think we have reason to believe that oxygen would not be necessary, as the margin is evidently wide enough to allow for the demands of the tissues during rest up to 30,000 ft. or higher, and, moreover, we can become acclimatised to a smaller amount than usual; but to ascend a mountain in a balloon or by railway are not methods which commend themselves to members of this Club.

The method of carrying oxygen requires careful consideration, but I think it must be in the form of the compressed gas in metal cylinders, preferably small ones.

Provided he have plenty of time, plenty of suitable food, and fine weather, I see nothing unavoidable in the condition of the atmosphere at high altitudes to prevent a man with healthy organs from ascending the highest point on the earth's surface.

It only remains for me to acknowledge my indebtedness to Mr. Victor G. Plarr, the librarian of the Royal College of Surgeons, and Mr. W. M. Rorison, for their valuable assistance in translation work, and for their efforts in obtaining for me much of the bibliography which would otherwise have been difficult to secure; also to Mr. Clinton Dent for kindly looking through the paper and giving me the benefit of his experience to condense it into readable form.

Telephotography.

By CHARLES E. SHEA.

INVENTED in 1891 by that able scientist Mr. J. H. Dallmeyer, the telephotographic lens has now been before the public for a full decade, and it must be a matter for surprise that an appliance so valuable to the photographer has not, in this country at least, received more generally the recognition to which its powers and great utility entitle it. The reason, perhaps, is not far to seek, for, undoubtedly, the successful employment of the lens is attended by certain difficulties, and demands a care and attention to details not of such essential importance in the case of the R.R., and other lenses with which the photographer is more usually familiar. But that these inherent difficulties cannot be overcome by any one prepared to give ordinary attention to a few plain principles is not the fact.

The telephotographic lens may be described as an optical system, adapted to the camera, comprising within small weight and dimensions the magnifying capacity of a powerful

telescope, whereby we are enabled to photograph objects at distances impossible with the lens systems previously in use. Glancing briefly at some of the more obvious uses for this lens, we consider first its employment for military purposes. Here the lens should play an important part. It can do what no mere telescope can ever do. It can, from a distance completely removed from the longest range rifle fire, discover and record an accurate picture of the works erected by the hostile force. In the space of a second of time the telephoto lens can do all this, and can furnish the general in command with an exact plan, in every detail, of the enemy's position. When it is recognised, as is the fact, that the telephotograph of a village church clock, at a distance of two miles, has shown clearly the dial with sufficient definition to permit of the time being seen, it will be understood that all ordinary military works, down to the very cannon in position, must be clearly shown. What can be done by balloon telephotography the Italian military engineers have demonstrated.

To the sculptor and to the architect the telephoto lens is of great value, for oftentimes a group of statuary, a capital, or other architectural detail is in such a position that to obtain a picture free from distortion it is necessary to take it from an approximately equal elevation; and to do this with the ordinary R.R. or R.S. lens is sometimes impossible.

For pure landscape work the telephoto lens is absolutely indispensable. An instance is furnished by Schloss Taufers, in the Ahrnthal, in Tirol. The castle, one of the finest ruins in Tirol, is situated on an eminence just above the village of Sand in Taufers. It has a noble background of valley and mountain as seen from the meadows below the village, but to secure this view, while still retaining adequate dimensions for the Schloss, is, with the ordinary lens, impossible; for if we approach the Schloss sufficiently near to obtain any size and detail the background is entirely lost, being, in technical language, 'thrown down' by the tilting of the camera (even if provided with a 'rising front'), necessitated by the elevation of the ruin above the village. If very near the Schloss becomes a mere silhouette against the sky. But the difficulty is surmounted by the telephoto lens. We have but to return to the meadows a mile further away, near to the St. Walburg Kapelle, and our telephoto lens gives to us the picture we desire. The background is brought up in all its beauty, and the castle has dignity and due importance in the picture. The depth of focus (the correction for outstanding spherical aberration having been duly made by the rotation of lens

