SÉANCE DU VENDREDI 5 OCTOBRE, MATIN.

PRÉSIDENT DE SÉANCE : J. M. RAMBERG.

L'ORGANISATION DES CAMPAGNES DE PROSPECTION

RAMBERG. — According to the agenda, the discussions this morning are to be concentrated on field surveys. We are very sorry that our Russian colleagues from the Pulkovo Observatory, Drs. Melnikov and Kutcherov, have not arrived; I am sure that all of us would have been extremely interested in hearing about their experiences. We are glad, however, that other astronomers with great experience of field surveys and seeing expeditions will be able to tell us about site testing in Southern Africa, Chile and Australia.

I. — AFRIQUE DU SUD

J. DOMMANGET.

I have not prepared anything on the subject of the present session. The best I can do is to take as an example the organization of the field survey in Southern Africa, by the European Southern Observatory (E. S. O.) with which I was collaborating from November 1955 to March 1957.

When one arrives in a big country such as South Africa, one is quite undecided about the way to conduct a site survey, because of the extent of the country and of the small number of people available. In our case, we were four members only.

Under these conditions, there are, in my opinion, two completely different methods of approaching the problem. The first one consists in choosing, on a map, without climatologic or orographic considerations, a regular network of stations at which observations of image quality shall be made. Another method consists in choosing some stations in the different climatological and geographical regions of the country, for the first tests.

In the first case, it is very difficult, and generally impossible without a large staff, to organize cycles of observations at all the stations and thus be able to compare the different stations by statistical studies. On the other hand, one cannot be sure that a station chosen on a map will be representative of the surrounding region. These are the main reasons why I prefer the second method of starting a site survey. We used this method in South Africa.

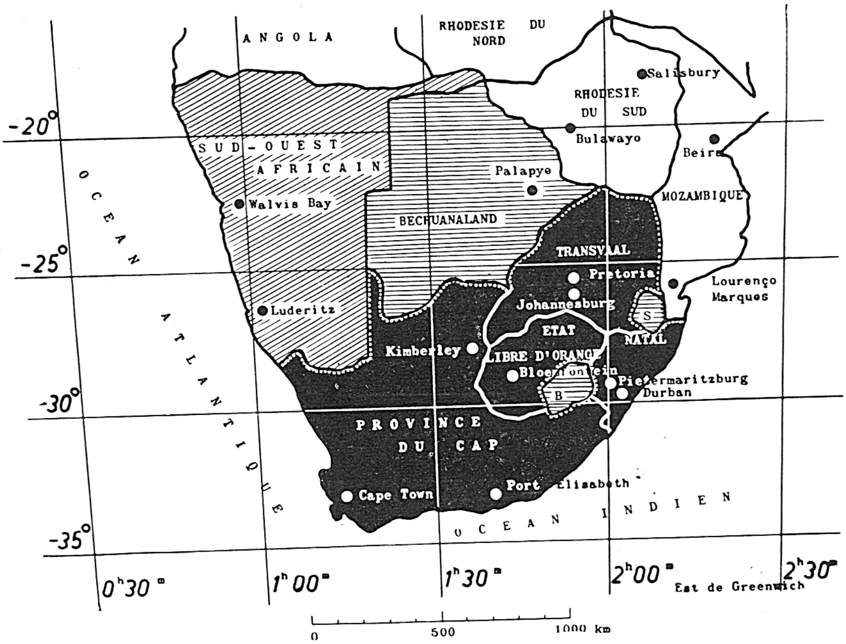


Fig. 62. — Political map of South Africa.

The Republic of South Africa has four provinces : the Cape Province, the Orange Free State, the Transvaal, and Natal. Its government is also the administrative authority in South-West Africa by order of the League of Nations (1920). The territories of Bechuanaland, Basutoland (B) and Swaziland (S) are British protectorates.

How did we choose the first stations ? After staying a few days at Cape Town (Royal Observatory), we left for our first headquarters : Bloemfontein (Boyden Observatory) (*fig.* 62) where Dr. Courtès and I observed for three months (December 1955 to February 1956 included). Our two colleagues, Dr. Elsässer and Mr. Heynekamp in the meantime travelled and observed in the surrounding country (Orange Free State and part of the Transvaal). After a few weeks, the main impression of Dr. Courtès and I was that in this region it would not be possible to find a good site for a big observatory, because of the systematic appearance of cloudiness at noon, growing in intensity is the afternoon and giving rise to heavy thunderstorms. This meteorological situation, typical in subtropical countries, ended generally in the first part of the

