By

PROFESSOR GIORGIO PICCARDI

Director of the Institute of Physical Chemistry
University of Florence
Florence, Italy

The Chemical Basis of Medical Climatology

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Chapter IV

SOLAR PHENOMENA AND CHEMICAL TESTS A SOLAR HYPOTHESIS

SOLAR ACTIVITY AND CHEMICAL TESTS

IN ORDER TO SHOW whether there exist a real dependence between solar activity (measured roughly using Wolf's R number) and the results of tests F and D, Becker carried out a general study on the subject.

First of all he considered the average of the three *magnitudes* R, F and D over periods of 27 days so that each group of 27 days represented the solar rotations according to Bartels. The first rotation considered was the 1612, which goes from March 13 to April 8, 1951, the last was the 1666, which goes from March 10 to April 5, 1955.

Directly comparing the rotation averages of D and R, a strict relationship is already discernible between the two magnitudes. The relationship becomes even better if an R average belonging to a given rotation is compared with the D average of the successive rotation. This fact must definitely be borne in mind in climatological studies!

In order to compare the oscillations of a short period, with a duration of from some weeks to some months, Becker calculated the current averages of five solar rotations. Five rotations are equivalent to 135 days. The 135-day duration still makes it possible to study an eventual annual variation (the relationship between R and D becomes that seen in Fig. 13). The constellations of points are so tightly arranged around the regression line that the calculation of the rotation coefficient becomes truly superfluous. The regression lines are:

test D $\%T = 0.34 \cdot R + 29$

test F $\%T = 0.23 \cdot R + 40$

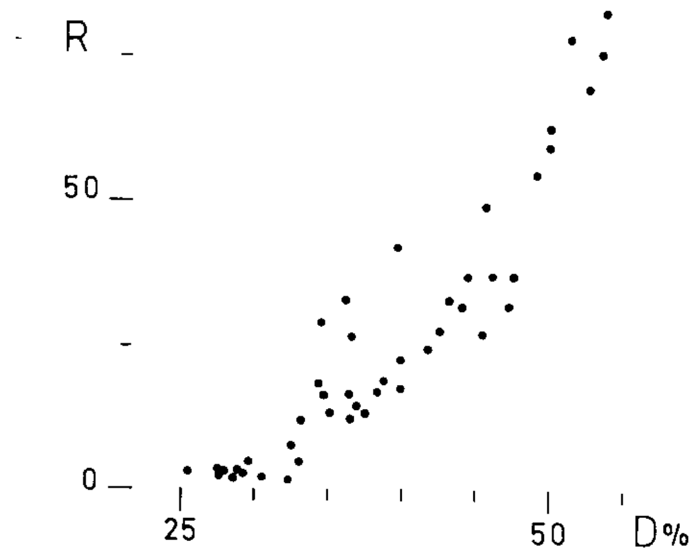

FIG. 13. Correlation between test D and solar activity, according to Becker. *On the abscissa:* test D. *On the ordinate:* Wolf's number R. Averages of rotation smoothed by fives.

To be certain that the discovered relationships were not due to a mere correlation between two magnitudes which were both by chance in the process of diminishing, Becker calculated the current averages of 13 rotations of R, of F and of D, and compared them. Figure 14 gives an idea of the results of this comparison. The three magnitudes reveal a minimum in correspondence with the 1653 rotations—that is, in correspondence with the minimum of solar activity during the period April-May, 1954.

The three curves begin tightly united, they diminish, touch the minimum and rise together once again with such perfect agreement that it is not possible to consider this an accidental or ordinary correlation. Becker, at that time, did not believe that the marked annual minimum of test D, recurring regularly at the end of winter or at the beginning of spring, had to be considered as a separate phenomenon, independent of solar activity. According to him, it could have been a minimum which depended on a chance minimum of solar activity; but then, the persistence of the

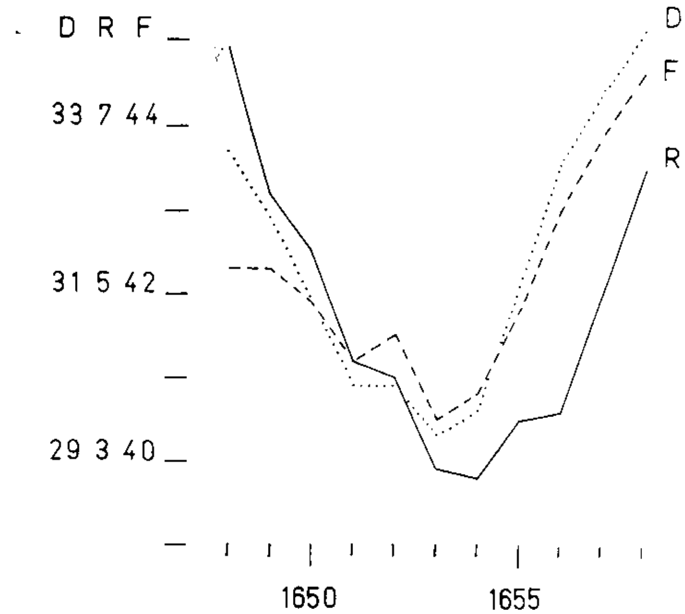

FIG. 14. Test D *(dotted line)*, test F *(heavy line)* and R, Wolf's number *(continual line)*, in function of time. *On the abscissa:* the time in solar rotations according to Bartels. *On the ordinate:* tests F and D and Wolf's number R. Rotation averages smoothed to 13.

annual minimum of test D, without R presenting any corresponding minimum, led him to review the problem some years later. In fact, after due calculation, Becker found that while *the spring minimum of test D is statistically real, the presumed spring minimum of the solar spots is statistically unreal.* From a statistical point of view, the test D minimum exists, the R minimum does not exist. The test D minimum therefore has nothing to do with solar activity.

