EUROPEAN SOUTHERN OBSERVATORY

BULLETIN NO. 4

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 3.60 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, at an altitude of 2400 m.

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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. 4

July 1968

Edited by European Southern Observatory, Office of the Director
Bergedorfer Straße 131, 205 Hamburg 80, Fed. Rep. of Germany

ESO BULLETIN NO. 4

CONTENTS

ANNOUNCEMENT OF THE ESO DIRECTORATE

Applications for the use of the ESO 1 m Photometric Telescope for the period March 1 — September 1, 1969

Applications for the use of the above mentioned telescope within the above period may now be submitted to the

Directorate of the European Southern Observatory
131 Bergedorfer Straße, 205 Hamburg 80, W. Germany.

The applications should be received by the Directorate **not later than September 1, 1968.** Applicants may expect to be informed by November 1, 1968 whether, and how much, time will be granted.

The application should, apart from a general description of the objectives of the program, contain such particulars as

(a) required auxiliary instrumentation,
(b) most desirable period(s) of observing,
(c) number of stars and the distribution of the apparent magnitudes,
(d) required accuracy of the quantities to be determined,
(e) possible restrictions with regard to moon phase,
(f) the applicant's previous experience in observing,

etc., as are useful for judging the required observing time and instrumental facilities.

Some particulars about the ESO photometer have been published in M. de Vries's article in ESO Bulletin No. 1, 1966.

The application should normally be endorsed by the Director of the applicant's Institute. It will be reviewed by the ESO Scientific Programs Committee.

The ESO Budget provides for travel funds and for fixed allowances for lodging and food to such an extent that, as a rule, it will not be necessary for the applicants to whom observing time is granted (or for their Institute) to contribute financially. Defrayal of travel expenses of accompanying wives is foreseen to a limited extent and only in case the observers will have to stay in Chile for a period of at least 6 months. Particulars are fixed in the ESO Rules for Visiting Astronomers. It is assumed that, generally, applicants have employment in their home-countries and that this employment, with the applicant's salary, social securities and pension rights, will in principle continue during his stay at the ESO observatory. Applications by astronomers who do not have such employment will require special treatment by the ESO Directorate.

Observing periods granted may range from several weeks to several months, and observers may have to share the telescope for alternating use depending on the nature of their observing program.

All visiting astronomers are subject to the internal rules for La Silla and the Santiago Headquarters adopted by the Management. The ESO Management will aim at the most efficient use of its facilities and counts on the collaboration of all visiting astronomers in pursuing this purpose.

Applications should be clearly typed so as to allow proper copying for internal use at the Directorate.

Copies of this announcement have been sent in June 1968 to all astronomical institutes in the ESO countries.

Hamburg-Bergedorf, June 1968

NOTIFICATION DE LA DIRECTION DE L'ESO

Demandes de missions d'observation avec le télescope photométrique de 1 m de l'ESO, pendant la période du 1^er^ mars au 1^er^ septembre 1969

Dès à présent, des demandes pour l'utilisation du télescope ci-dessus mentionné, pendant la période portée en référence, peuvent être soumises à la

Direction de European Southern Observatory
131, Bergedorfer Straße, 205 Hamburg 80, Allemagne.

Les demandes doivent être présentées, **au plus tard, jusqu'au 1er septembre 1968.** Les candidats seront informés, vers le 1er novembre 1968, si leur demande est acceptée et combien de temps leur sera accordé.

Les demandes, outre une description générale des objectifs du programme, devront contenir des détails tels que

(a) l'instrumentation auxiliaire requise,
(b) la période (ou les périodes) préférée(s) pour l'observation,
(c) le nombre d'étoiles et la distribution des magnitudes apparentes,
(d) l'exactitude demandée des quantités à déterminer,
(e) restrictions possibles en ce qui concerne la phase de la lune,
(f) expérience antérieure dans l'observation,

etc., qui sont utiles pour juger le temps d'observation requis ainsi que les facilités instrumentales à pourvoir.

Quelques caractéristiques du photomètre de l'ESO ont été publiées par M. de Vries dans un article paru dans le Bulletin ESO No. 1, 1966.

La demande normalement doit être visée par le Directeur de l'Institut auquel appartient le candidat. Elle sera examinée par le Comité des Programmes Scientifiques de l'ESO.

Le budget de l'ESO prévoit des moyens financiers pour les voyages et des sommes fixes pour le logement et les repas, de sorte que, en règle générale, il ne sera pas nécessaire que le candidat, ayant obtenu du temps d'observation (ou son Institut), contribue aux frais. Il est prévu que les frais de voyage de l'épouse accompagnant l'astronome visiteur seront remboursés dans certaines limites, pourvu que l'observateur ait à travailler pour ESO au Chili pendant 6 mois au moins. Les détails y relatifs sont déterminés dans le Règlement de l'ESO pour Astronomes Visiteurs. Il est supposé que les candidats sont employés dans leurs pays d'origine et que cet emploi, avec le salaire du candidat, sa sécurité sociale et ses droits à la pension, continuera, en principe, pendant son stage à l'observatoire de l'ESO. Des candidatures par d'astronomes n'ayant pas un tel emploi, feront l'objet d'une étude spéciale par la Direction de l'ESO.

Les durées d'observation peuvent varier entre quelques semaines et quelques mois, et il est possible que les observateurs doivent utiliser le télescope par équipe, selon la nature de leur programme d'observation.

Tous les astronomes visiteurs sont soumis au règlement interne, adopté par la Direction, pour l'observatoire de La Silla et l'institut à Santiago. La Direction de l'ESO s'appliquera à faire servir ses installations de la façon la plus efficace et compte sur la collaboration de tous les astronomes visiteurs, afin d'atteindre ce but.

Les demandes doivent être écrites à la machine, afin de permettre le tirage de copies pour usage interne à la Direction.

Les instituts astronomiques dans les pays membres de l'ESO ont reçu des copies de cette notification.

Hamburg-Bergedorf, juin 1968

REPORT ON THE PROGRAM OF THE DANJON ASTROLABE AT SANTIAGO

F. Noël

The astrolabe program, a joint project of the Universidad de Chile and ESO (cf. ESO Ann. Rep. 1965, p. 10; 1966, p. 14) was started in November 1965. ESO provided the astrolabe and an integrating chronograph, and the Universidad de Chile the chronometric equipment. Staff members of the Cerro Calán Observatory are in charge of the observations.

1. The program

The observation program is essentially a chain method. It consists of 233 FK4 and 24 FK4 supplementary stars arranged in 11 groups (fundamental groups) of 28 transits distributed equally in azimuth. Three consecutive groups are observed by the same observer in one night.

After the observations of the 11 fundamental groups were completed (December 1966), the observations of a new series of 11 groups (catalogue groups) began. These groups are composed also of FK4 and FK4 supplementary stars and are observed as the middle group of the night between two fundamental groups. The stars of the catalogue groups are observed in both transits and their coordinates will be referred to the system defined by the fundamental groups. The fundamental groups were prepared at the Paris Observatory and the catalogue groups at Santiago.

The reductions of the observations are made with the 7040 IBM computer of the Paris Observatory applying the method adopted by B. Guinot (1954 b) for the Paris astrolabe. The analysis and interpretation of the results are being made at Cerro Calán. After a preliminary reduction, corrections in zenith distance are derived for each star with respect to the mean of its group. A definitive solution is obtained by applying these corrections to the computed zenith distance of the stars. So, these new solutions of a group are comparable even if the group is not completely observed.

2. Zenith distance residuals of the stars

Up to December 1966, 458 series (fundamental groups) were observed with a total of 12432 transits, thus each star was observed an average of about 27 times.

Most of the stars gave strong residuals in zenith distance. The mean standard deviation of these residuals for a single transit is $\pm 0\overset{''}{.}21$. This value was deduced from the definitive solution given by the fundamental groups and represents the real internal accuracy of the instrument at its location on Cerro Calán.

The mean standard deviation obtained for a group is in time $\pm\ 0\overset{s}{.}004$ and in latitude $\pm\ 0\overset{\prime\prime}{.}06$.

For each star of the program a weighted mean of its observed residuals in zenith distance was computed with an average mean error of $\pm\ 0\overset{\prime\prime}{.}04$. An analysis of these weighted mean residuals leads to the conclusion that there is no significant dependence on spectral type or magnitude nor does the mean error depend on the azimuth of the stars (see Table I). Thus there appear to be no appreciable local effects influencing the results of the observations. Hence the residuals in zenith distance must be largely due to individual and systematic errors of the catalogue, as we shall see later.

Table I: Danjon Astrolabe of Cerro Calán

a) The mean zenith distance residuals (R. M.) and the mean error (ε) arranged according to spectral type and magnitude.

	R. M. ($0\overset{\prime\prime}{.}01$)		ε ($0\overset{\prime\prime}{.}01$)	
Spectral type:				
B	+ 2.5	± 2.7	22.7	± 0.6
A	+ 2.1	2.2	21.0	0.5
F	– 4.6	2.8	21.5	0.6
G	+ 1.6	4.1	21.5	0.8
K	– 1.0	1.8	22.3	0.4
M	– 2.7	4.3	20.2	0.7
Magnitude:				
1.9 to 3.0	– 3.8	± 5.3	22.2	± 0.9
3.1 „ 4.0	– 2.5	1.9	20.9	0.4
4.1 „ 5.0	– 2.1	1.6	21.7	0.4
5.1 „ 6.0	+ 4.1	1.6	23.4	0.4

b) The mean error (ε) as a function of the azimuth.

Azimuth	ε (0″01)
20°— 40°	± 19.9
40 — 60	22.2
60 — 80	23.4
80 — 100	25.2
100 — 120	23.8
120 — 140	24.2
130 — 160	21.9
150 — 170	21.0
190 — 210	19.5
200 — 230	20.1
220 — 240	20.9
240 — 260	24.6
260 — 280	23.1
280 — 300	22.3
300 — 320	21.6
320 — 340	± 21.7

3. $\Delta\alpha_\delta$ investigation

From the analysis of the relation between the mean zenith distance residuals and the azimuth, it is possible to investigate the $\Delta\alpha_\delta$ error of the FK4 catalogue.

The stars are divided into equal azimuth intervals. For the stars of the same interval, the average "mean zenith distance residual", R. M., and mean declination, $<\delta>$, are computed. Let Z be the mean azimuth of the interval, R. M. (E) the mean residual of an azimuth interval at the east and R. M. (W) the mean residual of the corresponding interval at the west, and let φ be the latitude of the instrument. B. Guinot (cf. Ref. 1954 a) has shown that for every azimuth interval

$$\Delta\alpha_\delta \text{ (Astrolabe-FK4)} = \frac{\text{R. M. (E)} - \text{R. M. (W)}}{30 \sin Z \cos \varphi} + K$$

where K is a constant.

The distribution of the stars in the azimuth groups with respect to right ascension is quite uniform so that the error $\Delta\alpha_\alpha$ can be considered as negligible.

