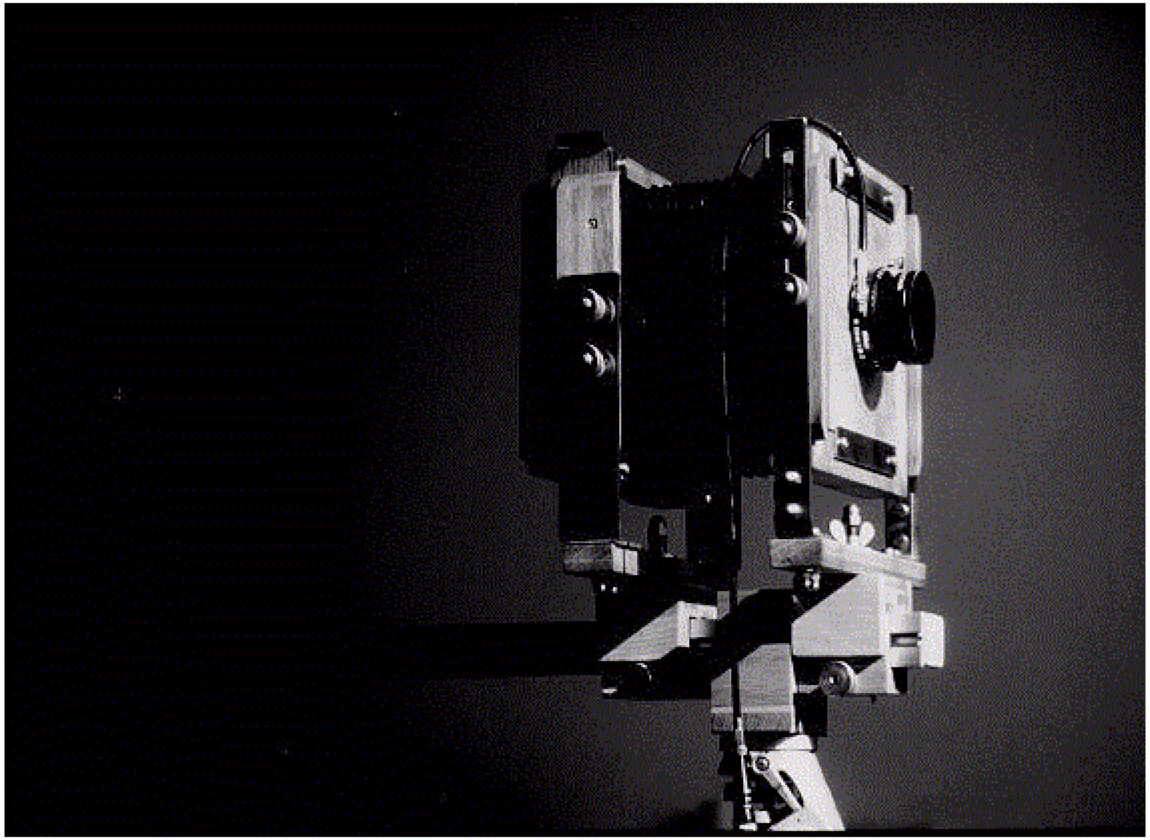
Building a Large Format Camera

Jon Grepstad

Second, revised edition

Oslo 2000



Hertug Skules gate 12
0652 Oslo, Norway
Second revised edition
First edition: 1996

E-mail: gjon@online.no
World Wide Web: http://home.online.no/~gjon/

ISBN 82-993938-1-7

Preface

In the spring of 1991 I came across an article on building your own large format camera. The article, published in 1988 in a Swedish photo magazine, was based on the advice and experience of a professional Swedish camera builder, Kurt Lundell.

In the summer and autumn of 1991 I built my first monorail camera of oak, brass and aluminum. I was inspired by Kurt Lundell’s article but collected information from a large number of sources. I read articles in photo magazines, bought books about large format cameras, borrowed books from libraries about classic cameras, and studied specifications and pictures in sales brochures for most brands of current view cameras. On the basis of my reading I made sketches, then scale drawings on graph paper, and then went to the local lumber-yard to look for suitable woods. I experimented with various solutions for details of the camera and made numerous visits to hardware stores to find the right types of screws or potential metal parts. During the construction process a number of drawings were revised and changed.

I have written this manual because building a large format camera is a greatly rewarding experience which I want to share with others. During the past six years I have spent considerable time on the Internet and have noticed with increasing frequency questions about sources and plans for building your own view camera. A few books or pamphlets are around, in English or German. Although they are useful as sources of inspiration or guidance, I feel they all have their shortcomings. There are several details I think should be improved. I also think a view camera should not only be a good tool for making images, but it should also be a beautiful object in itself.

This manual provides instructions and plans for a 4 x 5 in. monorail camera built of hardwood, and with some brass and aluminum parts. The focusing system is based on friction focusing. The lens, of course, will have to be bought. It is also suggested that you buy the bellows and the ground glass. However, my book provides references and sources for those who wish to make their own bellows, as well as instructions for grinding your own glass. *Building a Large Format Camera* is aimed at woodworkers with average skills and experience. The basic principles of a camera are simple. Building a camera requires patience and accuracy, but is far easier than making, for instance, a stringed instrument. Building a camera may take 50–80 hours. Part of the pleasure is pondering over details and alternative designs.

My design is largely modular. Parts may be replaced with other parts of different designs to meet your needs and preferences. The front and rear standards, for instance, may be customized depending on your needs for camera movements. You may construct an extra frame for attaching a second bellows for extreme close-ups or long telephoto lenses. The 4 x 5 spring back may be replaced with a step-up adapter for the 5 x 7 image format. A lamp housing and a negative carrier may be added along with a table-top optical bench to transform the camera into a horizontal enlarger, and so forth.

These plans and instructions are for a 4 x 5 camera. But the plans may be scaled up for a 5 x 7 or an 8 x 10 camera. Crucial information on the position of the ground glass for these formats is found in chapter 4.3. Advice for scaling up is given in chapter 6.5.

If you have questions about the design, please feel free to contact me. To the extent that my time permits it I will try to reply. If possible, use e-mail. If you are using postal mail, please enclose a self-addressed envelope and international reply coupons to cover postage. Also, if there are things in this guide you feel should be improved, please let me know! I would like *Building a Large Format Camera* to be an inspiring and practical guide for woodworkers and photographers who want to build their own camera.

English is not my native language. I wish to thank my dear friend Yvette, who read an early draft of this manual and commented on the language. I am solely responsible for the final text.

The first edition of this book appeared in April 1996. In the second edition I have added more photographs of the camera and have inserted a number of drawings in the text. I have included instructions for a more sophisticated design of the ground glass frame. The bibliography and other references have been updated. In particular more references to sources on bellows-making have been included.

Oslo, Norway, 1 January 2000

Jon Grepstad

Contents

1 Large Format Cameras

Large format cameras are cameras that take film generally in sizes 4 x 5 in., 5 x 7 in. or 8 x 10 in. (or 10 x 12 cm, 13 x 18 cm, 20 x 24 cm). Large format cameras usually fall into one of two categories:

– field cameras
– monorail cameras

Field cameras are collapsible flatbed cameras that fold up into a box. Monorail cameras are mounted on a monorail.

1.1 Benefits of Large Format Cameras

Camera movements

Front and rear frames may be moved (rise/fall, shift, tilt, swing) in order to control image field, perspective and depth of field. This is a major advantage over “rigid” 35 mm SLRs and medium format cameras.

Large film size

Large film size gives sharper images and better tonality. Negatives may be contact printed. The large negative size (5 x 7 and 8 x 10 even more than 4 x 5) goes well with alternative processes.

Individual sheets of film

Large format cameras take individual sheets of film. Change from one type of film to another is therefore simple. Sheets may be developed individually for optimum results. Polaroid film may be used for test shots or for permanent images or negatives.

Contemplative approach

Photography with large format cameras is slow. The process demands careful planning. Much effort is invested in each image. The slowness stimulates a conscious approach to photography.

1.2 Drawbacks of Large Format Cameras

Expensive equipment

Large format cameras are generally expensive, though second hand cameras may be bought at a reasonable price.

Heavy and bulky equipment

The equipment is heavier and bulkier than 35 mm and medium format cameras. A good tripod is required.

Longer exposures

When using large format lenses you normally shut down to apertures f/16–f/32 or more. Exposures are often longer than in 35 mm and medium format photography. Some subjects therefore lend themselves better to large format photography than others.

Manual operation

Large format cameras are basically manual. Whether this is a drawback or not is debatable. Manual operation means that most things are slower than in 35 mm and medium format photography: loading film holders, setting up the camera, focusing and composing, light measuring, setting aperture, and exposure. But manual operation is one of the things that make for the contemplative approach of large format photography.

On the whole, what you see as benefits and what you regard as drawbacks may depend on your individual taste and your personal approach to photography.

2 Designing and Building a Large Format Camera

Designing and building a large format camera may be an inexpensive entry to this field of photography. Building a large format camera is definitely a very rewarding experience. It is far easier than building a musical instrument. Taking pictures with a camera you have designed and built yourself is a great pleasure.

This manual provides plans for a 4 x 5 in. monorail camera. Materials may amount to $ 60–90, depending on design and choice of woods and metal parts. The ground glass and bellows may be bought for a total of $ 130. If you want to make the ground glass and the bellows yourself, some references and instructions are provided. With the optical bench removed the camera measures approx. 20 x 25 x 10 cm. The weight depends on your choice of wood and metal parts. A camera built of oak, my own favorite, will be about 3.0–3.3 kg, the optical bench included. The optical bench weighs about 1 kg if the sliders and tripod block are made of oak. Other woods are lighter.

Building a monorail camera is easier than building a collapsible flatbed (field) camera. Only general woodworking skills and experience are needed. Traditional woodworking virtues such as accuracy and patience are rewarded—and will be reflected in the final object. To build the camera you need ordinary woodworking tools: an electric drill (a drill press is useful, but not necessary), bits for wood and metal, a bench vise, various saws (backsaw or tenon saw, fret saw, coping saw and hacksaw), a miter box, a carpenter’s square (engineer’s try-square), straight tip and cross-head screwdrivers, metal files, wood files, a center punch, clamps (miter or corner clamps are useful but not required), a smoothing plane, a knife, chisels, calipers, a metal ruler, sandpaper of assorted grades. In addition you will need wood glue, matte black paint for some internal parts and oil for wood finish.

The materials are mainly wood. The rail is aluminum. Standards are in 2–3 mm brass. There are some brass fittings. Various types of screws and threaded inserts or pronged T-nuts will be needed. Suitable hardwoods are cherry, mahogany, walnut, rosewood, oak, ash or even birch. All wood should be well seasoned. You will also need some plywood. More detailed information about materials is given below.

Most drawings are to scale 1 : 2. The measurements are metrical. One crucial measurement (the depth of a standard film holder) is also given in inches.
A conversion table is found the end of this manual.
A freeware conversion program for Windows can be downloaded here:
http://home.online.no/~gjon/depth.htm.

2.1 List of Materials

Exact measurements are given in millimeters. Approximate minimum lengths are in centimeters. My own choice of materials is determined by the supply of woods and metal parts in my area. Thus I use 5 or 6 mm oak as the basis of many parts in my design because planed oak strip or moulding of excellent quality is easily available with the right dimensions from my lumber-yard. I have also used teak for cameras.

Before you start on your camera project, you should find out what materials are supplied by your local lumber-yard and hardware store. Many dimensions may be adjusted to match the materials available. You may also choose to change some of the details in my design. The following list of materials is meant only as a point of departure.

2.1.1 Wood

Frames:
Planed hardwood 30 x 6 mm: approx. 160 cm
Planed hardwood 24 x 6 mm: approx. 160 cm
8 mm plywood: approx. 20 x 40 cm
Planed hardwood 35 x 10 mm: approx. 32 cm (frame connectors)
Planed hardwood 16 x 6 mm: approx. 80 cm
Veneer strip: 10 x 2 mm: four pieces approx. 15 cm long.

Lens board:
4 mm birch plywood: 140 x 140 mm
Planed hardwood approx. 20 x 6 mm: approx. 60 cm

Front Panel (undrilled lens board):
4 mm birch plywood: 140 x 140 mm
Planed hardwood approx. 20 x 6 mm: approx. 60 cm

Spring Back:
8 mm plywood: 184 x 184 mm (back panel)
Planed hardwood 20 x 6 mm: approx. 80 cm (film holder seat)
Planed hardwood 10 x 6 mm: approx. 45 cm (film holder seat)
Planed hardwood 12 x 6 mm: 40 cm (film holder seat)
4 mm birch plywood: approx. 120 x 155 mm (ground glass frame—exact measurements should be taken from a film holder)
Planed hardwood 24 x 10 mm: approx. 32 cm (ground glass frame)
Planed hardwood 24 x 6 mm: approx. 45 cm (ground glass frame)
Planed hardwood 20 x 5 mm: approx. 22 cm (ground glass frame)

Standards:
Planed hardwood 30 x 15 mm: approx. 45 cm

Sliders and tripod block:
Planed hardwood 9 x 45 mm: approx. 80 cm
Planed hardwood 15 x 20 mm: approx. 20 cm
Planed hardwood 15 x 6 mm: approx. 20 cm
Planed hardwood 30 x 6 mm: approx. 30 cm
Planed hardwood 18 x 6 mm: approx. 30 cm
4 mm birch plywood: 66 x 45 mm

2.1.2 Metal

Rail:
Aluminum rail 30 x 30 mm: approx. 38 cm

Standards:
Brass 20 x 2 mm: 280 mm (front standard)
Brass 20 x 2 mm: 280 mm (front standard)
Brass 40 x 2 mm: 200 mm (rear standard)
Brass 40 x 2 mm: 200 mm (rear standard)
Angle irons approx. 35 x 35 x 15 mm (two for front standard)

Lens board lock (retainers):
Brass 125 x 18 x 2 mm (upper lock plate)
Brass 120 x 18 x 2 mm (lower lock plate)
Brass 105 x 10 x 2 mm (cover plate for upper lock)

Spring back lock (retainers):
Brass 40 x 20 x 1 mm (bottom)
Brass 40 x 20 x 1 mm (bottom)
Brass 65 x 45 x 1 mm (top lock)
Brass 65 x 45 x 1 mm (top lock)
Brass 50 x 10 x 1 mm (cover plate for top lock)
Brass 50 x 10 x 1 mm (cover plate for top lock)

Spring back springs:
Leaf springs approx. 165 x 5 mm (two springs)

Ground glass frame:
Brass 100 x 4 x 0.8 mm (for the correct positioning of the ground glass)

Bellows retainers and reinforcement of corners:

Brass 25 x 38 x 1 mm (8 pieces)

Tripod block:
Brass 66 x 45 x 1 mm

2.1.3 Screws, threaded inserts, bolts and nuts

The most common types of screws are not listed. Length of screws depends on design and is normally not listed.