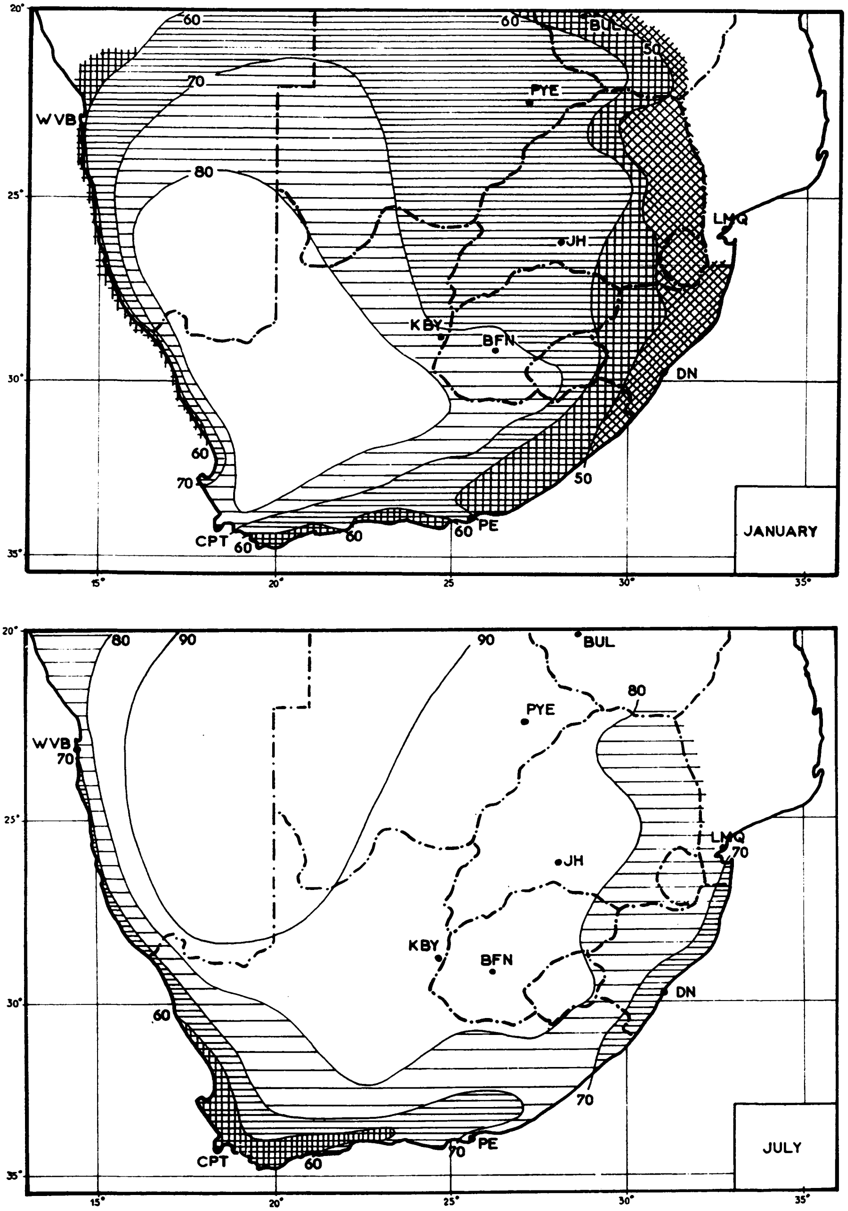


Fig. 63. — **Average duration of bright sunshine expressed as percent of possible sunshine.**
(T. Schumann, *Sunshine and cloudiness in South Africa*
Weater Bureau, Department of Transport, W. B. 14, Pretoria, 1950.)

night. So we had to resolve a first problem : does another region exist in South Africa where night observations are not affected by systematic diurnal cycles of cloudiness ? From the information given by the staff of the Weather Bureau of Pretoria to our German and Dutch colleagues, we learned that cloudiness observations were generally made at 8 o'clock in the morning at the meteorological stations and also at some places, at 2 o'clock in the afternoon. But no observations were made at night. On the other hand, the maps published by the Weather Bureau of the mean cloudiness and mean sunshine duration (daytime observations) do not show big differences between regions, for instance between the Orange Free State and the Karroo (*fig.* 63). Moreover, they did not

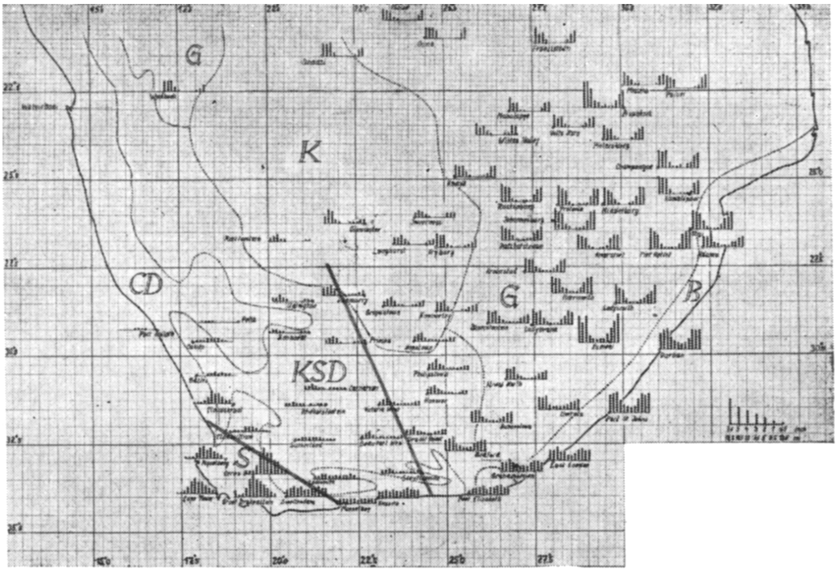


Fig. 64. — Mean monthly rainfall and vegetation areas.
(H. Siedentopf, *Climate of the Union of South Africa.*
Astronomical Institute of the University, Tübingen, 1955.)

show the three different types of climate existing in the Republic of South Africa. Naturally, this last point is very well-known to the meteorological observers and staff of Pretoria, but more on a climatological point of view than on systematic synoptic observations. So, there were no direct observations by which we could compare different regions : Only the map of annual rainfall distribution by months (*fig.* 64) shows the existence of three different climatological regions : one region corresponding to the north-east part of the Republic of South Africa, where important rainfall is observed from November to March; another region corresponding to the Cape Peninsula and its surroundings, where the rainfall distribution is just the reverse of that of the first region; and an intermediate region where much less rain fall is observed throughout the year. We were informed by meteorological and astronomical observers that in the two regions of seasonal rainfall, cloudiness and rainfall were in quite good agreement. But we did not know whether the intermediate region of less rainfall was also a region of less cloudiness. We had thus to study this important point on the spot itself by travelling in the region and by discussing the problem with the meteorological observers themselves and also with all other reliable people (Town clerks, officers of Forestry Department, etc.).

