ctLow, Photographer · Dec 15, 2019 · 8 min read

A Photographer's Perspective

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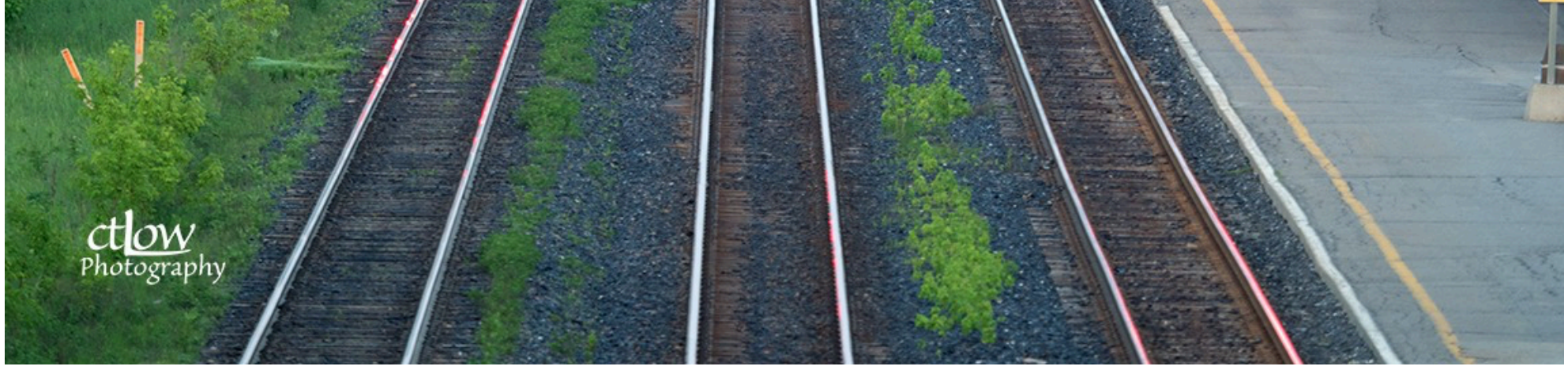
Let's See If I've Got This Straight

Can I level with you?

Most of us love curves, but it does matter than we keep straight lines straight and right angles right (in photography as in life). Occasionally a few things puzzle me, such as a line which I thought should lean left leans right, so I elected to approach this *foundational* dilemma (yes it's that serious!) with a little experimentation.

So ... control your excitement, but ... yes, I'm writing this particular blog-entry for us geeks. For the rest of you normal people, hang in here for a bit and see what happens. You may find something interesting (or beautiful).



A classic example of art-perspective: train tracks appearing to converge as they recede into the distance

Train tracks appear to converge as they get farther away—quite normal, although we know that the tracks always remain parallel, but it also looks this way to our *eyes* (I mean "to our brains"). (Note also how including curves contributes to the composition.)

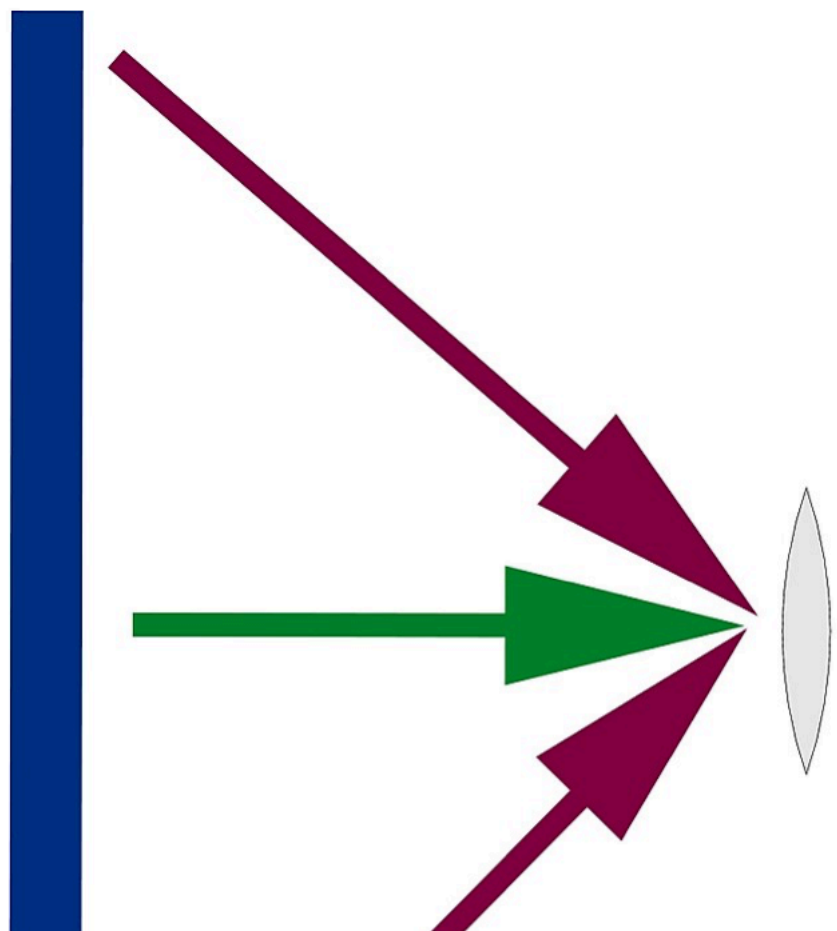
Rectilinear

I would like to mention something about the wonder of rectilinear lens design. Most of the lenses we use, and often take for granted, arose as the product of hundreds of years of incremental improvements (starting in 1839 apparently) in both the design and manufacturing of these truly incredible pieces of hardware.