Frames:
Control screws (adjustment screws):
Six threaded inserts (or pronged T-nuts): thread diameter 5 mm (M5)
Six knurled screws or knurled nuts with screws: diameter 5 mm (M5)
Twelve washers: for screws with diameter 5 mm (M5)

Sliders and tripod block:
For attaching the tripod block to the tripod:
One threaded insert (or pronged T-nut) for the tripod block: inner diameter 3/8 inch or 10 mm (M10). The threaded insert should fit the tripod screw, with or without a tripod screw adapter.

For attaching the crosspiece ("beam") of the standards to the sliders:
Two hex-head brass bolts: diameter 6 mm (M6), length depends on design
Two knurled screws or knurled nuts with screws: diameter 6 mm (M6)
Two washers for M6 (6 mm) screws (to go under the wing nuts)
Two brass wing nuts: diameter 6 mm (M6)
Two brass cap nuts (acorn nuts): diameter 6 mm (M6)
Fastening screws for the sliders:
Three brass bolts: diameter 5 mm (M5), length approx. 70 mm
Three brass wing nuts: diameter 5 mm (M5)
Three brass cap nuts (acorn nuts): diameter 5 mm (M5)
Six washers: for screws with diameter 5 mm (M5)

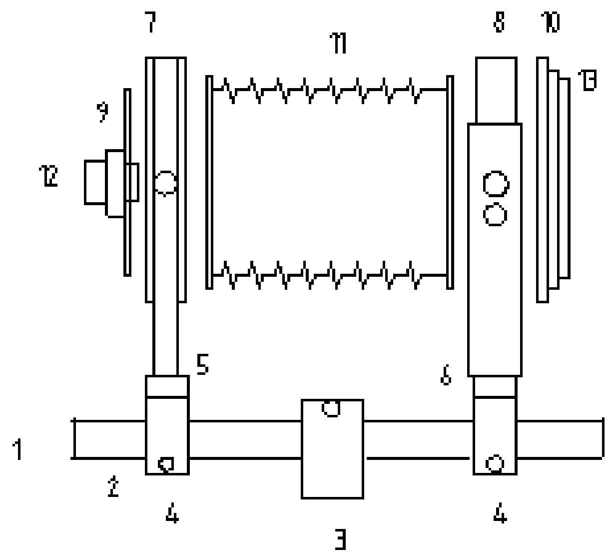
Standards:
For attaching the brass uprights to the crosspiece:
Eight cheese-head (flatheaded) brass machine screws: length 24 mm
Eight brass cap nuts (acorn nuts)
For the angle-irons:
Eight brass cheese-head machine screws: length 6 mm
Eight brass cap nuts (acorn nuts)

Notes: Pronged T-nuts are sometimes also referred to as captive nuts or spiked nuts. On how to make knurled screws from knurled nuts and machine screws, see section 4.6 and Figure 26.

3 The Basic Outline

The camera proper rests on an optical bench (1). The optical bench consists of an aluminum rail (2), a tripod block (3) and two sliders (4).

The sliders carry the front and rear standards (5 and 6). The standards in turn hold the front and rear frames (7 and 8). The lens board (9) is attached to the front frame, the spring back (10) to the rear frame. Between the front and rear frames is the bellows (11).

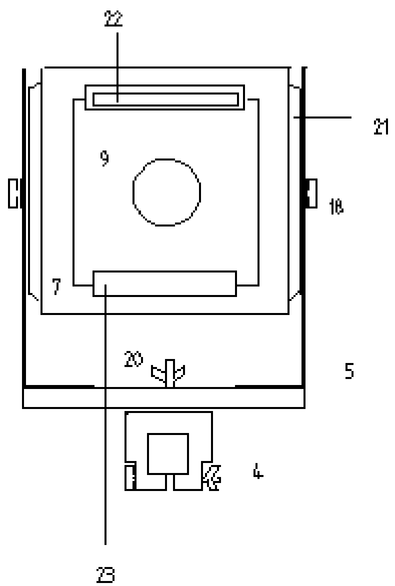


Exploded and simplified view of the monorail camera

A lens (12) is mounted on the lens board. The spring back consists of a back panel, a film holder seat and a ground glass frame (13). The ground glass frame holds the ground glass (14) and fits into the film holder seat (15). Two flat (leaf) springs (16) press the ground glass frame against the back panel. The ground glass frame holds the film holder in place when the holder is inserted.

A simple lock mechanism (17) attaches the spring back to the rear frame. The spring back may be positioned for horizontal or vertical formats. Changes from the horizontal to the vertical format are made by sliding the two upper locks open, removing the back, rotating it 90 degrees, repositioning it and sliding the locks back in place.

Threaded inserts (or pronged T-nuts) and knurled screws (18) are used for holding and locking the front and rear frames in the standards. On either side of the frames, between the frames and the standards, there is a frame connector (21). Wing screws and knurled nuts (19) are used for fastening or locking the sliders when focusing. Bolts and wing nuts (20) are used for fastening the frames to the sliders. A lens board lock (22 and 23) attaches the lens board to the front frame.



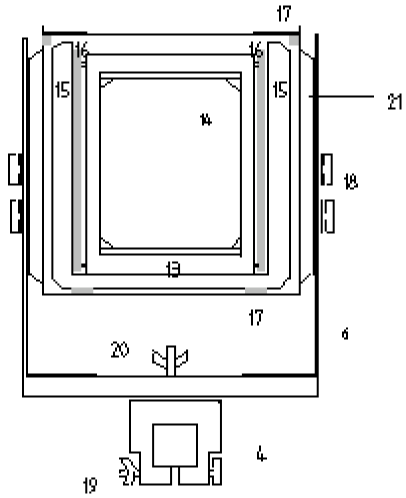
Front view of the monorail camera.

The position of the ground glass is the one really critical measurement in the camera design. The ground surface (focusing plane) of the ground glass has to coincide with the film plane when a film holder is inserted.

Other important measurements are the dimensions of the front and rear standards including the positioning of the holes and slots. These determine the potential rise and fall of the front frame, and the degree of tilt of the rear frame.

The internal measurements of the front and rear frames should accommodate a standard bellows. The film holder seat in the spring back should be made to the measurements of a film holder.

Most other measurements of your camera may differ to some extent from those given in these plans if you want to change the design outlined here.



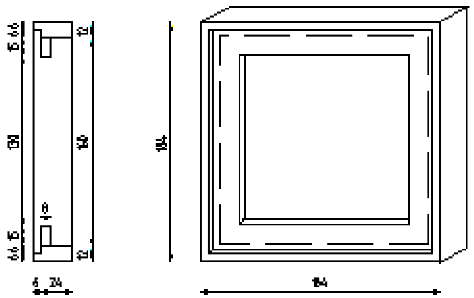
End view of the monorail camera

4 The Construction Process

Make the front and rear frames first. Then make the lens board and the spring back. Finally make the standards and the optical bench.

4.1 The Front and Rear Frames

The frames and the bellows constitute the camera proper. The frames are made of two strips of planed hardwood, 30 x 6 mm and 24 x 6 mm, which are glued together to make a strip 30 x 12 mm with a 6 x 6 mm rabbet (Figures 4 and 5).



Front frame

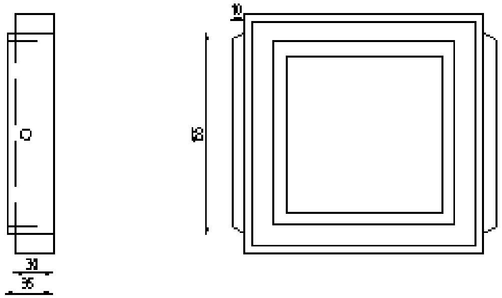
Eight pieces, each 184 mm long, are cut and mitered 45 degrees. (The corners may be dovetailed instead of mitered, but dovetailing is not necessary.) The internal measurements are 160 x 160 x 24 mm to accommodate a standard bellows. (Note: The frames of a standard Cambo bellows are 162 x 162 mm. The bellows frames may be cut to 160 x 160 mm, or you may increase the internal measurements by 2–3 mm.)

Four pieces are glued together to form a frame. The external measurements are 184 x 184 x 30mm. Corner clamps (used for gluing picture frames) are useful for holding the pieces in place and for exerting pressure. They are inexpensive and can be found in a hardware store.

The next step is to make two plywood squares, with the same external dimensions, to go inside the frames, one for the front frame and one for the back. They are made of 8 mm plywood, 160 x 160 mm. The plywood square for the front frame has a cutout 120 x 120 mm (Figure 6). The cutout in the piece for the rear frame is 130 x 130 mm (Figure 10). The plywood squares are glued to the inside of the frames (Figures 7 and 11).

(The front and rear frames may also be made with a rabbet of 10 x 6 mm, instead of 6 x 6 mm. The plywood squares will then have be made of 4 mm plywood, 172 x 172 x 4 mm. The cutouts are the same as in the description above. The squares are then glued to the rabbets in the frames.)

For the front frame four strips of 172 x 16 x 6 mm hardwood are mitered to form a frame to go in the rabbet on top of the plywood (Figure 4). The pieces are glued to the plywood and the rabbet in the front frame. The front frame will now have an opening 140 x 140 mm for the lens board. Thin strips of wood (veneer), 140 x 10 x 2 mm, are glued to the plywood to accommodate the lens board which is 4 mm thick (Figures 4 and 13).



Front frame with "frame connector"

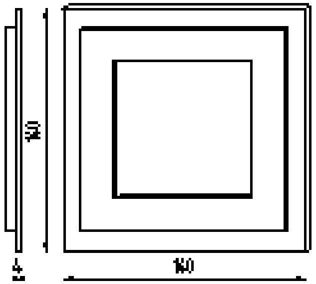
The front and rear frames will later be attached to the standards with threaded inserts (or pronged T-nuts) and knurled screws or knobs. On either side of the frames, between the frames and the standards, a piece 155 x 35 x 10 mm is added for the threaded insert (Figures 8 and 12). Each piece, or “frame connector”, is fastened to the frame with two screws. The use of “frame connectors” may be unique to my camera design. The advantage is that holes for threaded inserts are made in the “frame connectors”, not in the frames proper. If you happen to be inaccurate while drilling the holes for the inserts, your frame is not spoiled. You just make a new “frame connector” and drill a new hole.
It also means that at a later stage, when you have been experimenting with your camera for some time and have become familiar with camera movements, you may easily change the pivot points for tilt (by moving the holes for the inserts forward or back) if you find that practical for your purposes. You just make a couple of new “frame connectors”, put the holes where you want them for your camera movements, and fasten the pieces to the frames.

In other words, the “frame connectors” are a safeguard against inaccuracies while you are building the camera and they give you greater flexibility for customizing your camera. Note that the holes for the threaded inserts should be level with the optical axis, i.e. an axis 90 degrees on the center of your lens.

The thickness of the frame connectors depends on the size of your threaded inserts. Many inserts will need a thickness (depth) of 12 mm or 15 mm. In this design the frame connectors are 10 mm which is sufficient if you are using pronged T-nuts. If you make the frame connectors thicker you will also have to make the beams of the standards longer. Because the exact dimensions of the frame connectors and the positioning of the holes for the threaded inserts or pronged T-nuts depend on the design and dimensions of the standards, it is suggested you make the frame connectors in conjunction with the standards. See section 4.6.

4.2 The Lens Board

The lens board is made of 4 mm birch plywood or other hard plywood (Figure 13). It may also be made of strips of 4 mm hardwood glued together to make a square board. If you use the latter method, care has to be taken that the board is plane and that it does not warp.

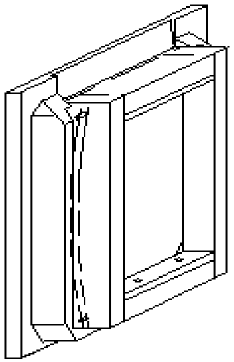


Lens board

The measurements are 140 x 140 x 4 mm. A light trap (baffle) on the inside of the lens board is made by gluing a frame of four pieces of 20 x 6 mm hardwood on to the back of the lens board. The light trap frame fits into the 120 x 120 mm cutout in the plywood in the front frame (Figure 4). To cut a hole for the lens, see section 4.8.

You should make an extra panel the same size as the lens board to replace the lens board when the lens board is not attached. This panel—an undrilled lens board— helps keep dust away from the interior of the camera when the camera is stored.

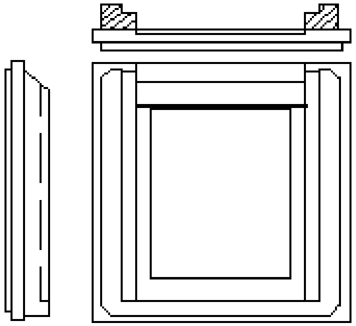
4.3 The Spring Back



Spring back

The panel of the spring back is made of plywood, 184 x 184 x 8 mm (Figures 14, 15 and 16). It may also be made of a number of pieces of hardwood joined together. In the latter case great care has to be taken that the spring back is plane and that it does not warp. The back panel has a cutout of 100 x 120 mm. A frame made of four pieces of hardwood, 172 x 20 x 6 mm, is glued to the inside of the back panel. This frame serves as a light trap mechanism, similar to the light trap frame of the lens board. It fits into the rabbet in the rear frame and helps hold the spring back in place.

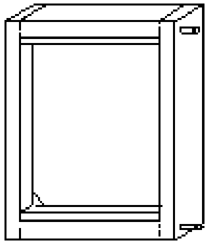
Use a film holder to mark the critical measurements of the spring back. Draw a film holder on graph paper. Use a copier to make a copy on a transparency. Place the transparency on the back panel. Mark the critical measurements. My own drawing of a standard film holder is reproduced in Figure 32. Note that the external dimensions of standard film holders for 4 x 5 in. and 9 x 12 cm sheet film are the same. The depth of the film holders is also the same.



Spring back

The groove for the locating ridge of the film holder (Figure 16) may be routed or cut carefully with a sharp knife and chisel. The groove should cross the direction of the grain in the surface layer of the plywood. Use a thin file to clean the groove. The groove holds the film holder in place and also serves as a light trap.

