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REPORT

ON THE

ADMINISTRATION

OF THE

METEOROLOGICAL DEPARTMENT

OF THE

GOVERNMENT OF INDIA

IN

1922-23

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REPORT ON THE ADMINISTRATION OF THE METEOROLOGICAL DEPARTMENT OF THE GOVERNMENT OF INDIA IN 1922-23.

1. Chief features of the year.

The serious shortness of gazetted staff which has for some years crippled the activity of the department has been remedied in the course of the present year by recruitment of Indian science graduates for the various vacant posts, under the new time-scale pay sanctioned in December 1921 by the Secretary of State. With these improved conditions it had been hoped that when the newly appointed officers should have assimilated their meteorological training, it would be possible to tackle arrears of work such as the inspection of observatories, the production of revised editions of the Atlas of the Indian Seas, the Handbook of Storms in the Indian Seas, and the preparation of type maps of Indian weather, which would greatly help in improving the accuracy of the daily forecasts and warnings. But although many of these activities are now within reach, the most urgent of them all, inspection of observatories, has been deferred by the unexpected reduction, in the new budget for 1923-24, of the monetary allotment for travelling allowances. In these circumstances the position of the last five or six years must continue for the present, and adequate inspection by the more responsible officers cannot be undertaken either for routine observatories or for those specially used for cyclone warning at sea. At present the staff of officers as a whole have direct recent knowledge of only about 10 out of more than 250 observatories under charge of the department ; and it has to be recognised that although all the vacant gazetted posts have been recently filled, the prospect of improvement in respect of inspections is still disappointing.

In these days of criticism that Indianisation in the services proceeds at too slow a rate, it is worth while to note what has happened in this department. The policy of Indianisation was definitely adopted over two years ago and the personnel occupying the thirteen posts of the grades of Meteorologist and Assistant Meteorologist, of which three are half-time appointments, has changed from 10 Europeans and 3 Indians in September 1919 to 3 Europeans and 10 Indians in March 1923. This change has not been helped forward by any retirement on proportionate pension, for that privilege has been denied to this department.

In the main observatories the staff has been considerably modified in the course of the year. Mr. Evershed retired on the 26th February 1923 from the directorship of Kodaikanal Observatory, a post which he had occupied with very conspicuous distinction for twelve years. His work on solar physics stands in the front rank of achievement, and has met with world-wide appreciation. For Bombay Observatory a new Director was appointed in April, and has been under training in Simla. Calcutta Observatory lost the services of Dr. E. P. Harrison, by his acceptance of a Home appointment under the Admiralty ; and Agra Observatory lost its only remaining European officer, Mr. Field, who was transferred to Simla in March to tide over difficult times at headquarters during the leave first of Dr. Normand and then of Dr. Walker.

In the direction of research, a feature of this year has been the expedition under charge of Mr. Evershed from Kodaikanal to make photographic observations in Australia on the total eclipse of the sun. Interest in solar eclipses has in recent

years become world-wide in view of their importance in verifying the theory of Einstein; and it is a matter of congratulation that India should have been represented among the several expeditions engaged on this work.

The department has continued its determination of upper air movements, a knowledge of which is extending our facilities for interpreting weather changes, laying the foundation for types of forecasting not hitherto possible from surface observations, and preparing for the inevitably coming demand for the precise information necessary to safeguard aeroplane flying and minimise its cost. A feature of immediate public service has been evolved as a result of requests in 1920 and 1921 by the Military authorities for balloon parties to attend three artillery camps at which gun-calibration and practice were to be undertaken. The work of the Agra balloon parties was then found useful, and was followed this year by demands for some 8 or 9 similar parties to attend artillery camps ranging from Quetta to Belgaum. This point is further dealt with in paragraph 8 below.

On the loss of Dr. Harrison it became necessary to remove to Simla the duties of warning for cyclones in the Bay of Bengal, and for floods inland around the Bay, duties which from the earliest days of the department have been assigned to the Meteorological Office at Calcutta; and with this transfer completed, the whole system of warnings for storms and cyclones in both sea areas and on land throughout India now lies permanently with the Headquarters' Staff.

During the year these warnings, as issued, were on the whole satisfactory (but see paragraph 5) for the eight storms in the Bay and the two in the Arabian Sea.

In response to orders calling for retrenchments the department reduced its expenditure during the course of the year by Rs. 37,000 below the originally sanctioned budget allotment of Rs. 7·14 lakhs. Amongst the items of reduction mention may be made of the stoppage of publication of both the Bombay and Madras Daily Weather Reports from the 1st January 1923 to the end of the year under review. In future the issue of these reports, and of the Calcutta Daily Weather Report is to be restricted to 6 months, 9 months and 10½ months respectively, in the year, the periods of suspended publication being the seasons of least rainfall in the Presidencies. Further, the stations reporting to Calcutta have been reduced in number, and now represent only Assam, Bengal, and Bihar and Orissa; similar curtailment for the Madras Report was also decided upon. Other retrenchments were arranged for by the replacement of the Monthly Weather Review by a much briefer Monthly Weather Report, the abolition of the Assistant Director's post at Kodaikanal Observatory and by drastic restrictions in the free distribution lists of the various weather reports. Proposals were also submitted for the abolition of the half-time post of Meteorologist, Bombay, and the amalgamation of the Bombay Meteorological Office with the Colaba Observatory.

2. Leave and new Appointments.

Dr. Gilbert T. Walker proceeded on eight months' leave on average pay on the 8th February 1923. Mr. J. H. Field was appointed to officiate as Director-General of Observatories.

Mr. J. H. Field was on 26 days' leave on average salary (privilege leave) from the 21st September to the 16th October 1922 inclusive.