"Rectilinear" means that straight lines will remain straight as they pass through the lens.

Lenses have many other jobs beside linearity, such as keeping all of the colours in a scene in focus on the same plane, because colours split apart when passing through lenses (think "prisms"). All camera lenses also have the Herculean task of controlling numerous internal reflections.

These lenses then also focus on a plane, the edges of which reside further away than the centres. Note how much longer are the red arrows from the edges to the (simple) lens vs. the green arrow from the centre—not as critical at long distances, but it matters immensely up closer.



Rectilinear lenses have to accomplish this while focussing at distances near or far, and in the case of zoom lenses, at varying magnifications.

In order to achieve all of these demanding standards, the designers and manufacturers use:

The edges of the focal plane are far away!

- multiples lenses inside what we refer to as "the lens", the various "lens elements" made of high-quality glass (and some plastic), some of these often using extra-low-dispersion (i.e. not cheaper!) glass;
- some of the elements having exotically special designs called "asymmetric" and "aspherical", and
- many of them coated with special anti-reflective coatings.

Uh, ya: these are complicated pieces of machinery, built with incredible precision

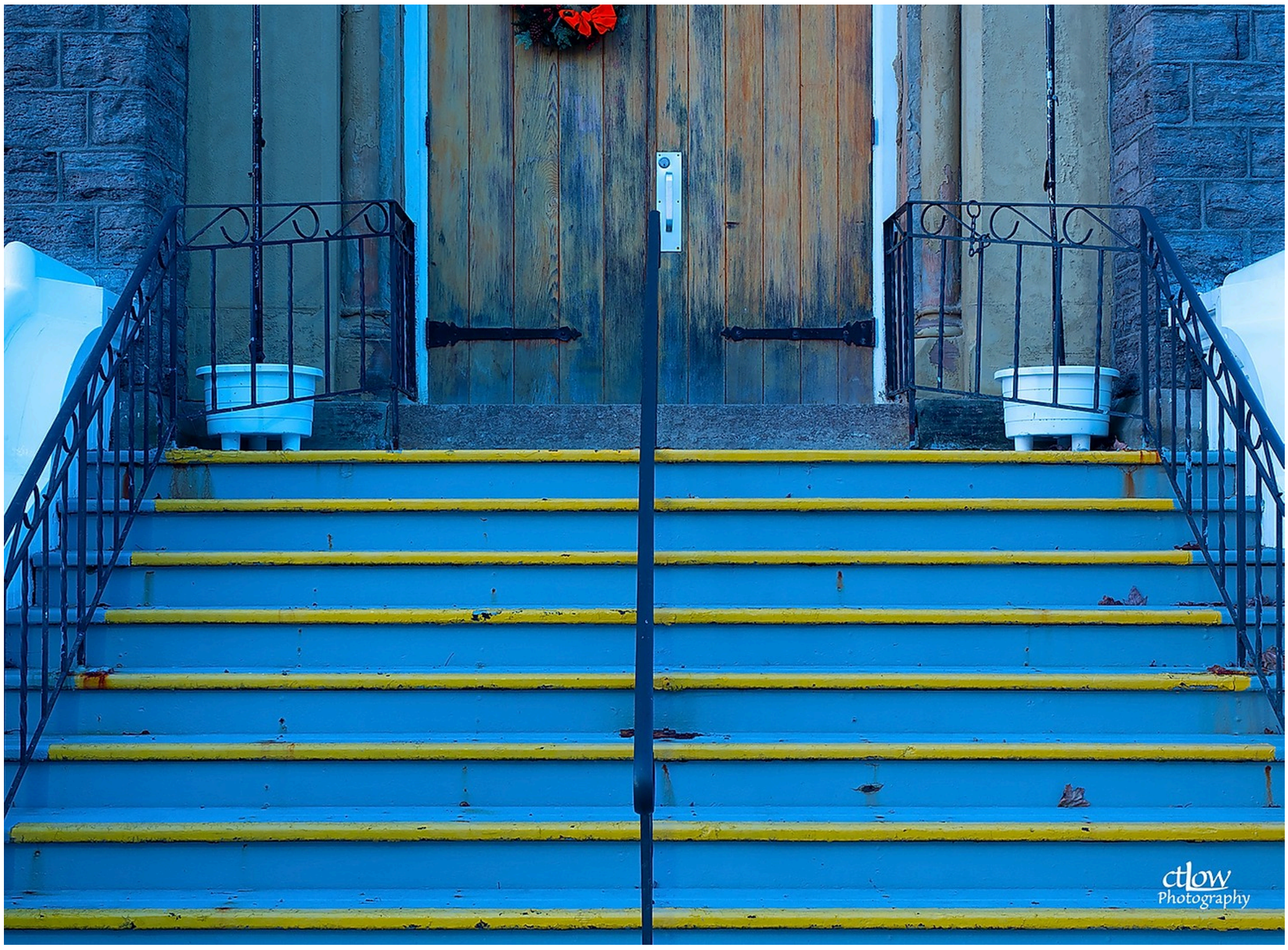
So when your lens works properly (or when it works exceptionally well), then that happens because the industry has made it happen, not because it just happens. I find the entire process astounding.