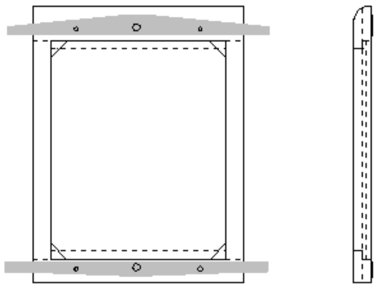
The film holder seat (Figure 17) is glued to the back panel and fastened by screws from the inside. The internal measurements are taken from a film holder.



Gound glass frame (simple design)

This edition of my book offers two designs of the ground glass frame. If you choose my basic design of a ground glass frame, suitable wood for the film holder seat walls is 20 x 6 mm hardwood strips glued together to form pieces 20 mm wide and 18 mm thick. Note that the two vertical pieces have a rabbet approx. 10 x 6 mm to accommodate the leaf springs holding the ground glass frame (Figure 17).

If you decide to use my more elaborate design of a ground glass frame, the film holder seat walls should be approx. 20 x 12 mm with a rabbet of approx. 10 x 6 mm. See figures and detailed instructions in the Addendum on page 37. The following instructions are for the basic ground glass frame.



Ground glass frame (advanced design)

Get a ground glass before you make the ground glass frame. A standard ground glass is fairly inexpensive and may be bought from a view camera dealer. An intense screen or a ground glass with a fresnel lens in many circumstances gives a brighter viewing image but costs more than a simple ground glass and are not really needed. Usually the corners of the ground glass are cut off to make it easier to check on vignetting (see section 8.2) and to permit movement of air when the bellows is extended or compressed.

A fresnel lens is a thin sheet of plastic with concentric stepped rings which works like a condenser lens. The fresnel lens should be placed on top of the ground glass, between the ground glass and the photographer, so that the focusing surface of the ground glass is not displaced. The fresnel patterns, which should face the photographer, distribute the image brightness over the ground glass and make the corners lighter.

As mentioned above you may choose between two ground glass frame designs. If you choose the simple design (Figures 18 and 19), the ground glass frame is made of 4 mm birch plywood and a frame of 10 x 24 mm hardwood. A rectangular piece is cut from the plywood to fit in the film holder seat (approx. 120 x 155 mm). Then a rectangular window (cutout) is made in the piece of plywood (approx. 101 x 121 mm). The width of the window should be the same as the width of the ground glass. The height should be a few mm less than the ground glass, and slightly larger than the viewing area of the ground glass. The viewing area is normally marked by black lines. The hardwood frame is then glued to the plywood. Two pieces of hardwood (approx. 4 x 18 mm) are cut the same length as the internal width of the ground glass frame. These are locks or retainers for keeping the ground glass in place. They are screwed on to the bottom and top walls of the ground glass assembly when the ground glass is positioned in the frame.

Positioning the ground glass is the most critical detail in the design. The focusing surface of the ground glass has to be in the same position as the emulsion of the film when a film holder is inserted. The critical measurement is 4.8 mm. (The ANSI standard for the depth of a standard film holder is 0.1972" plus minus 0.007". Most film has a base of 0.007". When film is loaded in the film holder, the depth is 0.190". This is the measurement used by Sinar cameras. Wisner cameras use a compromise of 0.192" to allow for wear on the wood and because Tech Pan film has a base of

0.004"). 4.8 mm is the distance from the external surface of the birch plywood to the focusing surface of the ground glass. Since the plywood is 4 mm, a 0.8 mm strip of brass is placed between the plywood and the ground glass at the top and bottom ends of the frame. You may use a Vernier caliper gauge to check the measurement. Vernier calipers take measurements to 0.1 mm or less. They are available in some hardware stores for approx. $ 20. Some hardware stores also have reasonable micrometers. Both may be bought from Micro-Tools at http://www.micro-tools.com/

Note 1: If you you are building a 5 x 7 in. camera, the ANSI standard for the depth of a 5 x 7 film holder is 0.228" plus minus 0.010", or 5.8 mm plus minus 0.25 mm. When 0.007" film is loaded, the depth is 0.221" or 5.6 mm.

Note 2: If you are building an 8 x 10 in. camera, the ANSI standard for the depth of an 8 x 10 film holder is 0.260" plus minus 0.016", or 6.6 mm plus minus 0.4 mm. When film is loaded, the depth is 0.253" or 6.4 mm.

A spring mechanism (Figures 14 and 15) attaches the ground glass frame to the film holder seat. The leaf springs may be made from the spring used in “flexible sink and drain cleaners” (a long flexible spring with a ball on one end used for cleaning stopped kitchen drains etc.) which available in hardware stores. They are inexpensive. You may also use metal from a bandsaw blade or other saw blades where the teeth have been ground or filed off. The leaf springs of a car windshield wiper can also be used for springs. Some watchmakers may also have some suitable springs from older clocks lying around.

You cut two pieces approximately 170 mm each from the spring. The leaf springs may be fastened to the rabbet in the film holder seat with one or two screws each. You may consider placing a small piece of wood between the screws and the leaf spring. You determine the pressure the leaf springs exert by making the piece of wood shorter or longer. My more elaborate ground glass frame suggests a different retaining mechanism for the leaf springs.

Either end of the spring rests on a screw or stud in the ground glass frame (simple ground glass frame design) or on a piece of brass (more elaborate ground glass design) and thus exerts pressure on the ground glass frame. Practice with inserting a film holder to check that the pressure is right. The ends of the leaf springs may be bent with a pair of pliers to form a U around the studs. Make sure the springs are long enough for the necessary movements.

The type of leaf spring mechanism used in this camera design dates back to around 1860 in the history of camera making. It became popular in the US from the 1890's onwards. An interesting alternative spring mechanism (”rat-trap” style) is found in Partridge 1992.

4.4 Lock Mechanism for the Spring Back

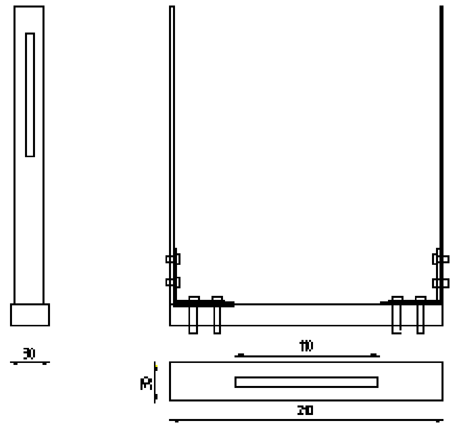
The spring back is held in place in the rear frame by two L-shaped brass pieces at the bottom of the frame and two movable locks with a cover plate at the top of the frame. The locks are made of 1 mm brass. This mechanism makes changes from the horizontal to the vertical format easy. (Figures 20 and 21). Use a file to smooth the corners of these and other metal parts.

4.5 Lock Mechanism for the Lens Board

Large format lenses are mounted on lens boards. To change the lens you change the lens board. There are various types of mechanisms for holding the lens board in place. For this camera the lens board locks are three pieces of 2 mm brass. The lower lens board lock plate is 120 x 18 x 2 mm and is fastened to the front frame by two screws. The upper lock consists of the upper lens board lock plate which is 125 x 18 x 2 mm and a cover plate of 105 x 10 x 2 mm. The larger piece has two slanted slots for screws and serves as a sliding catch (Figure 20).

4.6 Standards

Large format cameras have on-axis tilt or base-tilt. Some have both. On-axis tilt means that the front and rear frames tilt on the optical axis (center of lens or film plane). Most monorail cameras have on-axis tilt. Base-tilt means that the pivot point for the tilt is located along the bed of the camera. Field cameras generally have base-tilt for the rear frame.



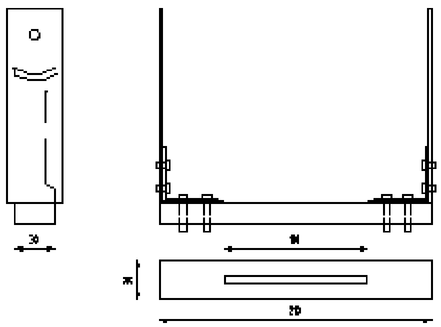
Front standard

The standards are made of a hardwood ”beam” or crosspiece (approx. 210 x 30 x 15 mm) and two L-shaped uprights in 2-3 mm brass. You may cut the brass yourself with a hacksaw or have a machine shop do it for you. Each hardwood beam has a 70–110 mm long slot for the slider attachment screw. The size of the screw determines the width of the slot. I use M6 (6 mm) screws. The slot makes possible the shift movements of the front and rear frames.

The uprights of the front standard are two L-shaped strips of brass, 280 x 20 x 2 mm. The vertical part of the L-shape is 230 mm. A 95 mm long slot is made in each standard for the front frame control screw. Use a drill and a fretsaw to make the slot. This slot is for the rise and fall movement of the front frame. The width of the slot is determined by the type of screw used to hold the front frame. I use M5 (5 mm) screws. The control screws (knurled screws) go into the threaded inserts (or pronged T-nuts) in the frame connectors. The L-shaped uprights are fixed to the beam by cheese-head (flat-headed) machine screws. I use M5 (5 mm) screws here. The screws are fastened with cap nuts (acorn nuts) under the hardwood beam. You may also use ordinary nuts with washers. The corners of the L-shaped uprights may be reinforced by angle-irons. If necessary put thin washers between the brass uprights and the angle-irons.

The uprights of the rear standard are two L-shaped strips of brass, 200 x 40 x 2 mm. The vertical part of the L-shape is 150 mm. The rear standards hold the rear frame by means of two control screws (knurled screws) on either side. One screw is for the pivot hole, the other for adjustments (camera movements). The slot for the adjustment screw is shaped like an arc to allow tilt movements. The center of the arc is the center of the pivot hole. The positioning of the circular slot determines the degree of tilt possible. I suggest the distance to the pivot hole be 25–30 mm.

Note that when the film holder is in the horizontal position the maximum degree of backward tilt is determined by the positioning of the rear standard uprights. If the frame connectors are 10 mm thick, as suggested above in section 4.1, the handle of the film holder dark slide will hit the standard upright when the tilt is more than approx. 18–20 degrees (depending on your positioning of the frame connectors and the positioning of the adjustment slot). If you want more backward tilt, you may (1) place the insert for the control screw further to the front of the frame connector piece or (2) shape the rear brass uprights to accept more tilt by making a cutout in the lower part of the upright (Figure 23).



Rear standard
What is said above applies only to backward tilt of the rear frame when the film holder is in the horizontal position, not to the forward tilt of the frame. Forward tilt of the rear frame is not limited by the shape of the rear standard, only by the control screw arc. Nor is tilt limited by the standards when the film holder is in the vertical position.

The front standards will accept 80 mm rise (more than is needed) and about 15 mm fall of the front frame. If you want more fall you just make the rear upright longer and raise the pivot hole and the arced slot for the control screw. If you only occasionally need more front fall you may set up your camera with the monorail not in the horizontal position but slanting slightly forward. My experience is that I need more front rise than fall.

The standards may also be made only of hardwood (beam and uprights). Metal uprights may look better but wooden uprights conduct less vibration. My personal choice is 2 mm brass reinforced with angle-irons. Vibration has not been a problem.

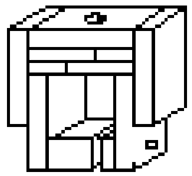
The front and rear frames are attached to the standards with knurled screws or knobs. The thread diameter is 5 mm (M5). If you have problems finding the right type of screws, you may screw a cheese-head (flat-headed) machine screw into a knurled nut, apply some torque, and thus get a beautiful knurled screw with the right dimensions (Figure 26). I use zinc-coated knurled nuts and brass screws for making control knobs. The screws fit into the threaded inserts (or pronged T-nuts) in the frame connectors. A washer is placed between the knurled screw and the standard. Another washer is placed between the standard and the frame connector. The frame connectors should be fastened to the frames with two screws each. The back of the connectors should be flush with the back of the frames.

Note that the positioning of the holes for the control screws affects camera movements. I suggest the holes be placed 15 mm from the front of the frame connectors (Figure 24). As the dimensions of your camera may differ somewhat from my drawings, you should make sketches based on the exact dimensions of your camera before you decide on the positioning of the holes for the control screws in the rear standard. You may use a protractor to measure tilt angles.

When the camera is set up, the beams (crosspieces) of the standards rest on the sliders. The 6 mm (M6) screw in each slider fits in the slot in the beam. A brass wing nut is used for locking. A washer is placed under the nut. The end of the 6 mm (M6) screw may be capped with a brass cap nut (acorn nut). Knurled nuts or locking levers may be used instead of wing nuts. My preference is for brass wing nuts because they are easy to turn and because I avoid plastic knobs or levers for esthetic reasons. Some black plastic levers go well with teak, however.

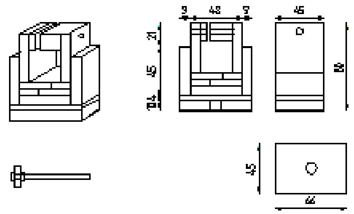
4.7 The Optical Bench

The optical bench consists of an aluminum rail, 30 x 30 x 380 mm), a tripod block and two sliders for carrying the standards. The sliders are the focusing system of the camera.



Slider

The sliders and the tripod block are basically of the same design (Figures 25 and 26). The sliders have an M6 (6 mm) screw for the standards; the tripod block has a 3/8 inch or a 10 mm threaded insert (or pronged T-nut) for the tripod screw. (A standard ¼ inch tripod screw adapter will fit both the 3/8 inch and the 10 mm insert.) The sliders and the tripod block are made of hardwood, preferably of a number of pieces that are glued together. I use 6 mm and 9 mm hardwood strips. In my design the sliders are 66 x 66 x 30 mm *or* 66 x 66 x 45 mm. Thirty mm should be sufficient depth to produce a sturdy slider but 45 may be even sturdier. Forty-five mm depth may be too much if you are using wide angle lenses. However, you can set up your camera with the tripod block in front of the sliders to reduce the distance between the front and rear frames. The sliders and the tripod block may also be made of metal or Delrin, a strong plastic material. I have good experience with wood, which I feel gives the right friction when focusing. Care should be taken that the internal measurements of the sliders are accurate (30 x 30 mm). They should be made tight and be adjusted by careful sanding or filing.