CROMOSPHERIC ERUPTIONS AND CHEMICAL TESTS

Having verified the existence of a relationship between Wolf's number and the results of tests F and D, Becker wanted to find out whether one of the phenomena which depend on solar activity was capable of influencing the chemical tests by itself. He examined the more conspicuous second and third class cromospheric eruptions reported in the Quarterly Bulletin on Solar Activity. The eruptions chosen were those observed contemporaneously by various observatories, with the same intensity, or those recorded at stations possessing a known and reproduceable scale of intensity. For the period 1951 to 1953, 37 eruptions remained after the choice was made.

The days in which the chosen solar eruptions took place were used as point days (zero days, Stichtage) for the superimposition of the results of test F and D, according to the *n-method*.

Figure 15 illustrates the average values of the results of tests F and D, on the superimposed days—that is, on the four days preceding that of the eruption (−4, −3, −2, −1), on the day of eruption (0), on the four days following the eruption (+1, +2, +3,

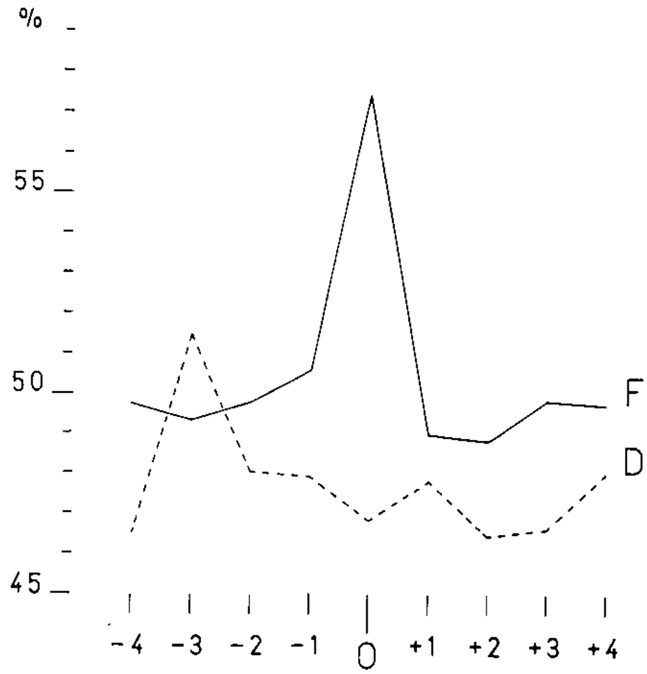

FIG. 15. Effect of solar eruptions on test F *(continual line)* and test D *(dotted line)*, according to Becker. Method of superposed epochs. *On the abscissa:* the day of eruption (O), four days before and four days after. *On the ordinate:* the averages of tests F and D. Note how the eruption influence test F and not test D

+4). The effect of the eruption appears sharply in test F, nil in test D. The effect of the eruption consists of a sharp rise of value in test F, directly observable in 80% of the single cases.

Table XIV illustrates the average values of the superimposed data, year by year.

TABLE XIV

Year	*Days*								
	—4	*—3*	*—2*	*—1*	*0*	*+1*	*+2*	*+3*	*+4*
1951	53.6	57.5	60.2	60.2	63.7	60.1	55.7	55.8	55.0
1952	45.1	43.6	39.8	40.6	54.8	39.1	41.2	46.5	47.2
1953	44.0	40.0	42.0	46.0	57.0	40.0	48.8	44.0	45.0

The effect is highly evident even for the individual years.

In order to check the validity of the discovered relationship, Becker treated the considered data with a special method, calculating the average of the values of F on the four days preceding and the four days following the day of the eruption. The dispersion, comparing proved to be ±2.74. Then, on the basis of this dispersion, comparing the displacement of the F values on the days of the eruption with the remaining eight days, he found that the shift average is +9.5. The effect of the eruption is therefore 3.5 times greater than the dispersion (found on the basis of the particular method adopted) and is thus statistically certain.

Becker then examined the differences between the average values of the single superimposed days, submitting them to the *t-test* proof. He was thus able to show in a completely different manner that the relationship arrived at was perfectly dependable. Even subjecting the relationship to a highly exacting criterion, that of requiring that the remainder probability (*Restwahrscheinlichkeit*) not surpass the value of 0.3%, the relationship remained fully confirmed.

Then Becker studied the annual behaviour of the two tests, F and D, and found that while test F revealed a sinusoidal behaviour with a minimum in the summer, test D revealed a non-sinusoidal behaviour. We have already referred and will again refer to the importance of this fact and its consequences.

Burkard, studying the results of tests F and D as compared with various geophysical phenomena, found that the chemical tests indicated some connection or other with the variation in pressure in the 96 mb stratum or with the density of first five km of the troposphere or with geomagnetic disturbances. But the scarcity of observational material did not permit him to certify the discovered relationships with the finality that he would have wished.

However, note must be made in this connection that magnetic storms and phenomena of the high atmosphere largely depend on solar phenomena; as a result, the chemical tests, which are certainly related to solar phenomena, also had to be related more or less closely with the geophysical phenomena studied by Burkard.

The problem of the relationships between solar and geophysical phenomena and chemical tests was later critically analysed by Berg. The results of his critical examination, embracing all of the results published by the various authors up to that time, were published in *Vol. XXX of Probleme der Kosmischen Physik.:* "Solar terrestrische Beziehungen in Meteorologie und Biologie." Berg's final judgment was as following:

"The T% is not only a function similar to R. The relationship binding the T% to solar activity is much more developed and complex.

