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THE JOINT ORGANIZATION FOR SOLAR OBSERVATIONS (JOSO) AND THE LARGE EARTH-BASED SOLAR TELESCOPE (LEST) FOUNDATION.

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RIASSUNTO. I progetti JOSO e LEST costituiscono le più ambiziose imprese in corso di realizzazione nel campo dell'osservazione solare ottica da terra.

Dopo aver rapidamente accennato alle metodologie che hanno permesso di individuare, nell'ambito del progetto JOSO, siti *ideali* per l'osservazione solare ottica da terra, vengono descritte le caratteristiche, le potenzialità ed i limiti della strumentazione solare ottica che si sta concentrando, sempre nell'ambito del progetto JOSO, nelle Isole Canarie.

Vengono inoltre descritte le finalità della Fondazione LEST e le caratteristiche del grande telescopio solare che costituirà per gli anni novanta e per i primi decenni del prossimo millennio lo strumento più importante per lo studio del Sole.

1 INTRODUCTION

During the XIII General Assembly of the International Astronomical Union (Praha, 1967) discussions started between European astronomers on the possibility of establishing a modern optical solar observatory with advanced instrumentation in a site specially selected for high resolution observations of the solar atmospheric structures with good continuity.

After several meetings between interested astronomers and surveying inspection visits to various prospective sites, the Joint Organization for Solar Observations (JOSO) was founded during a meeting in Catania in December 1969.

The JOSO *statement of intentions* was issued in June 1970 and signed for

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France by R. Michard and J. Rosch, for Germany (F.R.G.) by K.O. Kiepenheuer and E.H. Schroeter, for Italy by G. Godoli and G. Righini, for Netherlands by C. de Jager, for Norvey by P. Maltby, for Sweden by J.O. Stenflo and for Switzerland by M. Waldmeier.

The programme of JOSO involved three main phases:

1st search for an *ideal* observatory site with systematic and coordinated investigations of the meteorological and astronomical properties of a great number of possible sites;

2nd installation of medium sized instruments at the chosen site: these instruments could be already existing or new solar telescopes and could be international or national telescopes which would be put at the disposal of JOSO;

3rd construction of the LEST (at this time the acronym LEST standed for Large European Solar Telescope), an instrument for visible and near infrared solar astronomy that should surpass the best instruments yet existing elsewhere.

At present Austria, Belgium, Greece, Ireland (as an observer), Israel and Spain have also joined JOSO.

TABLE 1/1 - The JOSO Board meetings

Meeting N.o	Place	Date
1	Catania, Italy	December 1969
2	Utrecht, Holland	April 1970
3	Paris, France	November 1970
4	Lagos, Portugal	March 1971
5	London, U.K.	January 1972
6	Firenze, Italy	January 1973
7	Berne, Switzerland	March 1974
8	Firenze, Italy	February 1975
9	Paris, France	June 1976
10	La Laguna, Tenerife, Spain	October 1977
11	La Laguna, Tenerife, Spain	November 1978
12	Firenze, Italy	March 1980
13	Villach, Austria	October 1981
14	Paris-Meudon, France	December 1982
15	Zuerich, Switzerland	January 1984
16	Freiburg, F.R.G.	December 1984
17	La Laguna, Tenerife, Spain	January 1986

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JOSO is governed by a Board. France, Germany and Italy have two members on the Board; the other countries one member. Alternate members assure the presence of the various countries to the Board meetings and decisions. The Board meets generally once a year. The Boards meetings (see Table 1/1) have always been milestone for the progress of optical Solar Physics in Europe. The Board has formed ad hoc Working Groups to solve specific problems.

JOSO activities are reviewed in Annual Reports published since 1970 and in series of internal Reports.

2 THE FIRST PHASE OF JOSO: THE SITE TESTING CAMPAIGN

The purpose of the first phase of JOSO, carried out during the period 1969-1979, was the search for an *ideal* observatory site. This mean a site in which solar seeing allows a spatial resolution of the order of 0.1 arcsec for long periods of time during the whole year. The average annual amount of sunshine hours is not the main parameter but an amount greater than 2500 hours is expected.

The results of the JOSO site testing campaign have been recently thorougly reviewed by Brandt and Righini (1985a, 1985b). In the first of these papers relationships between solar seeing and atmospheric physics are also deeply investigated.

We remind the reader here that the term seeing includes *blurring, image motion* and *scintillation*: all these effects are produced by fluctuations of the air index of refraction. In the optical range these fluctuations are mainly due to the microthermal inhomogeneities of the atmosphere. The major contribution to solar seeing generally comes from convection due to ground heating during the day.

At the beginning of the JOSO site testing campaign efforts were directed to eliminate the convection at the ground, following the sea-breeze concept. According to this concept, in sea level sites on the coast, with prevailing winds from the sea, homogeneous airmasses may be transported inland from the sea and bring good seeing conditions. Many sea level sites on the coast in Sicily, Greece, Spain, North Africa have been explored. Already during these first explorations, sites were found with excellent seeing conditions extending several times over periods of more than an hour. The best angular resolution obtained was about 0.25 arcsec.

One of the main results at this stage of the JOSO site testing campaign was the understanding that, also in conditions of prevailing winds from the sea, counter sea breezes, produced during the day at intermediate heights by heated land, can transport inhomogeneous air masses on the line of sight bringing bad seeing conditions.

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Attention was therefore shifted to well detached islands small and flat enough not to produce a thermal wind system of its own or to atlantic coasts of Europe where the impinging on oceanic maritime airmasses prevented the formation of a counter sea breeze.

Finally, island sites situated in the middle of large oceanic bodies of water under predominantly high pressure atmospheric regions, at altitudes above the cloud inversion layer, were considered.

Following these lines of thought more than 40 sites have been inspected during the JOSO site testing campaign executing basic meteorological observations, microthermal observations with sensors on masts or airplanes or balloon, telescopic optical or photoelectric observations.

At the end of this site testing campaign, described as the most extensive ever made, two sites on the Canary Islands have been chosen: Izaña, in Tenerife at an altitude of 2392 m, and Roque de Los Muchachos, in La Palma at an altitude of 2426 m.

A comparison between the two sites seems to indicate that Izaña may be considered a superior site since Roque de Los Muchachos may suffer, during the day, from the influence of the nearby caldera. However Roque de Los Muchachos appears also to be an outstanding site.

3 THE SECOND PHASE OF JOSO: THE INSTALLATION OF MEDIUM SIZED INSTRUMENTS

The second phase of JOSO is realized through bilateral treaties between Spain and the countries which are setting up instruments at the selected sites. The first Agreements with Spain were signed on May 1979 by Sweden, Denmark and the U.K.. This agreement also includes the plans for a Northern Hemisphere Observatory (NHO) for night-time observations. On April 1983, the Federal Republic of Germany also, formally adhered to the agreement.

According to these treaties Spain authorizes scientific institutions of those countries which have signed the Agreement to place their telescopes at the Izaña (Tenerife) and at the Roque de Los Muchachos (La Palma) sites. Spain agrees to provide general services: in return Spain shall have at its disposal at least 20% of the observing time, of each of the telescopes and instruments installed in the observatories, free of change (Sanchez, 1985).

