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THE SIXTY-INCH REFLECTOR OF THE MOUNT WILSON SOLAR OBSERVATORY.*

By E. A. FATH.

THE new sixty-inch reflecting telescope of the Mount Wilson Solar Observatory has been in operation for about one year. It is primarily a reflector of the Newtonian type with an aperture of sixty inches and a focal length of twenty-five feet. The outer section of the tube carrying the Newtonian plane mirror can be replaced by similar sections carrying convex mirrors which reflect the cone of light back toward the large mirror. Then by introducing a plane mirror in the path of the beam near the lower end of the tube

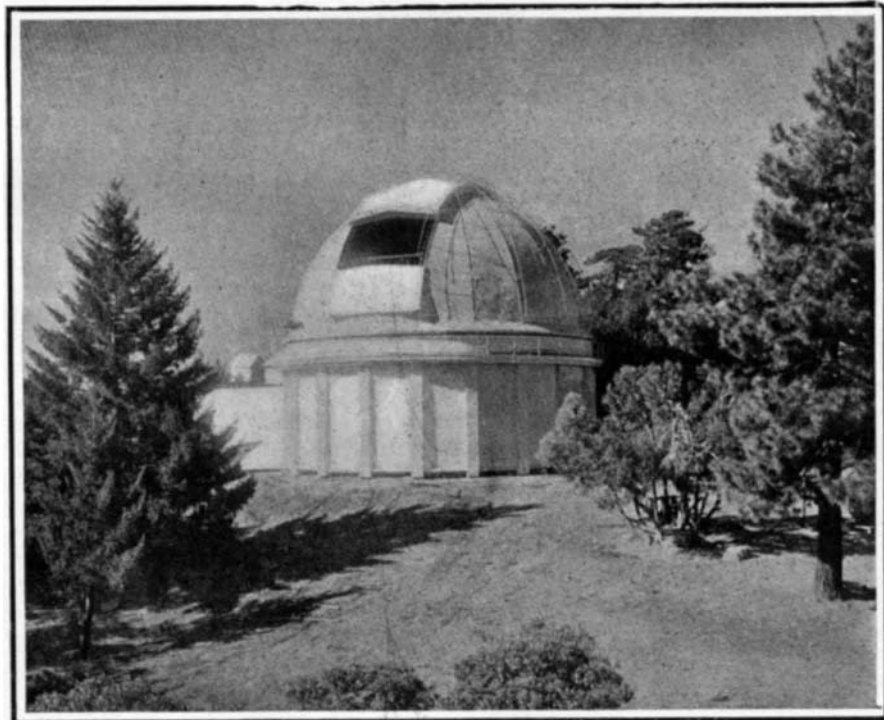
to throw the beam out to the side it is possible to obtain equivalent focal lengths of 80, 100 or 150 feet. For direct photography either the 25- or 100-foot focus is used; for spectrographic work the 25-, 80- or 150-foot combinations are available.

The steel tube is of skeleton construction, exceedingly rigid and weighs only four tons. It is carried by a massive fork at the upper end of the polar axis. Most of the weight is taken off the bearings of this axis by means of an iron float fastened to it and buoyed up by mercury. The moving parts of the telescope weigh about twenty-three tons.

