BOND (Wm C.)

Description of the Observatory at Cambridge – mass.

Case

VI.

Description of the Observatory at Cambridge, Massachusetts.

By WILLIAM CRANCH BOND.

(*Communicated to the Academy, November 8th*, 1848.)

The Observatory is situated on an eminence elevated about fifty feet above the general plain on which are the buildings of the University, and is seventy feet above the tide-waters of Charles River. This height is found sufficient to give from the dome an horizon almost uninterrupted, to within two or three degrees of altitude, in every direction. The grounds appropriated to it comprise six acres and a half. It is distant three quarters of a mile northwest from University Hall, and three miles and a half west-northwest from the State House in Boston.

Plate I., Fig. 1, is a ground plan of the principal buildings and of those appropriated to magnetic and meteorological purposes; at

A is the equatorial room and pier.

B, The transit-circle room.

C, The prime-vertical apartment.

In the smaller buildings,

a, The situation of the four-foot meridian-transit instrument.

b, The horizontal-force magnetometer.

c, The declination magnetometer.

b′ and *c′*, The reading telescopes of the magnetometers.

d, The small altitude and azimuth instrument.

In the construction of the buildings which protect the magnetic instruments, iron has been entirely excluded.

The wires connecting with a system of magnetic-telegraph lines, extending to most of the principal cities of the United States, are brought into the building containing the four-foot transit instrument, at *a*.

e is the situation of the standard barometer, made by Newman.

f, The transit or sidereal clock.

g, The deep well, for temperature of the earth at different depths below the surface.

G is a building used for miscellaneous purposes, chiefly for observation of the magnetic inclination; no iron was used in its construction.

H, The smaller prime-vertical room.

D, The computing room.

E, The observer's dwelling-house.

The western wing, indicated by dotted lines at *F*, *F'*, *F''*, is not yet built.

That part of the main building which is appropriated to the great refractor is thirty-two feet square. The foundations of the walls are of granite blocks, which are from two to three feet in thickness below the surface of the ground. Above, the walls are of brick, laid in cement; on the outside, they are carried up square to the coving. Within, the corners are arched towards the centre in such a manner as gradually to bring the interior to a circular form for the support of the dome, leaving at each of the four corners a recess five feet in depth, with a chord of eight feet four inches in the lower room. In the dome room the recesses are each five feet deep, and the chord is eight feet eight inches. The ceiling of the lower apartment is arched inward towards the pier, but is entirely insulated from it.

Of the four recesses in the dome, the northeastern is occupied by two closets for lamps, books, apparatus belonging to the telescope, &c., and by a balance-chair, which is used as a ready means of conveyance of the observer to and from the rooms below. The southeastern recess contains the machinery for turning the dome. The southwestern is the ordinary entrance, and in the northwestern is deposited the comet-seeker when not in use, with seats, table, &c., for an assistant.

The windows of the dome are provided with iron balconies, which are found to be convenient in using the comet-seeker and other smaller instruments. There is a firm plank flooring to these balconies, with provision for centring the tripod-stand of the comet-seeker, which brings its polar axis at once so nearly to the meridian, (the axis being duly elevated to the altitude of the pole by a spirit-level,) that an object discovered in sweeping may at once be referred to the large telescope. The work of adjustment occupies but a few minutes, and the instrument is readily transferred from one balcony to another. The floor of the dome is supported by an arched frame-work springing from the walls of the building, and secured by a curb encircling, but not touching, the pier.

Plate I., Fig. 2, is a north and south section of the foundations of the walls of the equatorial and prime-vertical rooms, and of their respective piers; at *a a* are the foundations of the outer walls, and at *b b* those of the inner walls; the latter support the dome. The foundation of the great pier is a grouting, composed of cement and coarse gravel, twenty-two feet in diameter at its base, which is twenty-six feet below the natural surface of the ground; the depth of this mass is ten feet. When the grouting had become well consolidated, the pier was commenced with blocks of granite four feet in length by two in thickness.

The pier rises thirty-three feet, to the floor of the dome, in the form of a frustum of a cone, twenty feet in diameter at the base and ten feet at the top. It is surmounted by a capstone of ten feet in diameter and twenty-two inches in thickness. Upon this stands the granite tripod support, of eleven tons' weight; its height is eleven feet. From the top of the tripod to the ceiling of the dome is sixteen feet; the ball on the outside is one foot eight inches above the ceiling; making the entire height from the foundation seventy-three feet. In building the pier, the mason fitted each block to a steady bearing before any cement was inserted.

The form of the granite pedestal, to which the bed-plate of the equatorial mounting of the telescope is attached, will be best understood by reference to Plate II. The base of this pedestal is seven feet one inch on the east and west sides, four feet five inches on the north, and three feet five inches on the south sides. It rests on the cap-stone by three bearings, so situated in regard to the centre of gravity of the whole block and telescope that each bearing supports a nearly equal share of the weight. These bearings are protuberances left when the stone was worked. This method I have adopted with all the piers, as it insures steadiness and admits of easy change of position. Of this we have had an instance in the mounting of the great equatorial, where the azimuth screws came home before the adjustments were completed; by the application of a jack-screw to the base in the line of two of the supports, the whole pedestal and telescope were moved into the required position round the third support as a centre, without perceptible jar or risk of injury.

The piers for the prime-vertical transit, Plate I., Fig. 2, and for the transit-circle, have their foundations of grouting at eighteen feet below the surface. In these, the grouting is inclosed in a pyramidal casing of brick-work, curving inward, and supporting a granite block eight feet long, four feet wide, and twenty-two inches thick; on this block rest the tripod-pillars supporting the Ys of the instruments.

The dome covering the great equatorial is a hemisphere of thirty feet interior diameter, framed with stout ribs of plank, and covered with copper on the outside, on a sheathing of thin boards. The ceiling within is of wood, the air being allowed to circulate between the inner and outer coverings. We have been gratified to find that the internal temperature quickly approximates to the external, during sudden changes.

A circle of granite surmounts the walls. On this is secured an iron plate ten inches in width, hollowed in the middle; a similar track is laid on and bolted to the under section of the dome; and between them are placed eight iron spheres, eight inches in diameter, upon which the dome rolls.

The openings for the telescope are nearly five feet in width, extending from three degrees beyond the zenith to as many below the horizon, the entire aperture being available. The shutters are divided into three compartments, the two upper moving on an iron railway, with rollers at distances of a foot apart, to relieve the friction. The shutters are worked by means of endless chains, acting in toothed wheels, turned by a crank and pinion; the leading of these chains, as well as the position of the crank, is shown in Plate V., Fig. 1. The third and lowest division of the shutters is subdivided into three parts, each of which is counterpoised by weights traversing within the dome, and acting in the same manner as those of ordinary window-sashes. The frames of all are of ash, covered with copper sheathing, and they are perfectly weather-proof. The machinery occupies but little room, and the whole is easily managed.