Table II: Danjon Astrolabe of Cerro Calán

	Investigation of $\Delta\alpha_\delta$ (Astrolabe — FK4)				
Azimuth (Z)	n	$<\delta>$	15 sin Z cos φ	R. M. (0″001)	
20°— 40°	25	− 7°4	+ 6.7	− 29	± 21
40 — 60	28	12.5	9.7	+ 35	20
60 — 80	22	19.1	11.6	− 34	25
80 — 100	6	29.6	12.4	− 98	87
100 — 120	23	40.2	11.4	+ 68	37
120 — 140	28	48.9	9.3	+ 02	51
130 — 160	30	54.5	7.2	− 109	36
150 — 170	14	− 60.2	+ 4.3	− 165	64
190 — 210	23	− 59.3	− 4.8	+ 111	± 64
200 — 230	24	54.5	7.2	+ 95	35
220 — 240	23	48.5	9.4	+ 55	43
240 — 260	19	37.7	11.8	− 171	41
260 — 280	12	27.5	12.4	− 20	45
280 — 300	18	19.3	11.7	− 57	39
300 — 320	33	11.5	9.3	+ 25	25
320 — 340	19	− 7.0	− 6.5	+ 68	22

$<\delta>$	15 sin Z cos φ	½ [R. M. (E) — R. M. (W)] (0″001)		$\Delta\alpha$ (0ˢ001)		n*
− 7.2	6.6	− 48	± 15	− 07	± 02	44
12.0	9.5	+ 05	16	+ 01	02	61
19.2	11.6	+ 12	23	+ 01	02	40
28.0	12.4	− 39	49	− 03	04	18
38.9	11.6	+ 120	28	+ 10	02	42
48.6	9.4	− 26	34	− 03	04	51
54.5	7.2	− 102	25	− 14	03	64
− 59.7	4.6	− 138	45	− 30	10	37

n*: number of stars

The results of the $\Delta\alpha_\delta$ investigation in the sense of astrolabe minus FK4 are given in Table II and can be seen in Fig. 1.

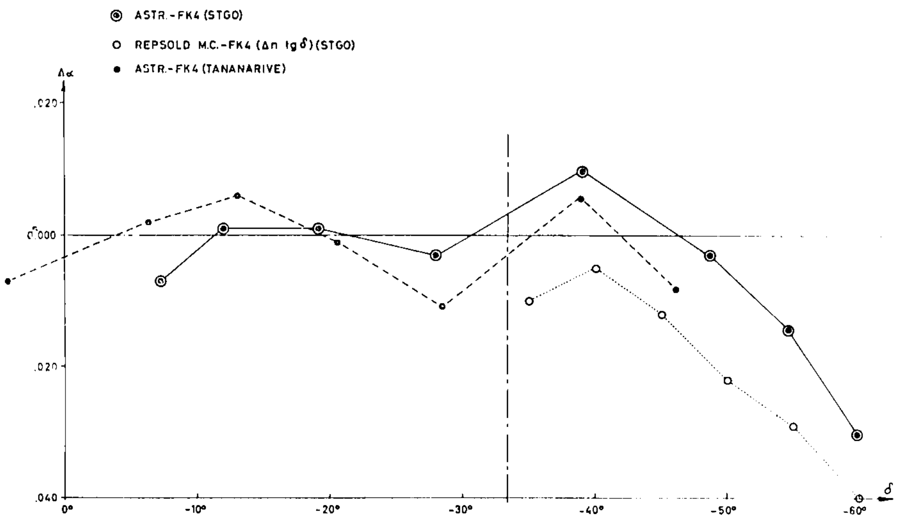

Fig. 1: The FK4 $\Delta\alpha_\delta$ error as deduced from observations made with the Danjon Astrolabe at Santiago.

Using the series of fundamental stars done with the Repsold Meridian Circle at Cerro Calán, which are being used in the SRS and BS program according to an agreement between the Academy of Sciences of the U. S. S. R. and the Universidad de Chile, a similar declination dependence of Δα in FK4 was obtained (Table III, Fig. 1).

Table III: Declination dependence of Δα (R. M. C.-FK 4)
Repsold Meridian Circle of Cerro Calán (R. M. C.)

δ	Δα E+W (0ˢ001)	
— 35°	— 10	± 3
— 40	— 5	4
— 45	— 12	5
— 50	— 22	6
— 55	— 29	7
— 60	— 40	± 8

In "Résultats des observations faites à Tananarive avec l'Astrolabe A. Danjon" by M. Lefebvre and B. Guinot published in "Journal des Observateurs", vol. 49, No. 11 and 12, the individual corrections $\Delta\alpha$ (Astr. — FK4) for 113 stars are given. Using these results, we made an estimation of the $\Delta\alpha_\delta$ error.

The results are the following (n is the number of stars):

$<\delta>$	$\Delta\alpha$ $(0\overset{\mathrm{s}}{.}001)$	n
$+\ 5\overset{\circ}{.}7$	− 07	15
− 6.3	+ 02	9
− 13.1	+ 06	16
− 20.6	− 01	30
− 28.4	− 11	29
− 38.8	+ 06	10
− 45.9	− 08	4

The results are plotted in Fig. 1.

The Tananarive curve was obtained from a very low number of star corrections, so it is possible that some points of the curve are affected by another type of systematic and individual errors.

The systematic difference between the astrolabe and the Meridian Circle curves is due to the different origins of the two instrumental systems (Meridian Circle from $\delta = +30^\circ$ to $\delta = -30^\circ$; Astrolabe from $\delta = -5^\circ$ to $\delta = -63^\circ$). However, the three curves show a satisfactory agreement which allows us to suppose that the distortion of the right ascension with respect to the declination observed by the astrolabe in the FK4 system is really due to an error of the $\Delta\alpha_\delta$ type and not to an instrumental error or local or personal effects.

These results have been presented at the meeting of Commission VIII at the XIIIth IAU Assembly in Prague (1967).

4. Time determinations

The results of the time determinations are sent weekly to the Bureau International de l'Heure (B. I. H.). They enter into the determination of the "Heure définitive". The earth rotation (TU 1) observed during 1966 in the astrolabe and referred to the uniform time scale defined by the WWV time signals is plotted in Fig. 2. Each point represents the weighted mean of about 25 time determinations. The circles represent the definitive TU 1 computed by the B. I. H. and referred to the Co-ordinated Universal Time (TUC). The two time scales WWV and TUC are not strictly comparable, their differences, however, are practically negligible.

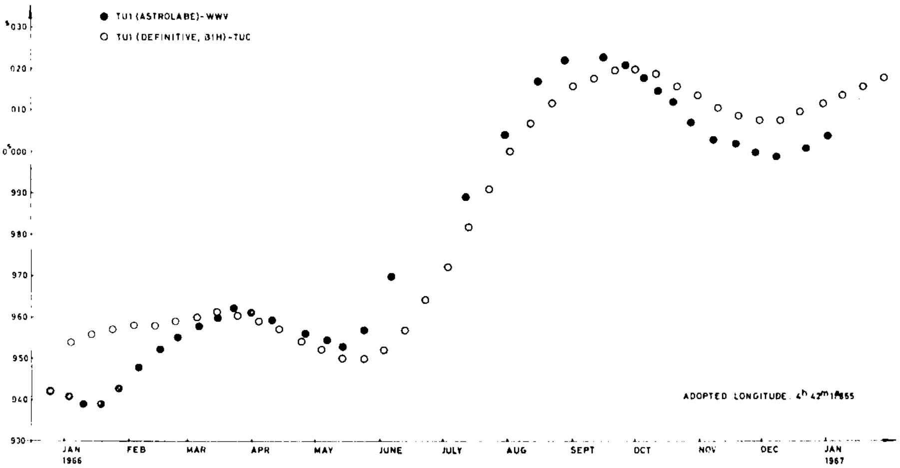

Fig. 2: The earth rotation during 1966 observed with the Danjon Astrolabe of Santiago.

5. Latitude determinations

The latitude determinations are sent monthly to the International Polar Motion Service (I. P. M. S.). The curve of the latitude variation observed with the astrolable and compared with the normal variation of the latitude (circles) computed by the I. P. M. S., is shown in Fig. 3.

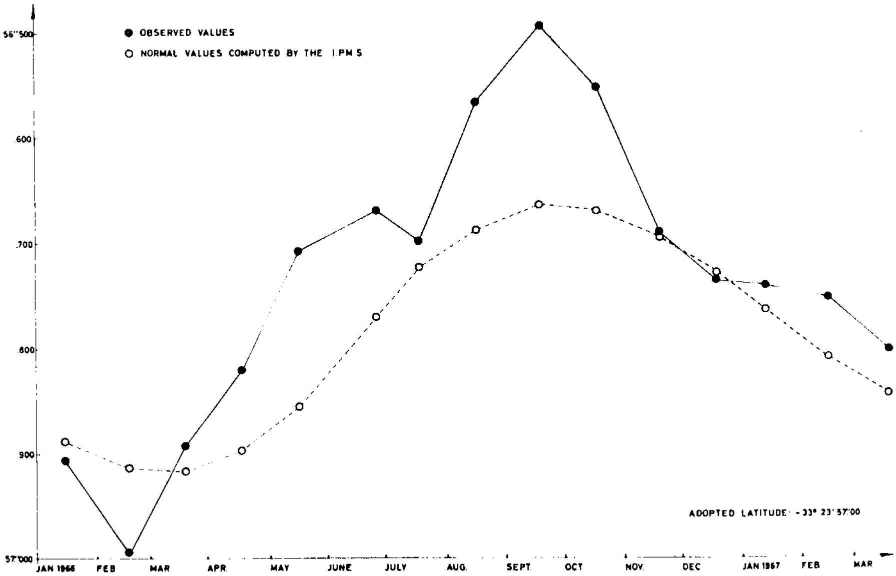

Fig. 3: Latitude variation observed with the Danjon Astrolabe at Santiago.

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CURRENT PHOTOMETRIC WORK ON LA SILLA

A. Blaauw

For the benefit of those who plan projects with the ESO 1 meter photometric telescope, and hence may profit from acquaintance with programs carried out by others, we present here a summary of what has been done so far on La Silla and of work to be carried out in the near future. This information supplements general information on southern hemisphere work given elsewhere; we refer in particular to the Information Bulletin for the Southern Hemisphere.

A description of the "ESO photometer", which has been in use for most of the projects described below, has been given by M. de Vries in ESO Bulletin No. 1. So far, it has been used with the three cells: the 1 P 21, the EMI and the RCA 7102, and with the filter sets containing filters corresponding with the color bands u, v, b, y (Strömgren 1963), R, Q, P, N, M, L, K (Borgman 1960), and U, B, V, R, I (Johnson 1965). Some data relevant to these filters are given in Appendix II to this article.