So, at the end of February 1956, we went down to the southern part of the intermediate region (Little Karroo and Great Karroo); the southern part because the Committee of the E. S. O. asked to find a place as far South as possible for various astronomical reasons. A strong correlation between night cloudiness and rainfall was immediately found and convinced us to prospect this region in more detail.

To-day, my opinion on the organization of the first stage in a site survey is that it must consist mainly in travelling for a few months by car in the country, making as numerous contacts as possible with officials and meteorological observers, discussing on the spot the meteorological observations and statistics, and studying the topographical situation of the different places that may be chosen for later astronomical observations. Only after this, the second stage may start with observations at different stations of a chosen network.

In Southern Africa, we chose first a station having an altitude as high as possible, in the Swartberg Mountain (*fig.* 17 and *plate* I *a*) at roughly 1800 m. A few nights of observations in March of 1956, showed that the turbulence observed with a 25 cm aperture, using the diffraction ring method (Danjon scale), was very great (between 0.5″ and 1.0″). This important turbulence could be easily understood by considering the orographic situation. The motion of clouds coming over the ridge of the mountain made visible the turbulent motion of the air : we had thus to choose another station. This was done by moving to the North, on the Great Karroo, because : 1. the general level of the Great Karroo is higher than that of the Little Karroo and 2. the cloudiness seemed to be less on the northern side of the Swartberg Mountain than to the South. Observations were made during a few nights near the small town of Prince Albert, a few miles from the Swartberg in the Great Karroo. The difference in quality between this station and the preceding on the Swartberg was quite remarkable. Moreover, a systematic effect in azimuth confirmed the origin of the strong turbulence observed on the Swartberg : all observations made to the South at large zenith distance (over the ridge of the Swartberg) gave high values of turbulence, although the observations made over the Great Karroo gave the best images we ever saw in South Africa (turbulence of roughly 0.10″). I think we had there a definite proof that the mountain disturb the quality of the images, probably by dynamical effects.

On this basis we chose a station on the Great Karroo, as high as possible, sufficiently far from the Swartberg Mountain to avoid its orographic turbulent effect and also on the assumption that, as a first approximation, the image quality would be the same at all places on the Karroo owing to the uniformity of the local topography. The station chosen

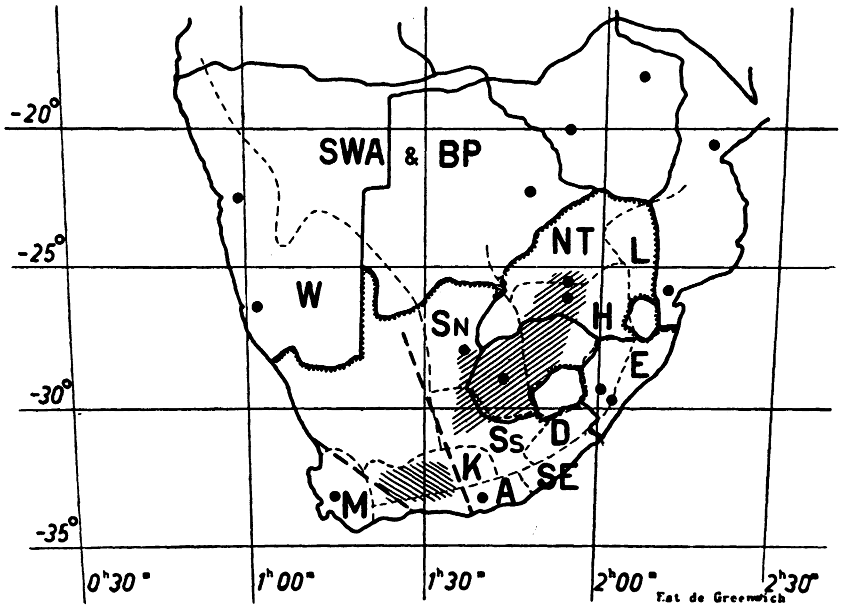


Fig. 65. — Climatological areas in South Africa.

The two shaded regions are those considered by the members of the E. S. O. expedition for their survey. The two dotted straight lines are the limits considered in figure 64 between the three areas of different mean rainfall distribution over the year.

was situated near Zeekougat (*fig.* 17), a spot more than a village. No effect in azimuth was observed there, so the station was retained as the first to be considered in our network.

But other stations had to be found in the same region. At this time we received, from an observer working at Laingsburg for the Weather Bureau, a detailed map giving all the climatological regions of South Africa (*fig.* 65) with their characteristics.

On this map, we found that we were starting our survey in a region called K corresponding to the two Karroos and having interesting

