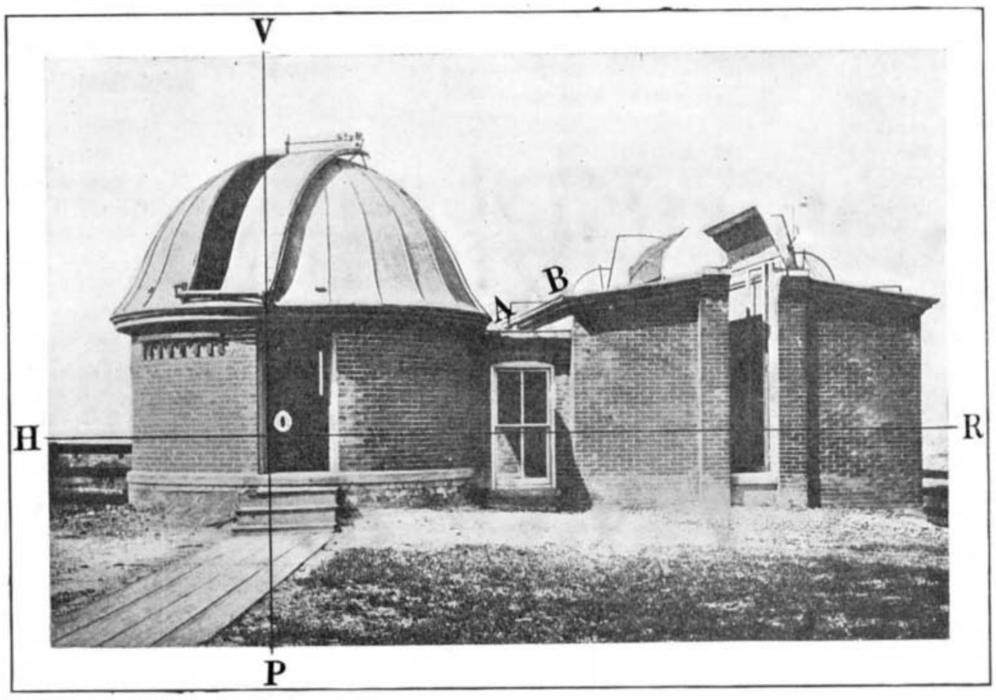
WHERE WAS THE CAMERA SET UP?

BY WILLIAM F. RIGGE, S. J.

In a former issue of this journal (September 24, 1904) I solved the problem as to *when* this photograph of the Creighton University Observatory (at Omaha, Neb.) was taken. In the present one I wish to find *where* the photograph was taken from, that is, to determine the exact spot at which the camera was set up. The solution of this problem is much easier than that of the first, and that in practice as well as in theory.

There are in general, I might say, two methods of solving the present problem, the physical and the mathematical methods. The physical method would consist in walking toward or away from the building, and by a careful scrutiny of the view it presents to the eye, to find the spot from which this view is identical with that shown on the photograph. This method might be capable of giving very good results. But as its principles are not evident, there is nothing to be learned from it. Moreover, the solution it offers would become impossible, when this access to the building for some reason or other becomes impossible.

The mathematical method makes use of the principles of perspective, and obtains its results from a few simple measurements executed upon the building and upon the photograph. In case it should be impossible to obtain these measures from the building itself, its plans, elevations, or at least the necessary specifications, must be supposed to be obtainable. To explain this mathematical method is the purpose of the present article.

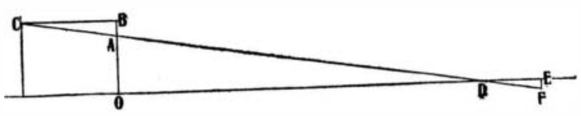


WHERE DID THE PHOTOGRAPHER STAND WHO TOOK THIS PICTURE?

We begin our attack upon the problem by determining the position of the horizon line, HR, upon the photograph, that is, of the line which is on a level with the camera. As the equatorial room of the Observatory is circular in shape, each horizontal row of bricks and each mortar line is in reality a circle. But as the eye, or the camera, can be on a level with, or in the plane of, only one of them, this one alone must appear on the photograph as a straight line, while all the rest must appear to be more or less curved. For this reason the horizon line, HR, must not only run perfectly straight through a row of bricks or a mortar line across the whole building and across all buildings, whatsoever their shapes may be, shown on the same photograph, but it is also the only line that can be so drawn. In our case this horizon line runs through the middle of the seventh row of bricks above the water table of the equatorial room. Measurement upon the building then shows that the camera was 18⅜ inches above the level of this floor.