In the next two years the second phase of JOSO will be over. Table 3/1 summarizes the main characteristics of the instruments in operation or under construction.

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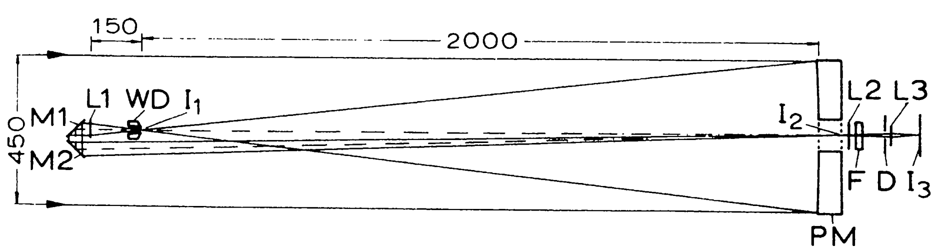
TABLE 3/1 - The JOSO second phase. Instruments in operation or under construction.

Diameter (cm)	Description	Country	Site	Operated from	Referen. No.
25	Heliographic	Spain	Tenerife	1969	3.6
40	Vacuun Newton Telescope	F.R.G. and Spain	Tenerife	1972	3.6
50	Vertical Vacuum Refractor	Sweden	La Palma	1985	3.9
45	Vacuum Gregory Telescope	F.R.G.	Tenerife	1986	3.4
60	Vacuum Tower Telescope	F.R.G.	Tenerife	1987	3.5
45	Open Telescope	Holland	La Palma	under construct.	3.1
90	Polarization free Vacuum Telescope	France	Tenerife	under construct.	3.2
	Solar Laboratory	Spain	Tenerife	under construct.	3.8

3.1 The Dutch 45 cm Open Telescope (OP).

A peculiar telescope is under construction at Utrecht (Hammerschlag and Zwaan, 1976).

The optical configuration is shown in fig. 3.1/1. The diaphgram in the prime forms is cooled by water and air suction.



PM	=	primary mirror	F	=	location for filter, etc.
WD	=	cooled diaphragm	D	=	diaphragm against the sky light, L2 forms an image of L1 in the plane of D
L1	=	(objective) lens	I_1	=	primary image
L2	=	field lens	I_2	=	image near field lens
L3	=	(ocular) lens	I_3	=	final image
M1 M2	=	flat mirrors			

Fig. 3.1/1 - The optical scheme of the Dutch Open Telescope.

The mechanical structure of the telescope and tower is very open and light, yet sufficiently stiff against wind forces. The telescope operates in open air without a protecting dome. This kind of design minimizes the heating of the air and consequently the image degradation in the neighbourhood of the telescope.

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Tower and telescope are bolted together from smaller parts which can be transported by truck (the heaviest parts weigh only 800 kg). Consequently the instrument can be moved from one site to another. Minor modifications in the telescope mount allow operation at various geographic latitudes. This instrument could therefore be used also for further site assessment aimed to find the best location for LEST (see N.o 5) (Zwaan, 1980).

3.2 The French 90 cm polarization-free Vacuum Telescope (THEMIS).

French astronomers have under construction an instrument called THEMIS (Télescope Héliographique pour l'Etude du Magnétisme et des Instabilités Solaires) designed to understand the nature of the solar magnetic fields.

The design fulfils the following requirements (Rayrole, 1983):

a) high spatial resolution in horizontal directions;
b) sufficient resolution in height (obtained with observations in several spectral lines with a sufficient spectral resolution);
c) separation of the effects of thermo-dynamical and velocity parameters from magnetic effects (again obtained with observations in several spectral lines);
d) accurate polarization measurements;
e) adequate time coverage to follow the evolution of individual structures;
f) precise tracking and scanning mechanisms;
g) sufficient field of view to observe the behaviour of different structures.

THEMIS is a 90 cm evacuated Ritchey-Chrétien telescope with an azimuthal mount (Rayrole, 1983; Mein and Rayrole, 1985). The equivalent focal length is 15 m. The polarization analyser is put at the prime focus. Between the polarization analyser and the spectral analyser many exchangeable optics can be placed: a field enlarger, a rotator, an active mirror which compensates fast image motions. Two dimensional spectroscopy can be achieved by an analysis perpendicular to the spectrograph dispersion.

The spectrograph includes a long predisperser (7.5 m) and an echelle spectrograph (8.5 m) which provides high dispersion spectra (5 mm/A).

3.3 The French Multichannel Subtractive Double Pass (MSDP) device for the German Vacuum Tower Telescope.

The 60 cm German Vacuum Tower Telescope (VTT) (see N.o 3.5) will include, as a basic equipment, a MSDP device for bidimensional spectroscopy (Mein, 1977) built at the Paris-Meudon Observatory as a result of a cooperation initiated in 1975 with J.P. Mehltretter and continued with the staff of the Kiepenheuer Institut (Mein, 1984).

The two MSDP devices at present in operation at the Meudon Solar Tower and Pic du Midi Turret Dome can observe only one spectral line at a time while the MSDP fitted to the VTT will observe two lines simultaneously with 9 or 11 channels for each one. Other pairs of lines can be observed by fast automatic shifts of the optics. The field of view can be increased up to 4'x4'.

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3.4 The German 45 cm Vacuum Gregory Telescope (VGT).

The use of a Gregory type telescope for solar observations is based on an idea by ten Bruggencate who underlined the disadvantage of a Cassegrain system in which the secondary mirror is illuminated by light originating from the whole solar disk. Only a small part of the solar disc is actually observed (Schroeter et al. 1985).

The first evacuated solar Gregory-Coudé telescope had been mounted in 1959 at the Locarno (Switzerland) solar station of the Gottingen Observatory and was successfully operated from Summer 1962 through July 1984. In August 1984 this instrument was dismounted and transported to Gottinga for modifications suitable to the latitude of the Tenerife site.

The Vacuum Gregory Telescope has a parabolic main mirror with diameter of 45 cm and focal length of 250 cm. The solar image is formed on a water-cooled copper disc. A small hole (0.25 cm in diameter) selects 1/10 of the solar diameter for further enlargement by the elliptical secondary mirror (Gregory) that enlarges this part of the solar disc by a factor of 10, thus yielding an effective focal length of 2500 cm. Two flat mirrors deflect the light into the declination axis and then into the hour axis on which the spectrograph entrance is aligned (fig. 3.4/1).