No lens attains perfection, but some come very, very close.

For those of us serious about our photography, have a good camera, and have excellent

lenses.

How do rectilinear images look?



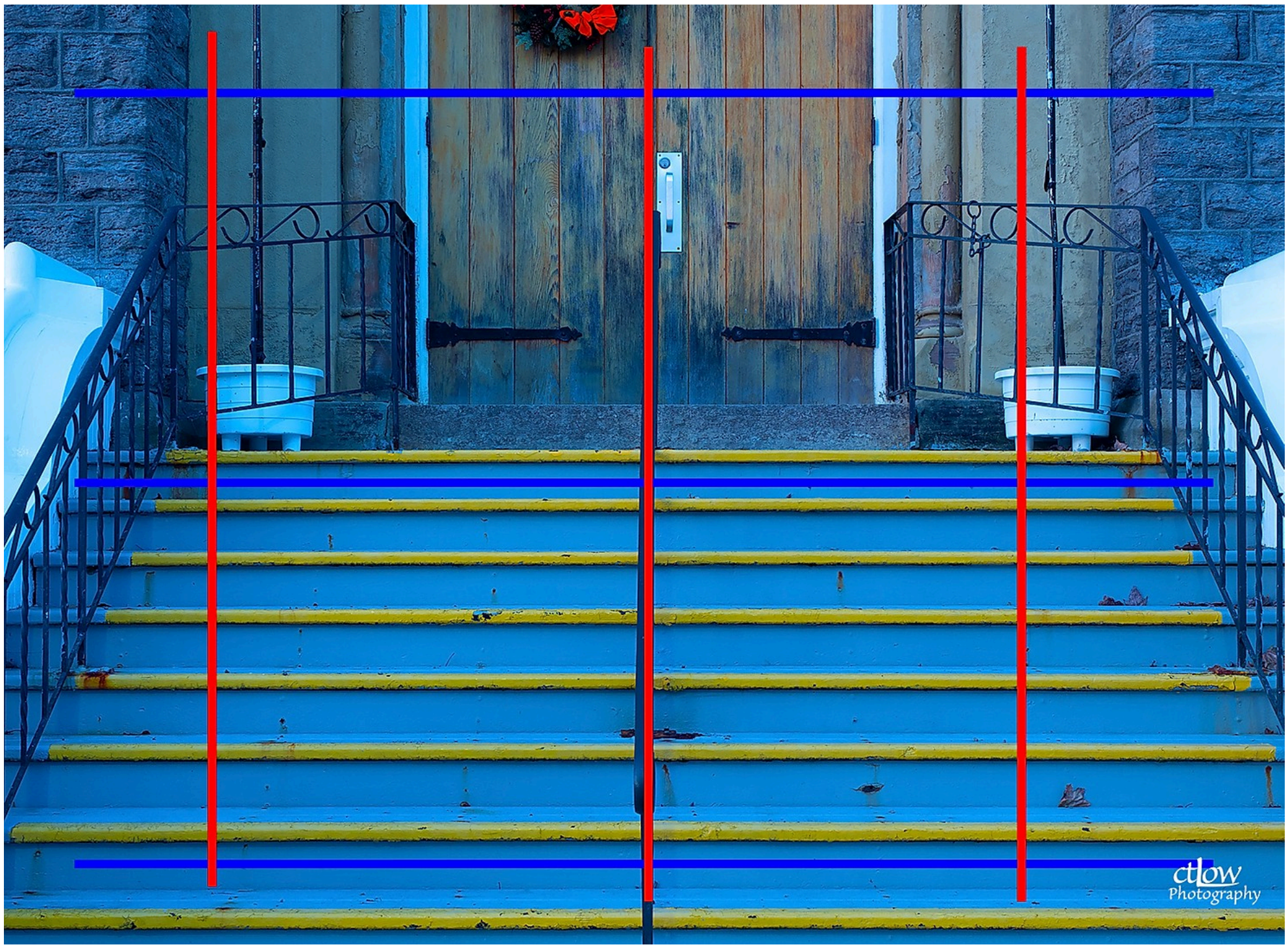
Normal lens, straight and level: straight is straight, right angles are right angles

I made this photo with the camera level, in every axis, so:

- level side-to-side;
- level in front-to-back tilt;
- critically, square to the building, i.e. the camera centred on the doors and the doors smack in the middle of the image.

Under those circumstances, and because the industry builds rectilinear lenses like this, not only have all of the straight lines have remained straight, but also the parallel lines have remained parallel. I can illustrate that with the following overlays, in which the three red vertical lines remain parallel with each, and the three blue horizontal lines similarly remain parallel to themselves. The lines correspond with vertical and horizontal

lines in the image.