Dr. Normand returned from 8 months and 22 days' combined leave on the 12th December 1922.

Dr. S. K. Banerji joined the department on the 11th April 1922, was appointed Meteorologist, and posted to Bombay.

Dr. B. N. Banerji joined the department on the 11th January 1923, was appointed Meteorologist, and posted to Simla.

Mr. G. Chatterjee was granted leave on average pay for one month and 21 days from the 9th March 1923.

Mr. J. Evershed retired on superannuation pension from the 26th February 1923.

Dr. T. Royds was appointed Director, Kodaikanal and Madras Observatories, from the 26th February 1923 on his personal pay. The Assistant Director's post has been abolished as a measure of retrenchment.

Professor P. C. Mahalanobis took over officiating charge of the post of Meteorologist, Calcutta, from Dr. E. P. Harrison on the 7th November 1922.

Mr. S. Sitaramayya, B.A., was granted 28 months' leave from the 9th September 1922 preparatory to retirement. Mr. A. R. Malik, M.A., B.Sc., was appointed to act.

Mr. V. Doraiswamy Iyer, B.A., was appointed Assistant Director, Agra Upper Air Observatory from the 25th May 1922, but remained posted at Simla.

Rao Sahib V. V. Iyer took over charge of the post of Meteorologist, Bombay, on 1st March 1923 from Mr. W. A. V. D'Rozario : Mr. L. L. Rao took charge of the same post on 28th March 1923 from Rao Sahib V. V. Iyer.

3. The system of storm warning.

The work of warning the Arabian Sea ports of the approach of cyclonic storms or of bad weather was done throughout the year from Simla. The warnings for the Bay ports were, as in previous years, in charge of the Meteorologist, Calcutta, up to the 7th November 1922, but after that date this duty was permanently transferred to Simla, where all warning work of every description is now concentrated. This change is likely to be advantageous on public grounds, for it allows of collective consideration by two or more professional meteorologists of points of difficult interpretation during cyclones, when telegrams of the special observations called for have come in by night or day ; and it should be possible to reduce the errors of judgment which necessarily occurred from time to time when the duties lay entirely on the shoulders of a single half-time officer in Calcutta.

Thirty-two ports are warned for storms in the Arabian Sea, and forty ports and fourteen River Police Stations for storms in the Bay of Bengal. Of the Bay ports thirteen get additional information regarding the particular sections of the Bay in which weather is disturbed, a special system of 'locality signals,' being in use for this purpose. Shipping at sea is also supplied with the latest information regarding the weather by means of wireless bulletins, which are broadcasted twice daily from the radio stations at Bombay, Karachi, Calcutta, Rangoon, Madras, Port Blair Matara (Ceylon) and Aden. The weather bulletins from Matara and Aden were started in March 1920 at the request of the Admiralty. A complete account of the warning system may be found in the "Code of Storm Warning Signals for use at Indian Ports," obtainable from the Superintendent of Government Printing, India, at Calcutta.

4. Warnings for storms in the Bay of Bengal.

During the year warnings were issued for 27 periods of disturbed weather; the disturbances developed into slight or moderate storms during five of these periods, and into cyclones during three. Of the former storms two were of the usual monsoon type forming at the head of the Bay; one formed in the Gulf of Manaar and passing out into the Arabian Sea, intensified there into a moderate storm; one was of short duration and dissipated at sea and the fifth formed in the south of the Bay and crossed the Burma coast near Sandoway. The warnings were correct for all these storms. The three cyclones occurred in the periods 19th to 24th April, 8th to 10th November and 17th to 23rd November. During the April cyclone, which formed to the south-east of the Andamans and crossed the Chittagong coast near Cox's Bazar, the warnings were correct except towards the end when the intensity of the storm was under-estimated and the danger signal was not hoisted at Cox's Bazar. During the first cyclone of November which crossed over Akyab, the warnings contemplated its crossing to the north of that station; but danger signals were kept flying at all ports likely to be affected, including Akyab. In the case of the second cyclone of November, it was believed to be approaching the coast between Cocanada and Masulipatam much faster than it actually did, as very severe weather was experienced there even when it was well out at sea; the warnings to the ports were however correct.

5. Warnings for storms in the Arabian Sea during the year.

The Simla office warns the west coast ports not only for storms but also for squally weather, especially at the beginning of the monsoon. There were 12 periods of disturbed weather for which warnings were issued: during 10 of these the warnings were for squally weather or strong winds connected with the monsoon. In the remaining two periods the warnings were for a cyclone and a storm. For the first of these, which affected the south-east Arabian Sea from the 18th to the 22nd April, warnings were inadequate as the coast observations did not definitely indicate its existence during its earlier days, and such indications as appeared were not fully appreciated. The warnings for the second, in December, were correct, mainly through the great help received by wireless from ships' observations at sea, an advantage which had not been available in the earlier storm in April.

In regard to that earlier storm, it has been said above that warnings were inadequate for reasons given; but it should be added that the Principal Port Officer, Travancore, Alleppey, made certain strong criticisms of the warning action taken during the earlier stages of the storm, in so far as small coasting craft were concerned. Damage to such craft by squally weather was reported to the extent of Rs. 12,000, and the Port Officer held the view that this would have been averted had the warnings been suitable and timely.

