Plate 1

The David Dunlap Observatory from the air, looking south-west

DESCRIPTION OF THE BUILDINGS AND EQUIPMENT

By R. K. Young

Introduction

THE David Dunlap Observatory, the gift of Mrs. Jessie Donalda Dunlap to the University of Toronto as a memorial to her husband, was formally opened on May 31, 1935.[1]

The progress of astronomy as a department of the University during the past twenty-five years has been due to the continued efforts of Dr. C. A. Chant to emphasize its importance as a cultural subject in education and as a training for the advanced student. It was a part of his plan, even from a very early date, that the University should have an observatory and contribute to the knowledge of the subject, but it was hardly expected that the money for its erection would be obtained from the provincial grant to the University. In an institution striving to meet the needs of the Province and expanding rapidly, chief emphasis in the field of science is placed on subjects more immediately utilitarian. Not until these had been taken care of would the claims of a pure science like astronomy be considered.

The interest in the subject in recent years has been much increased by the spectacular discoveries, which have greatly extended our knowledge of the universe, and which have appealed to the imagination. Astronomy owes much to the great body of amateurs whose interest has strengthened the desire that a large telescope might be situated within the Province. David Alexander Dunlap was one of these. He was a member of the Royal Astronomical Society of Canada and attended the meetings of the Toronto centre. Dr. Chant in all his lectures before the Society and throughout the country emphasized the observational side of astronomy and the need of an observatory. It was his hope that aid in this project would be received from Mr. Dunlap, but the latter's death in 1924 prevented this. When, some time later, Professor Chant suggested to Mrs. Dunlap that she should provide

[1]Journal of the Royal Astronomical Society of Canada, September, 1935.

the observatory as a memorial to her husband, the suggestion met with a sympathetic response. Indeed, Mrs. Dunlap shared her husband's interest in astronomy.

General Plans and Location

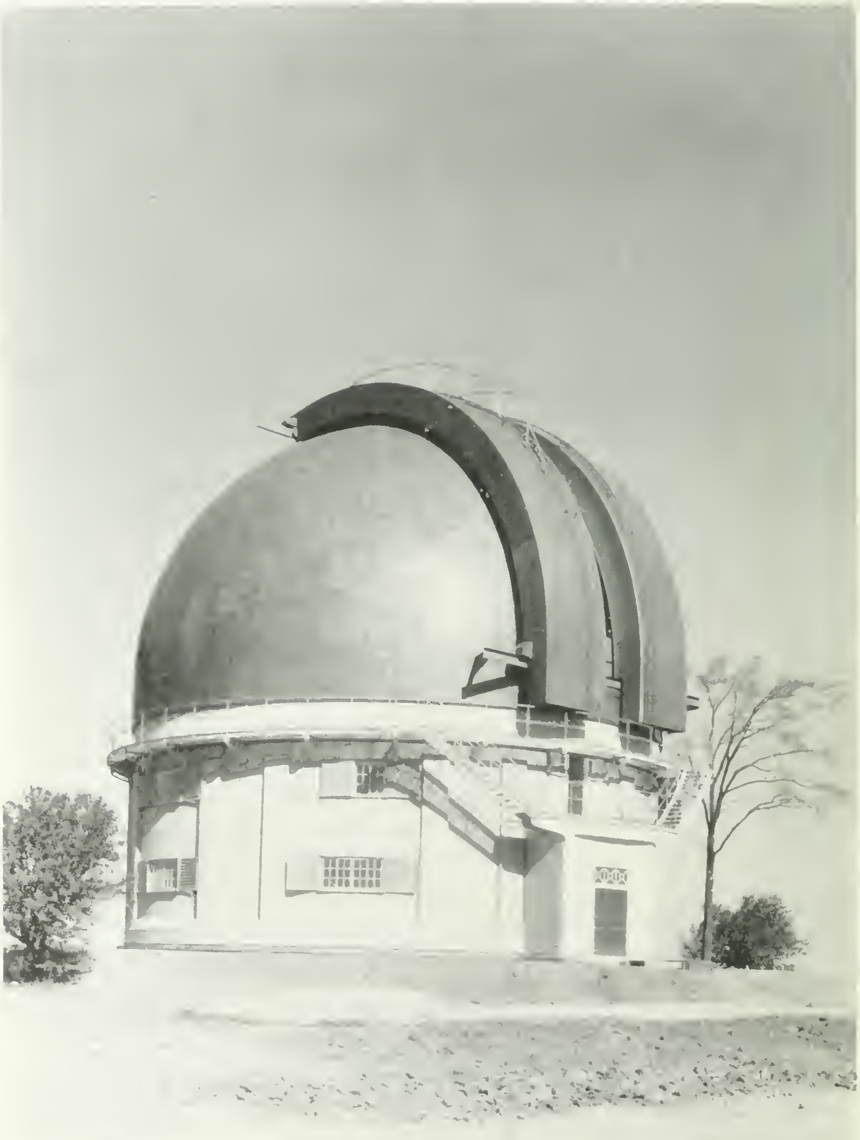
In 1927 Mrs. Dunlap expressed her willingness to provide the observatory but it was not until June of 1928 that we were in a position to call for estimates. The choice of instruments was an important point to decide. From the first, it was felt that a large reflector would be the most useful and economical instrument to push research in stellar astronomy, partly because the reflector is, size for size, cheaper than a refractor, but largely also because the writer's experience had been mostly in astronomical spectroscopy and the great light-gathering power of the reflector makes it a very suitable instrument in this field of astronomy. Former experience at the observatory at Ottawa as well as tests with smaller telescopes made us aware that we could not expect the best seeing conditions and it was necessary to plan programmes of work which did not require the finest definition. All these considerations led us to adopt the large reflector as a choice for the main instrument of research. Two buildings were planned: one, a steel structure to house the large telescope; the other, an administration building for office work and the reduction of observations. There was no haste about the construction of the latter building since it offered no particular difficulties, but the telescope was ordered as soon as possible because the time required for its construction was somewhat uncertain, this being especially true of the large mirror which forms the main optical part of the large telescope.

The location of the observatory was an important point to decide. It was almost essential from the standpoint of economy that it be located near Toronto. There can be no doubt that the output of the telescope would be much larger if it were placed nearer the equator. However, this would require a larger staff to carry on the courses of instruction at the University, and the research work at the observatory as well. Dr. Chant and the writer spent many afternoons inspecting maps of the neighbourhood of Toronto and visiting possible sites. It was not thought advisable to go more than twenty-five miles away from the city, and locations north or north-west were much preferable to those east of the city.

Most of our clear weather comes with west or north-west winds, and at these times the smoke of the city is blown east, or south-east A considerable amount of experimenting was carried on to determine the transparency of the air and the sky-illumination from the city lights, at thirty, fifteen, and four miles from the city. In this regard the stations thirty and fifteen miles away proved far superior to that near the city, especially in the amount of sky-illumination. The gain between thirty and fifteen miles did not seem to warrant placing the observatory at the more distant station. The site finally chosen is about twelve miles north of the city limits and is situated on a rise of ground about one hundred feet above the surrounding country which slopes gently away on all sides giving a good view. (Plate I). The elevation is eight hundred feet above sea-level. At present the land around the observatory is quite open, with a few trees and shrubs scattered here and there. From an astronomical point of view, it would be better if the land were more heavily wooded. It is hoped to be able to plant trees and shrubs on the one hundred and seventy-nine acres in the middle of which the observatory is situated. The approximate position of the observatory as taken from large scale maps, one mile to the inch, is, longitude $5^h\ 17^m\ 41^s.3$ W., latitude $43°\ 51'\ 46''$ N.

Awarding the Contracts

Comparatively few firms possess machinery large enough to handle the massive castings of a great telescope, and there are still fewer with experience in telescope building. The tentative specifications were sent to four firms: Carl Zeiss in Germany; Sir Howard Grubb, Parsons & Company in England; Warner & Swasey Company of Cleveland; and J. W. Fecker of Pittsburgh. The Warner & Swasey Company did not submit a tender, and the design of the Carl Zeiss firm was considered less satisfactory than the one selected. There was not much difference in the design or price of the other two, but after due consideration it was decided to accept the tender of the English company. This was a very fortunate choice because the decrease in the pound sterling and advance in the American dollar made the cost much less than it would have been had the contract been let in the United States. It was very satisfactory to be able to let the contract to a firm that could contract for the complete structure, dome, telescope



Dome from the south-west

and optical parts, for this ensured the finished equipment would assemble without difficulty and it also saved a tremendous amount of time in correspondence and travel. In the description of the telescope and building which follow, the aim has been to describe the various points of construction, so that prospective observatories may obtain some ideas that may be of service in their own problems.

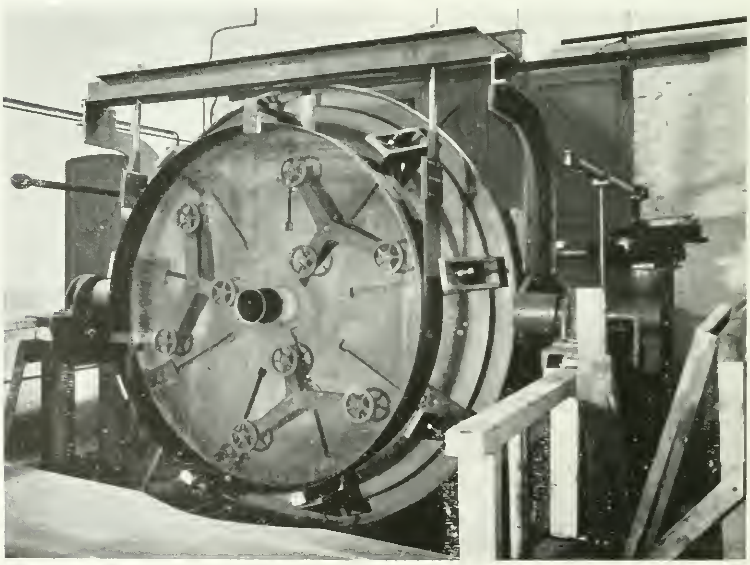
The Circular Steel Building and Dome

The building to house the telescope (Plate II) was ordered in November, 1931, and it was received in Toronto on July 31, 1933. The foundation for the building and the cement piers had previously been constructed and were in readiness to receive the building.

The foundation of the walls of the building is of cement and is extended below frost level. Preliminary borings were made before the location was selected to determine the nature of the ground under the piers. It is hard clay. The piers (Plate III (a)) go down to a depth of twenty-five feet and are hollow, with walls eighteen inches thick, heavily reinforced with steel. The hollow pier is more satisfactory than a solid one. They are amply strong and much lighter, with a correspondingly less tendency to subside. The space inside is very convenient for use. Below ground there are four rooms, six feet by eight feet, two in each pier, and above ground there are three more rooms, one in the south pier and two in the north. One of these, the upper room in the north pier, is very convenient as a dark room for loading and unloading plate holders. Another is utilized as a battery room for the low-voltage system about the telescope. So far the other rooms have not been used. They will be very useful, especially the underground rooms, for mounting instruments that require stability. We have experienced no difficulty from moisture in these rooms.

The circular building is sixty feet in outside diameter, sheathed inside and out with steel sheeting carried by twenty-four stanchions which bear upon their tops a strong annular girder. The entrance is on the ground level on the south side through a small porch with two pairs of steel doors. This gives access to the lower floor. The lower story is thirteen feet high and on this floor is placed a motor-generator set for supplying direct current to all the motors of the telescope, the dome-turning gear and the electric control

PLATE III—(a, b)



(a) The cement piers and base for 61-ft. dome

(b) Mirror on edge, ready for testing

panels and fuse boards, and a part is enclosed as a silvering room. A steel stairway leads to the upper floor which is of reinforced concrete, supported in steel I-beams. It has stood three winters without showing any tendency to develop cracks due to extremes of temperature. A doorway on this floor leads outside to the top of the porch over the entrance and thence a short stairway gives access to a gallery running around the outside of the building at a height of twenty-three feet above the ground level.

The hemispherical dome is sixty-one feet in outside and fifty-seven feet in inside diameter, the walls being double. The inside and outside covering are of "agasote", a hard paper product. The outside cover is one-half inch thick and the inside covering one-quarter inch. In addition, the outside has a sheeting of copper. The opening in the dome is fifteen feet wide and extends from the horizontal to seven feet beyond the zenith. It is covered by two parallel-moving shutters running on rails at the top and bottom of the dome. These shutters are operated by steel cables which are wound on a drum operated by a motor. The motor is of nine-tenths horse-power and the shutters can be opened in one minute. Some difficulty was experienced at first in getting the shutters to open and close parallel. This was due, for the most part, to a differential stretch in the cables between the bottom of the shutters and the top. As this stretch has gradually worked itself out and also because the guiding rollers were freed to some extent, the difficulty has disappeared. It is quite possible that a chain or gear system might be better. Two wind screens made of sail-cloth are mounted in the opening. One rises from the bottom and the other descends from the top. They are motor-operated and can be made to approach each other, so as to allow just enough room for the beam of light to reach the main mirror.

