EUROPEAN SOUTHERN OBSERVATORY

BULLETIN NO. 1

The Governments of Belgium, the Federal Republic of Germany, France, the Netherlands, and Sweden have signed a Convention[1] concerning the erection of a powerful astronomical observatory on October 5, 1962.

By this Convention a European organization for astronomical research in the Southern Hemisphere is created. The purpose of this organization is the construction, equipment, and operation of an astronomical observatory situated in the Southern Hemisphere. The initial program comprises the following subjects:

1. a 1.00 m photoelectric telescope,
2. a 1.50 m spectrographic telescope,
3. a 1.00 m Schmidt telescope,
4. a 3.50 m telescope,
5. auxiliary equipment necessary to carry out research programs,
6. the buildings necessary to shelter the scientific equipment as well as the administration of the observatory and the housing of personnel.

The site of the observatory will be in the middle between the Pacific coast and the high chain of the Andes, 600 km north of Santiago de Chile, on La Silla.

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[1] The ESO Management will on request readily provide for copies of the Paris Convention of 5 October 1962.

Organisation Européenne pour des Recherches Astronomiques
dans l'Hémisphère Austral

EUROPEAN SOUTHERN OBSERVATORY

BULLETIN NO. 1

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ESO BULLETIN NO. 1

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FOREWORD

The European Southern Observatory is an institution which, besides its legal, financial, and organizational foundations, besides the work done in meetings of its Council, Finance Committee, Instrumentation Committee, besides the activity of its Management in Europe and Chile, needs the permanent support of the astronomers in its member states. It is their observatory which is being constructed, it is their vital energy which justifies the whole project.

The time of tentative discussions, of hesitating attempts, and pioneering improvisations has passed. The plans for the first instruments and buildings are nearing completion. The large instrument of 3.5 m aperture is steadily approaching a state of determinateness which soon will demand the study of almost innumerable details, the logistics of which has to be prepared.

At this state of the whole project it is appropriate to begin with the publication of a journal, called ESO Bulletin, to appear several times a year. It will serve the purpose of communicating to astronomers reports, plans, design studies, facts of any sort which might illustrate the project in its various aspects.

The Management hopes that the ESO Bulletin will help to spread informations from the lack of which the project has sometimes suffered.

Hamburg-Bergedorf, October 1966

O. Heckmann
Director, ESO

BERTIL LINDBLAD

Professor Bertil Lindblad, Astronomer of the Royal Swedish Academy of Science and Director of the Stockholm Observatory, died on the 25th of June 1965.

Bertil Lindblad was for several decades the central personage of Swedish astronomy and also a great authority in the international astronomical world. He was born in 1895 and studied at the University of Uppsala where he graduated and acquired docentship in 1920.

Already in 1927 at the age of 32, B. Lindblad was appointed astronomer of the Swedish Academy of Science and consequently also director of the Stockholm Observatory and professor of astronomy at the University of Stockholm (at that time Stockholms Högskola). B. Lindblad's first great task as astronomer of the academy was to plan the buildings and instrumental equipment of the new institution, when the Stockholm Observatory was moved from the centre of the town to Saltsjöbaden. The new observatory was finished in 1931; it has been a worthy frame for Bertil Lindblad's intense and prosperous scientific work.

Already in the years 1920—21, when as a scholarship holder he worked at the Mount Wilson, Lick, and Harvard Observatories, B. Lindblad became familiar with the branch of astronomical research where he would make one of his greatest contributions, the problem of determining the luminosities, and therewith indirectly also the distances of stars from their spectra. The study of the distances of stars and their distribution in space led B. Lindblad on to theoretical problems connected with the movements of stars. B. Lindblad's work in this field opened up new prospects and led among other things to the idea of the rotation of the Galaxy. In later years B. Lindblad became more and more absorbed by the realm of galaxies. In questions concerning the origin of the spiral structure, the rotation and the stability of galaxies, B. Lindblad was one of the outstanding authorities.

Among the many tasks of honour entrusted to Bertil Lindblad may here be mentioned that he was president of the International Astronomical Union 1948—1952 and president of the International Council of Scientific Unions 1952—1953. He was one of the leading figures of the Royal Swedish Academy of Science. From 1951 to his death he was president of the Swedish Research Council. A short time before his death he had been appointed president of the Nobel Foundation.

By his solid knowledge, not least within optics and instrumental theory, his intimate familiarity with current topics of astronomical research and his never failing judgement, Bertil Lindblad from the very beginning became one of the front-rank promoters in the ESO-organization. At his sudden death he stood right in the midst of the realization of the ESO project: at the meeting of the ESO Council in Stockholm on the 1st and 2nd of June 1965 Bertil Lindblad was unanimously elected president of the Council. One thing is certain: Bertil Lindblad's enthusiastic and generous achievement within the ESO-organization high above all narrow national restraints has been and will remain a pattern within the Organization.

Hamburg-Bergedorf
October 1966

Jöran M. Ramberg

A DOCUMENT CONCERNING THE ASTRONOMICAL COMPARISON BETWEEN SOUTH AFRICA AND CHILE

In June 1963 the ESO astronomers Ch. Fehrenbach, O. Heckmann, A. B. Muller, J. H. Oort, and H. Siedentopf met the AURA astronomers F. K. Edmondson, N. U. Mayall, and J. Stock in Chile. On 10 June they had a final discussion on the summit of Morado Mountain about the climatic properties of South Africa and Chile as far as they are astronomically relevant.

A document was later presented to the ESO Council which had the following text:

Comparison between conditions in South Africa and Chile

1. Cloudiness

Statistics indicate that the number of clear nights on Mt. Tololo near Vicuña is about 40 % larger than in the Zeekoegat — Beaufort West area in South Africa. It would seem that approximately the same percentage difference applies to "photometric" nights. The total number of "photometric" nights on Tololo is estimated to be between 220 and 240 per year. There is in Chile a stronger tendency for long periods of consecutive clear nights.

2. Seeing

No satisfactory direct comparison between South Africa and Chile is possible because of the difference in the methods used to determine the quality of the seeing. However, there is considerable evidence showing that average seeing conditions in the region investigated south of Vicuña are sensibly superior to those found at the Californian observatories and at the Observatoire de Haute Provence. On Tololo, for the entire observing period, Stock finds that 60 % of the time the image diameters computed for a large telescope were smaller than 1″. At Lick this occurs less than 25 % of the time. At the Lick Observatory a diameter as small as 0.5″ is rare, while according to Stock's data a diameter smaller than 0.5″ would occur on about 25 % of the clear nights.

It is interesting to note that Dr. Bowen has determined the light efficiency for his spectrographs on the basis of an average image size of 2″. Stock, on the other hand, has only once observed an image diameter larger than 2.5″. Muller reports that in a complete fortnight on Tololo he has never had poor seeing.

3. Change of temperature during the night

These changes are much less on Tololo and Morado than in South Africa. According to Mayall and Fehrenbach the quality of the seeing is correlated with the fall in temperature during the night in the sense that good seeing generally occurs when the temperature drop is small.

The small change of temperature is of great importance for the constancy of the mirrors. An additional advantage of the small drop in temperature is that the relative humidity stays smaller during the night.

4. Wind velocity

The average wind velocity on Tololo is higher than at Zeekoegat, but lower than on Rockdale Mountain¹⁾. Data on this will be given in the following report.

5. Latitude

Tololo and Morado are at —30.2°; the Karroo region where we have observed in South Africa is at —32.5°.

6. Extinction

Though the photometric measures made on Tololo may indicate an extinction which is slightly greater than that corresponding to Rayleigh scattering by the atmosphere, the precision of the photometric results shows that any possible dust layer must be so homogeneous that the measurements are not adversely affected.

On the basis of these data we think that Chile is definitely to be preferred from the astronomical point of view.

Addendum (1966):

The comparatively unfavourable conditions in the Karroo area were definitely confirmed by the Zeekoegat group of radial velocity observers (see report of Ch. Fehrenbach, p. 22).

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1) Cape Province, South Africa.

COMPARISON BETWEEN SOUTH AFRICA AND CHILE

H. Siedentopf †

The following Report was approved by the ESO Commission for Site-Testing in autumn 1963 and presented to the Provisional ESO Committee (the later Council) during its 21st Meeting on 15 November 1963 at Bonn. It was written by the late Heinrich Siedentopf during his last days in the hospital. (Editor)

The ESO expeditions have obtained useful observations of all kinds for South Africa, but for Chile we have to rely on J. Stock's Technical Report No. 2[1] from May 1963 and on the few results obtained during the short visit of A. B. Muller. The difference of observers and methods makes the comparison sometimes uncertain. For the mountain Morado that for different reasons is considered[2] as the only suitable site for ESO in Chile practically no observations exist.

1. Number of clear nights. Fortunately the difference in the number of clear nights between Chile and South Africa is convincing, and no doubt is possible about the superiority of Chile in this respect. Below we give the number of clear nights for 3 regions in both countries. The African data have been calculated by J. Pfleiderer from the observing books of the Cape and the Boyden Observatory and of the Tübingen group on Rockdale Mt. for the time November 1961 until November 1962, the Chilean data are from Table VI in Stock's report. They cover a time of several years. As mentioned in the introduction the root mean square deviation for the yearly number of clear night hours at Boyden Obs. is ± 11 %. If we consider this value as typical, we see that the difference between the Tololo region and all regions in South Africa is more than three times the mean deviation. So the difference must be considered as statistically significant even if the cloudiness in the Beaufort West region was a little above normal during 1961/62.

Number of clear night hours per year

34° Capetown 1961/62	1470	33½° Santiago	1675
32½° Rockdale Mt. 1961/62	1285	30° Tololo	2300
29° Boyden Obs. 1961/62	1750	27½° Copiapó	2760

We get a similar result if we compare the relative number of clear nights. A clear night is defined as a night with at least six successive cloudless hours. This definition is identical with Stock's definition of a photometric night. The comparison is made in Fig. 1.

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[1] Chile Site Survey. Astronomical observing conditions in North-Central Chile. May, 1963. Kitt Peak National Observatory, Tucson, Arizona.

[2] in 1963 (added 1966; Edit.)

The data for the three African stations are taken from the ESO observations, the data for Tololo from Fig. 13 in Stock's report. The observations at the three African stations do not cover the same period. So it happens that Rockdale has the highest mean value since the observations stopped there before the bad months at the end of 62 and the beginning of 63. We can consider a value near 40 % clear nights as typical for the Beaufort West region and a value near 70 % as typical for the Tololo region. That means about 75 % more clear nights in Chile. This is nearly the same proportion as in the total number of clear night hours if we compare the Rockdale and the Tololo values given above.

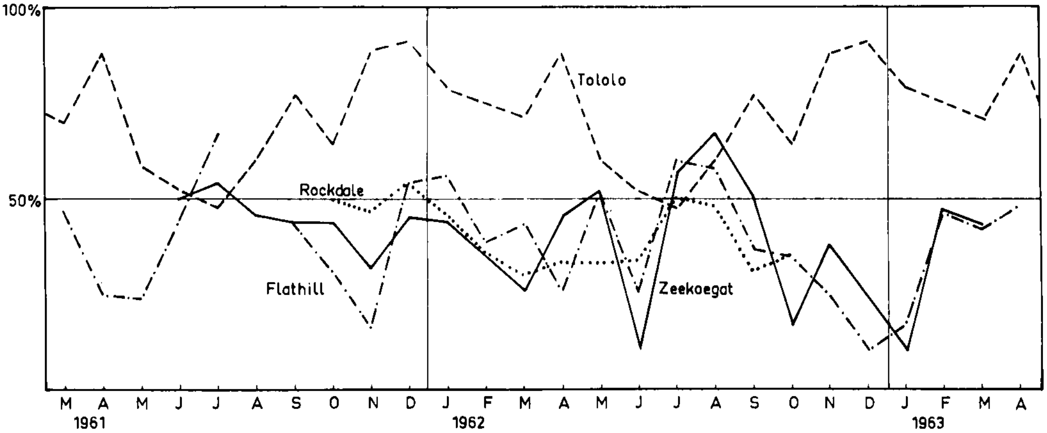

Fig. 1: Relative number of clear nights in South Africa 1961—1963 (ESO Seeing Expedition) and Tololo (mean value of photometric nights after Stock)

Mean values during the observation period:

Rockdale	40 %	Tololo	71 %
Zeekoegat	39 %		
Flathill	38 %		

So we can expect that a Morado observatory has around 75 % more observing hours than an observatory in the Beaufort West region. It must also be mentioned that long periods of consecutive clear nights occur much more frequently in the Tololo region than in South Africa.