Plate V., Fig. 1, is a section of the dome, intended to illustrate the arrangement for working the shutters. At *a*, *b*, *c*, *d*, they are represented as closed; *a* and *b* are similar, each being nine feet long. The frames are of two-inch-square ash; there are in each nine cross-bars, besides the end-pieces, and the whole is covered simply by copper, painted, in order that they may be as light as possible consistently with the requisite strength.

A transverse section of *a* is shown in Fig. 2, where, at *a′ a′*, &c., the shutter bears, by iron rollers inserted into the framework of shutters, upon the dome; and at *b′ b′*, on each side, near the ends, are like rollers, to relieve the friction which might take place during high winds, causing a lateral pressure.

In Fig. 1, *h h*, &c. shows the track of the chains by which the shutters are raised and lowered. At *f* there is an iron arm, which is secured to the upper shutter, and projects downwards within the middle one. To this arm one end of the chain is secured, and leads forward from *f*, passes round a pulley at *g*, and then back over pulleys at *h h*, &c., keeping nearly the curvature of the dome, and downward to *i*, where it is received on a toothed pulley of seven inches diameter, like that shown in Plate IV., Fig. 2, letter *i*. The chain then leads upward, supported in place by rollers, in the direction *h h*, until it reaches *f*, where it is riveted to the other end, thus forming a continuous chain. It will be borne in mind, that there is precisely a like arrangement of chains and pulleys for each side of each shutter, and by reference to the plate it will be understood that, on turning the crank at *i* forward, the shutter will be opened; if turned backward, the shutter will be closed.

At *k k*, Plate V., Fig. 1, are two iron rails secured to the outside of the dome; they receive the shutter *a* when it is rolled back; there are separate rollers for this track, seen at *c′ c′*, &c., Fig. 3. They have proved safe guides, when the dome has been much encumbered with ice and snow. Fig. 3, at *a′ a′*, &c., are iron rollers about one inch in diameter; they bear the weight of the shutter, resting on the frame of the dome at the sides of the opening.

The arrangements for the middle shutter are similar to those for the upper one; the only difference consists in placing the iron arm to which the chain is fastened at the upper, instead of the lower, part, and leading its chains down to the pulley at *o*, Fig. 1. The chain is then carried up along the edge of the opening, round the ceiling of the dome, and down to *i*, where there is another toothed pulley to receive it.

Plate V., Fig. 1, at *n* is given an edge view of the iron frame supporting the wheels and pinions for moving the chains of the shutters. This frame is six feet two inches wide by twelve feet high, and is firmly bolted at its upper part to the dome, at *p*. The upright part is of bar-iron three inches wide by three quarters of an inch thick; the cross-bracing bars are two inches wide by half an inch thick. At *q* are bolt-holes, intended for attaching the observing-chair to the frame to be carried round with the dome. It is not, however, used, as the driving-wheel of the chair is found to be more convenient, and brings this motion immediately under the control of the observer.

The axles of the wheels at *i* are six feet long, and near the ends have toothed pulleys, like the one shown in Plate IV., Fig. 2, letter *i*. There are four of these pulleys, each of them seven inches in diameter. The axle carrying the chain of the upper shutter is a hollow cylinder, and the axle of the lower shutter passes through it. The power-gearing of both is on the right-hand side of the frame, and consists of two iron wheels (one for each axle) of eleven inches in diameter, and a double-headed pinion of three inches in diameter. To the pinion-arbor is attached a crank of one foot purchase. The pinions have an end motion, that they may readily be changed from one wheel to the other, the same crank moving either shutter up or down.

For turning the dome, a series of toothed iron plates, with a curvature of fourteen feet nine inches radius, is fastened to its lower section, forming a contrate wheel of twenty-nine feet and a half in diameter. Into this is geared a wheel four feet in diameter, acting vertically in the recess at the southeast corner. The weight of the dome is about fourteen tons, and it can be moved through an entire revolution by a single person in thirty or forty seconds.

In addition to the security resulting from the weight of the dome constantly tending to bring the balls to the middle of the curved rail, and consequently to produce a coincidence of the centres of the upper and lower circles, eight iron braces are fastened to the wall, seen in Plate II., and present rollers of three inches in diameter to the interior of the dome. These are designed to prevent an accumulation of oscillation during high winds, rather than to act as guides on ordinary occasions. The form of these and of a part of the machinery is exhibited in Plate II.

Plates III. and IV. represent perspective and sectional views of the observing-chair.

Plate IV., Fig. 1, at *a a* is seen a portion of the wooden frame ; *b b* is a section of the box confining the counterpoise weight *c*, attached to the chain *d d*, which passes over a pulley at *f*, and is secured to the chair at *e*. There is the same arrangement on the opposite side. The two balance-weights exceed the weight of the chair by one hundred pounds. The chain *g g* is attached to the upper extremity of the iron rail at *h*. It passes round the toothed wheel *i*, and then upwards over the plain iron pulley at *k*, thence downwards till it is made fast to the arm of the axle of the *tension weight*, the purpose of which is to preserve constantly a safe gearing of the chain in the toothed wheel *i*. The action of the chain and pulleys is seen in Fig. 2.

The chains, side and edge views of which are given in Fig. 3, are made after the same manner as the fusee-chain of a watch ; the links are each an inch and a half long, and, being all struck out in the same die, are uniform in size. The teeth in the wheel *i* have spaces corresponding to a link of the chain, and are cut down in the middle, as seen in Figs. 2 and 4, to admit the inner connecting link, so as to allow the outside links of the chain to fall into the spaces between the teeth of the wheel, giving a perfectly safe holdfast for the chain.

In Fig. 4 the wheel for elevating the chair is seen attached to the shaft *m* ; this shaft is turned by means of the endless screw *n*, Fig. 5, working in the wheel *o*, as seen in Figs. 4 and 5. On the top of the shaft *p*, Fig. 5, is a round table, *q*, serving as a convenient stand for the observer's note-book, &c.

It will be seen that by turning the handle *r*, motion will be communicated to the shaft *m*, which is attached to the seat of the chair in such a manner as to elevate or lower the chair as occasion may require. The endless screw *n* was selected for giving the motion, in preference to any form of ratchet or lever work, for its security against the accidents to which the latter are always liable.