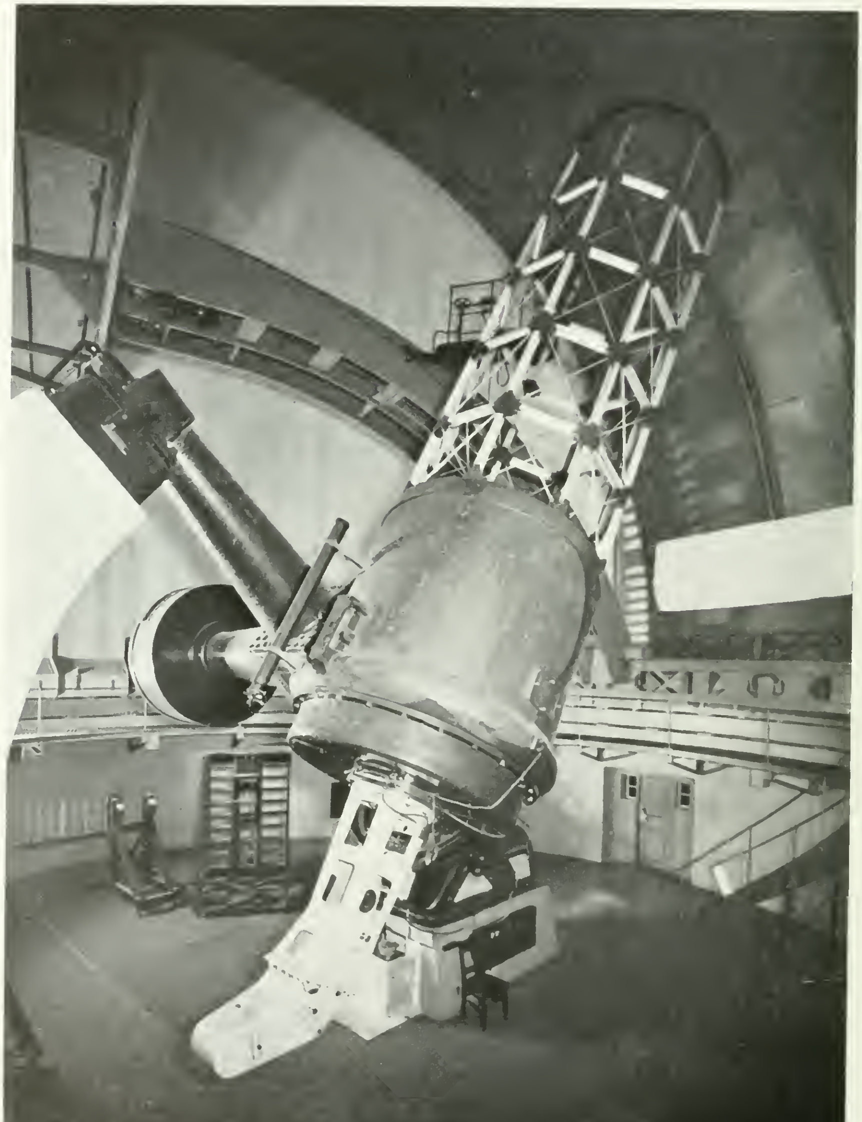
The dome is supported on twenty-four steel rollers, twenty-seven inches in diameter, mounted in self-aligning ball bearings and the rollers run on a flat annular rail. Sixteen pairs of lateral rollers keep the dome centred. The dome is rotated by a seven and one-half horse-power motor which actuates a driving sheave. An endless steel cable passes around the dome and down to the driving sheave. There are two grooves in the driving sheave and the cable passes twice around the turning sheave and tension pulley. Fifteen hundred pounds tension is used. The cable has never slipped on the sheave. It is inclined to slip on the dome in a

PLATE IV

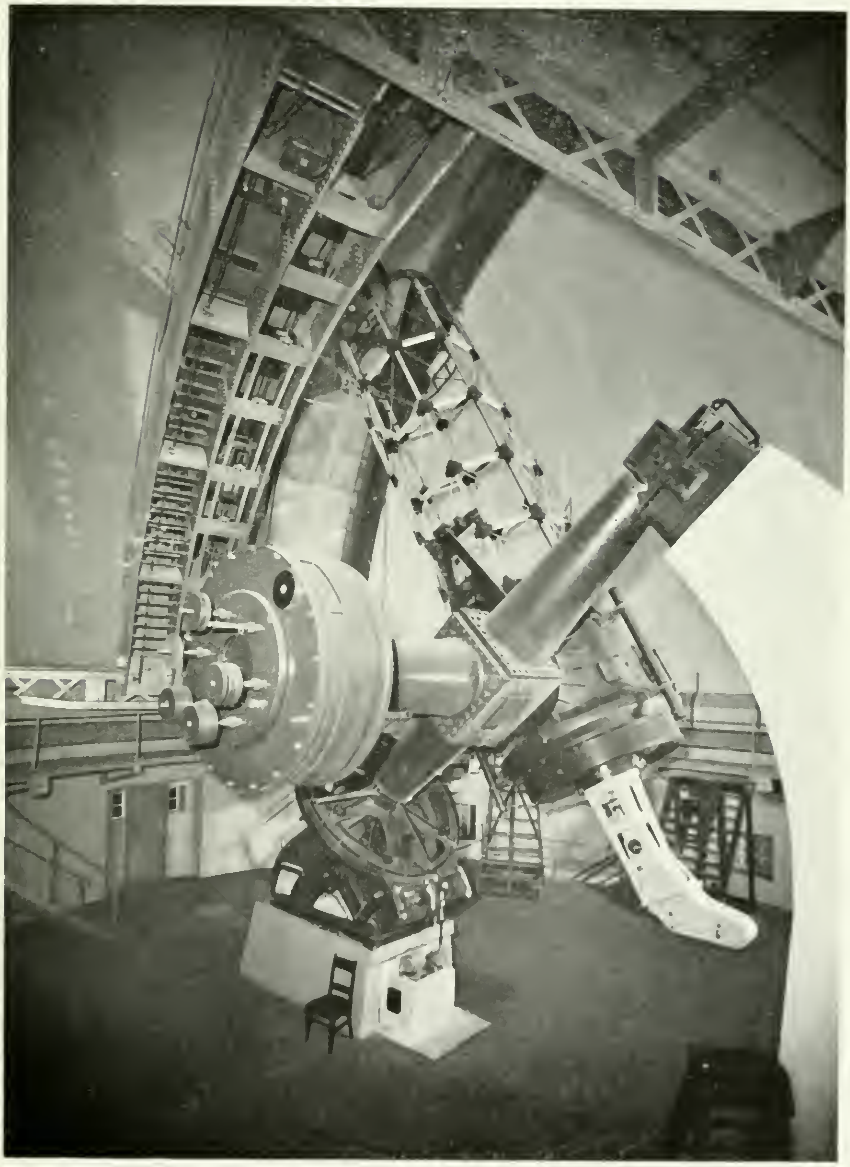
The bridge and observing platform erected in the workshop at Newcastle-on-Tyne high wind. To prevent this, V-brackets were placed on the channel which carries the cable around the dome. A more efficient arrangement will probably consist in lining this channel with wood, to give the cable something to "bite into". The dome makes one revolution in eight minutes.

Probably no feature of the dome for a large reflector is more difficult to design than the means for observing conveniently at the Newtonian focus. One has only to examine the various methods that have been tried to realize that each new architect has been dissatisfied with former models. When the designs for the seventy-four-inch telescope and dome were being drawn, I suggested that a bridge might be supported on platforms and the engineers of the Messrs. Grubb-Parsons worked out the design which we have adopted (Plate IV). The illustration shows the bridge in the workshop in England. Owing to the confined quarters in the dome, it is difficult to obtain a satisfactory picture there. It can however be seen in Plates V, VI. Two segmental platforms, one at the base of the opening and one at the back and sixteen feet higher, carry a bridge which spans the two. The size of these platforms is such that their inside chords are 35 and 45 feet. The bridge is supported on rails along the inner edges of the platforms and can be moved laterally from one side of the dome to the other. The horizontal distance between the platforms is thirty feet and the bridge, which is in the form of an arc, is five feet, six inches wide. On the right-hand side of the bridge is a stairway for the observer and on the left-hand side a truck carrying a movable platform can run from the top to the bottom of the bridge. The observer on the platform can raise or lower the platform, move the bridge from left to right or *vice versa* or rotate the dome. In addition the special platform for the observer can be turned about a vertical pivot by means of a hand wheel. In practically all positions of the telescope the observer can obtain a very convenient position. We have been using the telescope at the Newtonian focus for the observation of clusters. These are mostly in the southern sky and the bridge and the platform are very satisfactory. If one had a varied programme involving reversals of the telescope and pointings in widely different parts of the sky, there would be considerable time lost in obtaining the best positions for work. However, this trouble is almost inevitable at the Newtonian focus and we have been well satisfied with the way the bridge and platform has worked

PLATE V



Telescope from the west, tube on west side of piers



Telescope from the east, tube on west side of piers out. As stated before, the dome and circular building arrived in Toronto on July 31, 1933, and it was erected on the site by the Dominion Bridge Company of Toronto, the work being supervised by the foremen of the maker's shop. The erection of the building and the telescope took about four months, though there were a great many details for the astronomers to put into final shape before observation could be begun.

The Telescope Mounting

The order for the telescope was placed in May, 1930, and the finished mounting was received in October, 1933. A very excellent description of the instrument has appeared in "Engineering" for March 9, 30 and April 20, 1934, to whom we are indebted for permission to reproduce a number of illustrations. It consequently seems unnecessary to enter into all the details of construction. Those who desire to see these may consult the article mentioned above. Only those features will be mentioned which may be novel or may serve in future designs.

The telescope has now been used for about eighteen months in the most rigorous climate in which it has ever been attempted to operate a large reflector. This has presented a number of problems and difficulties which had to be overcome and a record of these may also be useful. The general plan of the mounting may be seen in Plates V and VI. The design is based to a considerable extent on that of the Victoria telescope which has performed so well for many years. Only in certain details have alternative designs been used in an endeavour to improve results.

The main mirror cell is shown in half section in figure 1. The back supports consist of nine circular pads in groups of three each. This is a simple support compared to that in the seventy-two inch telescope at Victoria or in the sixty inch at Mount Wilson. We have no reason to believe that it is not adequate. The back supports are also shown in Plate III (b). This picture was taken in the optical shop in England. The back supports which may be seen through the glass are the same as used in the telescope. The lateral support consists of eighteen weighted levers which operate on a flexible band. This kind of support has been used in other large telescopes and some such arrangement is essential.

The surface of the mirror is covered by a large iris diaphragm, shown in Plate VII. It closes down to a circle twelve inches in diameter at which time the leaves close around a central core. In practice all the sides of the mirror are loosely packed with absorbent cotton so that the chamber of which the silvered surface forms the bottom has a very small volume and is nearly air tight. This is an important feature with us, because the very changeable climate, cold and then warm, leads to conditions which cause the telescope to sweat. A hothouse heater cable, drawing five amperes at one hundred and ten volts, has been clipped to the inside of the cell and this small amount of heat is sufficient under ordinary conditions to keep the chamber dry and preserve the silver coat. If the heat is left on for a day or more, a noticeable distortion of the

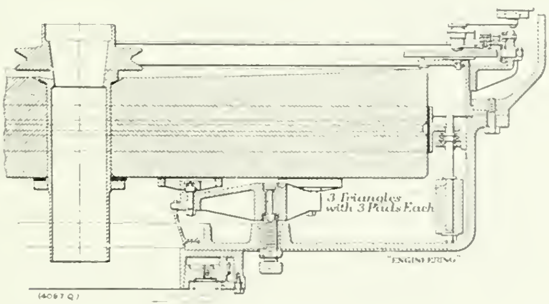
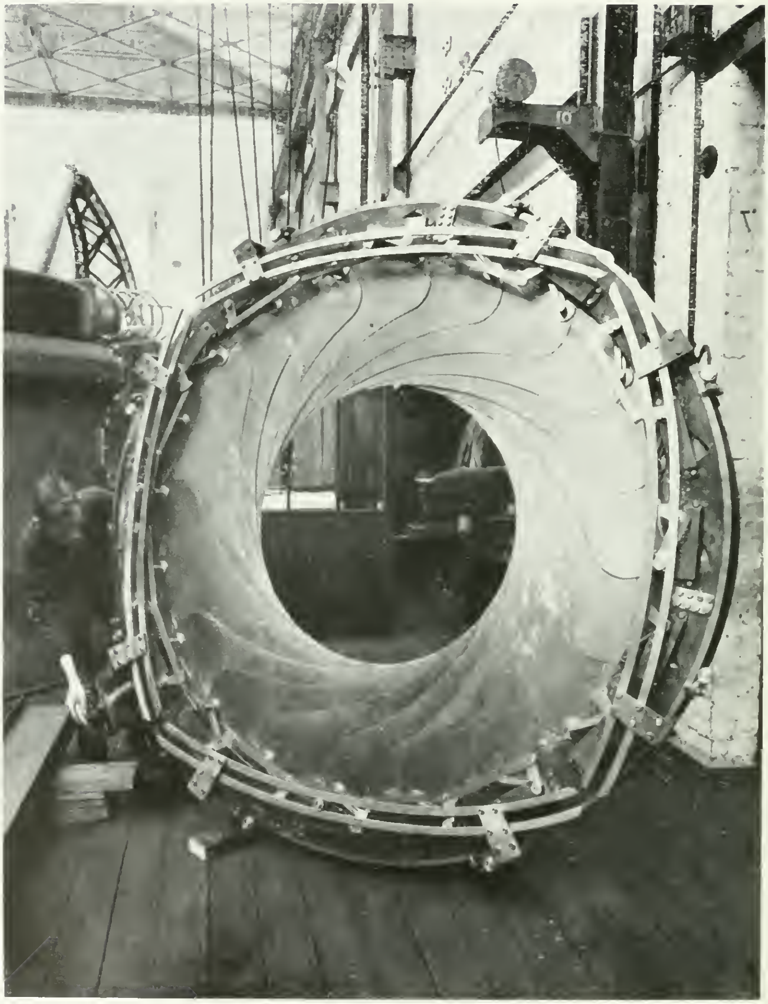


Figure 1
Half section of mirror and cell

surface is observed, though nothing very bad, and by taking the heat off as soon as the humidity outside shows signs of dropping, the figure of the mirror at night is quite satisfactory. We have found the iris diaphragm a very convenient method for covering the mirror. Some care has to be taken in the design of the central plug, which is left permanently in position. In order that it may resist the acids and solutions used in silvering the mirror, it is built of pressed paper impregnated with shellac. Care has to be taken that the holes in the plug through which the silvering solution drains out through the centre do not impede the flow of the spent solutions or prevent the surface becoming free from one solution before another is added in the process of cleaning the surface for silvering.