2. Turbulence and image motion. The possibilities of comparison are meagre. For the turbulence value t_0 we have for Chile only a short series of observations with a Danjon-telescope on Tololo by Muller. The mean value of t_0 derived from his report No. 1 is more favourable than the mean values obtained by the ESO observers in South Africa during 1961/62:

Tololo (Muller) $t_0 = 0.21''$
Zeekoegat 61/62 $t_0 = 0.28''$
Flathill 61/62 $t_0 = 0.31''$

For image motion, the observations by McSharry with the AURA double beam telescope at Zeekoegat and on Flathill during the months June, July and August 1963 can be compared with the values of the AURA observers on Tololo during 1961/62 given in Stock's report. The comparison is somewhat doubtful since the individual scale is different for different observers as can be seen from Stock's report. If we compare the values of Stock's Fig. 9 (observer Stock) with the values of McSharry reduced by Muller we come to certain distribution functions. If we take from these the 50 %-values of the absolute image motion (that means 50 % of the observations give smaller image motions) we get the following results:

Tololo Stock 1961	m_0 (50 %) = 0.40″
Tololo Stock 1962	m_0 (50 %) = 0.25″
Zeekoegat McSharry 1963	m_0 (50 %) = 0.56″
Flathill McSharry 1963	m_0 (50 %) = 0.82″

So it seems that the image motion on Tololo is distinctly smaller than at the African sites, especially if we remember that on Tololo the double beam instrument stood on the ground whereas at Zeekoegat and Flathill it was 4 m above the ground.

Both turbulence and image motion observations indicate better seeing on Tololo than in South Africa, and it can be hoped that the same holds for Morado. It should however be mentioned, as Rösch pointed out, that the lee waves from Tololo caused by the generally blowing northwind may influence the seeing on Morado.

3. The temperature drop during clear nights. We can only compare Tololo and the ESO sites in South Africa. No data are available to establish a comparison between the ESO sites and Morado.

In his Technical Report no. 2, page 44, Stock gives an example of the temperature fluctuations on Tololo. According to him, this example is typical for the temperature conditions through the year. The most interesting feature of this graph is the small temperature change during the night. The average temperature drop during these nights as read from this graph is of the order of 1,8 degrees Celsius. This is in agreement with the temperature change found by Muller and McSharry during their visit to Tololo, being on the average of the order of 1,3° C. The following table gives the data for the sites Zeekoegat, Flathill, and Tololo.

Site	Number of clear nights	Average temperature drop in °C
Zeekoegat	54	4,2
Flathill	92	5,8
Tololo 1 (M. and McSh.)	14	1,3
Tololo 2 (Stock)	7	1,8

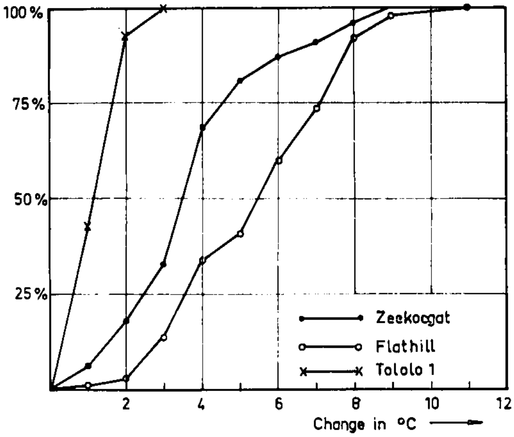

Fig. 2: Temperature drop during the night

Fig. 2 showing the cumulative distribution functions for the three sites demonstrates the superiority of Tololo. We can expect that the conditions on Morado are similar, the slope of the mountain top should be sufficient to cause a downflow of the cold air during the night.

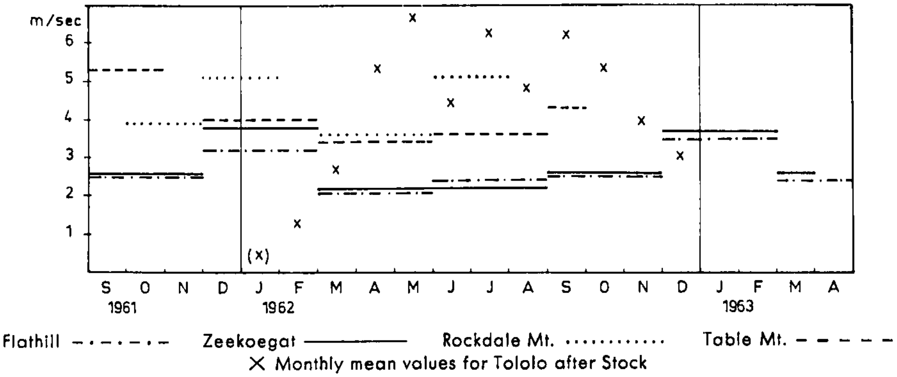

Fig. 3. Average seasonal wind velocities in South Africa and Chile

4. Average wind velocities. In Fig. 3 the seasonal mean values of the wind velocities for four African stations are compared with the monthly mean values for Tololo taken from Stock's report. During the greatest part of the year the Tololo values are higher than the values of Flathill and Zeekoegat, even higher than the values of Rockdale where during the Tübingen photometric expedition the wind sometimes was very disturbing.

The wind on Morado will be very similar to the wind on Tololo. A careful construction of the domes is therefore necessary to get a sufficient protection of the instruments against the wind.

5. Atmospheric transparency. From the ESO site testing work the extinction values E_B and E_V in the blue and the visual spectral regions are available for Zeekoegat and Flathill. The reductions were done by Pesch. For Rockdale Mt. we have the results from the Tübingen photometric group. For Tololo, we find in Stock's report values for 38 nights from May to August 1962 (E_V only for 8 nights). The following table shows the mean values of the observed extinction coefficients and the value for a dustfree atmosphere.

	E_V	E_B	
Zeekoegat (59 nights)	$0.^{m}18$	$0.^{m}31$	1060 m
Flathill (44 nights)	$0.^{m}16$	$0.^{m}28$	1540 m
Rockdale (40 nights)	$0.^{m}13$	$0.^{m}25$	1860 m
Tololo (8/38 nights)	$0.^{m}13$	$0.^{m}26$	2200 m
Rayleigh scattering + O_3-absorption for 2000 m	$0.^{m}115$	$0.^{m}22$	

The observed mean values for Tololo and Rockdale are close to the values of a pure Rayleigh atmosphere, so the dust content above both places must be very small. Since the accuracy of the mean values is about ± $0.^{m}02$, we can state that the transparency in the Tololo region is at least of the same quality as in the Beaufort West region.

6. Conclusion. From the astronomical point of view the Tololo region should be preferred to the Zeekoegat-Klaversvlei region: it offers a much greater number of clear nights and apparently also a somewhat better image quality, the atmospheric transparency is comparable to the best African sites, and the small drop of temperature during the night is very favourable for astronomical observations. Only the high wind velocities may be a certain disadvantage but they can be overcome by appropriate engineering work. The conditions on Morado cannot be much different from the conditions on Tololo. At any rate a careful meteorological exploration of Morado (e.g. wind, temperature, humidity, temperature fluctuations in different heights above ground, seeing with different methods) is necessary before the places and the heights of the domes are chosen.

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METEOROLOGICAL OBSERVATIONS ON LA SILLA IN 1965

A. B. Muller

Introduction

Whereas in 1964 meteorological observations on La Silla were very fragmentary, they became more regular in 1965. Nevertheless, they still show various insufficiencies caused by the typical conditions of a not yet developed and very isolated desert area.

In the following, only such data are communicated as are based on firm observations. In the case of wind direction and relative humidity, only some indications are given because the observations were not very reliable. The information about 1966 will be more complete.

It was not before 15 January 1965 that our work at the mountain "La Silla" could start. On 20 January an emergency camp was installed near the summit ridge. As the weather was rather good, it was possible to live in tents. All transport to the top was done with horses and mules. Two different tracks were used. The first one was one hour by car through Quebrada Pedernales and two hours on horse back through Quebrada Algarrobillo. This track needed difficult preparations because of the transport of horses through the Quebrada Pedernales with fodder for the animals. The second track which was finally chosen went directly from Camp Pelícano to the top of La Silla. The distance of about 15 km. took five hours on horse back. During March a provisional camp of wooden houses was constructed on the mountain and came into use in April. This camp was used troughout the year. Although conditions were pretty hard, the team spirit was excellent and enabled us to collect a valuable amount of information on the weather during 1965. Under the prevailing conditions it was impossible to continue the observations over the week-ends.

The observations concern clouds, wind velocity, temperature, and humidity.

Clouds

In the period from 20 January till and including 31 December, observations were collected over 219 nights which is 63 % of the 346 possible nights.

A comparison was made between the percentage of photometric clear nights obtained (by different observers) at La Silla and Tololo over 1965. All nights having six or more continuously clear hours were defined as "photometric nights". As 1965 is said to be an exceptionally poor year, a comparison for Tololo was made for the years 1962, 1964, and 1965 (see Table 1).

Table 1: Percentage of photometric nights

Month	Tololo			La Silla
	1962	1964	1965	1965
January	78	81	68	—
February	76	98	89	73
March	70	65	77	79
April	88	67	46	33
May	59	58	52	15
June	51	43	20	6
July	47	68	28	9
August	60	77	45	25
September	77	86	67	63
October	64	68	55	63
November	88	77	60	65
December	90	77	77	77

In 1965 conditions at Tololo were slightly better, but this may result from the fact that at La Silla no continuous observations were made, as already mentioned in the introduction. The table shows that 1965 was poor compared to the other years. It is worth-while mentioning that normally the nights were either totally clear or totally cloudy. Nights with changing cloudiness were relatively rare. Among the 219 observed nights, 76 nights were totally clear, 93 nights completely cloudy, and 50 nights partly cloudy. Of these 50 nights, 30 were photometric nights.

Wind velocity

Fig. 1 gives the profile of the top of La Silla in the north-west — south-east direction.

Wind measurements were performed at the points indicated by:

(1), height 2393 m;
(2), height 2405 m;
(3), height 2444 m;

but most of the time at (2) and (3).

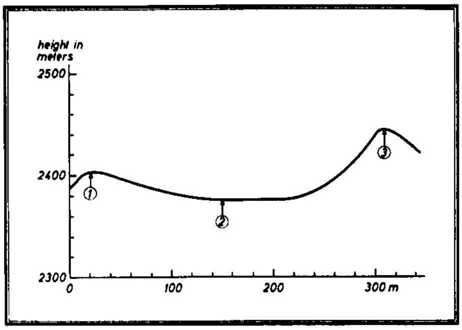

Fig. 1: Profile of La Silla

Because of a number of technical difficulties, the instruments were not in regular use. Therefore, the wind results are not based on continuous observations throughout the year. A wind recording was made every two hours for photometric clear nights only. The results for the sites (2) and (3) are compiled in the tables 2 and 3 respectively.

Table 2: Frequency of wind velocity v during clear nights in 1965 on site (2)

v	J	F	M	A	M	J	J	A	S	O	N	D	T	%
0—1			3					2	1	5			11	4
1—2			13					5	5	11			45	18
2—3			15	1			1	8	6	3			79	31
3—4			23	1			3	4	11	4			125	49
4—5			17	1		1	1	5	21	10			181	71
5—6			9				1	5	5	6			207	81
6—7			4			2		2	5	1			221	86
7—8			2						2	3			228	89
8—9			1						5	1			235	92
9—10			2						4	1			242	94
10—11									5				247	96
11—12										1			248	97
12—13			2							1			251	98
13—14														
14—15				1									252	98
15—16														
16—17				3									255	100
17—18				1									256	100

The monthly frequencies of wind velocities are given between the limits in m/s of the first column. T gives the frequency sums below the higher limit of the first column.