"Here, for the first time, we have the connection between a terrestrial experiment and a solar phenomena. This connection remains valid, even adopting the severe conventional statistical criterion of a remainder probability not over 0.3%. As a result of this, even the relationships disclosed by other authors which have already been recognized as being less certain or as being of a merely indicative nature, take on a certain significance."

CHEMICAL TEST D AND SOLAR ACTIVITY REPORT OVER TEN YEARS

A more profound study of the relationship between R and D was not too easy because of a conspicuous disturbance inflicted upon test D by a factor that was *non-solar* or, more precisely, that was not solar activity, and thus independent of Wolf's number. The factor in question is to be linked with the motion of the

Earth, since the disturbance is periodical and this period is one year. (3)

In 1956, Becker formulated a mathematical procedure capable of freeing the relationship between R and D from the relationship between D and the non-solar factor. The procedure was as follows:

1) To subdivide the daily values of R and D into groups of 27, according to the solar rotations of Bartels, and to calculate the *rotation averages*, both of R and of D.

2) To calculate the average of the first 13 rotation averages and to allot it to the seventh of the 13 rotations considered, both of R and of D.

3) Step by step, to shift the averages to 13; that is, to "smooth" the rotation averages, both of R and D, to 13.

Thirteen rotations cover 351 days; that is nearly a year. Each average smoothed to 13 thus approximately represents an *annual average*. Since the annual average takes in and reduces the annual variation of D almost to zero, one obtains, by comparing the smoothed averages of R and of D, a *relationship that is exempt, or nearly so, from the influx of the non-solar factor.*

On the basis of this procedure, the behaviour of D as related with R was studied in 70 consecutive rotations, from 1618 to 1681, inclusive, with a minimum of solar activity from April to May, 1954 (4).

Today, after nine years of uninterrupted experimentation, *after having encountered a minimum and a maximum of solar activity*, I am in a position to set out the general characteristics of the relationship between R and D, determined on the basis of the excellent method proposed by Becker.

In the graph of Figure 16 referred to, *3 quantities are represented:* R, on the abscissa; D, on the ordinate; *the time*, on the plane of the graph, is represented by the number of the order of the rotations.

The relationship between R and D is strikingly evidenced.

Starting from rotation 1618, D, in the course of time, fell little by little as R fell, until reaching the minimum value in correspond-

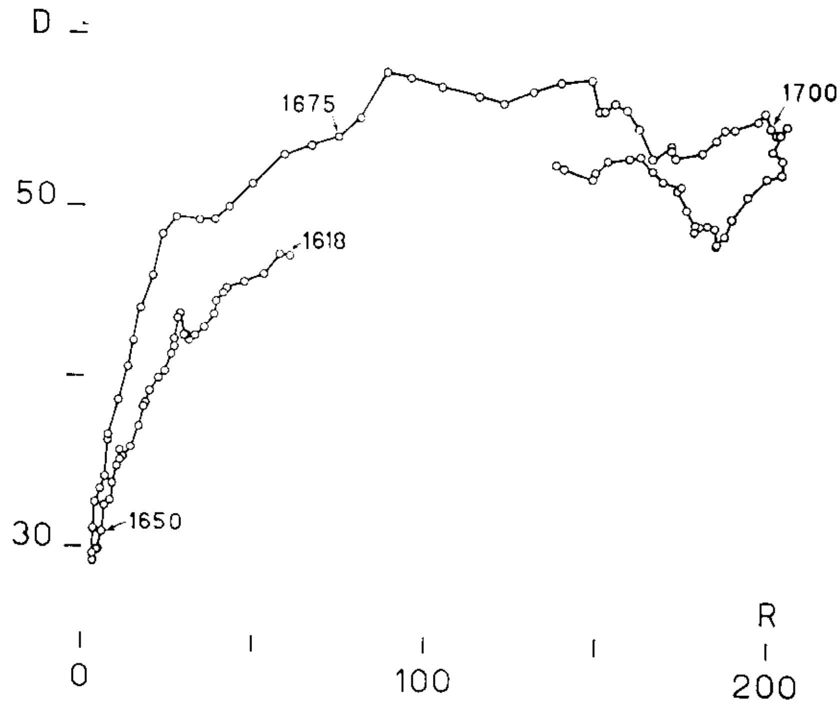

FIG. 16. Relation between test D and Wolf's number R, according to Becker. *On the abscissa:* Wolf's number R. *On the ordinate:* test D. Rotation averages smoothed to 13. The numbers on the graph indicate the rotation numbers according to Bartels.

ence with the minimum value of R (rotation 1653). The old solar cycle had reached its conclusion.

Following this, D, in the course of time, rose by degrees as R rose, and the new solar cycle was evolving.

But D did not follow R to the point of maximum value. While R, surpassing the value of 100, continued to—even surpassing (by a slight degree)—the value of 200, D remained practically constant, as if at that moment it had reached a *state of saturation.* The oscillations or irregularities that are noted in its behaviour are very likely due to a carryover from the annual variation independent of R, not completely eliminated by the smoothing to 13.

During the diminishing stage of the solar activity, D followed a path slightly different from that followed in the rising stage of the very same solar activity, remaining at inferior values and clearly showing a tendency to adhere to the course followed during the diminishing stage of the preceding solar cycle. Test D therefore presents *hysteris* compared with R.

Saturation and *hysteris* are highly important facts for anyone wishing to study phenomena revealed by chemical tests and the chemical tests themselves.

