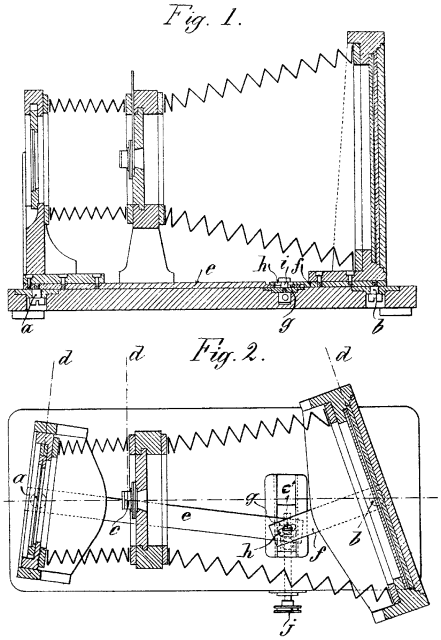
Scheimpflug's Patent

by Harold M. Merklinger
as published in *Photo Techniques*, Nov/Dec 1996.

Many large format photographers will know of the "Scheimpflug Principle", and a few will be aware that Theodor Scheimpflug of Austria is the person after whom the principle is named. But it will probably come as a surprise to most to learn that Scheimpflug himself disclaimed inventing the rule that now bears his name. The Scheimpflug Principle (or rule or condition) provides guidance on how a camera lens and/or back should be tilted when focusing upon a plane that is not parallel to the film. This short article is intended to provide a little historical background and technical information about Scheimpflug and his patent.

If Scheimpflug did not invent this rule, who did? Scheimpflug cites only one reference, and that is to the British Patent of Monsieur Jules Carpentier of Paris. In 1901 Carpentier had patented an enlarger for correcting converging verticals. Carpentier made this claim: "I have investigated the law which governs the correlation between the inclination of the plane of the negative and that of the sensitized surface to that of the optical axis of the lens...and I find that the relationship is this:—If the two planes are sufficiently prolonged they must intersect in the plane perpendicular to the said axis and passing through the optical center of the lens." Carpentier's apparatus for maintaining this condition is shown in (his) Figures 1 and 2.



Jules Carpentier's 1901 British Patent (GB 1139/1901) contains four drawings, Figures 1 and 2 of which are shown here. This is his enlarger for correcting converging verticals. The movements of the plate holder and the paper holder are constrained to obey the principle we today call "the Scheimpflug Rule"

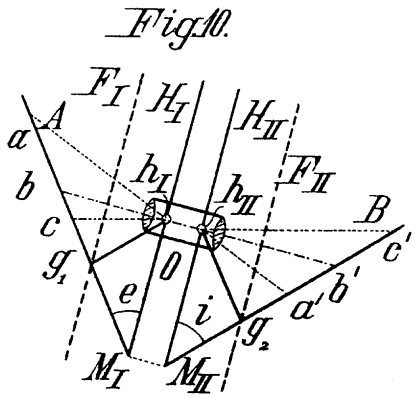


Figure 10 of Theodor Scheimpflug's 1904 British Patent (GB 1196/1904) illustrates how the optical system of a single compound objective lens is constrained by three geometrical principles. In today's language, A represents the subject plane, F_I the front focal plane of the lens, H_I the first principle plane (nodal plane) of the lens, H_{II} the second or rear nodal plane, F_{II} the rear focal plane, and B the film plane. The hinge line and reciprocal hinge line are noted g_1 and g_2 respectively. M_I and M_{II} represent the split Scheimpflug line needed to describe the behavior of a 'thick' lens.

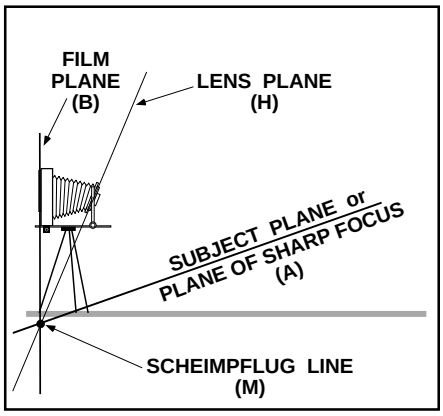
Despite understanding of the "Scheimpflug Principle" as early as 1901, knowledge of the principle and the association of the principle with Scheimpflug have been slow to develop, especially outside Europe. The 1951 book *Lenses in Photography* by Rudolf Kingslake notes that "when a lens is used to form an image of a small sloping object, the object plane, the image plane, and the median plane through the lens all meet together at a common point." But Kingslake describes his proof of this principle as approximate, and one could cite numerous books on view cameras printed in North America up to the 1980s that show diagrams violating the rule.

According to J. Radford, writing in the *British Journal of Photography*, the German publication *International Photo Technik* is responsible for introducing the term "the Scheimpflug Rule" to describe the optical condition first described by Carpentier. Radford further illuminates the life of the Captain Theodor Scheimpflug of Vienna, and how he came be interested in the alteration of perspective in existing photographs. Radford points to the two early twentieth century British patents awarded to Jules Carpentier of Paris and Theodor Scheimpflug of Vienna.