Table 3: Frequency of wind velocity during clear nights in 1965 on site (3)

v	J	F	M	A	M	J	J	A	S	O	N	D	T	%
0—1			4						2	16	11	11	44	9
1—2			3					3	4	6	25	19	104	21
2—3			16					2	6	12	17	13	170	35
3—4			9	2				5	7	18	18	9	238	49
4—5			21	4				1	11	7	13	15	310	64
5—6			5					2	17	2	16	16	368	76
6—7			4					4	12	4	8	9	409	84
7—8			1					1	3		5	7	426	88
8—9			1					1	4	1	2	8	443	91
9—10			2					1	1			10	457	94
10—11											1	6	464	95
11—12			1						1		1	9	476	98
12—13								1				4	481	99
13—14			2									2	485	100
14—15												1	486	100

The monthly frequencies of wind velocities are given between the limits in m/s of the first column. T gives the frequency sums below the higher limit of the first column.

The last columns give the percentage of observations with velocities equal or smaller than the velocity indicated in its respective row.

Table 4 was compiled for the months in which simultaneous observations are available for both sites (2) and (3).

Table 4: Frequency of wind velocity in simultaneous observations at (2) and (3)

v	Site (2)						Site (3)					
	M	A	S	O	T	%	M	A	S	O	T	%
0—1	3	2	1	5	11	5	4		2	16	22	10
1—2	13	5	5	11	45	19	3	3	4	6	38	17
2—3	15	8	6	3	77	32	16	2	6	12	74	33
3—4	23	4	11	4	119	50	9	5	7	18	113	50
4—5	17	5	21	10	172	72	21	1	11	7	153	68
5—6	9	5	5	6	197	82	5	2	17	2	179	80
6—7	4	2	5	1	209	87	4	4	12	4	203	91
7—8	2		2	3	216	90	1	1	3		208	93
8—9	1		5	1	223	93	1	1	4	1	215	96
9—10	2		4	1	230	96	2	1	1		219	98
10—11			5		235	98						
11—12				1	236	99	1		1		221	99
12—13	2			1	239	100		1			222	99
13—14							2				224	100
14—15												

Table 4 shows that there was no remarkable difference in wind velocities between the sites (2) and (3).

We failed to register the very strong winds which occurred in July, but because conditions between Tololo and La Silla are not very different, it is certain that several times wind velocities went over 120 km/h, which is equivalent to 33 m/sec.

Since both windmeters were calibrated against a standard instrument, the only possible error can be the deviation of the standard instrument itself. These deviations, however, will have little influence on the general aspect of the results.

Wind direction

The prevailing wind direction during clear nights is from the north. The observations of 1965 do not allow a detailed study of the general performance. Special attention will be given to this part in 1966.

Temperature

Maximum and minimum temperatures

The differences of the maximum day temperature T_{max} with the following minimum night temperature T_{min} were measured from calibrated maximum and minimum thermometers. Table 5 gives the results for site (2).

Table 5: Number of days N with given difference of $T_{max} - T_{min}$ in 1965

$T_{max} - T_{min}$ in C°	N	$T_{max} - T_{min}$ in C°	N
1	1	14	22
2	1	15	11
3	4	16	13
4	9	17	2
5	7	18	2
6	23	19	2
7	9	20	2
8	40	21	
9	14	22	
10	47	23	
11	9	24	
12	22	25	1
13	14		

From this table it is clear that temperature differences of more than 16° occurred seldom.

Temperature changes during the night

From the 106 photometric clear nights, temperature registrations exist for 86 nights. For these 86 nights the temperature change was measured.

The results are compiled in table 6.

Table 6: Temperature gradients ΔT between evening and morning temperature during photometric nights

Temp. Diff. (in C°)	Frequency	Total	%
0,6	4	4	5
1,2	9	13	15
1,8	22	35	41
2,4	24	59	69
3,0	11	70	81
3,5	7	77	89
4,1	5	82	95
4,7	1	83	97
5,3	1	84	98
5,9	2	86	100

The first column gives the intervals of Δ T in degrees Celsius.

The second column F indicates the number of nights during which a certain Δ T as indicated in the first column occurred.

The third column T gives the number of nights during which Δ T was equal to or less than the temperature gradient indicated in the first column of its row. The last column gives the percentage of the frequency.

The queer temperature intervals are due to the fact that all readings and reductions were originally made in degrees Fahrenheit and were converted afterwards in degrees Celsius.

It is a striking feature of La Silla that the temperature gradients during the photometric nights are comparatively small. Similar results were found at the mountains Tololo and La Peineta.

Relative humidity

The 1965 measurements of relative humidity are very incomplete. The low number of reliable results indicate that relative humidity is normally below 50 %.
In 1966 measurements will be made regularly with a psychrometer.

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LA STATION DE L'ESO A ZEEKOEGAT EN AFRIQUE DU SUD

Ch. Fehrenbach

Après cinq ans d'activité, la Station Astronomique de Zeekoegat a cessé de fonctionner en février 1966. Il est normal de faire le point de cette expérience qui clôt l'activité de l'Organisation Européenne en Afrique du Sud.

Les très nombreux astronomes et techniciens, en très grande partie français, mais aussi allemands et suisses, qui ont travaillé dans la province du Cap, gardent tous le meilleur souvenir de la rude beauté de ce pays, de ses habitants blancs et noirs. Ils remercient leurs collègues de Pretoria, Capetown, Bloemfontein et Johannesburg et le Council of Scientific and Industrial Research (CSIR) pour leur aide amicale et ils pensent avec nostalgie aux habitants du Karroo, à leur amitié si cordiale. Ils ont aussi beaucoup apprécié l'aide et le dévouement de leurs serviteurs indigènes.

Le prisme objectif installé à Zeekoegat est un prisme à champ normal, tel qu'il a été décrit dans de nombreuses publications de l'Oberservatoire de Haute Provence¹⁾.

Le prisme objectif à champ normal est constitué par un prisme de flint auquel est accolé un prisme de crown-baryum. Ces deux verres ont le même indice pour $\lambda = 4175$. L'angle du prisme en flint est de $\alpha = 10{,}5$ degrés. Celui de crown-baryum diffère de 35″, de sorte que la vision directe est réalisée pour 4210 Å.

Le tableau suivant donne les caractéristiques de l'ensemble :

objectif : diamètre utile : 38,5 cm
distance focale : 399,4 cm
plaque 16 × 16 cm — champ 2 × 2 degrés avec lentille de champ
dispersion pour l'indice n_0 (4210 Å) = 110 Å/mm
Une vitesse radiale de 4 km/sec produit un déplacement de un micron de l'un des spectres par rapport à l'autre.
Magnitude limite : 12,5 pour une pose de deux fois 2 heures.

La monture est une monture à berceau, formée d'un cadre comprenant deux tubes de 50 cm de diamètre, reliés à leurs deux extrémités par deux plaques en aluminium. Ce type d'instrument est dérivé des instruments de la carte du ciel, mais

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1) A. Couder et Ch. Fehrenbach, Pub. Obs. de H^{te} Prov., vol. 4, n° 32. Marcelle Duflot, Pub. Obs. de H^{te} Prov., vol. 5, n° 37.

l'axe de déclinaison ne passe pas par l'axe polaire. Il est, au contraire, situé à une cinquantaine de cm au-dessus de cet axe, de sorte que l'instrument permet ainsi de pointer le pôle céleste.

L'entraînement de cet instrument, réalisé par la Société REOSC, est un entraînement à galet.

La lunette-guide a 26 cm de diamètre et 400 cm de distance focale. L'instrument lui-même est constitué par deux tubes de 50 cm de diamètre, liés par deux plaques de base dont l'une soutient les deux objectifs, l'autre l'oculaire de guidage et la plaque photographique. L'instrument est équilibré de façon à éviter toute torsion de l'ensemble : de cette façon, les petites flexions inévitables sont les mêmes pour la lunette-guide et la lunette photographique.

Nous désirons faire un certain nombre de remarques au point de vue scientifique et technique.

Sur le plan météorologique nous ne pouvons cacher que les conditions ont été beaucoup moins bonnes que les prévisions déduites des observations préliminaires. Il est hors de doute que les années 1964/1965 ont été des années exceptionnellement mauvaises; ces circonstances ne sont d'ailleurs pas particulières au Karroo et même à l'Afrique du Sud. La statistique des observations météorologiques qui sera publiée ultérieurement montrera, par des chiffres, ces conditions.

D'autre part, il est apparu de façon très nette qu'à côté de la transparence de l'atmosphère et de la turbulence, la variation thermique diurne est un facteur d'une importance absolument capitale. Les grands télescopes, mais aussi le prisme objectif de 40 cm, sont très sensibles aux variations thermiques; il en est résulté, surtout pendant la période estivale des observations des Nuages de Magellan, de novembre à février, des variations de foyer et des déformations du prisme que nous n'observons pratiquement pas à l'Observatoire de Haute Provence avec un instrument identique. Il faut dire que les variations thermiques ne sont pas aussi fortes en Provence.

Nous avons pris de grandes précautions pour éviter ces difficultés et nous pensons que la conception de l'abri, au point de vue thermique, était excellente : protection extérieure en tôle blanche, distante des murs, toit intérieur isolant amovible. Cette construction, qui a bien fonctionné, n'est néanmoins pas à recommander; le fait de ne pouvoir observer qu'à 2 heures de part et d'autre du méridien, parfaitement normal pour nos observations, nous a gêné dans l'observation de phénomènes exceptionnels, notamment pour la Comète Ikeya.

Mais je pense que les considérations financières nous ont fait commettre une erreur majeure : l'instrument était disposé trop près du sol. Fort de cette expérience, l'instrument sera placé au Chili, dans une coupole classique, à une hauteur beaucoup plus grande au-dessus du sol. D'autre part, les écarts de températures diurnes sont 4 ou 5 fois plus petits dans les Préandes que dans le Karroo, ou dans les autres régions que nous connaissons en Afrique, Klaversvlei, près de Beaufort-West et aussi Bloemfontein où d'autres effets thermiques sont gênants.

Il serait faux de conclure que les conditions astronomiques ne sont pas bonnes dans le Karroo, mais notre conviction est qu'elles sont bien meilleures dans les Préandes, à la latitude de La Serena.

Avant de donner les résultats de nos observations astronomiques, je désire attirer l'attention sur l'organisation administrative et les problèmes humains.

Certes, la réussite et l'adaptation au pays a été très variable. Les pionniers, MM. Ray et Sagazan, qui ont édifié l'abri et l'instrument, ont rencontré des conditions extrêmement pénibles. Rien n'était aussi avancé que ne le laissaient supposer les prévisions très optimistes de notre architecte local; les conditions financières faites à ces premiers techniciens, comme à nos premiers observateurs de site, n'étaient pas suffisantes.

M. et Mme Duflot, qui ont inauguré la Station et ont fait les premières observations, ont effectué un très bon travail, mais dans des conditions rendues difficiles par l'absence d'une aide technique suffisante : il est difficile de mettre en service et de faire fonctionner un instrument astronomique important et délicat lorsqu'on est en plein désert, loin de toute tradition astronomique.

Les circonstances seront très différentes au Chili, à condition que dès le début l'Observatoire dispose de techniciens avertis — et je crains que notre plan actuel ne soit un peu déficient sur ce point.

De nombreuses équipes ont séjourné en Afrique du Sud et je peux seulement les nommer :

M. Ray, M. Sagazan
M. Ch. Fehrenbach
M. et Mme Duflot
M. et Mme Cruvellier
M. Florsch
M. et Mme Peyrin
M. Tison
M. Prévôt et M. Rochette
M. Peytremann
M. et Mme Kaufmann
M. et Mme Petit
M. Courtès
M. Bouigue

Les familles, sans aucun doute, ont eu une vie beaucoup plus facile que les célibataires et je profite de cette occasion pour demander que le Conseil de l'ESO examine le problème des conditions de vie de nos astronomes et techniciens avec beaucoup d'attention.

Je pense que l'organisation administrative et financière en Afrique du Sud était bonne et nous devons tenir compte de cette expérience pour notre organisation au Chili.

Il est, à mon avis, essentiel, dans toute la mesure du possible, de ne pas séparer les familles : les incidences financières sont certainement négligeables et compensées par une augmentation d'efficacité.