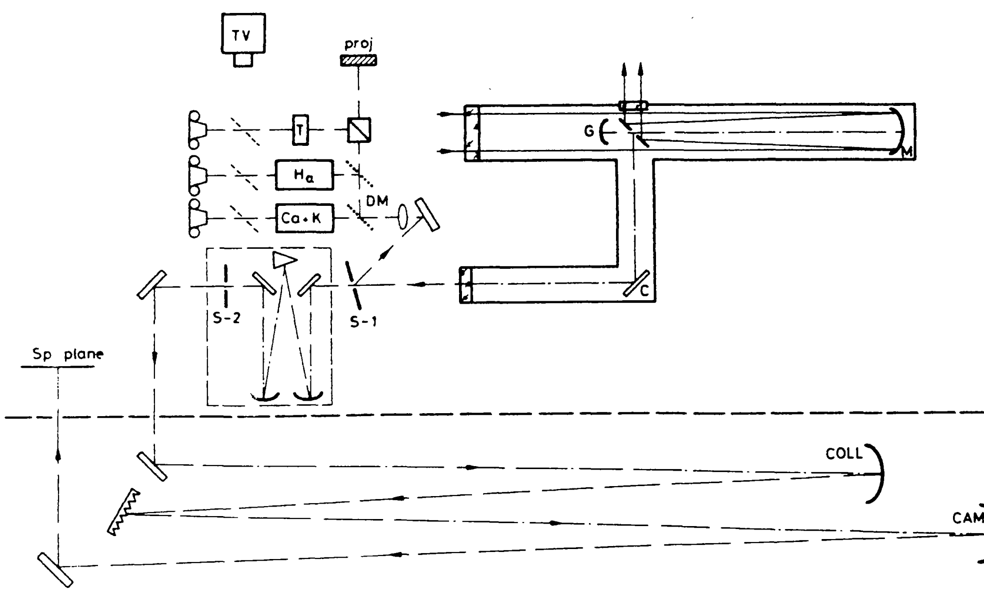

Fig. 3.4/1 - The optical scheme of the German Vacuum Gregory Coudé Telescope (by courtesy of E.N. Schroeter, D. Soltau and E. Wiehr).

The main spectrograph of the Czerny type is one floor below the observing room. The spectrograph achieves a resolving power of 10^5 with stray light of the order of 1%

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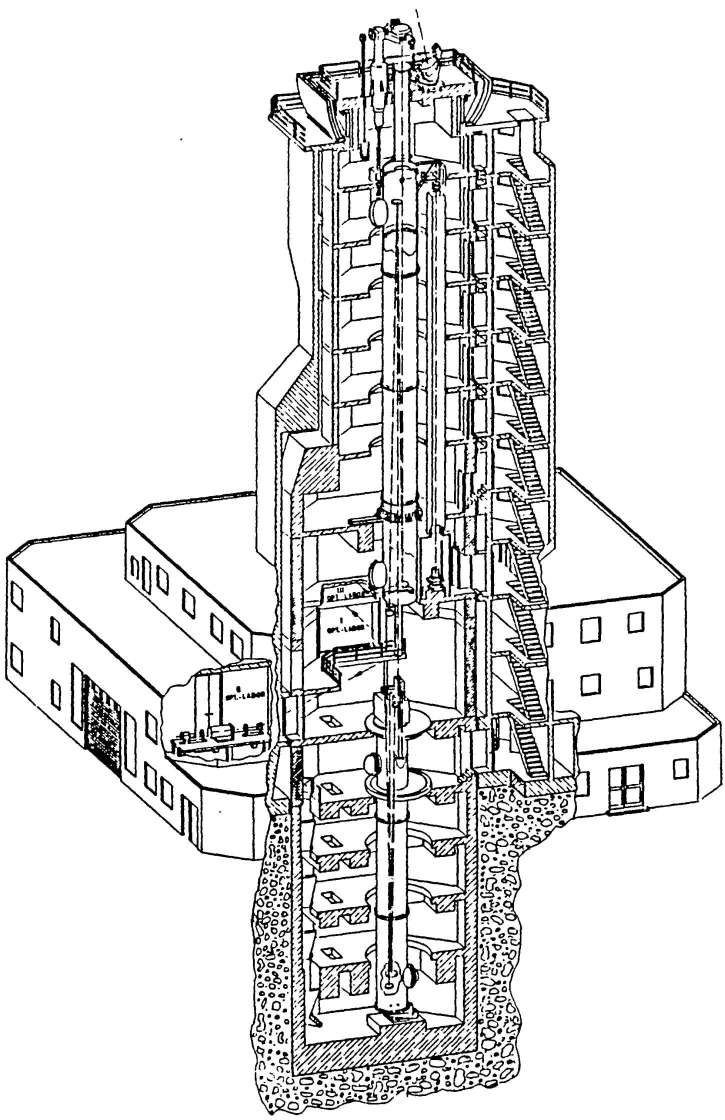

Fig. 3.5/1 - An exploded view of the German Vacuum Tower Telescope bulding as seen from East-South-East (by courtesy of E.H. Schroeter, D. Soltau and E. Wiehr).

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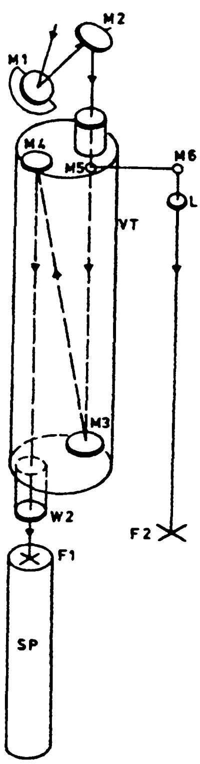
With the aid of dichroic mirrors, simultaneous observations in Ca II K, Hα and white light can be made on TV, 35 mm camera or projection screen (fig. 3.4/1).

3.5 The German 60 cm Vacuum Tower Telescope (VTT).

The Vacuum Tower Telescope was developed by the late Dr. J.P. Mehltretter since 1973 at the Fraunhofer Institut at Friburg (since 1978 named Kiepenheuer-Institut fur Sonnenphysics) (Soltau, 1984; Schroeter et al., 1985).

A classical coelostat configuration with a vertical tower telescope has been chosen (fig. 3.5/1). Fig. 3.5/2 shows the optical scheme of the system. The coelostat rests on a platform at 33.5 m above ground. The light passes two 80 cm flat Zerodur mirrors and the 75 cm entrance window of the evacuated telescope tank. Near the bottom of this tank (25 m long and 2 m wide) there is the spherical 75 cm, f/66 main mirror. The beam is folded by a flat mirror near the top of the tank and leaves the vacuum tank through a 20 cm exit window. The solar image covers 600" at a scale of 4".5/mm. The image can be focussed on the entrance slit of the vertical main spectrograph



M1,M2	Coelostat and second flat mirrors Ø 800 mm, Zerodur
W1	Entrance window Ø 750 mm, UBK 7
M3	Primary spherical mirror Ø 700 mm, f=45m Zerodur
M4	Folding flat mirror Ø 550 mm, ↓↑± 1m (focus)
W2	Exit window, Ø 200 mm
F1	Focal plane, f/75 4."6/mm, field ~14'
M5,M6	Flat mirrors, auxiliary beam for photoelect.guider
L	Guider lens f~ 20 m
F2	Guider image
VT	Vacuum tank
SP	Spectrograph

Fig. 3.5/2 - The optical scheme of the German Vacuum Tower Telescope (by courtesy of E.H. Schroeter, D. Soltau and E. Wiehr).