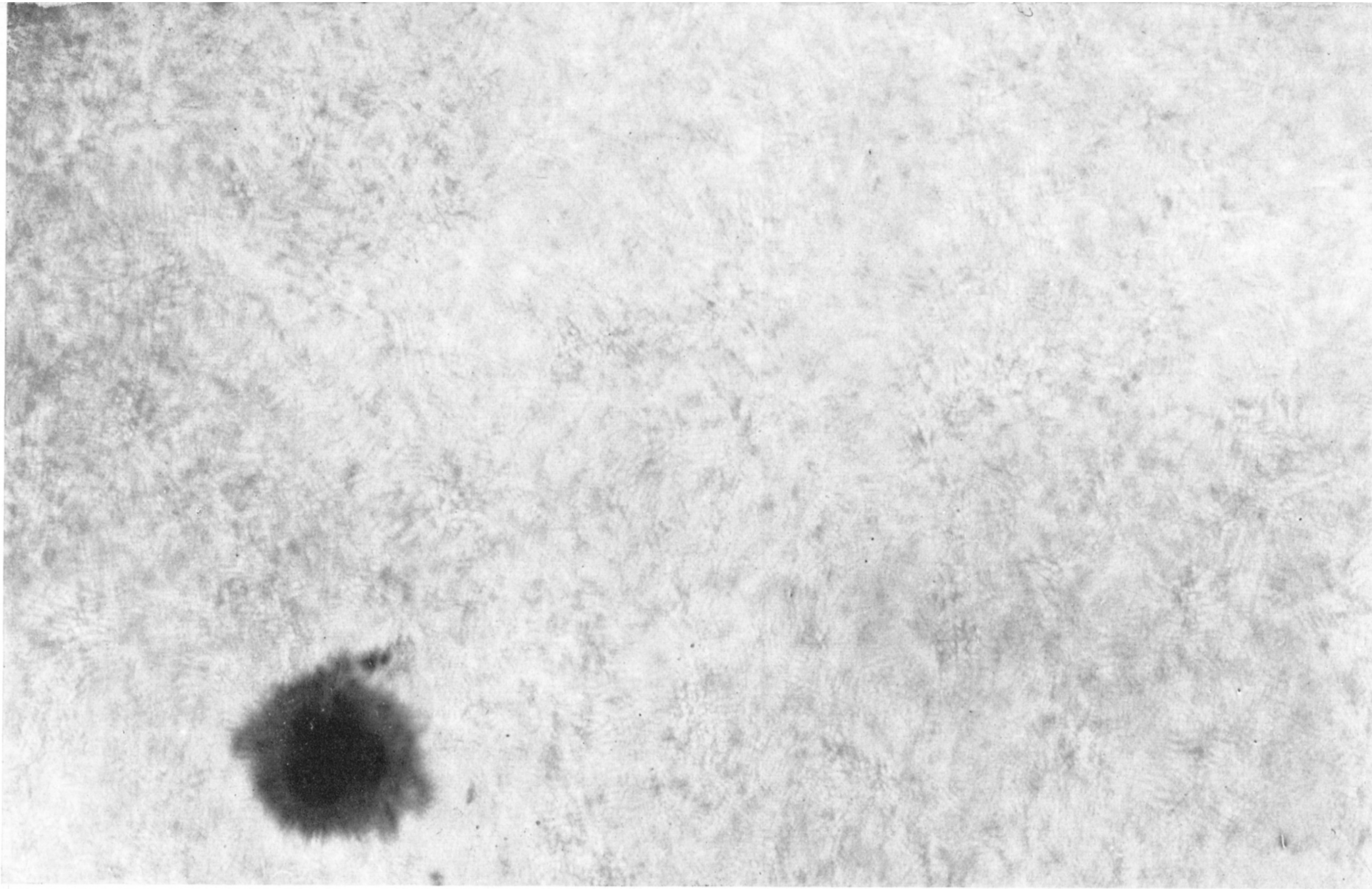
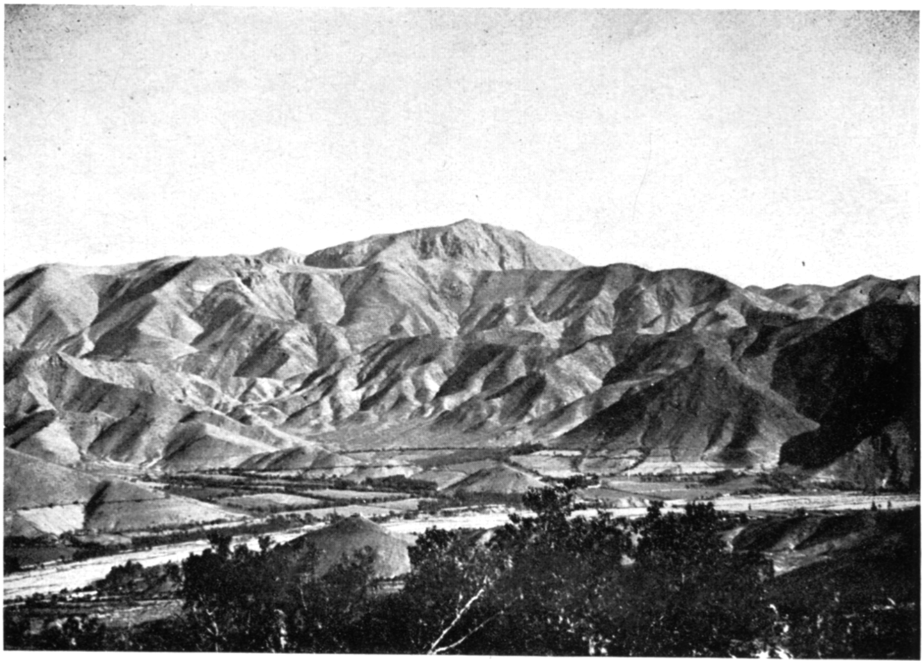
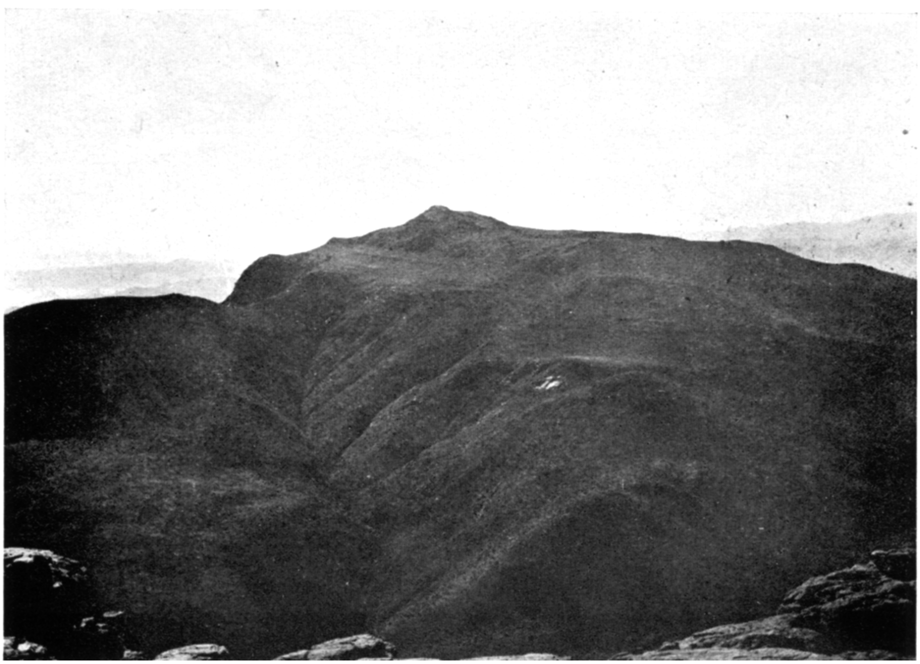


