 2$, when they were above 50%. Although the percentages of large storms without flares $\geqq 1-$ are zero for 1957 and 1959, in 1961 they already reach 60%. This circumstance can easily be explained on the conception of a large number of flares in the years around the maximum (see Tab. I ).

3) For the investigation of geomagnetic storms in relation to flares to be complete, one must also consider ssc which are likely to be connected with sudden solar phenomena on the CM, such as flares etc. We investigated 128 ssc chosen from the graphs of prof. J. Bartels. In this part of the work flares of importance $\geqq 2$ which occurred in the interval from $0^\circ$ to $10^\circ$ from the CM were used. The heights of the percentages of geomagnetic storms with ssc from 1957-62 not preceded by flares are plotted in Fig. 4. Beginning with 1958 these are values above 50 %. The maximum is reached in 1961 (93%). It is seen that not even with geomagnetic storms with a sudden commencement is any connection found with flares in the neighbourhood of the CM.

Table II. Percentage of number of large geomagnetic storms (Kpmax $\geqq$ 7+, Kpmin. $\geqq$ 5-), not preceded by any flare from $0^\circ$ -$10^\circ$ from CM. Number of flares before storm.

| Year | Number of storm | Without flares from -3 to -1 day: $\geqq 3$ number | $\geqq 3$ % | $\geqq 2$ number | $\geqq 2$ % | $\geqq 1-$ number | $\geqq 1-$ % | Number of flares from -3 to -1 day: $\geqq 3$ | $\geqq 2$ | $\geqq 1-$ | from 0 to +2 day: $\geqq 3$ | $\geqq 2$ | $\geqq 1-$ | before-after: $\geqq 3$ | $\geqq 2$ | $\geqq 1-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 2nd half | 7 | 2 | 29 | 1 | 14 | 0 | 0 | 9 | 27 | 91 | 2 | 5 | 30 | +7 | +22 | +61 |
| 1958 | 9 | 7 | 78 | 5 | 55 | 2 | 22 | 2 | 14 | 59 | 0 | 4 | 39 | +2 | +10 | +20 |
| 1959 | 8 | 4 | 50 | 4 | 50 | 0 | 0 | 4 | 11 | 64 | 0 | 4 | 17 | +4 | +7 | +47 |
| 1960 | 12 | 7 | 58 | 7 | 58 | 3 | 25 | 5 | 7 | 56 | 2 | 10 | 49 | +3 | -3 | +7 |
| 1961 | 5 | 5 | 100 | 5 | 100 | 3 | 60 | 0 | 0 | 16 | 0 | 1 | 17 | 0 | -1 | - 1 |