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designed for high spatial and spectral resolution on a wide field of view or directed by an additional plane mirror in one of three optical laboratories.

Fig. 3.5/3 shows the optical scheme of the vertical main spectrograph. A 4 m spectrograph acts as a predisperser to select the spectral region of interest which then enters the 15 m main spectrograph. The slit length can be as large as 540" to cover almost all the field of view. The whole spectrograph is mounted in a vertical tank situated beneath the telescope. It can be rotated around an axis through the middle of the entrance slit so that the orientation of the slit with respect to the solar image can be chosen according to the type of observation.

The French Multichannel Subtractive Double Pass device (see N.o 3.3) and the Italian Bidimensional Spectroscopic Unit (see N.o 3.7) will be installed in two of the three optical laboratories of the VVT.

3.6 The German-Spanish 40 cm Vacuum Newton Telescope (VNT).

The first solar instrument at the Canary Islands was the Spanish 25 cm Razdow refractor for white light and Hα heliography installed on a 13 m high tower. At present this instrument is being adapted to work in connection with the Spanish Solar Laboratory (see N.o 3.8) and the tower houses since 1972 an evacuated Newton type telescope built in the workshop of the Fraunhofer (now Kiepenheuer) Institut fur Sonnenphysik

The Vacuum Newton Telescope has a 40 cm (f/7.5) primary parabolic mirror of Zerodur, a field stop of 200 arcsec diameter near the prime focus and an achromatic lens magnifying system that brings the effective focal length to 37.5 m corresponding to a final image scale of 5.5 arcsec/mm (fig. 3.6/1). Interference filters, Hα or Ca II K Halle birifringent filters, step wedge for photographic calibration can be inserted into the beam (Brandt and Righini, 1985a).

3.7 The Italian Bidimensional Spectroscopic Unit (BSU) for the German Vacuum Tower Telescope.

The Italian contribution to the second phase of the JOSO project is a focal-plane facility for the German Vacuum Tower Telescope (VTT) (see N.o 3.5) of the Kiepenheuer-Institute (Cavallini et al., 1982).

This facility was at first intended simply as a Universal Birefringent Filter (UBF) built by the Zeiss firm but in the project development it has been transformed into a complex unit for bidimensional spectroscopy. The basic idea is to control the filter in real time with a medium-sized spectrograph which delivers to a computer, via a diode array, the pass band shape of the filter. The filter performance is completed by a K line filter and an Hα filter that allows a tuning of ± 16 A. The use of a Fabry-Perot interferometer in cascade with the UBF is planned to reach a spectral resolution higher than that supplied by the filter.

3.8 The Spanish Solar Laboratory (SL).

The Instituto de Astrofisica de Canarias (IAC) is setting up a Solar

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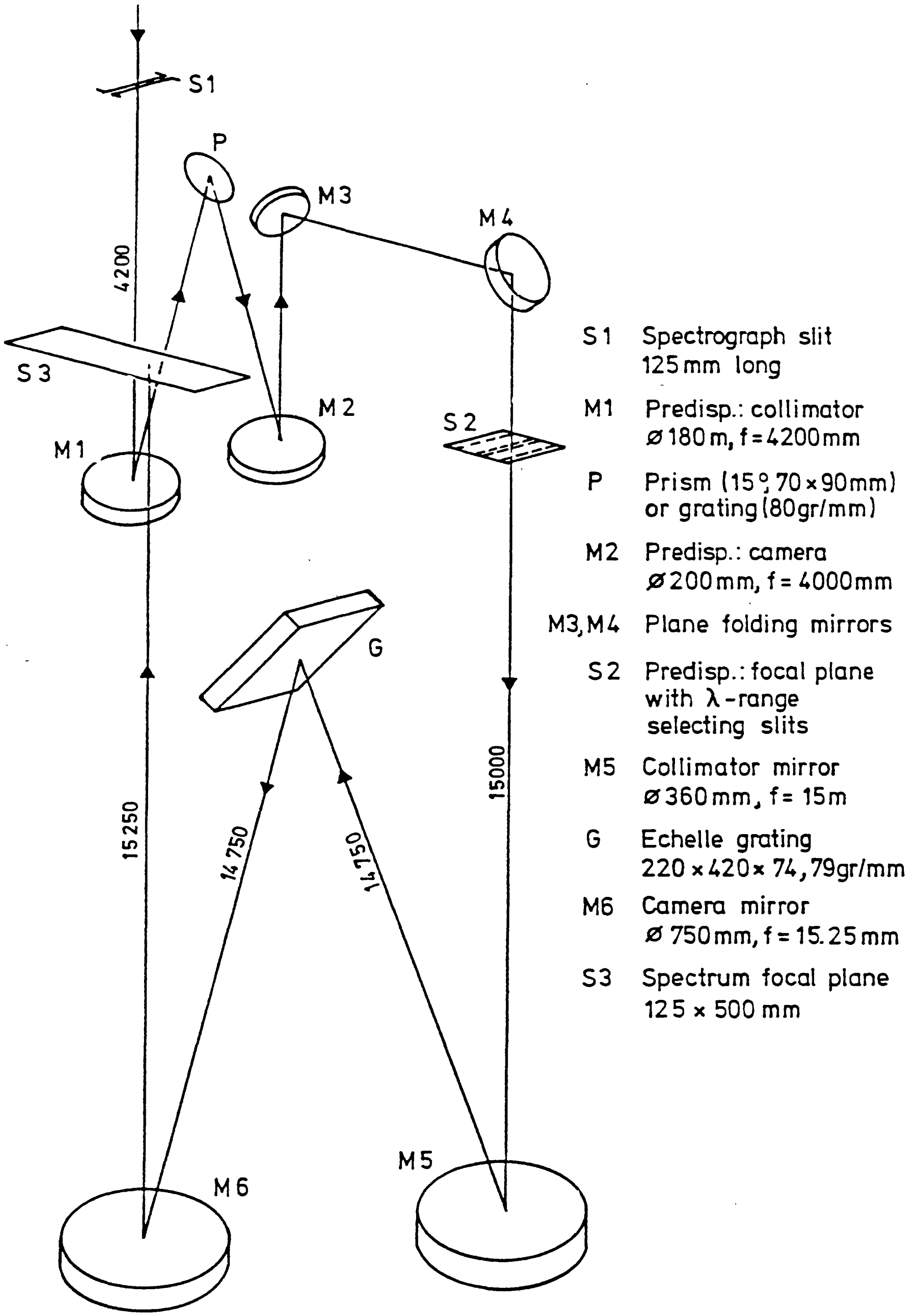

Fig. 3.5/3 - The optical scheme of the vertical main spectrograph of the German Vacuum Tower Telescope (by courtesy of E.H. Schroeter, D. Soltau and E. Wiehr).