An examination in the light of the information now available shows that the grounds for his criticism were not unreal; and while the main operations of the cyclone were properly dealt with, this failure during the early stages of its formation is an instance—fortunately small—of the serious consequences which may result from an inadequate staff provision at warning headquarters: it was a direct result of shortness of officers at the time. Vacant posts have since been filled with officers now to be trained, but with the recent amalgamation of all Indian cyclone warnings for both Arabian Sea and Bay of Bengal by transfer of the latter warnings to Simla, the staff is again below what is necessary to deal these matters of potential disaster at sea and loss on

A further point which militates against the attainment of highest efficiency in cyclone warning duties is the fact that for many years past it has been impossible to spare a responsible officer from a deficient staff to tour the coast ports used in this warning service. The last occasion of such a tour was in 1915, and there has been for some years the need to redetermine instrument exposures known to have become bad, to fix new instruments in many places, and to change observing personnel where this has lost a full sense of responsibility or could be better replaced by local officers more directly connected with the ports concerned.

The duties of cyclone warning are so important that the department takes a serious view of the present position, where the costs of the needed additional staff are so incomparably smaller than the interests involved. The matter of staff is under consideration by Government, but it is understood that the present financial position renders difficult the provision desired.

6. Flood and Storm Warning, and Weather Forecasts to District, Irrigation, Railway and other Officers.

This work was done jointly by Simla and Calcutta Meteorological Offices up to the 7th November 1922, and entirely by the former after that date. The arrangements have been made at various times and differ considerably in character, according to the nature and extent of the flood or weather warnings required by the officers concerned. In most cases these officers require telegrams either warning them of advancing storms likely to give heavy rain, or informing them of the actual occurrence of heavy rainfall likely to give rise to severe floods which might injure railways or canal works; and in other cases, they require warnings or forecasts of the weather for as long a period beforehand as possible.

At the end of the year the number on our lists of district officers and officers in the irrigation, railway and other departments to whom flood warnings, weather forecasts or intimations of the likelihood of rain during the dry season were to be sent by this department was 188. There were also 20 officers of the Telegraph Department requiring warnings, mostly for strong winds.

In order to provide against serious loss of life and property in inland Bengal when a cyclone from the Bay crosses the coast, 461 officers were added during the previous year (1921-22) to the list of those to be warned in such cases, and with the transfer of all such duties to Simla the whole work is now under the charge of Headquarters. Of these officers 40 hoist the signals shown in Appendix D of the "Code of Storm Warning Signals" whenever warned to do so.

The number of special forecasts and warning messages issued by the Department during the year was 4,166, and in addition 825 telegrams of actual heavy rainfall were sent by meteorological observers direct to various officers.

Instructions were issued by the Government of India in 1898 that every officer to whom storm or flood warnings are sent should, in the month of January of each year or, in the case of military expeditions, at the close of the campaign, forward to the head of this department a brief return of the warnings received and should also report whether the warnings were satisfactory and whether any changes might be made to increase the usefulness of the warnings.

Reports on the storm and flood warnings for the calendar year 1922 were received from 51 officers. Of these 28 stated that the warnings were satisfactory, 18 gave no remarks, and the remaining 5 offered suggestions or criticism. Out of

these last named officers two, the Port Officers of Chittagong and Akyab proposed the transfer of the duties of taking meteorological observations to their charge on the ground that they could offer more knowledgeable help than the present observers, and would be able to telegraph voluntarily any important weather changes during the actual progress of storms. The suggestion conforms with the views of the department, and such changes will be brought about there and elsewhere when an opportunity arises for a responsible officer to visit the stations.

The Sub-Divisional Officer, Dehri Workshops Division, also made some suggestions regarding the improvement of warnings for his area.

On the whole a comparison of the warnings with the actual subsequent rainfall shows that the system is working satisfactorily, and that most of the warnings issued were of value to the recipients. As illustrations the following extracts from reports may be of interest : —

The Executive Engineer, Ambala Provincial Division, wrote : " the flood warnings were timely received and were satisfactory in every respect ".

The Superintending Engineer, Indus Left Bank Division, stated that " warnings conveyed by them (telegrams) were generally timely and met requirements."

The Chief Engineer, Indus River Commission, stated that " the warnings were timely and satisfactory in every respect and no change in the system is wanted. I appreciate the care and regularity with which the warnings are issued by the Meteorological Department."

Warnings to Military Authorities in Waziristan.

Telegraphic forecasts of the likelihood of bad weather were sent throughout the year to five different and changing centres in connection with the Waziristan field operations. Opinions as to the utility and possible improvement of the system were invited from responsible officers, and all of them recognized the forecasts as accurate and valuable. The General Officer Commanding, Waziristan Force, suggested that day-to-day forecasts should be sent as " Priority " messages and in response to this wish, warnings when they relate to the day on which they are issued, are now sent as " XXW-Storm " telegrams. The General Officer Commanding, Kohat District, as well as the Intelligence Bureau, Kohat District, says that occasionally the change of weather predicted in the warnings was experienced some hours before the time announced ; it is understood, however, that full value was obtained from these warnings in basing on them the movements of troops and animal convoys.

7. Supply of Meteorological Information.

From time to time special information was supplied to the meteorological departments of England, Australia and Egypt. Climatological and other data, at times involving special calculations, were also provided for sanitary and other officers of Government as well as for those private firms who were willing to pay for the service. The extent to which the department is utilized in this manner will be seen from the curves B and C in the graph at the end of this report.

8. Upper Air Work.

The Upper Air work centres round the observatory at Agra, which supplies material and equipment to the outstations spread over India and Burma, where

pilot balloons are sent up daily ; and exercises close supervision over their work. Information on certain features of the upper air currents is telegraphed to Simla for use in daily forecasting.

The pilot balloons are made of guttapercha tissue about one thousandth of an inch in thickness. They are filled with hydrogen and released, carrying a tail of standard length (usually 100 metres), and are observed as long as possible through a theodolite, while regular timed readings are taken of their horizontal and vertical angles, and of the apparent lengths of their tails as seen in the theodolite. With these measurements the height, distance and geographical course of the balloon can be calculated.