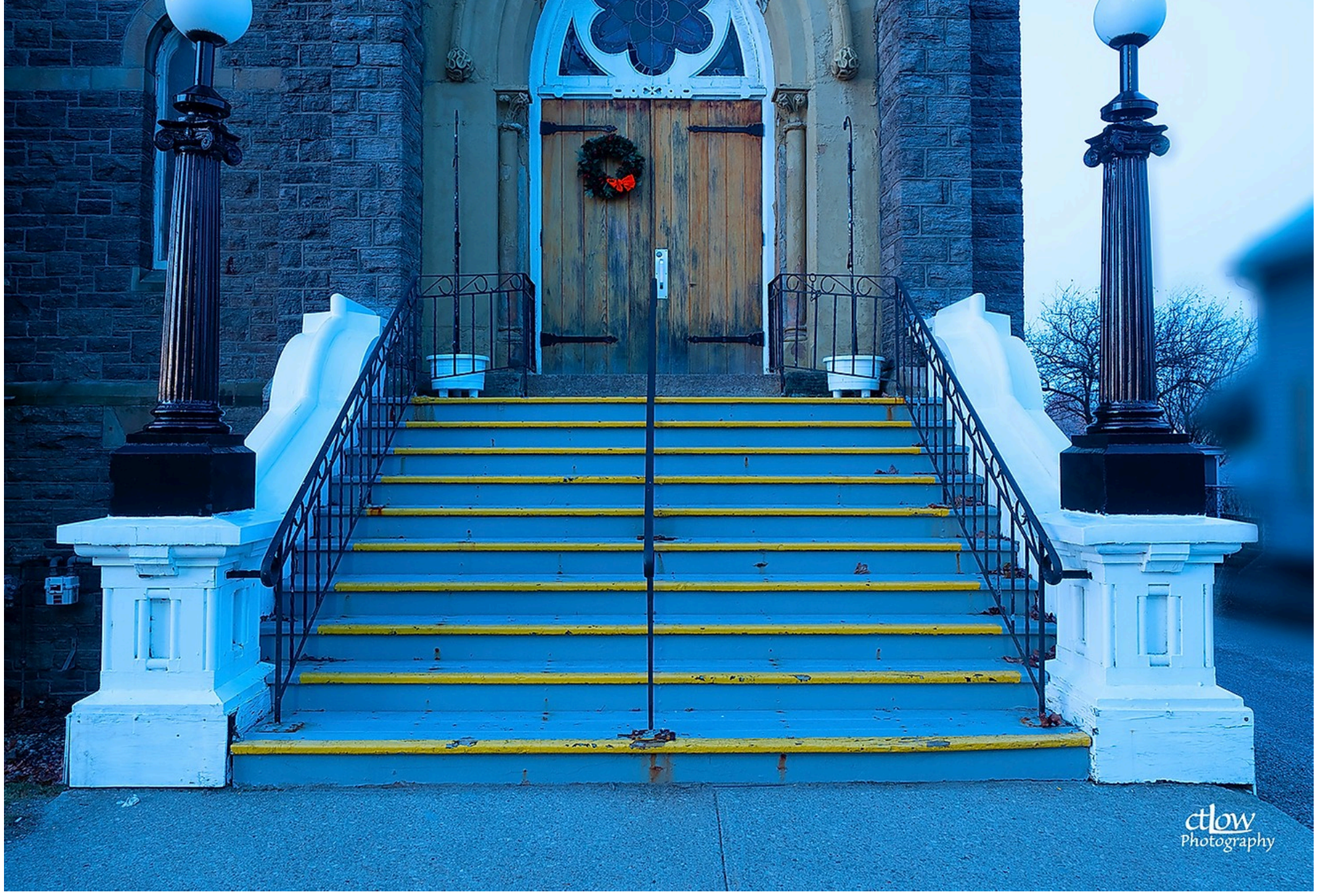
Straight and level visually confirmed

But you know that won't last for long!

Nonetheless, so far so good, and may I apologize for the bland image, but i) I required that exact vantage to make my point, and ii) the photos from here on in will become more engrossing. I haven't found a more beautiful building in Brockville which also illustrates these principles. (Thank you, First Presbyterian Church!)

Normal - Another important technical note involves the "normal" focal length, said roughly to replicate the perspective as seen by the human eye (brain!), or sometimes called "one-times" magnification (i.e. we multiply by one, "1x", mathematically meaning no magnification). So, I made the photograph above with a normal lens. Normal was often ascribed to a 50 mm lens in the days of 35 mm photography, and is now about 33 mm with an APS-C sensor, so if you find that helpful to know then great, and if not then don't worry about it.

Wide - What happens if we don't move the camera, but zoom out?



Wide-angle lens, otherwise the same scene as above, camera not moved

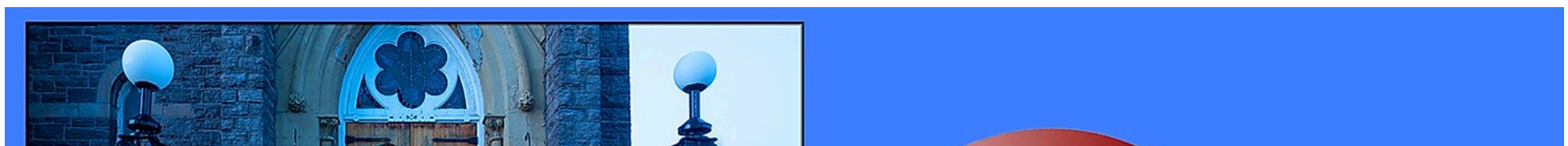
The magnification here is half, 0.5x, i.e. zoomed *out* by a factor of two, twice as wide and twice as tall as "normal". Notice that the doors appear further away, even though the camera did not move.

Because of the competence of the lens designers, rectilinearity still holds, straight staying straight, parallel staying parallel. (The more eagle-eyed among you will notice that the left-most light post is not vertical, but that's the post, not the lens.)