In order to make the eye of the observer move in a circle concentric with that de scribed by the eye-piece of the telescope, and at the same time to preserve the horizontal position of the seat, two curved iron rails are secured to the frame on each side of the chair. On these rails the chair moves, being supported in front and back on rollers, at *s s* and *t t*. To fulfil the required conditions, the radius of curvature of each rail was made nearly equal to the radius of the circle described by the eye-piece of the telescope. The centre of curvature of the front rail is placed, relatively to the centre of motion of the telescope, as the eye of the observer is to the axis *k*, Fig. 1 ; the upper part of the rail being carried back far enough not to interfere with the motions of the telescope. The centre of curvature of the back rail is placed relatively to the centre of the front rail as the axis *u u* is to the axis *k*.

The geometrical principle made use of may be illustrated by describing three circles of equal radii from the apices of any triangle, *a b c*, as centres; the relative positions of *a*, *b*, and *c* being those of the observer's eye, and the axes *k* and *u u*.

Plate IV., Fig. 6, shows the arrangement for altering the position of the part of the chair supporting the head and back. Attached to the chair at *x*, Fig. 1, is a box for holding the different eye-pieces.

To facilitate the horizontal motion of the chair, two rails, seen in Plates II. and III., of round inch-iron are let into the floor of the dome; the inner track is on a radius of seven feet four inches, and the outer of twelve feet four inches. On these rails the whole frame moves on four wheels, with grooves adapted to the rail. A driving-wheel, seen in Plate III., at the back part of the frame, runs on the outside track. It has a double groove, one fitted to the track, and the other with spurs to prevent the slipping of a rope which passes round it. This rope leads over pulleys on the top rail of the frame, and passes down within reach of the observer and round a pulley fastened to the lower front rail of the frame. To this pulley is attached a spiral spring, to preserve an equable tension on the rope.

This contrivance enables the observer, without leaving his seat, to move the chair round on the railway, while at the same time he is able to adjust his position in altitude. Whatever may be the position of the telescope, a proper movement of the driving-wheel and of the endless screw brings the observer's eye to the eye-piece of the telescope. The machinery above described is found on trial to fulfil perfectly the objects for which it was designed, giving the observer entire command over his position, and combining security with ease and steadiness of motion.

The Great Refractor. — This instrument was made at the establishment of Messrs. Merz & Mahler, at Munich, Bavaria. The extreme diameter of the object-glass is fifteen and a half English inches. The effective aperture is fourteen and ninety-five hundredths inches, the solar focus being twenty-two feet six inches. From the outer surface of the object-glass to the intersection of the declination-axis is thirteen feet seven inches. From the intersection of the declination-axis to the solar focus is eight feet eleven inches.

The centre of motion of the whole instrument is twelve feet nine inches above the floor of the dome. The entire length of the declination-axis from its junction with the bed-plate of the tube is six feet; the axis is of steel, or steel-cased, and its bearings are three feet eight inches apart, and are relieved by four friction-wheels three and a half inches in diameter.

The declination-circle is twenty-six inches in diameter, reading by four verniers to four seconds of arc. The polar axis is also of steel; its length, from the end-bearing of its lower pivot to its junction with the bed of the declination-axis, is three feet ten inches, and its bearings are two feet eight inches apart. The upper bearing is relieved by two friction-wheels seven inches in diameter, attached to the short arm of a lever, which moves on a steel pin below the axis; the longer arm of the lever passes through the upright part of the cradle of the lower axis, and supports at its forked extremity the balance-weight of the polar axis. The lower or southern end of the axis rests against a plate of hard metal, which is capable of adjustment by means of a stout capstan-headed screw.

The hour-circle is eighteen inches in diameter, and reads by two verniers to single seconds of time.

The cradle in which the polar axis rests is of brass, four feet ten inches long by nine broad, and is four inches deep. This is secured to the bed-plate by twelve large steel screws. The bed-plate itself is attached to the stone tripod by six screw-bolts.

The tube of the telescope is of wood, veneered with mahogany and polished on the outside. Within, it is lined with paper, and is strengthened by iron diaphragms. The flexure of the tube is counteracted, and its balance preserved, by two brass rods seventeen feet in length, having at their extremities nearest the eye-end brass spheres filled with lead, eight inches in diameter. These rods turn on a universal joint near the middle or centre of motion, and oppose the influence of gravitation on the longer and heavier part of the tube in every position.

The focal length of the finder telescope is forty-five inches, and its aperture three inches.

Sidereal motion is communicated to the telescope by means of clock-work, regulated by the friction of centrifugal balls. There are eighteen eye-pieces of the following description. The powers given I have determined by means of a Dolland dynameter.

Annular Micrometers.		*Plain Eye-pieces.*	
No. 1.	Power, 103.	No. 1.	Power, 222.
2.	" 172.	2.	" 333.
3.	" 229.	3.	" 505.
4.	" 373.	4.	" 767.
		5.	" 1118.

Spider-line Micrometers.

No. 1.	Power, 141.	Field of view,	12′.
2.	" 206.	" "	9.
3.	" 316.	" "	7.
4.	" 401.	" "	4.
5.	" 688.	" "	3.
6.	" 861.	" "	2.
7.	" 1243.	" "	2.
8.	" 1561.	" "	1.
9.	" 2004.	" "	1.

The position-circle of the micrometer at the divisions is seven inches in diameter, reading by two verniers to single minutes. The head of the micrometer-screw is divided into one hundred parts, each being of the value of one tenth of a second of arc nearly. The equality of the values of the revolutions and half-revolutions of the screw has been examined over a space of fifty revolutions by transits of Polaris.

Revolutions in different parts of the screw are found to be sensibly equal, and no irregularities were detected beyond the limits of errors to which the determination was liable.

The values of a revolution of the screw for different temperatures are as follows: —

Temperature Fahrenheit,	0°.	Value of r =	9.771.
" "	+16.	"	.797.
" "	+61.	"	.801.
" "	+82.	"	.813.

Final value of one revolution: —

$$r = 9.''800 + 0.''00026\ (t^\circ - 50^\circ).$$

The dilatation of the screw seems to have greater effect on the value of r than the increase of focal distance, arising from the expansion of the object-glass.

The workmanship of the machinery of the mounting is creditable to the makers, and the general plan combines strength with simplicity and convenience of management. The friction of the various actions is greatly relieved by the judicious arrangement of counterpoises and friction-wheels, so that the whole is moved with great ease by a single finger, though weighing about three tons.

It has been objected to the German form of mounting a telescope equatorially, that it requires reversal whenever the object under examination crosses the meridian. This is felt as a practical inconvenience with the Cambridge equatorial only in small zenith distances, since in most instances the telescope passes the meridian by more than an hour of right ascension, and always by more than two hours in southern declinations.