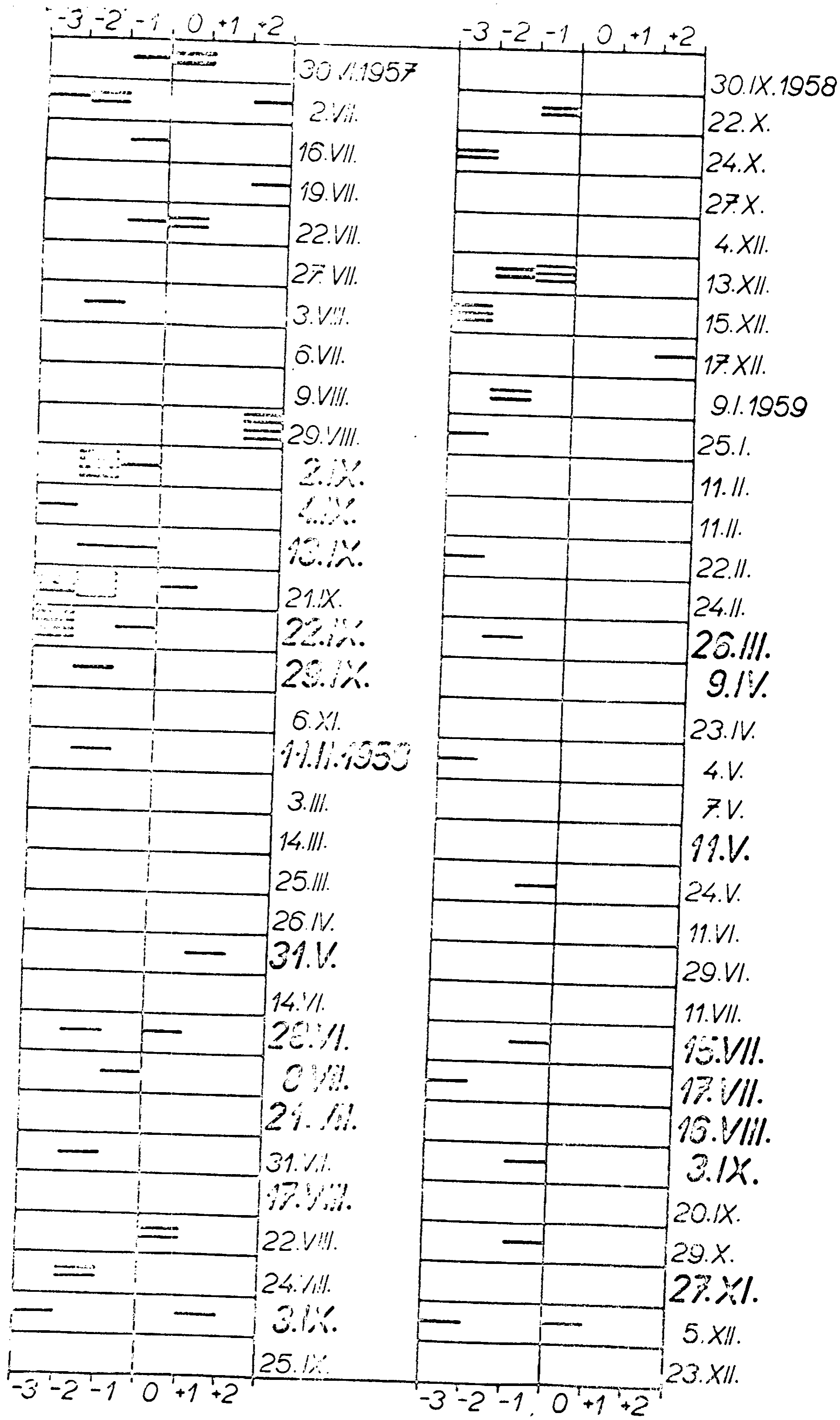


Fig.5a. Time distribution of occurrence of larger chromospheric flares $\geqq 2$ (denoted by horizontal abscissa on corresponding day), befor (from -3 to -1 day) and after ssc (from 0 to +2 day), at distances from $0^{o}$ to $10^{o}$ from CM - in IGY and IGC - periods of greater solar activity. Data of strong storms are denoted by larger letters.

