ANNUAL REPORT* OF THE KODAIKANAL OBSERVATORY FOR THE YEAR 1956.

General.—On February 17, 1956 news was received of the sudden and untimely death of Prof. M. N. Saha on the previous day. The observatory was declared closed for the afternoon of February 17 as a mark of respect to the memory of the late Prof. Saha. On November 23 news was received of the death of Mr. John Evershed who was Assistant Director of the Kodaikanal Observatory from 1907 to 1911 and Director from 1911 to 1922; as a mark of respect to his memory the observatory was closed for the rest of the day.

On a request from the International Astronomical Union this observatory agreed to participate in the international co-operation on the study of the development of sunspot-groups and in the co-operative photographic flare patrol during 1957-58.

Information regarding the observations (Optical, Magnetic and Ionospheric) of the great solar flare of 1956, February 23, made at this observatory was supplied on request to several scientific institutions and individual scientists in the U.K., Germany and the U.S.A. A brief account of these observations will be found in the Indian Journal of Meteorology and Geophysics (Vol. 8, No. 1, 1957).

In connection with the international photographic and visual patrol of Mars during the 1956 opposition, observations were made with the 20″ Grubb Reflector and 8″ Cooke Refractor whenever weather permitted.

Dr. A. K. Das continued to serve on the Indian National Committee for the International Geophysical Year. Dr. Das attended the fifth meeting of the Standing Advisory Board for Astronomy and Astrophysics held at New Delhi on 18-12-56.

Steps were taken for placing final orders with Messrs. Recherches et Etudes D'Optique et de Sciences Connexes, Paris, for an 8″ Coronagraph for this observatory. The optical parts for the Coronagraph will be constructed at the Institut d' Optique Theorique et Appliquee of Paris.

Scientific Co-operation.—Exchange of spectroheliograms with foreign observatories was continued. 284 K disc spectroheliograms for the period October 1955—September 1956 were sent to the Cambridge University Observatories. For the period July 1955—June 1956 52 H-alpha disc and 53 K disc spectroheliograms were received from the Meudon Observatory, France and 67 H-alpha disc and 84 K prominence spectroheliograms from the Mt. Wilson Observatory, U.S.A.

*This report deals chiefly with the astronomical and allied geophysical work of the Kodaikanal Observatory. The meteorological data will be published in the India Weather Review, the Seismological data in the Seismological Bulletin and the administrative details in the Administration Report of the India Meteorological Department.

Copies of daily spectroheliograms (disc in H-alpha and K and limb in K) were supplied in fortnightly batches to the Fraunhofer Institute, Germany for the preparation of daily solar charts.

Two photoheliograms together with the relevant zero plates for certain specified dates in 1955-56 were supplied to the Astronomer Royal, Royal Greenwich Observatory, England.

Quarterly statements relating to solar flares were sent, as in previous years, to the Meudon Observatory, France, and to the Royal Greenwich Observatory, England.

Periodical statements of data of solar flares, relative sunspot numbers, ionospheric parameters and SIDs, information relating to central meridian passage of prominent sunspots and forecasts of expected magnetic and ionospheric disturbances were supplied to a number of interested institutions in India.

Monthly median values of F_2 layer critical frequency and maximum usable frequency factor for 3000 Km transmission were supplied, as in previous years, to the Central Radio Propagation Laboratory, National Bureau of Standards, U.S.A. Quarterly statements of monthly median values of all ionospheric parameters were also supplied to the above institution and to the Radio Research Station, Slough, England. Magnetic storm data were sent every quarter to Prof. John A. Simpson of the University of Chicago. The practice of broadcasting URSIGRAMMES relating to solar and geomagnetic activity was continued.

Instruments.—The present instrumental equipment of the observatory can be broadly classified under the following heads :—

(a) *Astronomical and spectroscopic instruments*

(1) Six-inch Cooke Equatorial with a grating spectroscope attached for observing prominences.

(2) Six-inch Lerebours and Secretan Equatorial, reconstructed by Grubb for direct solar photography. A five-inch astrographic camera is also mounted on the same equatorial.

(3) Six-inch stellar telescope by T. Cooke and Sons, York.