There are, however, one or two points in which the instrument is susceptible of improvement. The arrangement of the divisions of both the declination and hour-circles is awkward, and the reading off of both attended with needless trouble. The screw for adjusting the focus of the eye-pieces has too fine a thread and is inconveniently situated. The clock for regulating the movement of the telescope is disproportionate to the other parts of the instrument, and in cold weather requires frequent adjustment.

In every other particular, I believe we have reason to be perfectly satisfied. The object-glass, by far the most important part of the instrument, is an admirable specimen of the skill of Messrs. Merz & Son. Its defining excellence is such, that powers of from seven to twelve hundred are habitually used in the measurement of double stars. On rare occasions, a power of two thousand has shown well the disks of Neptune and of the satellites of Jupiter. With powers of seven and eight hundred, we have separated the disks of stars whose measured distance has proved to be 0.″3.

With a power of one hundred and forty-one, the sixth star of the trapezium of Orion is distinctly separated from its bright companion. The fifth star we have seen after sunrise. This star is classed as of the thirteenth magnitude.

The satellites of Neptune and the inner and eighth satellites of Saturn are seen steadily, as well as the edge of its ring, at what is called its disappearance.

I consider the smallness of the disks of the stars which are given by this object-glass an indication of remarkable excellence. Soon after mounting the telescope, we had several caps made for reducing the aperture. These we have since entirely discarded, having found on trial that the whole aperture may be used without injury to the definition.

The Transit Circle. — The *meridian-circle* in some respects resembles the circle designed and made by Troughton for the Imperial Academy at St. Petersburg, which ultimately, in the hands of Mr. Groombridge at Blackheath, rendered such important services to astronomy. Many improvements have, however, been introduced. To the Groombridge circle there were four reading microscopes, which were supported by long brass arms. The Cambridge circle has eight micrometer reading microscopes, and these are attached immediately to the granite pier. For the plumb-line, a striding level is substituted, which, combined with the method of reflection from quicksilver at the nadir point, affords an independent means of ascertaining the amount of collimation of the mid wire without reversal of the pivots; there is, however, apparatus for reversing the instrument.

Beside the usual mode of illuminating the field through the axis, there are facilities for illuminating the wires in a dark field. The eye-piece is provided with two micrometers, one having a vertical and the other a horizontal movement; double friction-wheels, with spiral springs, to relieve the pressure of the pivots upon the Ys, have been applied instead of the single wheel; abutting pieces, with double thumb-screws, are placed at the ends of the pivots on the bearing-plates, to secure the axis against lateral motion. The frame of the instrument appears simple, firm, and symmetrical. The circles are four feet in diameter, being cast in one piece, and are both graduated on silver, from 0° to 360°, into five-minute spaces.

The telescope has an object-glass, by Merz, of four and one eighth inches aperture, and sixty inches focal length. The eight reading microscopes serve to bisect diametrically both circles; the five-minute spaces of the limbs are subdivided by the micrometers, a single division of the micrometer-head being equal to one second of arc, and may be read by estimation to two tenths of a second.

The length of the axis, between the shoulders of the pivots, is two feet two inches; the pivots are of steel, two and a half inches in diameter, and the same in length; the bearing-plates of the Ys are eight inches broad and twelve inches long; they are secured to the granite piers by screws passing into nuts, which are firmly imbedded with plaster of Paris in the stone.

The friction-wheels, for relieving the pressure of the axis-pivots upon the Y's, are supported by plates, eleven inches and a half by twelve inches, secured to the piers. These plates carry also the screw of slow motion, which is brought into action by means of a clamp embracing the axis of the telescope. Plate VI. is a perspective view of the meridian-circle, mounted on its piers. The room in which it is placed is seventeen by eighteen feet, and twelve feet high. A description of the shutters of the roof in this room will answer for those of the prime-vertical, as they differ only in position.

Plate V., Fig. 4, is a sectional view of the southern shutter. It extends down about two feet on the north side, and is quite close at the apex, *r*. The movement is horizontal, east and west, on rollers running on iron rails laid on the outside and inside of the roof of the building, the bearings being at *r r r* and *t*. At *s* is a strong iron arm, secured to the shutter; the form and action of this iron arm are better seen in fig. 6; it is made fast to the shutter at *u*. At the end, *v*, a rope is fastened and carried first forward toward the opening, passing round the pulley *x*. It then leads back, over the pulley *y*, down to *z*, where it is secured to the wheel *z*. The diameter of this wheel is proportioned to the distance which the shutter requires to be moved, so that a turn and a half of the crank z' suffice to open or close the shutter. The other part of the rope, from *v*, leads over the pulley y', and is wound round and fastened to the wheel *z*, in the opposite direction; so that the turning of the crank z' in one direction serves to open, and in the other to close, the shutter.

Fig. 5 of the same plate is a section of the northern shutter, where the same parts, acting in a similar manner, are indicated by the same letters, accented. This part moves independently of the southern, and has a like arrangement for opening and closing, only that the two open in opposite directions, one east and the other west.

This plan has been found to answer completely the intended purpose. The shutters are perfectly weather-proof, and the division into two parts, by keeping the northern part closed during high and cold northerly winds, affords comfort to the observer and protection to the instrument. The southern opening has a range of 110°.

The lesser equatorial is mounted in a detached building, situated about two hundred feet northwest of the great central pier. This building is of wood, and twelve feet in diameter; it turns on iron balls of six inches in diameter, moving in hollow, cast-iron ways. It is turned by hand, without any machinery. The telescope has an object-glass of four and an eighth inches diameter, by Merz, and sixty inches focus, and is provided with spider-line, double-image (Airy's), and annular micrometers. The mounting is by Simms, and its support a granite pedestal entirely isolated from the building.

The comet-seeker is by Merz, and is equatorially mounted after the German fashion. It is portable, and is used from the balconies of the dome; the aperture of its object-glass is four inches, and its field of view four degrees.