PLANCHE XIII. — Le « *réseau photosphérique* » de Janssen. Le diamètre apparent moyen de la tache (pénombre comprise) est de 40". (Cliché Belorizky.)



(*a*) Tololo seen from a distance of 25 km to the North-East.



(*b*) Closer view of Tololo.

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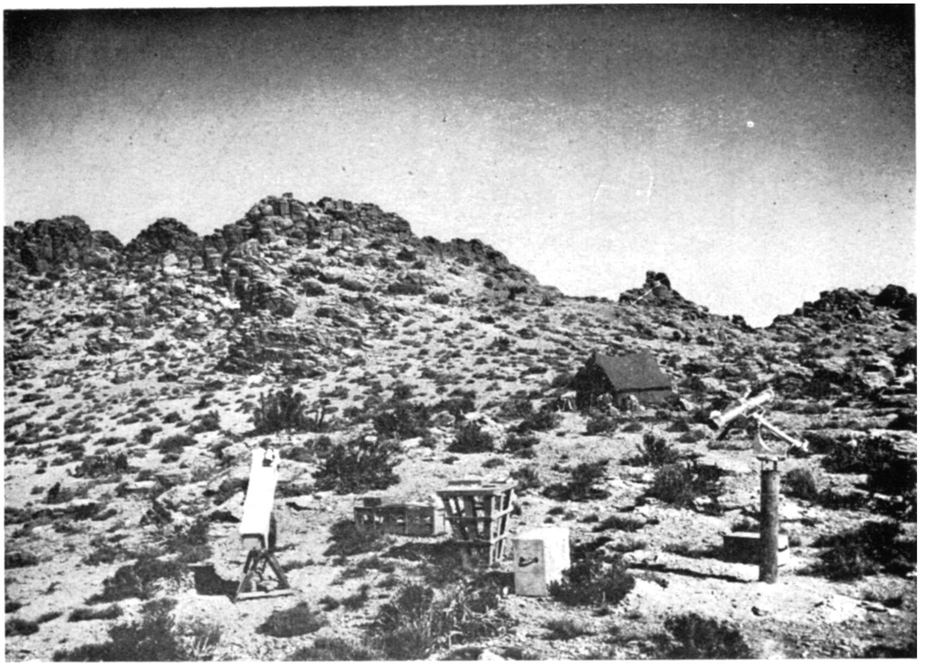
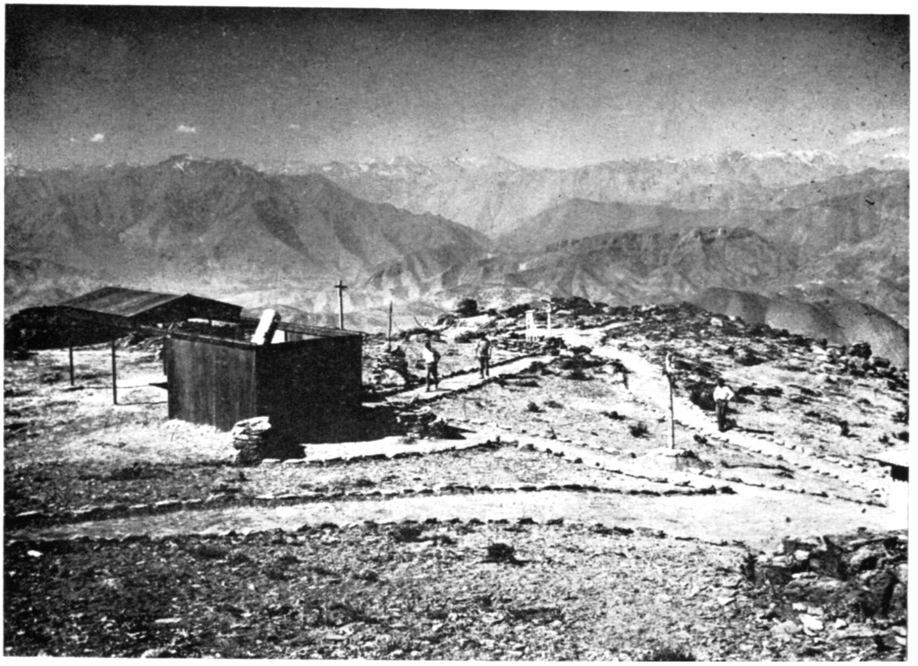


(*a*) How we started in Tololo.



(*b*) What Tololo is like now.

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(*a*) Fog at the foot of Tololo.