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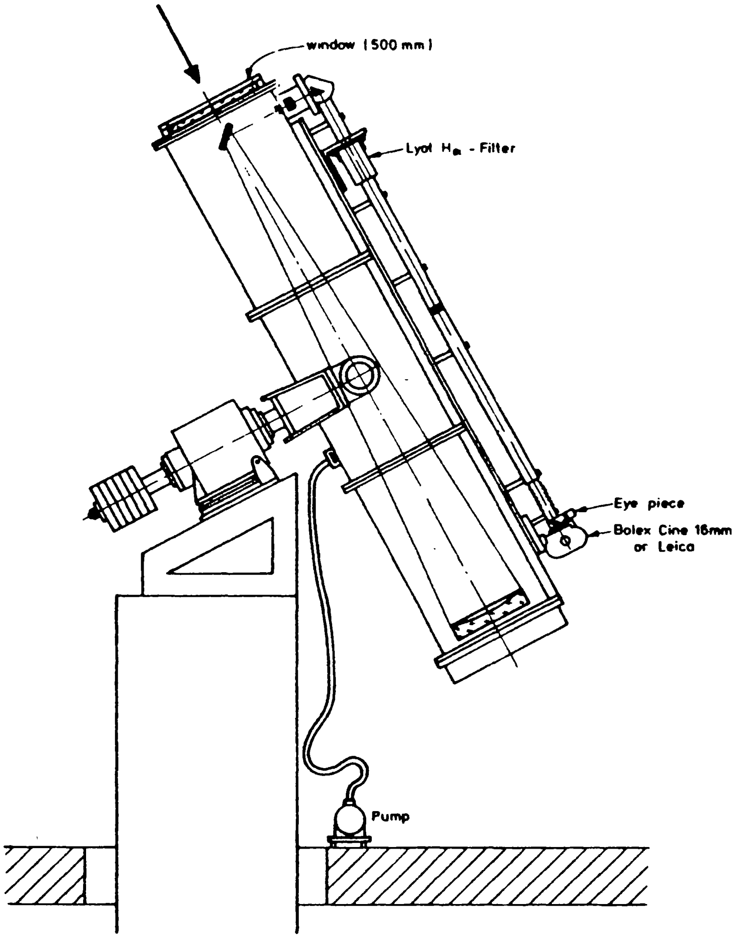

Fig. 3.6/1 - The German Vacuum Newton Telescope (by courtesy of P.N. Brandt and A. Righini)

Laboratory for continuous observations of the Sun with temporal resolutions suitable to the parameter being measured (Roca Cortes, 1985).

Instruments are being developed for observations of the Sun as a star and for observations with spatial resolution.

The instrumentation with no spatial resolving power will perform measurements of radial velocity, broad-band visible photometry, spectrophotometry of Ca II H and K line emissions. As we pointed out many years ago (Godoli, 1967 and 1968), the study of the Sun as a star is the first step in the research on stellar activity of solar type. It is unbelievable that today we know several stellar parameters related to stellar activity of solar

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type better than we know the solar ones. It is therefore necessary to observe the Sun as a star for a long time interval to cover several solar activity magnetic cycles.

The instrumentation designed for observations with spatial resolution, will perform velocity measurements for the study of the differential rotation, meridional circulation, giant cells, oscillations. Full disc Hα image and white light image will give information on the development and rotation of active regions.

3.9 The Swedish 50 cm Vertical Vacuum Refractor (VVR).

The Swedish Capri solar instruments had been transferred to La Palma in 1978 and were put into use in early 1982). The instruments included a 60 cm flat heliostat and a 44 cm stationary Cassegrain telescope, an Ultra variable Resolution Single Interferometer Echelle Spectrograph (URSIES) (Fay and Wyller, 1972) and a subtractive double-dispersion spectrograph.

In the first arrangement used in La Palma the heliostat, at the top of a newly built solar tower, via an inclined 80 cm flat mirror, directed a parallel beam through a 12 meter long vertical vacuum tube into the Cassegrain telescope mounted vertically. This optical system was a stop-gap solution but soon it became apparent that this was not a very satisfactory system in terms of scattered light and thermally induced image distorsion. During 1982-83 extensive observations with a 25 cm f/ 75 singlet lens placed on top of the

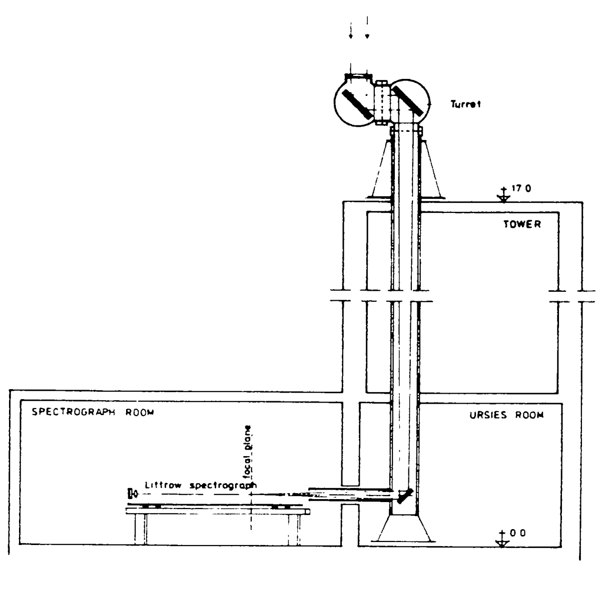

Fig. 3.9/1 - Vertical cross section of the new Swedish Vertical Vacuum Refractor (by courtesy of G.B. Scharmer, D.S. Brown, L. Petterson and J. Rehn).

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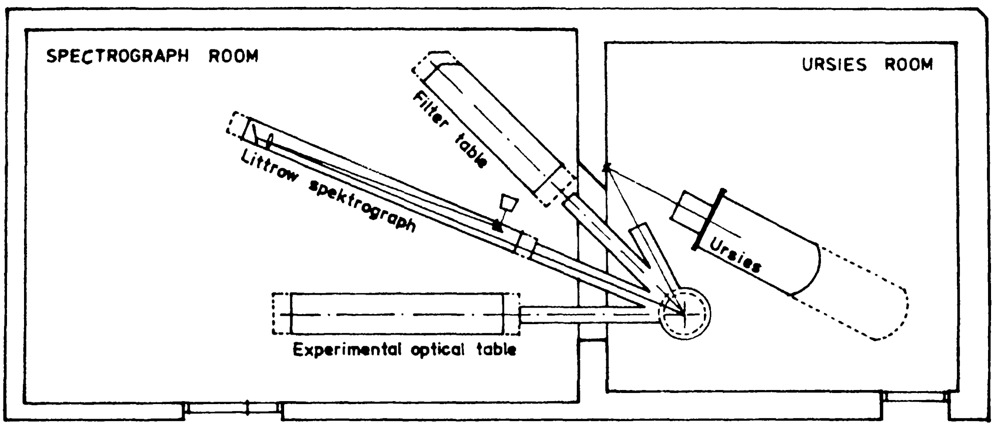

Fig. 3.9/2 - Horizontal cross section of the two spectrograph rooms at the Swedish Vertical Vacuum Refractor (by courtesy of G.B. Scharmer, D.S. Brown, L. Petterson and J. Rehn).

entrance window of the vacuum tube were made. Diffraction limited white light pictures have frequently been obtained so that a construction of a larger refractor has been motivated (Wyller and Scharmer, 1985).