By the principles of perspective, all lines parallel to one another in space will meet, if produced upon the photograph, at a certain definite point, called the vanishing point. If the lines are horizontal, this point must be on the horizon line, HR. As we wish to find the distance the camera was set up in front, or south, as well as east or west, of the building, we select the horizontal lines running north and south. Unfortunately, the present photograph has only one such line to offer, but that one is well defined, and it is amply sufficient for the purpose. This is the line AB, the west edge of the roof of the transit room, the edges of the transit shutters not being judged sufficiently reliable for the present determination. We produce the image of the line AB on the photograph until it intersects the horizon line, HR, in the vanishing point, O, through which the vertical line, VP, may then be drawn. It is plain that the line drawn from the camera to the point, O, is also horizontal and due north and south and projected into the point, O, itself. Hence, if we measure the distance of the point, O, almost at the very edge of the door frame, from the middle of the door, which is due south of the center of the equatorial room, we can determine how far the camera was set up west of the center of the dome. This measurement may be executed either upon the door itself or upon its image on the photograph, since we know that here the scale gives us 18⅜ inches as the distance from the horizon line, HR, to the water table of the building. The result is that the camera was set up 15¼ inches west of the center of the dome. This is therefore our second co-ordinate.

The next part of the problem is to determine the distance of the camera from the front of the building. Let us imagine a plane drawn in space through the edge of the roof, AB, and the point, O. This will give us Fig. 2. D is the camera, that is, the optical center of its lens. O and B are the corresponding points O and B on the photograph. C is the true place in space of the point, A, that is, of the north end of the edge of the roof, and A is its apparent place as seen on the photograph. The plane of the photograph is perpendicular to the line OD at the point, O, and hence OD is the distance due south of the optical center of the lens from the south end of the edge of the roof, B.



How the Distance of the Camera from the Front of the Building was Determined.

In Fig. 2 we have two similar triangles, AOD and ABC, and hence the proportion:

$$\frac{AO}{AB} = \frac{OD}{CB}, \text{ whence } OD = \frac{AO}{AB} CB.$$

As the ratio $\frac{AO}{AB}$ is the same on the photograph as it is on the building, the problem is thus very much simplified in practice, since all we need for its solution are the length of CB measured on the roof, and the lengths of AO and AB measured on the photograph on any scale whatever. The edge of the roof, CB, was found to be 17 feet 10¼ inches, and AO and AB on the photograph were found to be 11.31 and 2.96 respectively on a scale of fifths of an inch. Hence by proportion OD is equal to 68 feet 2¼ inches. As the cornice overhangs 7¾ inches, the distance of the optical center of the lens from the south front of the transit room was 68 feet 10 inches. By additional measurement we find that the camera was set up 72 feet 7 inches south of the center of the dome, which is the third co-ordinate, or 64 ft. 7 in. south of front door.

We can now also find the focal length of the lens. Knowing that twenty-five bricks at the front door measure 72¼ inches in reality and 1¼ inches on the photograph, we see that the photograph reduced the size of this object 57.8 times. Then on Fig. 2, where the triangle, DEF, has been enlarged ten times, we have a proportion similar to $\frac{AO}{EF} = \frac{OD}{DE}$, that is, we divide the distance of the camera by 57.8, and get $ED = 13.47$ inches as the effective focal length of the camera for this photograph. Erecting a perpendicular 13.47 inches long to the plane of the original photograph at the point, O, we are in a condition to reconstruct the whole observatory in all its three dimensions.

The solution presented in this article supposes that the plane of the photograph, the picture plane as it is called, was parallel to the front of the observatory, that is, at right angles to the line running from the camera to the point, O, instead of to the center of the picture, that is, the point half-way between H and R. As the latter position is the usual one for a plate, and was therefore most probably the actual one in this instance, the picture plane made an angle of about 8 degrees with the front of the observatory. Hence, all lines parallel to HR were shortened very nearly in the ratio of the cosine of 8 degrees, that is, about one per cent, a quantity too small to affect the results.