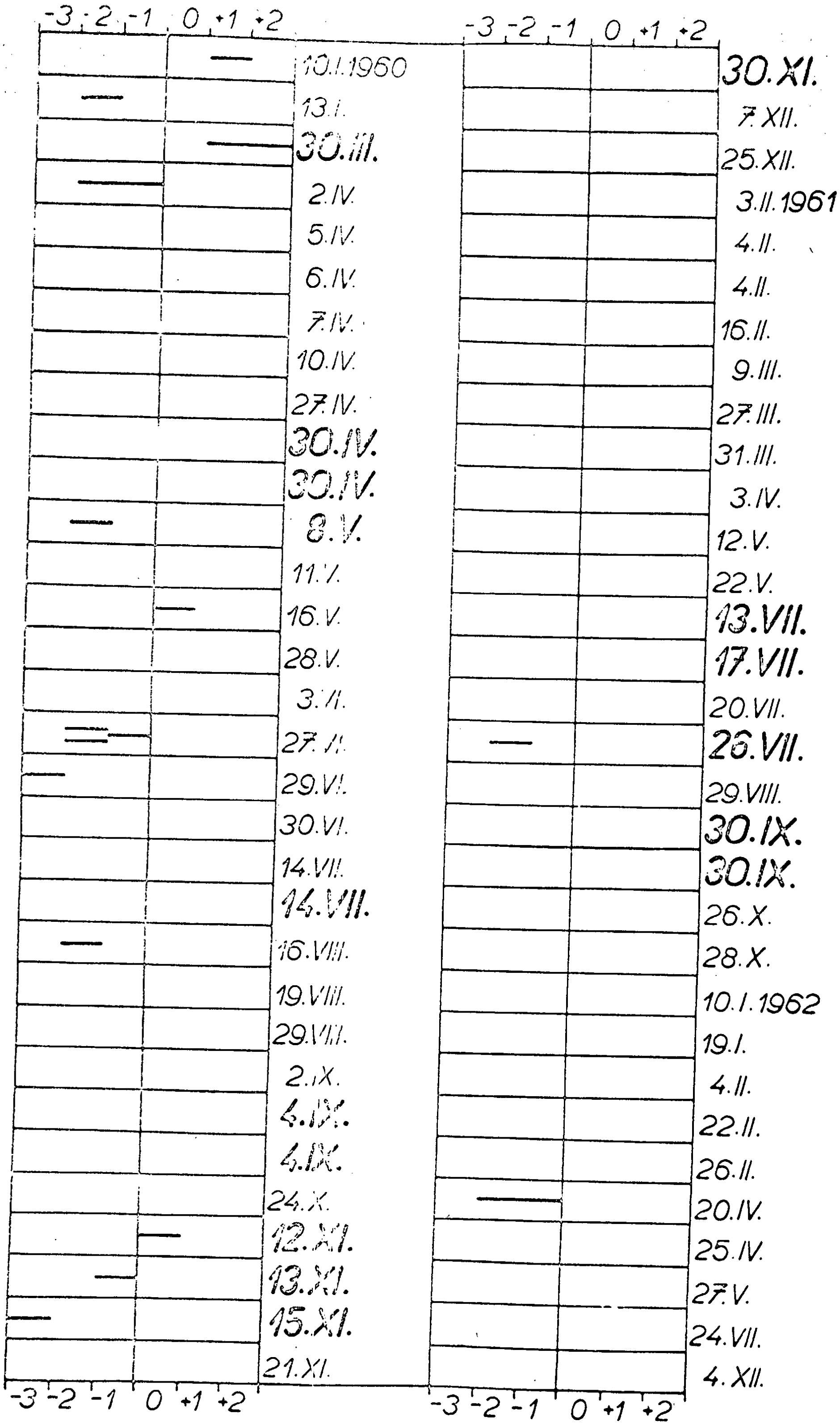


Fig. 5b. Time distribution of occurrence of larger chromospheric flares ≧ 2 ( denoted by horizontal abscissa on corresponding day), before ( from -3 to-1 day) and after ssc ( from 0 to +2 day), at distances from $0^{o}$ to $10^{o}$ from CM - periods of smaller solar activity. Data of strong storms are denoted by larger letters.

The second part of Tab. II compares the number of flares occurring in the interval of one to three days before the geomagnetic storm (large storms and flares $\geq 3$, $\geq 2$ and $\geq 1-$) with the number of flares not occurring until after the commencement of the storm up to the +2 day. The result is very instructive. The number of flares preceding is somewhat higher so that the difference in the two numbers gives positive numbers except for 1961. For medium and large flares it is zero in 1960. It is seen again, primarily for medium and large flares, that the value of the difference decreases with a decrease in the total number of flares. However, despite everything, there exists on the average a sort of predominance of the number of flares occurring before compared with the number of flares occurring after the commencement of a geomagnetic storm. In order to determine this more exactly for a larger number of cases, a similar investigation was made for a set of all ssc. The results are plotted in Fig. 5 a and 5 b ( all storms with ssc, appart from one large storm on 30.III. 1960, which had gradual commencement).It is seen that here, too, flares occur both before and after the commencement of a storm. If , however, we add up all the flares we obtain a higher number before storms (73) than after storms (21) . If, in addition, we consider that this graph gives a high percentage of geomagnetic storms not preceded by any flares (68%) and simultaneously also a certain percentage when flares occurred only after the commencement of the storm(7%) then it be deduced that if there exists a connection between geomagnetic storms with ssc and flares it must be qite limited and indirect.