Although wide-angle lenses exaggerate perspective, making far objects seem further away than to the eye (compare with the previous "normal-lens" photograph), not even all photographers know that this perspective distortion effect has *no foundation in reality*.

I mean, just wow. I shouldn't have just thrown that in there without warning you.

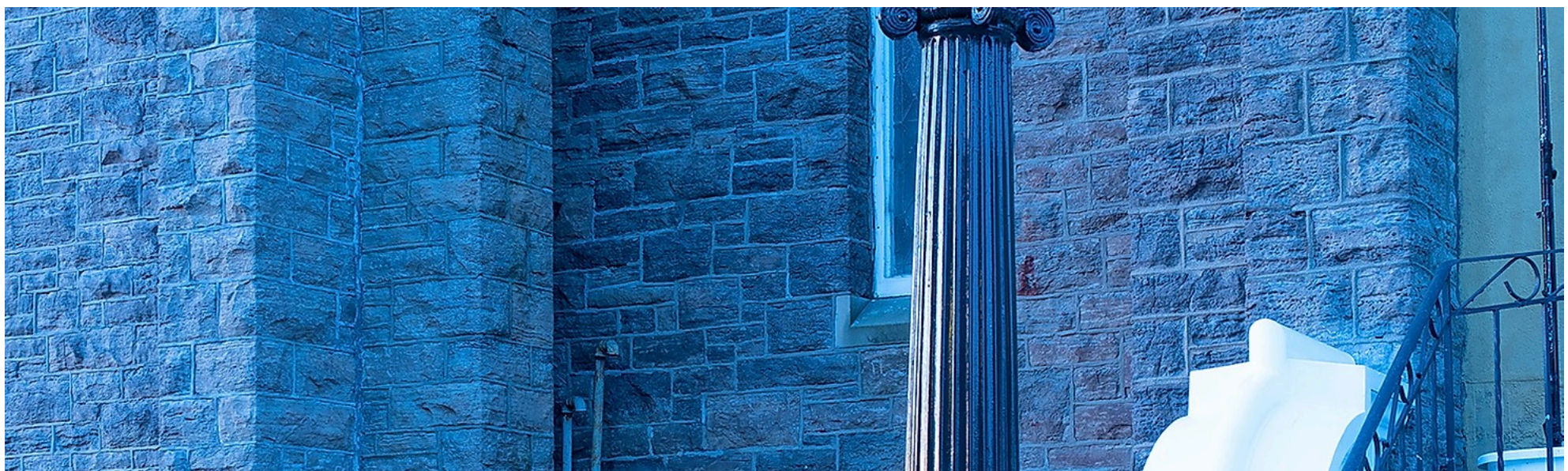
Check out what happens below when we crop out the centre, outlined in black, of the wide-angle photograph in the upper left: it becomes identical to the normal photograph, a few above. I always marvel when I see that, because of the power of this particular illusion.