Tripod block with screws and brass plate

A hole is drilled in each slider for an M6 (6 mm) hex-head bolt to hold the beam of the front and rear standards. The bolt is inserted from inside the slider before the bottom pieces of the sliders are glued in place (Figure 25). An M5 (5 mm) wing screw with a knurled nut is used as a locking screw in each slider. If you have problems finding a wing screw long enough, you may make one by screwing a long machine screw into a wing nut (see the preceding section and Figure 26). On top of the tripod block you may fasten a 2 mm brass plate with four counter-sunk screws. At the center of the plate there is a hole slightly larger than the tripod socket.

4.8 Mounting the Lens on the Lens Board

Mark the center of the lens board. Use a compass to draw a circle the size of the rear thread of your lens. Cut the hole with a coping saw or fretsaw. Use a file and sandpaper to make the hole perfectly circular and slightly larger than the rear thread of your lens but smaller than the retaining ring of the lens. Place the rear thread of the lens in the hole and fasten the retaining ring. Note that different lenses will have rear rings with different diameters depending on the type of shutter. Mounting the lens on the lens board should be the last step in the construction of the camera.

4.9 Attaching the Bellows

The bellows may be glued to the front and rear frames. An interchangeable bellows, however, has benefits over a non-removable bellows. You may want to remove the bellows for giving your camera another coat of oil, or you may want to have the freedom to use a bag bellows with short lenses, or to make an accessory frame for a second bellows for extreme close-ups or a long telephoto lens.
My personal choice is a kind of brass retaining lock made of 1 mm brass sheet. The lock also serves to strengthen the corners of the frames. However, since each piece is attached with two screws, this mechanism is not practical for frequent or quick change of bellows (Figure 27).

An alternative solution, which makes change of bellows fairly easy, is to attach the bellows to the frames with one screw in each corner of the bellows frame.

4.10 Finishing the Wood

Internal wooden parts should be painted matte black. The external surfaces of the hardwood parts should be given one or several coats of oil or your favorite wood finish suitable for the hardwood you have chosen. Brass parts should be polished with brass polish from time to time.

5 Testing the Camera

5.1 Testing for Light Leaks

If you have followed the instructions and your work has been accurate there is little danger that the camera is not light proof. However, to test it for light leaks you may place it in bright light for half an hour with a film holder inserted and the film holder's dark slide pulled out while the shutter is closed. When you develop the film there should be no fogging. If you have made the bellows yourself or have bought a second hand bellows and want to test it for pinholes, you can use the same method. You can also put the camera in a dark room and put a flashlight into the bellows (ground glass holder removed). Light will then leak from pinholes.

5.2 Testing Focusing

Put a long folding rule or a long tape measure on the floor of room. Place objects at regular intervals along the rule. Expose with maximum aperture to reduce depth of field. Develop, check results. Use a depth of field scale (or calculations) to check the results. The front and rear frames should be in a neutral position (no tilt) when you are testing.

6 Appendices

6.1 Making a Ground Glass

This manual assumes that you buy the ground glass. They are fairly inexpensive for 4 x 5 cameras but rather expensive for larger formats. A brightscreen or a ground glass with a fresnel lens give a brighter viewing image in many circumstances. A standard ground glass may cost about $ 20–30 and is available from large format camera dealers. Brightscreens and fresnel lenses will be more expensive.

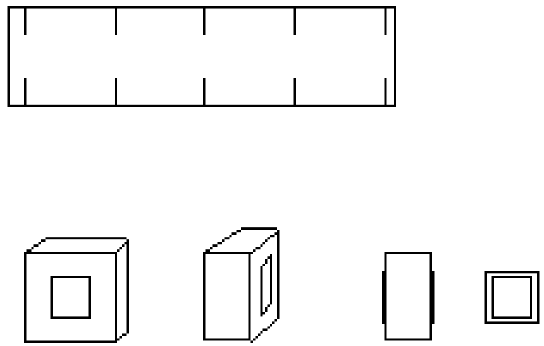
Sheets of ground glass may also be bought from a glazier. Coarse-grain ground glass makes focusing on finer details difficult. You may also make a ground glass of excellent quality yourself. Take a sheet of plate glass (about 12 x 12 in.), spread half a teaspoonful of # 600 carborundum (silicon carbide) or # 500 corundum grit onto the plate, saturate the grit with a teaspoonful of water. The 4 x 5 ground glass-to-be is then placed on the grit and gently rotated. The grinding may take about five to ten minutes. You may find it useful to have an extra ground glass in case your regular ground glass breaks. Carborundum should be available in lapidary shops.

6.2 Making a Bellows

This manual also assumes that you buy a standard bellows or has a bellows custom made for you. You will find some bellows makers listed under Addresses at the end of the book or in my View Camera Construction FAQ at http://home.online.no/~gjon/lffaq.htm. Standard bellows for most brands of cameras tend to be expensive. However, there is a standard Cambo bellows which is available at a price of approximately $ 105. A custom made bellows may be about $ 130. If you want to make the bellows yourself, useful advice is found in West 1995, pp. 35–44, in Robinson 1996, Romney 1990, and in *Camera Making*, a fascinating collection of articles from the British magazine *Amateur Photographer* 1887–1995. Hasluck 1907 is an old valuable source (chapter ”Miscellaneous Items”). An excellent online source is Doug Bardell's web site at http://www.cyberbeach.net/~dbardell/bellows.html.

To make a bellows you will need two kinds of fabrics, one for the inner lining, the other for the outer covering. For the lining you may use dull black fabric or rubberized nylon. The cover may be rubberized nylon, fabric used for lightproof curtains, or thin leather. The latter may be a more expensive option. For the ribs you will need thin card stock.

To make a bag bellows for wide-angle photography is considerably easier than making a pleated bellows (Figure 28). Bag bellows are used to facilitate camera movements when you are using wide-angle lenses. They are also useful for normal lenses if you need a lot of movements, e.g. front rise or fall. To make a bag bellows you need some light proof material, approx. 30 x 120 cm (available in some stores which sell curtains and shades and from darkroom equipment dealers), textile glue and two 3–4 mm plywood squares, 160 x 160 mm for the bellows frames.



Bag bellows

Make a paper dummy first. Cut the material as in Figure 28. A cutout, 130 x 130 mm, is made in the plywood squares. The bellows is glued to the plywood squares. The frames have to accommodate the bellows retaining locks of the front and rear frames. You may also glue two smaller squares, 140 x 140 mm with a cutout 130 x 130 mm, on the inside of the bellows to make the construction stronger. Make sure the internal of your bellows does not reflect light. You may also use thin leather for the bellows and aluminum for the bellows frames. The bellows in Figure 28 has a maximum extension of approx. 220 mm. If you need a larger bellows you just increase the dimensions.

6.3 Making a Camera Case

The camera with accessories fits easily in a standard backpack. The monorail with the tripod block and sliders attached is taken off the camera proper and packed separately. So is the lens board with lens. You should have an undrilled lens board for the front frame to keep dust away when your lens board with the lens is removed. The lens board with the lens should be packed carefully to deaden shocks. Even though it takes some space, you may decide to make a special case for the lens board (Figure 29).

A standard backpack or a bag is most practical for transporting your camera. For storing it you may make a case of aluminum profiles and 7 mm laminated flooring. An alternative to laminated flooring is plywood. My own camera case has a compartment structure of teak which fits the internal measurements of the case. The camera with standards goes into one compartment, the rail in another, accessories in a third, etc. (Figure 30).

6.4 Step-up Adapter for the 5 x 7 Format

A step-up adapter for the 5 x 7 inch format may replace the 4 x 5 inch spring back. A basic sketch is found in Figure 31. Unlike the rest of the plans in this manual, this sketch has not been tested by my own experience. I have not so far made a step-up adapter myself since I do not have a lens for this format. The basic construction, however, dates back to the 1880’s in the history of camera making. A similar step-up adapter is available today for Osaka, Nagaoka, Wista and other field cameras. I offer the sketch merely for inspiration for those who would like to try to build one. The sketch is for a tapered step-up adapter. An adapter with rectangular sides is easier to make and should work equally well. The step-up panel and film holder seat should be made to the measurements of a film holder. Since the film plane is pushed rather far back from the standards camera movements are, of course, altered.

6.5 Scaling the Plans up for an 8 x 10 Camera

The plans in this book may be scaled up for building an 8 x 10 camera. The critical measurements—the depth of film holders—are found in section 4.3 above. If you decide to build an 8 x 10 camera, you should start with the back frame. Get an 8 x 10 film holder and adapt the dimensions to the film holder. In order to reduce weight and bulk you may consider making the front frame smaller than the rear frame and have a tapered bellows instead of a square one. You may use the plans and dimensions in this book for the front frame. In fact, if you have already built a 4 x 5 camera based on the plans in this book, the front frame may be used also for an 8 x 10 camera, provided the bellows is detachable. When you have made the front and rear frames, and the spring back, you should make the standards and the optical bench. Wood may be a better choice than metal for the standards of an 8 x 10 camera. Before you make the standards you have to decide what camera movements you want. The optical bench may be built around a monorail as in this book, or you may use two rails as in Rudolf Mittelmann's design, at http://www.geocities.com/SoHo/Suite/7013/foto/index.html

For a beautiful and functional 8 x 10 camera built of teak and based on my design, and with a bellows made according to Doug Bardell's instructions, see Marcus Carlsson's camera, at
http://home.online.no/~gjon/marcus.htm.
For an 8 x 10 camera under construction, see my web pages at: http://home.online.no/~gjon/lf8x10.htm.

Lenses in shutters for 8 x 10 cameras tend to be expensive. Lenses in barrel, e.g. processing lenses which are not mounted in a shutter, are fairly inexpensive on the used market, for instance on eBay. With expose times of 1 second or more you may use a lens cap for shutter, or you may buy a reasonable Packard shutter. See my View Camera Construction FAQ at http://home.online.no/~gjon/lffaq.htm.

7 Notes on Lenses for Beginners

7.1 Covering Power of Lenses

Lenses for large format cameras have to allow for camera movements—rise and fall, shift, tilt and swing. Therefore the *circle of good definition* or *image circle*—the circular area in the image plane where the lens forms an image of acceptable definition—has to be larger than a film sheet itself. This is a major difference between lenses for large format cameras and lenses for rigid-bodied 35 mm cameras or medium format cameras.

The diagonal of a 4 x 5 in. film sheet is is approx.150 mm. If a lens has a circle of good definition with a diagonal of 210 mm, there will be a total of approx. 60 –70 mm for rise/fall or right/left shift, distributed on each side. More exactly, there will be 38 mm for rise and fall, 33 mm for lateral shift on either side when the film is the horizontal position.

The circle of good definition (lens coverage) is a crucial specification to look for when buying a lens. It should be noted that stopping down a lens usually increases the circle. Lens manufacturers typically specify the covering power of a lens with the diaphragm set at f/22. If a larger aperture is used, the covering power will decrease. A normal lens with a focal length of 150 mm will typically have an image circle of approx. 210 mm at f/22; at f/5.6 the circle may be approx. 174 mm. At f/22 the angle of view is 70 degrees, at f/5.6 only 60 degrees. Lenses with a large circle of good definition generally have more lens elements than lenses with less covering power.

7.2 Normal, Wide-Angle and Telephoto Lenses

Normal lenses have a focal length corresponding more or less to the diagonal of the film. A typical normal lens for a 4 x 5 in. camera has a focal length of 150 mm or 180 mm. 210 mm is also considered a normal lens, sometimes referred to as a long normal.

Wide-angle lenses have a focal length shorter than the film sheet diagonal. For 4 x 5 in. cameras the focal length of wide-angles may extend from 65 to 120 mm. A typical wide-angle lens would be 90 mm. To use a short wide-angle lens you may need a recessed lens board. Instead of pleated bellows a bag bellows is often used to facilitate camera movements.

A telephoto lens for a 4 x 5 in. camera typically has a focal length of 360 mm. Telephoto lenses and short wide-angle lenses are expensive.

The following table indicates how large format lenses for 4 x 5 compare to lenses for 35 mm cameras or medium format cameras.

Film	**Diagonal**	**Focal length**					
35 mm	43 mm	25	32	***43***	52	60	90
6x6 cm	80 mm	46	58	***75***	95	110	165
6x9 cm	100 mm	58	75	***100***	120	135	210
4x5 in.	150 mm	90	120	***150***	180	210	320

7.3 Buying a Lens

When you buy a lens you should plan ahead. Because lenses are expensive most people will start out with a single lens, usually a normal lens. A lens 150–210 mm is often regarded as a good choice for most general purposes. If you are planning to get a wide-angle lens later, or a telephoto lens, this should be taken into consideration when settling on a focal length for a first lens. Steve Simmons (1987) gives good advice on building a lens system for a 4 x 5 camera. A lens with a large circle of good definition, a lens allowing camera movements, should be preferred to the more inexpensive lenses with less covering power.

A new lens is expensive. Second hand lenses are available in some stores or are advertised in photo magazines. In the US, the Shutterbug magazine is often referred to as a good source. On the Internet, eBay is a good source: http://www.ebay.com/ For black and white photography an older lens may give good results. Some sources for used lenses and other equipment are listed under Addresses at the end of this book. Sources for information about lenses are listed under Internet sources.

8 Operating the Camera

One of the most readable introductions to large format photography is Steve Simmons: Using the View Camera—A Creative Guide to Large Format Photography (New York: Amphoto 1987, revised edition 1992). I recommend the book warmly. The following is only meant as a very simple guide.

8.1 Loading Film Holders

Sheet film generally comes in packages of 10, 25 or 100 sheets. The sheets are often packaged in a foil in a box within another box. Each sheet of film has a notch pattern cut into one of its corners. The notch pattern identifies the type of film and also helps you locate the emulsion side of the film in the dark. You should get familiar with the film holders before trying to load film.

Place your film holders on a table. Turn off the lights. Open the film box, then open the foil or pouch inside the box and remove the piece of cardboard from the top of the film stack. Locate the notch pattern. Your index finger should rest on the notch pattern (top right-hand corner) when the emulsion side is facing you.

Take one sheet of film in your right hand, your index finger resting on the notch pattern in the top the right-hand corner. Open the flap at the bottom end of the film holder. Slide the film sheet under the guide rails inside the holder. Close the flap when the sheet of film is inserted properly. Push the dark slide into the holder. The dark slide locks the film flap of the holder. The white side of the handle of the dark slide should face outwards. After exposure the dark slide is turned so that the black side of the handle is out. In this way you know which film sheets have been exposed and which have not. Exposure data may be written in the label area on the film holder.