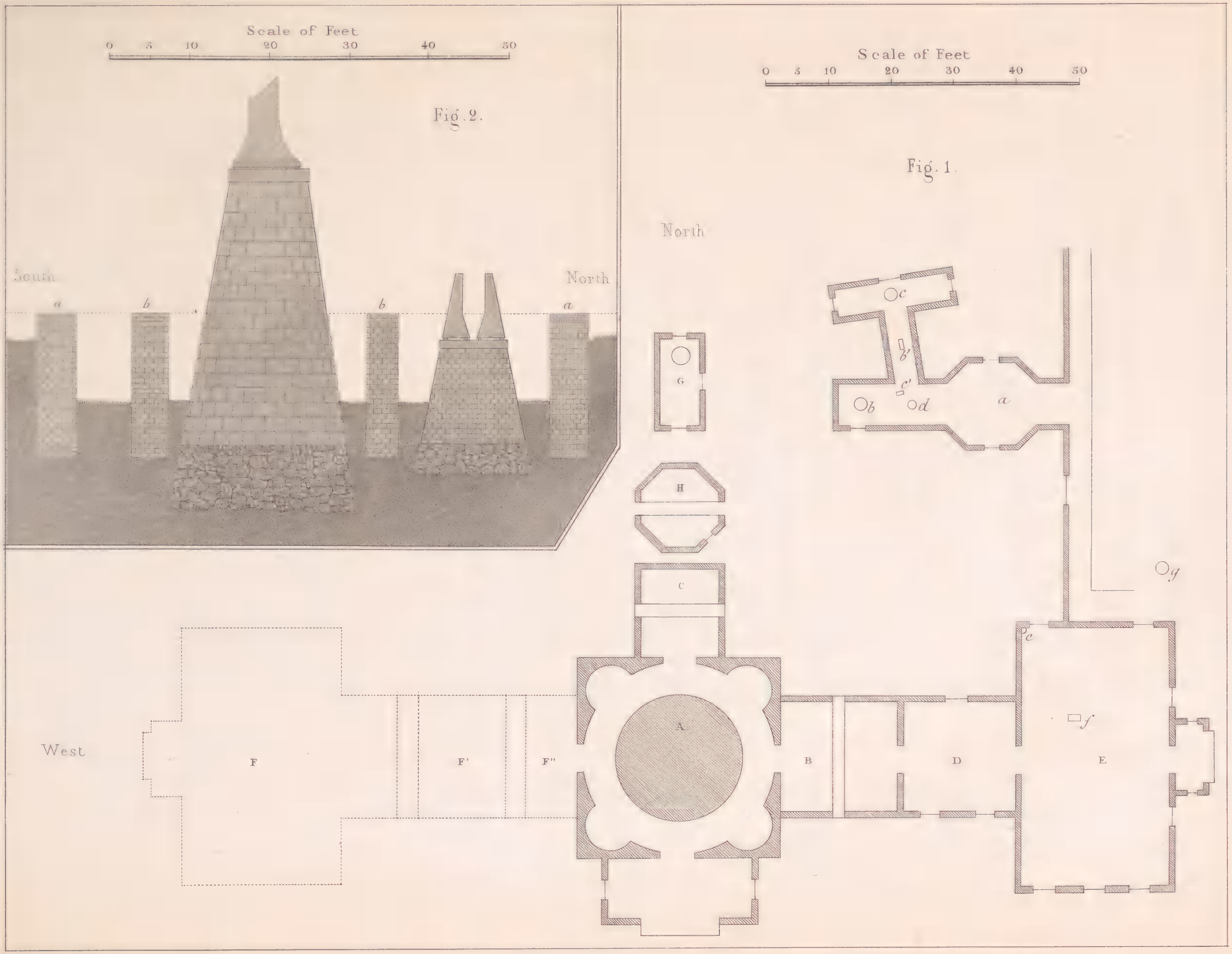
A transit instrument of four feet, made by Troughton & Simms, is mounted on granite piers, in the meridian at *a*, Plate I., Fig. 1. It has also been occasionally used as a prime-vertical instrument on the pier in the room *c*, an extra pair of Ys being provided for it for that purpose.

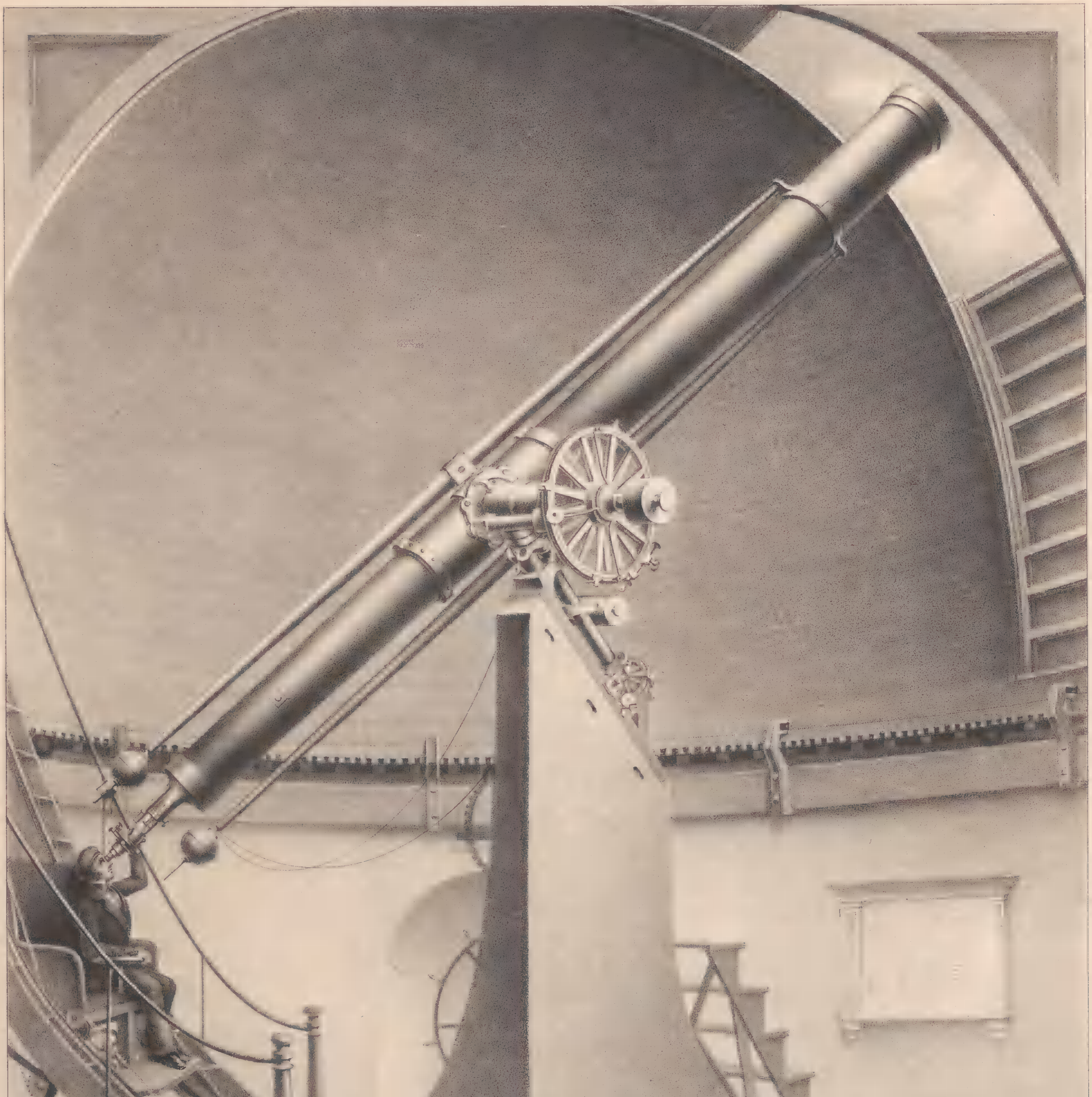
An eighteen-inch variation transit, or altitude and azimuth instrument, is placed on a wooden tripod at *a*. This is used in the adjustment of the magnetic apparatus, which consists of a Lloyd declination-magnetometer at *c*, and a horizontal-force bifilar magnetometer at *b*.