A complete description of the new telescope system has been published by Scharmer et al. (1985). The telescope design was partly restricted by the existing tower. A turret solution on an alt-azimuth mount has been adopted. Fig. 3.9/1 is a vertical cross-section of the complete optical and vacuum system. A 50 cm achromatic doublet (f = 22.35 m) is the entrance window of the vacuum system. A first 72 cm flat mirror reflects the light from the lens along the elevation axis to a second 80 cm (oversized) flat mirror which reflects the light down to the URSIES room where a 20 cm flat mirror feeds four focal plane instruments (fig. 3.9/2). There are three 11 cm vacuum windows for three of the exit ports and a Barlow lens (56 m effective focal length) for the fourth exit port.

Focal plane instruments include a new version of URSIES, a short Littrow spectrograph for subarcsecond spectrophotometry with a spectral resolution of 250000, an optical table for Lyot-Öhman filters an optical table for guest investigators.

4 POSSIBLE SIMULTANEOUS AND COMPLEMENTARY OBSERVATIONS OF THE SUN AT THE CANARY ISLANDS

When, in a few years, the second phase of JOSO will be completed two decades after the JOSO foundation, European astronomers will have at their

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disposal a concentration of solar telescopes only comparable to that of the USA National Solar Observatory (NSO).

We remind the reader that NSO was recently established as a division of the US National Optical Astronomy Observatories (NOAO). NSO is operated by the Association of Universities for Research in Astronomy (AURA) as a national research center under contract with the US National Science Foundation (NSF). NSO consists of two sites: the Sacramento Peak Observatory, at Sunspot, New Mexico, and Kitt Peak, in Tucson, Arizona. Affiliated with the NSO are the Solar Research Branch of the US Air Force Geophysics Laboratory (AFGL) at Sacramento Peak and the National Aeronautics and Space Administration (NASA) Southwest Station in Tucson.

We can hardly imagine the amount of precious information we will be able to collect on phenomena of the solar atmosphere performing simultaneous and complementary observations at the solar telescopes of the Canary Islands.

The Spanish SL will allow the localization of the studied phenomenon in the phase of the parameters concerning the Sun as a star, and the observation of the relationships among the phenomenon and other manifestations of active and quiet regions. Details of these relationships will be observed with higher spatial resolution at the filter table of the Swedish VVR and the German-Spanish VNT.

At the spectrograph of the German VGT and VTT and at the Swedish URSIES spectroscopic information as Doppler shifts and line profiles will be obtained with the highest spectroscopic resolution.

At the Italian BSU the vertical behaviour of the phenomenon will be observed while the French MSDP will allow observations of vertically rapidly moving structures along the phenomenon.

With the French THEMIS high spatial resolution observations of magnetic fields associated with the phenomenon will be performed at several heights; relationships between thermodynamical, velocity and magnetic effects will be observed.

If the phenomenon is to be kept under observation even after the local sunset at the Canary Islands, the American colleagues of the NSO can continue the work with their solar telescopes at Sac Peak and Kit Peak.

Naturally to coordinate such an amount of different simultaneous and complementary observations, observers must communicate continuously via a radio-link system.

Unfortunately really fine structures and associated magnetic fields (fundamental in the physical processes involved) that, according to recent studies, should have dimension of the order of 70 km (0.1 arcsec) will still be missed: only LEST will allow solar astronomers to observe them.

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5 THE THIRD PHASE OF JOSO: THE CONSTRUCTION OF LEST

5.1 The LEST Foundation.

For the realization of the third phase of JOSO a new organizational framework was needed since JOSO did not have a legal status.

At the JOSO Board meeting in Paris, 1982, following an invitation of the Royal Swedish Academy of Sciences, which in its session of October 1982 voted in favor of accepting the role as a host-organization for a LEST Foundation, it was agreed to establish the LEST Foundation in April 1983.

Actually the LEST Foundation was brought into existence at the Royal Swedish Academy of Sciences in Stockholm, on April 26th, 1983. Only four JOSO countries joined the LEST Foundation at that time: Israel (through the Israeli Committee for Space of the Israel Academy of Sciences and Humanities), Norway (through the Institute of Theoretical Astrophysics of the Oslo University), Sweden (through the Royal Swedish Academy of Sciences) and Switzerland (through the Swiss Federal Institute of Technology, ETH, Zurich).

In 1983 Italy and Federal Republic of Germany applied for membership, which could be granted by the President of the Foundation according to a provisional regulation that was valid until the end of 1983. Italy became a member through the Consiglio Nazionale delle Ricerche in August 1983 and Germany became a member through the Kiepenheuer Institut fur Sonnenphysik, Freiburg, in December 1983.

In July 1983 Australia had already indicated strong interest in joining the LEST Foundation. In June 1984 Australia formally applied for membership in the LEST Foundation through the Department of Science and Technology in Canberra. A newly established Solar Physics Association of Australia (SPAA) would assist by playing the coordinating role within Australia between solar physicists at Australian universities, CSIRO and government organizations. Australia was officially accepted as a member of the LEST Foundation at the 3rd General Assembly held in Freiburg on December 1984. Australia was the first country to break the European boundaries for LEST: with its admission LEST became a truly global international enterprise.

In March 1985 the membership application of the People's Republic of China was presented through the Yunnan Observatory of the Chinese Academy of Sciences. The following month, in April, the membership application of the USA was also presented through the University Corporation for Atmospheric Research (UCAR) in Boulder, Colorado. At the 4th LEST General Assembly held in Tenerife on January 1986 these applications were unanimously approved so that now the LEST Foundation is formed by

Australia, Federal Republic of Germany, Israel, Italy, Norway, People's Republic of China, Sweden, Switzerland, USA

Austria, Belgium and Japan could present their application in a later time.

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To reflect the fact that, after the admission of Australia, the People's Republic of China and USA LEST is no longer solely a European project but a global international scientific effort, during January 1986 General Assembly of the Foundation it was decided to change the meaning of the acronym LEST from

Large European Solar Telescope

to

Large Earth-based Solar Telescope.

The General Assembly of Member Organizations is the highest authority of the LEST Foundation and determines its general policy.

The 1st LEST General Assembly immediately followed the LEST founding meeting in Stockholm (April 1983). Successive General Assemblies were held in Zurich (January 1984), Freiburg, F.R.G. (December 1984), Tenerife (January 1986).

The executive organ of the LEST Foundation is the Council. It consists of the President, the Vice President, the Secretary General and two other members elected by the General Assembly for a period of up to three years. The Executive Secretary has the right to attend - without voting power - all meetings of the Council.

The actual execution of the LEST project is handled by a LEST *Project Group* under a *Project Director*. A Scientific and Technical Advisory Committee will closely follow the development of the Project and assist the Project Director on matters relevant to the final planning and construction of LEST.

LEST activities are reviewed in its Annual Report published since 1983 and in a series of Technical Reports.