4) What from this interdependence may have , can be determined as follows. It was shown earlier that a geomagnetic storm occurred after a flare if an unstable filament or active centre with unstable filaments, surges etc., were simultaneously on the CM or even better in the centre of the solar disc [20], [21]. Since the opinion is still held that large flares are after all connected with geomagnetic storms, an investigation of the solar situations during the occurrence of large flares was made

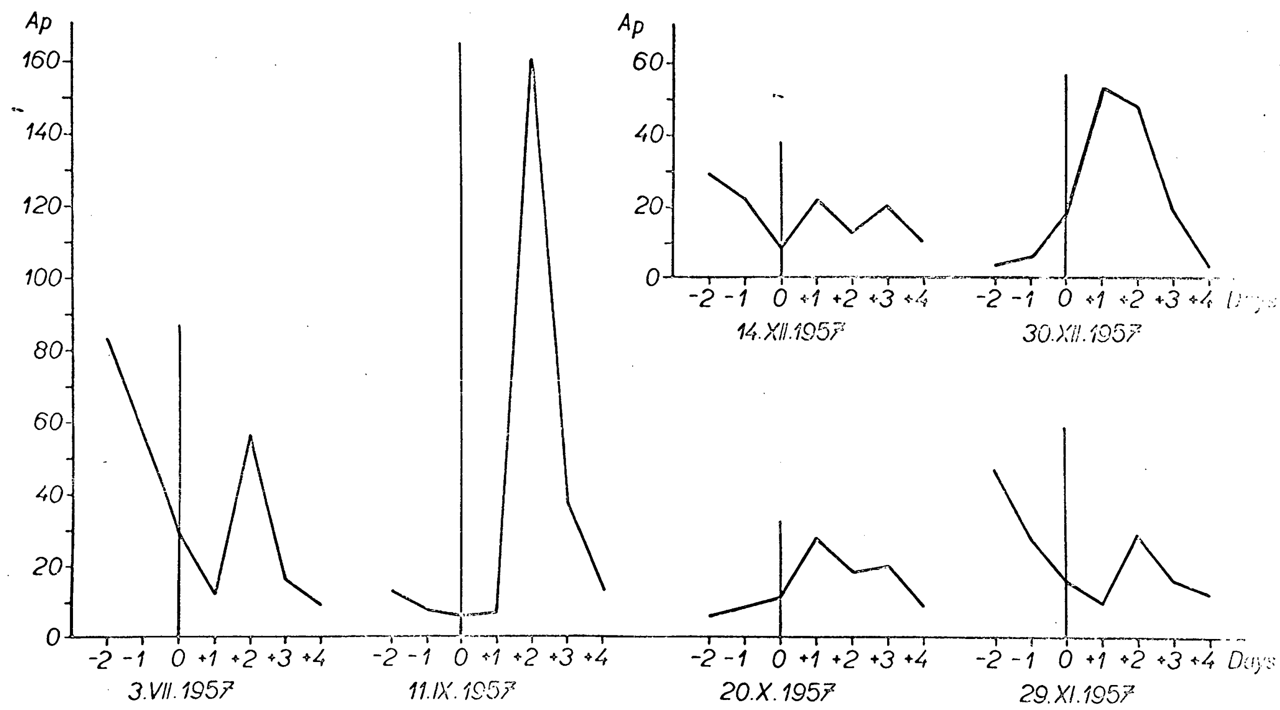


Fig. 6. Course of Ap-indices after large flare (imp. ≧ 3-) during simultaneous presence of unstable filament in centre of visible solar disc (day of occurrence of flare is zero day) year 1957 (flare from corrected catalogue C.S.Warwick)