FLUCTUATIONS OF THE CHEMICAL TESTS AND NATURAL PHENOMENA

The Results of the Periodical Analysis

Understanding the relationship between the results of our chemical tests and those of other natural fluctuating phenomena was a matter of greatest importance to us. There existed a particular means, highly suitable for the carrying out of this type of investigation: the periodical analysis according to Vercelli and Labrouste. It was proposed by Dr. Mosetti of the Trieste Geophysical Observatory who later concerned himself with its application.

Vercelli and Labrouste's periodical analysis is a very different thing from the periodic analysis according to Fourier. In resolving a function of time in periodicities, periodical analysis reveals any series of periodicity, while periodic analysis reveals only harmonic series. Applied to phenomena of a harmonic nature (tides, for example), periodical analysis gives the same results as periodic analysis. Since the results of our tests were not of a harmonic nature, it was infinitely preferable to make use of the Vercelli's periodical analysis, which allows much greater scope to the investigation.

The periodical analysis conducted by Mosetti on the results of the chemical tests revealed that the very same results, considered as functions of time, could be resolved into many sinusoidal periodicities, whose lengths when placed in ascending order formed a geometrical progression whose rate is $\sqrt{2}$.

On that occasion, Mosetti made the observation that the data regarding very many fluctuating natural phenomena, both physical and biological, when treated with Vercelli and Labrouste's periodical analysis or similar methods, gave rise at first glance to periods of the same length. This held true examining the periodicity of the order of days and the periodicity of the order of months or years. The periods thus established almost always appeared to be arrangeable according to a geometric progression with an average rate of $\sqrt{2}$.

Taking a year as the basic period and calculating multiples and submultiples according to $\sqrt{2}$, a theoretical succession of values may be constructed which faithfully approximates the succession of periods found in the case of natural phenomena.

This observation is of the greatest importance even though it must be considered as being very rough. The most disparate phenomena follow the $\sqrt{2}$ law:

raininess (rainfall)
solar spots
solar activity
magnetic activity
sun hours
solar radiation
cancer mortality
frequency of pulmonary diseases
tree growth
sea levels
atmospheric pressure
barometric waves
chemical test F
chemical test D
chemical test P
varves

The fact the chemical tests obey a very general law obliges us to think that the precipitations of oxychloride of bismuth have been influenced by the same events which have influenced other phenomena in the past and which are continuing to influence them now. Even this had to happen if the chemical tests were truly capable of taking into account spacial actions as, indeed, they were.

What is extraordinarily interesting, because of the general deductions which it makes possible, is the study of *varves*.

Varves, as is well-known, are finely stratified sediments, often alternating sands and clays, that form in placid waters: lakes, ponds, marshes, etc., in glacial zones. Both recent varves, in the process of formation, and fossilized varves have been studied. According to Zeuner, the same periodic oscillations have been discerned on the basis of periodical analysis, in fossilized varves as have been discerned in the case of other natural phenomena.

If we take a year as the basic period, one of the multiples, according to $\sqrt{2}$, is 11.4 years—that is, the average period of solar spots. The following corresponding periods have been observed in fossilized varves:

Precambrian	11.3 years
Superior Devonian	11.4 "
Inferior Carboniferous	11.4 "
Eocene	12 "
Oligocene	11.5 "

Periodicities existed even hundreds of millions of years ago, and thus were the same as today with respect to one of the more important cycles, that of sun spots.

As pointed out earlier, the chemical tests obey the $\sqrt{2}$ law. Our experiments have not yet covered an entire solar cycle, but the greater part of one has been covered: nine and one-half years out of eleven. What we have seen is already sufficiently clear There is no doubt that chemical test D will close its cycle together with the sun spots.

While I am on the subject, I would like to point out that in the field of climatology, the periodical analysis according to Vercelli and Labrouste will be a highly valued means of investigation because in revealing, as it does, true rhythms (not choosing just the harmonic rhythms), it can show which phenomena are in true mutual relationship, even if the raw data do not reveal similar behaviours. Test F and test D, during the diminishing phase of the old solar cycle, revealed what was apparently a highly varying behaviour, but under periodical analysis they revealed the same periods.

Thus periodical analysis would be an analytical method to introduce in order to establish once and for all which are the periods comprising the periodicity of the natural phenomena of climatological interest.

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A SOLAR HYPOTHESIS

Experimental Data

Among the regularly-conducted studies which have been under way since March 1, 1951, there was one which, we believe, merited development from an astronomical and geophysical point of view: the study that was carried out by means of test D.

The results of test D may be correlated with *solar activity R.* For practical reasons, we have adopted the spot number R (Wolf's number), published in Zurich by Prof. Waldemeyer, as the measure of solar activity.

The correspondence between D and R is shown in Figure 17. On the abscissa: the time (in years); on the ordinate: the annual average of D and of R. The parallelism of the two curves is perfect: the test D minimum falls in coincidence with the R minimum.

But test D, in addition to the secular variation, also reveals a pronounced annual variation marked by a very low minimum in correspondence with the month of March.