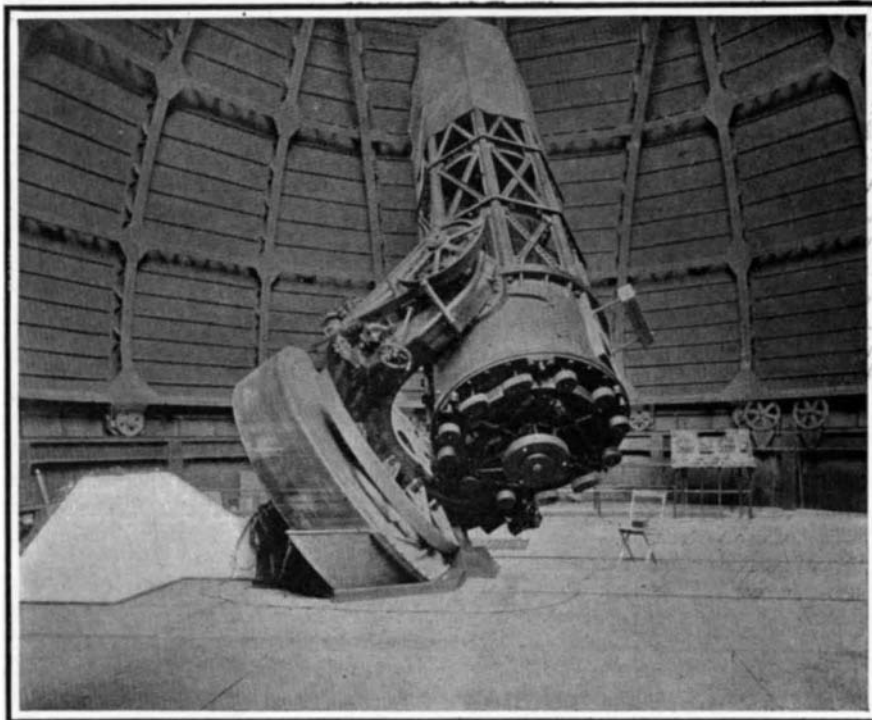
The driving clock, which stands six feet high, is of the Warner & Swasey type such as is used for the Yerkes and Lick refractors. There is, however, one important modification. Instead of the governor

being connected with the driving shaft by means of the ordinary system of gears it is connected directly through a small worm gear. The weight for the clock consists of sixteen cast-iron disks, each weighing about one hundred pounds. The winding of the clock is automatic. When the weight is nearly down, it closes a circuit and an electric motor then winds it up. When the weight has reached the proper height, it breaks the motor circuit. The clock thus needs no attention throughout the night. The large worm gear which rotates the telescope is ten feet in diameter. When properly rated the clock runs very accurately. Frequently the guiding star will remain on the cross-wires of the guiding eyepiece for five minutes at a time.

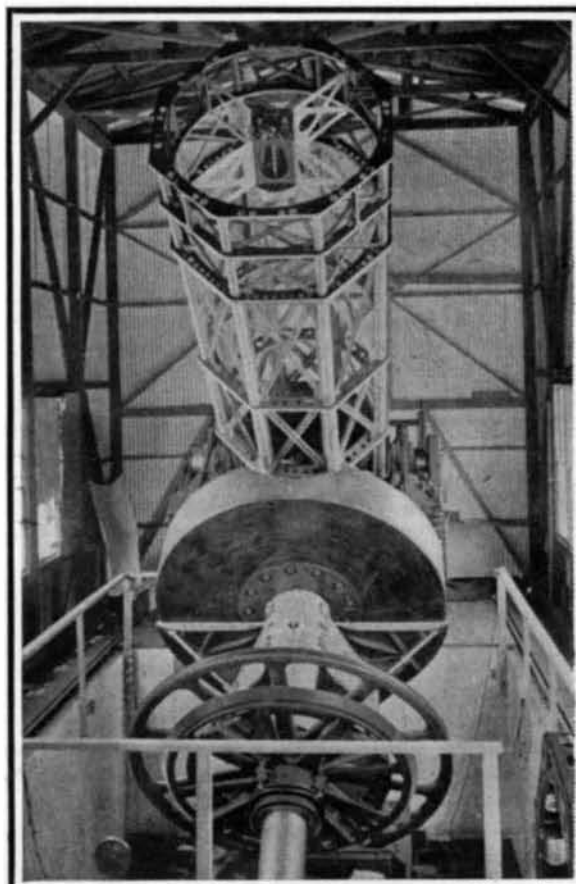
The optical properties of the large mirror are of