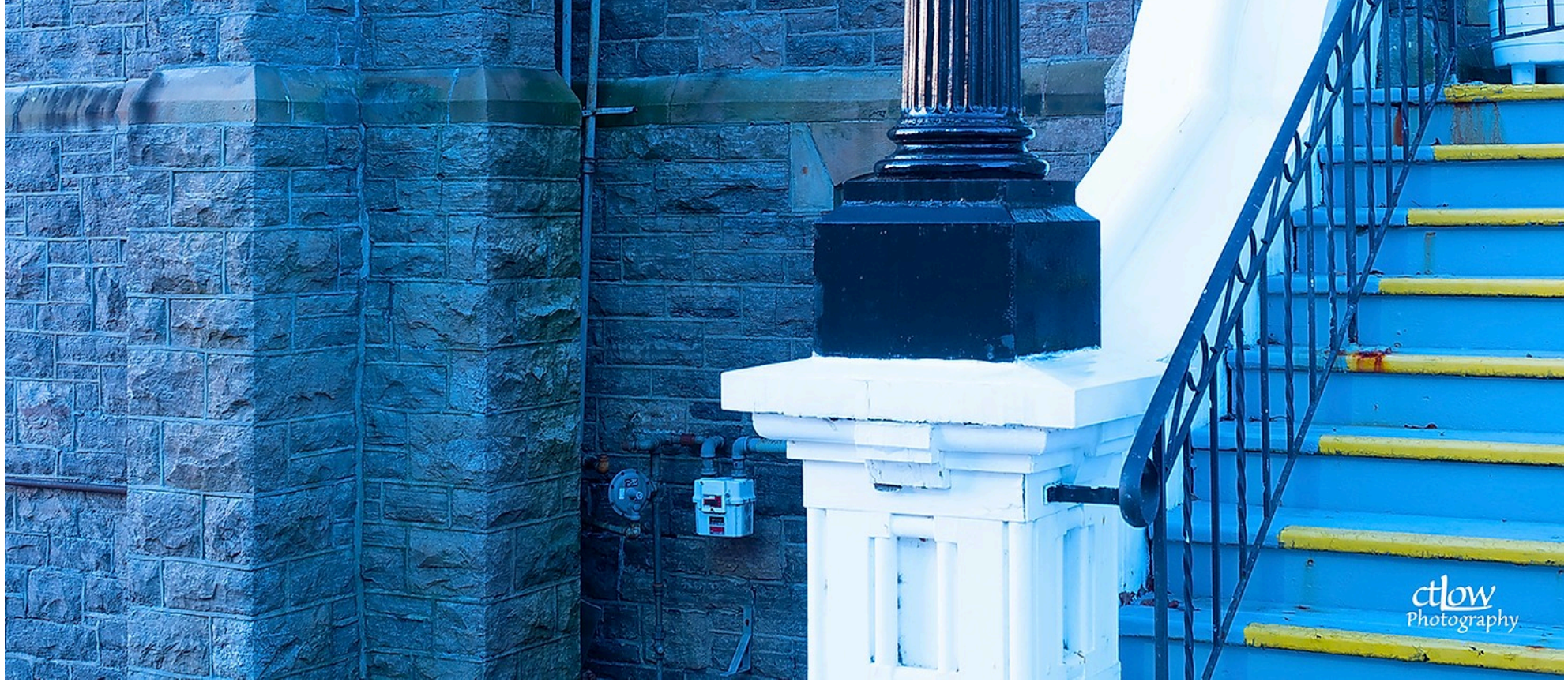


Cropping out the centre of a wide-angle-lens photograph produces exactly the same perspective as that with a normal lens, several photographs above.

The extra distance, the magnification-distortion, of a wide-angle lens, then, is simply illusory. I find it even less intuitive that the well-known phenomenon of telephoto compression is also not real—but that's a topic for another day.

To the left, to the left - Now we're going to play with these concepts. First, I show a normal-lens image (not a wide-angle or telephoto) for which I turned the camera—leaving it otherwise in exactly the same spot, on a tripod—to the left. Now, like our railway tracks above (except turned to the side rather than tilted down), the further to the left in the image, the further away things become, so they look smaller, and that leads, through several steps of mathematics, geometry and logic, to the lines, which we know to be level and parallel, appearing to converge.





Normal lens, everything still level, but with the camera rotated left, so no longer perpendicular to the structure

Actual right angles no longer measure on the photograph as such.

Brain-seeing - Our eyes see this convergence too, but it impinges *less* than it does with a camera, as our brains construct for us an image which almost never corresponds exactly with the optical information collected by our eyes. (I mean: eyeballs have pronounced sphericity, and also record everything upside-down and left-to-right; yet, we see everything the right way around, and as if flat—our brains do that for us.)

Convergence of this less dramatic degree can be hard to see, as our brains compensate for it, but the grid lines might

Convergence of this less dramatic degree can be hard to see, as our brains compensate for it, but the grid lines might help illustrate what's going on

Above, straight remains straight, as always with rectilinear lenses, but lines converge as they recede. Note that the two vertical red lines equal each other in length, so the blue lines must be converging. The central blue line stays roughly horizontal, because it's at about lens-height. Verticals remain vertical (more or less) because the camera remains level.

In the next image, nothing has changed except for switching to a wide-angle lens.

Wide angle lens, nothing else changed from the previous normal-lens photograph

It has become clearer that receding parallel lines, the horizontal ones in the example above, appear to converge. The verticals essentially stay vertical, because the lens has remained horizontal.

Wide-angle lens illustration. It is hard to imagine that the angles are the same as with the normal lens, from precisely the same spot, a few photographs above. It's a powerful illusion.

Next, let's look up.

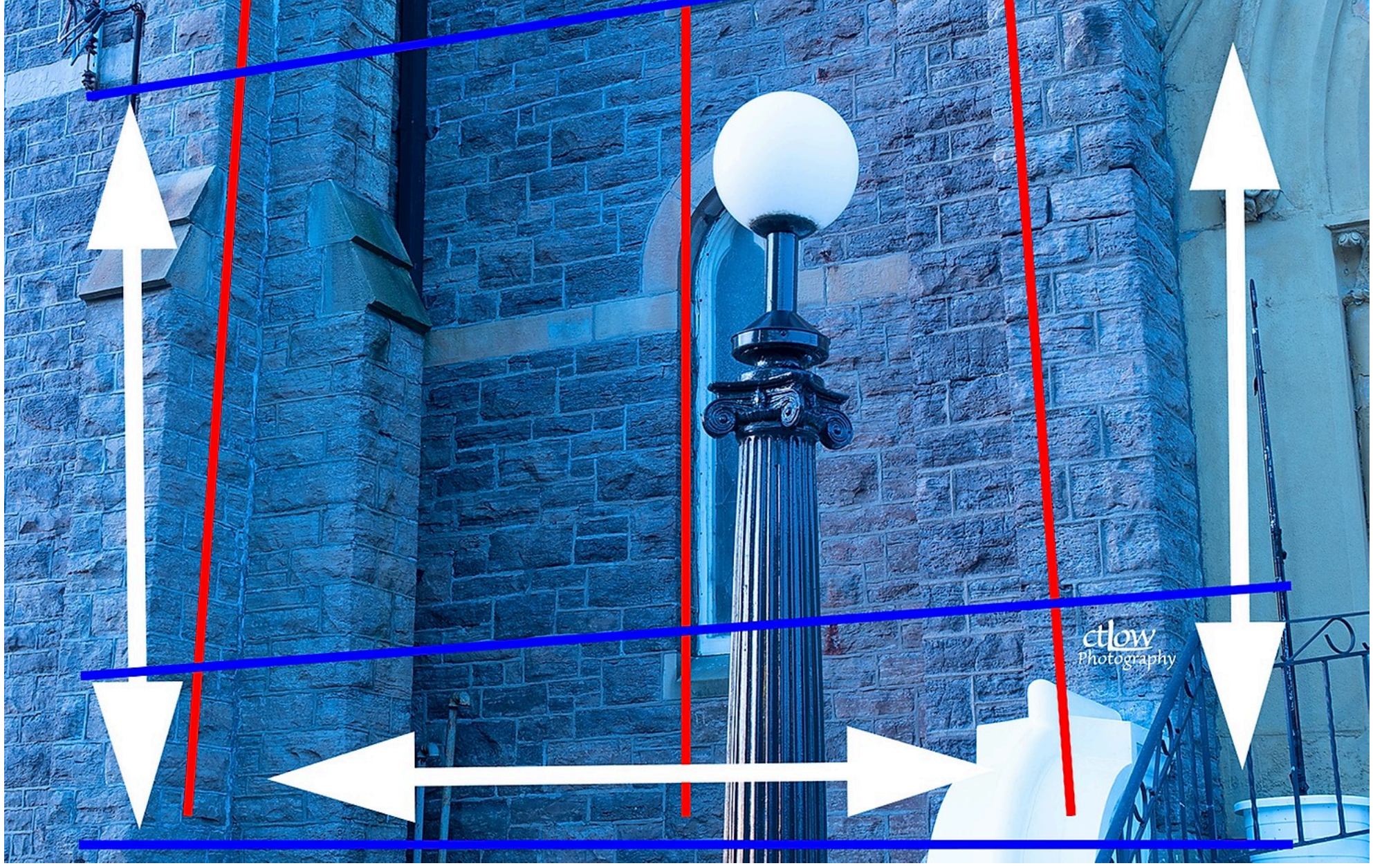
Normal lens, camera remains level side-to-side, again facing square to the building, but now tilted up, so the converging lines appear to the top of the image