Pour terminer, nous donnons ici la liste des champs étudiés et le nombre de clichés obtenus :

Nombre de champs commencés ou terminés au Grand Prisme Objectif :

Petit Nuage de Magellan	20 Champs
Relation Petit Nuage-Grand Nuage	15 Champs
Grand Nuage de Magellan	26 Champs
Relation Grand Nuage-Voie Lactée	24 Champs
Voie Lactée et région Pôle Galactique	71 Champs
soit	156 Champs

Nombre de clichés : 1250

Nombre de clichés Z I interférométriques, Nuages de Magellan et Galaxie : 75

Les communications suivantes de ESO ont été publiées :

1 Ch. Fehrenbach et Marcelle Duflot 1962
La reconnaissance des étoiles brillantes faisant partie des Nuages de Magellan

2 Ch. Fehrenbach et Marcelle Duflot 1962
Deux étoiles à grande vitesse découvertes dans le ciel austral

3 Ch. Fehrenbach et Marcelle Duflot 1964
Reconnaissance d'étoiles appartenant au Grand Nuage de Magellan à l'aide d'un prisme objectif à champ normal

4 Ch. Fehrenbach et Marcelle Duflot 1964
Objets à émission du Grand Nuage de Magellan sur des clichés de prisme objectif

5 Albert Florsch et Nicole Carozzi 1965
(transmise par Ch. Fehrenbach)
Etoiles à grande vitesse entre les Nuages de Magellan

6 Ch. Fehrenbach, Marcelle et André Duflot 1965
Vitesses radiales dans la direction du Grand Nuage de Magellan
Mesures de vitesses radiales dans la direction du Grand Nuage de Magellan

7 Note aux Comptes-Rendus : Astrophysique 1966
Ch. Fehrenbach et Marcelle Duflot
(transmise par Ch. Fehrenbach)
Détermination de la rotation des Nuages de Magellan à l'aide du Prisme Objectif

Prof. Dr. Ch. Fehrenbach, Directeur de
l'Observatoire de Marseille,
2, Place le Verrier, Marseille 4^{e}, France

SUMMARY OF THE CONVENTION BETWEEN THE GOVERNMENT OF CHILE AND ESO, SIGNED IN NOVEMBER 1963

The Government of the Republic of Chile has signed, the two Houses of the Chilean Parliament have ratified, and the ESO Council has approved a Convention in which the Government recognizes the international personality of ESO as well as its legal personality in Chile.

In addition the Government grants to ESO the same immunities, prerogatives, privileges, and facilities which apply to the Economic Commission for Latin America of the United Nations given by the Convention, signed in Santiago the 16th of February 1953.

Most important for ESO's practical work are the following regulations:

The properties of ESO shall be exempted from all direct taxes and from customs duties; ESO shall be exempted from all prohibitions and restrictions on the importation of articles for ESO's official use.

1 m PHOTOMETRIC TELESCOPE

B. G. Hooghoudt[1]

General

The telescope has been designed specifically for photoelectric measurements in the Cassegrain focus by a single observer. No provision for a Newton or coudé focus has been made. Larger fields were not considered and the traditional type of optics was specified. An auxiliary Nasmyth (i.e. folded Cassegrain) focus has been included.

Basic requirements have been:

1. Bulky auxiliary equipment should be attached to the telescope. A weight of 150 kg and a length of 1.20 meter were chosen as maximum values.
2. The position of the observer should be convenient, with easy access to the eyepiece and control apparatus.

   A fork mounting with adequate freedom for Cassegrain equipment, to be combined with a moving platform in the permanent dome building, could fulfil this properly.
3. Pointing of the telescope should be in sequence with a photoelectric observing program.

   A fast and accurate presetting system for the coordinate selection has therefore been included.

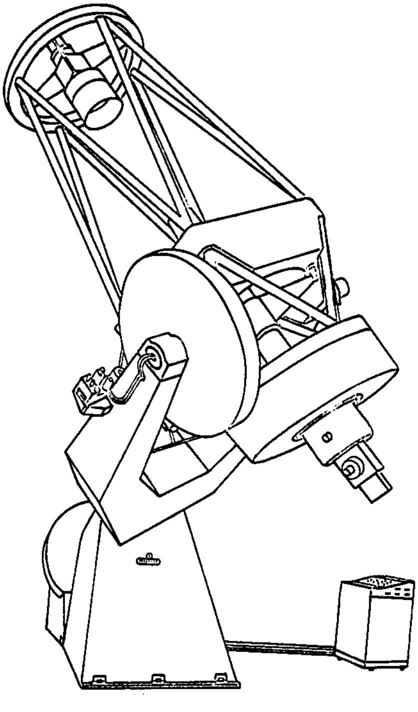

Fig. 1: 1 m Photometric Telescope

The optics

The f/4.5 paraboloid primary mirror has been made from a low expansion glass (Therman of Schott, Jena). The hyperboloid secondary for the f/15 Cassegrain focus and the flat third mirror are from fused quartz (Heraeus).

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[1] Consulting Engineer, Leiden, Holland

The change-over between the 2 foci (Nasmyth and Cassegrain) can be done rapidly by manual insertion or removal of the third mirror cell in the light-shield tube.

The secondary mirror cell is mounted on a focussing box with electric control, suspended on fins from the front of the telescope tube. The adjusting range in the Cassegrain focus is 20 cm from its nominal position.

A floating pad system with counterpoised levers, axially and radially 6 each, supports the main mirror.

In the central mirror hole is a radial defining unit, while 3 axial pads are fixed for axial alignment.

The Cassegrain and Nasmyth auxiliary equipment can be bolted to the telescope by means of rotating tables.

The tube

Based on the Serrurier compensating system, the telescope tube consists of a square centerpiece supporting the focal and mirror sections, each made up from a ring with 8 tubular struts, arranged to assure the gravity deflection of the ring being parallel to the centerpiece. The deflection of the focal and mirror rings is therefore also parallel to each other, while the actual deflection values can be made equal by the proper choice of the tubular struts. The optical axes of both sections will thus stay accurately aligned in all positions of the telescope tube.

The mounting

A fork mounting with adequate room for Cassegrain equipment has been chosen in view of its inherently high mechanical stability. The design of the fork structure minimizes the differential flexure depending on hour angle position. In Fig. 2 the gravity flexure, parallel to the fork plane (HA = 90°), is given for typical fork structures, in comparison with the flexure perpendicular to the fork plane (HA = 0). It is evident that only the proper combination of (A) and (C) will lead to a polar alignment correction that is independent from the hour angle position.

The declination and polar axis ball bearings are preloaded to prevent backlash.

The drives

A worm-wormgear system in both coordinates combines accuracy with the definition in position required for the presetting system.

In Fig. 3 the measured errors are given for the declination drive; the precision in right ascension is the same. At a wormgear radius of 70 cm, 1 second of arc corresponds to 3.5 micron tangentially. Taking into regard that several teeth are

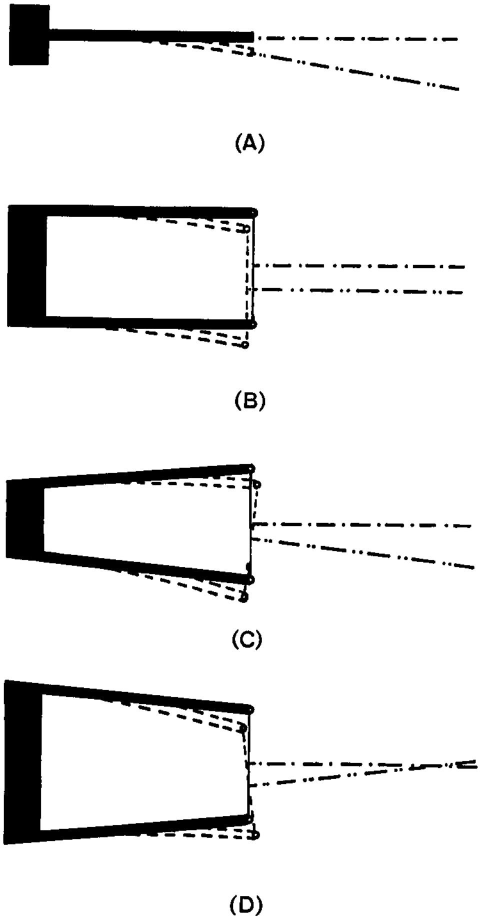


Fig. 2: A: Gravity flexure perpendicular to fork plane. B, C, D: Gravity flexure parallel to the fork plane for typical fork structures

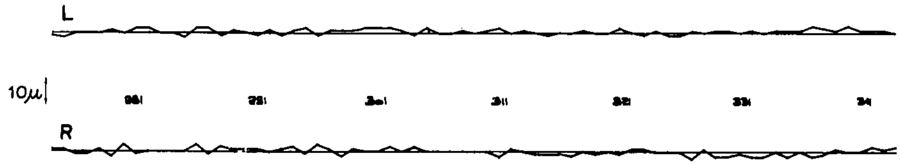


Fig. 3: Typical teeth errors in wormgear (left and right flanges)

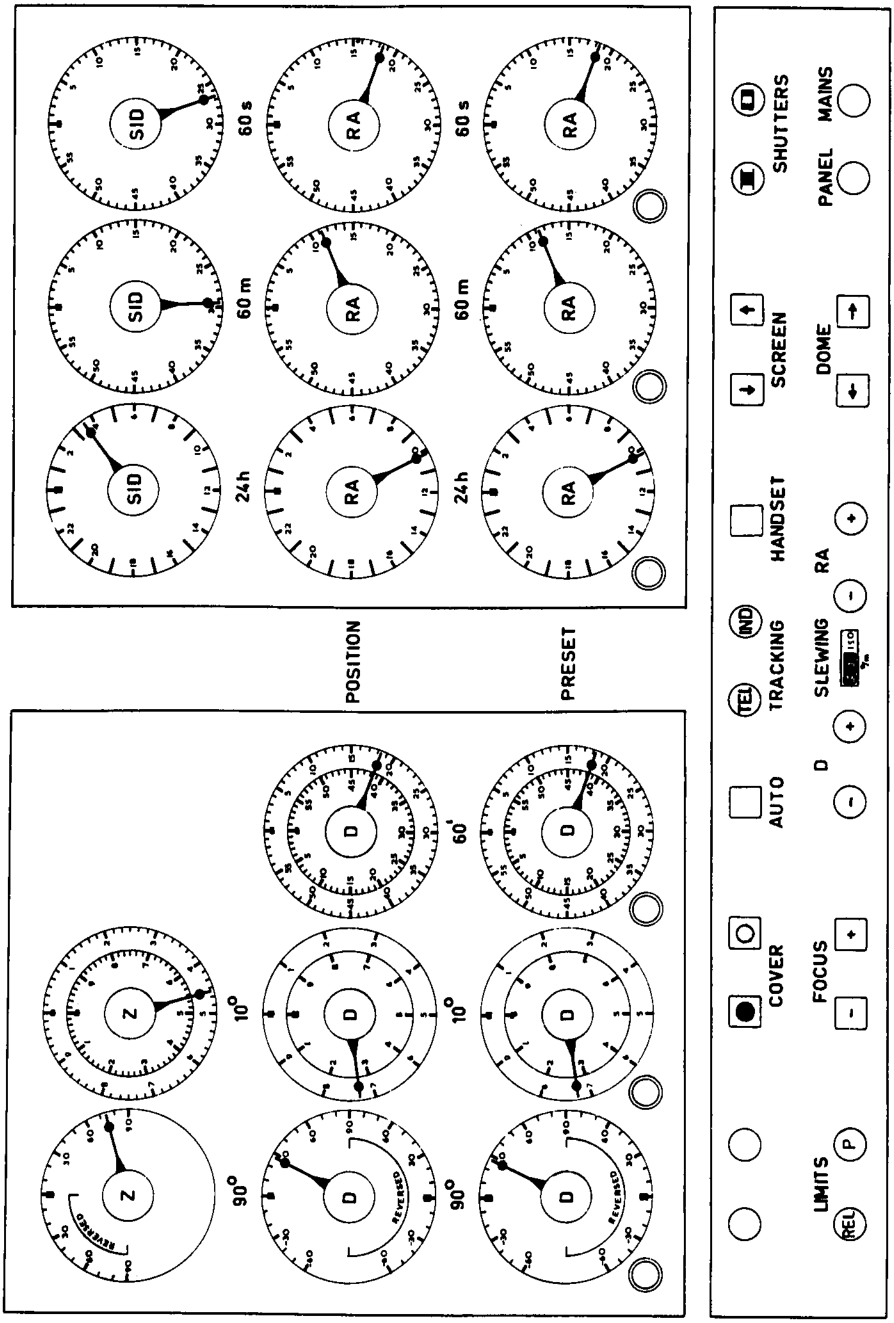


Fig. 4: Control panel, indicators presetting system

in engagement and that both flanges are used, the averaging effect will produce a very high driving accuracy. Periodic errors due to the worm rotation are not expected.