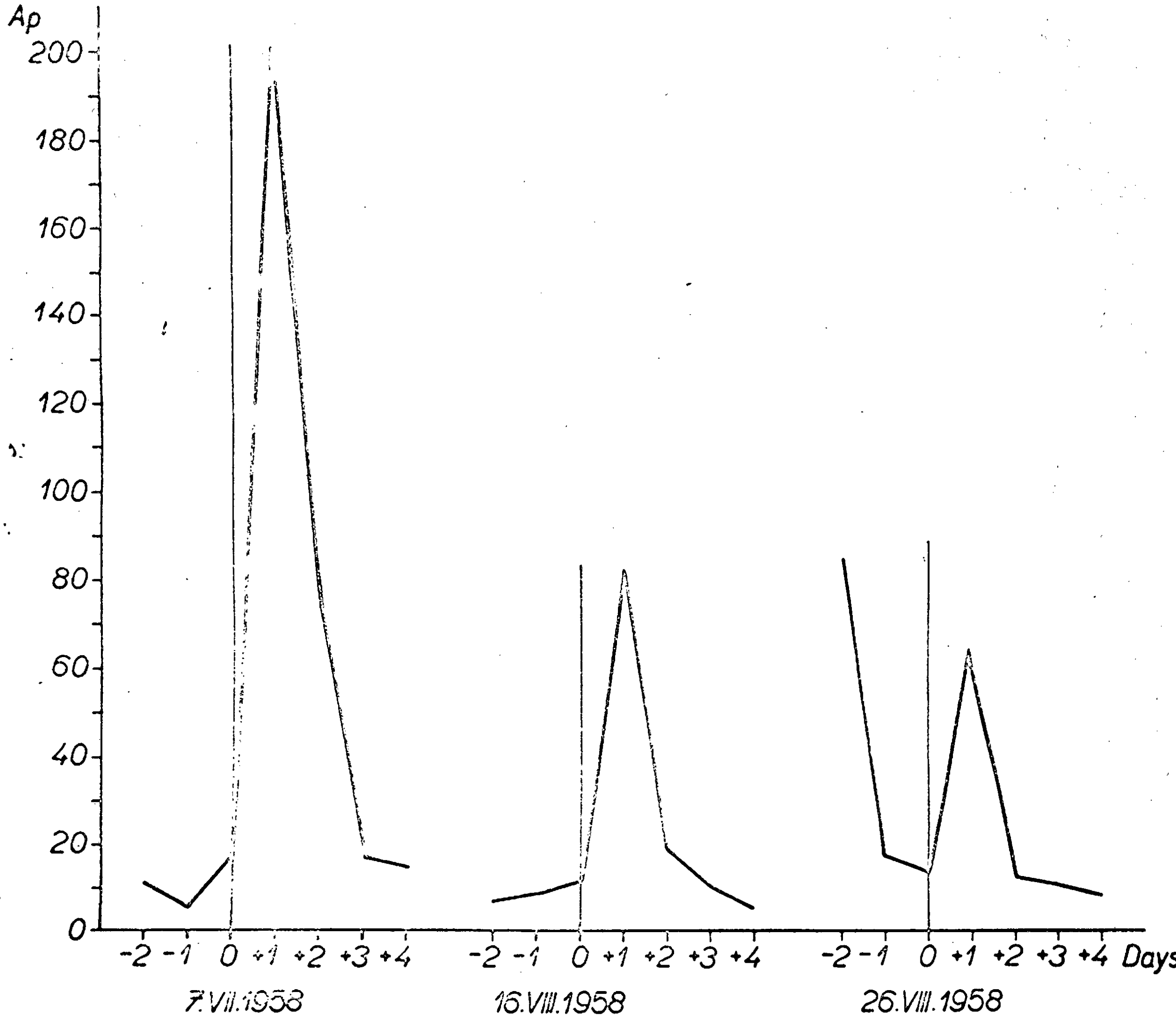


Fig.7. Course of AP-indices after large flare (imp. $\geqq$ 3-) during simultaneous presence of unstable filament in centre of visible solar disc ( day of flare occurrence is zero day ), year 1958 (flare from corrected catalogue of C.S.Warwick ).