A 6-foot balloon, ready to go up, is shown in figure 1 (on plate at the end), while figure 3 is a picture of a balloon-maker joining the guttapercha segments to form a finished balloon. Usually only 2-foot and 3-foot balloons are used.

Such balloons (3-foot) reach heights as great as 10 miles while still in sight in the theodolite telescope, and in clear weather may sometimes be kept in view up to total distances of nearly 60 miles, accurate measurements of wind velocity and direction being taken over the first 30 miles of their courses. At heights of 4 miles and upwards the cold weather winds of northern India often reach a strength of 100 miles per hour, and are occasionally stronger still, while calms prevail at the surface.

In former years a large number of trials were made with such balloons carrying small self-recording instruments known as meteorographs, of which figure 4 (plate at end) shows the Dines' type. Such an instrument registers accurately the pressure and temperature, and roughly the humidity, at all heights during its ascent and descent ; it weighs just about an ounce and has sometimes in Europe reached heights as great as 15 miles. Steel marking points attached to the recording portions make indelible records on a silvered sheet of metal or glass, the whole record being about the size of a postage stamp, and requiring a micrometer microscope to decipher it. Before use these instruments have to be calibrated for pressure in special air-pump apparatus, and for low temperature (such as exists in the upper air) by immersing them in petrol, cooled with carbonic acid snow to about −60°C (108° of Fahrenheit frost).

On descent a meteorograph may land as far as a hundred miles, or even more, from the place at which it was sent up ; and to secure its return, a label in several vernaculars is attached to each instrument-basket sent on a flight. The finders (of whom two are illustrated in figure 2) get a reward for delivering the basket to the District Officer in good condition. About 70 per cent. of such instruments are usually recovered.

Besides the work of computation of upper air data, the complete analysis of cloud observations, taken regularly several times a day at 11 stations in India, is also a routine business in Agra. Repair of instruments belonging to the department is undertaken at the workshop of the observatory.

An important feature of the year was the organization of a service of " meteor " parties for the artillery practice camps to which a reference has been made in paragraph 1 of this report. The requirements of the military authorities were met, but with some difficulty on account of inadequacy of observing staff at Agra : and

the step proves to have been fully warranted as judged by expressions of appreciation from Army Headquarters. It is understood, indeed, that the detailed numerical information on wind strengths and varying directions obtained by balloons several times daily during gun-practice is now considered indispensable; and the department has since been asked further to co-operate by devising some practical form of affiliation between Agra Observatory and Field Service organizations on war frontiers. It appears that it may become necessary to consider for the future some provision of extra trained staff for this work, if the scientific work of the Agra Observatory is not to be handicapped.

Among the contemplated activities at Agra may be mentioned the extension of pilot balloon work, the re-starting of meteorograph flights, night flights with ordinary balloons and a study of the temperature gradient above ground.

9. Researches by the Simla Staff.

Shortness of gazetted staff again prevented a start being made on the preparation of type maps for daily forecasting, which have for some years been regarded as an important requirement.

A paper by Dr. Walker on "A preliminary study of world weather", based on statistical study of weather changes in different parts of the world, was prepared for publication.

It has been discovered that the westerly components of upper air winds at Agra at a height of about 4 miles, as prevailing from the middle of September to the middle of October show a close relationship with the precipitation in north-west India in the winter following. This matter is being followed up in view of its probable high value, should it prove to be supported by a larger series of years of observation.

10. Observatories.

The Director of the Solar Physics Observatory at Kodaikanal published a report on astronomical work for 1922.

The Observatory takes a prominent part in the world-wide programme in hand by the International Astronomical Union. At a meeting in Rome in 1922 the Union allotted to India (Kodaikanal) the task of collecting from all contributing observatories in other countries the photographs of solar prominences and of the sun's disc taken in monochromatic (H 8) light, and of measuring them systematically. This work was begun regularly in January 1923.

The routine at Kodaikanal includes, among other things, taking and measuring photoheliograms and spectro-heliograms, and observations of sun-spots and prominences. Photos of two prominences—vast eruptions of glowing masses of vapour, rising from the sun's surface with velocities sometimes as great as 500 miles a second—may be seen in figs. 5 and 6 on the plate at the end of this report. *Fig.* 5 shows a typical prominence associated with a sun-spot and composed of hydrogen, helium, sodium, magnesium and iron. It was about 50,000 miles high, and lasted for more than 4 months, with continual variations in shape. Fig. 6 is another prominence composed of hydrogen, calcium and helium, and extending to a height of nearly 100,000 miles. At its first appearance it was a quarter of a million miles high, and its life was nearly 3 months. Measurements of prominences are possible only when they are on the limb of the sun, where they can appear repeatedly on account of the solar rotation.

Figs. 7 and 8 are photographs taken on 29th and 31st December 1922 showing sunspots appearing in different positions on the disc on account of the rotation of the sun in the intervening two days. The complete period of this rotation at the solar equator is 25 days, and 27½ days at 45° of solar latitude. The bright patches on these photos are regions where hot calcium vapour has been brought up from lower levels by a solar disturbance.

In the course of his study at Kodaikanal of the solar spectrum Mr. Evershed has found displacements of the spectrum lines of sodium and iron which are comparable in amount with what should occur, on the Einstein theory, as a result of the sun's gravitation: his work thus lends experimental support to the theory and prediction of this effect.

In regard to structural matters in the equipment of the Observatory the only development during the year was the replacement of the existing roof of the spectro-heliograph building by a double roof for reducing the variation of temperature inside the building.