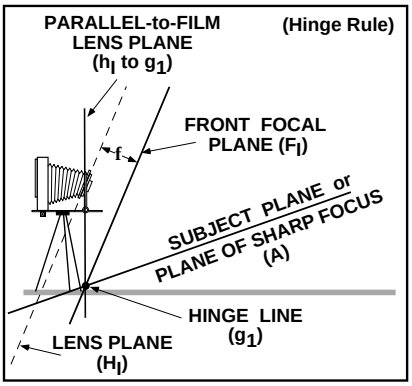
I was recently able to obtain copies of these patents; they prove most interesting. In his 1904 patent, Scheimpflug notes that the optical principle we have come to call "the Scheimpflug Rule" is "well known". Indeed he credits Carpentier's 1901 Patent as being the pinnacle of it's earlier application.

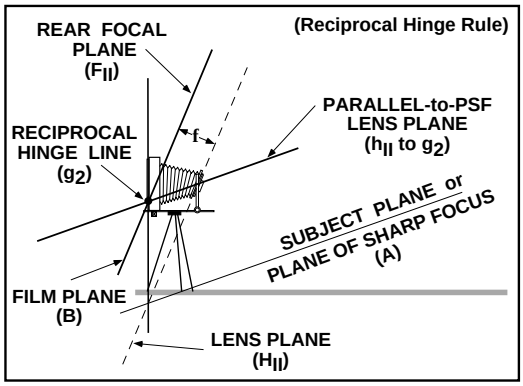
One could make a good case therefore to rename the "Scheimpflug Principle" the "Carpentier Principle". It is not unusual in the field of inventions for public credit to be attributed to the 'wrong' inventor. How many people, for example, believe that Henry Ford invented the motor car? Enthusiasts knowledgeable about automobiles will usually name Gottlieb Daimler and/or Karl Benz of 1885, but Siegfried Marcus of Vienna and George Brayton of Boston demonstrated vehicles powered by internal combustion engines as early as 1875. In the field of optics, it has also recently been brought to light that the "Schmidt camera"—utilizing a spherical mirror and corrector plate—was actually invented in the form of a projector by G. H. Kellner for possible use in automobile headlights.

Carpentier is not clear on how he came to make his discovery, but there is some reason to believe that his observation was empirical, that is, based on experiment. Scheimpflug studied the subject in considerably greater depth, describing not only the use of single lenses, but multi-lens, mirror, and mixed lens-mirror optical systems for achieving almost any conceivable perspective distortion or



Scheimpflug's third principle is illustrated here in relation to a view camera. It is identical to Carpentier's observation published three years before Scheimpflug's patent.





Scheimpflug's fourth principle can be considered as two separate rules as illustrated here. The term "hinge rule" is not due to Scheimpflug, but this aspect of Scheimpflug's fourth rule describes how the plane of sharp focus (A) rotates about the hinge line (g_1) as the back of the camera is focused. The "reciprocal hinge rule" describes what happens as the back of a camera is tilted about a suitable axis (g_2) in the rear focal plane of the lens (F_{II}).

correction for an existing negative or print.

Accompanying this article are several diagrams illustrating Scheimpflug's principles and two of the special cameras he designed.

It should be noted that neither inventor appears to have been interested in applying the technique to the taking of the original photograph. Rather both gentlemen concentrated on cameras or enlargers used to rectify the distortions present in previously taken photographs. They were concerned exclusively with subjects that really were flat planes. Neither patent describes how to set-up a camera for the original photograph, although the optical theory described is applicable to that problem. And neither patent offers any explanation of depth of field.

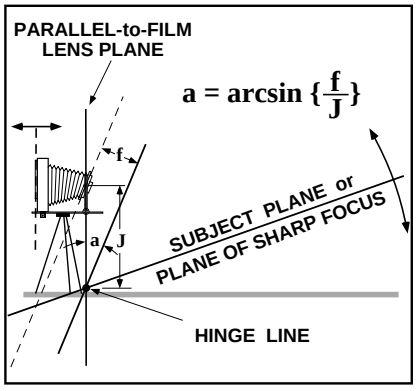
Theodor Scheimpflug makes reference to several optical principles. Principle No. 1 is that a photograph is, in a mathematical sense, a perspective representation of the scene with the front nodal point of the camera as the center of projection. Rule No. 2 is that the image of a plane is itself a plane. Principle No. 3 is the one that has come to bear his name. These first three principles are described in the patent as "well known". Scheimpflug's new contributions commence with his Principle No. 4, to be described in the following paragraph. Principles 5 and beyond relate to the use of mirror lenses, and optical systems having more than one mirror or lens. (Note: Scheimpflug did not actually number his new contributions; only the established principles are actually assigned numbers in the patent document.)