8.2 Taking Pictures

1. Set up the tripod.
2. Set up the camera.
3. Open the shutter using the preview lever.
4. Focus and compose the image. Use a loupe or a magnifying glass to check sharpness. The loupe must allow for the thickness of the ground glass.
5. Calculate exposure taking bellows factor into account. You may use a separate light meter or the light meter of a SLR for measuring the light.
6. Stop down the lens.
7. Check the corners for possible vignetting. Look through the cut out corners of the ground glass. You should see the whole lens opening in the diaphragm.
8. Close the shutter.
9. Set shutter speed.

10. Cock the shutter.
11. Insert the film holder.
12. Pull out the dark slide.
13. Wait a while before exposure to let the camera come to rest to avoid vibrations.
14. Expose.
15. Reverse the dark slide, black side of handle out, and reinsert the slide.
16. Take out the film holder.
17. Write exposure data on the film holder label.

8.3 Exposure and Bellows Factor

Bellows extension may affect exposure. This is the case when the camera-to-subject distance is less than ten times the focal length of the lens. Thus, if you are using a 150 mm lens, the bellows factor has to be taken into account if the camera-to-subject distance is less than 150 cm. Increased bellows extension means that less light reaches the film plane. The mathematical formula for calculating effective f-stop in close-up work is as follows:

$$\frac{\text{f-stop x lens-to-film plane distance}}{\text{focal length of lens}}$$

In other words: Multiply the indicated f-stop by the lens-to-film plane distance and divide by the focal length of the lens.

A rule of thumb: For every 25 per cent increase in bellows length, add one half-stop of exposure. For a 50 per cent increase in bellows extension, add one stop.

8.4 Depth of Field, Hyperfocal Distance, Circle of Confusion, and Depth of Focus

Depth of field is the amount of subject depth measured toward and away from the camera lens that appears acceptably sharp in the image.

The hyperfocal distance is the focusing distance that gives the most depth of field for a given f-number setting. In other words: the point (or plane) you focus at in order to achieve a depth of field that extends to infinity. The focusing point or plane is called the principal point of focus in theoretical discussions of the optics of depth of field. When focusing at the hyperfocal distance, everything from half that distance to infinity will be sharp in the image. Thus if the hyperfocal distance is 8 m, everything from 4 m on will appear sharp in the image.

Hyperfocal distance may also be explained as follows: When a lens is focused on infinity, the depth of field extends from infinity to a point nearer the camera. The distance from the camera to this near limit of the sharp field is called the hyperfocal distance. If the lens is focused on the hyperfocal distance, the depth of field extends from half the hyperfocal distance to infinity.

The formula for calculating hyperfocal distance is:

$$H = \frac{F \times F}{f \times d}$$

Key:
H = hyperfocal distance
F = lens focal length
f = lens f-number
d = diameter of circle of confusion

The circle of confusion, sometimes called the circle of least confusion, is a circle so small that it is no longer perceived as a circle but as a point by the human at eye at an average viewing distance. If an image of a point is a circle larger than the circle of confusion, the image will be seen as out of focus and blurry. If the image of the point is smaller than the circle of confusion, the image is perceived as being in focus and sharp. The diameter of the circle of confusion is an important factor in the perception of basic image sharpness. Note that the diameter of least confusion depends on the degree of enlargement of the negative. A negative made for large enlargements requires a smaller circle of confusion than a negative made for smaller enlargements or for contact printing. In a normal *print* viewed at an average distance the circle of confusion is often taken to be 0.3 or 0.25 mm. In smaller *film* formats the circle of confusion will be smaller to allow for enlargement.

For our purposes here the diameter of the circle of confusion for film size 4 x 5 in. is taken to be 0.15 mm. (For critical work the diameter may be set at 0.09 mm. For film size 6 x 6 cm or 2 ¼ x 2 ¼ in. the circle of confusion is often stipulated at 0.075 mm. For 35 mm the circle of confusion is often set at 0.03 mm.)

Depth of *field* extends on either side of the principal plane of focus. Depth of *focus* similarly extends before and behind the film plane. In other words, depth of focus is the area where the film plane my be placed and still produce an image of acceptable sharpness. It is, so to speak, the focusing latitude seen from the point of view of the film. The formula for determining depth of focus is:

DFoc = EA x d x 2

Key:
Dfoc = depth of focus
EA = effective aperture
d = diameter of circle of confusion

Example:
If the effective aperture is 22 and the diameter of the circle of confusion is 0.15 mm, depth of focus is 22 x 0.15 mm x 2 = 6.6 mm. In other words 3.3 mm on either side of the the film plane.

If you have little bellows extension, effective aperture will be roughly identical with the f-stop. (The f-stop is the aperture when the focusing distance is set at infinity.) If your subject requires considerable bellows extension, effective aperture will differ from the f-numbering. If the lens-to-subject distance is more than ten times the focal length of the lens, you do not have to worry about effective aperture. You may take the effective aperture to be identical to the numerical aperture (f-stop). If subject-to-lens distance is less than ten times the focal length of your lens, you should take effective aperture into consideration. The formula for calculating effective aperture is:

$$EA = \frac{v}{da}$$

Key:
EA = effective aperture
v = lens-to-film distance
da = diameter of the lens aperture

The diameter of the lens aperture is the focal length of the lens divided by the f-stop. If your 150 mm lens is set at f/22, the diameter of the lens aperture is 7.22 mm.

Example:

If the lens-to-image distance is 220 mm and the diameter of the lens aperture is 7.22 mm (f-stop 22), effective aperture is approximately 30.5.
When the hyperfocal distance is known, the near and far limits of depth of field can be calculated. The formula for calculating the near limit of depth of field:

$$NL = \frac{H \times u}{H + (u - F)}$$

Key:
NL = near limit of depth of field
H = hyperfocal distance
u = lens-to-subject distance (principal plane of focus)
F = lens focal length

The formula for calculating the far limit of depth of field is:

$$FL = \frac{H \times u}{H - (u - F)}$$

Key:
FL = Far limit of depth of field
H = hyperfocal distance
u = lens-to-subject distance (principal plane of focus)
F = lens focal length

A pocket calculator is useful when doing these calculations. There are also computer programs (freeware or shareware) available. See Addresses at the end of this guide.

8.4.1 Depth of Field and Hyperfocal Distance

The formulas listed here may look rather daunting to the beginner. They are included partly as background for the following table showing depth of field and hyperfocal distance.

The table gives a survey of hyperfocal distances for various lenses for 4 x 5 in. cameras, set at various f-stops. Near limits of depth of field in unenclosed numbers. Hyperfocal distances in parentheses. Figures are rounded off. Circle of confusion is 0.15 mm.

Focal Length	**f/4**	**f/5.6**	**f/8**	**f/11**
65 mm	3.5 m (7 m)	2.5 m (5 m)	1.75 m (3.5 m)	1.3 m (2.6 m)
90 mm	6.75 (13.5)	4.8 (9.6)	3.4 (6.75)	2.5 (4.9)
105 mm	9.2 (18.4)	6.5 (13.1)	4.6 (9.2)	3.4 (6.7)
120 mm	12 (24)	8.6 (17.1)	6 (12)	4.4 (8.7)
135 mm	15 (30)	10.8 (21.6)	7.6 (15.2)	5.5 (11)
150 mm		13.4 (26.8)	9.4 (18.75)	6.8 (13.6
165 mm		16.2 (32.4)	11.4 (22.7)	8.3 (16.5)
210 mm				13.5 (27)

Focal Length	**f/16**	**f/22**	**f/32**	**f/45**
65 mm	09 m (1.8 m)	0.65 m (1.3 m)	0.44 m (0.88 m)	0.31 m (0.625)
90 mm	1.7 (3.4)	1.25 (2.5)	0.85 (1.7)	0.6 (1.2)
105 mm	2.3 (4.6)	1.6 (3.3)	1.2 (2.3)	0.8 (1.6)
120 mm	3 (6)	2.2 (4.4)	1.5 (3)	1 (2.1)
135 mm	3.8 (7.6)	2.8 (5.5)	1.9 (3.8)	1.4 (2.7)
150 mm	4.7 (9.4)	3.4 (6.8)	2.4 (4.7)	1.65 (3.3)
165 mm	5.7 (11.3)	4.2 (8.25)	2.9 (5.7)	2 (4)
210 mm	9.2 (18.4)	6.5 (13.4)	4.6 (9.2)	3.3 (6.5)
300 mm		13.5 (27.3)	9.4 (18.8)	6.5 (13.3)

8.5 Camera Movements

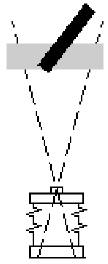
One of the great benefits of large format cameras is camera movements. Camera movements make it possible to control perspective, depth of field and image area.

In discussions of camera movements one has to distinguish between (a) film plane, (b) lens plane, and (c) subject plane (plane of focus). As long as the subject plane and the film plane are parallel, perspective is not changed. Swinging or tilting the lens plane changes the subject plane but has no effect on perspective. Swinging or tilting the film plane alters perspective. Swinging or tilting both lens plane and film plane alters perspective.

In short:
1 Swinging or tilting the front frame changes depth of field but does not alter perspective.
2 Swinging or tilting the back frame changes both perspective and depth of field.
3 Vertical and parallel lines in the subject (e.g. building, trees) are rendered parallel if the film plane is parallel to the subject.

No movements

Large format lenses have long focal lengths and thus limited depth of field. A large format camera used without any movements produces images with unaltered perspective and limited depth of field. Subject plane and film plane are parallel.



Rise and fall

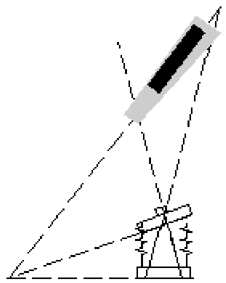
Raising or lowering the front frame affects the image field (the part of the subject covered by the film) but does not change perspective or depth of field. Subject plane and film plane are parallel. Typical situation (front rise): photographing a tall building or a mountain.

Shift

Shifting the front or rear frame is the horizontal equivalent of rise and fall. Shift (lateral movements) does not change perspective or depth of field but affects the image field. Shift centers the subject when we are not standing in front of the subject.

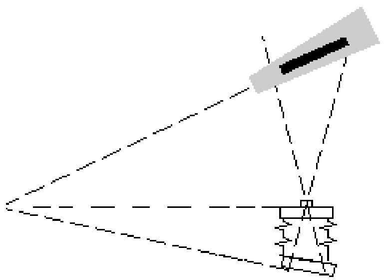
Front swing or tilt

Swinging or tilting the lens plane alters subject plane but does not change perspective.



Back swing or tilt

Swinging or tilting the film plane alters perspective and changes the subject plane.



Summary

Rise/fall and shift are used to center a tall or elongated subject. Front tilt or swing is used to control the subject plane to increase depth of field. Back swing or tilt is used to alter the perspective or the proportions of the subject.

To render vertical and parallel lines (e.g. a building) as vertical and parallel the film plane has to be vertical.

If the subject plane, lens plane and film plane are parallel, the focal plane will coincide with the subject plane.

If the subject plane is not parallel with the film plane, tilting or swinging the lens plane may have the focal plane coincide with the subject plane.

The Scheimpflug Rule

The principles behind camera movements and depth of field are summarized in the Scheimpflug rule (named after Theodor Scheimpflug, an Austrian army captain with an interest in photogrammetry). The rule states that a subject will be rendered with the greatest sharpness when the extended lines drawn from the subject plane, the film plane and the lens plane all meet (intersect) at one point. (See the above figures.)

8.6 Developing Sheet Film

Color film (positive or negative) should be processed by a lab. You give the lab the film in a light proof box. Ask the lab to give you the box back. Light proof boxes are useful.

You may process your black and white film yourself – in a tank, a drum or in trays. I suggest you start with trays.

Develop only one or two sheets at a time until you get some experience. With practice you may process six 4 x 5 in. sheets at a time. For 4 x 5 in. film use 8 x 10 in. trays. Use gloves to avoid skin contact with the chemicals.

Lay out three trays—one for the developer, one for the stop bath, one for the fixer. In addition you need one pre-soak tray for each sheet of film. Put the sheets in the pre-soak trays with the emulsion side up to make sure there are no bubbles on the film's surface.

When you move the sheet of film into the developer, the emulsion side should be down. As you put each sheet of film in the developer, it should be swished back and forth to avoid air bubbles sticking to the emulsion. Slide another sheet of film into the developer tray and repeat the same procedure. Be careful so you do not scratch the emulsion. The same procedure is repeated for a third sheet of film, if you are developing that many sheets at a time.

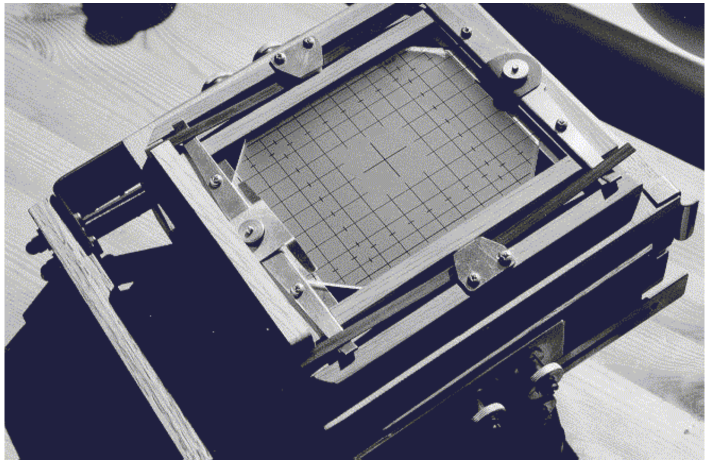
You agitate the film sheets by taking the bottom sheet, freeing it from the pile and placing it on top of the stack. This is a slow and continuous process. You should turn the entire stack four times every minute. You should also rotate the stack 90 degrees every two minutes so that the film is pulled in different directions.

When the timer buzzes, you move the film, sheet by sheet, into the stop bath. Swish the sheets gently so that the entire emulsion quickly comes into contact with the acetic acid. Agitate the stack of film the same way as you did during development. The film sheets are then moved into the fixer and agitated. When the fixing time is up, you turn on the lights.

The sheets may be washed in a tray of running water and are then given a rinse in a very weak dilution of a wetting agent (Photo-Flo or other). You then hang the negatives to dry in a dust-free place. The developer and stop bath are normally dumped. The fixer can be used again.

