ruins of another abbey, but the bad light, combined with the unpleasant nature of the surroundings, prevented us getting a shot at it. We decide that we have had "Not too much Cashel, but just Cashel enough," during the short period of our stay here, so we engage a car for Gould Cross Station en route for Dublin.

The morning finds us bent upon a stroll round Dublin, and through its principal streets—Sackville Street and O'Connell Street—we pass on our way to the R. C. Cathedral. Before looking through Trinity College, we glance at the stately buildings formerly (and not impossibly again) the Parliament Houses of Ireland. After passing through the House of Lords in the interior, we see on the opposite bank of the Liffey the Seat of Justice, viz., the Four Courts. With a run round the Castle precincts, noticing Chapel Royal, our business in Dublin is completed.

We now drive to the Amiens Street Station, and book for our last excursion, viz., the Hill of Howth. The train runs round the north side of Dublin Bay, along a narrow neck of land, with open sea on either side shining in the brilliant sunshine, and soon reaches Howth. We climb up its quaint straggling street, hanging on, as it were, by its eyebrows to the hill side, and are soon by the abbey gate. The magnificent view that here unfolds itself makes one agree with Bradbury, when he says that a visit to Howth is alone worth visiting Ireland for, even if there were nothing else to see.

At our feet is the Abbey of Howth, beyond, the wide-reaching arms of that gigantic failure, Howth Harbour; and further still, bright and clear, though several miles away, the Island of Ireland's Eye stands out sharp and distinct, and the ruins on it can be distinguished with the naked eye.

Lovers of wild rocky coves, bold headlands, and rugged coast lines, can here find ample subjects for studies, with ever-changing effects, and beautiful in every mood and phase of the unrestful sea and wind.

Howth Castle (the ancestral residence of the Earls of Howth), where, according to tradition, the fate of their "long ancestral line" is dependent upon the life of a famous yew tree of fabulous age—we see and photograph.

Then, tired, but delighted with our week's excursion, we return to Dublin, and the boat from North Wall bears us away from the Emerald Isle.

LESSONS DERIVED FROM PIN-HOLE PHOTOGRAPHS.

BY BARNARD S. PROCTOR.*

THE rule for finding the focus of a lens for an object at any distance, its focus for parallel rays being known, is as follows: Multiply the distance of the object by the focus, and divide the product by the distance minus the focus; *e.g.*, the distance being ten yards, and the focus for parallel rays ten inches, multiply 360 inches by 10 inches=3600, and divide by 360 minus 10, *i.e.*, by 350.

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350)3600(10·28
    350
    1000
     700
    3000
    2800
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The focus for an object at ten yards distance is thus found to be 10·28 inches. Or you may take the focus as a unit, state the distance of the object in foci, and divide by the same number minus one. Thus, 10 yards=36 foci, divide by 35 foci=1·028, the distance expressed in foci, and convertible into inches by multiplying by 10. Suppose you are taking a view with a 10-inch focus lens, your foreground being 9 to 10 yards distance and the background as many miles away, you focus for 10 yards, and have the objects at 9 yards, and those at 9 miles about equally out of focus; the focus for the former being about $\frac{1}{4}$-inch behind the plate, and that of the latter being $\frac{1}{4}$-inch in front of the plate. The size of the stop which may be tolerated under these circumstances will be such as, when its diameter is divided by 40, gives a fine just visible point, the reason for which you will readily see. The objects too near and too far are $\frac{1}{4}$-inch out of focus; $\frac{1}{4}$-inch is $\frac{1}{40}$ of the distance between the aperture and the plate. The cone of light which passes through the aperture comes to a point at its focus, but will, if intercepted by the plate at $\frac{39}{40}$ of its focal distance, still have a measurable size of $\frac{1}{40}$ that it had as it passed through the lens. Another cone of light which has come to a focus $\frac{1}{4}$-inch before it reaches the plate will diverge again to practically the same extent by the time it meets the plate.