(4) 20-inch Reflecting telescope by Grubb.

(5) 8-inch Refracting Telescope.

(6) Six-inch transit instrument and barrel chronograph.

(7) 4½-inch refractors-2 Nos. (one by Cooke and another by Grubb).

(8) Spectroheliograph made by the Cambridge Scientific Instrument Co., with an 18-inch Cooke siderostat and 12-inch Cooke photovisual lens of 21-ft. focal length, used for photoghaphs in the K line.

(9) An auxiliary spectroheliograph using a 6-inch Anderson grating designed and built in this observatory is attached to the above for taking spectroheliograms in the H-alpha line.

(10) Hale spectrohelioscope together with a five-inch coelostat kindly loaned by the Mt. Wilson Observatory. A camera is attached to the instrument for photographing the spectra of solar flares, prominences, etc. simultaneously with their visual observation. The camera gives a dispersion of about 3A/mm. in the 3rd order.

(11) Spectrograph I : With 3½-prisms in Littrow mount and about 14 ft. focus, designed and built in this observatory. This is fed by a 12-inch Foucault siderostat in conjunction with an eight-inch lens.

(12) Spectrograph II:10 ft. concave grating in Rowland mounting designed and built in this observatory. A 10-inch polar siderostat designed and constructed in this observatory feeds this spectrograph independently. The polar siderostat is working temporarily with a 6-inch mirror until a mirror of appropriate size becomes available.

(13) Spectrograph III : 20 ft. plane grating spectrograph in Littrow mount using a 6¼-inch Michelson grating, designed and built in this observatory. The spectrograph is so constructed that the grating can be quickly moved aside by turning a handle and a system of 3½ prisms can be brought into use in its place.

The spectrograph is fed by the 18-inch Foucault siderostat in conjunction with the 21-foot Cooke photovisual lens and an auxiliary mirror. Alternatively it can also be fed by a 12-inch coelostat, designed and built at this observatory in conjunction with a 40 ft. lens.

(14) Spectrograph IV : Grating spectrograph in angular mounting with collimator lens of about 7 ft. focus and camera lens of about 14 ft. focus using a 3¼ inch Rowland plane grating, designed and built in this observatory.

The spectrograph is fed by the 18-inch Foucault siderostat in conjunction with either an 18-inch parabolic mirror of 10 ft. focal length or an 8-inch lens of 10 ft. focal length.

(15) Spectrograph V : 20 ft. concave grating spectrograph, in Eagle mount designed and built at the observatory.

The spectrograph can be fed either by the 18-inch Foucault siderostat and 21-foot Cooke photovisual lens or by the 12-inch coelostat and the 40 ft. lens.

(16) Spectrograph VI : With 1½ prisms in Littrow mount and 6 feet focal length, designed and constructed at the observatory specially for eclipse observation. The spectrograph has been constructed so as to be capable of rotation about the optical axis. Sunlight is fed into the spectrograph from a coelostat also constructed at the observatory.

(17) Hilger E315 Quartz spectrograph.

(18) Standardising spectrograph.

(19) Cambridge photoelectric microphotometer.

(20) Harvard Visual Sky Photometer.

(21) Dobson Ozone Spectrophotometer.

(22) Two monochromators to work in conjunction with solar spectrographs (designed and built in this observatory).

(23) Direct Recording Photoelectric Spectrophotometer (designed and built in this observatory) for solar line-contour work.

(24) Large Lummer Interferometer (Quartz) by Hilger.

(25) Fabry-Perot Etalon.

(26) Photoelectric non-recording sky Photometer (designed and built in this observaory) for visual study of sky radiation.

(27) Three Hilger comparators for measuring spectrograms.

(28) Large Induction Coil capable of giving up to 16-inch sparks.

(29) Large Dubois Electromagnet.

(30) Four mean time clocks—

(i) Kullberg M. 6326,

(ii) Shelton,

(iii) Arnold and Dent,

(iv) W. Ottway and Co.

(31) One sidereal clock by T. Cooke and sons, York.

(32) Three mean time chronometers—

(i) Kullberg No. 6299,

(ii) Frodsham No. 3476,

(iii) Mercer No. 19443.