Film sheets may also be processed in a drum, e.g. Jobo Multitank 2521. For tank development, see Steve Simmons 1987.

Addendum: A more elaborate ground glass frame



The ground glass frame in the first edition of my book *Building a Large Format Camera* (1996) is fairly simple (see above 4.3 and Figures 18 and 19). The following is my most recent design of a ground glass frame. Both designs work well. My latest design, however, is more elegant and makes it easy to add or remove a fresnel lens in the field. This ground glass frame is thinner than in my first design (approx. 10–11 mm).

Figure I (top right): The ground glass frame is made of 4 mm birch plywood and a frame of 5 or 6 mm hardwood strip. The external dimensions of the ground glass frame are approx. 120 x 160 mm. A rectangular window (cutout) is made in the piece of plywood (approx. 101 x 121 mm). The width of the window should be the same as the width of the ground glass.

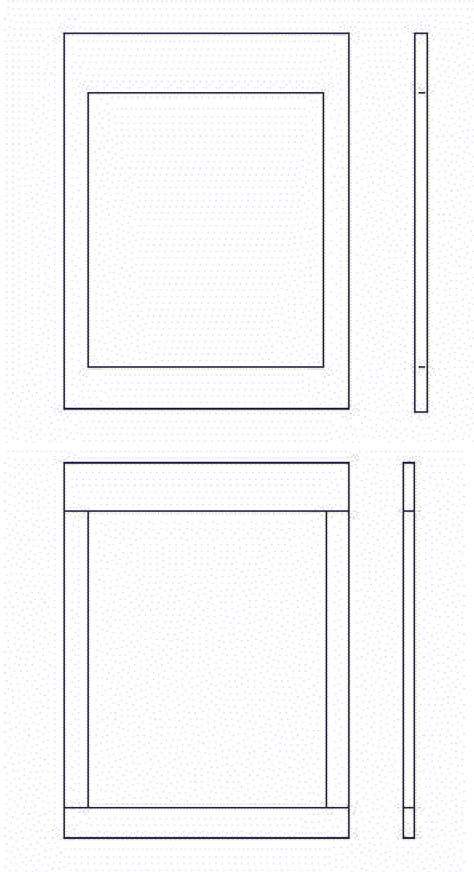


Figure II (above): Pieces of 5 or 6 mm hardwood strip are cut to form a frame which is glued on top of the birch plywood. The top piece is about 20 mm wide and the bottom piece13 mm wide. When they are glued to the plywood there will be a 5 mm ledge for the ground glass.

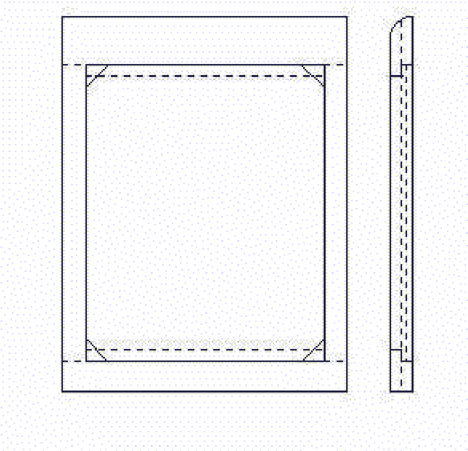
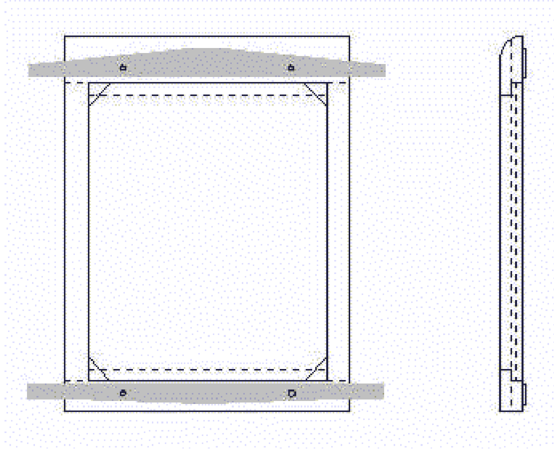


Figure III (above): When the ground glass eventually is installed two pieces of 0.8 mm brass shim are placed between the birch plywood and the ground glass so that the focusing surface of the ground glass is 4.8 mm from the bottom surface of the ground glass frame. The ANSI standard has a plus minus tolerance of 0.18 mm. Use a pair of Vernier calipers or a micrometer to check the measurements.

Figure IV (top right): The grey strips in the figure are made from 1.5 or 2 mm brass. The strips will eventually go under the leaf springs which keep the ground glass frame in place in the film holder seat. Three holes are drilled in the brass strips, two for the screws attaching the strips to the ground glass holder, the third in the middle for the retaining mechanism which holds the ground glass in place.



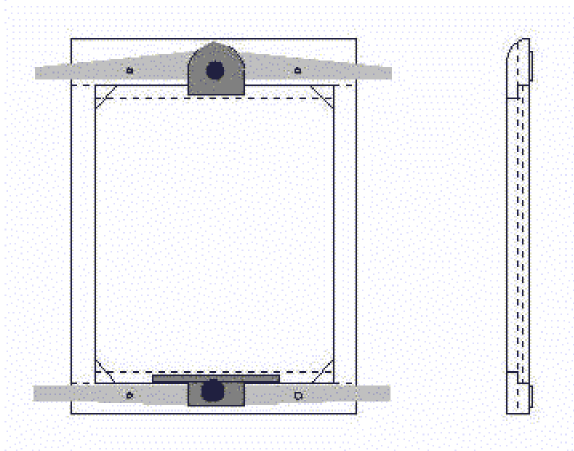


Figure V (above): The mechanism which holds the ground glass in place is made of 1 mm brass. (See Figure VI.) A hole is drilled in both pieces. There will be a screw from underneath the ground glass frame which goes through the hole. A thumb nut, the black disk in the drawing, is used for fastening.

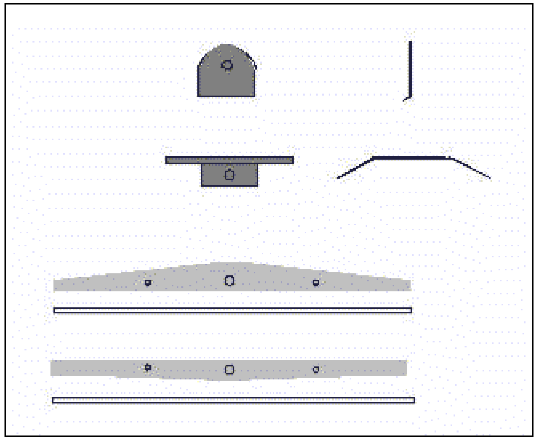


Figure VI : The drawing shows the pieces of brass from above and in profile. The bottom piece is bent to form a spring which exerts a certain pressure on the ground glass. The top piece is bent about 60–70 degrees.

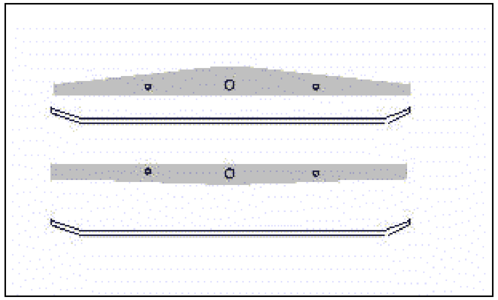


Figure VII: The ends of the brass strips are bent upwards to keep the leaf spring in place.

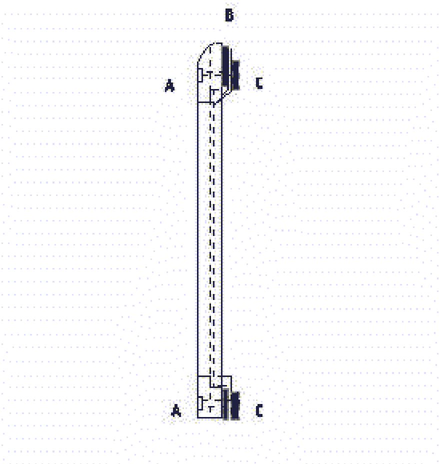


Figure VIII: The brass strips (B) and the ground glass retaining mechanism are held in place by screws (A) from underneath the ground glass frame. Knurled nuts (thumb nuts) (C) are used for fastening.

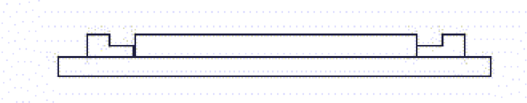
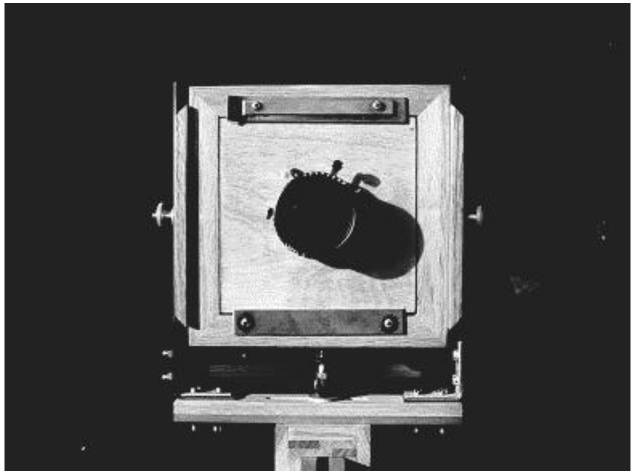
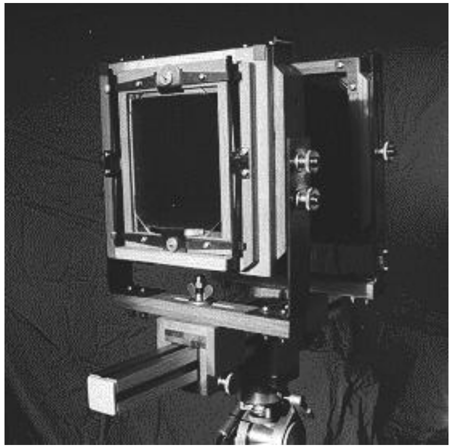


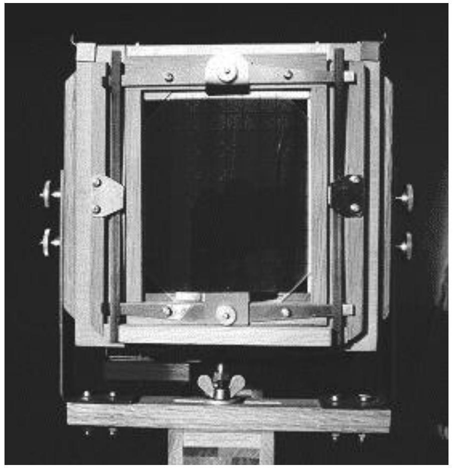
Figure IX: Top view of the camera back with film holder seat and ground glass frame. Leaf springs and retainers for leaf springs not shown. The film holder seat may be made of 6 x 20 mm hardwood strip with 6 x 10 mm hardwood strip glued on top to form a rabbet approx. 6 x 10 mm for the leaf springs.

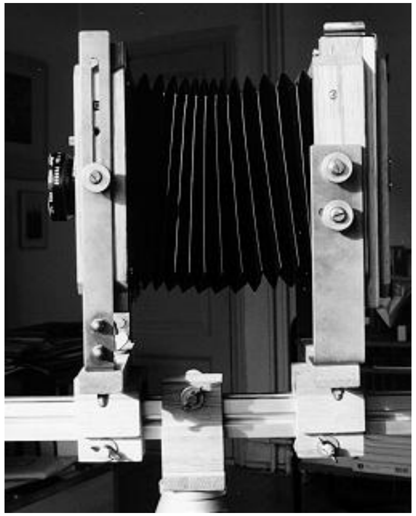
Pictures of the Camera

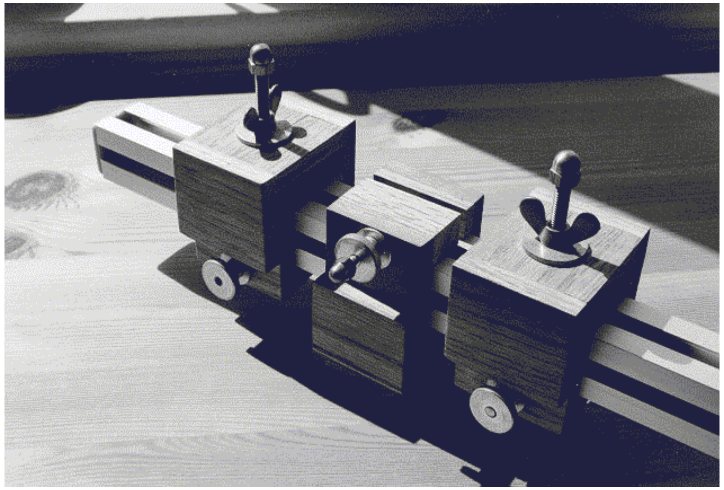


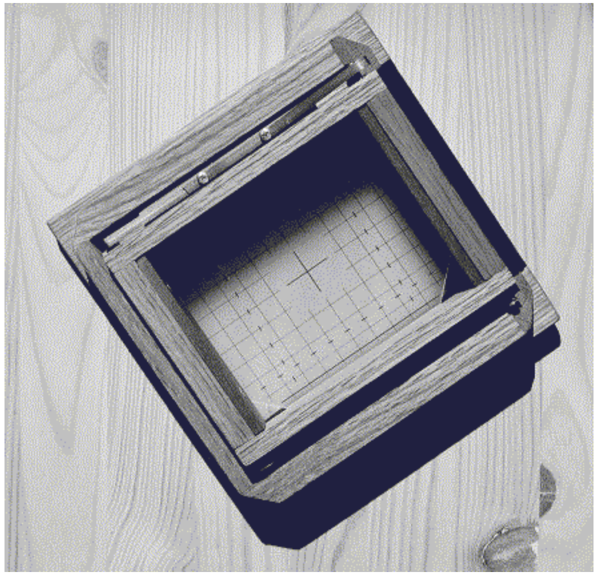


Front, rear and side view of the camera.