5.2 The need for LEST.

The needs for solar research facilities have been largely neglected in the last decade, although efforts of modern observational solar physics have been focussed on achieving the highest spatial resolution of the fine structures of solar phenomena and of associated magnetic fields: a spatial resolution of at least 0.1 arcsec or 70 km in linear extent on the solar surface and a much lower level of contaminating telescope polarization than that of any existing large solar telescope are required (Godoli et al., 1978; Dunn, 1981; Wyller, 1983; Athay et al., 1985; Muller, 1985; Wyller, 1986).

Both the Field (1982) Report on Astronomy in USA in the 1980's and the Bonnet et al. (1982) Report on Solar Physics in Europe for the 1980's issued by the European Physical Society recommended a strengthening of ground-based solar research facilities in addition to solar research from space.

5.3 LEST Design.

A frame of Reference for the LEST phase A feasibility study was formulated and accepted at the JOSO Board meeting of Firenze (1980). The

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final requirements that emerged from further consultations were:

a) high spatial resolution:
   at least 0.3 arcsec
   preferably 0.1 arcsec;
b) adequate pointing and tracking capabilities;
c) low instrumental polarization;
d) low straylight level;
e) field of view:
   acceptable 2 arcmin
   preferable 0.5 degree;
f) access to IR:
   acceptable $\lambda \leqslant 2$ µm
   preferable $\lambda \leqslant 10$ µm;
g) effective image scale:
   acceptable in the range of f/30 - f/60
   preferable faster for observations of night-time objects.

A first draft for a phase A feasibility study on principal aspects of the LEST design was presented at the JOSO Board meeting in Villach, 1981 (Engvold and Hefter, 1981). The JOSO Board accepted the main concepts and the final phase A study was published in 1982 (Engvold and Hefter, 1982). Further studies have been published on an extensive series of Technical Reports.

The resulting final design can be regarded as a next generation solar telescope for the following features:

a) large aperture;
b) direct pointing to the Sun;
c) optical system that permit high precision polarimetric measurements;
d) system for real time alignment control and correction;
e) active optics for the stabilization of the solar image;
f) adactive optics for blurring correction;
g) Helium filled light path of the telescope;
h) remote control via international computer network.

Fig. 5.3/1 shows the optical scheme of the LEST. The telescope is a Gregorian type with an additional concave mirror behind the primary mirror. At the prime focus of the 240 cm f/2.3 parabolic objective mirror a combined diaphragm and heat rejection system is placed. The concave mirror re-images the Gregorian focus, via two flat mirrors, to the instruments at the basis of the tower.

The polarimeter package is placed at the secondary focus and contains two piezoelastic modulators, followed by linear polarizer.

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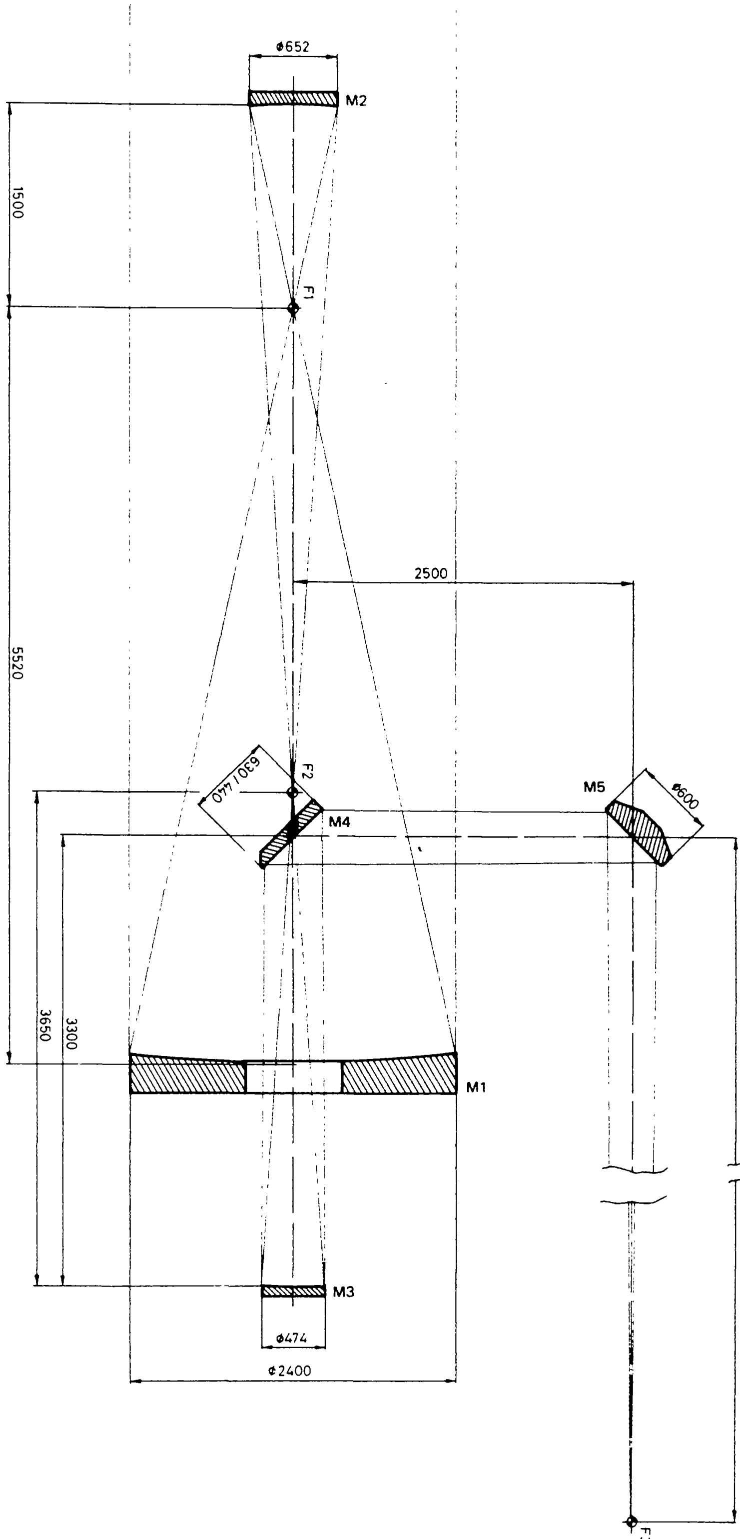

Fig. 5.3/1 - The optical scheme of the LEST.

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The telescope is sealed with an entrance window: the optical path is filled with Helium gas to reduce the internal seeing effects and to permit the use of a thin entrance window.

The telescope sits on top of a double tower 25 m above ground (fig. 5.3/2). The outer tower supports the dome structure, the inner tower and the telescope platform. The telescope is mounted in a tube protruding through the dome. The tube and the dome rotate around two axes, one vertical and one inclined 45° to the vertical direction. Since the azimuth axis is offset from the center of rotation of the elevation axis, a third axis of rotation is needed.

5.4 Post focus equipments.

The vertical beam of light coming from the telescope focus on a rotating table *(rotator)* inside the tower (fig. 5.3/1). The rotator can accomodate post focus equipments up to 7 m long. Six more post focus instruments can be located on the floor around the rotator.