(33) Two tape chronographs, one by Fuess and the other by Breguet.

(34) Cooke Theodolite.

(35) Meridian Circle (by Troughton & Simms) belonging to the old Madras Observatory. It is at present dismantled.

(b) *Magnetic Instruments.*

(36) Kew Magnetometer No. 3.

(37) Earth Inductor (No. 46, Wild pattern) by Schulze of Potsdam.

(38) Horizontal Force Magnetograph (Watson type).

(39) Vertical Force Magnetograph (Watson type).

(40) Declination Magnetograph (Watson type).

(41) Dip Circle (Kew Pattern).

(42) La Cour H, D and V Magnetographs.

(43) Askania Magnetic Field Balance with photoelectric recording outfit.

(44) La Cour Quartz Horizontal Magnetometer.

(45) La Cour Magnetometric Zero Balance.

(46) Quick-run Recorder for use with Askania Magnetic Field Balance.

(c) *Electronic instruments.*

(47) Multi-Frequency Automatic Ionosphere Recorder — C.R.P.L. Model C-3.
(48) Dawe Universal Impedance Bridge — Model 314A.
(49) Taylor Valve Tester.
(50) Avo Wide Range Signal Generator.
(51) Cossor Double-beam Oscilloscope — Model 1035.
(52) Marconi Valve Voltmeter.
(53) Marconi Video Oscillator.
(54) Marconi Signal Generator — Type 801A.
(55) Megacycle Meter.
(56) Dawe Pulse Generator — Type 412A.
(57) Hallicrafters Receiver —Type SX-62.
(58) B.P.L. Resistance —Tuned Oscillator —Model LO63.
(59) Dawe Q-Meter — Type 622 C.
(60) Eddystone Receiver —Type 504.
(61) Browning Oscillosynchroscope —Model GL-22-A.
(62) Browning Sweep Calibrator —Model GL-22A.
(63) Squarewave and Pulse Generator-Cintel-Type 1873.
(64) R. F. Impedance Bridge with Oscillator-detector Unit.
(65) 100 Mc/s. Radio Telescope (designed and built in this observatory).
(66) Three Hammarlund Communication Receivers.
(67) Avo Electronic Testmeter.
(68) Nagard High Gain D. C. Amplifier.
(69) Absorption Wavemeter (E.M.I.)
(70) 10 cm. Solar Radiometer — Model J 76.

(d) *Workshop-Machinery*

(71) 6″ Cooke Lathe.
(72) 5″ Wilfin Lathe.
(73) 5″ Jessop Lathe.
(74) 'Victoria' Model U2 Milling Machine.
(75) 'Cooper' 24-inch Shaping Machine.
(76) 'Cobra' 9-inch Hacksaw Machine.
(77) 'Cruickshank' Combined Grinding & Buffing Machine.
(78) 'Adcock & Shipley' Slitting Machine.
(79) Canedy 'Otto' Drilling Machine.
(80) 'Davla' Saw Bench.
(81) Smith's Hearth.
(82) Adcock & Shipley Optical Centring Lathe.

(e) *Other Instruments.*

(83) Small dividing engine by the Cambridge Scientific Instrument Co., Ltd.

(84) Milne-Shaw Seismograph (E-W component).

(85) A complete set of meteorological instruments.

(86) Kolhörster Cosmic Ray Recorder.

(87) Microscope — 2 Nos.

(88) Aldis Epidiascope.

(89) 16 mm. Cine Projecter.

Weather Conditions.—Weather conditions were more favourable during 1956 for solar observations than in the previous year. Photoheliograms were made on 309 days and visual observations were possible on 305 days as compared to 289 days each in 1955. H-alpha disc, K disc and K prominence spectroheliograms were taken on 301, 293 and 267 days as compared to 275, 264 and 258 days respectively in the previous year. Observations with the spectroheliscope were made on 295 days.

The average definition of the sun's image on a scale in which 1 is the worst and 5 the best was 2.3. There were 18 days on which the definition was 4 or better.