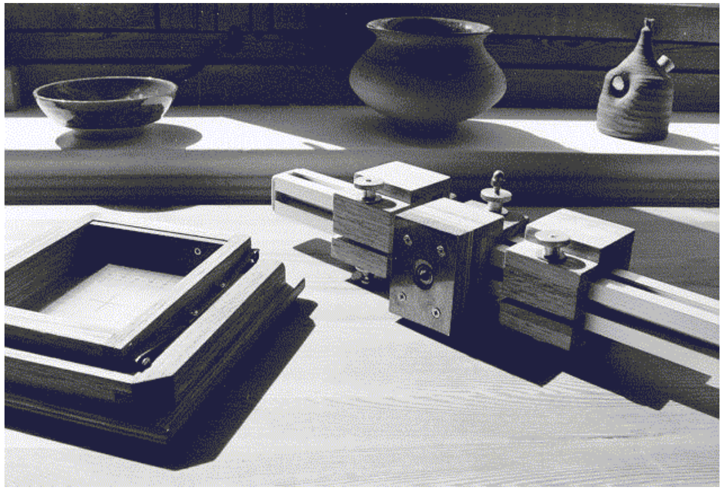


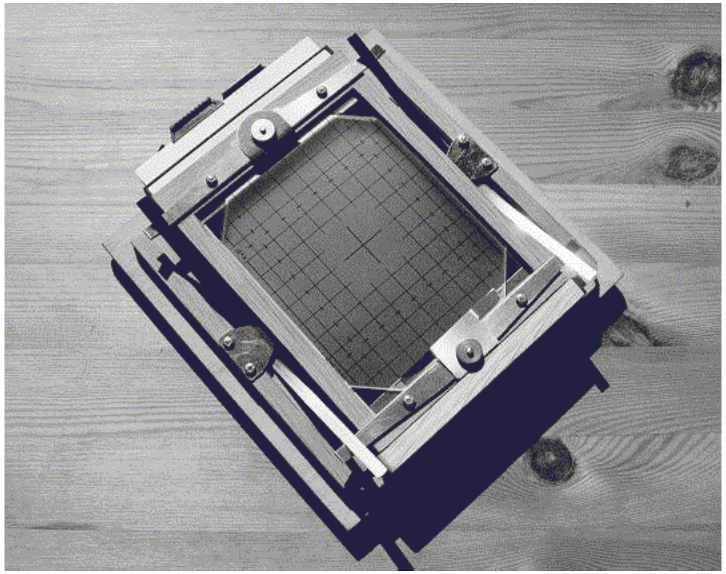


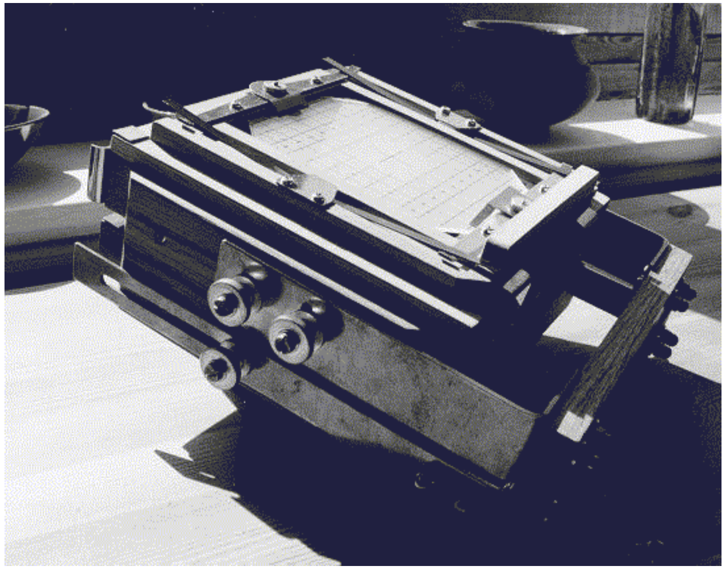




The optical bench viewed from above and from below.
Right: The two ground glass frame designs. In the second picture a film holder is inserted in the spring back.







Left: The camera folded is about 25 x 25 x 10 cm.

Below: A picture of the back of my 4 x 5 in. camera. A blue towel served as a focusing cloth on this hot summer day in the western part of Norway. A loupe case resting on the monorail. The picture was taken while I was testing a new springback.

Larger versions of these pictures are found at my web site: http://home.online.no/~gjon/jgcam.htm.

Literature and References

Adams, Ansel. *The Camera.* 11th printing. Boston–Toronto–London: Little, Brown and Company, 1991. 210 pages. ISBN 0-8212-1092-0.

Alt, Patrick. "Refurbishing View Cameras." *View Camera*, March/April 1995. Sacrameento, CA.

Altenbernd, Nicholas. "Budget Large Format. A Do-It-Yourself Enlarger Project." *Camera and Darkroom*, January 1993, pp. 12–16. N. Hollywood, CA. (Enlarger back for 4 x 5 Bender camera.)

Blaker, Alfred A. "Applied Depth of Field". *Camera and Darkroom Photography,* March–September 1991. N. Hollywood, CA.

Camera Making. Elstree, Herts: Oldtimer Cameras Ltd., 1996. 226 pages. (*Amateur Photographer* Articles on camera and bellows making 1887–1995.) Oldtimer Cameras Ltd., P. O. Box 28, Elstree, Herts WD6 4SY, England.

Davis, Dennis. "Wooden Cameras from the United Kingdom." *View Camera*, May–June 1991, pp. 53–58. Sacrameento, CA. (The Lisjon camera kit (no longer availbale), the Nesbitt and Walker cameras.)

Englander, Joe. "ReadyLoad, QuickLoad, Shoot. A Comparison of 4x5 Film Holders." *Camera and Darkroom*, April 1995, pp. 52–57. (Comparison of film holder depths.)

Fader Photo Works. *Porta Vu II. 4 x 5 View Camera Kit. Assembly Instructions*. Ann Arbor, Mich: Fader Photo Works, n.d. 8 pp.

Foto for alle. Populær Mekanik, 1, 1951. København (Copenhagen): Forlaget P.M., 1951. 96 pages.

Fuller, Tom. "Five–Seven. The forgotten format revisited." *Camera and Darkroom* , January 1994, pp. 52–58. N. Hollywood, CA. (Information on 5x7 step-up adapter for 4x5 field cameras.)

Fuller, Tom. "The Bender 4x5 View Camera Kit." *Camera and Darkroom Photography*, June 1991, pp. 25–27. Beverly Hills, CA.

Gutierrez, Al. "Build a View Camera." *Popular Science Do-It-Yourself Yearbook 1992*. pp. 111–118. ISBN 0-696-11111-X.

Hasluck, Paul N. *The Book of Photography—Practical, Theoretic and Applied*. London–Paris–New York & Melbourne: Cassell And Company, 1907. (The chapter "Miscellaneous Items" has instructions for making square and tapered bellows.)

Helm, Peter. *Selbstbau einer Grossformat-Fachkamera*. Titz-Gevelsdorf: Verlag Peter Helm, 1989. 6th edition. 84 pages. ISBN 3-88673-000-X. (Instructions for making a simple monorail camera of metal.)

Håkansson, Patrik and Lundell, Kurt. "Bygg din egen storformatskamera." *Aktuell fotografi* 7–8, 1988, pp. 64–68.

Stockholm 1988. Also see correction in *Aktuell fotografi* 9, 1988.

Höglund, Arne. "Förstorad förstoringsapparat." *Foto*, July–August 1987, pp. 68–69. Stockholm 1987. (Sketches for a DIY 4 x 5 inch enlarger.)

Johnson, Evan P. "A Brake for Your Dolly." *Photography Handbook*. A Fawcett Book 106. Greenwich, CT: Fawcett Publications, 1950. pp. 90–91, 138. (Plans for a wooden tripod dolly with brakes.)

Layton, John. "Designing and building your own camera," *View Camera*, March–April 1995, pp. 38–44. Sacramento, CA.

Layton, John. "Build your own 4 x 5 field-view camera," *View Camera*, November–December 1996, pp.48–56. Sacrameento, CA.

Michelsen, Jim. "Stabilt fotostativ." *Teknikk og hobby*, okt. 1955. pp. 74–75. Oslo: Nasjonalforlaget 1955. (Plans for wooden tripod.)

Mönks, Thomas. *Grossformatkamera selbst gebaut*. Stuttgart: Lindemanns Verlag, 1991. (Third edition)

Newlands, Gerald. "Think Big. A do-it-yourself slide-copier project." *Camera and Darkroom*, June 1993, pp. 14–15. N. Hollywood, CA.

Ott, Joseph. "Universal Enlarger." *Popular Mechanics.* Chicago: Popular Mechanics Company, 1942. pp. 118–121.

Partridge, Graham. *5 x 4 Camera*. Henly-on-Thames 1992. 35 pages. (Plans for a rigid baseboard, non-collapsible, flatbed camera. Also plans for a tapered bellows.)

Photography with large format cameras. Kodak Publication O–18. Rochester: Eastman Kodak Company, 1988. 96 pages. ISBN 0-87985-476-6.

Rittsel, Pär. "Ett välpussat bygge för stora bilder." *Foto*, October 1980, pp. 20–21. Stockholm, 1980. (About the Lester Fader camera kit.)

Robinson, Mike. "How to build a camera bellows." *View Camera*, July–August 1996, pp.52–54. Sacrameento, CA.

Romney, Edward H. *Bellows Making Text*. Drayton, SC, 1977 and 1990. 14 pages.

Romney, Ed and James Tannehill. *Build a view camera*. 23 pages. Drayton, SC, 1979. ISBN 1-886996-63-6. (Plans for easily built 2 x 3 metal view camera, expandable to 4 x 5.

Romney, Ed. *Build a wooden plate camera*. 15 pages. Drayton, SC, 1995. (Reprint of anonymous encyclopedia article. 73 scale drawings of a typical 3x4 or 4x5 camera such as Sinclair Una, Cycle Graphic or Century.)

Spreadbury, S. "Into View. A Home-Made 4 x 5in Camera." *Amateur Photographer*, 13 March 1982. pp. 127–128.

Simmons, Steve. *Using the View Camera*. 2nd edition. New York: Amphoto, 1987. 144 pages. ISBN 0-8174-6347-X.

Revised edition 1992. (Excellent introduction to large format photography.)

Sittenauer, Herbert. "Alptraum Grossformat." *Fotomagazin* 4/94. pp. 74-76.

Smith, Arthur H. "Spring Back for your Camera." *Photography Handbook*. A Fawcett Book 106. Greenwich, CT: Fawcett Publications, 1950. pp. 101–103.

Stone, Jim. *A User's Guide to the View Camera*. Boston: Little Brown and Company, 1987. 192 pages.

Stroebel, Leslie D. *View Camera Technique*. 5th edition. New York–Boston–London: Focal Press 1986. 310 pages. ISBN 0-240-51711-3. 6th edtion 1993, 320 pages. ISBN: 0-240-80158X . (The classic reference work on large format photography.)

Stroebel, Leslie D. *View Camera Basics*. Boston–Oxford–Melbourne: Focal Press, 1995. 162 pages. ISBN 0-240-80220-9.

Tomosy, Thomas. *Restoring Classic & Collectible Cameras*. Buffalo, NY: Amherst Media, 1998. 176 pages. ISBN 0-936262-59-1. (Instructions on bellows making etc.)

Wernersson, Mats. "Vi bygger en storformatskamera for 2 200 kr." *Foto*, 11/1996, pp. 58–59. Helsingborg, 1996. (About the Bender kit.)

West, Bert. *Build your own view camera*. Highland Park, IL: Dogstar Publishing, 1995. 112 pages. ISBN 1-886757-07-0. (Useful instructions for making pleated bellows.)

"Wooden Camera Wrap-up." *View Camera*, November–December 1994, pp. 32–37. Sacrameento, CA. (Round table discussion with leading US wooden field camera manufacturers.)

Zeichner, Robert A. "How to Align your Ground Glass." *View Camera*, November–December 1996. pp 57–59. Sacrameento, CA.

Internet sources:

Archive of the International Society of Handbuilt Cameras. http://www.mail-archive.com/cameramakers@ilist.net/

Bardell, Doug. Field Cameras. http://www.cyberbeach.net/~dbardell/

Bardell, Doug. How to make bellows. http://www.cyberbeach.net/~dbardell/

eBay: http://www.ebay.com/
Online auction site. (Used lenses, cameras, camera parts, bellows etc.)

Grepstad, Jon. View Camera Construction FAQ. http://home.online.no/~gjon/

Grepstad, Jon. Depth of Field and Other Technical Information. http://home.online.no/~gjon/

Grepstad, Jon. Photographic Lenses—Some Books, Articles and Online Information. http://home.online.no/~gjon/

Gudzinowicz, Michael. Large-Format Lens Specifications. http://www.graflex.org/lenses/lens-spec.html

International Society of Handbuilt Cameras. http://www.cnsp.com/mdesign/handbuil.htm

Micro-Tools, http://www.micro-tools.com/
Camera repair/restoration tools, vernier calipers, micrometers etc.

Mittelmann, Rudolf. Large Format Photography. (Plans). http://www.geocities.com/SoHo/Suite/7013/foto/index.html

Mottweiler, Kurt. Bellows Design. http://www.cnsp.com/mdesign/links.htm

Quang-Tuan Luong. Large Format Photography. http://www.cs.berkeley.edu/~qtluong/photography/lf/index.html

Technical Books on Photography by Harald M. Merklinger. http://Fox.nstn.ca:80/~hmmerk/ (Articles, diagrams and .mov-files about depth of field, the Scheimpflug rule, and the "Hinge rule".)

Vail, James. View Camera Construction Plans. http://www.srv.net/~vail/

History of Camera Design – Some Sources

Coe, Brian. *Cameras. From Daguerrotypes to Instant Pictures*. Gothenburg: Nordbok, 1978. 240 pages. (One of the best sources on the subject.)

Gernsheim, Helmut and Alison. *The History of Photography from the Camera Obscura to the Beginning of the Modern Era*. New York: McGraw-Hill,1969. 599 pages.

Lothrop, Eaton S. *A Century of Cameras from the Collection of the International Museum of Photography at George Eastman House.* Dobbs Ferry, New York: Morgan & Morgan, 1973. 150 pages. ISBN 0-87100-044-x.

Pizzighelli, G. *Anleitung zur Photographie für Anfänger*. Druck und Verlag von Wilhelm Knapp, 1887. Facsimile Lindemanns Verlag, Stuttgart 1992. 160 pages. ISBN 3-928126-40-7.

Smith, R.C. *Antique Cameras*. London and Vancouver: David & Charles 1975.

Stroebel, Leslie D. *View Camera Technique*. 5th edition. New York–Boston–London: Focal Press, 1986. 310 pages. ISBN 0-240-51711-3.