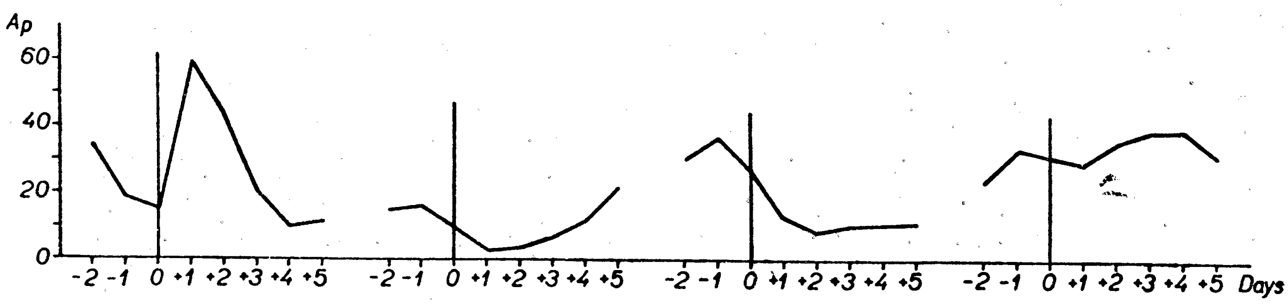


Fig. 8. Course of average AP-indices (method of superposed epochs) after large flare in period of IGY. a) in presence of unstable filament (8 cases), b) during simultaneous CMP of active centre without essential changes (2 cases), c) in centre of solar disc no unstable filament or other phenomenon on day when flare occurred (10 cases), d) CMP of unstable filaments was not simultaneous with flare (23 cases).

at the suggestion of C.S. Warwick, who kindly supplied the reworked catalogue of large flares from the IGY. From the list of days on which large flares certainly occurred, the following groups were chosen: 1) with simultaneous occurrence ( in the limits of one day) of filaments in the centre of the solar disc regardless of the position of the flare and its distance from the CM and also from the filament, 2) with simultaneous CMP of the active centre without flare activity, 3) without the presence of an unstable filament, and likewise in the absence of other phenomena, 4) the occurrence of unstable filaments was not simultaneous, the filament either preceded or followed the day when large flare occurred. The results are given in Figs 6-7 which show the course of the Ap-indices plotted for the different days characterized by the occurrence of at least one flare from 1957 (2nd half) and 1958 for group 1) , i.e. for the cases when an unstable filament was present in the centre of the solar disc. Figures 8 a,b, c and d are valid successively for all above-mentioned groups; in them are plotted the courses of the average Ap-indices calculated on the basis of the method of superposed epochs. It is seen from all the graphs 6 -8 that an unstable filament was necessary in order that a geomagnetic storm might occur; the presence of a flare was not decisive. If a filament was not present a decrease occurred in the Ap-indices after a flare.

In Fig. 8 d the maxima are not pronounced and are displaced as a consequence of the uncorresponding and displaced passages of unstable filaments. In the case of Fig. 8 b the decrease is caused by the CMP of the active centre which does not vary very much. It is seen from all this that flares cannot be directly connected with the occurrence of geomagnetic storms. The slight trace of connection, based on the fact that there is a larger number of flares before the commencement of a storm than after it, may be the consequence only of an direct connection with which we shall deal in the analysis of the results.

## Recapitulation and analysis of results.

It must be borne in mind that 1) a direct connection between flares and geomagnetic storms is disputable if it is considered that is obtained in only 50 % of the cases [13]; 2) if geomagnetic storms exist in periods when flares do not occur, a direct connection must be considered doubtful ; 3) in no case did flares prove suitable as an indicator of geomagnetic storms in prognoses ; 4) statistical papers dealing with the connection between flares and geomagnetic storms and giving results based on the average values of Ap-indices, exhibit low and unpronounced maxima [9],[10]. This fact in itself raises doubts as to the hypothesis on the direct connection between geomagnetic storms and flares [11] . 5) The fact that in the period before and after minimum no connection between flares and geomagnetic storms is obtained [7] is a confirmation of the incorrectness of the flare hypothesis. 6) Not the slightest connection between the importance of a flare and the occurrence of a geomagnetic storm was obtained in any convincing manner. There are many large geomagnetic storms preceded only by the weakest flare.

Apart from this there are also the results of the present paper where material from 30.VI. 1957 to the end of 1962 was used. It was found that 7) there exist high percentages of the number of geomagnetic storms before which not a single flare was observed even in relatively long intervals (up to three days before). The percentages decrease if the chosen interval is longer and more flares are taken into consideration, and increase with a decrease in the number of flares (they also depend on limitations as regards distance from CM and importance and on the period of the eleven-year cycle). It is thus clear that we have to do with only a statistical effect. The larger the number of elements being compared, the more frequently it happens that both fall simultaneously into the chosen time interval and this is even more likely if a longer interval is chosen. When there is a large number of flares (see Tab. I. Fig 1 ) it is more likely that one will occur by chance in the interval of three days before a geomagnetic storm beyond the maximum than beyond or before the minimum, when the number of flares disproportionately falls, while the number of geomagnetic storms decreases much less. This fact was proved for all geomagnetic storms : from Kpmax $\geq$ 5+, and for large storms: Kpmax $\geq$ 7+ and Kpmin $\geq$ 5-, and also for all ssc. If the percentages of sudden commencements without a flare are compared with other storms the latter are somewhat lower although they are still large. 8) The apparent connection between flares and geomagnetic storms can be explained by the simultaneous occurrence of other effects on the CM and possibly directly in the centre of the solar disc, as has been shown earlier [20], [8].