Colaba Observatory and Alibag Magnetic Observatory remained in good condition throughout the year. The more important of the scientific data which result from the work at these observatories will be found in the annual volume which is now to replace the old quinquennial volume of Bombay data.

At the Colaba Observatory an extensive routine activity is the rating of Royal Indian Marine and Royal Navy Chronometers, of which more than 200 were issued to ships, after rate-testing. In addition to its usual work this observatory will soon have the additional duty of issuing the Bombay Daily Weather Report, as the Bombay Meteorological Office is to be amalgamated with the Observatory.

The Madras Observatory supplies time, astronomically determined, to the whole of the country. Calcutta broadcasts time signals independently at certain hours of the day for ships at sea and in order to render possible an accurate comparison between the Calcutta and Madras clocks, a new wireless receiving apparatus was set up at the Madras Observatory.

The purely meteorological observatories under the department's care number 283 of which 237 were maintained by the Government of India; these include stations as far afield as Tehran, Kashgar, Aden and Seychelles. According to the classification given in the report for 1918-19, the departmental observatories consisted this year of 5 of the first class, 185 third class, 23 fourth class and 24 fifth class.

The maintenance of these observatories, the supply to them of tested instruments, and the careful scrutiny of their observations to detect mistakes, naturally entail much work of a routine character at headquarters. The correctness of observations depends upon the continuance of good exposure and good condition of instruments at observatories, and upon the accuracy of reading by observers. The former point can only be ensured by inspection visits of trained officers, but for many years this need has had to be neglected. The latter point can to some extent be estimated at headquarters from the data received. An idea of the standard of accuracy maintained in reading the instruments may be obtained from the number

of mistakes detected in the data for the Indian Daily Weather Report. The stations of great reliability in which no mistake or at most one has been detected, numbered 33, and the number at which more than 50 mistakes were made was 2. The average number of mistakes during the year at the remaining stations was 12.

11. Inspection of Observatories.

This essential requirement for the maintenance of accuracy in results suffered again, as in the previous seven years, from shortage of staff, but although towards the close of the year the complement of gazetted officers became full, an improvement in respect of inspection cannot be expected in the near future on account of the new restrictions in travelling grants (see paragraph 1). During the year, 24 stations were inspected by gazetted officers and others, while the Director-General of Observatories and the Officiating Director-General of Observatories made inspections at the principal observatories at Alipore, Madras, Bombay and Agra.

12. Marine Meteorology.

Wireless weather messages from ships at sea and the ships' logs to which access is obtained at the ports of Bombay and Calcutta are the main sources of marine data collected by the department.

The object of the system of radio messages from ships is mainly to supplement coast observations in cyclone warning work. In the absence of observations from the sea areas it was not always easy to draw correct conclusions about the position, movement and intensity of storms. This was the case particularly with disturbances in the Arabian Sea, for which inferences had in general to be drawn from the very insufficient observations from the western coast line of India. The system was organized in 1914, but with the outbreak of war it remained in abeyance till it was reopened in 1920; subsequently in July 1921 the Marconi Company agreed to help the department by allowing these telegrams to be transmitted free of ships charges. It worked fairly well during the year and messages from ships, not only those in the vicinity of the storm but also vessels at considerable distances from the centre, were found useful in determinations of position and course.

With the permanent transfer to Simla in November 1922, of the work of storm warning for the Bay of Bengal the number of W/T messages from ships received at Simla during the year rose to 956, and the thanks of the department for these are due to the commanders of ships, sailing in Indian waters. There is still much scope for improvement in the direction of fuller co-operation between ships and this department.

In regard to the second source of marine data, the work of visiting ships and copying logs at Calcutta and Bombay is entrusted to clerks from the local offices of the department. The number of ships visited was materially less than the arrivals, but was as large as an inadequate staff could deal with.

The data thus obtained are utilised in the preparation of charts of disturbances in the Bay of Bengal and the Arabian Sea, for future reference in connection with the storm warning work of the department, and in drawing up an account of the storms of the year for publication in the India Weather Review (Annual Summary).

13. Snowfall Registration in the mountain districts to the north and west of India.

The information as to the amount, distribution and time of occurrence of the snowfall in the Himalayan and Afghan mountain areas was on the whole tolerably complete, and the thanks of the department are again due to the various officers who have collected and forwarded it.

14. Rainfall Registration.

The registration of rainfall in India has always been carried out by the provincial authorities. In 1889 a uniform system was introduced by the Government of India, and the Director-General of Observatories was made consulting officer in connection with this work. His advice is sought regarding the starting of new raingauge stations, and he receives annual reports upon the efficiency of the work from the local controlling officers who are in most of the provinces the Directors of Agriculture or of Land Records.

The following is a statement of the number of raingauge stations supplying data for publication in the "Rainfall of India" as they stood in March 1923 :—

Province.	Number of stations.	Province.	Number of stations.
Burma	238	Baluchistan	85
Assam	126	Rajputana	178
Bengal	251	Central India	96
Bihar and Orissa	313	Central Provinces and Berar ..	189
United Provinces	276	Bombay and Sind	289
Punjab	191	Hyderabad	18
Kashmir	39	Mysore (exeluding raingauges in taluks).	77
North-West Frontier Province ..	35	Madras (including feudatory States)	525

In 1920 the necessity of frequent inspections of raingauges was brought to the notice of the officers in charge of rainfall registration, and subsequent reports have shown a decided improvement in this respect.

The following notes are based on the reports for 1922-23 of these officers :—

Burma.—There were 237 stations as against 230 last year. Out of these 18 were meteorological observatories, 29 were under the Public Works Department, 2 belonged to the Agricultural Department, and the rest were supervised by civil officers. One hundred and ninety-two raingauge stations were inspected during the year, out of which 160 were reported good and the remainder in fair condition ; the chief defects reported were, as usual, nearness to buildings and trees.