The following programs were observed or are in preparation:

a) In November 1966 J. Borgman, in connection with tests of the then recently installed telescope, measured O and early B stars. A photometer belonging to the Kapteyn Observatory at Roden was used. From the results, which are being incorporated into the recent work of M. de Vries, we abstract the extinction coefficients listed in Appendix II to this article.

b) In the period December 1966 — March 1967, J. P. Brunet used the same photometer for U, B, V photometry of stars identified as members of the Magellanic Clouds by Fehrenbach and associates by means of the Zeekoegat (South Africa) observations with the ESO radial velocity astrograph.

c) In May and June 1967, M. de Vries and H.C.D. Visser of Groningen-Roden carried out exploratory programs with the ESO photometer built at the Kapteyn Observatory.

d) During September and October 1967, M. de Vries and J. Wijnbergen made test observations with the "K-photometer" for infra-red work around $\lambda = 2.2\ \mu$ of the Kapteyn Observatory. This photometer, which has been used again during more recent work of de Vries, will soon become the property of ESO. A description will appear in another issue of this Bulletin.

e) From October 16, 1967, to February 10, 1968, the ESO photometer was used for the u v b y photometry of faint G and K stars at intermediate and high latitudes by A. Blaauw, T. van't Foort and S. Baas. Some details concerning this program are communicated in Appendix I to this article.

f) During the bright moon periods of November and December 1967 and January 1968, Dr. J. Stock and Dr. E. Mendoza of Cerro Calán Observatory in Santiago used the ESO photometer for various programs.

g) In February and March 1968, A. Behr of Göttingen tested and adjusted the polarimeter built for ESO at the Göttingen Observatory.

h) From early February to May 20, 1968, M. de Vries carried out two multichannel programs: photometry of stars in the Scorpio-Centaurus association, and an investigation of the interstellar extinction law over a large section of the southern Milky Way. About 150 stars in Scorpio Centaurus were measured in the bands u, v, b, y, R, Q, P and I and a small number among these in the infra-red K band. The purpose of this program is extension of the multichannel work on northern B stars by Borgman (published in B.A.N. Vol. 15, p. 255). The observations for the interstellar extinction law were done at these same wavelenghts; about 130 O, Bo and supergiant B1 — B3 stars were observed, a few also with the K photometer.

Currently (June through August 1968) the following programs are observed:

j) E. H. Geyer, Bonn, during the dark moon periods, various objects in ω centauri: the eclipsing variable V 78, pop. II Cepheids, blue horizontal branch stars, stars on giant and subgiant branches (uvby).

k) U. Haug, Tübingen: UBV sequences in NGC 5617, NGC 5662, NGC 5606 and Tr. 22, UBV measures of OB stars in the direction of the galactic centre for determination of interstellar absorption.

l) A. Ardeberg, Lund, during the bright moon periods: UBV photometry in a 6 square degree field centered on $l^{II} = 353^\circ$, $b^{II} = +3^\circ$ for investigation of the interstellar absorption and the stellar density distribution.

The months September and October 1968 are reserved for mounting the telescope in its new dome and other instrumental projects. During the period November 1968 — April 1969, part of the time will be used for the following projects:

m) J. Denoyelle, Uccle: UBV photometry of OB stars in the association I Vel and in Carina, and possibly some β Can. Maj. stars.

n) H. Mauder, Bamberg: UBV light curves of the EW stars BV 421, 646, 610, 513, 449, 480.

o) W. Seggewiss, Bonn: UBV sequences in areas at the galactic longitudes 212°, 223°, 242°, 262°, 279°, 300°; UBV light curves of T Tauri and RW Aur variables.

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APPENDIX I

The G, K stars program in the Selected Areas at intermediate and high latitudes

uvby Photometry of relatively faint stars of types G5 and later in some Kapteyn Selected Areas at declination 0°, + 15°, + 30° is being carried out by Blaauw and associates. A first, extensive program was done in the period October 1967 to February 1968. Although various initial difficulties with the photometer had to be overcome, a satisfactory material of measures could already be collected. A central square degree area has been observed, with normally 2 observations per star and an intended accuracy around ± m 01 (p.e.). The limiting photographic magnitude is, with few exceptions, about 13.0 except for the u band where it is brighter for the latest types. The following areas have been observed so far: SA 52, 53, 68 (partly), 69, 70, 71, 72, 77, 91, 92, 93, 94, 95, 114, 115.

This program forms part of an extensive project conducted by the author in collaboration with associates at Groningen and at the McCormick Observatory. Its principal purpose is the determination of the distributional and kinematical properties of the older disk population of the Galaxy in a volume up to several kiloparsecs from the sun. The photometry referred to before will serve as a first step in the quantitative discrimination of the stars of the older population, and subsequently in determining for these stars the density gradient parallel to the galactic plane in the direction from galactic centre to anticentre, and perpendicular to the plane. The intermediate and high latitudes at which the areas are chosen cover stars in a layer between 500 and 1000 ps from the plane over a range of several kiloparsecs distance from the galactic centre — say R = 8 to 12 kps. It may be pointed out that, at a distance 1000 pc from the plane, the abundance of the younger population embodied by the "strong line stars" in the solar neighborhood probably does not exceed two percent as compared to 40 percent near the plane. Hence the majority of the faint high latitude giants belong to the disk categories "weak-line" or "high-velocity". Furthermore, at about photographic magnitude 12, the majority of the late type stars are giants, not foreground dwarfs. Thus most of the stars observed will turn out to belong to the category sought for.

This program has its counterpart in two projects carried out at the McCormick Observatory. They aim at the determination of the kinematic properties which are required for the dynamical interpretation of the results of the density analyses. Proper motions of stars down to about photographic magnitude 12.0 are redetermined, using McCormick plates, taken in the years 1915—1930 for earlier proper motion programs, as a first epoch, and modern plates for the second one. The relative proper motions are expected to have probable errors not exceeding ± ″002, corresponding to errors in the linear tangential velocities of a few kilometers per second. Since nearly all of these fields are centered on bright parallax stars — many of them in the FK4 catalogue — reduction to absolute motion with an accuracy of ″002 seems possible. The program therefore may, as an important byproduct, produce an improved determination of the precessional corrections.

Photometry similar to that for the GK stars in the SA's has been carried out for the McCormick fields at Kitt Peak National Observatory. Thus, this McCormick — Kitt Peak program in combination with the La Silla project is expected to produce a comprehensive basis for the study of the space distribution and dynamics of the old disk population.

APPENDIX II

Some preliminary values of the extinction coefficients at La Silla

The table below collects a few preliminary results on extinction coefficients obtained at La Silla in the course of some of the programs mentioned before, done with the 1 meter telescope.

Column I represents results obtained by Borgman in November 1966. Since the coefficients for the broad bands U, B, V are color dependent, it should be kept in mind that these values were derived from observations of O and early B-type stars. The photometer and an unrefrigerated multiplier of the Kapteyn Observatory were used. The probable errors are of the order of a few thousands of a magnitude. The u filter was a preliminary one, it deviated rather strongly from the "standard" wavelength listed in the last column.

Column II represents mean values obtained from a provisional reduction of the SA program of October 1967 — February 1968. A dry-ice cooled 1 P21 multiplier (no. ESO 101) was used in the ESO photometer. The extinction stars from which these coefficients were derived are the E standard pairs at Dec. –45°. The probable errors are about $\pm {}^{m}0015$. An indication was found of an additional "gray" (color-independent) extinction coefficient of ${}^{m}03$ during the second half of January 1968; these observations were done on brighter and more northern standard stars for reduction to the Kitt Peak uvby system. The multiplier used showed considerable temperature effects in its color sensitivity.

Results of a systematic program of extinction measures in UBV with some smaller telescopes conducted under supervision of Dr. A. B. Muller will be communicated separately.

Photometric work on La Silla

	I Borgman Nov. 1966 Roden photometer	II Blaauw et al Oct. 1967—Feb. 1968 ESO photometer	III Standard Wavelength Å
	m		
V	.114		color dependent
B	.219		
U	.510		
y	.112	.138	5470
b	.180	.201	4670
v	.290	.311	4110
u	.497	.554	3500
P	.394		3750
Q	.456		3560
R	.698		3295

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METEOROLOGICAL OBSERVATIONS ON LA SILLA IN 1967

A. B. Muller

Introduction

During the first half of 1967, meteorological observations were continued on La Silla at the two sites S and T. (See ESO Bulletin No. 3, page 46.) During the second half of 1967 the observations were continued at site S, whereas the observations at T were interrupted due to road construction activity in connection with the preparation of the site for the 3.6 m telescope building. The meteorological station at T was moved to the lower summit at 2.400 m above sea level, where observations were continued during July and August. The observations at the lower summit also had to be interrupted for reasons of danger during the road construction. Because the lower summit is close to T, all observations at T and at the lower summit are tabled under letter T.

From May onwards the observations were supervised by Hans Schuster who also compiled the final tables for 1967.

In moving the windmeter from T to the lower summit the instrument was damaged, so that no wind velocity observations are available for the lower summit during the second half of the year.

For site S continuous observations were obtained throughout the year with one exception during June when La Silla was evacuated for several days due to snow storms.

As in the previous years, the observations concern clouds, wind velocity, wind direction, temperature and humidity.

Clouds

The observations cover all 365 nights of the year. In Table 1 the percentage of photometric clear nights are given for each month. The observations of 1965 and 1966 are also given for comparison. All nights having six or more continuously clear hours are defined as "photometric nights".

Table 1: Percentage of photometric nights

Month	1965	La Silla 1966	1967
January	—	100	94
February	73	96	100
March	79	94	90
April	33	57	73
May	15	58	35
June	6	47	67
July	9	36	52
August	25	64	39
September	63	70	52
October	63	64	58
November	65	50	57
December	77	94	71

Out of the total of 3.681 hours during which observations might have been made, 2.412 hours were totally clear in 1967, compared with 2.481 in 1966.

The number of photometric clear nights for 1966 and 1967 were respectively 252 and 239, so that one can say that 1967 was nearly as good as 1966.

In Fig. 1 the percentage of clear nights, indicated on the vertical axis, is plotted against the months of the year for 1965, 1966 and 1967, indicated on the horizontal axis.