There is no doubt today about the actual existence of this minimum, from a statistical point of view. *This minimum is not accidental.*

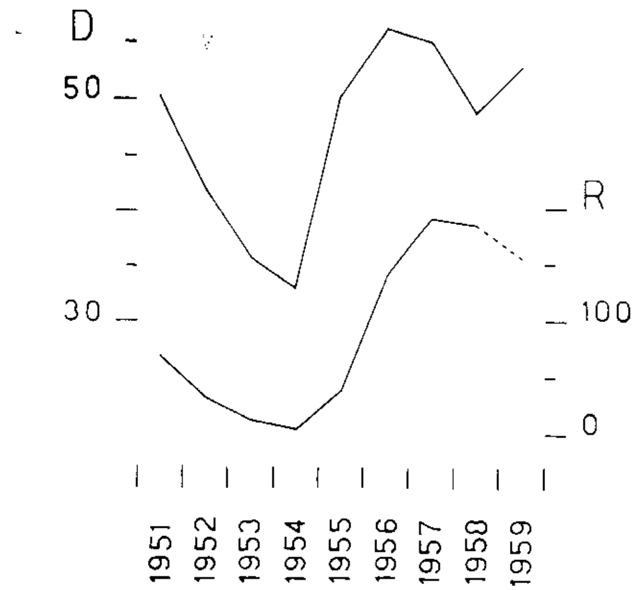

FIG. 17. Test D *(above)* and Wolf's number R *(below)*. Annual averages. *On the abscissa:* the time in years. *On the ordinate:* test D (scale at the left) and R (scale at the right). Note the parallelism of the two curves.

On the other hand, R reveals no annual variation; this fact is demonstrated in Figure 18. On the abscissa: the 12 months of the years; on the ordinate: the monthly averages of D, and the monthly averages of R over 9½ years.

The behaviour of R is completely different from that of test D. *The annual minimum of D is therefore not to be connected with solar activity.*

To what can we attribute this minimum which is so low and which recurs every year, roughly at the same time, with astonishing constancy? This minimum has appeared for 10 consecutive years, very marked when solar activity was reduced, less marked and more or less distorted when solar activity was strong and violent, as during the beginning of the last solar cycle. The annual minimum of D has also been recorded at Vienna in 1953 and 1954 during the minimum of solar activity, by Piccardi and Doat.

The annual variation of D is not sinusoidal but is, instead, cycloidal. The strange nature of this variation has led us to search

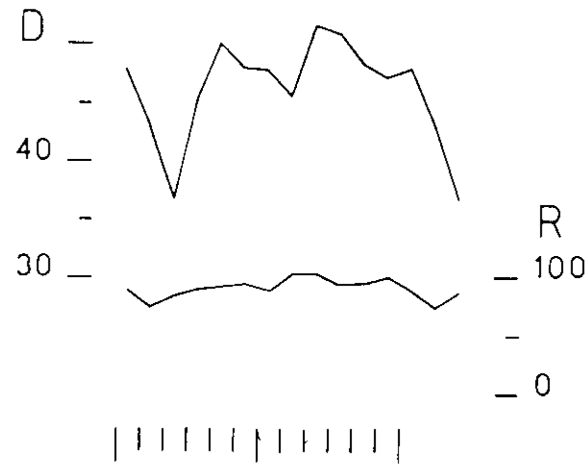

FIG. 18. Test D *(above)* and Wolf's number R *(below)* in the course of a year. *On the abscissa:* the twelve months of the year. *On the ordinate:* test D *(left scale)* and Wolf's number R *(right scale).* Monthly averages on nine yers. Note the marked minimum of Test D in March and the little minimum in August. Note also how Wolf's number does not present minima in correspondence with March and August. The minima od test D have nothing to do with solar activity.

for, in the space which surrounds us, a phenomenon which might manifest a similar behaviour, occurring all by itself with an annual rhythm. The result of the search has been the *solar hypothesis* which is the subject of this chapter.

The Solar Hypothesis

We know that the sun moves, together with all the bodies which are bound to it, towards the constellation Hercules. Standard apex: $\alpha = 270°$, $\zeta = 30°$ (in equatorial coordinates). Its motion is uniform and rectilinear; its speed (constant for us): 19-20 Km/sec.

We know too that the Earth turns about the sun at an approximate average speed of 30 km/sec.

From the combination of these two motions, one rectilinear and uniform, the other circular and uniform roughly speaking, a *helicoidal trajectory* results. *This is the helicoidal motion of the Earth in the Galaxy, referred* to the neighboring stars (Fig. 19).

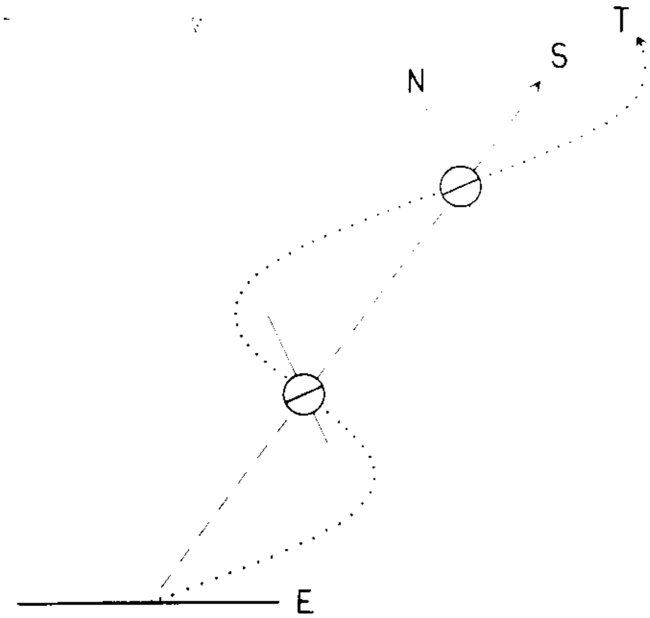

FIG. 19. Helicoidal motion of the Earth in the Galaxy.
E = plan of the ecliptic (profile);
S = solar apex;
N = direction of north pole;
T = helicoidal path of the Earth.