The somewhat larger number of flares occurring before geomagnetic storms compared with that following after the commencement of a storm indicates a slight connection, although this is limited compared with the high percentages of storm occurrence without a flare. This is just what can be found from the observations: that during a flare there is sometimes a greater probability of the occurrence of a geomagnetic storm although at other times this is not true at all. It seems that not always but only sometimes do flares have the tendency to precede the occurrence of a geomagnetic storm. And this is just what, as a consequence of point 8), is the cause of the rise in Ap-indices after a flare. The indirect connection can be explained by the presence of other affects. These are primarily unstable filaments ; their change from filaments of other types shows that not even here is there a simple connection but that a profounder significance must be ascribed to this circumstance. This means a completely new view of the relations between solar and geomagnetic activity: flares occur mostly in active centres. In such places there are strong magnetic fields, which are manifest, although with smaller intensity, also in the chromosphere and in the corona. The way in thich such fields are distributed in the space above active centres is designed by the chromospheric structure and the shapes of the filaments-prominences. When changes occur in the local magnetic field a change takes place in the chromospheric and coronal structures and this can be studied with great certainty on hydrogen masses above the active centre and its neighbourhood. Under certain conditions the filaments and chromospheric structure disapear altogether. It can be deduced from this that in such cases changes occurred in the given layers which had the result that the field was " disappear " there. This apparently, primarily concerns one of its components. It can occur suddenly or gradually, temporarily or permanently. During such changes flares often, though not always, occur. Since the "disappearance" of the local magnetic field in the centre of the solar disc - under certain conditions also outside the centre but on the CM - always means the advent of a geomagnetic storm [21], [22], [23] flares are also classified among processes which occur around the same time as the commencement of the geoamgnetic storm appears on the Sun.

The question remains, what is important from the point of view of theoretical opinion as well as for practical use: are flares the cause of changes in local magnetic fields or their consequence ? This will certainly be the subject of discussion for a long time to come, until the very nature of flares is known. A flare as the cause of a disturbance of magnetic field in the chromosphere is also considered by M.A. Ellison [24]. Perhaps this question could be answered by the conception of a combination of magnetic and electric conditions in the outer solar layers.

It is also necessary to explain some facts which, if incorrectly interpreted, might lead to controversies. This is primarily the question of changes and the possible annulling of chromospheric fields. These occur sometimes during a flare and at other times simply without it. Flares occur in the majority of cases above active centres with a complex structure of magnetic fields. It can be expected that a very effective interferance will be required to annul chromospheric fields which in this case have considerable intensity. And it is during a flare (often regardless of the importance) that the disappearence of chromospheric structure and filaments can be observed in diffrent places. On the other hand, if the fields are very weak such as those distributed above facular areas without sunspots a quite smal change is enough to bring about such an effect. In such cases quite insignificant flares are usually present in the active region or its surroundings or flares do not occur there at all.

It is certain, of course, that sometimes, after a certain time after a flare, the chromospheric structure is restored to what it was befor and the filaments also appear as though they had not disappeared at all. This happens if it is in a region above strong photospheric fields. As soon as after a flare in the outer layers above the active centre is renewed the normal state, i.e. the state they had before, than the hydrogen masses, partly still unionized and partly already recombined, begin to rewind around the lines of force of the still existing magnetic field reaching here from the photosphere. Tis would explain the coronal origin of prominences considered by K.O. Kiepenheuer [25].