Iris diapragm at half aperture

Another feature in connection with the telescope tube is the method of focusing the Cassegrain mirror. This is shown in cross-section in figure 2 (b). It will be noted that a small motor has been used to push the Cassegrain focus forward or backward by a screw feed. The observer at the Cassegrain focus watches the

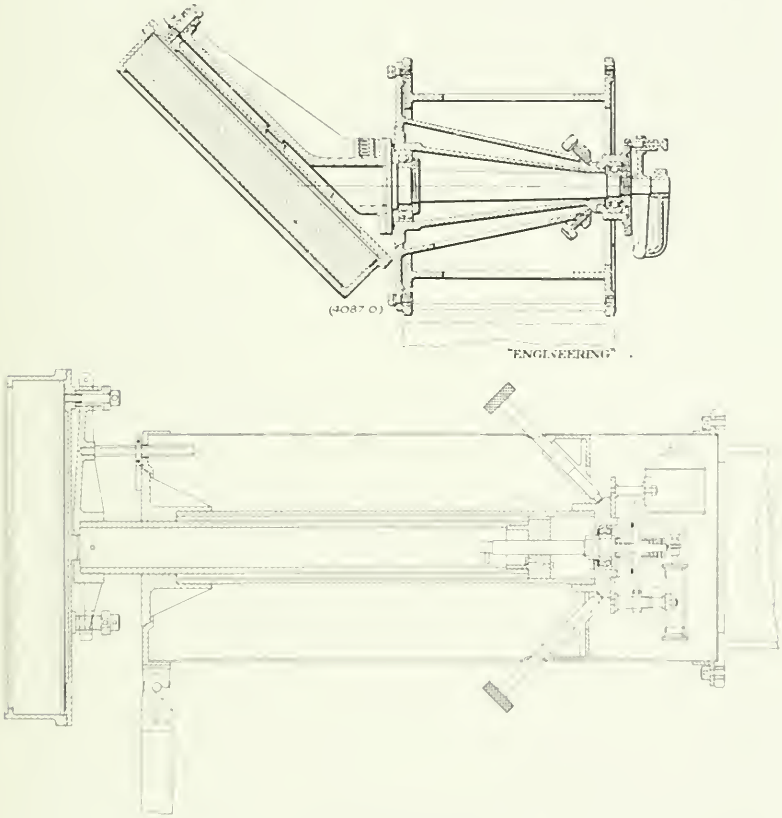


Figure 2 (a, b)
(a) Newtonian mirror mounting
(b) Casegrain mirror mounting

images and presses a button to operate this motor. It functions very well. Some apprehension was felt, in adopting this design, that the motor would vibrate the telescope unduly. However, while the effect can be seen on the image it is not sufficient to prevent the observer ascertaining the correct focus and the vibration subsides in a second when the motor is stopped.

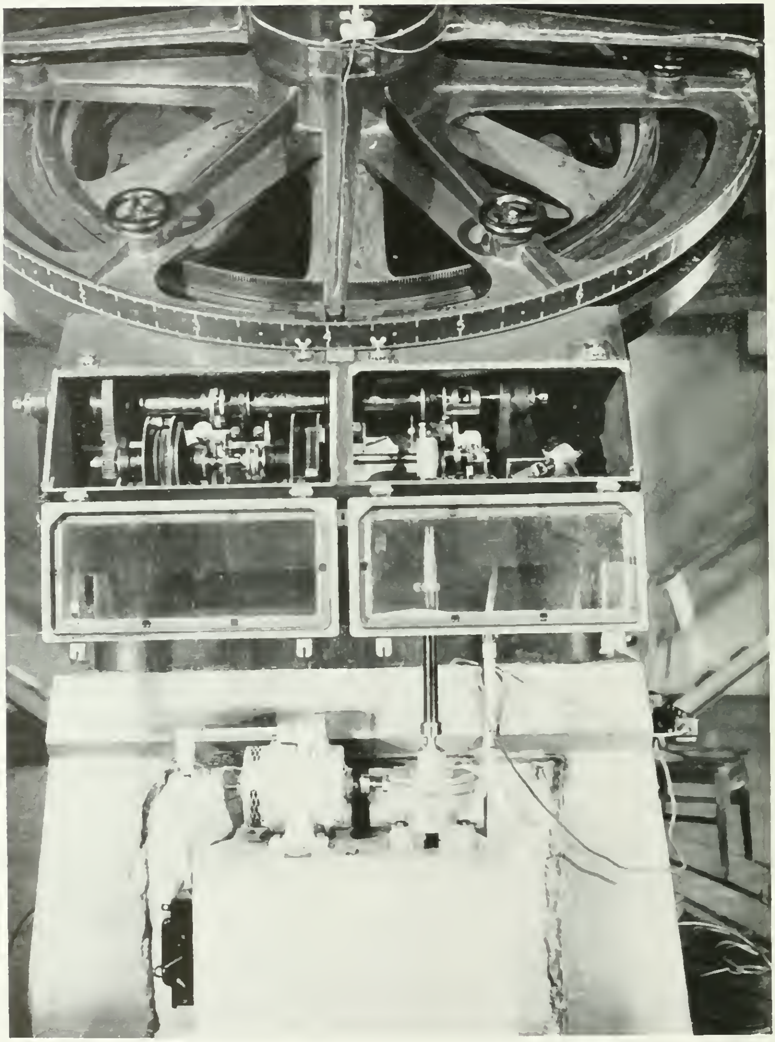
The telescope tube is built in three parts. The lower part consists of the mirror cell which is fastened to the central casting by 24 bolts around a flange on its edge. The central section is a steel casting 7 feet in diameter and weighs 6 tons. It is formed with a heavy boss on one side to which the declination axis is bolted. The upper part of the tube is of skeleton construction being built of duralumin I-beams with steel gusset plates and braced with duralumin cross-braces. These latter are threaded right-and-left-hand and tightened so that they are under tension in all positions of the tube. Tests made in the laboratory show that the differential flexure in the tube at the upper end between a vertical and a horizontal position amounts to 1/16 inch only.

The declination axis is a steel forging 13 feet in length and weighs 3½ tons. It is formed with a flange 3 feet 5 inches in diameter on its inner end where it is bolted to the telescope tube. In order to reduce the flow of heat between the massive declination and polar axis to the central piece of the tube, this flange was cut away so as to leave a ring contact only. The writer's experience with the telescope at Victoria indicated that this flow of heat might be a source of astigmatism in the mirror. If the temperature is changing rapidly, the tube takes up the temperature of the surroundings more quickly than the declination and polar axis so that there is a temperature gradient between the two. The mirror at Victoria occasionally showed astigmatism in the meridian plane.

The polar axis is shown in Plate IX as assembled in the workshop of the makers with all the circles fitted to the lower end. The axis is 22 feet long and weighs 9 tons. It is built in three sections, a central cubical steel box and two tubular tapered steel sleeves bolted to the central box and having steel pivots shrunk into the ends. It turns on self-aligning ball-bearings and a thrust bearing at the lower end. On one side of the central cubical box is bolted a tapered steel sleeve which has a cylindrical hollow drum at its outer end. This sleeve serves to support the declination axis and the drum houses the motors for turning the telescope in declination. It also carried all the necessary counterweights to balance the telescope and the declination circle. The latter is fitted with two small geared drums which enable the telescope to be set in declination to the nearest minute of arc.

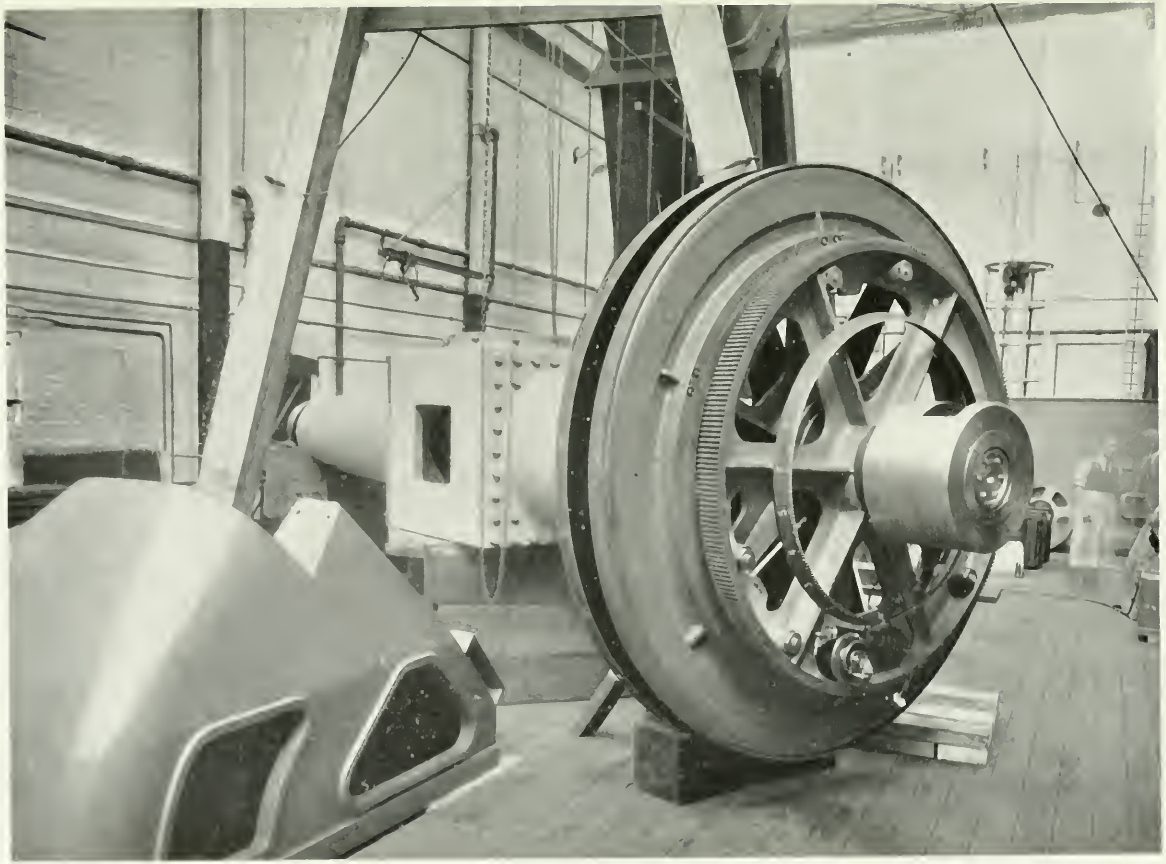
The method by which the telescope is driven to counteract the rotation of the earth is an important item in a telescope design.