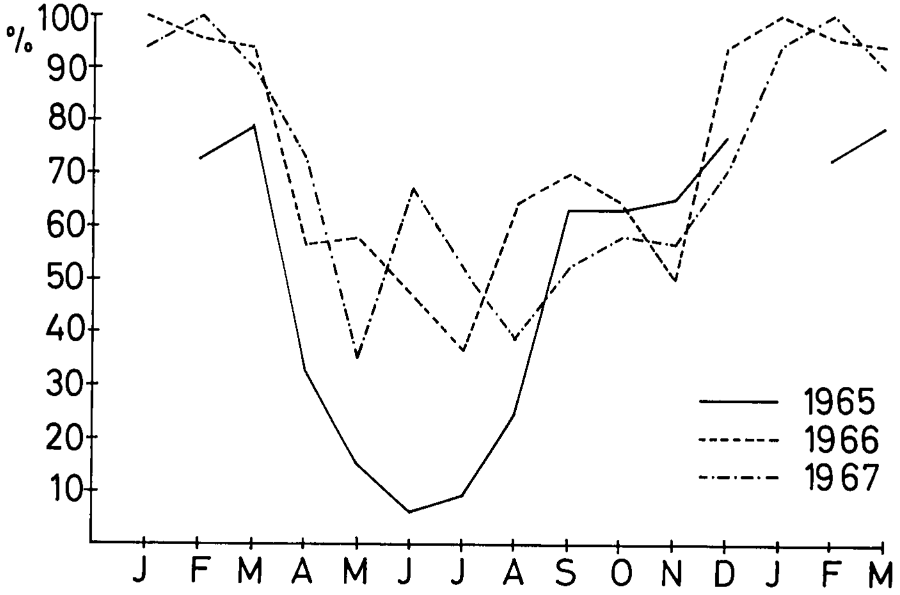

Fig. 1: Photometric nights.

Wind velocities during each month

In Table 2 the maximum wind velocities in m/s are given for each month as recorded at sites S and T. The maximum wind velocities are taken from all observations regardless of cloudiness.

Table 2

Month 1967	Maximum wind velocity at S in m/s	at T in m/s
January	11	12
February	12	13
March	16	17
April	13	13
May	29	22
June	23	19
July	22	—
August	21	—
September	20	—
October	18	—
November	16	—
December	14	—

In Fig. 2 the maximum wind velocity at S is plotted against the month of the year for 1966 and 1967. On the vertical axis the wind velocity is given in m/s, on the horizontal axis the months of the year are given.

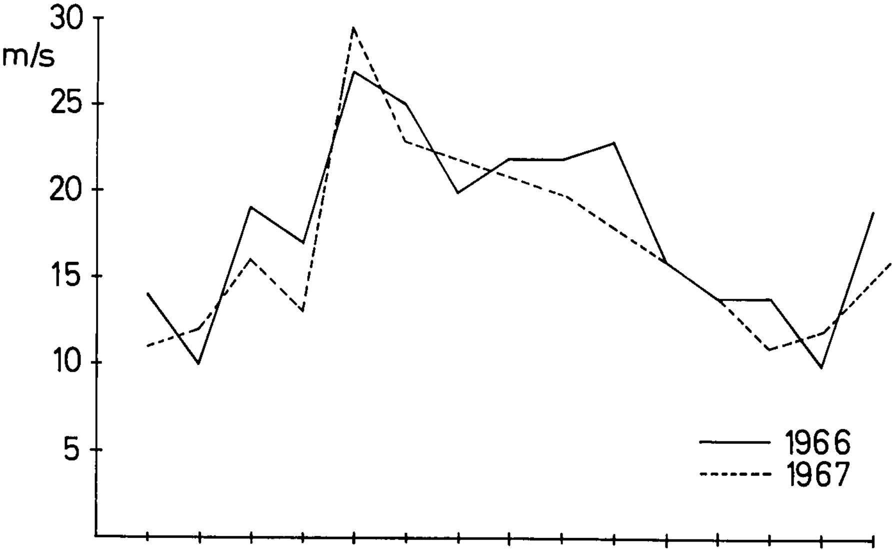

Fig. 2: Maximum wind velocity at site S.

Wind velocities during photometric nights

Average wind velocities in m/s were read every two hours from recordings obtained at S throughout the year and at T during the first half of the year.

Table 3

v	Jan.		Feb.		Mar.		Apr.		May		June	
m/s	S	T	S	T	S	T	S	T	S	T	S	T
1	28	11	23	8	12	6	7	18	0	0	0	0
2	55	38	52	41	46	28	30	37	0	1	7	5
3	81	60	80	57	64	54	52	54	4	6	13	12
4	93	79	101	87	85	69	76	72	7	10	21	18
5	102	97	115	103	95	85	88	93	10	12	29	24
6	105	103	121	117	104	98	97	100	15	20	33	29
7	111	107	129	125	111	106	114	112	25	25	39	39
8	113	108	131	130	119	114	121	117	33	32	51	56
9	115	110	134	134	123	121	127	121	43	44	63	65
10	115	112	136	135	126	125	129	126	53	58	70	72
11	116	114	137	137		126	129	128	63	63	74	75
12		116	139	138			131	131	64	64	76	81
13				139			132	132	65	66	80	82
14									66		84	90
15											90	92
16											92	93
17											93	93
18											93	93
19											93	94
20											93	
21											93	
22											94	
v	3.1	3.9	3.6	4.3	3.9	4.6	4.6	4.6	8.2	7.9	8.3	8.2

Table 3 Continued

v	Jul.		Aug.		Sep.		Oct.		Nov.		Dec.	
m/s	S	T	S	T	S	T	S	T	S	T	S	T
1	3		0		2		5		5		7	
2	7		5		10		17		19		22	
3	17		6		12		36		40		37	
4	24		13		15		47		51		54	
5	32		19		22		58		61		70	
6	37		26		26		62		66		78	
7	45		31		29		68		73		84	
8	48		51		36		74		76		94	
9	54		59		43		83		79		101	
10	61		62		45		86		84		105	
11	70		63		52				89		106	
12	76		65		54				94		108	
13	83		70		59				96		109	
14	89		71		67						110	
15	93		72		72							
16	95				73							
17	96				77							
18					79							
19												
20												
21												
22												
v	8.2		7.5		9.3		4.7		5.3		5.1	

Table 3 gives for sites S and T the number of observations with a wind velocity equal to or less than velocity "v" as indicated in the first column.

As far as observations at S and at T are given the observations are simultaneous observations.

The last row, indicated by v, gives for each month of the year the average wind velocity at S and, as far as possible, at T during photometric nights.

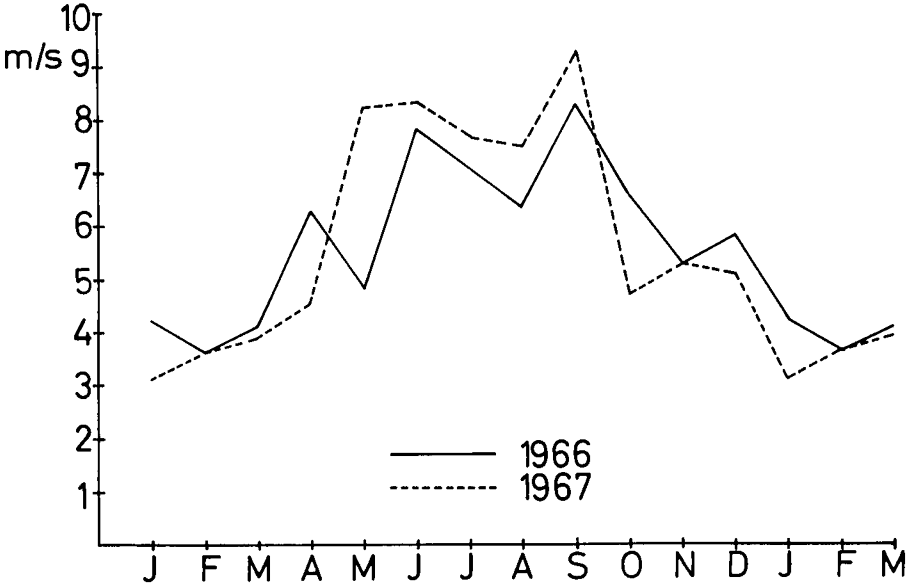

Fig. 3: Average wind velocity at site S.

In Fig. 3 the average wind velocities for 1966 and 1967 are plotted against the months of the year. The vertical axis gives the average wind velocity in m/s, the horizontal axis gives the months of the year.

Wind directions during photometric nights

Table 4

W. D.	J	F	M	A	M	J	J	A	S	O	N	D	All 1967 in %
S	44	33	2	44	0	0	5	11	9	14	59	31	10,1
SSW	3	2	0	0	0	0	3	12	0	23	11	29	3,5
SW	42	25	65	40	0	0	8	6	2	3	7	5	8,3
WSW	0	0	0	1	0	1	0	0	2	0	0	0	0,2
W	20	32	26	10	1	0	1	1	0	1	1	0	3,8
WNW	1	0	0	1	0	1	1	0	0	1	0	0	0,2
NW	24	23	61	56	0	22	5	2	4	3	2	0	8,2
NNW	4	0	1	0	0	10	0	1	1	2	1	1	0,9
N	97	126	75	56	34	92	24	15	43	27	8	26	25,0
NNE	7	4	0	0	0	43	67	42	49	44	19	18	11,9
NE	18	32	50	53	91	46	72	44	49	52	54	21	23,7
ENE	0	0	0	0	0	1	6	2	1	1	3	7	0,6
E	0	1	0	0	6	0	4	5	0	3	7	15	1,7
ESE	0	0	0	0	0	0	2	1	1	0	1	2	0,3
SE	1	2	0	3	0	0	5	1	0	3	8	2	1,0
SSE	0	0	0	0	0	0	5	1	2	3	3	7	0,6

At site S only, wind directions were observed every hour. Table 4 gives for each month of the year the number of hourly observations with a wind direction as indicated in the first column. This table is based on observations taken during photometric nights only. The last column in Table 4 gives the total results in percentage for 1967. The results show that throughout the year the prevailing wind during clear nights is from N-NNE-NE.

The total results in percentage for 1967 are also given in diagram-form in Fig. 4.

The percentages are plotted against their compass directions. The radius of the circle corresponds to 25 % as found for the direction N in the overall average of 1967.