Another objection to considering flares as the cause of changes in magnetic fields might be the fact that the changes in local magnetic fields actually occur before the flares. But , according to our own subjective impressions obtained during observations, the changes before flares are of a different kind to those observed immediately after them. Before a flare there is an increase in intensity and extent of the field which becomes more and more complicated. Then surges and small filaments are produced. These are phenomena of short duration. It depends on the aspect from which we explain the process leading to the annulling of the field. In any case, however, we must admit that we have here the conditions for th superposition of fields and their temporary compensation, which is manifes differently in different places. These are changes appearing rather as isolated cases. While large and extensive changes occur only during the flare and after it. If an active centre is observed just after a flare, it can be said that a considerable and very striking simplification of the chromospheric structure has taken place and sometimes it completely disappears over large areas. Anyone who deals with the observation and study of fine chromospheric structure and filaments can find this difference himself and there are certainly many who have already observed it.

However , there should be no misunderstanding. The question of whether a flare is the cause or consequence of changes in magnetic fields in the chromosphere cannot for the time being be decided even by the arguments given here. It should also be borne in mind that, whatever the case, one cannot in any case speak of a direct and universal connection between flares and geomagnetic storms. This might be permissible perhaps only in very limited cases when annulling of the fields occurred in the active centre just in the centre of the solar disc or under certain conditions on the CM and when flares also occurred just in this centre. But even then the connection would be indirect. The actual and nearest indicators of this fact are always unstable filaments. This can be explained by means of the known relation between filaments and coronal formations extending above them. As has already been shown [3] a geomagnetic storm occurs when some coronal formation is directed toward the Earth. The density of the coronal plasma, in other words the density of the corpuscular streams is apparently directly related to the magnitude of the geomagnetic storm and vice versa. A filament and the chromosphere obviously contribute by their masses so that after their ionization, which occurs in certain layers of the corona - apparently layers at heights to, which the rising prominences reach - the coronal plasma becomes denser. As was to be expected perhaps, there definitely exists no simple relation between the size of a filament and the magnitude of a geomagnetic storm. This is natural since the main question here is to what percentage the atoms were ionized. It is not impossible, however, that the necessary parameters could be determined by a detailed study, e.g. by determining the amount of masses which returned to the chromospere etc.

On the basis of the above considerations and whole series of working hypotheses and using the results of observations , a new method of fore -

casting geomagnetic activity, disturbances and quiet, was elaborated [26]. Its successful try-out in practice proves the correctness both of the method itself and of the corresponding hypotheses. In order to be able to forecast every geomagnetic storm with maximum accuracy, a correct and continuous observations of the Sun is required. Only in this way is it possible to record all sudden and of short duration phenomena which precede the occurrence of geomagnetic storms. And only in this way will it be possible to forecast each period of absolute geomagnetic quiet which folows after the CMP of an active centre in and also above which the magnetic field was not annulled.

Table III. The connection between flares and some solar and geophysical phenomena as seen from the results obtained hitherto.

a) Immediate results :

| | | | |
|---|---|---|---|
| 1) disappearing filaments rising prominences | exist also without flares | no dependent directly on importance of flare | limited indirect connection |
| 2) SFE | exist only with flare | dependent directly on importance of flare | possible direct connection |
| 3) Dellinger effect | exist only with flare | dependent directly on impottance of flare | possible direct connection |

b) Later results:

| | | | |
|---|---|---|---|
| 4) geomagnetic storms | exist also without flares (high percentage well above 50%) not all flares are followed by geomagnetic storms (50%) | not directly dependent on importance of flare | limited indirect connection |

5) polar aurorae are accompanying phenomenon of geomagnetic storms and the same holds for them as for storms.

To sum ap, it must be explained what form the connection between flares and some solar and geophysical effects, has judging by what we have had the opportunity to observe. The analysis is given in Tab.III, according to which the SFE and Dellinger effect begin immediately after a flare, depend on the magnitude of its importance and are thus directly related to it. Meanwhile, however , the disappearing filaments--rising prominences, despite the fact that they occur near to the flare in time - and often absolutely simultaneously [27] - are, like the effects occuring after it in a longer time interval, i.e. geomagnetic storms and polar aurorae, indirectly related to the flare. In order to supplement Tab.III the connection between flares and radio outbursts will have to be verified in a radical manner. According to the work of J. Halenka [28] , one could deduce a certain dependence on the presence of a fialemnt.

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