The system used on the seventy-four inch is shown in Plate VIII. The first element in the system is a synchronous motor with appropriate gearing to give the sidereal rate from the mean time. When the telescope first arrived it had a gravity-driven conical pendulum but at our request Messrs. Grubb-Parsons furnished us with the synchronous motor which we have found very superior. The shaft from this gearing turns eighty revolutions per sidereal minute and connects with a worm gear which drives the lower shaft. The upper shaft is the driving worm for the telescope. If the synchronous motor is running at the correct speed the rate is transmitted to the driving worm and the telescope moves at the right speed. If the synchronous motor changes its rate, due to a change in the cycle, correcting gears are fitted on the lower shaft to adjust the rate before being transmitted to the worm. The manner in which the lower shaft functions is described as follows in "Engineering": "The lower shaft is made in five parts, of which the first part reading from left to right in Plate VIII carries the pinion driving the upper shaft, and this and the next two sections are connected through epicyclic-differential gearing. The third, fourth and fifth sections are also connected through epicyclic-differential gearing. On the centre section of the shaft is mounted, friction tight, a disk having twenty-four notches on the periphery, and opposite this disk is an electromagnet connected to the observatory seconds pendulum. This magnet, which is thus energized once per second, is provided with an armature of special shape, and this enters each of the notches in the disk, which is intended to make one revolution in twenty-four seconds. When the speed is correct, the entry of the armature into the notches has no effect, but if it should be fast or slow the disc is turned one way or the other relatively to the lower shaft. This relative motion operates a trigger connected to a spindle which passes longitudinally through the shaft and tilts a two-way mercury switch at the right end of the lower shaft; the effect of tilting this switch is to energize one of the two electromagnets, the armatures of which are arranged to hold one of the disks carrying the planet wheels of the epicyclic-differential gear, and in this way the lower shaft is slowed down or speeded up, as required." The second epicyclic-differential gear, viz., that on the left, is controlled by hand and is used for setting or shifting the image slightly in the field of view. The synchronous motor runs so well that we do not ordinarily need to use the seconds-



Synchronous motor drive and differential control

Plate IX



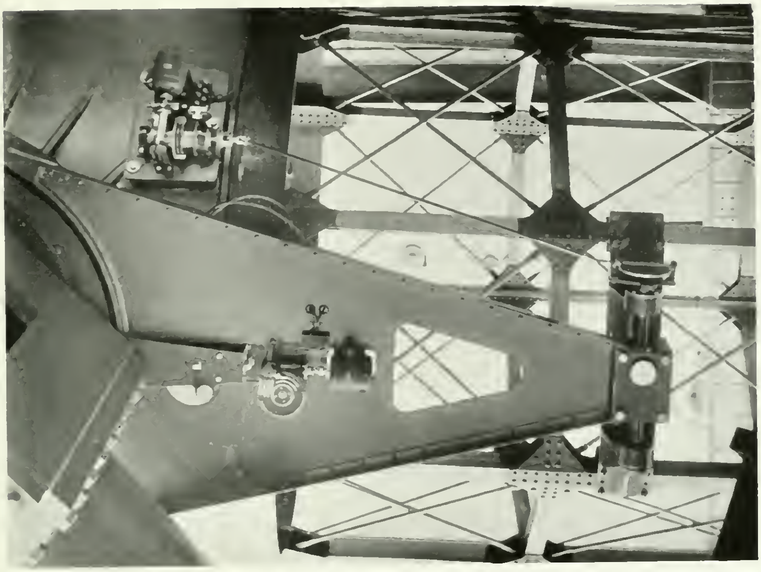
The Polar axis ready for mounting

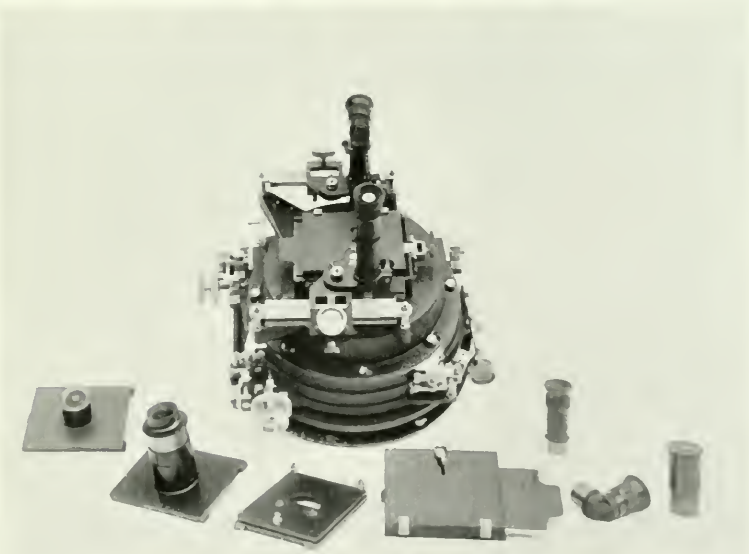
pendulum corrector. At times, however, the image will not move sufficiently on the slit and by weighting the pendulum, we introduce an arbitrary error to allow the image to drift more rapidly. The differential gearing is capable of taking care of rather wide variations in the driving speed but the Hydro-Electric Commission rate is so constant that for any telescope, except the very largest, it would seem sufficient to rely on the motor only. Plates X to XII show the instrument in various stages of construction in the manufacturer's shops at Newcastle-on-Tyne.

The Pyrex Mirror

When the telescope was ordered in 1930, we knew that the portion which would probably take the longest to complete was the big mirror. At that time, the Grubb-Parsons Company controlled the Parsons Optical Glass Works at Derby; and Sir Charles Parsons, the head of C. A. Parsons & Company, of which these other companies were subsidiaries, was confident that they could manufacture a suitable disk of glass for the telescope mirror. (Incidentally, Sir Charles Parsons was the youngest son of the Earl of Rosse, who completed a six-foot reflector in 1845.) But Sir Charles was in his seventy-sixth year when the order for our telescope was placed, and unfortunately he did not live to see the disk made. Had he lived, I have no doubt that his active interest and ingenuity would have solved the difficulties and pushed the task to completion. But in 1932, after his death, the disk had not yet been cast, and it seemed that the project for our observatory might be unduly delayed.

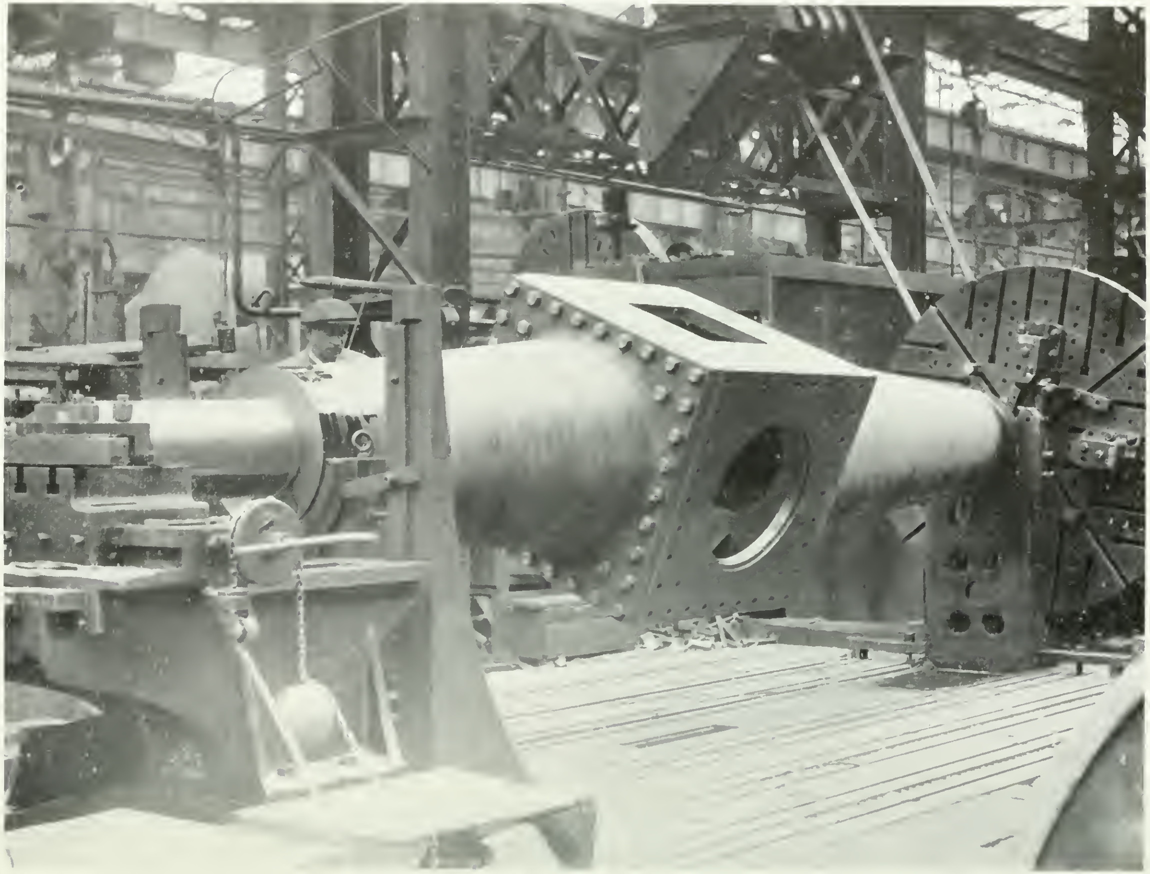
However, in 1932 unexpected help arrived in connection with the manufacture of telescope mirrors, which was not available in 1930. In the latter year the only firms which would undertake the manufacture of large disks were Carl Zeiss in Germany, and the Glass Works at Derby in England. On the American continent the Corning Glass Works, of Corning, N.Y., had made some small "Pyrex" disks of glass which were superior to any that had been previously made, but this firm was extensively engaged in the commercial manufacture of pyrex articles and was not prepared to undertake the expensive experimenting necessary to manufacture so large a disk as we required. Between 1930 and 1932, conditions changed. Plans had been put forward for the manufacture of a



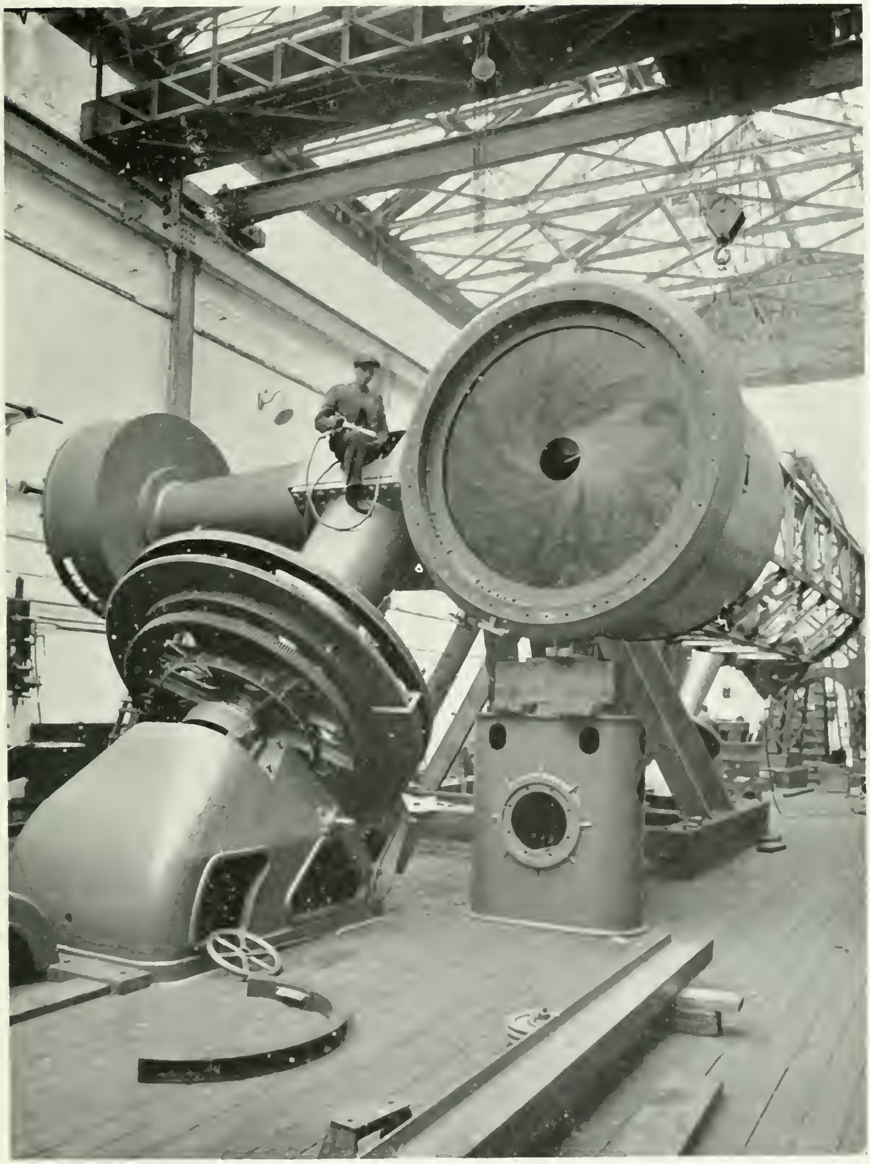


(a) Declination clamp and slow motion
(b) Newtonian double slide plate holder

Plate XI



Trueing up the polar axis



Telescope in the workshop at Newcastle

disk for a two-hundred inch telescope and time and money spent in finding out the most suitable material. In the end it was decided that pyrex glass offered the best hope of success for this disk. The Corning Glass Works was prevailed upon to install the necessary furnaces and annealing ovens for the task. We were informed late in 1932 that they were prepared within six months to cast our disk. From the first we should have chosen this material for the large mirror had it been available at that time. The Grubb-Parsons Company gave the contract for the manufacture of the raw disk of glass, which was to be shipped to England to be ground and polished into the final mirror.