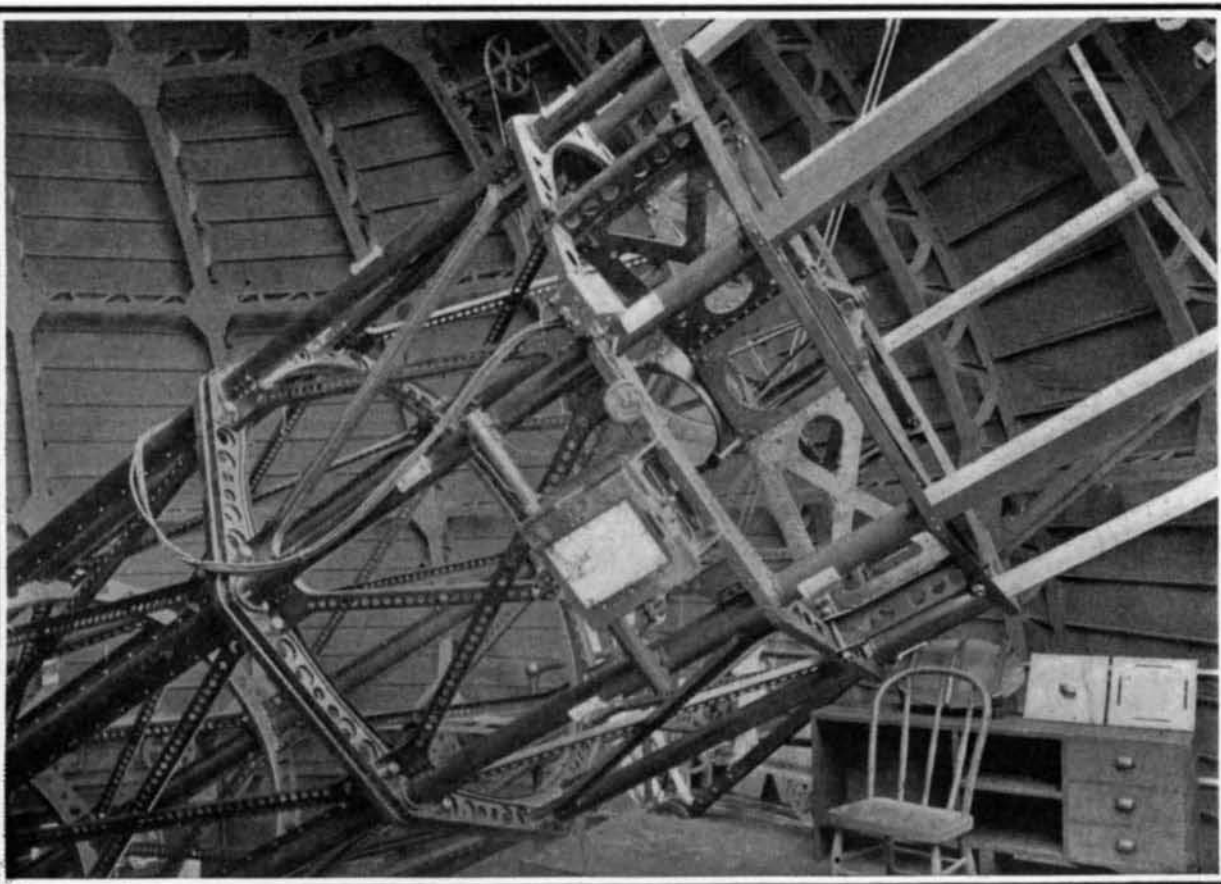
STEEL BUILDING AND DOME FOR USE OF SIXTY-INCH REFLECTOR.



SIXTY-INCH REFLECTOR MOUNTING IN DOME.



SIXTY-INCH REFLECTOR MOUNTING IN ERECTING SHOP.



DOUBLE-SLIDE PLATE-CARRIER IN PRINCIPAL FOCUS OF SIXTY-INCH REFLECTOR.