Assam.—Two stations were closed during the year and three stations opened ; on the 31st March 1923 there were 126 raingauge stations. The number of inspections reported is 150 against 160 of last year. The stations inspected were 110 against 114, and those not inspected 16 against 11 of last year.

Bengal.—Five new stations were opened during the year making a total of 251. Of these only 109 were inspected during the year ; the corresponding figure last year was 151. The smaller inspection list in 1922-23 was due to the curtailment of travelling grants.

Bihar and Orissa.—The number of stations was 313 including 29 stations in the Feudatory States and Tributary Mahals of Orissa. Inspection reports received (including those of a few stations inspected twice) numbered 264. According to District Officers' reports about 16 per cent. of stations were not inspected, but inspection cards were not received from 36 per cent. of the stations. It appears therefore that in 20 per cent. of the stations although inspected the reports did not reach the Agriculture Department. Steps are being taken to remedy the position disclosed.

United Provinces.—There were 288 stations including meteorological observatories: out of 272 stations under the supervision of district and canal officers, 74 per cent. were inspected as compared with 43 per cent. in the previous year.

The Punjab.—(Report of the Director of Land Records, for calendar year 1922). All the raingauges in charge of civil officers are in good condition, the number inspected once or twice being 115. Report from Karnal district is wanting. The raingauges in charge of canal officers are in good working order and officers have been inspecting them from time to time. Enquiries as to whether there were any stations in charge of district officers not included in the Monthly Rainfall Statement show that there are no such stations.

Kashmir.—The Meteorological Reporter states :—" The number of raingauges is 39 in all, out of which 31 are merely rain recording stations and 8 are meteorological observatories. The number of inspections of raingauge stations made during the year was 19 against 14 of last year, which is satisfactory."

North-West Frontier Province.—A paragraph dealing with raingauge inspection in the Annual Report of Land Records and Agriculture for 1921-22 states :—" The instructions for inspecting at least 75 per cent. of the raingauge stations each year have been complied with in all the districts except Kohat, where no raingauge station was inspected during the year. Necessary orders have been issued to the officers concerned to comply with the instructions." Twenty-eight raingauges were inspected during the year and practically all were in good working order.

Baluchistan.—The Revenue Commissioner writes :—" The raingauges in the Agency were regularly read by persons in charge and inspected occasionally by various officers."

Bombay and Sind.—The Director of Agriculture writes among other things :—" ..... out of a total of 278 gauges in the Presidency, as many as 206 or nearly 74 per cent. were inspected during the year under report as against 241 or 87 per cent. during the last year, while the total number of inspections during the year was 293 as against 354 of the previous year. In the Native States 37 gauges out of a total of 61 or nearly 61 per cent. were inspected during the year as against 54 or about 72 per cent. in the last year.

" These figures reveal the fact that the progress made during the previous year has not been maintained this year either in the Native States or the British districts. But though this is the case, when a comparison is made with the previous year, yet it compares well with the average number of inspections made during the years of the last quinquennium.....".

" The salient feature of the year under report, however, was the very close scrutiny exercised with regard to the Raingauge Inspection Reports received in this office. Every defect, however small, was brought to the notice of the proper authority and suggestions made till it was removed."

Central Provinces.—The number of inspections of raingauge stations in the Central Provinces during the year was 155 against 106 in the previous year and 202 in 1920-21. In Berar the number was 44 against 64 in the last year. It is stated that in 12 districts the inspecting officers had not made sufficient inspections in conformity with the instructions contained in paragraph 10 of Revenue Book Circular III-2.

Hyderabad.—The Superintending Engineer, Eastern Circle, states that 4 raingauge stations were inspected.

Mysore.—The number of stations in the Mysore State for recording rainfall was 226. The inspection of raingauges was on the whole satisfactory as 199 were inspected during this year against 184 in the previous year; expressed in percentages there was a rise from 81 to 88.

Madras.—The total number of raingauge stations in the Madras Presidency on the 31st March 1923 was 395, of these 355 were inspected or 90 per cent. as against 92 per cent. last year.

A general review of these reports shows that in Burma, Assam, Bihar and Orissa, the North-West Frontier Province, the Central Provinces, Mysore and Madras the proportion of inspection of raingauge stations was over 75 per cent., in the United Provinces and Bombay it was 74 per cent., in Kashmir and the Punjab it was about 60 per cent., while in Bengal and Hyderabad it was 44 per cent. and 22 per cent., respectively.

Heavy Rainfall Reports.

Heavy rainfall is occasionally so very local that small areas can have as much as 10" of rain without the Daily Weather Report conveying the least suggestion of it. With a view to have such useful data promptly available for the Daily Weather Report it had been arranged in 1921 with the approval of the Government of India that reports of 5 inches or more of rainfall should be telegraphed to Simla from raingauge stations at district head-quarters throughout the country. Very few of such telegrams were received in 1921 because the system was organized after the monsoon season of that year. The number of such telegrams was 146 during 1922-23.

15. Seismograph observations.

Seismological observations were recorded throughout the year by two Omori-Ewing seismographs at Simla, two at Calcutta and one at Bombay, and by a Milne seismograph at Kodaikanal. At Bombay (Colaba) there continued in use also two horizontal pendulum seismographs with specially elongated arms in their recording apparatus: a new Milne-Shaw machine was put into use there in February 1923. All the seismic data collected at these places were sent to the Seismological Committee of the British Association.