(*b*) View from Tololo towards the coast.

climatological characteristics. Therefore we decided to study this region in more detail. The station of Zeekougat having a roughly central position in the K region, we chose some stations all around the region K or on its boundary : at Laingsburg, Beaufort West, Willowmore, Oudtshoorn and Calitzdorp. Oudtshoorn was chosen as the principal station following a plan of organization given below, for different practical reasons (centre of commercial activity, workshop, post office, etc.).

Three sets of observations were systematically made each night at 1 h after sunset, around midnight, and 1 h before sunrise. Each set consisted in an estimation of the quality of the images by the diffraction ring method (Danjon scale; 10 stars chosen in different azimuths and at different heights : 15 mn time), the first and the last sets being also devoted to photometric observations of transparency and scintillation (45 mn of time). Observations of cloudiness, temperature, pressure and humidity were also made.

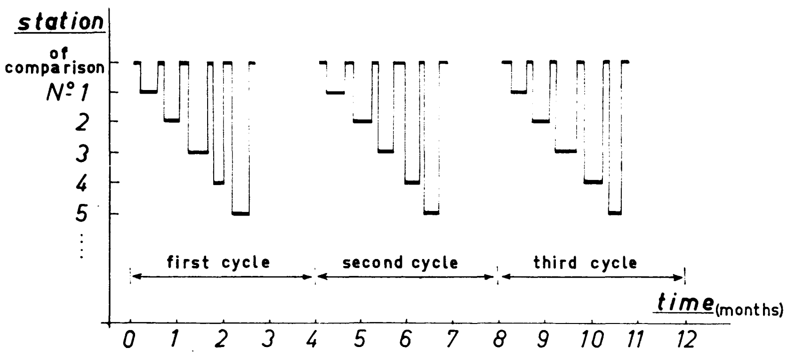

Fig. 66. — Principle of a site survey organisation in the case of distant observing stations (of the order of 50 to 100 miles for instance).

Only one comparison station and three cycles per year of routine observation in the other stations are considered. Each stay at the comparison station includes a minimum of two clear nights of observations; each one in the other stations is of at least five such nights.

Two or three nights were regularly spent at the principal station of Oudtshoorn before going to one of the other stations. In each of these, five nights of observations without any cloudiness were considered as a minimum to get enough information for statistical studies. The different stations were visited in a fixed order, three times a year in three cycles (*fig.* 66).

It was our opinion that disturbances in image quality may have only two origins : the local orographic situation and the general meteorological situation.

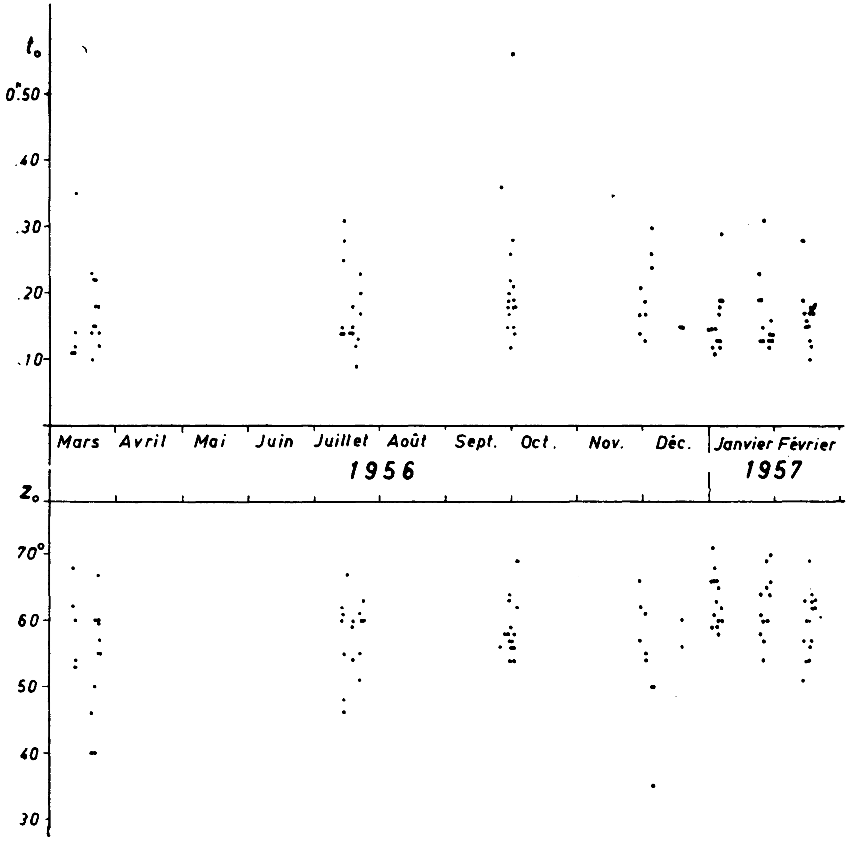

Fig. 67 *a*. — **Individual values of the turbulence (Danjon's scale) observed at Zeekougat from March 1956 to February 1957.**