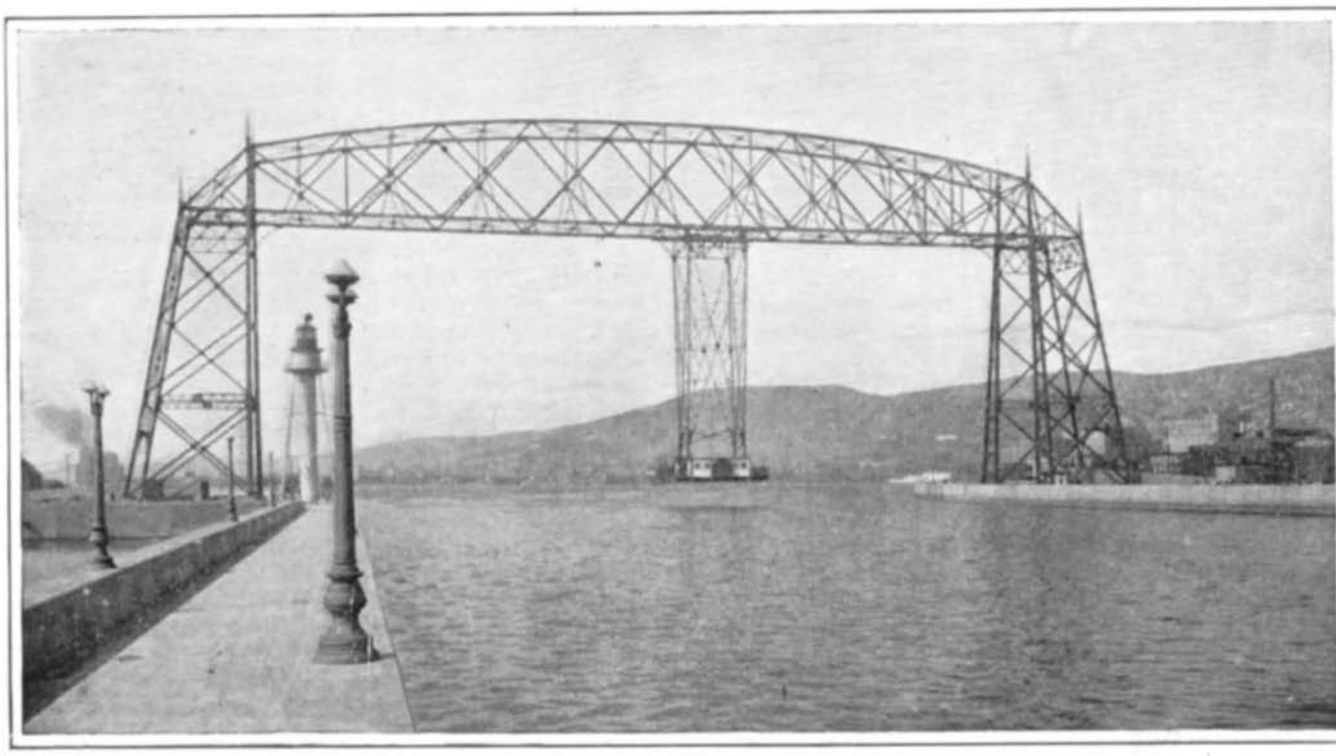
AN ELECTRICAL AERIAL FERRY.

BY FRANK C. PERKINS.

The aerial ferry at Duluth, the first structure of its kind in this country, has been completed and is now in operation.

The suspended ferry car has a normal speed of about four miles per hour, but the electrical motors and driving equipment are capable of propelling the car at twice that speed should it become desirable, and the passage of the canal can be made by the suspended ferry car in slightly over one minute.

There are two electric motors, each of 50-horse-power capacity, located under the floors of the car. These electric motors operate two drums, each of which is 9 feet in diameter, and on these drums are wound cables 1 inch in diameter, extending to the truss and then over idle wheels 9 feet in diameter through the inside of the lower chords to tower, where they are fastened, and thus produce the motion which causes the car to travel across the canal.



THE RECENTLY COMPLETED AERIAL FERRY AT DULUTH.

The canal was adopted by the United States government about four years ago, increasing its width from 240 to 300 feet, and constructing permanent piers of cribwork and concrete. Minnesota Point was con-