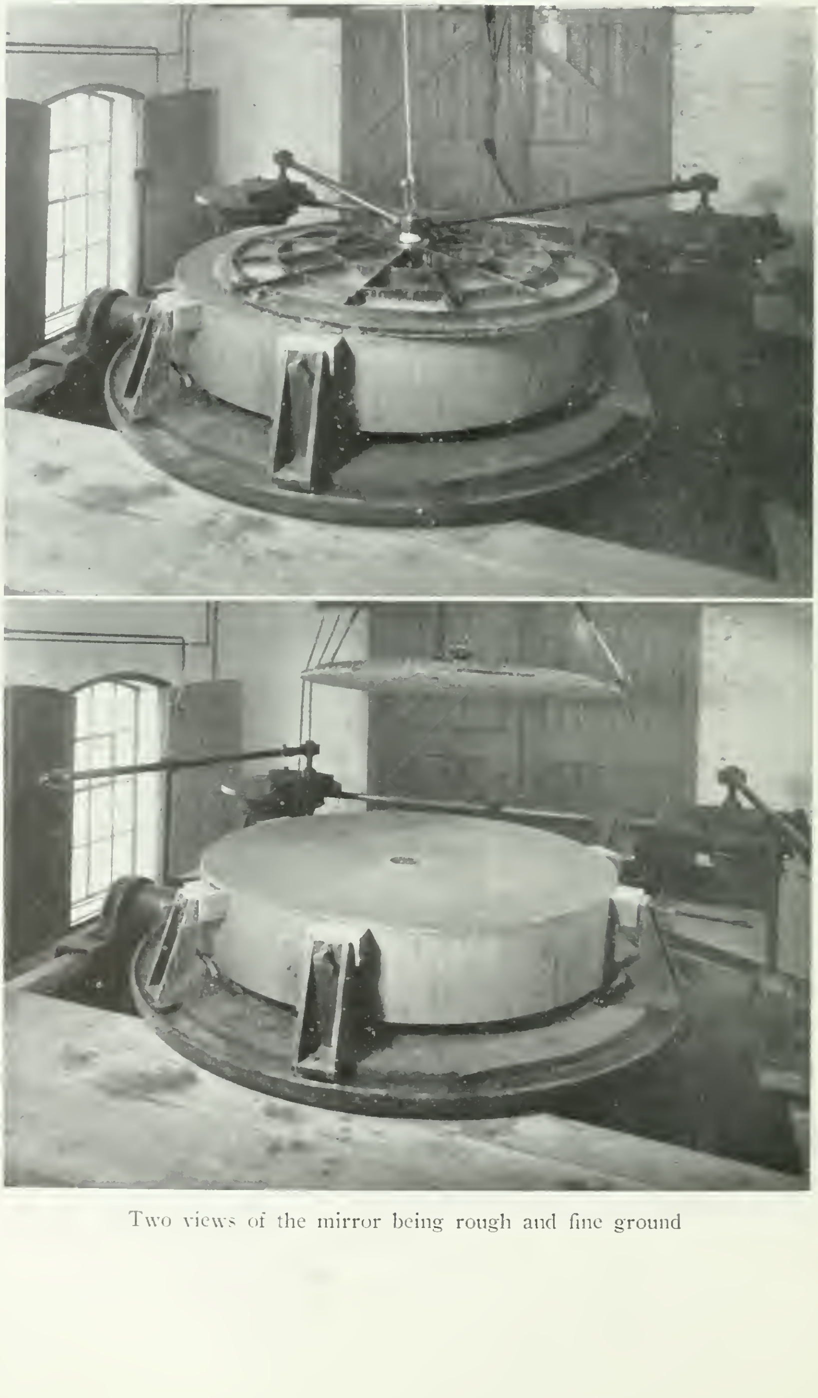
The mirror was cast on June 21, 1933, and came out of the annealing oven in September. It arrived in England in November. Plates XIII and XIV.) The disk at that time was fourteen inches thick and about two inches had to be taken off before it could be accommodated in the cell which had already been made. In spite of this delay the grinding and figuring was pushed forward with such dispatch that the makers reported the mirror as completed in February, 1935. Thus from the time the disk was cast till the mirror was completed, less than twenty months elapsed.

We think this constitutes a record in the grinding of large mirrors and great credit is due to the makers of the disk and to Messrs. Grubb-Parsons for the expedition with which they completed the task. It also speaks very highly of their facilities for handling such difficult problems and we are certain that any prospective purchaser may have every confidence in the ability of these firms to construct the mirror in as short a time as it is possible to have it done.

On March 9, 1935, the writer left for a trip to England to check the tests that had been made on the figure and to make further tests. These tests were carried out photographically in the laboratory of the Grubb-Parsons Company by the method suggested by Hartmann.

In this investigation the mirror was turned on edge and an artificial star placed near the centre of curvature. The surface of the mirror was then covered with a diaphragm having holes two inches in diameter cut at various distances from the centre along six diameters, the holes in each diameter, so arranged that on each two-inch zone of the mirror from eight inches from the centre to thirty-six inches from the centre there were four holes on two

(above): The desk on its arrival in England
(below): Grinding the central hole



Two views of the mirror being rough and fine ground diameters at right angles. (Plate XV.) The light from the artificial star reflected from the uncovered spots in the surface of the mirror was photographed on a plate, first a few inches inside the focus and then outside. Figure 3 shows a reproduction of a pair of such photographs. If the distance between two dots on one zone for a plate taken inside the focus is d_1 and the distance between the corresponding dots on the plate taken outside the focus is d_2, and a is the total separation between the plate taken inside the focus from that taken outside, then the focus of that zone is given by

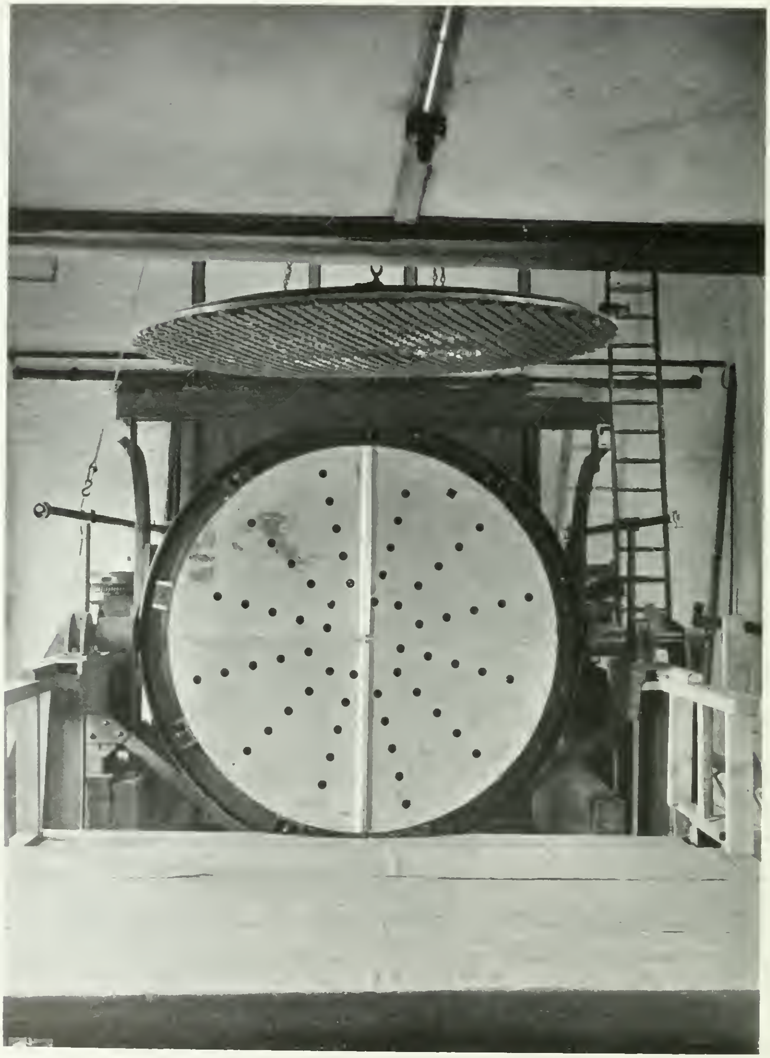
$$x = \frac{ad_1}{d_1 + d_2}$$

where x is the distance of the focal plane from the position of the

Figure 3
A pair of Hartmann photographs, both taken inside the focus

plate taken inside the focus. Both plates may also be taken on the same side of the focus in which case d_2 is negative in the above formula.

A great many plates were taken only a small fraction of which were suitable for measurement. The difficulty of getting good plates arises from vibrations and air currents within the testing tunnel and opportunity had to be seized when conditions led to steady images. In all, nine pairs of plates were measured. The results of these measures are shown in Table I.



Diaphragm over the mirror for the Hartmann test

TABLE I

Zone inches	Jan. 21 (1)	Jan. 21 (2)	Feb. 4 (1)	Feb. 4 (2)	Mar. 18 (1)	Mar. 18 (2)	Mar. 18 (3)	Mar. 22 (1)	Mar. 22 (2)
8	−0027	+0130	+0219	−0250	+0229	+0262	+0328	+0135	+0194
10	−0375	−0376	−0196	−0213	−0195	−0120	−0140	−0198	−0255
12	−0380	−0188	−0142	−0111	−0181	−0078	−0098	−0160	−0154
14	−0164	−0395	−0060	+0020	−0076	−0031	+0009	−0048	−0024
16	−0082	−0098	+0042	+0025	−0030	+0035	+0002	−0005	0000
18	−0093	−0030	−0053	−0055	−0198	−0160	−0053	−0093	−0106
20	+0024	−0040	−0054	−0144	−0188	−0170	−0136	−0096	−0090
22	+0002	+0026	−0056	−0014	−0094	−0058	−0139	−0055	−0076
24	+0010	+0029	+0068	+0009	−0016	0000	+0069	+0018	+0015
26	+0049	+0078	+0041	+0078	+0072	+0112	+0125	+0071	+0036
28	+0106	+0035	+0025	+0059	−0078	−0037	−0058	+0029	+0006
30	+0039	+0055	+0052	−0003	+0073	0000	+0071	+0021	+0014
32	+0052	+0022	−0011	+0060	+0055	+0065	+0101	−0001	−0004
34	+0001	−0024	−0141	−0066	−0166	−0160	−0090	−0042	−0041
36	−0021	−0043	+0086	−0046	+0204	+0207	+0033	+0114	+0119
T	Mean	of Fo	ur....	0.24	0.45	0.40	0.32	0.21	0.20

Column one gives the distance of the zone from the centre in inches and the following columns are the aberrations as measured and reduced to the Newtonian focus as shown by the various plates. The first four pairs were taken before the writer's arrival in England and were measured in duplicate; once by Mr. Manville of the Grubb-Parsons Company, and also by Professor Know-Shaw at the Radcliffe Observatory, Oxford. The remaining five were taken and measured by the writer. The aberrations are expressed in inches. It is customary, in order to be able to quote a number as representing the degree of perfection of a finished surface, to compute the mean circle of confusion in the image expressed in hundred-thousandths of the local length which Hartman calls T.

$$T = \frac{200000 \times \Sigma r^2 \; (aberration)}{F^2 \times 2r}$$

The focal plane having been chosen to make $\Sigma r^2 \times$ (*aberration*) a minimum. The value of T is shown at the bottom of the Table.

An inspection of the aberrations of the various zones shows that they are gratifyingly small and that they shift from plate to plate, this shift being for the most part as large as the aberrations themselves.

The original measures showed some signs of astigmatism in a horizontal and a vertical plane which if real would have been objectionable. In order to test if this really was the case, the mirror was rotated through various angles and always the measures showed the same planes of astigmatism. It is difficult to say whether it arose from stratification in the air tunnel or deformation of the mirror when set on edge. However, the stationary plane of this effect under rotation of the mirror was satisfactory evidence that the trouble lay in the method of testing and not in the mirror.

The tests in the laboratory are always made under better temperature conditions than obtained at the telescope. Nevertheless it was decided to make some tests after the mirror was in position. I was particularly anxious to do this, after the telescope had been in use some months because a visual inspection of the image convinced me that the pyrex disk was holding its figure remarkably well under very trying temperature variations. Accordingly a mask was made for the mirrors from cardboard and exposures made inside and outside the Newtonian focus, using α Cygni as a source on the evening of July 31, 1935. The temperature had risen from 68.5 F. at 6.00 a.m. to a maximum of 82.0 F. at 6.00 p.m. and by midnight had dropped to 72 F. The exposures were made at 11 p.m. and the test of the mirror was made consequently under rather extreme conditions. The openings in the diaphragm were arranged so that the aberrations could be measured in two directions at right angles to each other as in the laboratory tests. The plates were measured by Miss R. J. Northcott and the results shown in Table II. The results are given for each quadrant separately. Column one gives the distance of the zone from the centre. Columns two and three give the aberrations as deduced from the I, III quadrants and II, IV respectively and the last column the mean. The aberrations are expressed in inches.