Besides the above, the Observatory is furnished with four four-foot achromatic, and two reflecting telescopes, the necessary apparatus for meteorological observations, an astronomical clock, and several sidereal chronometers.

It is proper to add, that the necessary funds for the establishment of the Observatory, and for its permanent endowment, have been furnished mainly through the liberality of private citizens of Boston and its vicinity. The expense of the buildings and grounds has been defrayed by the University.

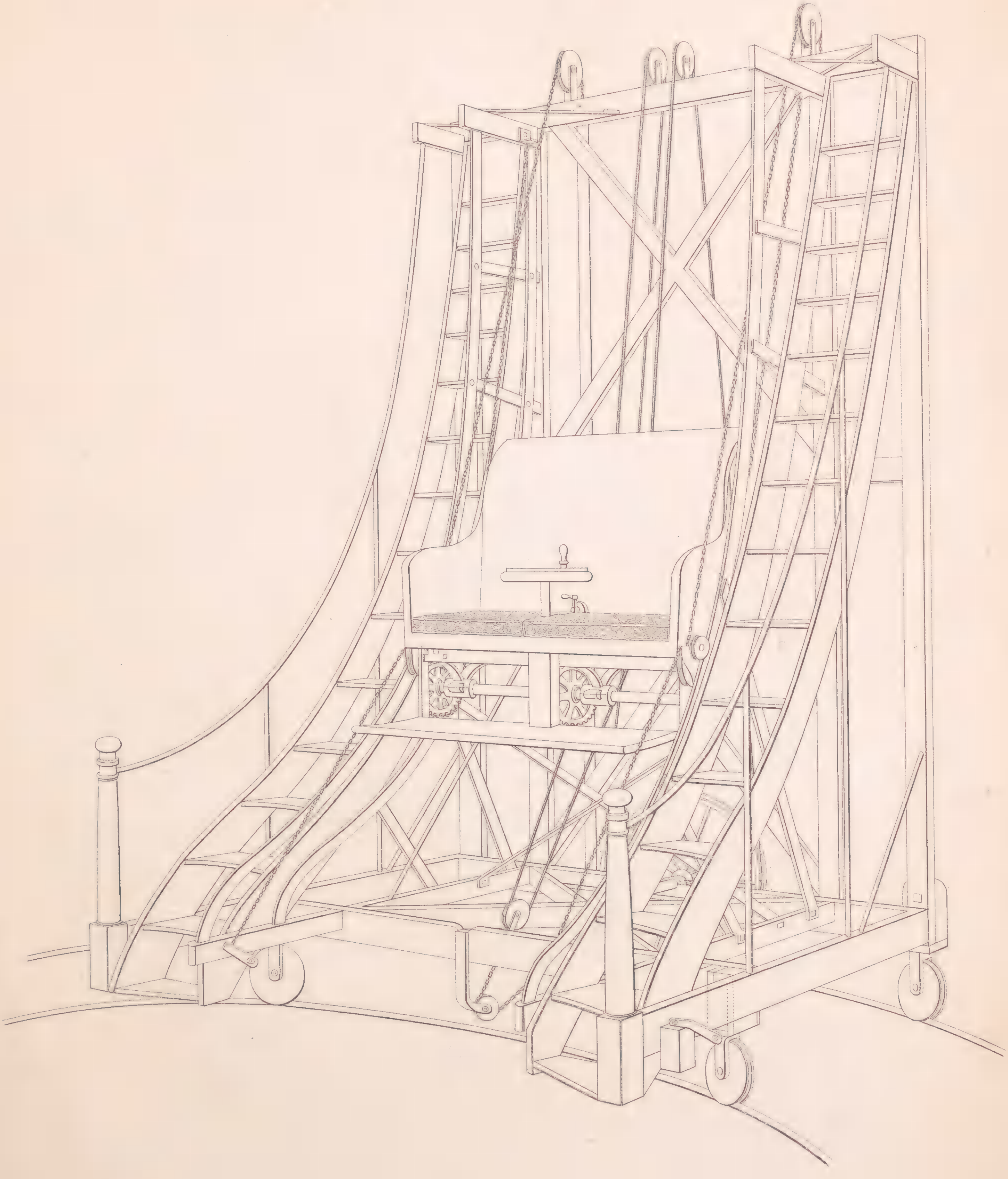
PLATE I.


Scale of Feet
0 5 10 20 30 40 50
Fig. 2.
South
North
a
b
b
a
Scale of Feet
0 5 10 20 30 40 50
Fig. 1.
North
West
a
b
c
d
b'
c'
e
f
g
A
B
C
D
E
F
F'
F''
G
H



of A Sonrel Cambridge Mass

THE CAMBRIDGE U.S. EQUATOREAL.



THE OBSERVER'S CHAIR.

Fig. 6.

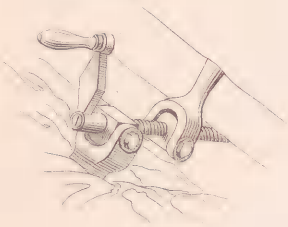


Fig. 3.

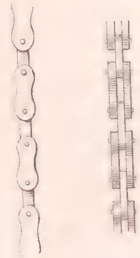


Fig. 5.

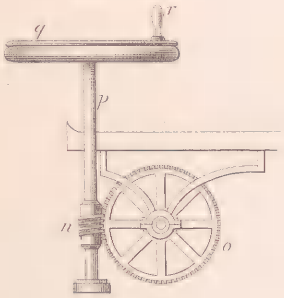


Fig. 2.

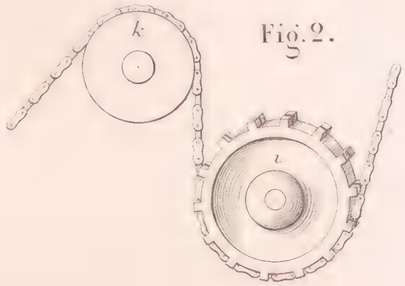


Fig. 4.