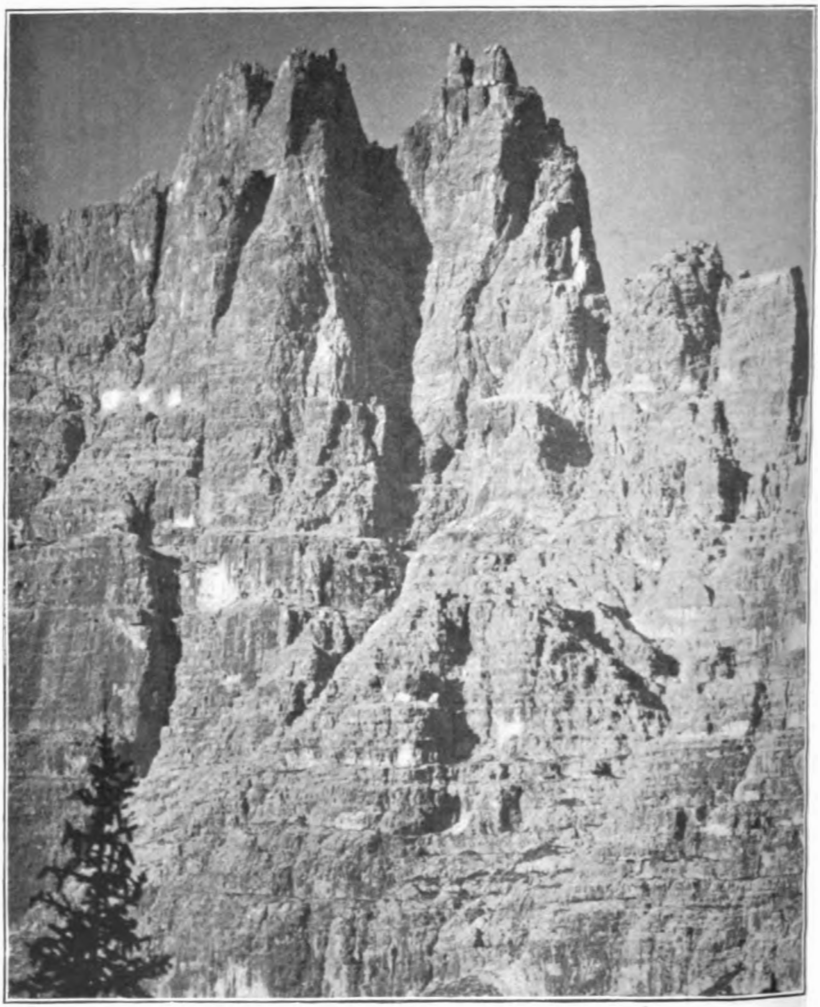


Photo by C. E. Shea] [*Swan Electric Engraving Co.*

THE CRODA DA LAGO, TIROL.

Taken from the Faloria Ridge, with Telephoto lens. High-power negative. Distance 4 miles. Amplification 9 linear.

referred to later on) and the defining power of the telephoto system are evidenced by the practically equal average sharpness of the castle and of the mountain-tops in the background, separated by a distance of over eight miles as the crow flies.

But to the mountaineer the lens has a very special value. In a paper by Sir Martin Conway, recently read before the Alpine Club, the author referred to the great change wrought by the growth of photography, and the development of its ally, the projecting lantern. The large majority of the members of our Club, it was pointed out, are generally unable to take their holiday in the remoter mountain ranges of the earth, but by the aid of the camera, observed Sir Martin Conway, 'if the Club could not go to the Himalayas or the Rockies the Himalayas and the Rockies could come to the Club.' * The telephoto lens extends this principle. Even the fortunate exploring member of our Club has limits placed by time, or other considerations, to the extent of his wanderings and explorations. What advantage, then, on the last day of the outward journey, and when the turning-point has been attained, to take, from some high peak, a view of the great unknown beyond, a peep into the unexplored, a clear and definite picture of things almost invisible with the ordinary lens with which the explorer is usually equipped.

And then the prospecting of a peak with the view of a 'new way up,' or other consideration of laudable Club ambition. Possibly a wide and deep valley intervenes between the mountain which it is desired to photograph and ground of a similar or at all approximate level. To take a view from the absolute foot of the mountain itself would, even with the full employment of the 'rising front,' necessitate a tilting of the camera by which the whole mountain would be, photographically, 'brought down,' and its perspective absolutely distorted. And so the telephoto lens, placed on the opposite side of the valley, bridges the difficulty and space, and gives us the picture which we desire free from distortion.