The most important post focus instruments studied are an Echelle grating spectrometer, an advanced Fourier transform spectrometer and a Super Universal Multichannel Filter, more complex than any in existence.

5.5 The site for LEST.

Although the results already obtained show unambiguously that the Canary Islands sites are about ten times better than the best sites used by Europeans, such Capri or Locarno, the internalization of the LEST Foundation suggests conducting a final site-testing campaign comparing the sites of the Canary Islands with those of Hawaii.

Two islands in Hawaii currently have observatories with a number of large telescopes on their mountain peaks: Maui is the site of Mt. Haleakala Solar Observatory (altitude 3000 m) and Hawaii is the site of the Mauna Kea Stellar Observatory (altitude 4200).

As far as stellar observations are concerned the available results seem to indicate that the average conditions on La Palma and Tenerife are little but significantly better than on Mauna Kea. However the LEST Foundation is performing an extensive final solar site testing campaign on La Palma, Tenerife and Hawaii before the ultimate selection of the LEST site is made.

5.6 The cost of LEST.

According to the latest extimation the total cost of the LEST programme will be 25 M$. The annual operation will cost 2 M$.

Table 5.6/1 shows the distribution of financial obbligations between member countries: OECD figures on gross national product are applied with a Ceiling of 33.3% and a share of 10% for the People's Republic of China.

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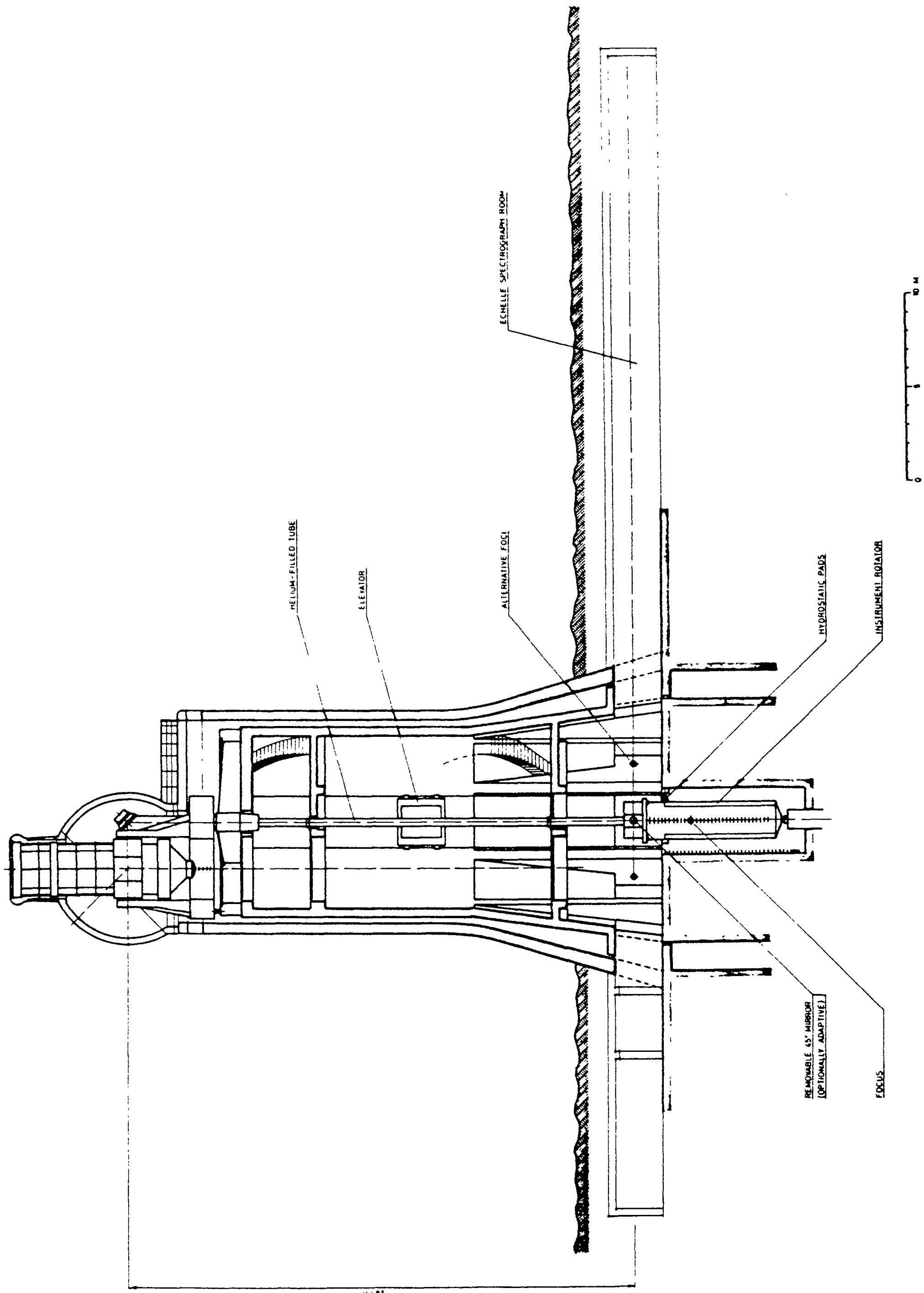

Fig. 5.3/2 - Vertical cross-section through the LEST tower and telescope.

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TABLE 5.6/1 - Financial obbligation for the LEST member countries.

Australia	6.0%
People's Republic of China	10.0%
F.R.G.	26.0%
Italy	14.1%
Israel	0.9%
Norway	2.2%
Sweden	3.6%
Switzerland	3.9%
U.S.A.	33.3%
	100.0%

At the meeting of the LEST Foundation Council on May 1986 it was decided to start the Project in January 1987. The funding agencies in the different countries have been requested to give their national contributions according to Table 5.6/1. If Austria, Belgium and Japan will also join the LEST Foundation, more complex post-focus instruments will be constructed. In accordance with the time schedule for the LEST Programme the total amount for the first year is 1.17 M$. The programme could be completed in 1991 so that LEST could be in operation for the next maximum of solar activity.

6 THE FUTURE OF JOSO

The problem of the future of JOSO arose at the JOSO Board meeting in January 1986.

Since the actual execution of the LEST will be handled by the LEST Foundation it could be thought that the JOSO programme will be accomplished when the second phase concerning the installation of the national medium sized instruments is completed.

In spite of that it has been realized that, also in the future, solar astronomers will need a forum for discussions on the possibilities and constraints of optical solar observations and for coordinating simultaneous and complementary observations. JOSO could act also as an advisory body in questions concerning LEST.

For these reasons it was decided that JOSO activities will go on even after the second phase is over.

The terms of reference of the two existing working groups (WG) have been slightly updated in order to take into account the new tasks of JOSO:

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WG 1 on *Site Assessment* will turn its interest to the potentialities and limits of the Earth-based optical solar observations; WG 2 on *Post-focus Instrumentation for LEST* will enlarge its interest to the post-focus instrumentation for solar observations. Two new WG's have been constituted: WG 3 will study the problems concerning data storage and change while WG 4 will study solar line asymmetries.

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