THE SIXTY-INCH REFLECTOR OF THE MOUNT WILSON SOLAR OBSERVATORY

the highest order. The surface is correct to about 0.000002 of an inch. This is 1/10 the wave length of sodium light. Under good atmospheric conditions star images measuring only 1.3 inches in diameter have been obtained on Seed "23" plates with exposures up to two hours in length.

The building and dome are built of steel throughout and rest on a concrete foundation. The walls are double with an air space of two feet between them and so arranged to permit a free circulation of air. The dome, which is fifty-eight feet in diameter, is covered, except in winter, with white canvas about two feet above the metal surface. It is found that in the summer this simple device to prevent the sun shining directly on the dome cuts in two the daily range of temperature within.

The building has two floors, the lower at the ground level, and the other, the operating floor, nineteen feet above this. The former is of cement and the latter of thin steel plates. The opening in the dome is sixteen feet wide, the shutter running back over the dome instead of opening to the side as in the usual type. The observing at the primary focus is done from a movable platform that can be raised or lowered along the curve of the dome opening. Electric

motors are used for all movements of the telescope, dome and observing platform.

The changes of temperature referred to above have an appreciable effect on the performance of the telescope owing to the changes in the focal setting as the tube cools during the night. With the canvas cover over the dome this amounted to only 0.04 of an inch during the average night. This, however, was still too great, especially for long exposures running over several hours. In order to further decrease the effect an insulating chamber of woolen blankets was made to be placed over the lower half of the tube, the mirror, the float, etc. Radiation from the floor is prevented by mats of the same material. The opening in the tube where the covering surrounds it is closed by a tight-fitting wooden cover lined with felt. Under average conditions the daily range of temperature within the cover has been reduced to 2 deg. Centigrade (35.6 Fahrenheit). This in turn has reduced the change of focal setting to 0.02 of an inch. During long exposures the plate can be removed and the focus corrected at intervals so that the plate is never out of focus by more than one or two-thousandths of an inch. The method of focusing is simple. A carefully ground knife edge is placed across the center

of the field and the image of a star at the center examined just as an artificial star image is examined in the optical shop. When the knife edge is at the focus of the mirror and is moved across the cone of rays, it causes the mirror to darken uniformly over its whole surface until all the light is cut off. This test is visual, the eye being placed close to the knife edge. By this method the focus can be determined with an accuracy of about 1/1000 of an inch in a minute or two.

A great variety of work is being undertaken with this telescope. At present it is being used for the photography of nebulae and star clusters; the photography and spectrographic work on all the regions that can be reached that are included in Kapteyn's "Plan of Selected Areas"; spectrographic work on the brighter stars, star clusters and nebulae and photometric work of various kinds.

Mr. Ritchey, who ground and figured the large mirror and designed the dome and mounting, is to be congratulated on the success he has achieved in completing such a great instrument, and we look forward to the day when the contemplated 100-inch reflector will be completed in the hope that it will prove even better than the sixty-inch.

SVEN HEDIN'S "TRANS-HIMALAYA."*

DISCOVERIES AND ADVENTURES IN TIBET.

THE special quest of Dr. Sven Hedin in his last and greatest journey of geographical exploration in Tibet was that hitherto unexplored range of mountains, which was believed to rise within the unsurveyed white patch of desert on the "Roof of the World" to the further side of the Tsangpo or Brahmaputra, behind the Himalayas. Although this immense chain, stretching for about 600 miles, is one of the mighty mountain ranges of the earth, and forms the northern watershed of the great Brahmaputra, as well as of the Upper Indus, yet its very existence, even, was largely the subject of conjecture.