Identical principle to looking left, except for aiming the camera up. Vertical lines converge as they recede, and in this case, horizontal lines remain horizontal and parallel, because the lens is side-to-side level, and exactly perpendicular to the building.

We're having more fun now. Let's ramp it up. In the following image, I have turned the camera to the left, *and* tilted it up, still always keeping it level side-to-side.

Normal lens, up and left, so things get funky

The above is not terribly dramatic, but we are seeing the combined effects of turning to the left and tilting up, illustrated below.



A busy illustration, but let's wade through it

Above, we made two adjustments (left and up), so now *two* sets of lines converge. The blue ones, representing things which in actuality are parallel, converge, and similarly, the red ones converge. The white arrows are all the same length (and exactly vertical or horizontal in the image), so illustrate that this is indeed happening.

Now, a wide-angle using exact same vantage:

Wide-angle, left, up

I think that what's happening is becoming more apparent. Did you notice that, although the camera is turned to the left and tilted up, it remains level side-to-side, which means that a vertical line right in the middle, and only in the middle, will look vertical. The top of the staircase is roughly at camera-height, so a line extending through it and across the stone seam in the wall will be roughly horizontal (illusion otherwise notwithstanding).

Conclusion - Unless a rectilinear lens aims straight at its subject, i.e. perpendicular to yon building (in this case), so therefore assuming receding lines:

- those lines will converge;
- a vertical line dead-centre, assuming no side-to-side camera tilt, remains vertical, and only the lines on either side of it will tilt (visually, not actually), in towards each other as they recede;
- *dis*similarly, a horizontal line at *camera-level* will remain horizontal, and only the lines above and below it will go off level as the camera turns; if the "horizon" is out-of-frame, then all of the horizontal lines (if on the same a plane) will also tilt in the same direction (but not the same amount, so still converging);
- (yikes!);
- the explanation for why tilting up and sideways at the same time does not do the same things to lines is complicated, and involves the verticals having no horizon, and also gets into issues of side-to-side camera-tilting, which we are intentionally *not* doing in this exercise ... but let's not hurt our heads.

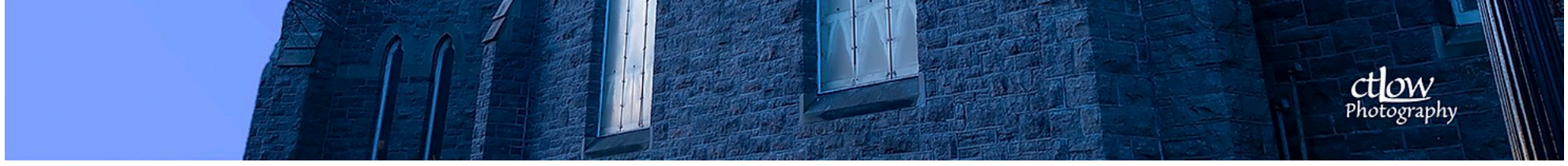
I would it were more simple! But at least we have some illustrations, in the foregoing, of what happens.

The apparent convergence of receding lines in rectilinear lenses, the lenses which we all routinely use, strikes me much more emphatically in photographs than it does in real life. Lots of other things which don't impact to our eyes (brains) also become more jarring, or at least more apparent, in photographs, so I see no reason why this should differ. Generally, I presume that our brains compensate somehow in a way which ceases when we gaze into a two-dimensional image.

But stand there and hold up a grid, and that will illustrate that convergence exists pretty much as it appears in a photograph.