From this fact an elementary calculation or a simple graph shows that:

1) during the month of March the Earth moves in its equatorial plane;

2) during the month of September the Earth moves, if not along its axis, then in a direction not too far removed from that of the North Pole;

3) the speed of the Earth's helicoidal displacement varies during the year and passes from a maximum in March (45 Km/sec.) to a minimum in September (24 Km/sec).

4) the Earth is displaced with the Northern hemisphere leading, except during a small part of the month of March.

If space were empty, empty of fields of matter and inactive, a consideration of this type would be of no importance. But today we know instead that both matter and fields exist in space. For this reason, *the displacement of a body such as the Earth in one direction or another is not inconsequential. Its general physical conditions must vary in the course of a year.*

I have tried to give an interpretation of the annual variation of test D. But the variation of test D need not be considered. The

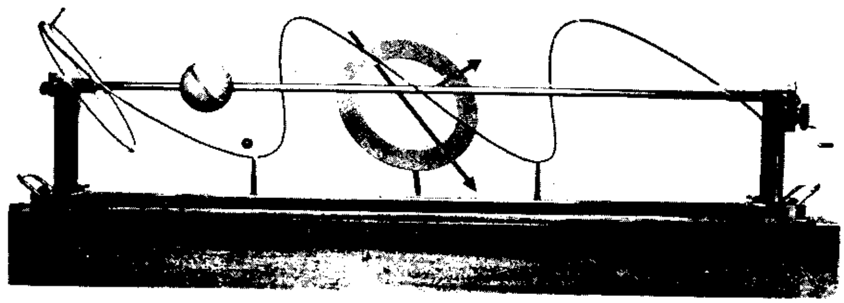

Fig. 20. Animated model of the helicoidal motion of the Earth in the Galaxy, presented at the Brussels World-Fair (side view).

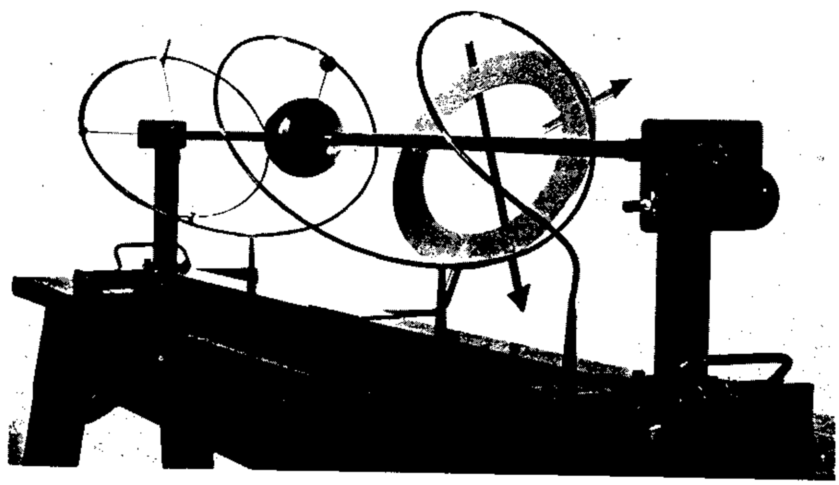

Fig. 21. Animated model of the helicoidal motion of the Earth in the Galaxy, presented at the Brussels World-Fair (close to).

hypothesis—that the helicoidal motion of the Earth in the Galaxy brings with it a regularly recurrent modification of the Earth's general physical conditions, with a *non-sinusoidal rhythm* going from March to March of the next year—*can exist as an idea on its own,* independent of the experimental facts which pointed to it. This is the *solar hypothesis*.

Considering the motion of the Earth in the Galaxy, it was necessary to determine in what manner the Earth was displaced towards the galactic centre.

The standard galactic coordinates of the centre are: $l = 325^\circ$, $b = 0^\circ$, the apex of the sun: $l = 23^\circ$, $b = 22^\circ$. From this fact it is easily deduced that during the month of March the Earth is directed approximately towards the galactic centre. The angle formed by its speed and the direction of the centre is at a minimum. To continue, during March, and only during March, the Earth is directed approximately, at maximum speed, towards the galactic centre—that is, along the lines of force of a radial field and perpendicular to the lines of force of a dipolar galactic field. This double condition will not be encountered again throughout the year. The conditions during March are thus quite exceptional.

The precise characteristics of the helicoidal orbit of the Earth have been recently calculated by Dr. Quilghini of the Rational Mechanics Institute of the University of Florence. A working model of the motion of the Earth in the Galaxy was displayed in 1958 at the Brussels Planetarium during the World Fair (Figs. 20, 21).

The Effect of Latitude and the Dissymmetry of the Northern and Southern Hemispheres

The fact that the Earth is displaced with the North Pole in a more or less leading position throughout the year, save for a very short period which corresponds with the month of March, should lead to a *dissymmetry* between the two hemispheres of the Earth and to an *effect of latitude*. The calculated maximum of dissymmetry occurs in correspondence with the month of September.

I have already considered a persistent difference between the data from Florence, Vienna and Brussels, *recorded during the period in which falls the annual minimum of test D:* January, February, March, April, for the years 1953, 1954 and 1955. Those years of minimum solar activity (Table XV).

TABLE XV

Year		*Test D*	
	Florence	*Vienna*	*Brussels*
1953	31.8	46.3	51.8
1954	29.9	40.2	54.7
1955	38.4	45.0	53.4
Averages	33.3	45.0	53.3

But the stations in Florence, Vienna and Brussels cover a zone too limited to derive a general picture from our observations.