A line of high peaks in this desolate region was first reported about 200 years ago by a party of surveyor-Lamas, who had been trained and sent out into Tibet by the Jesuits of Peking, under the patronage of the Emperor Kang-hsi; and the peaks, as located and named by these Tibetans, and rediscovered by recent travelers, figure on the rough map, published by D'Anville, in A. D. 1733. Brian Hodgson, in 1848, as the result of his inquiries in Nepal, depicted these peaks in his sketch-map as forming portions of a hypothetical range of mountains, stretching continuously from the Karakorum and Pamirs on the west to the Tengri Nor Lake near Lhasa on the southeast; and he assigned to it the name of "Nyenchen," after the name of the highest peak near its Lhasa end. In the map attached to Huc's travels, this range is also represented as an unbroken chain; and so, too, in Saunderson's map of 1879 in Markham's "Tibet"; while Grenard, the companion of the ill-fated de Rhins, in 1899, indicates it conjecturally as a double range, which Col. Burrard, of the Indian survey, in his recent book on the geography of Tibet, has called the "Kailas Range," after the famous Mount Olympus of the Hindus, at its northern end. So great, indeed, was the need for the exploration of these mountains deemed to be that the president of the Royal Geographical Society declared a few years ago that: "In the whole length, from the Tengri Nor to the Mariam La, no one has crossed them, so far as we know" (a statement, by the way, not absolutely correct, as the pundits Nain Sing and A.K. and Littledale had crossed them). "I believe nothing in Asia is of greater geographical importance than the exploration of this range of mountains."

This, then, is the range to which Dr. Hedin now assigns the appropriate name of "Trans-Himalaya," after having zigzagged across it by eight different passes, and after mapping out its contour in considerable detail.

More than this, the two handsome volumes in which Dr. Hedin tells the story of this great achievement differ from all his previous books on the "Forbidden Land" in possessing greater human and living interest. For the first time, after his many previous years of travel in that country, he has been able to penetrate beyond the desolate deserts and reach a portion of what he truly terms "Tibet proper, that is the part chiefly inhabited by a settled population." For this good fortune and for the more friendly treatment generally which he experienced at the hands of the Tibe-

tans he is indebted directly to the amicable relations established with Tibet by the British mission of 1904, none the less real and genuine though cultivated at the point of the bayonet. These relations of friendship and respect, strengthened and cemented by the visit of the Grand Tashi Lama to India in 1905 to meet the Prince of Wales, have enormously increased the prestige of the European throughout Tibet and Central Asia. Thus, a section of Younghusband's mission with four British officers, unaccompanied by any escort of their own, but relying solely on the protection of the Tibetans, was able to pass in a friendly way through those inhabited districts of Tibet, two years before Dr. Hedin visited them; and several other Europeans have visited the Tashi Lama's palace and the western capital. In particular, Lord Minto, the Viceroy of India, to whom the author gratefully dedicates his book, "used his influence with the Tashi Lama so that many doors in the forbidden land formerly tightly closed were opened to me."

The start, under such favorable conditions, was made in August, 1906, from Ladak, by way of Kashmir, as the recent treaty with China absolutely prohibited Europeans entering Tibet across the Indian frontier, and could not be relaxed by the Indian Government even in favor of Dr. Hedin, much to his freely expressed vexation. He gave out that he was proceeding to Turkestan, but in the solitudes, a few marches out of Leh, he crossed the lofty Karakorum range and turned southward into the great elevated Tibetan desert, the Chang-tang. Here he pushed on through the stark solitudes, day after day for two months, surveying the country, without meeting a soul until he crossed the Trans-Himalaya near the capital of Western Tibet. The first nomadic herdsmen he encountered were friendly and acted as guides and supplied provisions and baggage animals. They, as well as their chief, informed him of the friendly passage that way of the British officers, saying that "now Europeans seem to be privileged to pass through the country." In a few days more, Tibetan couriers arrived with his European letters, which had been sent on by the British agent through the Tashi Lama, at the request of Lord Minto; and accompanying these letters, were welcome stores of European provisions, newspapers, books, etc., as presents from the British agent at Gyantse; and, most important of all, an official to guide and assist Dr. Hedin through that inhabited portion of Tibet to the Tashi Lama's capital.