Table II

Distance inches	Aberrations I & III	Aberrations II & IV	Mean
10.5	+0087	+0228	+0158
12.5	+0008	+0114	+0061
14.5	+0102	+0228	+0165
16.5	+0024	+0248	+0136
18.5	+0055	−0028	+0014
20.5	−0122	+0012	−0055
12.5	−0028	+0110	−0041
24.5	+0020	+0004	+0012
26.5	+0043	+0043	+0043
28.5	−0091	+0035	−0028
30.5	−0071	−0165	−0118
32.5	−0169	−0087	−0128
34.5	−0169	−0098	−0134
36.5	−0260	−0189	−0225

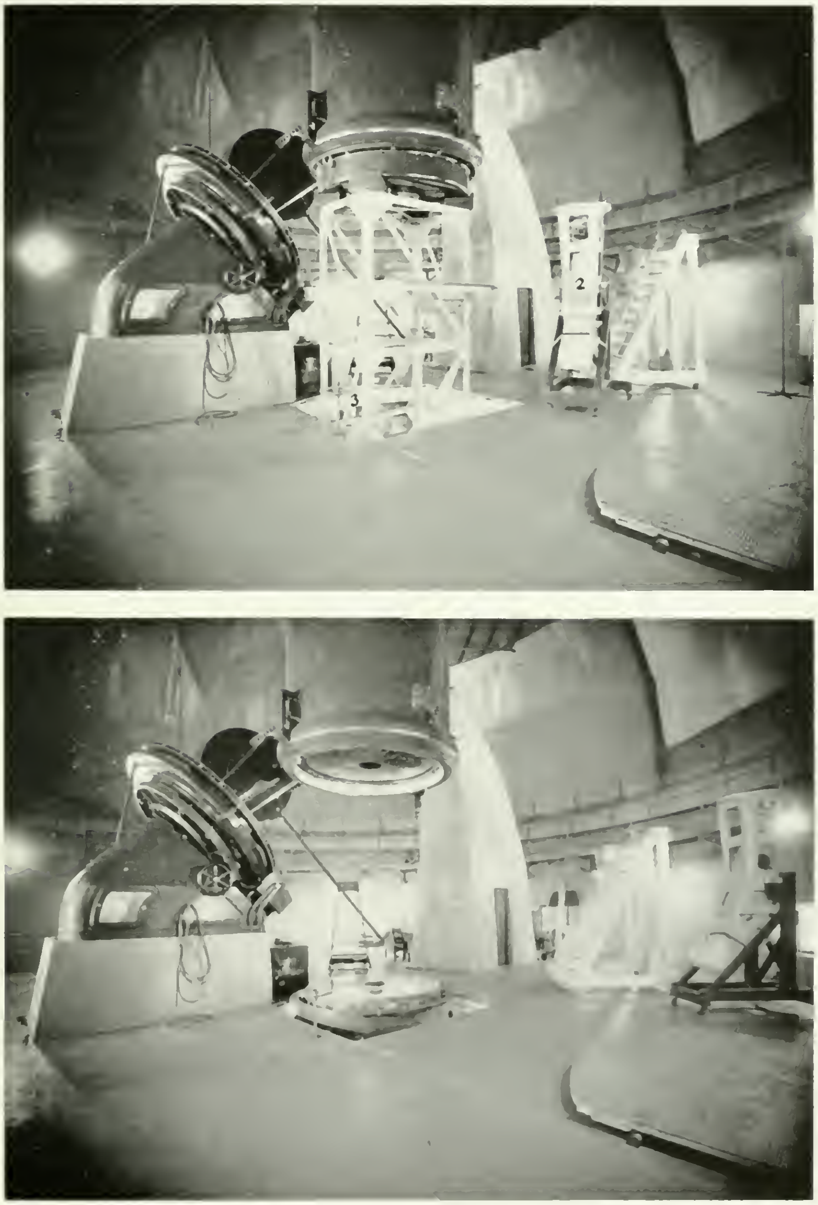
It will be seen that the figure was very good. The outside curled forward making the outside zones have too short a focus. This effect is not marked, considering the great temperature variation. The regularity of the residuals shows that the surface was very smooth. The mean aberrations in the last column make $T = 0.37$. Quadrants I & III give on the average a focus 0.0033 inches shorter than the mean and quadrants II & IV a focus longer by the same amount. Apart from the results of this test our experience during the eighteen months in which we have used the telescope has been that the mirror suffers very little from distortion and that whenever the seeing is good the image is satisfactory.

The Method of Silvering

The extreme changes in the temperature, especially during the winter, makes it difficult to preserve the silvered surface. Then, too, the process of silvering is more difficult in cold weather. It is essential that the mirror be removed from the telescope into a room which can be heated. The removal of the mirror involves a considerable amount of labour and always a little risk, and it is necessary to have things so arranged that both these are kept to a minimum.

When the telescope is turned to the zenith the base of the mirror cell is nine feet above the upper floor and twenty-two feet above the basement floor. The silvering room is on the lower floor and the mirror in its cell has to be brought down into it. We accomplish this by a very inexpensive but efficient method. An elevator built of angle iron runs on vertical I-beams and is counterbalanced by heavy cast-iron weights which are carried on steel ropes. These ropes pass over sheaves just below the level of the observing floor; and a worm and worm-wheel, hand-operated, can move the elevator up and down without any particular effort. After the telescope has been placed upright and lashed in position a trap door in the floor permits the elevator to be raised to support the mirror. As the elevator is raised the counterweights go to the bottom of the elevator pit. Those weights necessary to balance the elevator are strung on long eye-bolts. The ends of these eye-bolts pass through holes in extra counterweights when the elevator is in its highest position and by simply screwing on retaining nuts the necessary additional counterweights are attached to balance the extra weight of the mirror and cell. There is no difficulty experienced in turning the hand wheel to lower the extra four tons on the carriage. Plate XVI shows the manner in which this hoist functions. It is much less expensive than a hydraulic elevator and we think more safe and easier to operate than any drum-operated hoisting gear would be. When the mirror has been lowered into the silvering room the trap door is closed and, as an added precaution, a heavy canvas is stretched about three feet above the mirror to protect the surface from accident. The room can be warmed by electric heaters. The silvering process we use functions best at a temperature of from 40° to 50°F.

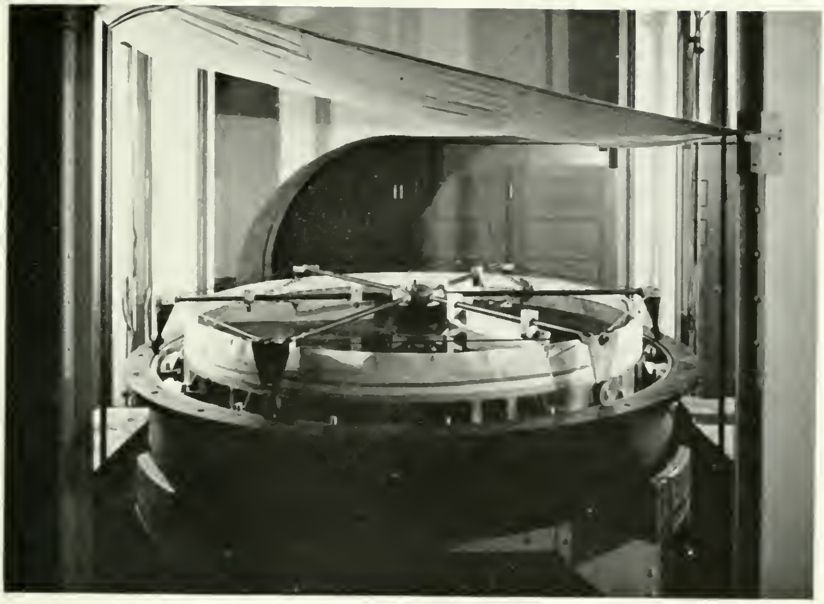
The number of formulae for silvering mirrors is very numerous. We have used a method that has many merits over anything I have previously employed. A description of it may be worth while. During my visit to England I had the privilege of watching the mirror being silvered in the laboratory there. The Grubb-Parsons Company are extensive manufacturers of search-light mirrors and have had a great deal of experience in silvering. I was particularly impressed with the small amount of silver they found it necessary to use. Their method was carefully explained to me and I saw it applied. We have never been able to make it work correctly. We have, however, adopted certain features of it and the method we use requires only about one quarter as much silver nitrate as is customary in the Brashear process. Our thanks are due to Messrs.



The hoist for removing the mirror for silvering

Grubb-Parsons for permission to publish this method, which we think may be of some service.

Before any band is placed on the mirror, the old coat is lightly rubbed with a flannelette cloth, soaked in water, to remove dust. The coat is then taken off with concentrated nitric acid. We use swabs made of soft flannelette, fastened to a pine base with a handle, and much prefer these to absorbent cotton, as the latter is liable to leave lint on the surface. This operation is best done before the band is put on, because there always is the small ledge where the bevel of the mirror meets the wall that can serve as a pocket for the acid, which is very difficult to remove from this recess later. When the surface has been thoroughly rubbed, the acid is rinsed off with ordinary tap water. It is then cleaned with tepid water and soap. We use swabs similar to those used for the acid and work the surface into a lather. The bulk of this soap is rinsed off and the band placed around the edge. We have found that a retaining band of oilcloth is better than waxed paper. There is always a danger of bits of paraffin coming off the waxed paper and paraffin will smear over the surface and prevent a bright coat near the edge. In order to make the band perfectly solution-tight, we cut large elastics from the inner tube of an automobile tire, cutting the tire in the plane of rotation of the wheel. These are about one and one-half inches wide and four people can stretch them over the oilcloth band. They produce a remarkably tight seal. Two bands are usually put on, one near the top edge of the mirror and one near the bottom overlapping the oilcloth so that the bottom half of the elastic band rests on the edge of the mirror-disc. When this has been done a hose is used to rinse the mirror very completely and get rid of all traces of soap. It is then rinsed in distilled water and enough distilled water left on the mirror to fill the concavity. The centre hole of the mirror is closed by inserting a wooden plug covered with rubber inside the centre hub. No provision is made on the silvering hoist for rocking the mirror but instead we have a stirring device to agitate the silvering solutions. This can be seen in Plate XVII. It consists of a spoked wheel, which turns on the central hub and the periphery runs on rollers around the edge of the mirror cell. Wooden vanes are attached to three of the spokes and adjusted to within three sixteenths of an inch from the surface of the mirror. This device is put on after the distilled water is on the mirror.



(above): The stirring device on the mirror
(below): The freshly silvered mirror being returned to the telescope

It usually takes about one-half an hour to mix the silvering solutions, and this operation is commenced about this interval by estimation before the completion of the cleaning of the surface. The solution for silvering the seventy-four inch mirror is as follows.

Silvering Solutions:

(A)	Water	320 oz.
	Silver Nitrate	226 grams
(B)	Water	40 oz.
	Caustic Potash	135 grams

Reducing Solution:

Water	16 oz.
Dextrose	37 grams

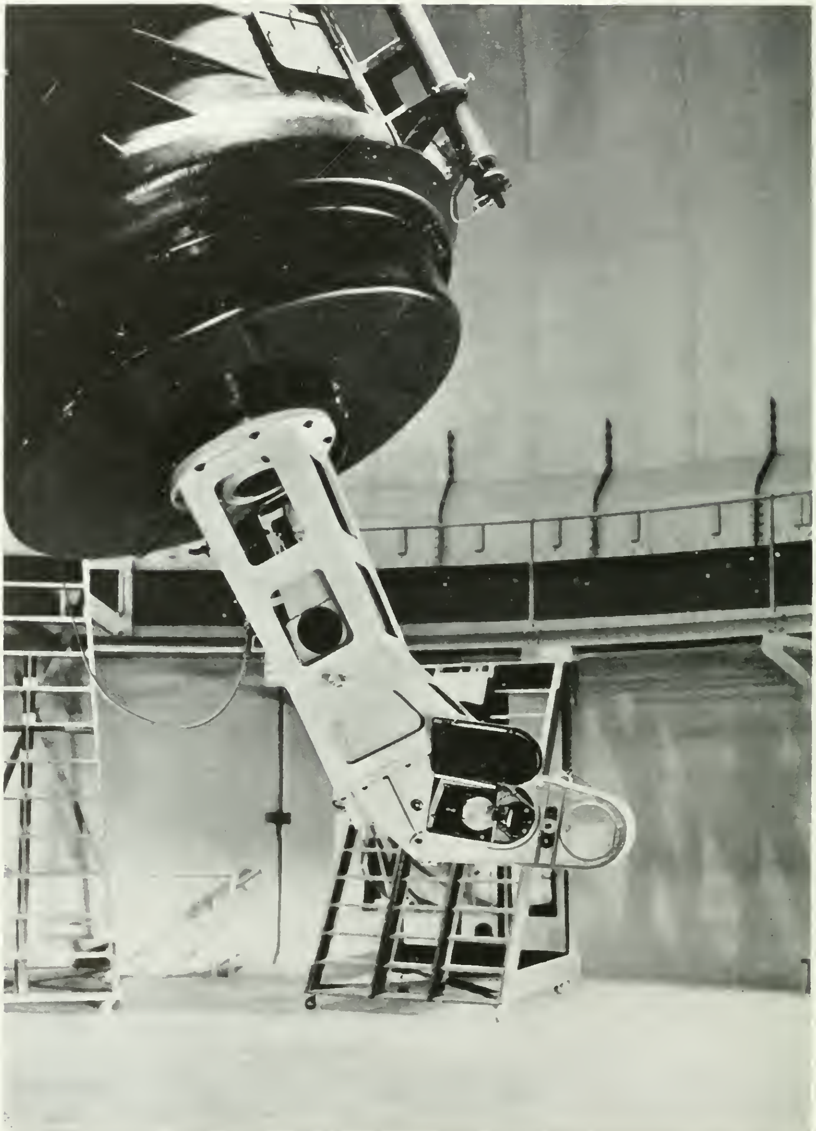
The process is carried out as in the Brashear method. Ammonia is added to (A) till the precipitate formed is re-dissolved, and then (B) is added. More ammonia is then added until the precipitate is again dissolved. It usually happens that there are some particles of matter left at this stage which have to be filtered out. When this has been done, a reserve silver nitrate solution is added until, on looking through a depth of three inches of the liquid, an opalescent straw colour is obtained. Twelve hundred ounces of distilled water are on the mirror and the reducing solution is added to the silvering solution immediately before being poured on the mirror. As mentioned before, the process works best at fairly low temperatures, 40° to 50°F., and at these temperatures will take from ten to fifteen minutes to deposit.