16. Time Signals.

The observatories at Madras, Calcutta and Bombay determine time from star observations, and communicate it to the local ports by time-ball signals. The distribution of time over the country generally is made from the Madras Observatory by a signal transmitted daily at 16 hrs. over the Indian telegraph system. A wireless time signal for the use of ships is broadcasted automatically twice daily from the Alipore Observatory at 1-30 and 13-30 G. M. T. through the Calcutta radio station. Arrangements for setting up a transmitter for similar wireless time signals at Bombay are being made with the Telegraph Department.

All time work was done satisfactorily throughout the year.

17. Publications.

Under the stress of the necessity to economise, important changes in the routine publications were carried out or decided upon during the year. The Monthly Weather Review, which was in arrears, had to be abolished from January 1921, and replaced by a Monthly Weather Report which was started from January 1923. For the intervening period the issues of the Annual Summary for 1921 and 1922 will be enlarged so as to embody all the monthly data.

With a view to further economy it was decided to stop periodically the provincial daily weather reports, the period of suspension for Bombay being fixed as 1st November to 30th April, for Madras 1st January to 31st March, and for Calcutta 15th November to 31st December; the change was brought into force from 1st January 1923.

As usual the Daily Weather Telegram was despatched to subscribers regularly about noon, and the weekly rainfall summary was supplied to the *Gazette of India* and to press correspondents in Simla.

In October 1922 was started a new Weekly Weather Report containing matter similar to that in the weekly summary published in the *Gazette of India*, and meant principally for prompt supply of information to the commercial public. Under

existing arrangements it will be published only during the monsoon period, *i.e.*, June to October.

The quinquennial volume of the Bombay Observatory has given place to an Annual Volume presenting the data in a modified form of two-hourly values of the more important elements recorded.

The routine publications of the department remain otherwise unchanged and the list of such publications as it stands now is given below :—

1. Indian Daily Weather Report.
2. Weekly Weather Report.
3. Monthly Weather Report.
4. Annual Supplement to the Daily Weather Report.
5. India Weather Review (Annual Summary).
6. Daily Rainfall of India.
7. Monthly Rainfall of India.
8. Report on the Administration of the Meteorological Department of the Government of India.
9. Memorandum on the probable character of the weather in north-west India in January, February and March.
10. Memorandum regarding the probable amount of monsoon rainfall.
11. Memorandum on the rainfall of June, July and the probable amount during August and September.
12. Statement of the rainfall and snowfall of north-west India in January, February and March, and a comparison of the seasonal forecast with the actual precipitation.
13. Statement of actual rainfall in June, July, August and September, and a comparison of the forecasts with the actual rainfall.
14. Kodaikanal Observatory Bulletins.
15. Annual Report of the Kodaikanal Observatory.
16. Calcutta Daily Weather Report.
17. Bombay Daily Weather Report.
18. Madras Daily Weather Report.

The following memoirs of the Indian Meteorological Department were published during the year :—

Volume XXIII, Part III, " Mean monthly characters of Upper Air winds deduced from the flights of pilot balloons at thirteen stations in India during the period 1910 to 1919 ", by J. H. Field.

Volume XXIII, Part IV, " The effects of oscillations and of ' lag ' on the readings of the Kew pattern barometer ", by E. P. Harrison.

Volume XXIII, Part V, " On cleaning and refilling various types of barometer, together with a description of several usual patterns ", by E. P. Harrison.

Volume XXIV, Part I, " On the seat of activity in the Upper Air ", by P. C. Mahalanobis.

Volume XXIV, Part II, " On errors of observation and upper air relationships ", by P. C. Mahalanobis.

Volume XXIV, Part III, " On exposures of thermometers in India ", by J. H. Field.

18. Library.

Of books and pamphlets, 632 were either purchased or received as presentation copies from scientific bodies for the libraries in Simla and Calcutta during the year.

In the Simla library the work of classification based on the schedule of the International Catalogue of Scientific Literature made further progress, current books and pamphlets were classified immediately on receipt. During the year 2,104 books and pamphlets were catalogued and card-indexed, according to subject and author.

19. Concluding Remarks.

The Meteorological Department owes a large part of its usefulness to the sympathetic assistance it receives from outside departments. Civil Surgeons and other officers of Government departments, as unpaid superintendents of observatories and in other capacities, help in the meteorological work; the Telegraph and Postal Departments assist in every way in the rapid transmission of meteorological information; at the same time they allow their employees to act as observers. The Indo-European Telegraph Department, also, by giving free transit to the daily messages of the Persian observatories, places a large amount of most useful information at the disposal of the Meteorological Department. Weekly telegrams were received from May to September from the Director of the Royal Alfred Observatory, Mauritius, as well as from the departmental observatories at Zanzibar and Seychelles. These telegrams gave valuable information of the weather conditions in the Indian Ocean and the department is indebted to the officers indicated for the punctual transmission of the information. Thanks are especially due to the Director of the Royal Alfred Observatory for his courtesy in placing the meteorological data of that observatory at the disposal of the Indian Meteorological Department.

The department is greatly indebted for important information about meteorological conditions prevailing before and during the south-west monsoon to the Controller, Physical Department, Cairo; the Directors of the Observatories at Buenos Ayres, Santiago and Batavia; the Astronomer Royal, Cape Town; Director, L'Observatoire Physique Central, Petrograd; M. Thorkell Thorkelsson, Löggildingarstofan, Reykjavik, Iceland; the Director of the Meteorological Services of the Azores, Ponta Delgada, and to the various officers around the Indian frontiers who have collected and supplied valuable snowfall information.

The thanks of the Department are also due to Mr. A. J. Bamford, Superintendent, Colombo Observatory for the very useful help he has rendered from time to time in connection with storm warning work.

Simla; J. H. FIELD,

The 6th August 1923. *Offg. Director-General of Observatories.*

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Upper Air Work.