Backlash in the driving system is prevented by a preloaded engagement of the worm into the wormgear.

The driving gearboxes have 3 motors with the following speeds:

1. **Slewing:** 75 and 100°/min
2. **Setting:** 0.2—3°/min continuously variable
   Guiding: 0.01—0.2°/min continuously variable
3. **Tracking:** for the polar axis drive 0.25°/min
   Scanning: for the declination drive 0.1—0.4°/min variable in 6 steps.

The overall setting accuracy of the presetting system is 1′.

The differential accuracy will be better.

The controls

The dials for the position readings and the presetting system have been built in the control cabinet that contains all electronics, relay switches, and the frequency standard (Fig. 4). The cabinet can be moved around or put on the platform.

A handset provides remote control of setting, guiding, focussing, dome, windscreen, and platform.

Manufacture

The optics was figured by Jenoptik, Jena, Germany.

The mounting and driving system has been built by Rademakers N.V., and the control cabinet by Weseman and Co. N.V., both in Rotterdam, Holland.

AUSZUG AUS DEM ABNAHME-PROTOKOLL DER OPTIK FÜR DAS PHOTOMETRISCHE TELESKOP VON 1 m ÖFFNUNG

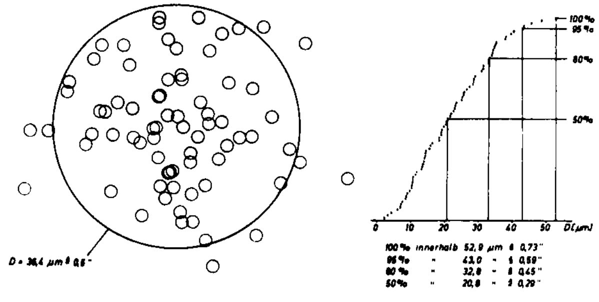
Die Abnahme fand statt im Auftrage von ESO im Werk Jenoptik Jena am 5. 8. 1964 durch Prof. Dr. P. Wellmann und Dr. H. G. Groth, München.

Das Cassegrain-System wurde mit und ohne Umlenkspiegel bei einem Abstand des Hauptspiegels vom Cassegrainspiegel von 3387 mm und der Schnittweite (Abstand des Cassegrainspiegels vom Fokus) von 3987 mm in Autokollimation visuell geprüft. Die Prüfung umfaßte eine Betrachtung des Beugungsbildes im Fokus, extra- und intrafokal bei Verwendung eines künstlichen Sternes mit einem Durchmesser von 0,01 mm und von Doppelsternen mit Mittenabständen der jeweiligen Doppelsterne von 0,1 mm entsprechend etwa 1,4 Bogensekunden und 0,025 mm entsprechend 0,35 Bogensekunden. Die verwendeten Mikroskopvergrößerungen betrugen 15 × und 40 ×. Das Beugungsbild zeigte nur geringe Abweichungen von der Rotationssymmetrie, die aber die geforderte Abbildungsleistung nicht beeinträchtigen. Die Qualität der Planfläche des Umlenkspiegels wurde an Hand von Interferenzaufnahmen nachgewiesen.

Die Beurteilung der an Hand der Durchstoßdiagramme erhaltenen Lichtkonzentrationen ergab, daß die Forderungen des Auftraggebers erfüllt sind. Vertraglich war festgelegt worden, daß 50 % der Lichtstrahlung innerhalb eines Kreises mit einem Durchmesser entsprechend 0,6 Bogensekunden und 100 % der Lichtstrahlung innerhalb eines Kreises mit einem Durchmesser entsprechend 3 Bogensekunden konzentriert sein sollen. Wie die in der Anlage beigefügten Durchstoßdiagramme zeigen, sind beim Cassegrainsystem mit und ohne Umlenkspiegel 50 % der Lichtstrahlung mit Sicherheit innerhalb 0,3 Bogensekunden und 100 % innerhalb etwa 0,7 Bogensekunden konzentriert.

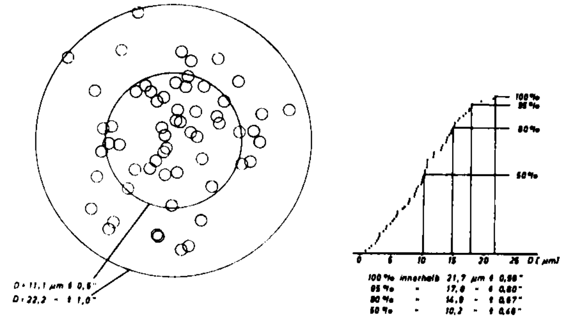
Die visuellen Prüfungen bestätigten diese Größenordnung.

Optik für das Photometrische Teleskop



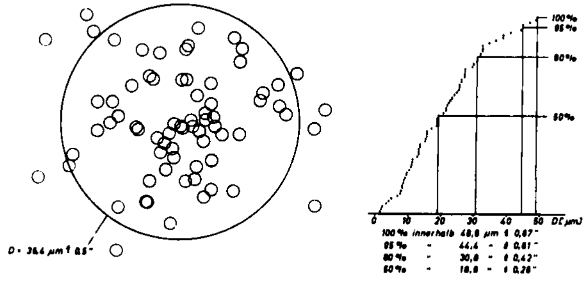
Durchstoß-Diagramm *Lichtkonzentration*

Cassegrainsystem 1000 / 4585 / 15000 mit Umlenkspiegel



Durchstoß-Diagramm *Lichtkonzentration*

Parabolspiegel 1016 / 4585



Durchstoß-Diagramm *Lichtkonzentration*

Cassegrainsystem 1000 / 4585 / 15000 ohne Umlenkspiegel

Prüfungsdiagramme der Optik des 1 m Photometrischen Teleskops

THE PHOTOMETRIC EQUIPMENT OF THE ESO 1 m TELESCOPE

M. de Vries

Introduction

In one of the meetings of the ESO Instrumentation Committee in the second half of 1962 the question arose whether it was recommendable to have the 1 m telescope equipped with a general-purpose photometer for use by the visiting astronomers. The members agreed upon this idea, and, after defining the facilities to be incorporated in the instrument, the task of making a design study was delegated to the newly set up Sub-Committee of the Photometer. Shortly afterwards, the offer by Borgman to do the final design and the actual construction at the Kapteyn Observatory at Roden, the Netherlands, was accepted.

In 1964 the integration of the optical and the electronic part started, following a suggestion of the author to complement the photometer with a semi-automatic data acquisition system. The good climate in Chile justifies the expectation of a continuously high collection rate of photometric data. To process these observations within a reasonable time, a formal acquisition system backed up by an electronic computer seems mandatory.

The photometer

This is a sequential multicolour instrument with facilities for offset guiding and scanning. In meeting all the demands it has become a versatile but rather complicated instrument, which is shown in Fig. 1.

The instrument consists basically of two boxes, the outer one being fixed to the Cassegrain turn-table of the telescope. This box holds also the wide-angle eyepiece which, for the purpose of offset guiding, can be placed anywhere within a square field with sides of 13 minutes of arc. The inner box contains the actual photometer with diaphragms, filters, and the detector unit; Fig. 2 shows the interior. Scanning of an extended object is accomplished by moving the inner box with respect to the outer frame along four rods parallel to the scanning direction. A spindle, perpendicular to the optical axis and driven by a motor via a two-speed gear box, drives this part of the instrument up and down while the telescope and consequently the eyepiece stay pointed at the guide star. The scanning speed can be adjusted between 1$^1/_2$ and 36 seconds of arc/sec by changing the supply source frequency of the motor; the actual value can be checked by reading the distance between markings at the recorder tracing. The maximum scanning range is 13 minutes of arc in any desired position angle. Also in stellar photometry the scanning facility can be made use of to alternate the measurements on a star with those on an adjacent sky region, while controlling the scanning drive motor by accurately adjustable limit switches, in accordance with the diaphragm size.

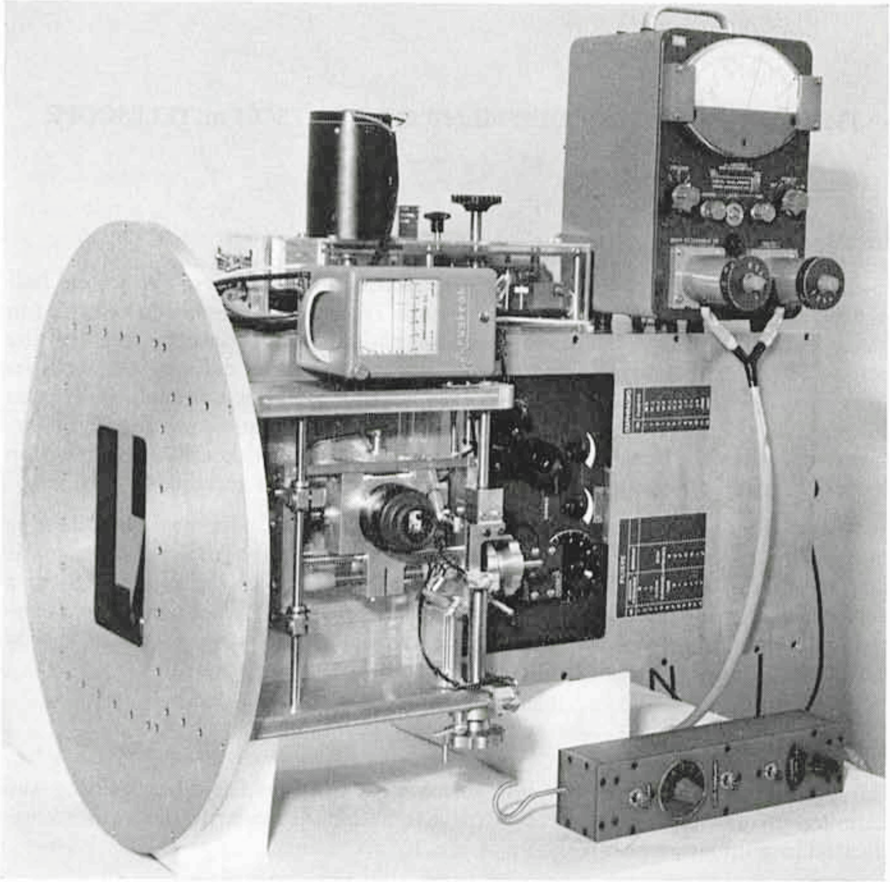


Fig. 1: The photometer with d. c. amplifier, recording monitor, and handset

The diaphragm section consists of a disc with 10 holes, ranging from 4 to 88 seconds of arc in diameter, and a viewing microscope. The filter disc, easily interchangeable, can accommodate 10 filters. These must be squares with sides of 1 inch, and their thickness preferably not exceeding 12 mm. As a standard outfit, the photometer is equipped with the filters for the U, B, V, R, I system of Johnson (1965), and for the intermediate bandwidth systems u, v, b, y of Strömgren (1963) and R, Q, P, N, M, L, K of Borgman (1960). The filter disc contains also a standard lightsource of the Čerenkov type, for internal calibration. Such a source, based on the Čerenkov radiation from Sr^{90} in plastic (van Albada and Borgman, 1960), has many advantages over the more conventional ones. It is small, it needs no external power, the emission and colour are independent of temperature, whereas the colour temperature is high; the B-V value measured for the source mounted in the ESO-photometer is $-0^{m}.23$.