There are, of course, other uses for the lens, but space does not permit of their description.

At the present time there are before the public several forms of the telephotographic lens, differing in important details. Some have for the 'positive' element of the system a R.R. or R.S. lens; others a single lens, or, again, a 'portrait' combination. Each has claimed for it certain advantages which the others do not possess. It is not pro-

* December 17, 1900. *A. J.* vol. xx. p. 295.

posed to enter now into a consideration of these points of difference, but the suggestions conveyed by this article are based upon the experience derived from the employment of the particular telephoto system used by the writer—in fact, that of the original inventor, Mr. J. H. Dallmeyer. This has for its 'tele-positive' a 'portrait' combination, one advantage of which is that by a suitable rotation of the back lens of the 'positive' element of the lens system provision is made for the correction for outstanding spherical aberration, or the dispersion of focus necessary where the view taken includes several widely different planes or distances in the one picture. This form of telephoto lens has two 'negative' elements, giving different powers of magnification with the same camera extension, and these are called the 'high power' and 'moderate power' negatives. It is advisable that both should be added to the equipment, but if subsequent enlargement of the telephoto picture is desired the beginner will find the 'moderate power' negative far more likely to furnish sharp results than the 'high power.' At the same time the 'high power' negative, when used with the utmost care and precision, will afford, perhaps, more striking and remarkable results. However, it is not for the beginner.

Briefly described the telephotographic lens is a long-focus lens having an almost infinite capacity for providing varying *equivalent* foci, the *back* focus of the combination being always much shorter than that of an ordinary lens of the same *equivalent* focus, which, with such ordinary lens, would require a camera extension quite impossible for practical purposes. The telephoto lens consists of two separate elements—namely, a 'positive' long-focus element in front, with a 'negative' short-focus element behind. Each element consists of four lenses. It is the adjustment of the distance between these two 'elements,' taken as separate units, which provides and controls the enormous range of *equivalent* foci; in other words, it is this adjustment, taken with the camera extension, which furnishes the power to decide the degree of magnification of the object photographed, thereby enabling the operator to obtain, at will, different magnifications of the same view from one and the same point. And it is also upon the accurate adjustment of this distance between the two elements that the perfect focussing of the picture upon the ground glass screen depends. And here we are brought face to face with the greatest of all the practical difficulties which attend the use of the telephotographic lens—that of accurate focussing—and upon a successful mastery of which the full use of the lens depends.

A rack and pinion screw is attached to the lens, which controls the distance between the two elements, a similar screw being attached also to the camera controlling the distance between the two elements constituting the telephoto lens, taken together as a unit, and the ground glass focussing screen. In practice it will be found that the accuracy of focus will depend far more on the correct adjustment of the two elements *inter se* than on the second focussing arrangement which affects the relation of the whole system and the screen. In time the operator will disregard the latter, as the writer invariably does, altogether. When using the moderate power 'negative' element it is necessary, before focussing, to draw out the sliding tube which holds the negative about half an inch.

Relying on the lens screw alone an apparent objection arises from the fact that even the hundredth of a turn of that screw will suffice to throw the picture absolutely out of focus; but in practice this is found to be a great advantage, for the very 'suddenness' of the action of the screw enables the operator to hit the correct focus more certainly and confidently than is possible with the 'slow motion' screw, which produces modifications of focus so gradual that a feeling of uncertainty is created as to when the maximum of sharpness is attained. The unavoidable magnification of the granulation of the ground glass of the screen under the high-power focussing glass, which it is advisable to use, assists to produce this feeling of uncertainty. At the outset the operator is almost inclined to say that the image on the screen at high magnifications never is sharp at all. And in a sense, owing to this granulation, this is true, and the actual maximum of sharpness seems always to remain in doubt. The method found by the writer to produce the best results is to purposely throw the image out of focus equally each way, and then to give the screw a turn half-way between the two extremes, and so to hit the mean between the two. It may appear in theory difficult to recognise the same degree of variation from sharp focus in each direction, but in practice this difficulty seems non-existent. Certainly by this means the writer has found the resulting picture far sharper than it has ever seemed to appear upon the screen. Of course a focussing cloth must be used, and a focussing glass with a 'rocking' front will be found of use when focussing by a high-light near the margin of the picture.