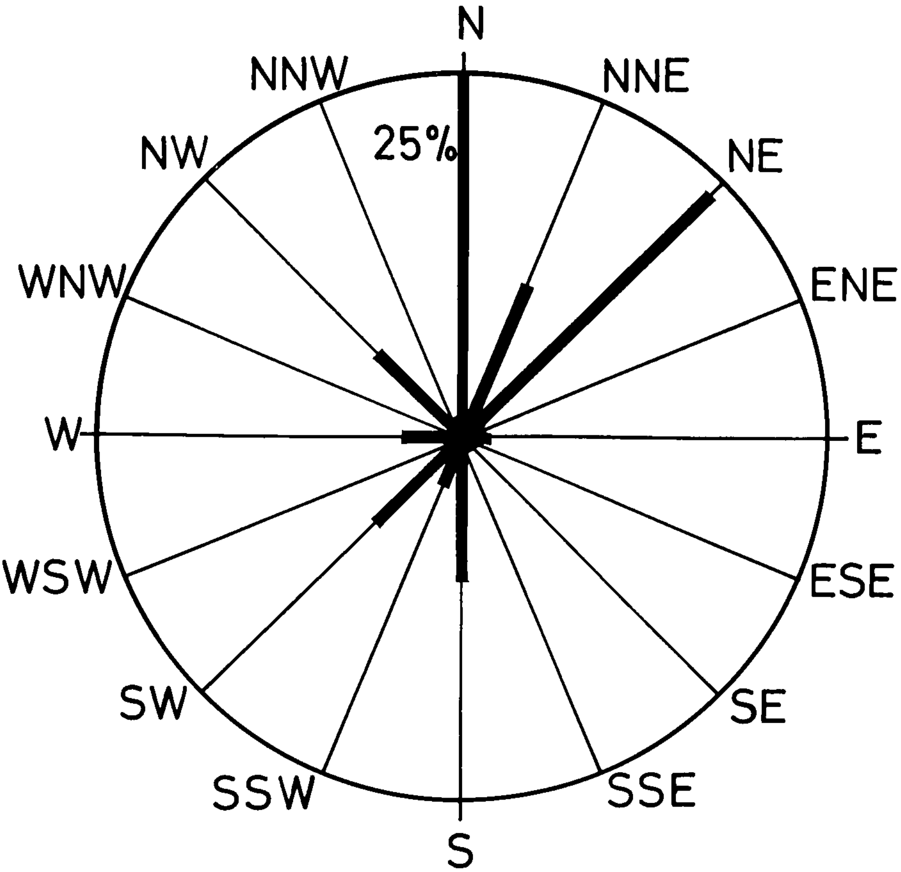

Fig. 4: Wind directions observed during 1967. The radius of the circle corresponds to 25 % as found for the direction N in the overall average of 1967.

Maximum and minimum temperatures during each month

Table 5

Month	S		T	
1967	Max.	Min.	Max.	Min.
Jan.	+ 25	+ 8	+ 24	+ 8
Feb.	+ 23	+ 8	+ 24	+ 9
March	+ 22	+ 4	+ 21	+ 4
Apr.	+ 27	+ 7	+ 25	+ 7
May	+ 21	+ 3	+ 22	+ 2
June	+ 16	− 4	+ 16	− 6
July	+ 18	− 6	+ 17	− 6
Aug.	+ 21	− 5	+ 20	− 6
Sept.	+ 22	− 6	—	—
Oct.	+ 25	− 2	—	—
Nov.	+ 24	0	—	—
Dec.	+ 24	+ 7	—	—

Table 5 gives for each month the maximum and the minimum temperature as measured at S and T. The temperatures were read daily, regardless of the cloudiness, from a maximum-minimum thermometer. In Fig. 5 maximum and minimum temperatures as measured at S in 1966 and 1967 are plotted against the months of the year. On the vertical axis the temperature is given in degrees Celsius, on the horizontal axis the months of the year.

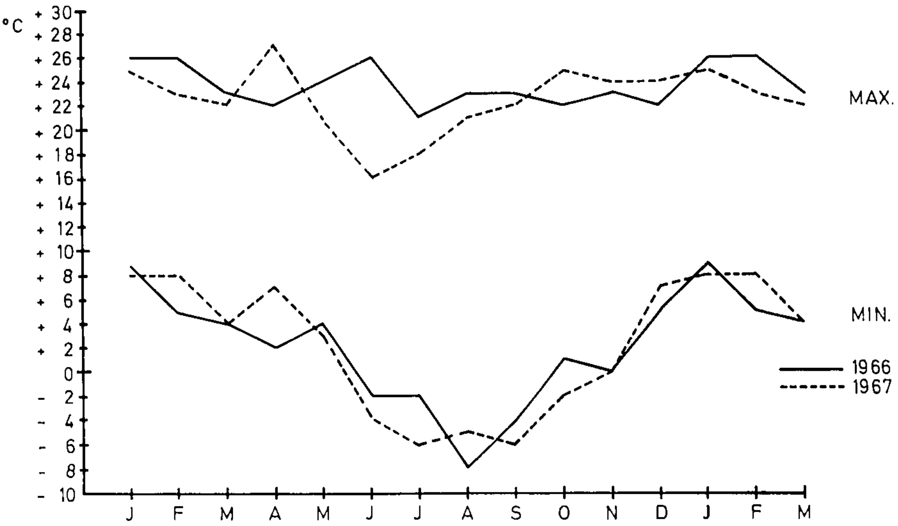

Fig. 5: Maximum and minimum temperatures at site S.

Table 6

T.D. °C	Jan. S	Jan. T	Feb. S	Feb. T	Mar. S	Mar. T	Apr. S	Apr. T	May S	May T	June S	June T
1	0	0	0	0	0	0	0	0	0	3	2	0
2	0	0	0	0	0	0	0	0	0	3	2	1
3	0	0	0	0	0	0	0	1	1	5	2	2
4	2	1	0	1	0	0	0	1	2	7	3	3
5	4	1	0	1	0	0	0	1	3	9	6	5
6	8	4	2	2	1	0	0	3	11	15	10	13
7	12	7	5	7	3	6	3	3	15	20	15	16
8	21	19	12	12	7	9	10	7	19	23	17	19
9	26	23	17	21	8	11	16	15	23	25	18	19
10	30	28	27	26	13	14	23	21	26	27	21	21
11	30	29	28	28	14	15	25	24	28	29	23	23
12	30	30			15		25	24	29	29	24	24
13	30	31					25	25	29	30		
14	31						26	26	31	30		
15										31		
16												
17												
18												
19												
20												

T.D. °C	July S	July T	Aug. S	Aug. T	Sept. S	Sept. T	Oct. S	Oct. T	Nov. S	Nov. T	Dec. S	Dec. T	All 1967 in % S
1	0	1	1	0	0		0		0		0		1
2	1	1	2	0	0		0		0		0		2
3	1	1	2	1	0		0		0		0		2
4	1	1	3	2	1		0		0		0		4
5	1	6	3	4	2		0		0		2		6
6	9	10	5	9	2		0		2		3		16
7	12	14	12	15	5		3		7		5		29
8	15	22	19	24	10		4		14		10		47
9	24	26	25	28	21		12		16		16		66
10	26	28	26	28	23		21		23		24		84
11	29	30	27	28	25		26		26		26		90
12	30	30	27	28	26		28		27		27		93
13	30	30	30	30	28		28		28		29		96
14	30	30	30	30	28		30		29		30		98
15	31	31	31	30	29		30		29		31		99
16				30	29		30		29				99
17				31	29		31		29				99
18					29				29				99
19					30				29				99
20									30				100

The differences between the maximum day temperature and the following minimum night temperature have been calculated and are given in Table 6 for all days and nights during the month regardless of the cloudiness. The table gives for each month the number of days for which the temperature difference was equal to or less than the value indicated in the first column.

The incompleteness of the observations in March and April was due to technical difficulties whereas the incompleteness in June was caused by bad weather.

The last column in Table 6 gives for site S the total results in percentage over the year. As in 1966 one sees that temperature changes of 12° C or more seldom occurred.

Maximum temperature fluctuations during photometric nights

Table 7 gives for each month, for sites S and T, the number of photometric nights during which the maximum temperature fluctuation occurring throughout the astronomical night was equal to or less than the values indicated in the first column.

The astronomical night is defined as the interval of time during which the sun is 18° or more below the observer's horizon. The peculiar values of ΔT are due to the conversion of degrees Fahrenheit into degrees Celsius.

The last column in Table 7 gives for site S the total results in percentage for 1967.

As in 1966 the observations show clearly the constancy of the temperature during photometric nights.

Table 7

ΔT °C	Jan.		Feb.		Mar.		Apr.		May		June	
	S	T	S	T	S	T	S	T	S	T	S	T
0.6	2	3	0	0	2	1	3	1	0	0	0	1
1.1	12	14	1	3	4	3	8	6	3	3	4	3
1.7	17	19	5	5	9	5	14	11	5	6	4	3
2.2	23	23	8	6	13	11	17	15	7	8	4	3
2.8	23	24	10	9	14	14	20	18	10	11	5	4
3.3	24	24	10	10			20	19	11		7	4
3.9	24	24	11	10			21	19				5
4.4	24	24		10			21	19				
5.0	25	25		11			22	20				
5.6								20				
6.1								22				
6.7												
7.2												
7.8												
8.3												

ΔT °C	July		Aug.		Sept.		Oct.		Nov.		Dec.		All 1967 in %
	S	T	S	T	S	T	S	T	S	T	S	T	S
0.6	1	1	1	2	0		0		0		0		5
1.1	2	6	4	7	4		4		6		0		27
1.7	10	9	7	9	4		4		6		0		44
2.2	13	11	8	11	10		12		11		9		70
2.8	14	12	10	12	10		12		11		9		77
3.3	14	13	11		10		17		15		18		89
3.9	16	14	11		14		17		17		21		96
4.4		14	12		15		18				21		98
5.0		14			15						22		99
5.6		14			16								100
6.1		14											
6.7		14											
7.2		15											
7.8		15											
8.3		16											

Relative humidity during photometric nights

The thermohygrographs were calibrated by comparison with a psychrometer. Because errors were found sometimes of the order of 20 to 30 % of the psychrometer results, wet and dry bulb hygrometers were installed in July. These hygrometers were read every hour during photometric nights and they were also calibrated against the psychrometer. The wet and dry bulb hygrometers can deviate between 5 % and 10 % from the psychrometer results.

Table 8

R.H.	Jan.		Feb.		Mar.		Apr.		May		June	
%	S	T	S	T	S	T	S	T	S	T	S	T
10	3	1	4	4	31	5	41	2	81	7	75	63
20	14	9	5	6	42	15	60	13	83	46	87	78
30	35	36	7	7	47	20	70	29	85	74	94	94
40	49	80	8	17	58	41	76	55	88	80	96	99
50	73	93	13	50	65	56	90	86	88	85	100	99
60	83	96	30	76	74	85	95	98	88	90		99
70	86	98	42	94	83	95	97	99	88	99		99
80	93	99	57	100	90	100	98	100	90	100		99
90	95	100	77		97		99		92			100
100	100		100		100		100		100			
R.H.	47	39	76	55	41	48	28	42	22	32	15	17

R.H.	July		Aug.		Sept.		Oct.		Nov.		Dec.		All 1967 in %
%	S	T	S	T	S	T	S	T	S	T	S	T	S
10	23	20	31	42	2		6		1		0		25
20	43	33	42	55	16		17		3		3		35
30	64	60	65	72	43		40		18		17		49
40	75	79	90	92	67		68		49		31		63
50	87	90	97	100	87		90		76		47		76
60	94	94	100		95		96		87		57		83
70	96	96			100		98		96		77		88
80	99	98					99		98		97		93
90	99	100					100		100		99		96
100	100										100		100
R.H.	32	33	27	24	35		34		43		53		

Table 8 gives for sites S and T and each month the percentage of hourly observations for which the relative humidity was equal to or less than the value indicated in the first column. The last column gives the total results in percentage for 1967. The last row, indicated R.H., gives for each month of the year the average relative humidity at S and T during photometric nights.