Sunspot activity.—With the approach of the maximum of the solar cycle there was a marked increase in sunspot activity during the year. The yearly mean latitude of all the observed spotgroups in the northern and southern hemispheres was 24°.6 and 21°.0 respectively as against 25°.1 and 25°.5 for the previous year. Details of sunspot observations are given in the following table :

Month		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
No. of new spotgroups	N	6	11	16	14	16	11	14	11	18	18	11	12	158
	S	9	12	10	18	15	9	8	13	12	16	12	15	149
Total		15	23	26	32	31	20	22	24	30	34	23	27	307
Mean daily number of spotgroups		3·51	5·00	6·83	7·33	6·00	4·78	6·62	6·40	7·90	6·72	6·88	6·89	6·24
Kodaikanal daily relative sunspot number*		62·6	88·3	107·9	115·0	102·7	81·1	99·6	116.6	132·5	110·9	129·3	126·5	106.1

Solar Flares.—54 solar flares were observed during the year, 46 of intensity 1, 7 of intensity 2 and 1 of intensity 3.

*The relative sunspot numbers published in the previous Annual Reports were based on the visual observation of a solar image of 8 inch diameter projected on a screen by a refractor of 2¾ inch aperture. From January 1955 the relative sunspot numbers are those computed from photoheliograms on a scale of 8 inch to the solar diameter obtained with a 6 inch refractor. The constant K in the formula for relative sunspot numbers is taken as 1.

Prominences.—With the approach of the maximum of the solar cycle prominence activity continued to be on the increase throughout 1956. The mean daily areas and numbers of calcium prominences at the limb as derived from photographs obtained at Kodaikanal were as follows :

1956	Area in Sq. minutes					Numbers				
	N	S	E	W	Total	N	S	E	W	Total
January–June	3·92	1·85	3·22	2·55	5·77	5·39	3·87	4·49	4·77	9·26
July–December	3·40	2·85	3·41	2·84	6·25	5·17	4·71	4·85	5·03	9·88
Whole year (weighted mean)	3·71	2·26	3·31	2·66	5·97	5·31	4·21	4·64	4·88	9·52

Compared with the previous year, prominence activity as represented by areas increased by 60% while the increase was 21% as judged by numbers.

In the northern hemisphere the distribution of areas in five-degree ranges of latitude showed a maximum at 55°-60° with a secondary maximum at 30°-35°. Compared to the previous year the zone of activity had thus advanced by about 15 degrees towards the pole. The maximum activity in the southern hemisphere was at 45°-50° with a less pronounced secondary maximum at 5°-10°. On the whole, activity was considerably less in the southern hemisphere than in the northern. There was an eastern preponderance in prominence areas, but the numbers showed a slight western excess.

Three metallic prominences were observed during the year.

Doppler shifts of the H-alpha line in prominences and absorption markings observed with the prominence spectroscope and the spectrohelioscope are summarised below :—

	North	South	East	West	To Red	To Violet	Both ways	Total
Prominences	142	102	138	106	4	..	240	244
Dark marking	22	13	21	14	2	1	32	35

The heights of 55 fairly tall prominences were measured in H-alpha, D3 and H-Beta lines with the prominence spectroscope. These were compared with the corresponding heights in the K line as obtained from the spectroheliograms. The average heights were:

K	H-alpha	D3	H-Beta
70″·5	58″·5	50″·3	46″·2

Seven instances of sudden disappearance of disk absorption markings and limb prominences were observed during the year.

The mean daily areas and numbers of hydrogen absorption markings on the disc as obtained from Kodaikanal records are given in the following table :

1956	Area in millionths of the sun's visible hemisphere (uncorrected for foreshortening)					Number				
	North	South	East	West	Total	North	South	East	West	Total
January-June	2744	1846	2355	2235	4590	17·67	11·56	14·96	14·27	29·23
July-December	3046	2175	2544	2677	5221	17·82	13·49	15·63	15·68	31·31
Whole year (weighted mean)	2882	1997	2442	2437	4879	17·74	12·43	15·26	14·91	30·17

Compared with the previous year there was in 1956 a considerable increase in activity as judged from the areas as well as the numbers of hydrogen absorption markings, the increase in areas being 169% and that in numbers 160%. The noteworthy feature of the distribution of areas in latitude in the northern hemisphere was a pronounced peak of activity in the 25°-30° zone with a clear secondary maximum at 60°-65°. In the southern hemisphere too there were two peaks of activity, one in the latitude belt 30°-35° and the other at 45°-50°. The activity as judged from hydrogen absorption markings was however less in the southern than in the northern hemisphere, as was also indicated by the limb prominences.