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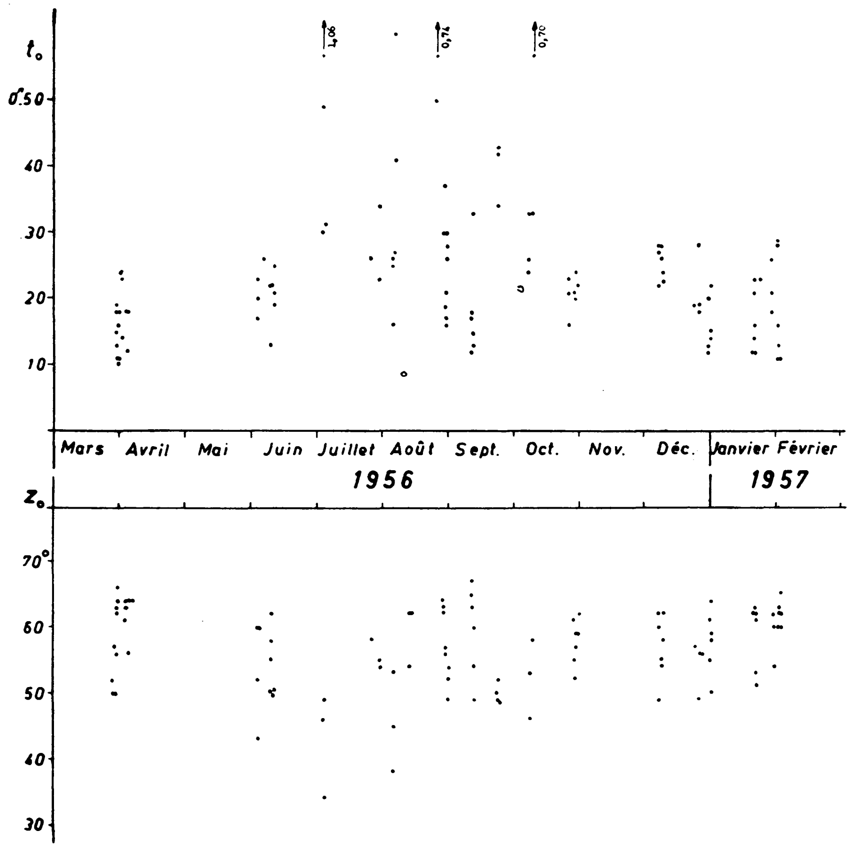

Fig. 67 *b.* — Same at Oudtshoorn.
(Our stays at Zeekougat were more frequent towards the end our survey because the results of observations gradually convinced us that Zeekougat was the best of our stations and that it was thus necessary to have more information on it).

If two stations are very near to each other (1 mile for instance) the meteorological situation may be considered to be the same at the two stations. In this case a few observations made simultaneously at the two stations are enough to show eventual differences in local orographic effects.

If on the other hand, the two stations are separated by distances of 50 to 100 miles for instance (as was the case for the network of our survey in the Karroo) one is never sure that at the same moment the meteorological situation is exactly the same at the two stations. So, it is of

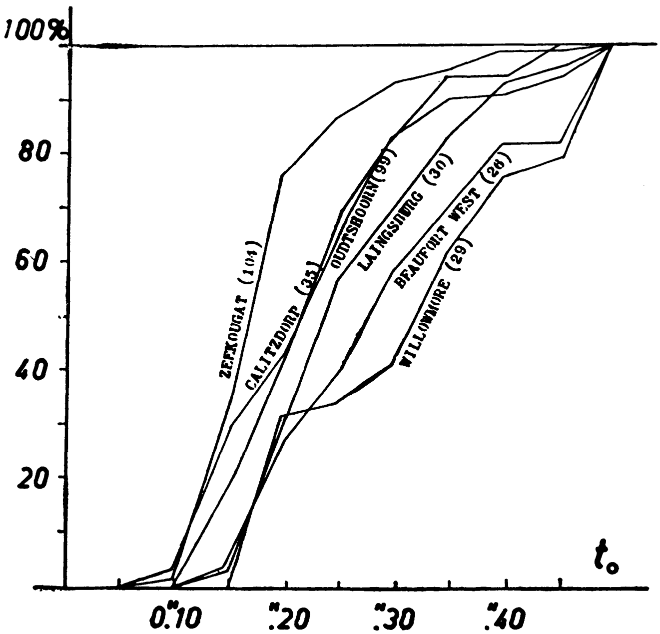

Fig. 68. — Diagram of cumulative frequency of the values of the turbulence t_0 (Danjon's scale) observed at all the stations in the Karroo.

no significance to make observations at exactly the same time. Only statistical studies of observations made in the same season (month or week) may lead to some conclusions regarding differences in local and seasonal effects. This is a justification, in my opinion, of the type of organization adopted for our survey.

In our case, the observations at one station were compared statistically to interpolated values obtained by considering the general evolution of the " seeing " at the principal station of Oudtshoorn (*fig.* 67 *a* et *b*). Diagrams of cumulative frequencies for the turbulence (Danjon scale) were also considered (*fig.* 68).

On examining our results we found that the best station was really Zeekougat. All the others showed some seasonal effects not only in image quality but also in the cloudiness. The transparency appeared to be the same everywhere, with only very small differences, of a few hundreths of magnitude, in the yellow band.

Now, during the last stage of the E. S. O. survey in South Africa, only two stations were considered : the station of Zeekougat for the reason we explained here, and a new station on the plateau situated to the north of Beaufort West, owing to the higher altitude of this region. This last stage started at the beginning of 1961 with continuous observations at the two spots, and will come to an end probably at the beginning of 1963. Then a definite choice shall have to be made.

Before ending this lecture, I want to make some comments on two important points.

The first one is this : Information on night cloudiness obtained in the way we were observing at our stations. following cycles of approximately three or four months, cannot lead to a statistical study of meteorological differences between stations. Only observations made continuously throughout the year at the different stations, by trained observers following fixed procedures, can give useful information. Therefore, on the same network as our " astronomical " stations, we established a meteorological network by trying to find some serious observers. These people were, for instance, the meteorological observer we had contacted at Laingsburg (the one who had given us the map of the climatological regions of South Africa), one sister of the Holy Cross Convent at Oudtshoorn, a farmer on the Karroo (near Zeekougat), a University student at Prince Albert, the Town clerk at Willowmore and a farmer, who makes also rainfall observations in the mountains north of Beaufort West. Naturally, regular control of the accuracy of their observations had to be made. This was done very easily by comparing their observations with ours during each stay in one or another spot, and also when we had the opportunity to pass by in the neighbourhood. Naturally, we never informed the observers, so that the control was made in the best conditions. The differences between observations made by the cloud observers and by ourselves never exceeded one-eighth. So on the basis of nearly one year's cloudiness observations, we found that the number of clear nights was highest in the region situated between Prince Albert and Zeekougat.