Incidents and instruments.

(For explanation see para. 8.)

Fig. 1.

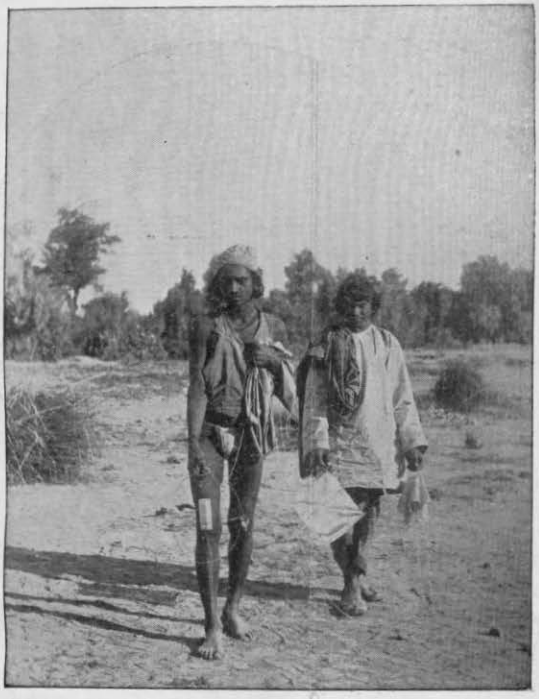

Fig. 2.

Fig. 3.

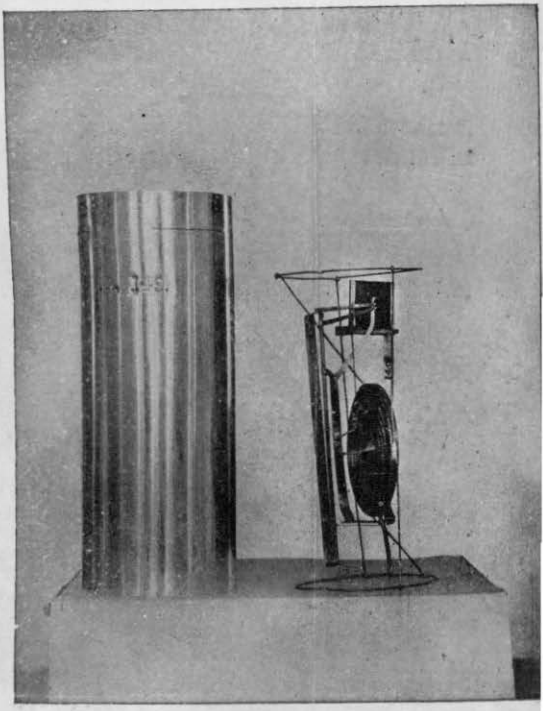

Fig. 4.

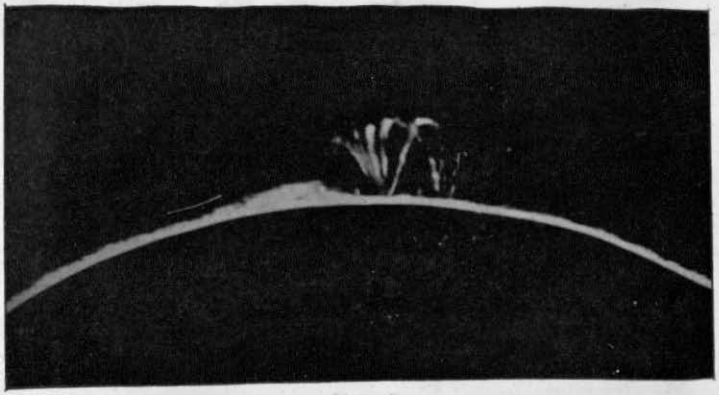

Fig. 5.

Fig. 6.

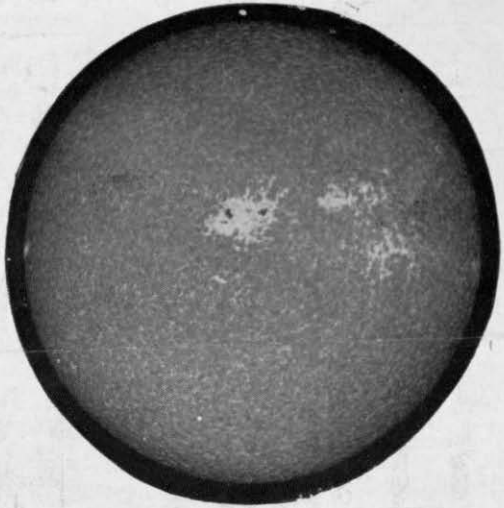

Fig. 7.

Sunspots :
showing rotation
of the sun.

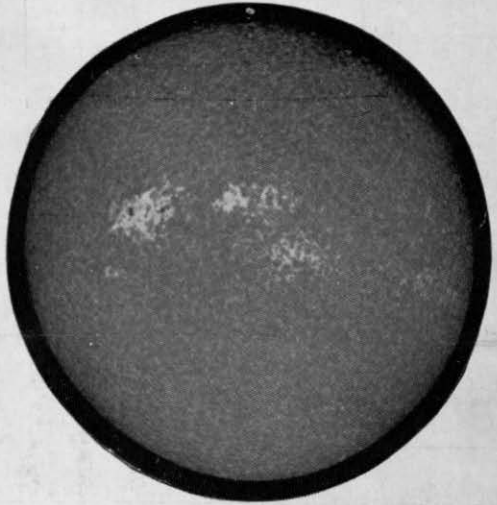

Fig. 8.

Kodaikanal Observatory.

GROWTH IN ACTIVITY AND COST