Thereafter, writes our author, "the route was as free to us as the uninhabited Chang-tung had been. We should pass black tents daily, be able to buy all we want. We enjoyed unlimited freedom, and had not a single man with us as escort or watchman." Arrived at the capital, Shigatse, he says, "the priests welcome us with kindly good-tempered smiles," and he was installed as the favored guest of the Tashi Lama, the second of the "Living Buddhas," who received him cordially several times. This high honor which he procured through Lord Minto, proved so invaluable to Dr. Hedin, that, as he writes, "eighteen months later it came about that chiefs and monks said Bonpo Chimbo (great lord!) we know that you are a friend of the Tashi Lama, and we are at your service!" His Holiness, it is interesting to learn, has been a keen photographer since his visit to India, when he was initiated into the mysteries of the art by

British officers. In his palace he has had a dark room fitted up, where the developing is done by one of the young priests who accompanied him to India. While halting at the Tashi Lama's capital, our traveler lightened his baggage by sending back to Europe, through the British officer at Gyantse, his survey records, note-books, photographic plates, rock-specimens, etc. Here, also, he witnessed the new-year's carnival and festivities, and was allowed to roam freely over the famous palace of the monastery of the Tashi Lama, a busy hive of four thousand ascetics; but, unfortunately, our author, through want of special knowledge, has not added anything to our information on these interesting subjects.

His stay at Tashilhunpo was brought suddenly to an end by the Chinese officials at Lhasa, who insisted on the Tibetans enforcing the treaty, so that Dr. Hedin was compelled to return forthwith to Ladak under a guard. On the way he succeeded in eluding his guard and made a detour across the Trans-Himalaya by two fresh passes; he also discovered a new western source of the Brahmaputra, and took a series of soundings over Lake Manasarowar, by means of his portable boat.

On return to Ladale, with characteristic pertinacity, he decided to make a second expedition back again to Tibet, in order to complete his partial exploration of the Trans-Himalaya, as he reflected that, "it was especially irritating to think that others might come here and rob me of these conquests." So with a fresh caravan, got together with the aid of the British officials, he plunged south once more through the terrible Tibetan deserts, and much astonished the discomfited Tibetan chiefs by his reappearance among them a year after they had got rid of him with such infinite pains. In this latter traverse, three more passes were surveyed, with the result, to quote the author's own words, that, "When I passed over the Trans-Himalaya for the eighth time at Surnge-la, I had the satisfaction of seeing all the old hypotheses fall down like a house of cards and a new ground plan laid down on the map of Asia, where before the blank patch yawned with its alluring "Unexplored." This mountain-system, it is remarked, cannot be called "a range," because it is a collection of several ranges, more or less parallel or branching off at various angles; Dr. Hedin, however, will find that somewhat similar features are displayed by the Himalayas themselves.

The narrative of the two years' strenuous journeyings for the survey of these formidable mountains, is written in a vigorous, direct style, which reflects the cheery optimism of this pioneer traveler as he pushed on undaunted, in the face of endless hardships and difficulties. It also shows him animating his men with something of his own abounding enthusiasm, without which, indeed, the exploration could never have been accomplished. The reader feels the swing of the caravan moving through the pages, with the thrill of reality and a pervading sense of danger ahead; though to many readers the repetition from day to day of the details of camp routine, and the reiterated records of the grim struggles of the men and the sufferings and painful deaths of the dwindling baggage animals, will doubtless make somewhat monotonous and unpleasant reading after a time.

Besides the geographical record, so important in it-

* "Trans-Himalaya, Discoveries and Adventures in Tibet." By Sven Hedin. With 388 illustrations from photographs, water-color sketches and drawings by the author and ten maps. In two volumes, Vol. i., pp. xxiii. + 496; vol. ii., pp. xvii + 441. (London: Macmillan & Co., Ltd., 1909.)