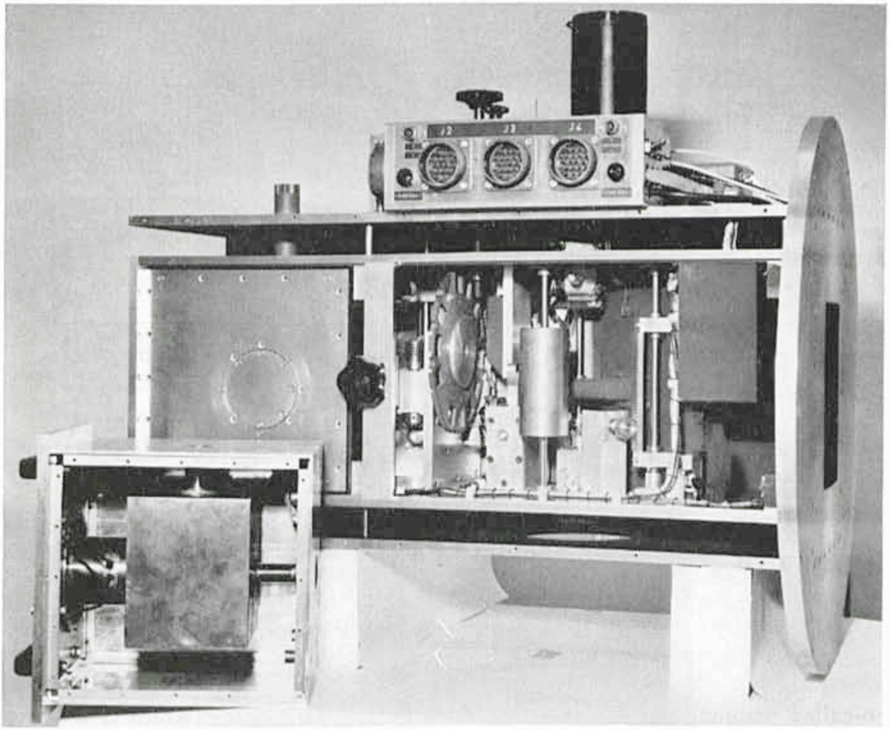


Fig. 2: The interior of the photometer. On the foreground a second "cold box" with an EMI 6256

The photomultipliers are placed in interchangeable refrigerated boxes. There are three of these detector units containing the EMI 6256A, the RCA 1P21, and the infrared-sensitive RCA 7102, resp. Several tubes of each type have been examined in order to select a suitable tube for the specific application.

The data acquisition system

The main purpose of the second part of the equipment is to provide all data necessary for a reduction of the measurements in a machine-readable form. The block diagram in Fig. 3 illustrates the basic principle of the complete system. The actual measuring channel consists of a d.c. amplifier with a recording monitor (mounted at the photometer, see Fig. 1), a voltage-to-frequency converter, and a digital counter with gate times of 1, 2, 4, 8, 16, 32, 64 and 128 seconds. These instruments act together as an integrating digital voltmeter with very good linearity.

The data originating from these units, and those from a digital clock, a manually set calendar, and the photometer settings are fed into a scanner/coupler. This part of the equipment scans the separate data sources in a predetermined order, the

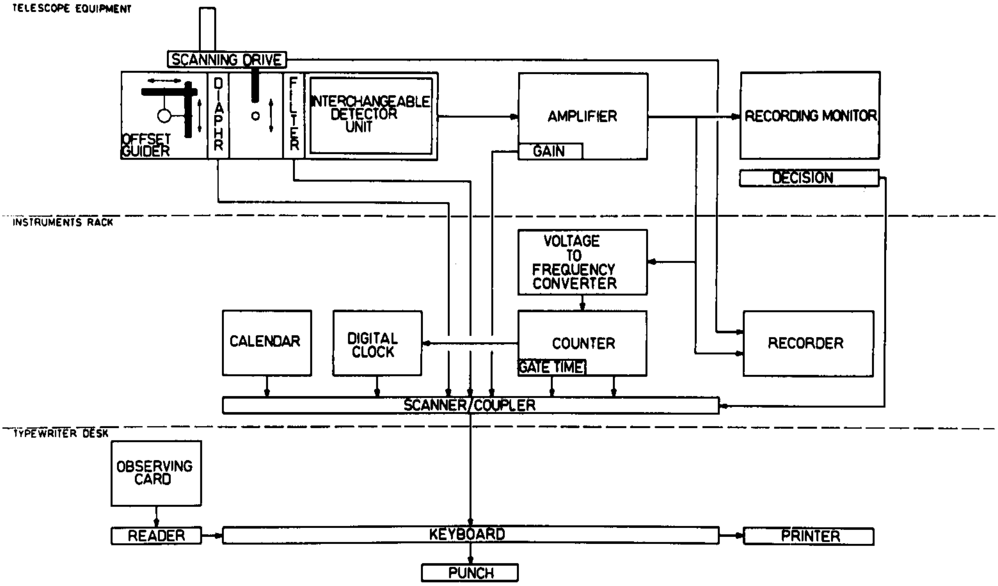


Fig. 3: The photometric measuring system

so-called scanning format, coupling them to the output unit which is a Flexowriter, recording the results in an eight-channel code on punched tape and printing them for visual inspection. The instruments rack and the Flexowriter are shown in Fig. 4.

The use of the Flexowriter has the further advantage of adding two independent input sources to the system; besides the keyboard it has a reader section accepting both prepunched tape and cards. Fig. 5 shows an example of such a card used to get all the relevant invariable data for the reduction of the measurements of a particular object on the output tape. For this purpose they have two obvious advantages over the common field-punched cards (e.g. IBM). There is no need for a separate punch and reader, as the cards can be prepared on the punch-section of the Flexowriter itself. Secondly, as the cards are punched only along one edge there is ample space left for a finding chart and other written information for the observer.

The use of this acquisition system results in a faster, more accurate, and less complicated observing routine, with little chance of making mistakes. Fig. 6 gives the outline of a typical observing cycle. After starting the Flexowriter to read the observing card the observer stays at his place at the telescope during the entire observing cycle. The system is remotely operated, all commands (including those for the scanning mode of the photometer) being given through the handset visible in Fig. 1.

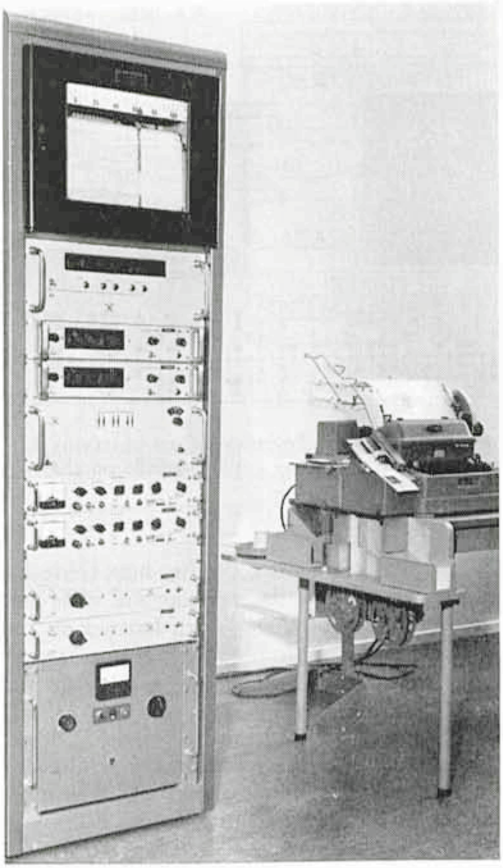


Fig. 4: The instruments rack and the Flexowriter

The measurement is initiated by actuating a push-button. The end of the integration automatically puts the scanner/coupler into operation. The Flexowriter records consecutively:

1. year, month, and day;
2. hours and minutes;
3. integration time and gain setting;
4. diaphragm and filter;
5. the actual measurement.

At this point the scanner, before returning to its home position, normally waits for the last information:

6. decision.

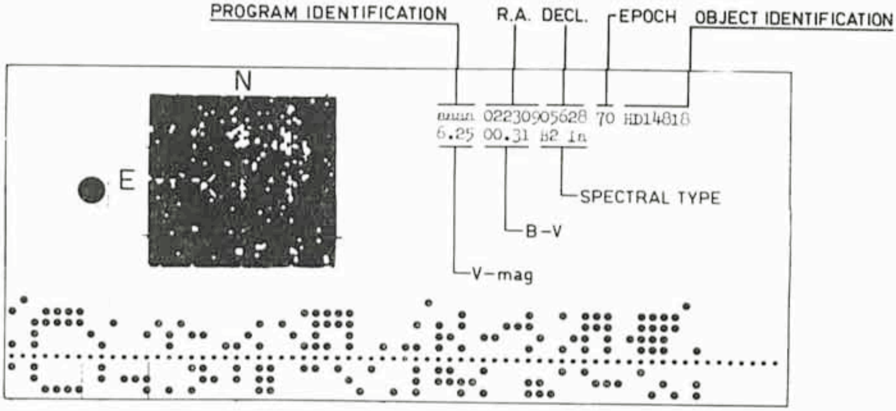


Fig. 5: An example of the frontside of an observing card. The information to be punched on these cards depends on the required input data of the reduction program.

The decision, i.e. the instruction for the computer how to deal with this particular measurement, is made by selecting the appropriate code number on a rotary switch and is registered by a push-button, both located on the handset. To cope with the difficulty of judging a value obtained by an integration, the amplified photocurrent is displayed on a recording monitor in the form of a miniature recorder mounted at the photometer (see Fig. 1).

In the scanning mode this method of recording the results can also be used, but the repetition rate is restricted by the Flexowriter, which needs approximately 6 seconds for punching and typing. In this case the decision selector is set at 0 (see Fig. 6) and the display time of the counter, normally infinite, must be reduced to a value slightly larger than the above mentioned dead time. Now, the scanner/coupler does not wait between the points (5) and (6) of the scanning format and the counter automatically starts a new integration.

During the dead time the photometer continues to scan the object, though the collection of information has been interrupted. If this is an objectionable procedure for a particular program the use of the continuous recording on a potentiometric recorder (Fig. 4, top of rack) may be preferred.

Concluding remarks

The electronic part of the equipment is more flexible than is apparent from the foregoing description. In its present form it can be used for dual-channel simultaneous photometry or polarimetry, without any modification. The scanning format of the scanner/coupler can be adjusted accordingly by a single switch; a second measuring channel is already provided for, as can be seen in Fig. 4.

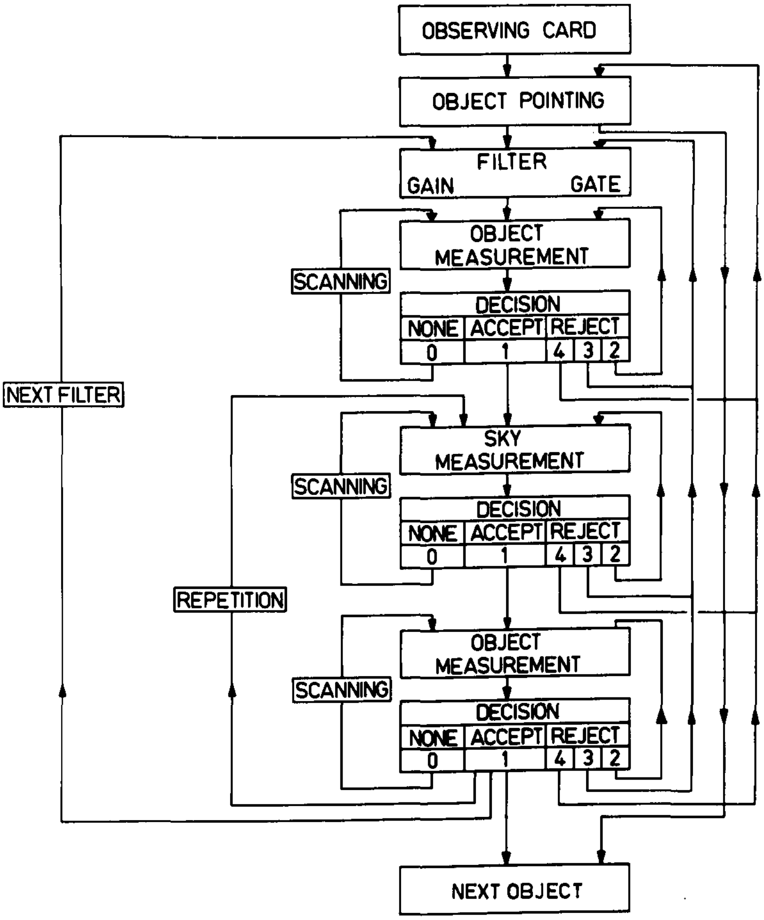


Fig. 6: The observing cycle

This second channel adds also to the reliability of the single channel operation, because in case of a breakdown anywhere in the active measuring channel the observer can switch immediately to the other channel without spoiling the uniformity of the scanning format. Moreover, all vital indications of the settings on the photometer and on the other telescope-mounted equipment are duplicated by thumbwheel switches on a separate panel, as are the command functions on the handset. If the observer does not conclude a measurement with a decision, the next measurement is not accepted by the Flexowriter until the previous data have been decided upon.