Then the question of diminished light due to every increase of amplification constitutes a very serious difficulty with

which the operator has to contend when great magnification is desired. At small amplifications, up to four or five linear, the matter is of no great importance, but when eight linear is reached the optical law of the decrease of illumination based on the squares of linear amplification furnishes but a small fraction of the light the operator is accustomed to with a R.R. lens of short focus; and this, coupled with the fact that, the positive element being in this case a 'portrait' combination, we must focus with the stop which we intend to use, provides a very real difficulty. Add to this the further fact that the yellow screen, used with isochromatic plates, being between the lenses, must be *in situ* while the focussing is taking place, and we are presented with a diminution of accustomed illumination, which at the outset greatly adds to the difficulty of focussing.

But after some practice these difficulties come to be disregarded, and it becomes possible, even with the isochromatic screen *in situ*, to use—as does the writer invariably—the smallest stop but one on the tele-positive, namely, No. 15 of Dallmeyer's decimal system, equivalent to *f*. 12·25 of the Photographical Society's standard.

In dealing with snow peaks, which provide strongly illumined contrasts, focussing is comparatively easy; but far greater difficulty arises when a rock face, especially on a sunless day, has to be dealt with.

The next point of the highest importance is that of correct exposure. In telephoto work the contrasts are likely to be poor and weak as compared with those obtained with the R.R. or R.S., and especially with the single lens. There is certainly with the former by no means that latitude for the correction of faulty exposure by careful development to which we are accustomed with the last-named lenses. Nevertheless it is the experience of the writer that equal contrast, and so called 'pluck,' in the negative can be obtained with the telephoto lens if—but only if—absolutely correct exposure be given to the plate. Such correctness of exposure depends on several considerations, each of which must be kept in view when the plate is to be exposed. Firstly, the actinic quality of the light has to be correctly estimated. Experience furnishes this power as an instinct; but until this position be attained the operator can use one or other of the actinometers, or exposure meters, which are now upon the market. The next, and in this section of the matter all-important, consideration is the 'intensity ratio,' or the actual *equivalent* or 'corresponding' focus of the telephoto