The International Geophysical Year (IGY) and the International Geophysical Cooperation (IGC) afforded us the opportunity of gathering data from widely separated localities as well as from the southern hemisphere: Uccle-Brussels, Tuebingen, Jungfraujoch, Vienna, Trieste, Genova, Florence, Castellana Grotte (Bari), Libreville, Leopoldville, Fort Dauphin, Kerguelen Islands. To these were added then Sapporo and Kumamoto (Japan), New Amsterdam Island and Tromsoe, but not in the picture of the works of the IGY.

The places in which *standardised observations* were made continuously and regularly during the AGI were: Brussels, Florence, Libreville, Leopoldville, Fort Dauphin and Kerguelen Islands. In some stations the observations were begun in 1957, in others in 1958. In some stations the observations finished at the end of 1959, in others thus are still going on. We can confront now the result obtained in the various stations only in the years 1958 and 1959 for reasons of homogeneity.

The dissymmetry between the two hemispheres becomes therefore most evident. In the Table XVI we report the annual averages of test F gathered in the places indicated in the years 1958 and 1959 and the general averages of two years. We report also the general averages of the data gathered in the two hemispheres.

The dissymmetry of the two hemispheres according to the solar hypothesis should be at a minimum during March and at a maximum during September. No tests were carried out at Leopold-

TABLE XVI

SEPTEMBER 1958 AND SEPTEMBER 1959 (TOTAL AVERAGES)

	F		*F*
Brussels	51.0		
Florence	50.3	northern hemisphere	49.7
Libreville	47.8		
Leopoldville	46.8		
Fort Dauphin	30.5	southern hemisphere	32.8
Kerguelen	21.2		

ville or at Kerguelen during March 1958; for September, however, we have the complete series of values of two years. Test F, which is on this occasion the most dependable for a general comparison, reveals very satisfactory patterns: Table XVII.

TABLE XVII

TOTAL AVERAGES OVER TWO YEARS: 1958 AND 1959

	F		*F*
Brussels	51.2		
Florence	49.9	northern hemisphere	50.1
Libreville	49.3		
Leopoldville	45.6		
Fort Dauphin	28.7	southern hemisphere	33.2
Kerguelen	25.4		

As one sees, the values of test F tend to diminish strongly with the increase of the latitude of the southern hemisphere and to remain constant or increase slightly with the increase of the latitude in the northern hemisphere.

There is no doubt therefore that test F accounts for dissymmetry predicted by the solar hypothesis; Test D hints at it less evidently and test P does not show it at all. It is possible to explain the diversity with the behaviour characteristics of the three tests towards natural phenomena.

Test F receives directly *all* the external actions capable of modifying the chemical reaction precipitation of bismuth oxychloride; test D *only* those which pass through the copper screen; test P, probably, only the electromagnetic fields. One remembers that test F is sensitive to the solar eruptions and consequent phenomena, and test D is not.

It is not necessary, for the moment however, to enter this field.

We know today that the general conditions of the southern hemisphere are very different from those of the northern hemisphere, not only from the geographic point of view, but also from the meteorological one. The problem was clearly stated by Van Mieghem in a general report on the meteorology of the Antarctic. On the other hand Lecce and Del Trono found a marked dissymmetry between the northern and southern hemispheres in the barometric field at 500 mb.

The Pattern of Test D in the Two Hemispheres

The solar hypothesis brings up another problem: if the annual minimum of test D depends upon the motion of the Earth in the Galaxy, this minimum should be observed not only in the northern hemisphere, but also, and *at the same time,* in the southern hemisphere. The *entire* Earth should feel the effects of the change in conditions resulting from its helicoidal motion.

Unfortunately, during the Spring of 1958 the chemical test research was interrupted for two months at Leopoldville and had not yet been initiated at Kerguelen.

The research was prolonged in these two places up through all of July 1960, that way it was possible to have the data of two complete years.

We can make a resume of the results regarding test D in this manner:

Let us distinguish above all the data gathered at northern and southern mean latitudes from those gathered nearest the equator, remembering that Libreville lies less than 1° N and Leopoldville about 4° S from the equator.

a) Test D at Northern and Southern Mean Latitude

If we calculate the monthly averages of *all* the data gathered in Uccle-Brussels and in Florence in 1957, 1958, 1959 and 1960, and all the useful data gathered at Fort Dauphin and Kerguelen and order them by month we obtain two functions of the time of D which have parallel behaviour.

Both present the large minimum and the little minimum *at the same time.* The effect of the helicoidal motion of the Earth seems therefore evident because they are independent of the seasonal effect.

In the North test D maintains itself on higher values and in the South on lesser values. The amplitude of the two functions are almost equal, perhaps the amplitude in the South is wider. The dissymmetry of the Earth depending upon the helicoidal motion seems therefore evident in the case of test D (Fig. 22).

The little August minimum divides the time function of D in two parts. In the North the first part (spring-summer) curve, the second part (autumnal-winter) comes to a sharp point. In the