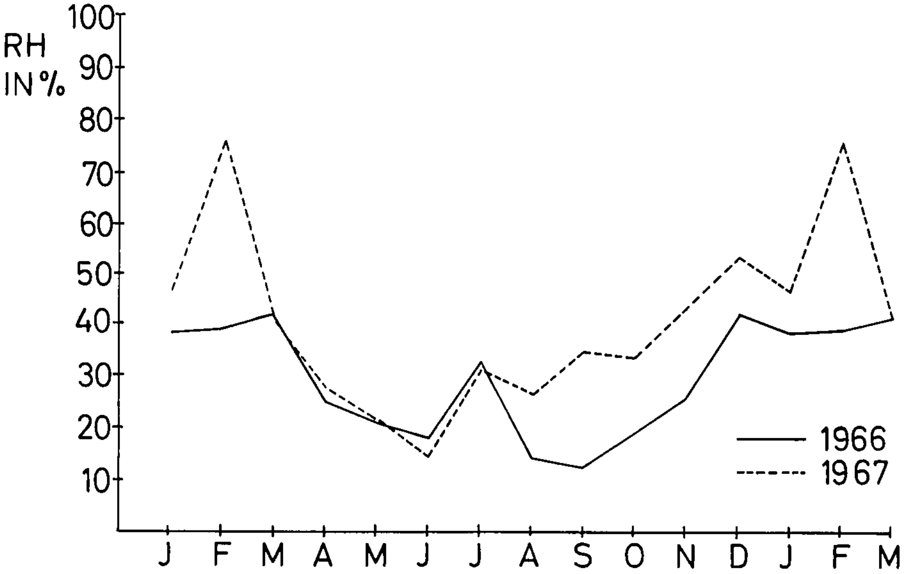

Fig. 6: Relative humidity at site S.

In Fig. 6 the R. H. at site S is given graphically for 1966 and 1967. The vertical axis gives the R.H., and the horizontal axis gives the months of the year.

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THE DOMES FOR THE PHOTOMETRIC, SPECTROGRAPHIC AND SCHMIDT TELESCOPES ON LA SILLA

W. Bauersachs

While these domes were being designed, an expert on rationalization matters asked me if they were really necessary, and it is said that there are astronomers who ask the same question, although for other reasons. Is the fact that domes have been built for a long time and will probably continue to be built really an answer? The decision lies with the telescope designer — and the finance committee. The rationalization expert yielded after a half-hour's discussion and withdrew his objections. The engineers who have been given the order do not ask why it should be built, but rather how it can best be built.

The outlines of the steel structures above the concrete buildings are now beginning to assume form at La Silla. The 13 m dome for the spectrographic instrument is almost completed, the structural steelwork of the 10 m dome for the photometric telescope is finished, while the ring girder and the elements of the spherical shell of the 14 m dome for the Schmidt telescope are now being welded. It has taken almost two years to reach this stage, and in that time the question "how best?" has often been posed.

Perhaps the following description will give some idea of the interplay between the wishes of the not always unanimous astronomers on the one hand, and the resourcefulness of the engineer who has to keep within his estimate on the other.

The static concept

For a dome, it can be taken almost for granted that the shell be employed as the supporting structure, especially if it is to be made of steel. Even with modern domes, however, resort has been made to a system of arched trusses and lattice ring purlins, no doubt in order to save weight. Unfortunately, I cannot provide exact comparisons, for costs are an important factor and these are seldom revealed.

The domes at La Silla are spherical shells consisting of 6-mm-thick pressed steel plate. Unfortunately, the wide observation slit with the large zenith opening cuts through this elegant supporting system, so that a pair of arched girders are required to stiffen the edges. The lower horizontal dome rim likewise needs a stiffening girder to transmit the horizontal forces.

The external loadings are very substantial, because in addition to the vertical deadweight the Chilean building regulations require allowance to be made for a horizontal seismic shock of 0.3 times the deadweight, while the exposed location of the buildings means that a maximum wind velocity of about 200 km/hour had

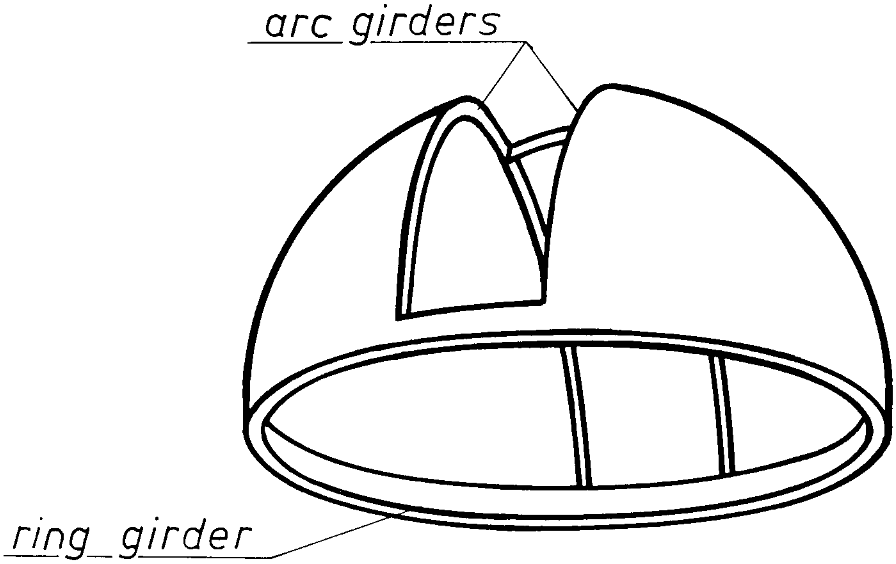

Fig. 1: Static system of dome.

to be assumed. Since the domes (with shutters closed in stormy weather) present a very favourable exposed area, however, the maximum wind load can be disregarded in as much as it does not coincide with the maximum seismic load.

Calculation of the stresses in the so easily described static system is a tedious process if the interaction of all the structural elements is to be considered. But even if only the major components are considered in the differential equations, the solution to the rim problem at the edges of the observation slit presents a number of difficulties. Fortunately, however, a relatively rough calculation for a statically simpler but less favourable substitute system showed that the plate thickness at the edges of the slit should be 2 to 3 mm. Such thin shells of the required size cannot be pressed in our workshops. The lower limit is about 6 mm, so that a more exact strength calculation was unnecessary.

Now a few words about the elastic buckling of the shell; here also we must depend on relatively rough approximations which give mathematical certainty against buckling, but are nevertheless purely theoretical because the finished shell can deviate from the truly spherical shape by an amount equal to several times the plate thickness. In the case of the three small domes for La Silla, therefore, rough calculations are enough in view of the more than adequate plate thickness.

In the case of the dome for the 3.6 m telescope, however, more precise calculations will be required, for at a diameter of 30 metres each unnecessary millimetre of plate thickness means about 12 tons extra weight.

The rotation system

The domes must rotate with the minimum of noise and vibration says the astronomer. Why do the cars on Route 1 of the Paris Metro run so silently? The Michelin people would be glad to tell us, but their pneumatic tyres for subway cars do not have sufficient carrying capacity for our purpose. There are also very quiet-running tramcars, thanks to individual rubber shock absorbers between the wheel hubs and their steel tyres. But their 5-ton carrying capacity is not enough for us, and a special design would be too costly. Eventually we found a firm willing to help in designing a wheel of 600 mm diameter to carry 10 tons — with a steel tread to withstand the high contact pressure between rail and wheel

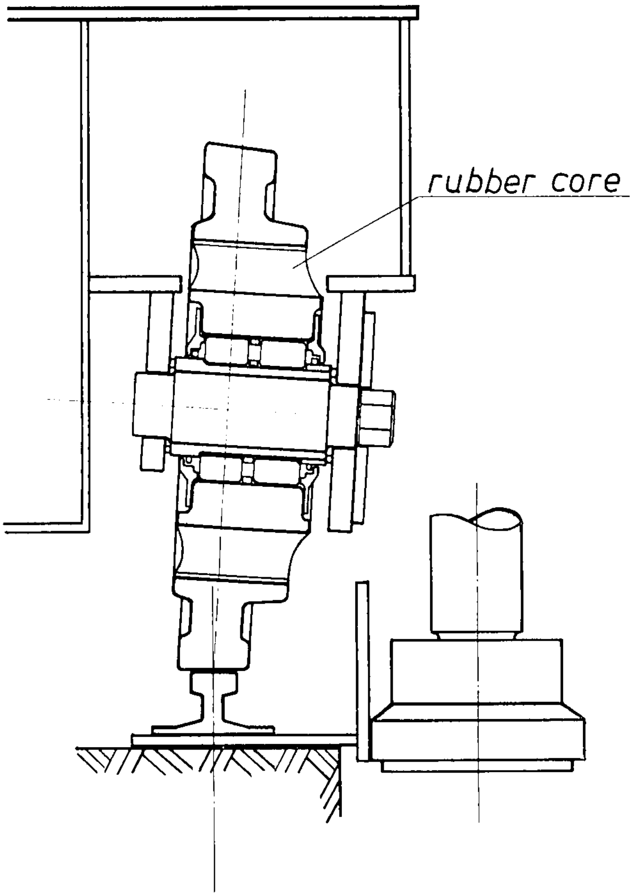

Fig. 2: Elastic wheel.

and an intermediate rubber element for elasticity and quiet running. It must have a bevelled tread and a sloping wheel axis, for the running surface of the rail must be truly horizontal. This is needed to prevent the dome from lifting as a result of horizontal displacement caused by temperature variations or wind pressure, which would result from a bevelled rail and which would also cause very irregular wheel loading.

This was the final approach to the problem. We had previously sought other answers, particularly at a stage when an extremely low wheel system seemed necessary. This will be explained later in the section dealing with the windscreens. We investigated many small wheels made entirely of flexible plastics, and also large axial ball bearings for 10 to 13 metres diameter depending on the particular dome. These bearings would have yielded two advantages, viz., simultaneous vertical and horizontal load carrying, and an airtight connection between the rotating dome and the concrete substructure. On the other hand, they produce disturbing noises — a fact which weighs heavily against them — and they are very costly. It's a pity, because it meant that we had to seek another way of sealing the gap at the lower edge of the dome and of transmitting the horizontal loads. The widely used slewing rim was rejected for several reasons; horizontal rollers are better, but we require twice as many of them than of large wheels. They run on a special rail which also serves to engage the rotation gear.