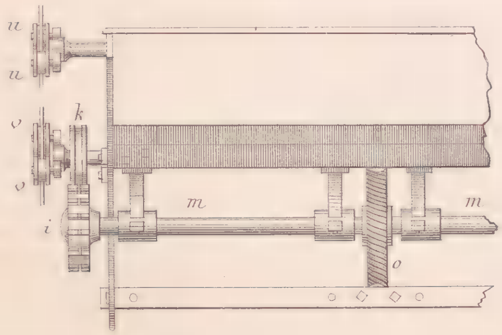
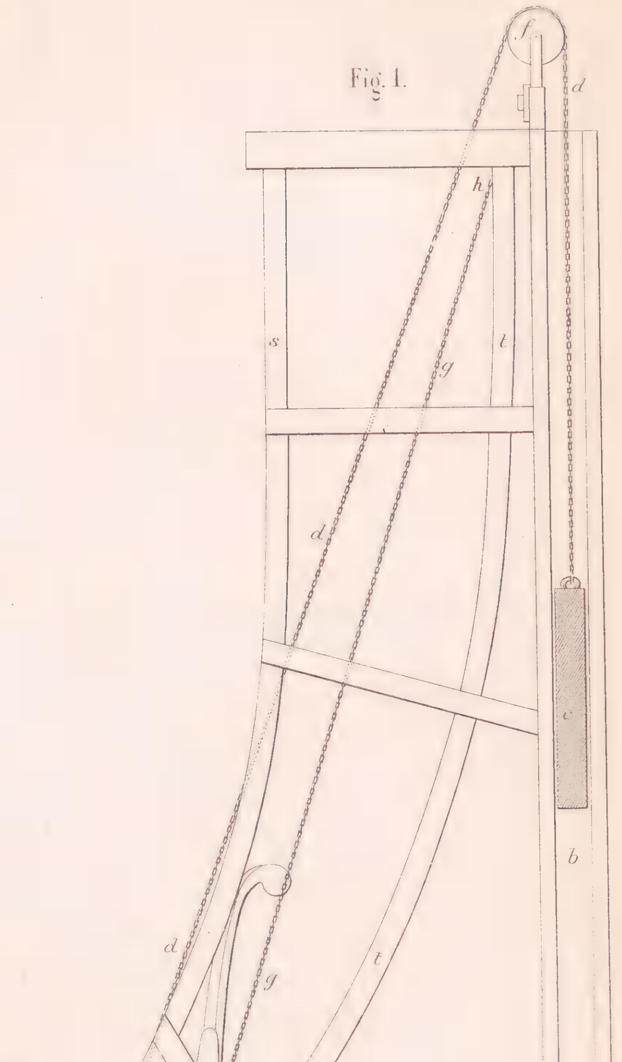
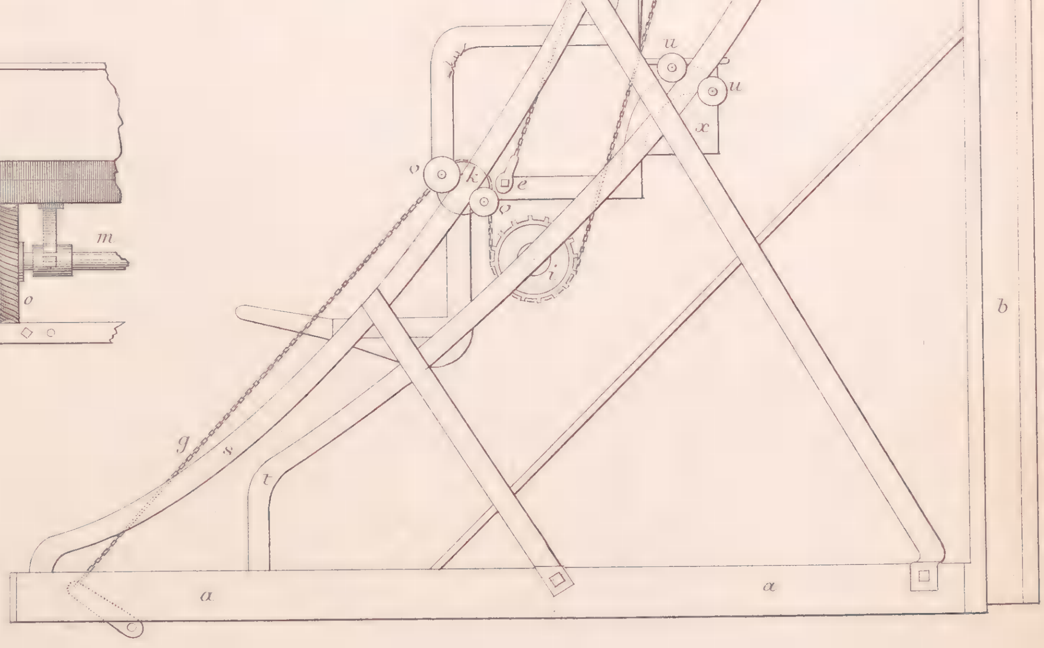


Fig. 1.

SECTION & DETAILS OF THE OBSERVER'S CHAIR.

PLATE V.