With an inch aperture the finest lines that are thus a $\frac{1}{4}$-inch out of focus will have a thickness of $\frac{1}{40}$th inch on the picture, a degree of focal aberration which, under many circumstances, would not be willingly tolerated; but if we put in a stop of $\frac{1}{10}$th inch diameter, these out-of-focus lines are reduced to a thickness of $\frac{1}{400}$th of an inch, a degree of fineness rarely required.

So far I had written before Mr. Pae's paper of February; now I may add a remark or two bearing upon what arose at that meeting.

It may be remembered that Mr. Pae drew a diagram of a camera with two foci on the black board, and that I objected to it as tending to mislead, from being so much out of proportion. He amended it, and, on my still objecting, challenged me to draw it as it ought to be. This I declined to do without a calculation. That calculation I now propose to put before you. The diagram represented a camera in section, to show the difference between the position of the focussing-screen when its distance is changed to bring into best focus two objects, the distance of one being 90 feet, and that of the other three miles.

He drew the camera, and represented one line as being 3 inches from the lens, this representing the focus for the objects at three miles' distance, and a second line in the unamended diagram was $4\frac{1}{2}$ inches from the lens, to represent the focus for objects at 90 feet. Taking the shorter form of the rule I previously quoted, we convert the three miles into terms of foci. Thus three miles $\times$ 5284 = 15840 feet $\times$ 4 = 63360 foci; divide this by the same number, minus 1—

$$63360 \div 63359 = 1{\cdot}0000015.$$

This is the measure or foci for parallel rays of the focus for an object three miles' distance, proceeding in the same way for the foreground, 90 feet = 360 foci $\div$ 359 = 1·0002785, giving as a difference between the two expressed in foci, 0·0002770, or, in fraction of an inch, 0·0008310—that is, with a 3-inch lens, there is rather less than $\frac{1}{1000}$th part of an inch difference between the foci for objects at 90 feet and at three miles. This, I think, is sufficient to show that I was justified in objecting to his drawing any inference regarding the distortion of objects due to the focal error in the case he took for illustration, and sufficient to justify my objection to his statement that he had observed focal error amounting to inches under the cirumstances he described.

Now let us see what would be the distance of an object from the lens which would give 4·2 inches focal distance as against 3 inches for the most distant objects. The rule in this case is—divide the observed focus by the observed focus minus the focus for parallel rays, the quotient gives the distance of the object expressed, or foci. The observed focus = 4·2, the focus for parallel rays 3·0; the difference is 1·2, which, divided into 4·2, = 3·5 — the distance of the object in foci $\times$ 3 = 10·5, the distance of the object in inches—$10\frac{1}{2}$ inches instead of 90 feet.

As I have criticised Mr. Pae without mercy, I have felt that I might call down upon myself an equally unmerciful treatment, and I have spoken of parallel rays with a measure of fear and trembling. I was conscious that the sun's rays might not be parallel, and after a little consideration I came to the conclusion that they might not be divergent either, so I resolved to calculate what they are likely to be, and have come to the conclusion that they are converging when they reach the face of the earth. The atmosphere is a refracting medium with an index of 1·000294, and a curvature of about 4,000 miles radius; any column of it bounded by a plane on the earth's surface is a thick plano-convex lens, the focus of which may be calculated by dividing the index of refraction by its excess above one (1·000294 $\div$ 0·000294=3402), which gives the focus in terms of the radius. 3402$\times$4000 gives 13608000 miles as the focus. The sun being seven or eight times that distance, its rays will be rather more convergent when they reach the earth's surface, than they were divergent when outside its atmosphere. To get truly parallel rays, we should catch a planet at about 13 millions of miles distance.

Reverting to Mr. Pae's diagram, the last point which I shall attempt to criticise to-night is his assumption that objects out of focus are consequently represented larger or smaller than they should be. Supposing for the moment that the focal differences had been approximately what Mr. Pae represented, what effect

* Continued from page 183.