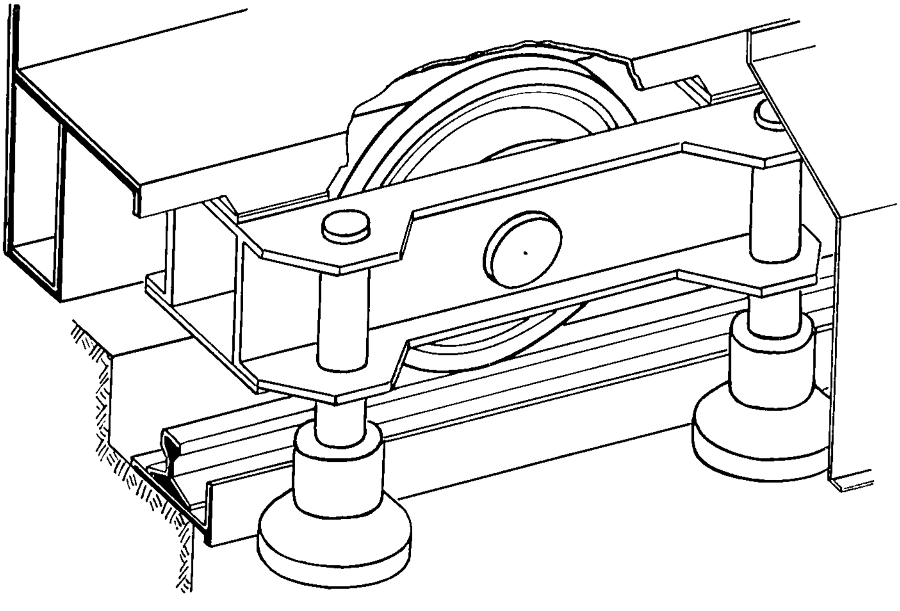

Fig. 3: Bearing and guiding wheels.

These horizontal rollers have no elastic suspension. They are so arranged that, depending on the position of the horizontal and guide forces, only two or three pairs of adjacent rollers are in contact with the rail. A horizontal play of about 10 mm for the dome is permissible.

All the wheels are fixed to the rotating dome, while the rails are anchored in the concrete substructure. Other designers have done it just the other way round, but our view was that the rails can be much more exactly adjusted in the concrete than on the welded steel ring girder. We allow a maximum deviation of only 1 mm from the theoretical elevation. The rubber tread of the wheels has an elastic range of 8 mm, but the smaller the deviation the quieter the system will run.

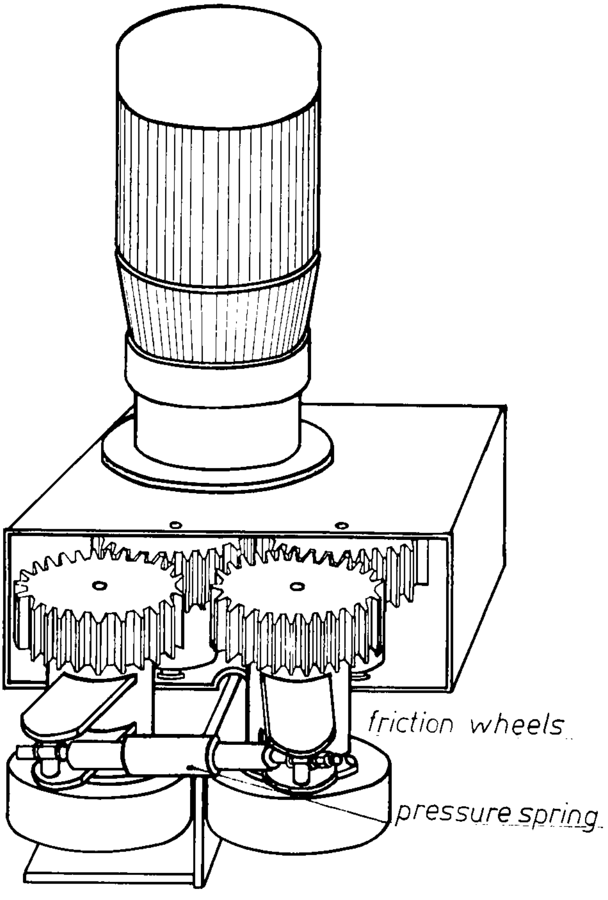

Fig. 4: Rotation drive.

The rotation drive is fully independent of the running wheels. Two diametrically opposed drive units engage with two horizontal friction wheels each on the same rail as the horizontal guide rollers. An adjustable spring system provides the necessary contact pressure for each friction-wheel pair, the advantage being that the friction wheels can be smaller and only the tangential drive force acts on the dome, while the radial contact forces balance each other. The drives rotate together with the dome. It would have been better to have them stationary and let the friction rail move, but it proved impossible to mount the latter on the ring girder in as much as the windscreen housing precludes the girder being circular.

The shutter

The conventional arrangement was followed, with two quadrant-shaped shutters on horizontal runways above and below providing the best solution. Less conventional is the hydraulic drive, which is really a stand-by facility, although a good one. It was specified that the shutters be capable of being driven top and bottom so that they can be moved in the event of icing up. Under normal circumstances no force is necessary — it requires only one man pushing from below. Two drives, however, need synchronization. If a mechanical shaft were used, this would have required not only the cardan links along the arch girder but also quite a large number of bevel gears — again owing to the windscreen housing. In addition to that, the many high-speed gear elements and cardan-shafts would have been very noisy. The electric shaft, on the other hand, was too costly as this would also have involved a synchronizing check facility. The only alternative, therefore, was to use hydraulics. Small oil pipes can be neatly led in and out, and the only sound is the gentle hum of the oil pump. Nor does synchronization pose a problem; we simply arranged the top and bottom cylinders in series and carried the piston rods straight through to ensure equal liquid flows. The oil which is forced out of the lower cylinder operates the upper cylinder and vice versa. Since leakage losses at the control valves are unavoidable, an auxiliary circuit is provided to parallel the cylinders at the end of the closing stroke and thus to compensate small relative piston displacements. This also ensures that the two shutter halves close well and press firmly against each other, for the closure is required to be both air-tight and dust-tight. This, of course, necessitates flexible seals, and these are made of neoprene on account of its superior weathering resistance. For the contact seals on the long curved rims we chose the "music note" section which has been used so successfully in hydraulics engineering, while flat sections were chosen for the short sliding seals on the upper and lower horizontal edges.

The windscreen system

No other detail has given us so much trouble. Indeed, it is scarcely believable that these windscreens could affect the design of almost every other component in some way.

The astronomers laid down the following requirements: first, the observation slit shall close from above and below so that only a square opening remains, and this to be capable of being shifted to any position between horizon and zenith; second, it shall be possible to have the whole slit open, i. e., to let the windscreen parts disappear completely; third, effective protection shall be provided against winds of up to 60 km/hour, with no fluttering or flapping of the screens.

Our answer was to provide two roller-blind systems between the arch girders and running within curved guide rails. One of the blinds closes the slit from below, and rolls up on a drum fitted in the ring girder below the slit. This drum magazine was the big problem; it had to be large enough to accommodate the whole lower blind, extending from the lower edge of the slit to the zenith opening position, but must not project beyond the ring girder into the observation slit since that would hinder observation of an object near the horizon. Space is restricted at the bottom by the concrete floor, the position of which is determined by the relatively small angle of the polar axis of the instruments. The available headroom at the spectrographic instrument is only about 600 mm, in which the following parts must be accommodated: rail and wheels for dome rotation (height 700 mm), ring girder as main support (height 600 mm), contact lines for power supply (height 400 mm) and the drum magazine itself (height 600 mm). How to achieve this? Extremely low rotation system? A shallower ring girder? By a minimum-sized magazine? By restricting the field of observation?

We settled for a compromise: ring girder and magazine box were arranged integral, which meant loss of the circular form with the box forming a chord; the wheels were placed inside next to the ring girder and moved laterally away from the vicinity of the observation slit; the parts which must be truly circular — contact lines, horizontal guide rail and friction-wheel rail — were accommodated in the fixed part on the concrete walls. The lowest observation position of the telescope with full mirror aperture had to be limited to 5 degrees above the horizon.

But to return to the windscreens. The need for a small magazine implied a roller, and the wind load required a rigid supporting element — hence the roller blind. The difficulty is that roller blinds are usually suspended vertically and not — as in our case — horizontally in the crown of the dome. The problem was overcome, however, when we found a sufficiently rigid aluminium section which was also narrow enough to let the drum magazine fit into the restricted space.

The other part of the roller blind, which closes the slit from above, caused much less difficulty. When retracted, most of it can remain in the part of the dome opposite the slit, with only a small portion having to be wound up over the ring girder.

Each of the two parts of the system has its own drive, consisting of the drive motor arranged opposite the slit and the spring motor at the lower edge. The drive motor controls direction of motion and speed, while the spring motor ensures that the blind is held taut and cannot rattle in the wind. The two parts can be operated singly or together. In the latter case, a preset observation opening will be slid either up or down. Unfortunately, the different coil diameters result in a slight but unavoidable change in the height of the opening when it is moved.

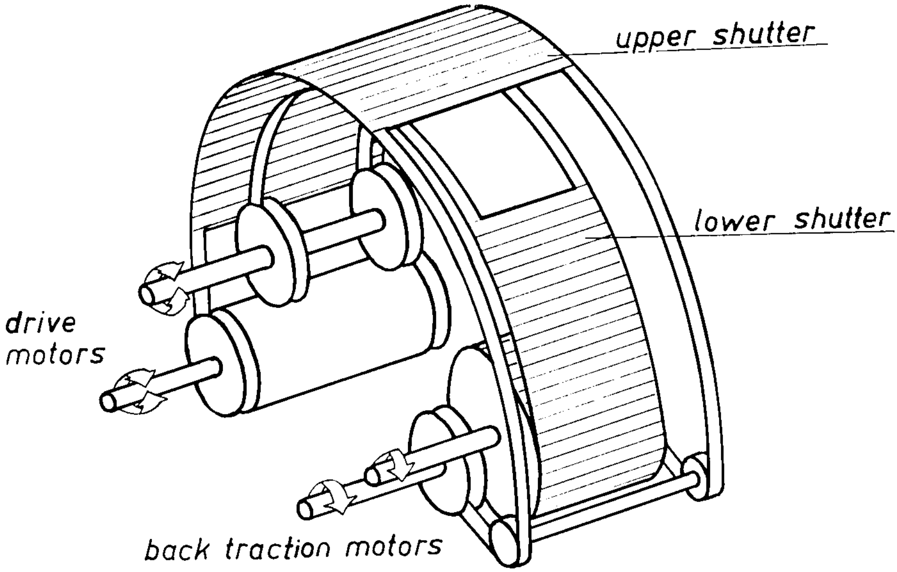

Fig. 5: Windscreen system.

It might be asked here whether it would not be advantageous to combine the two closures of the observation slit, i. e., the shutters and the windscreens, in a single system in which the magazine box could be eliminated. The new dome of the Haute Provence Observatory has such a system, although it would not satisfy every requirement in our particular case. For the dome of the 3.6 m ESO telescope a similar solution should be sought.