The second point concerns the instruments we used and the general equipment of one of our stations (*fig.* 69 and 70). I want to insist especially on the characteristic required of such instrumentation used in the first stage of an important, extended site survey in a country like South Africa. First of all, it is my opinion that we need simultaneously very light and transportable instruments and also very quick and direct

Fig. 69. — General view of an observing station (Calitzdorp).
On the same azimuthal mouting are :
— the reflecting telescope of 25 cm aperture used for visual observations (Danjon's scale of turbulence);
— the refractor of 11 cm aperture used for photometric work (transparency).

Fig. 70. — A complete site testing equipment ready for packing.

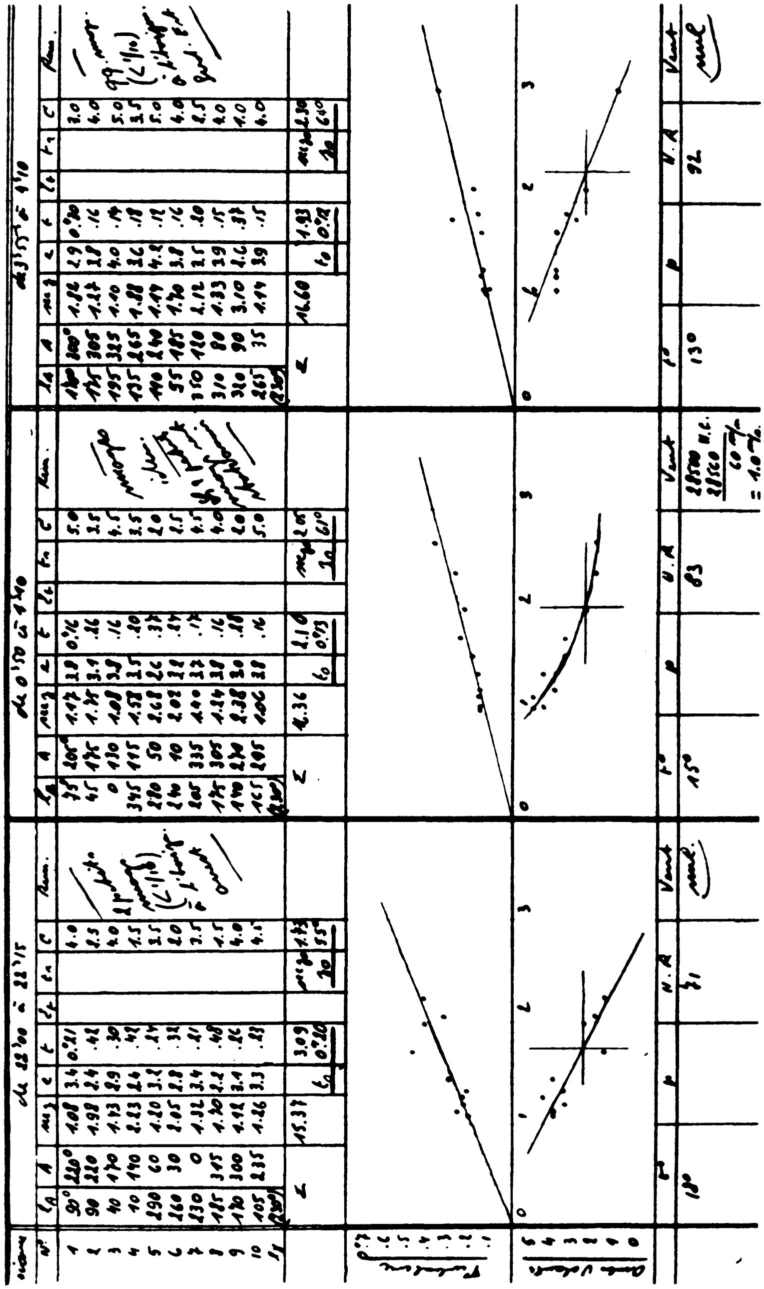

Fig. 71. — Reduction sheet for observations of turbulence made during one complete night.

methods of observation, especially methods which can give immediately some values representing alteration, agitation or scintillation. This is very important because it is often of great interest to be able to compare two spots near each other within a very small interval of time. The observations have to be made quickly, the instrument has to be dismantled and easily reassembled at the other spot to be ready for a new set of observations. Thus within a short time, after a few journeys to and fro, a decision may be taken concerning the relative quality of the two spots. On the other hand, direct reduction may indicate whether the survey is organized in the way best calculated to yield useful information. In our case, it was possible to drop some of our stations following the results of a few months of routine observations, showing for instance effects in azimuth.

In connection with this last point, I want to mention the importance of making observations in all directions. Dr. Coutrez observed in 1948 in the Belgian Congo (Kivu), a very surprising phenomenon : the value of the transparency was the same in all directions, in azimuth as well as in elevation. I recall also our own observations at Prince Albert, giving in the direction of the Karroo much better images than those obtained over the Swartberg Mountain.

Figure 71 shows a reduction sheet for the observations made during one complete night. This does not need any special explanation. Some more information may be found in my paper : *Le projet de création d'un observatoire européen en Union Sud-Africaine* (Communications de l'Observatoire royal de Belgique, n° 141, 1958).