The Spectrograph

The initial gift to the observatory provided for a single spectrograph. A one-prism instrument was chosen for use at the Cassegrain focus as being the most useful. Spectrographic work requires a wide variety of dispersions and of range of wave-lengths, but it is impossible to include in one instrument complete flexibility in this regard without sacrificing rigidity. Most early designs of spectrographs which were used on telescopes were of the so-called universal type and could be adapted for various dispersions and regions of the spectrum. These instruments suffered from the defect of flexure and recently observatories engaged in extensive radial velocity measures, have generally adopted the design worked out by Campbell and Wright at the Lick Observatory in 1905 and incorporated in the Mills spectrograph. The main feature of this design is that the spectrograph proper is of the box pattern cradled on a two-point support in a frame which is attached to the telescope. A return to the universal character was attempted in the spectrograph attached to the 72-inch telescope at Victoria, with very successful results. Nevertheless, the writer's experience with this instrument showed that more flexure was present than desirable. The extra loading necessary to make provision for one, two or three prisms and difficulties in introducing internal webbing in the box for the same reason prevent the spectrograph box being built as rigidly as it can be for a simpler instrument. While the idea of having the various dispersions incorporated in one instrument is very attractive, I decided against it, on account of the impossibility of getting rid of flexure and also because it was not anticipated that we should have much occasion for large dispersion. It is eminently desirable that spectrograms of the brighter stars be so observed, but if this is done the dispersion should be greater than is possible with prisms, unless used with very long cameras such as are possible with the Coudé form of mounting. No such arrangement was contemplated for the 74-inch telescope and consequently it seemed best to design a low-dispersion spectrograph for use on the faint stars and of great rigidity to render it suitable for radial velocity measures. The general form of the instrument can be seen in Plates V and XVIII. It was built by the Adam Hilger firm of London, England.

The Optical Parts

The optical parts of the spectrograph consist of the collimating lens of two and three-quarters inches clear aperture, a single sixty-three degree prism made from a light flint glass with high transmission in the violet region of the spectrum and alternately two camera lenses of approximately twenty-five inches and twelve inches focal length. The latter are cemented triplets, the glasses being chosen to be as transparent as possible in the region of shorter wave-lengths.



The Hilger spectrograph

The glass of the prism approximates Parsons' glass DF3, as given in their catalogue, and has the following refractive indices:

λ	Refraction	λ	Refraction
6563	1.61347	4861	1.63037
5893	1.61830	4340	1.64063

The makers have furnished us with the absorption curve of specimens of the glass as shown in figure 4. From these I have derived the following transmissions in per cent. through a thickness of one centimetre and through the prism.

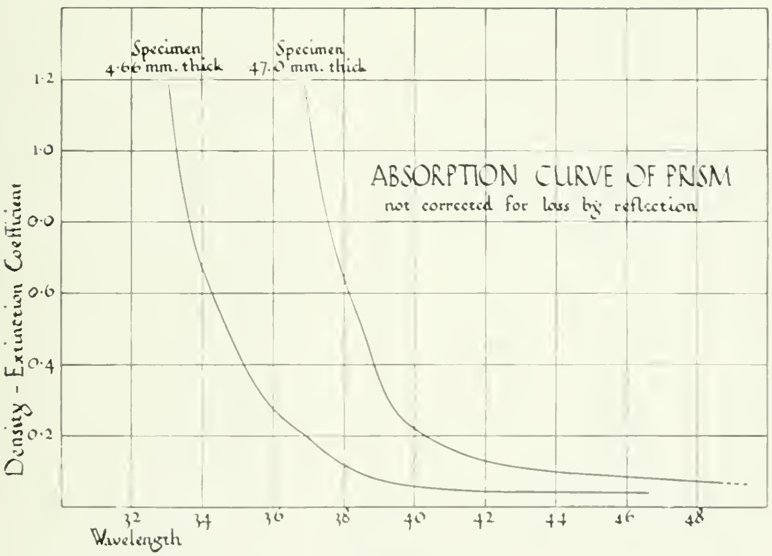


Figure 4

λ	Transmitted by 1 cm.	Transmitted by Prism
3700	61%	20%
3900	86	59
4100	94	76
4300	96	87
4500	97	89

All the surfaces have been figured by the interferometer method of compensating for internal strains and, as will be seen later from a discussion of the tests, the instrument gives excellent definition.

The Mounting

The general construction of the mounting and the relation of the various parts will be understood from figure 5. The spectrograph proper is of the box form heavily ribbed. It is made from a silicon aluminum casting. There is no collimator nor camera tube in the usual sense, the box itself serving this purpose. This form has the advantage that the internal bracing may be made stronger. The box is cradled in a frame so designed that in whatever position

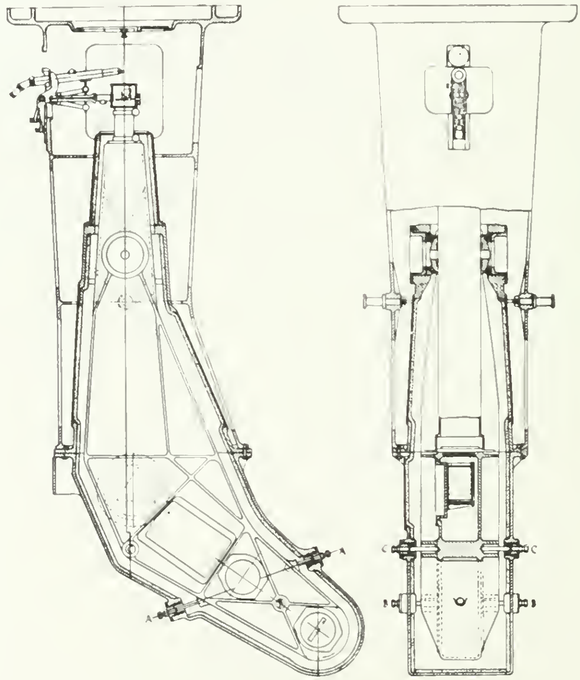


Figure 5

Longitudinal sections of the Hilger spectrograph

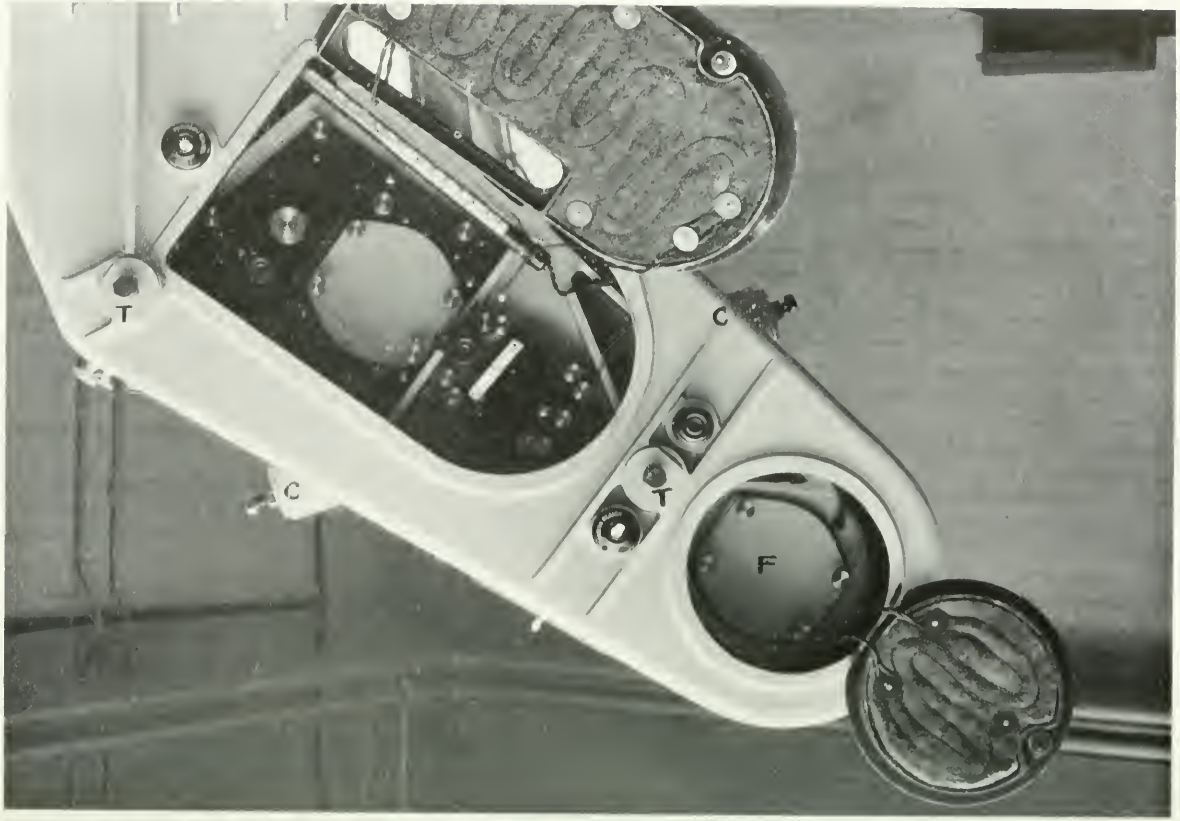
the telescope is pointing, the strains in the frame will not be transmitted to the box. A spherical bearing supports the upper end and permits freedom of motion in any direction. When the telescope is on the meridian the weight of the lower part of the box is taken by a pair of floating pins shown at *A,A* in figure 5. Motion in a direction at right angles to the meridian is prevented by two other pairs of floating pins *B,B* and *C,C*. As the telescop is moved away from the meridian the pins *B,B* and *C,C* assume part of the load but it will be observed that deformation in the frame is not transmitted to the box proper. All the floating pins are provided with adjusting screws to allow the spectrograph box to be set so that it is collimated with respect to the axis of the telescope tube.

The frame which supports the spectrograph is made in two parts. The upper part is a long box-like casting of silicon aluminum. A flange at its upper end attaches it to a ring at the back of the mirror cell. This ring is in the form of a worm-wheel and can be rotated to any desired position angle. A flange at the lower end of the box permits the lower half of the frame to be attached, which serves to support the lower end of the spectrograph and forms the heating case as well. Doors in the lower half of the frame, shown in Plate XIX, permit access to the spectrograph box. The inside of the frame is lined with felt about one-half an inch thick and the heating wires are distributed on the inside of this lining. The temperature is controlled by a mercury thermometer relay. The thermometer bulb is such that a rise of one degree centigrade produces an elevation of the mercury one-twelfth inch. It is placed close to the prism. This ensures that if stratification or inequalities in the temperature exist throughout the case, the index of refraction, air to glass, will remain unchanged.

The design of the camera holder and the manner in which the spectrograph can be adjusted to take a range of camera lenses is very neat. The camera holder consists of a cylindrical mounting shown in figure 6. It is attached by four knurled cap screws, and may be placed in any one of three positions. Adjustment for tilt is provided by the simple rotation of the cylinder. The plate holder is carried in a slide and can be shifted laterally, so as to permit a number of exposures on the same plate. The objective mount, shown in Plate XIX, is attached by knurled cap screws and carries also the gear for focusing, which is done by moving the objective. We have found that it is quite possible to change from one camera length to another and re-focus in fifteen minutes.

A drawing of the slit mechanism is shown in figure 7. This is very similar to that used on the spectrograph of the Dominion Astrophysical Observatory at Victoria. The slit jaws are of polished nickel, closed by spring pressure up to an adjustable stop,

PLATE XIX



Lower half of the Hilger spectrograph

which prevents the jaws coming in contact. Micrometer screw threads, fifty to the inch, with a drum divided into one hundred parts, permits the opening to be read to the ten-thousandth part of an inch. Light from the comparison arc is reflected into the slit by two small right angled prisms which are covered on their lower side by masks. Holes in these masks limit the length and position of the comparison lines. The prisms may be separated by means of a right-and-left-hand thread and the inner edges of the prisms are bevelled, so as to permit the passage of the light from the star. The length of the opening in the slit, which the light from the star may reach, increases near the apex of the prisms and these are mounted on a slide and by moving them backward or forward, the width of the spectrum may be varied. A spring catch with three notches locates three definite widths. The

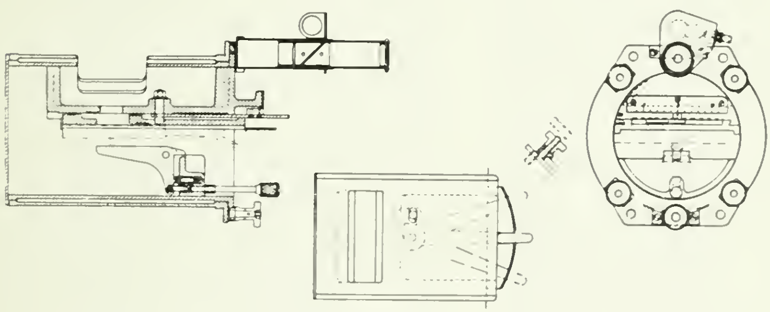


Figure 6

opening in the mask below the prism, shown at *D* in figure 7, permits the comparison to be substituted for the star spectrum, when the prisms are slid back, so that this opening is over the slit. This is very convenient for use in conjunction with the Hartmann method of focusing. To facilitate further the use of the method, the spectrograph is provided with shutters, shown at *D* in Plate XVIII, which can be adjusted on push rods to limit the beam of light to the apex half of the prism or to the base half at will. Guiding is done by a telescope which views the star image in the slit.

Constants and Tests of the Spectrograph

The internal adjustments of the position of the prism to minimum deviation at λ4150 and correct location with respect to the collimating and camera lenses had already been carried out before the instrument arrived and it was only necessary to check these. The collimation of the instrument to the axis of the telescope was effected by placing a small electric light bulb in the axis of the tube near the upper end and adjusting the spectrograph box until the light could be seen through a peep hole in the centre of the collimating lens, the rays having passed through the slit.