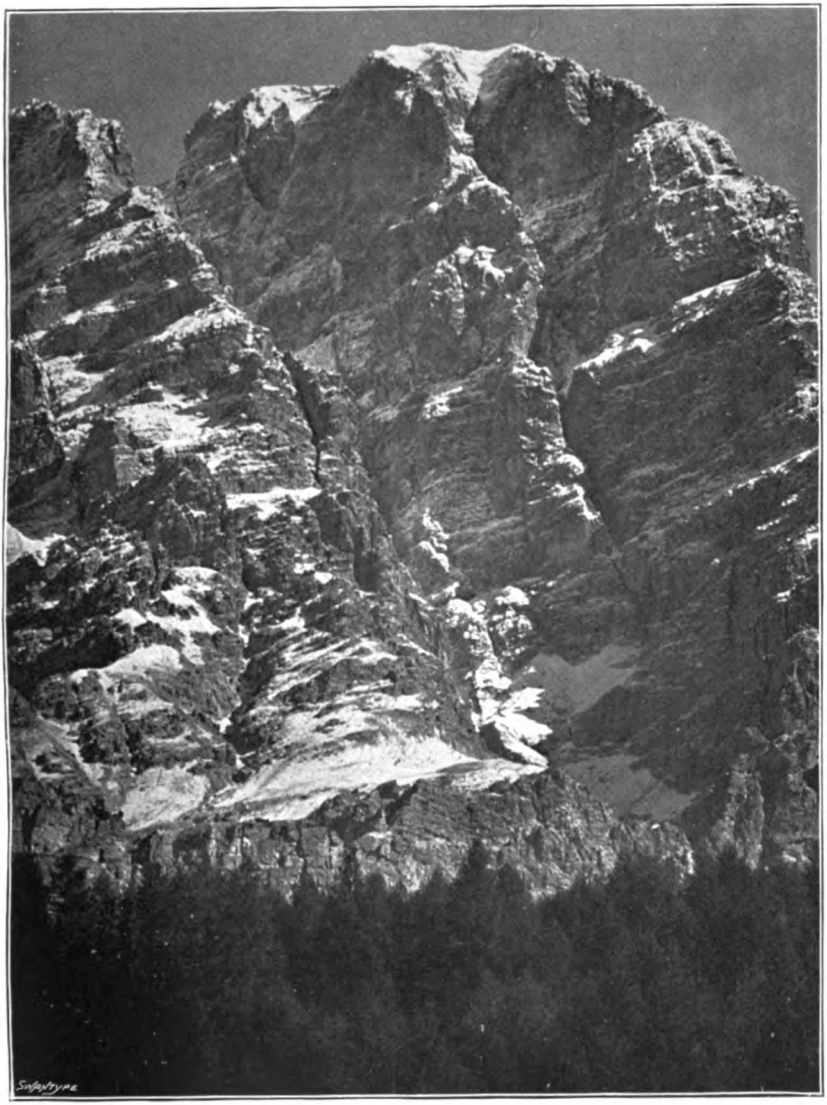


Photo by C. E. Shea] [*Swan Electric Engraving Co.*

THE MONTE CRISTALLO, TIROL.

Taken from beyond Cortina. Distance 5 miles. Amplification about 6 linear.

combination resulting from the camera extension (on which the question of magnification mainly depends), which the operator decides to employ for his particular picture. Here we have certain technical questions which cannot be shirked by the successful operator.

Before attempting to ascertain the 'intensity' we have to determine either the particular degree of linear amplification which we desire to obtain, if such be our object, or, more usually, having made our picture upon the screen, and brought it to focus, to ascertain what camera extension, or 'back focus,' has been needed in order to secure this result, and from these data to work out the 'intensity.'

Should it be desired to obtain a particular and definite magnification the camera extension necessary to secure this result may be found by setting the focussing screen at a distance from the negative lens equal to the focal length of the negative itself, minus one, multiplied by the magnification desired—*e.g.* for a magnification of four diameters, using a negative lens of a 3-in. focal length, the camera back, or screen, must be set at a distance of $4-1=3\times 3$, or 9 in., regardless of the focal length of the positive element, or lens, whatever that may be. But in most cases the object of the photographer would merely be to secure a picture irrespective of its exact magnification. To obtain this picture a certain camera extension will be found to have been required, and the consequent 'back focus,' or extension, will be but a matter of measurement.

There are two ways by which the corresponding foci and intensity ratios of the telephoto lens may be ascertained, the first given being mathematically correct, but the second is easier of working, and sufficiently approximately correct for all practical purposes. These are :—

(*a*) By means of the linear magnification of the image given by the positive element alone.

Magnification = divide distance from negative lens to focussing screen by the focal length of the negative lens, and add one to the result.

Corresponding focus = focus of positive lens multiplied by the magnification.

Intensity ratio = intensity of positive lens divided by the magnification.

(*b*) By means of the ratio between the foci of the positive and negative elements.

If the distance between the diaphragm slot and screen (when the lens is focussed on the object) be measured, and

this distance be increased in the same ratio as that known to exist between the foci of the two elements, the result will be the *equivalent* focus of the system.

The intensity is, of course, the *equivalent* focus thus ascertained divided by the clear aperture of the lens.

But many operators will prefer a 'royal road' to the results which may be easily worked out from the above rules, and to such the following tables may be of use :—

For Moderate Power Negative.

Back Focus*	Corresponding Focus	Intensity at Full Aperture
in.	in.	f.
5	15	12
6	17	14
7½	20	16
10	25	20
12	29	24
14¼	34	28

For High-Power Negative.