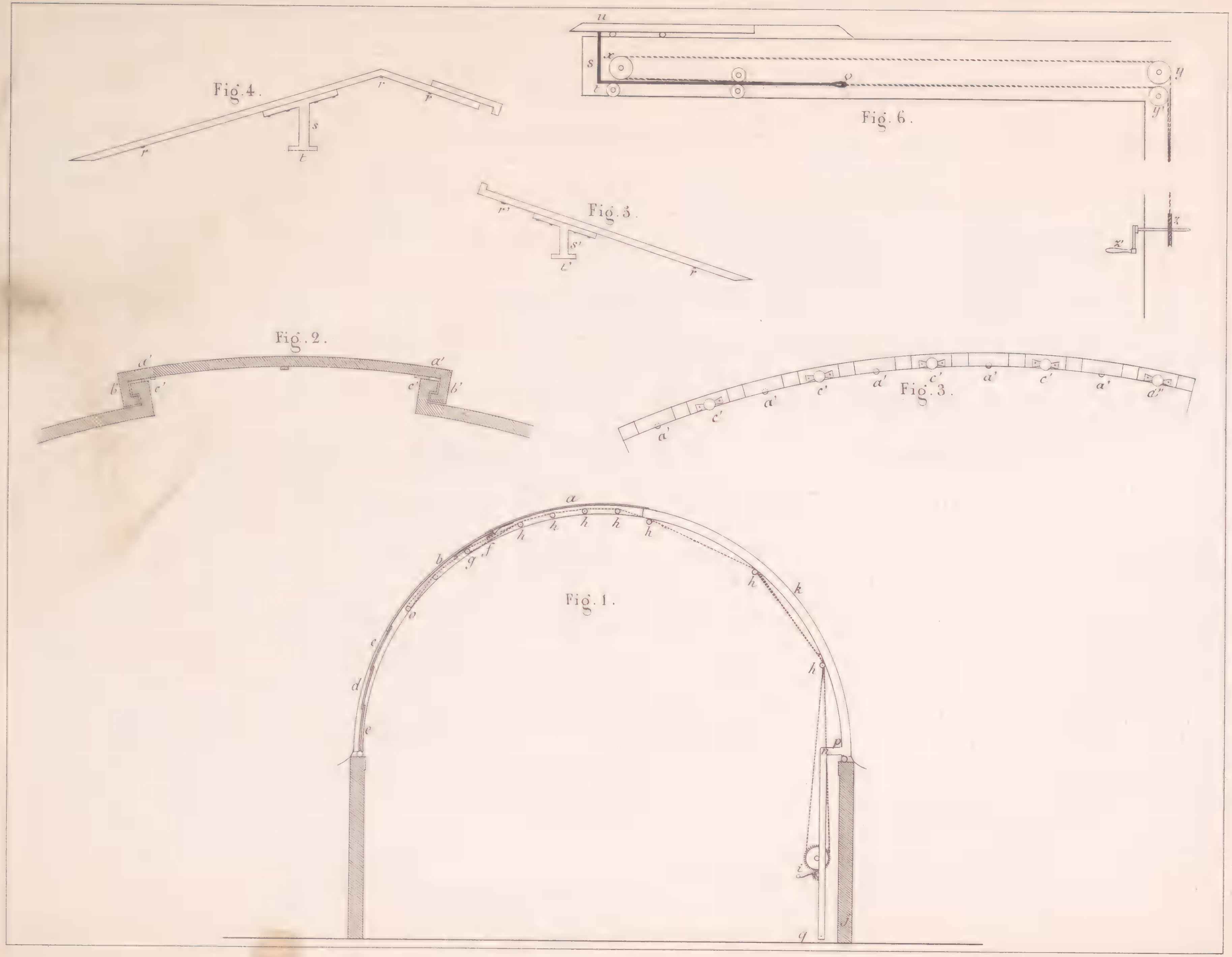
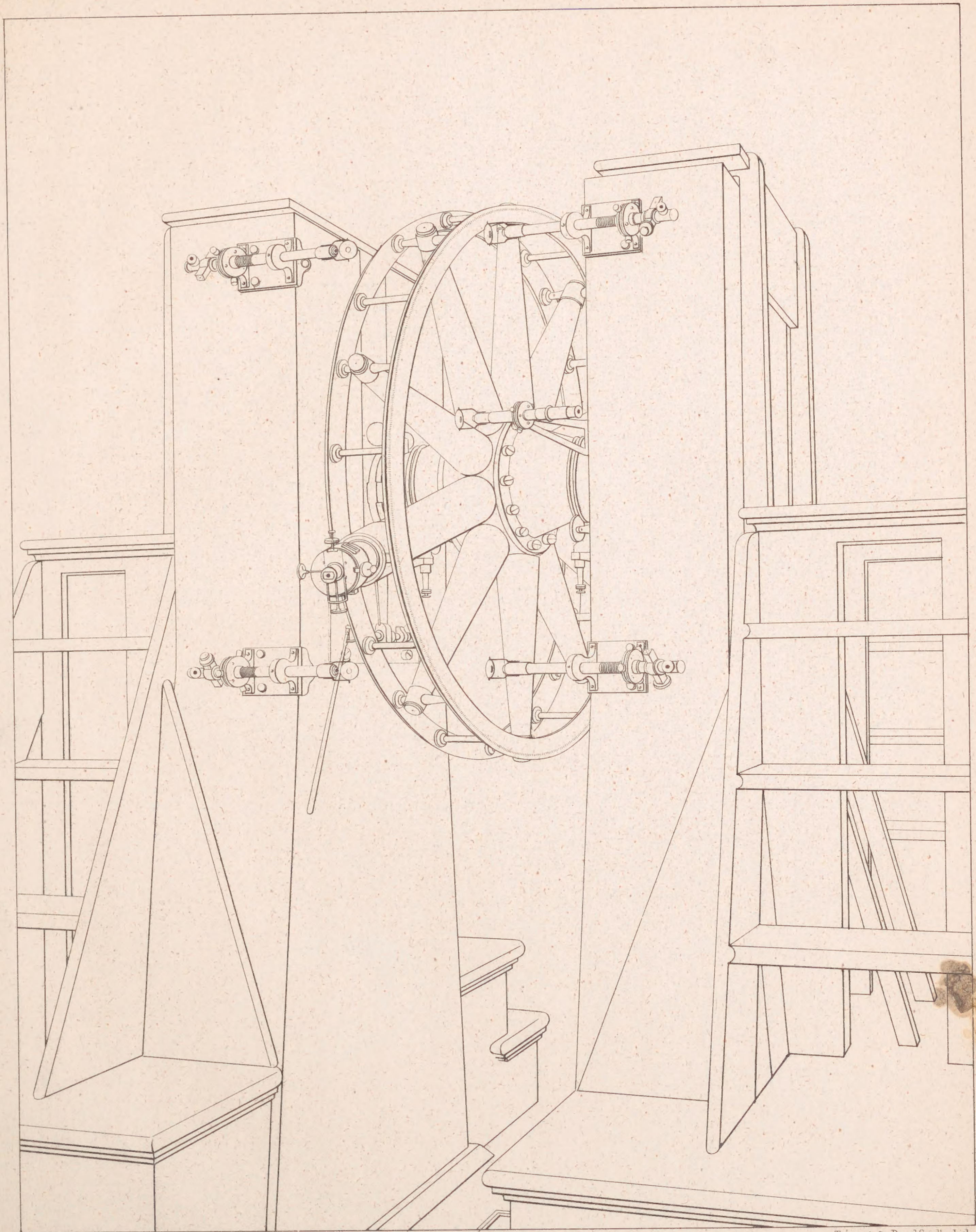


Fig. 4.
r
s
t
Fig. 6.
u
s
x
t
o
y
y'
z
z'
Fig. 5.
r'
s'
t'
Fig. 2.
a'
b'
c'
Fig. 3.
a'
c'
a''
Fig. 1.
a
b
c
d
e
f
g
h
i
j
k
n
o
p
q



A. Sonrel on stone, Boston.

Tappan & Bradford's Lith.

TRANSIT CIRCLE.