Determination of the focal properties of the lenses was carried

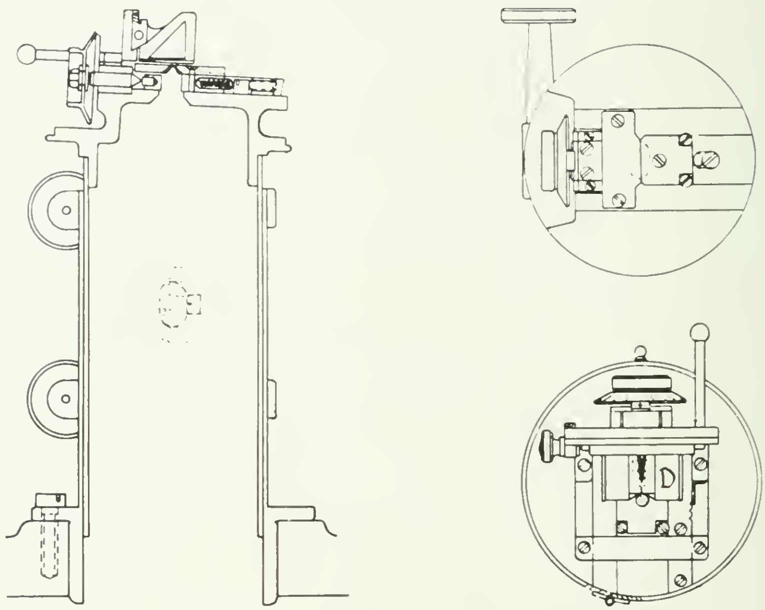
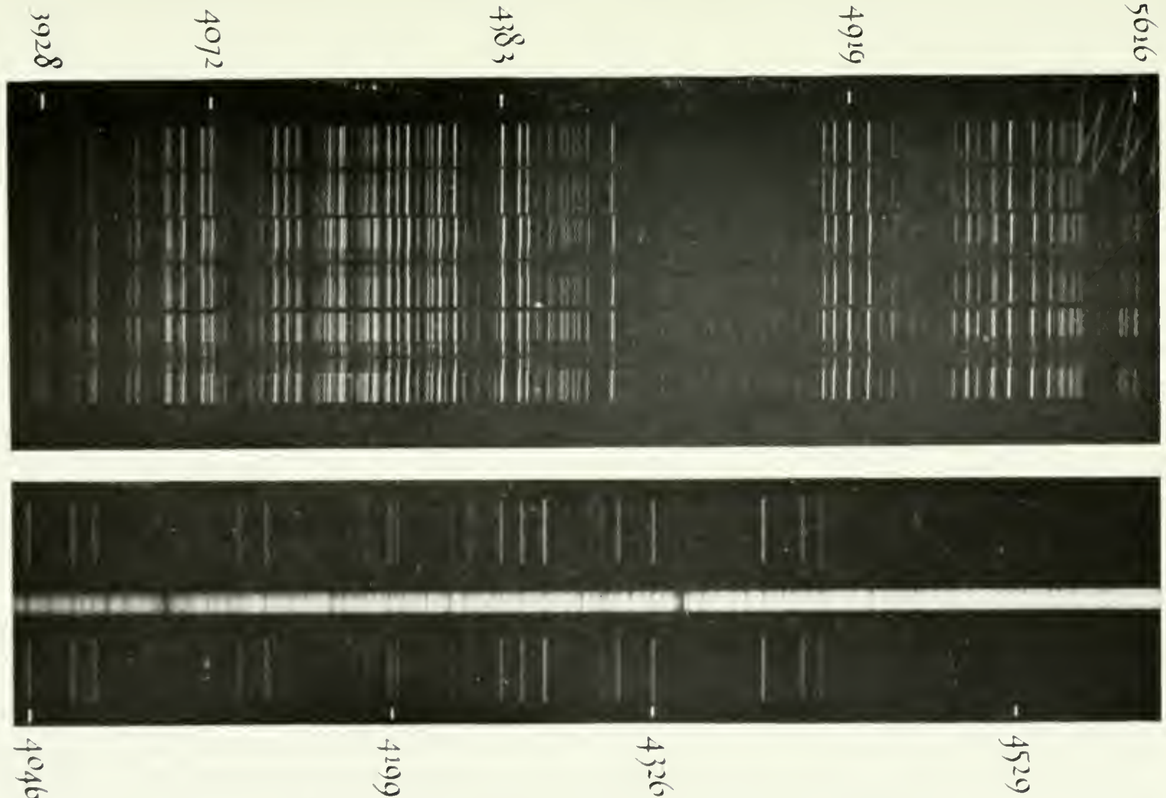


Figure 7
The slit mechanism

out by the Hartmann method. Plate XX(a) is a reproduction of a Hartmann focus test of the 25-inch camera, made at settings 23.0, 24.0, 23.5. The measurement of this plate is shown in figure 8 and the same figure also shows the focal curve for the short camera. For both cameras a wide range of spectrum is in focus to within $^1/_{10}$ mm. Plate XX(b) is a reproduction of HD 198726. The pair of lines λλ4199 are resolved in both the comparison and star. The instrument gives a computed resolving power at λ4200 of 40,000 and with ordinary plates and the normal slit width of 0.002

PLATE XX—(a, b)



(a) (above): The Hartmann focus test at settings 23.0, 24.0, 23.5
(b) (below): The spectrum of HD 198726

inch, a purity of about 10,000. Spectra of seventh magnitude stars may be obtained with the twenty-five inch camera under average seeing conditions and state of the silver coat on the main mirror in about seventy minutes. Good spectra have been obtained of an 8.0 magnitude star in one hour under good conditions. The dispersion with the twenty-five inch camera is 33A at Hγ and about half this with the shorter camera.

An investigation of the curvature correction has been carried out by Dr. Heard for the twenty-five inch camera. Spectrograms were taken of the iron arc and the sky, using the longest slit

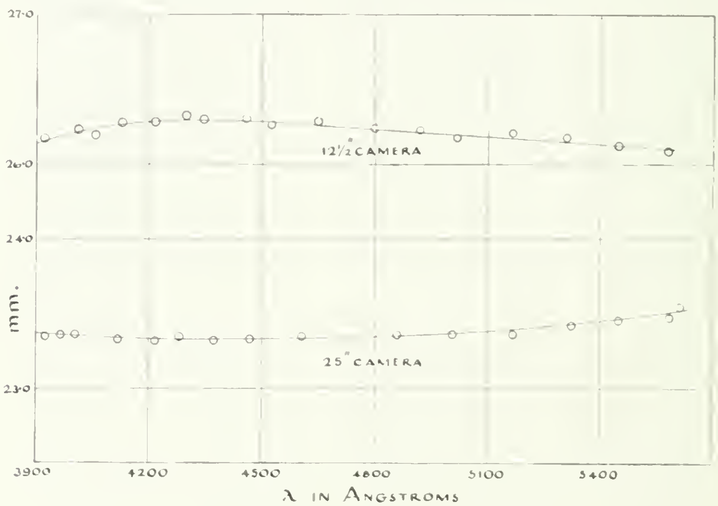


Figure 8

The focal curves of the 25-inch and 12½-inch cameras

possible. On the plates the equation of the lines is well represented by the parabola,

$$x = 0.00097y^2$$

where x is the distance along the dispersion and y the distance along the line, both expressed in half-millimetre. The exact magnitude of the correction to radial velocity which must be introduced depends on the point where the measurer bisects the comparison line. Assuming that this bisection is made at a distance from the tip of the line of about one-seventh its length, the curvature correction runs from about -1.5 km. at λ3959, to -2.9 km. at λ4900.

Since the opening of the observatory in 1935, the instrument has been in continuous use in radial velocity work, and about 1600 spectra have been secured. Most of these spectra are of stars in and near the Kapteyn areas in the northern hemisphere and brighter than magnitude 7.5. These spectra are of stars for which no results have been published. In order to check the consistency of the instrument, spectra have been secured of the standard velocity stars and bright stars observed at other observatories. The results of a comparison show a very satisfactory agreement and the probable error of a single plate with the twenty-five inch camera for a good-line star is about 1.5 km. per second.

The Administration Building

A general view of the location and ground immediately surrounding the 61-foot dome and Administration Building is shown in Plate I. The front view of the Administration Building is shown in Plate XXI. The plans for this building were prepared by the architects, Mathers and Haldenby. It is ninety-one feet long and forty-nine feet wide. The walls are constructed of Credit Valley limestone with trimmings of Queenston stone. The square entrance hall and stairway are finished in travertine.

The chief functions of the Administration Building are to provide a suitable place for studying the plates taken with the telescope, office space for the staff, and other rooms for laboratory work. In designing the building, however, we had to bear in mind not only the present contemplated programmes of work of the observatory but also the possible future needs.

Prior to the project of the 74-inch telescope, the writer had constructed a 19-inch telescope but, for lack of a suitable building or space for mounting, it had rested in storage. It seemed that this instrument would be a useful adjunct to the equipment. The disposition of numerous small domes about the grounds to house special pieces of apparatus is difficult to arrange and is costly. Consequently, we made provision on the roof for three domes. These look quite small in the photographs, but the centre dome is twenty-two feet clear inside and the other two, eighteen feet. The 19-inch reflecting telescope is housed in the south dome. The

Front view of Administration Building from the west other domes are vacant. We contemplate a refractor in the middle dome of 10 to 12-inch aperture and a battery of photographic lenses in the remaining dome. The piers inside these domes are carried on separate stringers entirely free from the floor and are carried by the main supporting walls of the building. We have not had sufficient observing time to draw any conclusions as to the suitability of this method of support. So far as can be judged from the visual image, the support is steady in ordinary weather, though not perfectly steady in a high wind. It has the advantage over the piers in this case of leaving the rooms below free from obstruction.

A fairly well-equipped workshop seemed a necessary part of the equipment. Modern astrophysics is continually requiring pieces of apparatus. Principal instruments are usually advantageously purchased from those who make a specialty of this type of apparatus. The smaller pieces, which have to be designed to meet the special requirements are best made under the eye of the user, because as the work proceeds ideas present themselves in the way of improvements, which can be embodied in the design, without additional cost, which is not the case when drawings are sent to a machine shop for completion.

The basement of the building is comprised of the machine shop, 31 x 16 feet, in which are located a milling machine, a lathe, drill press, shaper and grinder; the heating plant and the water tank; the library stack room, 26 x 19 feet; the clock room, 17 x 16 feet with piers for the sidereal and mean time clocks; the woodworking shop, 22 x 19 feet, and wash rooms. The main floor is given over to the office space, the main room of the library and a lecture hall. The library comprises about 600 monographs on Astronomy, Physics and Mathematics and 2500 volumes of Observatory Publications and Journals. A large fraction of the latter is on loan from the Royal Astronomical Society of Canada.

The second floor provides two additional offices, two laboratories, 31 x 16 feet and 20 x 19 feet, which accommodate the measuring engines, computing machines and photometers. The dark room and photographic room are also located on this floor. A special room is set aside for the donor of the observatory as a reception room.

Plate XXII

Library of the David Dunlap Observatory

The Staff and Work of the Observatory

The staff of the observatory is also the teaching staff at the University. The lecture session is carried on from the end of September till May and summer sessions are offered also. The courses of instruction include general courses and laboratory work for those taking Astronomy as a part of a liberal education, and more advanced courses in Astrophysics, Theoretical Astronomy, and Celestial Mechanics for those more deeply interested in the subject or who may desire to pursue Astronomy as a vocation.

The personnel of the observatory staff is as follows:

C. A. Chant, M.A., Ph.D., LL.D., F.R.S.C., *Professor Emeritus of Astrophysics and Director Emeritus of the David Dunlap Observatory.*
R. K. Young, B.A., Ph.D., F.R.S.C., *Professor and Director of the David Dunlap Observatory.*
F. S. Hogg, M.A., Ph.D., *Assistant Professor*
P. M. Millman, M.A., Ph.D., *Lecturer.*
J. F. Heard, M.A., Ph.D., *Lecturer.*
Mrs. H. S. Hogg, M.A., Ph.D., *Research Associate.*
Miss R. J. Northcott, M.A., *Computer.*
Miss F. S. Patterson, M.A., *Assistant Computer.*
Miss E. M. Fuller, B.A., *Librarian and Secretary.*
G. F. Longworth, *Night Assistant and Machinist.*

During the year and a half since the opening of the observatory work has been continued on a general programme of radial velocity determination for stars in and near the Kapteyn areas. 1600 spectrograms have been secured, of which about two-thirds have been measured and the results tabulated for publication. Observation of a number of eclipsing and spectroscopic binaries has been started. A list of these stars appears in the annual report of the council of the Royal Astronomical Society. (M.N. Vol. 97, No. 4.) Observations have been made at the Newtonian focus for the variables in globular star clusters and 178 photographs secured. The 19-inch telescope has been adapted for photography and will be used in photometric programmes.

In closing this brief description of the observatory, its equipment and work, thanks are due to the many firms and individuals who have contributed to its completion: to Sir Howard Grubb, Parsons and Company for the perfection of the mechanical details; to the Corning Glass Works for the construction of the "pyrex" disk; to Mr. Armstrong for the accuracy of the optical surfaces; to Adam

Main entrance Hall of the Administration Building

19-inch telescope

Hilger and Company for the excellent definition of the spectrograph; to the Superintendent of the University, Col. A. D. LePan and his assistants for their continual supervision of the installation; to the Dominion Bridge Company for the erection of the dome and telescope; to Mathers and Haldenby, architects, for the beautiful design of the Administration Building; lastly, to the enthusiasm and energy of the staff who have laboured to get the observatory under way.

David Dunlap Observatory,
March, 1937.