Back Focus	Corresponding Focus	Intensity at Full Aperture
in.	in.	f.
6½	26	21
7½	29	24
10½	36	29
13	45	36
15½	54	44
18½	63	50

The above refers only to the No. 1 or smallest of the series of telephoto lenses issued by Messrs. Dallmeyer, the positive lens of which works at full aperture at *f.* 4. Those of the larger sizes, Nos. 2 and 3, work at *f.* 3, and the tables would be calculated on a slightly different basis.

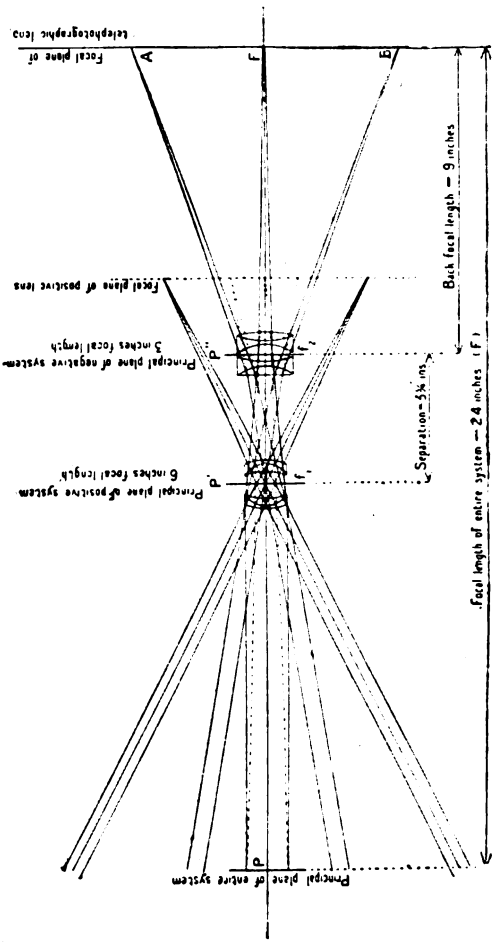
Having determined the 'intensity' at full aperture there comes the modifying influence of the particular stop used, a matter of very simple calculation known to all photographers; and then, again, the additional exposure necessitated by the particular isochromatic screen, if such be used. These points settled we have the correct exposure absolutely within our knowledge.

To those who may desire to realise more clearly the optical working of the telephotographic lens, the diagram on the next page, with explanation, will be of interest.

There are certain less vital points of detail which it may be well to notice. The stand supporting the camera must be absolutely rigid, the least tremor being magnified to the destruction of the sharpness of the picture. Having regard to the large size of the positive lens, and the necessity often for portability, it is not easy to obtain a shutter which on discharge gives no vibration. Hand exposure, with a cap fitting rather loosely, seems the safest method.

* To obtain the 'back focus' measure from the *flange* of the lens to the focussing screen and add 3½ in.

When the view to be photographed contains objects at various distances from the camera a dispersion of focus, whereby each important plane receives, so to speak, its appropriate share of average sharpness, is obtained by the rotation of the back cell of the positive element. As a



This diagram explains the action of the telephotographic lens :—
P′ is an ordinary photographic lens (in this instance of 6 in. focal length), preferably of an intensity of *f*/8 or higher.
P″ is the negative attachment (in this instance of 3 in. focal length) to the ordinary lens P′. P″ is preferably chosen about half the focal length of P′ for ordinary purposes.
The focussing screen A F B may be placed at any position behind P″. The greater the camera extension, the greater will be the magnification, but the less the rapidity.
In the case illustrated, where the camera extension from P″ is 9 in. and the distance between P′ and P″ has been adjusted to give a sharp focus, the Principal (or Nodal) plane of emission of the combination is thrown forward to a distance of 24 in. from the plate, or the equivalent focus is 24 in., with a back focal length of only 9 in.
Compare rules given :—
Back focal length $+ 1 = \frac{6}{3} + 1 =$ magnification $= 4$.
Focal length of P″ is 6 in., the equivalent focal length $= P' \times 4 = 6 \times 4 = 24$.
As focal length of P′ is 6 in., then the intensity of the combination is $\frac{P}{4} \times \frac{1}{4} = \frac{P}{32}$.
If P′ has an intensity of $\frac{P}{4}$, then the intensity of the combination is $\frac{P}{4} \times \frac{1}{4} = \frac{P}{32}$.

maximum half a turn for the high, and one turn for the moderate, power negatives.