Funkier - I'm throwing a few in here at the end just for (even more!) fun.

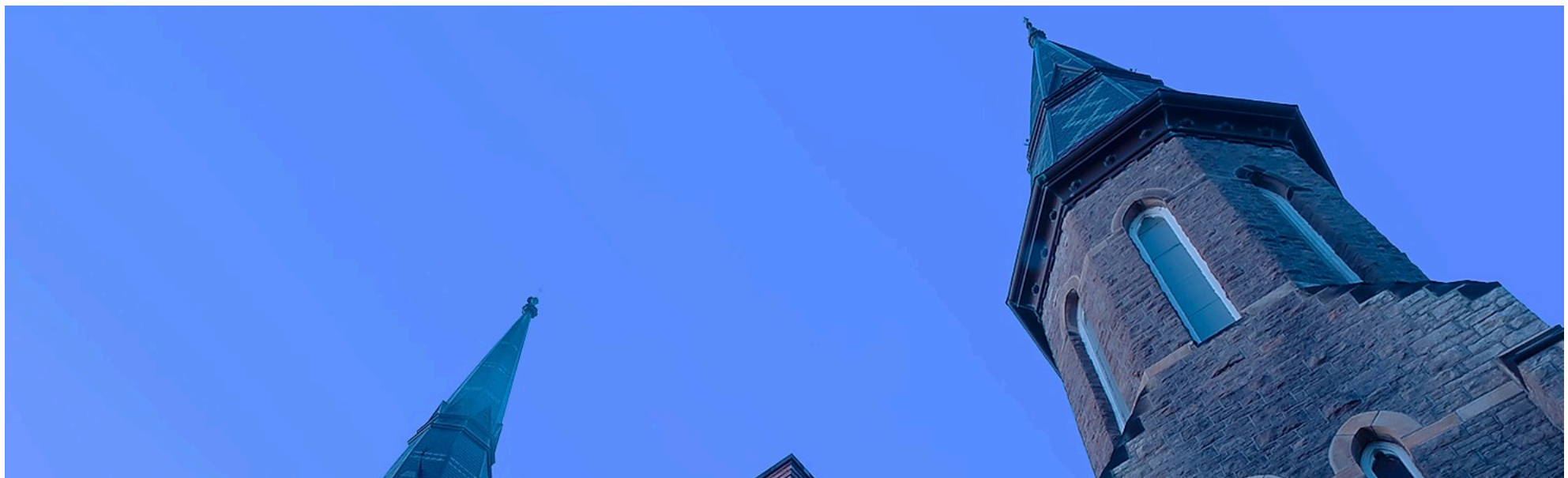
Normal lens, even more to the left, and even more upward tilt



Wide-angle, same vantage exactly as previous - both the vertical and horizontal apparent convergences are getting easier to see, and as always, the angles in the two preceding photographs are identical, however much they look as if they are not

Allow me to demonstrate once more that the apparently farther distance with a wide-angle lens is an illusion. It remains an illusion even when far off-axis, as these leftward-upward photographs illustrate.

Crop the centre (black box) even from this far-off-axis wide-angle image, and it looks identical to the normal-lens image, a few photographs above (isn't that amazing?!?)



Wide-angle, to the left, and using whatever extreme upward angulation is required to get all of the towers in, and just look at that convergence! The tower to the left is at a 45-degree angle to the rest of the wall, and that's doing some pretty wild stuff to the angles (but all the straight lines remain straight).

Ultra-wide-angle fish-eye lens - still from the exact same spot, square to the doors, as in all of the other photographs

"Fish-eye" connotes "*not* rectilinear", so straight lines now appear bent (and I think that's

just because rectilinearity is no longer optically possible at those de-magnifications [this about 1/4x]), so not meaningful to the present discussion, but ... fun to look at!

Overcoming convergence - Generally, I just accept the phenomenon, and indeed often quite like the way it looks, but for special circumstances there are ways around it.

One way is the "tilt-shift" lens, an expensive contraption with which I have no experience, in which the front lens element can move up and down and/or can change its angle relative to the rest of the lens.

Then, much can be done in editing ("post-processing"), and this was possible (but not easy) in physical darkrooms from days or yore, and it is certainly possible in the digital darkroom of image-editing software.

Overcoming convergence was not my topic today, but it may interest you to know that it happens.

Optical perspective in art also has a history, and different cultures at different times have drawn it dissimilarly. A plain photograph, because of the compromises entailed in rectilinear lens optics, allows no such variation. But "true" photographic rectilinear perspective doesn't always look the way we see the same scene with our brains.

So, that's convergence (the non-astrological kind).

While You're Here ...

Reminder: I make photographs and I sell photographs.

Art - Most of the photographs which you see on this web site are for sale. Prices at the time of writing, for example, for an 11x14" fine-art print with a generous white border would start at about $65, and you can go up or down from there. Check the rates page. More importantly, check out my gallery. I would love to provide you with a work of fine-art photography, or to discuss a commission.

Portraits - Book a sitting - the right frequency with which to commission formal

portraits is a bit more often.

Anything (almost ...)! Please inquire for photography categories such automotive, industrial, charitable ...

Another reminder: kindly leave a **comment**, or contact me to sign up for new blog notifications. I will very much appreciate referrals to potential new subscribers. I am very careful and respectful with your privacy.

Thank you so much for reading.

Charles T. Low
Photographer

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