In the preface to my book *Focusing the View Camera*, I stated "..this rule—which I have called the hinge rule...—is so simple, it seems unlikely to me that it has not been documented somewhere." I should have looked at Scheimpflug's patent! Scheimpflug states: "..if the counter axes...of the two perspective images...are determined by placing through the two nodal points...of the objective, planes parallel to the two image planes..., and causing the former planes to intersect the image planes, then the counteraxes are always situated in the focal planes...of the lens system." These words are nearly incomprehensible, but they actually describe two rules of optics: what I called the hinge rule, and, what I called the reciprocal hinge rule. This double rule, Scheimpflug's fourth principle, also leads back to Principle No 3, the Scheimpflug principle, as a corollary!

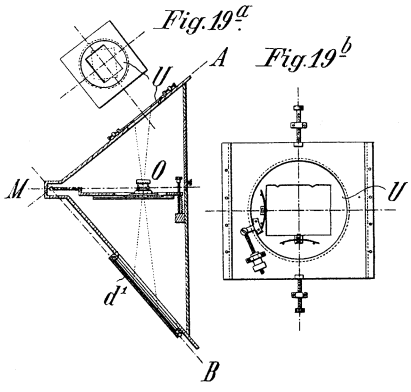
Perhaps surprisingly, we actually have in Scheimpflug's Principles Nos. 3 and 4, three rules such that any two of them are sufficient to solve the lens equation unambiguously. What this means is that neither the Scheimpflug Principle alone nor the hinge rule alone provides enough information to solve the view camera focus problem. Together, they do.

Equally well, we could use the Scheimpflug Rule and the reciprocal hinge rule to solve the problem. Or we could use the hinge rule and the reciprocal hinge rule. Any two of these three rules will suffice.

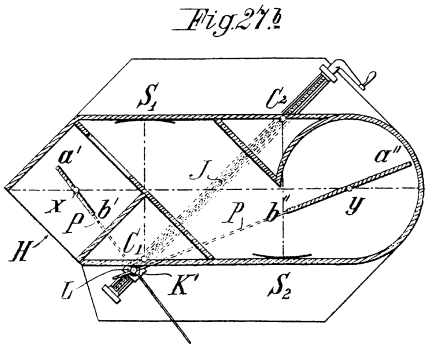
Each of the three rules requires three plane to intersect along a single common line. The planes in each rule are either shared with, or parallel to, the planes in the other two rules. All together, for thin lenses, we have seven planes defining three special parallel



The view camera photographer can use the hinge rule alone to determine the amount of lens tilt needed.



One of Scheimpflug's proposed cameras is shown in his Figure 19. Note how the lens is focused by swinging it about a pivot at the Scheimpflug line, M.



Scheimpflug's Figure 27 illustrates a special camera for producing "affinite" perspective corrections: a pure stretching of the image along one direction. The optics consists of two concave mirrors.

lines. For thick lenses there are eight planes and four parallel lines. It's curious that all these plane should be parallel to one-another; and it's mind-boggling to try to keep all the relationships clear in one's head.

Fortunately, the view camera photographer can make it all work by paying attention to only two planes and one line. The hinge rule is, to my way of thinking, the really useful relationship. Perspective considerations usually set the required angle of the camera back; most often the back will be vertical. And the photographer usually knows where he wishes to place the lens. He should also be able to visualize the plane on which he needs to focus. A plane parallel to the camera back, but passing through the lens, intersects the intended plane of sharp focus at the hinge line. If the distance from the lens to the hinge line is J, the geometry of the hinge rule tells us the lens tilt required: a = arcsin(f/J) where a is the lens tilt angle and f is the lens focal length. The "arcsin" mathematical function is available on most scientific calculators. The lens is tilted in a direction towards the hinge line. The camera back is then adjusted in position to put the image in focus. (The back should not be tilted or swung in this focusing action, just translated along the bed or monorail.) This method for focusing a camera is not described in Scheimpflug's patent, but he clearly knew all of the required relationships.

What's the bottom line of this discussion? Theodor Scheimpflug was not the inventor of the rule that bears his name. But he did study the view camera focus problem and explain the underlying physics in far greater detail than that for which he has generally been given credit.

References

(References to the patents of Carpentier and Scheimpflug are given in the captions.)

Rudolf Kingslake, *Lenses in Photography*, Case-Holt Corporation for Garden City Books, Garden City, New York, 1951.

J. Radford, "Theodor Scheimpflug", *The British Journal of Photography*, 19 May 1978, pages 446-447.

Harold M. Merklinger, *Focusing the View Camera*, published by the author, Ottawa 1993.

History of the Motor Car, Thomas Allen & Son Ltd., Toronto, 1970.

Roger W. Sinnot, "Telescope Making: An Array of Optical Oddities", *Sky and Telescope* Vol. 91, No. 1, page 85 (January 1996). See also G. H. Kellner, US Patent 969785, 13 Sep. 1910.