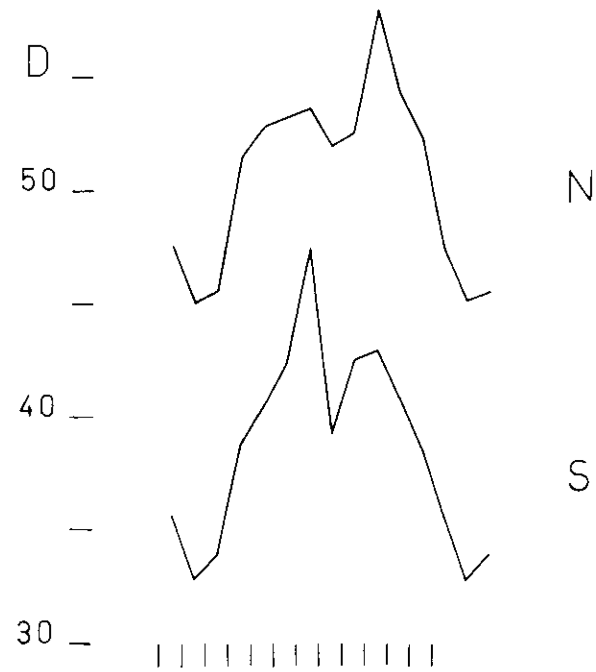

FIG. 22. Annual variation od test D in the northern and in the southern hemispheres (mean latitudes). *On the abscissa:* the twelve months of the year. *On the ordinate:* test D. Monthly averages of two years. Winter-spring minima and August minima appear together in both hemispheres. They do not depend upon a seasonal effect: thermic summer at the north and thermic winter at the south and vice versa.

South the inverse happens: the first part comes to a sharp point and the second curves. This is a *typical seasonal effect,* to place in relation to the height of the Sun on the horizon.

We could not hope for more or better. Test D shows one more time the effects of helicoidal motion of the Earth: large annual minimum, small annual minimum and dissymmetry between northern and southern hemispheres. Further, it shows us an ordinary seasonal effect.

b) Test D at the Equator

If we calculate the monthly averages of all the data gathered at Libreville and Leopoldville in the same period of time and order them by month, we obtain a time function of D which is about the inverse of those found for the northern and southern latitude averages.

Reversing the function, we find that it resembles very much the other two and is about coincident with the northern function.

The equatorial zone behaves therefore in a particular way. It is too soon to proceed to serious hypothesis. It would be necessary at this point to know what happens in the polar regions. Experiments are in course at Tromsoe at the Auroral Observatory, and there are also experiments going on in the Earth of King Baldwin in Antarctic. While at Tromsoe, thanks to the Norwegian physicists, the experiments are being carried on regularly and will have their results directly. In the Antarctic the immense general difficulties met by the Belgian expedition, have impeded the regularity of the experiments.

I shall not prolong this argument because the problem is still far from being resolved.

In the southern and in the equatorial zone the data was gathered by the Meteorological Service in the Belgian Congo and Ruanda Urundi directed by Prof. Van der Elst; by the French Overseas Meteorological Services of Gabon, Madagascar, Comore and Réunion Islands and by the French Expedition of the TAAF (Terres Australes et Antarctiques Françaises) to the Kerguelen Islands. Great was the interest in these enterprises shown by M. Viaut, Président de l'OMM (Organisation Météorologique Mondiale), by Prof. Roulleau, head of the Météorologie Nationale Francaise, and by Prof. Bost, Chef du Bureau Scientifique des Terres Australes et Antarctiques Françaises. Without the careful diligence of these people the study of the effects of latitude of the Earth's dissymmetry, etc., would not have been possible because we would not have known what happens in the southern hemisphere.

Figure 23 shows the synchronous mixer for IGY research.

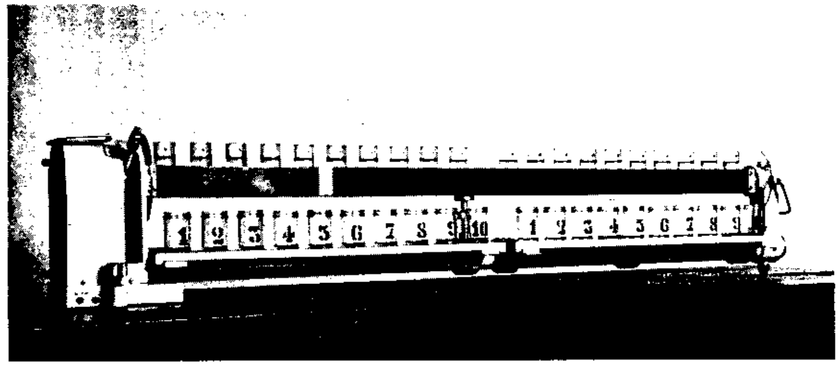

FIG. 23. The synchronous mixer model 20 A in distribution for systematic research in the Geophysical Year and the Geophysical Cooperation.

Test D and its Cosmogonical Sense

The annual variation of test D is of such importance that it is difficult to interpret it as a result of the interaction of weak fields, which are the terrestrial field and the exterior field in which the Earth moves. Until the present it was held that the fields which exist in space are weak, but this belief is not firm. *A much more profound and general cause must come into play.* Prof. Giao has considered the solar hypothesis from a point of view of relativistic cosmology and is able to explain the annual variation of test D in a quite general manner by means of relativity.

Giao, studying the problem of the existence and properties of Time (evolution, succession, sense), shows that besides the four-dimensional space-time solution (the physical Universe) the relativistic field equations also have a three-dimensional spacial solution. This solution is a three-dimensional Universe which performs a successive *exploration* of the four-dimensional physical Universe thus introducing an evolution, in other words a *real Time,* in the physical Universe. Giao analysed the important interactions of the three-dimensional and the four-dimensional Universe and shows that it is possible to explain the annual variation of the D test from relativistic point of view on the basis of the Earth's annual helicoidal motion as a manifestation of the energy flow representing the action of the three-dimensional Universe on the physical Universe.

Today the solar hypothesis, as I have shown, embodies extensive experimental results obtained during the IGY and IGC.

It is owing to this hypothesis that it was possible to foresee these facts, to seek them out and to study them.

It can thus be considered at least a *highly useful working hypothesis.*

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