The acquisition system is now undergoing operational tests in combination both with the ESO photometer and with a dual-channel instrument at the Kapteyn Observatory. The first results will soon be published (Borgman and de Vries, 1967).

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ESO COLLOQUIUM ON PHOTOMETRY

J. Borgman

A three day conference, called "ESO Colloquium on Photometry", was held at the Kapteyn Observatory, Roden, The Netherlands, on 9—11 February 1966. The conference was sponsored by ESO and had an attendance of 70 astronomers coming from all member states. In addition, some leading specialists from other countries were invited.

The meeting place, the Kapteyn Observatory, was chosen because the workshops of this institute had been the scene of the construction activities in connection with the photometer built for the 1 m photometric reflector which is currently being installed at La Silla in Chile. During the conference, the photometer with its data acquisition system was on display; a description of the photometer is given on page 35 of this issue by de Vries.

The time of the meeting, 9—11 February, was chosen to fit in with the (then expected) installation of the 1 m telescope and the shipment of the Roden-built instruments to Chile. It turned out to be an unlucky choice; heavy snow and icy roads blocked by fallen trees gave convincing evidence that the Dutch weather cannot be fully trusted to be cooperative for a midwinter conference.

The unusual weather conditions called for considerable improvisation. The participants turned out to be very compliant when it came to changes of meeting place, hotel accommodation, and individual travel plans. As a consequence, the program of the meeting could be fully finished.

Heckmann, Fehrenbach, Ramberg, and Muller gave information on the progress of the ESO program. When this report is being printed, there is considerable construction activity going on at La Silla. In the context of the subject of the conference the most important work is the construction of a temporary building for the 1 m telescope, which will be completed in October of this year. Permanent buildings for the 1 m photometric telescope, the 1.5 m spectrographic telescope, the 40 cm radial velocity astrograph and the 1 m Schmidt telescope are expected to be completed near the end of 1967. In the second building period ending in 1970, the building for the 3.5 m telescope will be constructed. Finished in 1970 will also be a number of service buildings at La Silla including a hostel and a dormitory as well as the Headquarters facilities in Santiago. The telescope program of ESO includes, besides the already finished 100 cm photometric telescope (described on page 28 by Hooghoudt), a spectrographic 152 cm telescope which can accommodate auxiliary instruments at the F/15 Cassegrain focus and at the F/30 coudé focus. Three spectrographs will be available for use with this telescope. The largest spectrograph, in the coudé room, will be a three gratings instrument equipped with three cameras. The telescope constructed by Réosc in Paris is almost completed; the same company will deliver the coudé spectrograph at the end of 1967. A number of important figures on this instrument are compiled in Table 2. Two more spectrographs, a nebular spectrograph with dispersions of 430 Å/mm and 150 Å/mm and a Cassegrain spectrograph with a dispersion of 150 Å/mm are presently being designed in Marseille.

The 100 cm Schmidt telescope will have the same focal distance as the 48 inch at Mt Palomar. A slightly smaller aperture has been chosen in order to facilitate the use of an objective prism (UBK7, dispersion 580 Å/mm at H_γ) as well as to improve the performance of the instrument in the ultraviolet.

The 40 cm radial velocity astrograph, now in operation in South Africa, will be installed in Chile as soon as its building has been completed. Its limiting magnitude ($V = 12$) for a dispersion of 110 Å/mm between H_γ and H_δ in a field of $2^\circ \times 2^\circ$ will continue to make this instrument a powerful tool for radial velocity surveys.

Already in operation is a Danjon Astrolabe which has been installed in Santiago at the Chilean Observatorio Nacional.

The largest instrument of ESO, and indeed the principal justification of the existence of ESO, will be a 350 cm telescope equipped with observer's cages at the primary and Cassegrain focus. The fused quartz blank for the primary mirror is being made by Corning. The telescope will be of the Ritchey-Chrétien type, F/8 Cassegrain focus, F/3 primary focus with a corrector, which renders images of 0.5 seconds of arc diameter over a field of 1 degree. The coudé room (focal ratio F/30) will be large enough to install gratings as large as 60 cm diameter, considerably larger than presently available. The mounting of the telescope will be a fork; the details are presently under study. A number of relevant figures on this telescope as well as on the other ESO telescopes are listed in Table 1, page 52.

An important paper dealing with the photometric equipment of the 1 meter telescope is discussed on page 35 by de Vries (Roden). Another approach to the problem of data acquisition and recording was reported by Tinbergen (Leiden). He described the digital system which has been designed for the Leiden Southern Station at Hartebeestpoortdam in South Africa. It differs from the system described by de Vries in that it is more flexible through the use of a patchboard to determine the typing and punching layout. In each channel an analogue integrator of the capacitor-charging type is provided for; a single auto-ranging digital voltmeter is switched from channel to channel. Non-automatic data (e.g. star name etc.) are being preset by pushbuttons.

Hardie (Nashville) discussed a number of practical aspects of photometric observing. He stressed the importance of meaningful determinations of the "constants" which are used in photometric reduction and transformation procedures. In virtually all photometric studies the work is governed by relations of the type:

$$m_0 = m - k'_m X + k''_m C X + \varepsilon C + Z_m$$

and

$$C_0 = \mu (C - k'_c X + k''_c C X) + Z_c$$

in which

1) m_0, C_0 are magnitude and colour outside the atmosphere (which is required for any universal or standard system being used by observers at different locations, altitudes, etc.);
2) m, C are raw magnitude and colour as read off the photometer apparatus;
3) X is air-mass;
4) k', k'' are the principal and colour-dependent extinction coefficients;
5) ε, μ are scale terms to convert from the observer's natural to the standard system (which will be 0 and 1 for a perfectly matched filter-cell combination);
6) Z_m, Z_c are zero-point terms dependent on instrumental parameters such as photomultiplier voltage and filter-transmission.

Of all these terms, the following are more or less constant in a given situation:

$$Z_m, Z_c, \varepsilon, \mu, k''_m, k''_c$$

Only k'_m and k'_c are likely to be widely variable and may require fastidious attention. Apart from special instances of differential work between very close stars, these principal extinction terms will virtually control the accuracy of the photometry. In general, it is pointless, inefficient, and inaccurate to carry out a reduction process which does not recognize the fact that some terms are constant, but regards all parameters as unknown in a solution. A least-squares solution for all unknowns simultaneously for every night will distribute among all parameters the errors which arise chiefly from k'_m and k'_c. A much more reliable solution will be obtained by critically determining the constants in a short but intensive observing program.

To determine the various constants, the most reliable method is to minimize all the possible effects of all other parameters and to maximize the effects of that being studied, i. e.:

i) to measure ε, μ, select stars of greatest possible range of colour, but of least range in air-mass;
ii) to measure the k'' terms, select very close pairs of widely differing colour over a wide range of air-mass;
iii) to measure k' and z terms, select stars of greatest possible range of air-mass, but of least range of colour.

Care taken in matching the response-functions of filter-cell combinations will result in better photometry. It is advisable to select filters which produce, for a given detector, transformation coefficients ε and μ as close as possible to $\varepsilon = 0$ and $\mu = 1$. The advantages are:

1. Convenience in applying small corrections.
2. Higher degree of accurate transformation, especially among stars of various luminosity classes, and different reddening.
3. Use of short method in extinction because any existing standard stars can be used.

In another paper Hardie pointed out an important source of error, which is associated with the use of high load resistances at the input of d.c. amplifiers. These resistors appear to be highly temperature dependent. It is vital to closely regulate the temperature of such resistors if one is to rely upon the constancy of the magnitude scale without the necessity of tedious and time-consuming calibrations throughout the working night.

Undoubtedly many of the errors and discrepancies among photometric studies which are to be found in the literature arise from the ignoring of this technical necessity. Errors of as much as 0.15 mag. can easily be generated by ordinary changes in temperature from that at which calibration was done. However, maintaining the scale resistors at a constant temperature will virtually eliminate such sources of error.

Since 1957, the Dyer Observatory amplifier has incorporated a thermostated section which maintains the scale resistors at a temperature of 46° C ± 0.°5. So long as the equipment is maintained running, the constancy of the calibration almost exceeds the capability of the calibrating process, and one can be confident that among whatever errors are found in the photometry, no more than $0^{m}.002$ can be attributed to the equipment. Calibrations are carried out about once every three months, and whenever the equipment has been turned off. An added convenience is a series of low-impedance trimmers (switched by the coarse scale switch) which permit compensation at the amplifier output for the departures from nominal value of the large resistors; thus the dial values are always maintained at 2.500, 5.000, 7.500, etc. ± $0.^{m}001$ eliminating the need for a calibration table.

Dachs (Tübingen) discussed the UBV extinction coefficients which had been found at the ESO photometric station on Rockdale Mountain in South Africa (1860 m elevation). Reasonable agreement could be established between these empirical numbers and the theoretical extinction coefficients as calculated for a dust-free atmosphere. Attention is drawn to the non-linear increase of the U-extinction with air-mass and its dependence on the colour of stars; these effects have to be taken into account in precision broad-band photometry.

Borgman (Groningen) reviewed the instrumental limitations for infrared photometry in the atmospheric windows, with reference to the photometric system established by H. L. Johnson and co-workers. Modern lead-sulfide detectors are now on the market with performance figures (e.g. noise equivalent power $<10^{-14}$ Watts) on which large observing programs in the 2.2 μ region can be based. Possibly ESO will have a need for such a photometer as an auxiliary instrument to the 1 meter telescope. A large section of the southern sky is still almost unexplored in the infrared; good equipment is not in operation south of Tonantzintla. For wavelengths longer than 2.2 μ it becomes increasingly advantageous to use larger aperture instruments than the 1 m telescope. If the 1.5 m telescope is not available for time-consuming photometric studies (likely, as it is a specialized instrument, earmarked for spectroscopy) ESO might consider to get an inexpensive large aperture telescope for infrared work; preliminary studies and experience indicate that a satisfactory 2 meter aperture telescope with an F/2 primary mirror and an F/10 Cassegrain focus can be made on a budget which does not exceed the expenditure for the 1 m telescope.

Westerlund (Mt Stromlo) described interference filter photometry carried out at Mt Stromlo and at the Siding Spring Observatory. The photometric system includes six narrow bands, four of which have effective wavelengths which agree well with those in Strömgren's four colour system. The peak transmission wavelengths and the half-widths (in Ångström units) of the filters are: y, 5480, 100; b, 4700, 100; v, 4090, 100; u_1, 3780, 30; u, 3640, 100; u_2, 3550, 100. For certain programs a red (R) and an infrared (I) wideband filter are added: R, 7000 Å; I, 8800 Å, approximately. In addition some narrow band filters are used occasionally, which isolate H_β, some He I and He II lines, the interstellar K-line and the 4430 Å band. The system has been used for studies of associations and clusters, Be stars, peculiar A stars, supergiants, high-velocity stars, variable stars, blue halo stars, and stars in the region of the Magellanic Clouds for establishing membership.

The photometry gives: a visual magnitude, y; a colour index, $b-y$; a metallic line index, $m' = v - b - 0.67\ (b-y)$; a measure of the Balmer discontinuity, $D = u_2 - v - 1.3\ (v-b)$; a measure of the depression at $\lambda = 3780$: $D' = u_1 - v - 0.67\ (v-b)$; and an ultraviolet colour index, $u_2 - u$.