The thermal insulation

The arrangement and type of insulation was the subject of much thought, but space here does not permit detailed discussion of the considerations involved. I shall therefore limit myself to a description of what was finally chosen.

The outer skin of the dome consists of 6 mm plate painted pure white with titanium dioxide as pigment to reflect as much as possible of the solar radiation. In spite of this, the daytime plate temperature will exceed that of the outdoor air. A certain internal cooling effect is obtained by means of an air gap of 150 mm into which outdoor air penetrates at the lower edge of the dome and from which it escapes near the crown. We expect this to produce an adequate natural air flow, but if it proves insufficient a number of fans can be fitted to the outlets at the top. On the inside of the air gap is the actual insulating layer consisting of rigid

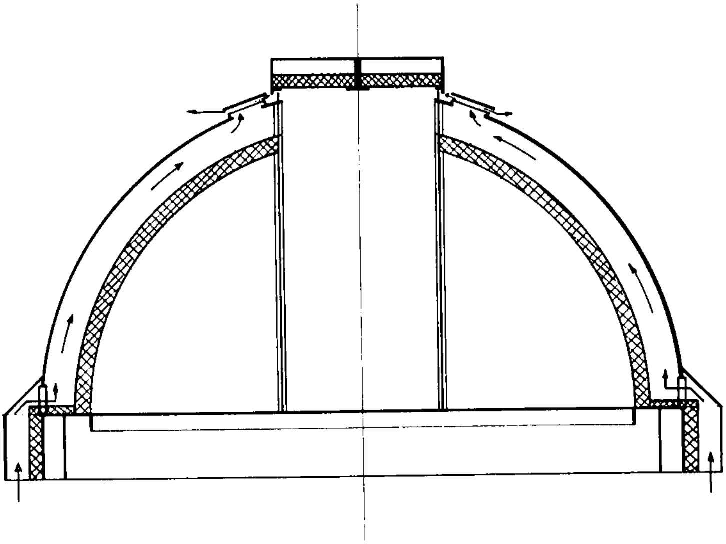

Fig. 6: Thermic isolation.

styrene foam panels 80 mm thick coated on the gap side with aluminium sheeting. This both provides additional protection against radiant heat and protects the styrene panels against condensation. All joints between the panels are, of course, carefully bonded and sealed. For attachment of the insulation, an assembly structure is used the steel parts of which are treated to inhibit corrosion by condensation. The finished insulation is — like the outer skin of the dome — self-supporting and no longer requires this support structure. Unlike the outer skin, however, the insulating panels are flat and trapezoidal in shape, so that the dome seen from inside appears to consist of innumerable facets. The visible surface will receive a glass-fabric-reinforced plastic plaster coated with latex paint to give a smooth, waterproof surface.

The pneumatic seal

In discussing the shutter it was mentioned that the closure should be both air- and dust-tight. Between the dome and the concrete base there is another gap which must be sealed, at least when the dome is stationary. The simplest method would be to fit a circumferential sliding seal of flat rubber. It was doubted, however, if this would give good closure all round, especially since it would be fitted in a place where it would be difficult to check its effectiveness. Another demerit of such a rubber seal is that it would offer frictional resistance when the dome is rotated and would therefore be subject to wear. The next idea was a circular trough filled with a suitable liquid in which a short skirting plate on the dome would be immersed. This would ensure perfect closure, permit full freedom of movement both horizontally and vertically, and produce no friction. The snag was to find this "suitable" liquid — one that would neither freeze nor evaporate, that would not leave a greasy film on everything it touched and would not produce harmful vapours. Not surprisingly, we did not find it.

The method finally chosen was to fit a circular hose which can be pumped up with compressed air when sealing is required. The type which we eventually adopted had been used in shipbuilding to seal hatch covers. Similar pneumatic closures are used for aircraft cabin doors, but for our requirements these are both too lightly designed and too costly.

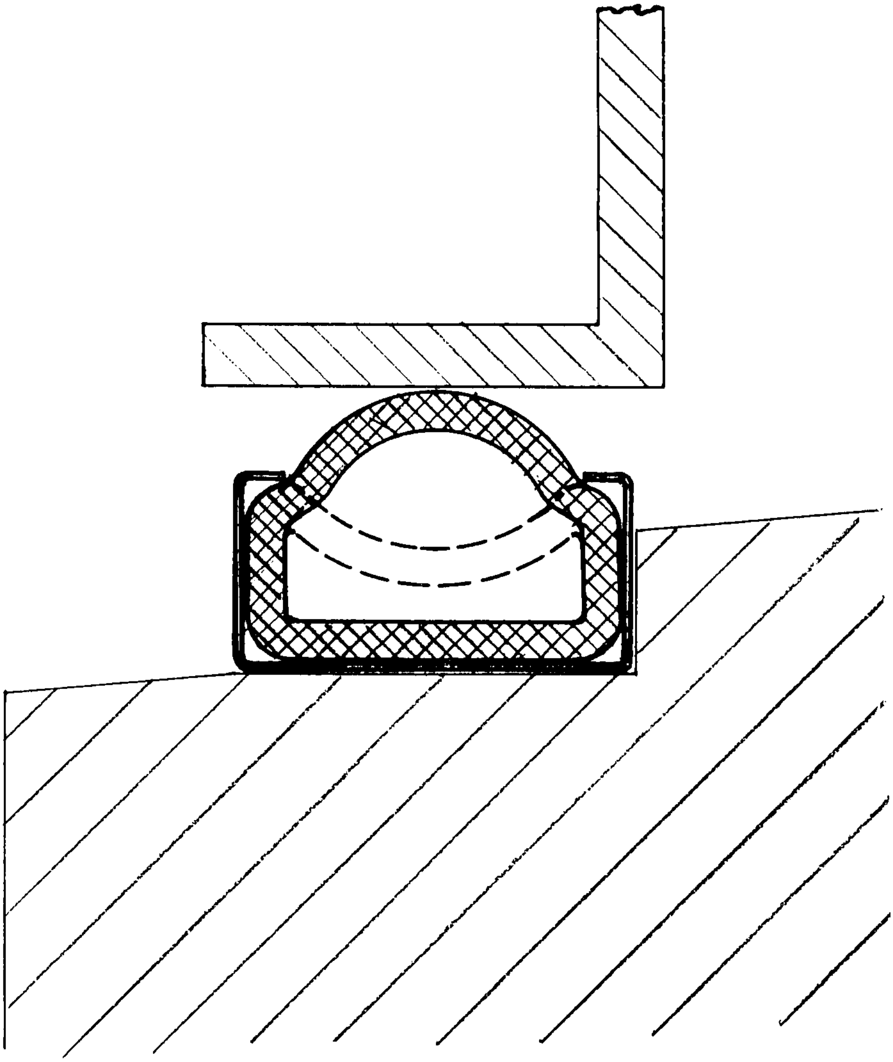

Fig. 7: Pneumatic seal.

The manufacturer advised us that the hose would have to be inserted in a sort of felloe which would enclose it firmly on three sides to prevent its floating up and out as a result of alternate filling and emptying. It would have been simpler, and better for the hose, to arrange the felloe similar to that of a car wheel and employ a curved form, but the need to permit horizontal movement of the dome precluded this arrangement since there is a difference of only 12 mm between the filled and empty hose profiles. Vertical guiding of the dome is much more exact, so we gave the felloe a flat bottom and provided small shoulders to prevent its riding out. With this method we also avoid the necessity of giving either the hose or the dome contact surface a truly circular form.

The hose will be inflated by a small air-compressor which can also be used to evacuate it in the event of icing. Electric safety switches ensure that the dome cannot be rotated as long as the hose is under pressure. Even if these failed to function, however, there would be no mishap for the friction would be so great that the rotation drive would simply slip harmlessly.

The power supply and electric controls

With a single exception — the compressor unit for the pneumatic seal — the drive motors for the various mechanical functions are all mounted in the moving part of the dome. This means that almost all control pulses and the power supply must be transmitted from the fixed to the moving part via contact lines. This was necessitated by the clause in the specification which stated that the dome should be able to be turned as often as desired without interference from cable loops or other power supply elements which might restrict free movement. In the limited space, however, we could accommodate only thirteen contact lines in spite of our having devised a system which needs a distance of only 32 mm between line centres. Four lines are used to transmit the power supply (360 V, 3 phase, 50 cps), and the remaining nine are insufficient to supply the control current and to transmit the ten necessary control commands (42 V, A.C.). A way out of the difficulty was found by providing direct control only for the functions which the astronomer requires during his observations, namely rotation of the dome and combined movement of the two windscreens. In the case of the spectrographic telescope there is also a large fan system to be operated in order to reduce turbulence in the dome slit. The other functions, such as opening and closing of the slit and individual operation of the windscreens, can be arranged in sequence with the aid of a step-by-step switch to transmit the appropriate control pulse on only two lines.

The problem could, of course, have been solved by other methods — by frequency modulation or by short-wave transmission to mention only two — but the arrangement described appeared to us to be the simplest and the least expensive.

Three-phase motors are used throughout, most of them with squirrel-cage rotors. The exceptions are the rotation drive motors and the spring motors for the roller blinds, these being capable of torque variation by connecting additional resistances into the rotor circuit. Where speed reduction is necessary we use ordinary geared-motor units.

All switch and control gear is accommodated in two cabinets, one in the dome and the other in the stationary part of the observation room. Between these are the contact lines secured to the concrete wall, while the current collectors rotate with the dome. All dome-operating functions can be controlled from the stationary cabinet, which is fitted with switches, pushbuttons and pilot lamps, etc. The astronomer, however, will not be obliged to operate the dome from this point; provision has been made for remote control from the main console on the telescope to which are linked small portable control panels close to the observing astronomer which enable him to rotate the dome and to move the windscreens jointly.

The three domes for the photometric, spectrographic and Schmidt telescopes are of basically the same design; only the dimensions vary. Certain parts, such as the running wheels, are identical. This is of advantage both with respect to design and construction work and also for operation and maintenance.

It has not been my aim here to give a full and detailed description of these domes, but rather to convey a general impression to the interested reader. Comprehensive descriptions of the domes of modern observatories are seldom found because astronomer authors are far more concerned with their telescope than with the dome. Only a few sketchy descriptions of modern domes in the U.S.A. could be found when we were making our planning studies for La Silla. Much more instructive were our visits of inspection to the new domes of the observatories in Hamburg and Haute Provence which the Management of ESO was kind enough to arrange for us. Unfortunately, we have not yet been able to visit the still more recent structures at Tautenburg near Jena and Ondřejov near Prague.

Many of the findings and conclusions arrived at in discussion with the senior technical experts of ESO will certainly be of assistance in the design work for the 30 m diameter dome for the 3.6 m ESO telescope. It must be borne in mind, however, that the site is far from any of the larger towns so that it will not be possible to get workmen there at short notice to do small specialist jobs. For our domes it was a general principle that they should be capable of being erected by a small qualified team. A report on the erection work will follow at a later date.

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