It has been indicated that the degree of magnification is largely dependent on camera extension, and the camera

wherewith M. Boissonnas took his noted view of Mont Blanc is said to have been nearly 6 ft. long and 2 ft. square—dimensions inconvenient in the case of high-class mountaineering. A quarter-plate camera with a 12-in. extension, or slightly more, will be found appropriate, the ¼ plate being a size convenient for subsequent enlargement.

The field covered at any particular camera extension must be duly considered. The 'angle of view' remains practically constant at all camera extensions. Obviously, therefore, the greater the extension the larger will be the plate covered. With the Dallmeyer No. 1 telephoto system, with the 'moderate power' negative, the 'angle of view' at full aperture is from 18° to 20°, and with the 'high power' negative about 13°. The plates covered will therefore work out thus:—

For Plate covered at Full Aperture	Back Focus necessary	
	For Moderate Power Negative	For High Power Negative
inches	inches	inches
4¼ × 3¼	5	6½
5 × 4	6	7½
6½ × 4¾	7½	10½
8½ × 6½	10	13
10½ × 8	12	15½
12 × 10	14½	18½

Camera extension, with its attendant increase of magnification, as already pointed out produces a corresponding increase of the 'equivalent focus' of the system. An optical law suggests that the limit placed upon magnification is reached when *f.* 72 is arrived at, the question of 'diffraction' then coming into play. However in practice, as in the case of M. Boissonnas's tele-view of Mt. Blanc, this limit has been safely passed.

In dealing with certain subjects it must be remembered that whereas the ordinary short focus lens distorts the picture by exaggerating the foreground and nearer objects, so the telephoto lens, at the other extreme, gives greater proportionate prominence to the more distant portions of the view—a matter of certain importance in dealing with architectural subjects. Telephoto views of snow peaks are best taken early in the morning before the sun has heated the atmosphere and created that quivering of the air which seems specially to affect the definition of snow and ice in the picture. In taking snow scenes the tendency is generally to avoid the difficulty connected with theoretically correct exposure by

Photo by C. E. Shea] [*Swan Electric Engraving Co.*

SCHLOSS TAUFERS, AHRNTHAL, TIROL.

From meadows near St. Walburg Kapelle; taken with Telephoto lens, moderate-power negative.
Distance of Castle 1½ mile; Snow-peaks 10 miles.

deliberately under-exposing; but although the snow portion of the picture will be clear and brilliant the foreground and shadows will be found dark and without detail. The old rule of the photographer to 'expose for the shadows' holds good in a measure even for the telephoto lens. The operator should not rest content until he attains for his telephoto picture a standard of all-round quality not so very far removed from the best results produced by the R.R. lens.

One expert writer on telephotography states that the peculiar advantages of the lens have to be purchased by a 'sacrifice of optical perfection as compared with well corrected photographic lenses of the usual type,' and that it possesses 'less brilliancy and definition and embraces a narrower angle' than such lenses. That the telephoto lens includes a narrower angle, not, in fact, exceeding 20°, is an unavoidable consequence of magnification, but it would seem that a fuller knowledge of the new lens, and appreciation of its difficulties and requirements, will lead to the conclusion that the loss of brilliancy and definition has been over-estimated, while it is certain that the lens places in the hands of the photographer a power the complete extent of which is not yet fully realised.

The first illustration shows views of the same object taken with an ordinary R.R. lens of 5·6 eq. fo., and with the telephoto lens, moderate power negative; amplification thirty times, super.

The second is a view of the Croda da Lago, in Tirol, taken with the telephoto lens, high power negative, from the opposite Faloria ridge, distance 4 miles; amplification about eighty times, super.

The third view is of the Monte Cristallo, with moderate power negative; distance 5 miles; amplification about thirty-six, super.

The fourth illustration is a view of Schloss Taufers, Tirol, taken for pictorial effect irrespective of particular magnification. Distance of castle, 1½ mile; mountain peaks, 10 miles; actual amplification about eighteen, super.