Radio Astronomy.—A receiver for 10Cm. radiation specially constructed for this Observatory by the Division of Radio Physics, Commonwealth Scientific and Industrial Research Organization, Australia was received. Preliminary tests of its performance were made; the antenna system of the Radio Telescope was under construction in the observatory workshop.

Geomagnetic observations.—Continuous photographic recording of H, Z and D with Watson and La Cour Magnetographs and visible recording of H with an Askania Field Balance were continued. Values of H, D and Z were determined weekly with the QHM Nos. 254, 255 and 256 and a BMZ. Absolute measurements of H and D with the Kew Magnetometer and of the vertical force with an Earth-Inductor were also made once every month.

One set of Eschenhagen variometers made by Askania Werke, Germany, was received, tested and kept ready for installation at one of the field stations to be set up in South India during the coming International Geophysical Year.

During the year under review, 33 storms including 18 of SC type were recorded with ranges in H between 468γ and 128γ.

Ionospheric observations.—Round-the-clock ionospheric observations with the C. R. P. L. type C-3 Ionosphere Recorder were continued.

Regular field-intensity measurements were made on two frequencies.

Cosmic Ray.—The Kolhorster Cosmic Ray Recorder which had not been functioning for sometime past was again put into regular operation.

Atmospheric Ozone.—The Dobson Ozone Spectrophotometer recently added to the equipment of the observatory was brought into use and regular observations of atmospheric ozone were commenced towards the end of the year.

Seismology.—The Milne-Shaw Seismograph (E-W) component recorded 145 earthquakes.

Meteorology.—Meteorological observations with all the visual and self-recording instruments were carried out as usual.

Library.—53 books and 1899 periodicals were added to the library.

Research work.—Under the Research Training Scheme sponsored by the Ministry of Education, Government of India, one Senior and two Junior Research Scholars were working in this observatory. The two Junior Research Scholars were released from the scheme in October 1956 after completion of their training.

The following problems in Astrophysics and Geophysics were under investigation :—

(1) The solar flare of 1956 February 23 and related geomagnetic and magnetic effects.

(2) Study of contours of solar Fraunhofer lines, especially their variation from the centre of the disc to the extreme limb.

(3) Study of variation of continuous absorption in the near ultraviolet solar spectrum.

(4) Study of the red-shift of solar spectrum lines and its relation to the theory of relativity.

(5) The distribution of calcium flocculi on the sun's disc.

(6) Study of the magnetic fields, if any, of Venus, Mercury and the Moon.

(7) Analysis of ionospheric and geomagnetic data collected in connection with the partial solar eclipse of 1955 December 14.

(8) Scattering in F layer over Kodaikanal.

(9) Total electron content per unit area of the ionosphere over Kodaikanal.

(10) Lunar daily variation of magnetic field at Kodaikanal.

Publications.—The following papers and notes were either published or prepared for publication :

(1) The Solar Flare of 1956 February 23 — Indian Journal of Meteorology and Geophysics.

(2) The Magnetic Field of Venus — Presented at the Indian Science Congress, 1957.

(3) Effect of Lightning Discharges on Magnetographs — Nature.

(4) Quarterly synopses of results of solar, magnetic and ionospheric observations — Indian Journal of Meteorology and Geophysics.

(5) Annual Report of the Kodaikanal Observatory for the year 1955.

(6) Kodaikanal Observatory Bulletin Nos. 142 and 143 giving summary of results of solar and magnetic observations.

(7) Reports to the Royal Astronomical Society, London on :
(a) The work of the Kodaikanal Observatory, and
(b) The Prominence activity for the year 1955.

KODAIKANAL OBSERVATORY
June 1957

A. K. DAS,
Deputy Director-General of Observatories

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