The relation between $b-y$ and $B-V$ is fairly smooth. For unreddened stars it may be represented by three linear portions of different slope, connected by curved parts around $B-V = 0$ (due to the effect on B of the crowded Balmer lines) and around $B-V = +0.75$ mag. (red giant stars).

The quantity D permits an accurate determination of the intrinsic colours of main sequence B stars:

$$(B-V)_0 = 0.24\,D - 0.25,$$

$$(b-y)_0 = 0.190\,D - 0.133.$$

70 % of the stars used to establish these relations fall within 0.01 mag. (in $B-V$) from the straight line.

A D'/D diagram permits the separation of most Be stars from main sequence stars. It also makes it possible to identify different age groups in an association.

An attempt has been made to calibrate D' as a luminosity criterion with the aid of the association Puppis III. It has been found, however, that all the peripheral members of the association are more evolved than those in the centre. If this is allowed for, D' gives an excellent relation to M_V for the stars which are still on the zero-age main sequence. Obviously, great care has to be taken in assigning ages and distance moduli to associations as well as luminosities to early-type stars which are not identified as members of well defined groups.

Elvius (Uppsala) spoke on the need of photoelectric scales for Kapteyn Selected Areas in the southern sky. Such scales are needed to calibrate the extensive photographic surveys, currently being carried out by the Swedish observers on the southern hemisphere. There are several problems concerning galactic structure which may with advantage be tackled by observations in these areas. As an example may be mentioned the distribution in height over and below the galactic plane of stars of various spectral types. The discussion in Ch. 3 of Stars and Stellar Systems Vol. 5 shows that e.g. the question of the true distribution of the late type giants is not at all settled; it has interesting implications as to the mass distribution in the solar neighbourhood. Those interested in participating in this type of work are requested to contact Elvius, who will try to provide maps with suggested sequences.

Fehrenbach (Marseille) reported on the progress of the work with the radial velocity astrograph in South Africa. The plates are covering the Magellanic Clouds, a region between the Clouds, and some regions between the Clouds and the Milky Way. In the Large Magellanic Cloud approximately 500 stars have been identified, in the Small Magellanic Cloud this number is about 50. Approximately 20 stars could positively be placed between the two Clouds.

The precision of the radial velocity measurements is comparable to that obtained by slit spectrographs. An important result is the establishment of the rotation of the LMC. It is highly desirable that the radial velocity survey be complemented by measurements of magnitudes and colours as well as by spectral classifications. This would constitute a valuable program for the 1 m photometric telescope. Lists of stars with coordinates and charts are being prepared.

Florsch (Strasbourg) discussed his material on the SMC obtained with the ESO radial velocity astrograph in South Africa. As a result of the poor image quality the uncertainty of a radial velocity determination from a single plate amounts to 15—20 km/s. As each star was measured on 8 plates, the final uncertainty should not exceed 7 km/s. The preliminary results include the finding of 65 high velocity stars, mostly of spectral type B and A, as well as a gradient of the radial velocities of SMC members of 9 km/s along the optical axis of the Cloud.

Geyer (Heidelberg) reported on his photometric studies in the globular cluster ω Centauri, based on plates taken with the ADH Baker-Schmidt camera at Boyden Station; the photometry was standardized by photoelectric sequences. When comparing photoelectric sequences from different authors, Geyer found considerable differences for the fainter stars, presumably caused by the difficulties associated with photometry in densely populated star regions. A large number of faint blue stars (down to $B-V = -0.3$ at $V = 15.5$) have been found. The RR Lyrae gap begins at $B - V = 0.18$, $V = 14.47$, and extends to $B - V = 0.44$; the colour borders of the gap coincide with those of the globular cluster M 3, indicating that the two clusters are reddened by the same probably very small amount. At least two luminous stars, V = 10.91, B−V = 0.43 and V = 12.95, B−V = 0.03, seem to be members of the cluster as indicated by their radial velocities.

Haug (Tübingen) reported on results obtained likewise with the ADH telescope at Boyden Observatory. On objective prism plates 105 stars of early spectral types were selected in Norma near l = 332°, b = −2° as well as 38 similar stars in Circinus near l = 321°, b = −1.5°. A comparison with the OB classification of G. Lyngå (Medd. Lund Obs. [II] nr. 141, 1964), which is possible for 63 stars, shows that he tends to ascribe higher luminosities to the stars. Most of his OB stars were classified as dB stars from the Boyden plates. Photoelectric UBV measurements of all stars were made with a 16″ reflector by Dachs, Haug, Pesch, and Pfleiderer on Rockdale Mountain near Beaufort West (South Africa). By treating all stars like main sequence stars in calculating reddening and distance, a number of stars are found which seem to have higher luminosities than main sequence stars. The most interesting group of such stars at l = 332°, b = −1° may have a distance of 4 kpc and is perhaps connected with regions of H_α emission.

Bigay (Lyon) discussed photoelectric photometry of B stars in SA 64. His study includes UBV photometry as well as narrow band photometry on H_β, H_γ, and H_δ. Combining this material with a number of spectral classifications of the Observatoire de Marseille it has been possible to assign absolute magnitudes to 120 stars in the area. The U−B, B−V diagram of these stars shows considerable scatter due to the very irregular interstellar reddening; the colour excess E_{B-V} varies from 0.05 mag. to 1.37 mag.

A study of the absorption as a function of distance reveals that the absorption increases rapidly with distance from the sun up to about 1000 to 1200 parsecs, where the average visual absorption reaches a value of about 2 mag., remaining almost constant out to at least 3 kpc, the approximate limit of the observations. Some nearby stars show considerable reddening: BSD 2387 at 150 pc has E_{B-V} = 1.20 mag. It is obvious that the absorbing clouds are part of the Cygnus arm. In the direction of SA 64 (l_{II} = 68°) the Perseus arm is at a distance of 4–5 kpc, which explains why no absorption could be found beyond 1200 pc.

Walraven (Leiden) described an advanced design for a photometer with an elaborate system for selection of wavelength regions. The system is based on the same principle which has been used successfully in a five-colour photometer at the Leiden Southern Station in South Africa.

A different, but likewise ambitious design was discussed by Brückner (Göttingen). His design is a 4-grating spectrometer with a prism-predisperser with photon-counting electronics. The spectrometer is designed for a 1.5 second of arc seeing image, corresponding with a channel width of 1 Å. The instrument is expected to be useful for radial velocity work as well, with an accuracy of better than 10 km/sec.

Mianes (Bordeaux) pointed out the distinct advantages of a signal amplifier where the dc signal is modulated by a vibrating capacitor. The advantages include elimination of zero drift as well as the possibility to use considerably smaller load resistors to measure the same signal current as compared with a classical dc amplifier. Mianes has used his instrument in a six-colour photometric study of 34 Cepheids. The relative reddening of these stars could be derived by the method described by Canavaggia (Ann. d'Aph. 18, 431).

Miss Canavaggia discussed the relative merits of the six-colour photometry and Strömgren's four-colour system. She concludes that very cool stars may look similar in the Strömgren system, whereas the R-I colours indicate distinctly different temperatures. The interpretation of the four-colour photometric data on cool stars should be complemented by a temperature parameter in the near infrared.

Schmidt-Kaler (Bonn) reported on the progress of his plans for a photometric refinement of the Schmidt-classified stars in the Hamburg-Cleveland survey of OB-stars. If this refinement would have to be done on the basis of slit spectra, an enormous amount of observing time would be needed: the survey includes 7241 stars down to magnitude 13. However, for 85-90 % of the stars absolute magnitudes may be established with mean errors of ± 0.3 mag. to ± 0.7 mag. if only UBV photometry is available in addition to the elementary classification of the surveys. This is particularly true for the natural groups dBe and OcB1; considering the small dispersion of intrinsic colours the last group may be used to find variations in the ratio E_{U-B}/E_{B-V}.

A joint observing program to obtain UBV photometry for all of the Hamburg-Cleveland stars has been initiated:

published data, esp. Hiltner	1400	
Haug	1100	(200 in common with Hiltner)
Bigay, Lunel	150	
Schmidt-Kaler	150	

4800 stars remain to be observed. Cooperation is invited, finding charts will be supplied.

Heintze (Utrecht) discussed the application of narrow-band photometry to the problem of determining the geometrical elements, the luminosity and the centre-limb variation of the surface brightness of the eclipsing binary SZ Camelopardalis. The earlier results of Wesselink and of Grygar are confirmed; the limb darkening coefficients, however, are closer to the theoretical values.

Behr (Göttingen) presented a paper on astronomical polarimetry. The polarization of light can be described by the degree of polarization

$$P = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$

and the plane of vibration φ_0 (maximum of the electric vector).

In astronomy the polarization is often measured as the difference between the maximum and minimum brightness of the star when the polarimeter is rotated about its axis; this quantity can be related to P:

$$P = m_{min} - m_{max} \approx 2.17\,P$$

for small amounts of polarization.

A more versatile means to describe polarized light is given by the Stokes parameters which in the case of linear polarization are

$$\begin{aligned} I &= I_{max} + I_{min} \\ Q &= (I_{max} - I_{min}) \cos 2\,\varphi_0 \\ U &= (I_{max} - I_{min}) \sin 2\,\varphi_0 \\ V &= O \end{aligned}$$

Here again as an analogon we can define a system of p_x, p_y parameters in astronomical magnitudes

$$\begin{aligned} p_x &= p \cos 2\varphi_0 \\ p_y &= p \sin 2\varphi_0 \end{aligned}$$

The great advantage of both systems of parameters becomes obvious in the case that polarization originates from different sources. The resulting polarization can then be found by vectorial addition of the respective parameters, in the first case (Stokes parameters) precisely, in the second case (p_x, p_y parameters) in very good approximation for small values of polarization. The Stokes parameters are needed to separate the influence of more than one light source (star + sky background), the p_x, p_y parameters in case that one light source is polarized by more than one polarizing agent (different interstellar clouds, instrumental polarization) or for statistical treatment of the measurements.

The accuracy of a polarization measurement as well as a standard photoelectric measurement is limited by the shot noise of the photocurrent from the star, from the sky background, of the thermionic dark current and by seeing noise. The dark current can be reduced to a negligible value by cooling, the seeing noise by using a differential method, rotating the polarimeter and measuring the difference of two light beams polarized by a Wollaston prism in planes of vibration perpendicular to each other. A final source of systematic errors due to instrumental polarization can be avoided by rotating the telescope and the polarimeter as a whole around its optical axis; this method, originally proposed by Behr, is now being used with a 24 inch telescope at Yerkes Observatory.

The paper by Behr was followed by a discussion where the point was raised whether ESO should not have a polarimeter added to the available auxiliary instruments with the photometric telescope. This question is presently being studied by Behr and Lodén.

Steinlin (Basle) reported on the relative merits of the UBV and RGU colour systems as well as on the question of how to evaluate a multicolour photometric system. He stressed the importance of selecting wavelength regions with due regard to the astrophysical problems which must be tackled.

This report has been based on notes made during the meeting as well as on abstracts of the papers which were kindly provided by several authors.

Table 1

Some figures on the ESO telescopes

	D (cm)	Focal ratios		
		pri.	Cas.	cou.
Photometric telescope	100		15	
Spectrographic telescope	152	4.5	15	30
Schmidt telescope	100	3		
Large telescope	350	3	8	30
Radial velocity astrograph	40	10		

Table 2

Some figures on the coudé spectrograph of the spectrographic telescope

camera focal length cm	focal ratio	field	dispersion	
41	2.05	20°	2600—4100—5600	30,7 Å/mm
			4250—5700—7150	31,0 Å/mm
			5000—7200—9400	48,2 Å/mm
67	3.3	20°	2600—4100—5600	12,4 Å/mm
			4250—5700—7150	12,4 Å/mm
			5000—7200—9400	19,1 Å/mm
250	12.5	10°	3070—3800—4530	3,4 Å/mm
			3570—4300—5020	
			4690—5400—6100	3,2 Å/mm
			5560—6300—6970	
			4910—6000—7160	5,1 Å/mm
			6700—7800—8930	

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