Talén, C.W. *Amatørfotografen*. Kristiania (Oslo): Steen'ske Bogtrykkeri og Forlag, 1901. (Third edition). 282 pages.

Willsberger, Johann. *Fotofaszination—Kameras, Bilder, Fotografen*. Bertelsmann Lexikon-Verlag: Gütersloh–Berlin–München–Wien, 1975. Danish edition. Kamerakavalkade gennem 150 år. ISBN 87-15-08232-6.

Addresses (US, UK and Scandinavian)

American Science & Surplus, 3605 Howard Street, Skokie, IL 60076. Phone (708) 982-0870. Fax (800) 934-0722. (Ground glass and other items. Mail order.)

Andrews Cameras, 16 Broad Street, Teddington, Middlesex, TW11 8RF, United Kingdom.
Phone (0181) 977 1064. Fax (0181) 977 4716. (Used lenses and other equipment.)

Beattie Systems, Inc., 2407 Guthrie Ave., Cleveland, TN 37311. Phone 800-251-6333 or 423-479-8566.
http://www.beattiesystems.com/index.html
(Beattie intenscreens.)

Bender Photographic, 19691D Beaver Valley Road, Leavenworth, WA 98826. Phone (800)776-3199 or (509)763-2626. Fax (509)763-1043.
http://www.benderphoto.com/ (The Bender kit.)

W.M. Berg, 499 Ocean Avenue, East Rockaway, NY 11518. Phone (516) 596 1700. Fax (516) 599 3274.
http://www.wmberg.com/ (Thumbs screws, knurled thumb nuts, threaded inserts, gears etc. B 97 is their master catalog. M 92 a catalog of metric parts and components.)

Calumet Photographic, 890 Supreme Dr., Bensenville, IL 60106. Phone 1-800-225-8638 (1-800-CALUMET).
http://www.calumetphoto.com/ (Standard Cambo bellows.)

Camera Bellows Ltd., Unit 3-5, St Pauls Road, Balsall Heath, Birmingham B12 8NG, United Kingdom. Phone (0121) 440 1695. Fax (0121) 440 0972. (Custom made bellows.)

Darkroom Aids Co., 3449 N. Lincoln Ave., Chicago, IL 60657. Phone (312) 248-4301.(Bellows cloth.)

Edmund Scientific, 101 East Gloucester Pike, Barrington, NJ 08007-1380. Phone (609) 573-6879. Fax (609) 573-1379 (orders). International Department: Phone (609) 573-6879. Fax (609) 573-6882. http://www.edmundscientific.com/
(Annual Refence Catalog, Hobbyist Edition, and Industrial/Educational Catalog.)

Galupki, Jürgen. Schärfentiefe. A Quick Basic depth-of-field calculator for MS-DOS. German text. Foto online
http://www.fotoline.ch/wissen/formtab/s-tiefe.htm

S.K. Grimes, 153 Hamlet Ave., P.O. Box 1724, Woonsocket, RI 02895. http://www.skgrimes.com/
Email: skgrimes@skgrimes.com. Phone 401-762-0857. Fax 401-762-0847. (Services for large format photographers, mounting of barrel lenses in shutters, cleaning of shutters, new shutters, adapters etc.).

Kozik Cameratechniek, Oude Sluis 6, 3111 Pk Schiedam, The Netherlands. Phone (010) 4703661. Fax (010) 4703661 (The Kozik kit, custom made bellows, used lenses.)

Oldtimer Cameras Ltd., P. O. Box 28, Elstree, Herts WD6 4SY, England. Phone (0181) 953 5479 or 953 2263. Fax (0181) 905 1705. Email: oldtimercameras@mcmail.com

Graham Partridge, 28 Bradley Road, Nuffield, Henley-on-Thames RG9 5SG. Phone (0491) 641155.
(Plans for 4 x 5 rigid baseboard camera.)

Photo-Graphic Systems, 412 Central S.E. Alburquerque, NM 87102. Phone (505) 247-9780. Fax (505) 243-4407.
http://www.pgsys.com/ (Used lenses and other equipment.)

Prokom ab, P.O. Box 430, 35106 Växjö, Sweden. Phone (070) 730 55 00. (Used lens and other equipment.)

Romney Publishing, P. O. Box 487, Drayton SC 29333. Phone (864) 597 1882. http://www.edromney.com/ (Bellows making text, plans for 2 x 3 metal camera, etc.)

Jonathan M. Sachs, 12 Ash Street, Cambridge, MA 02138. (Depth of field, a freeware depth of field calculator for Windows.) http://www.dl-c.com/dl.html

Schönherrs foto, Upplandsgatan 16, P.O. Box 45126, 10430 Stockholm, Sweden. Phone (08) 32 76 47. http://www.schoenherrsfoto.se/ (Used lenses.)

Shutterbug, Patch Publishing, 5211 S. Washington Ave., Titusville, FL 32780. http://www.shutterbug.net/ (Magazine, ads for second hand lenses etc.)

Stephen Shuart – "Large Format Specialist", PO Box 419, Kane, PA 16735-0419, Phone (814) 837-7786. Fax (814) 837-2248. E-mail: shuart@penn.com.
http://www.stephenshuart.com/
(Ground glass, used lenses and camera parts.)

M.R. Warner & Son Ltd., 22-26 Chapel Ash, Wolverhampton, W. Midlands WV3 OTS, United Kingdom. Phone (01902) 455255. (Used lenses and other equipment.)

Tandy Leather Company, P.O. Box 791, Fort Worth, TX 76101. http://www.tandyleather.com/index.html
(Leather for bellows. Have stores in most states in the US.)

View Camera, Steve Simmons Inc. , 1400 S St., Sacramento, CA 95814. E-mail: largformat@aol.com http://www.viewcamera.com/ (Magazine)

Western Bellows Company, 9340 7th St., Suite G, Rancho Cucamonga, CA 91730-5664. Phone (909) 980-0606.

Large Format Cameras and Lenses (US addresses mainly)

Arca Swiss Inc.: 442 W. Belden Street,
Chicago, IL 60614-3816. Phone: 773 248-2513.
Fax 773 248-2774 (Arca-Swiss, Phototechnik AG, CH-8810 Horegn, Switzerland. Phone (1) 725 61 60. Fax (1) 725 64 37.)

Ballester: Manufacturas Ballester, Monaco No. 291, Col. Zacahuitzco, Mexico 03550 D.F.
Phone (011) 525-674-4929. Fax (011) 525-672-2499.

Caltar: Calumet Photographic, 890 Supreme Dr., Bensenville, IL 60106. Phone: 1-800-225-8638 (1-800-CALUMET).

Cambo: Calumet Photographic, 890 Supreme Dr., Bensenville, IL 60106. Phone: 1-800-225-8638 (1-800-CALUMET). Or: Cambo Fotografische Industrie B.V., Postbus 200, 8260 AE Kampen, The Netherlands. Phone: (038) 3314644. Fax: (038) 3315110.

Canham Large-Format Cameras: 2038 E. Downing, Mesa, AZ 85213. Phone (602) 964-8624.

Ebony: Ebony Co., Ltd., Shin Oyama Building 1st Fl., 38-12 Oyama Kanai-cho, Itabashi-ku, Tokyo 173, Japan, Phone: +81-3-39723170. Fax: +81-3-59953738. E-mail: hiromi@ebonycamera.com. Or: Robert White, Unit 4 Alder Hills Industrial Estate, 16 Alder Hills, Poole, Dorset BH12 4AR, Phone: +44 1202 723046. Fax +44 1202 737428. E-mail: sales@robertwhite.co.uk

Fatif: Fatif S.r.l., Via Maniago, 12 - 20134 Milano, Italy. Phone +(39) (0)2-2157843. Fax +(39) (0)2-2153151

Gandolfi Ltd.: 24 Focus 303, South Way, Andover, Hants SP10 5 NY, United Kingdom. Phone (0264) 35 78 59.

Gowland: Peter Gowland, 609 Hightree Road, Santa Monica, CA 90402. Phone (310) 454-7867.

GranView: 2050 Executive Drive, Palm Springs, CA 92262. Phone (760) 323-9575. Fax (760) 323-9644

Hoffman Camera Corp.: 19 Grand Ave., Farmingdale, NY 11735. Phone (516) 694-4470.

Horseman Creative: P.O. Box 440028, St. Louis, MO 63144. Phone (800) 501-6866. Fax (800) 501-6867.

Inka: Inka Instruments Factory, Kampen b.v., P.O. Box 52, 8260 AB Kampen, The Netherlands. Phone (5202) 11932. Fax (5202) 260478.

Kirby Camera: Rayment Kirby, Coggers Farm, Horam, Heathfield, East Sussex TN21 OLF, United Kingdom. Phone (04353) 2148.

Kozik: Kozik Cameratechniek, Oude Sluis 6, 3111 Pk Schiedam, The Netherlands. Phone (010) 4703661. Fax (010) 4703661.

Linhof: HP Marketing Corp., 16 Chapin Rd., Pine Brook, NJ 07058. Phone (201) 808 9010. Linhof Präzisions-Kamera-Werke GMBH, P.O. Box 701229 D-8000 Munich 70. Phone (089) 72492-0. Fax (089) 72492250.

Lotus View Camera: viewcamera@weisserlotus.co.at http://www.lotusviewcamera.at/

Nagaoka: The Lens and Repro Equipment Corp., 33 West 17th St., New York, NY 10011. Phone (212) 675-1900.

Nikon Inc.: 1300 Walt Whitman Rd., Melville, NY 11747. Phone (516) 547-4200.

Osaka: Bromwell Marketing, 3 Allegheny Center, #111, Pittsburgh, PA 15212-5319. Phone (412) 321-4118.

Phillips: Phillips & Sons, P.O. Box 1281 Midland, MI 48641-1281. Phone/Fax (517) 835 7897.

Rodenstock: HP Marketing Corp., 16 Chapin Rd., Pine Brook NJ 07058. Phone (201) 808-9010.

Schneider Corp.: 400 Crossways Park Dr., Rochester, NY 14624. Phone (516) 496-8500.

Sinar: SinarBron Imaging, 17 Progress Street, Edison, NJ 08820. Phone (908) 754-5800. Fax (908) 754-5807. (Sinar AG, Shaffhausen, CH-8245 Feuerthalen, Switzerland. Phone (053) 293535. Fax (053) 293578.)

Toho: Toho Machine Co, 20-11 Naka-Jujo 3-Chome, Kita-Ku, Tokyo 114, Japan. Phone 81-33-908-0320 Fax 81-33-908-0522.

Toyo-View: Mamiya America Corporation, 8 Westchester Plaza, Elmsford, NY 10523. Phone (914) 347-3300. Fax (914) 347-3309.

Walker: Calumet Photographic, 890 Supreme Dr., Bensenville, IL 60106. Phone: 1-800-225-8638 (1-800-CALUMET). Robert White, Unit 4 Alder Hills Ind Est, 16 Alder Hills, Poole, Dorset, BH12 4AR, United Kingdom, Phone +44 (0)1202 723046, Fax +44 (0)1202 737428

Wisner Classic Manufacturing co. Inc.: P.O. Box 21, Marion, MA 02738. Phone (508) 748-0975.

Wista: Fields and Views Inc., P.O. Box 132, Old Chatham, NY 12136. Phone (212) 779-1471.

Zone VI: Calumet Photographic, 890 Supreme Dr., Bensenville, IL 60106. Phone: 1-800-225-8638 (1-800-CALUMET).

Conversion Table

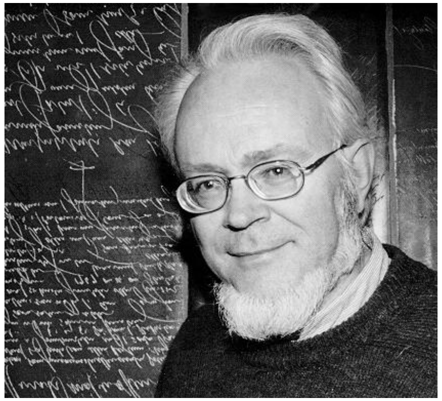
1 mm = 0.039370 inch
1 inch = 25.400 mm

inch	mm
1	25.400
2	50.800
3	76.200
4	101.600
5	127.000
6	152.400
7	177.800
8	203.200
9	228.600
10	254.000
11	279.400
12	303.800
½	12.700
¼	6.3500
¾	19.0500
1/8	3.1750
3/8	9.5250
5/8	15.8750
7/8	22.2250
1/16	1.58750
3/16	4.76250
5/16	7.93750
7/16	11.11250
9/16	14.28750
11/16	17.46250
13/16	20.63750
15/16	23.81250
1/32	0.79375
2/32	2.38125
5/32	3.96875
7/32	5.55625
9/32	7.14375
11/32	8.73125
13/32	10.31875
15/32	11.90625
17/32	13.49375
19/32	15.08125
21/32	16.66875
23/32	18.25625
25/32	19.84375
27/32	21.43125
29/32	23.01875
31/32	24.60625

Conversion software (freeware) can be downloaded from:

http://home.online.no/~gjon/depth.htm

About the Author



I was born in Norway in 1944 and have lived nearly all my life here. I studied English, French and literary theory at the University of Bergen in Norway, and also spent a year in the US as a foreign student at Wesleyan University, Middletown, Connecticut, studying English and American literature, and Italian and Latin.

Photograph: Eli Berge

As a young boy and teenager I was fascinated by woodworking and mechanics. I remember I admired my grandfather, who owned a small farm and who died when my mother was only five years old, for building an organ from a kit. I also admired one of my uncles, an arts and craft teacher, who built a beautiful fishing rod from bamboo and hickory. From the age of eleven I used to read regularly the Norwegian edition of *Mechanix Illustrated*. When I was in my early teens I built a camera tripod based on an article in that magazine. Thirty years later I built a similar tripod using materials which were not available to me in my boyhood.

I developed an interest in visual form and photography when I was a young boy, but photography was pretty expensive when I grew up. My father, who was a teacher in a countryside community, had a Kodak Brownie E. My own first camera was a 35 mm Dacora Dignette with a Steinheil Cassar lens, which my parents bought me second hand in 1959. It cost NOK 150, which was quite a lot of money at the time. The camera served me well for years and I still have it.

I started working more seriously on photography in the late 1980s. In 1991 my interests turned to large format photography and I built my first large format camera. In 1996 I wrote the first version of *Building a Large Format Camera*, which has been bought by ardent amateur photographers and woodworkers in North and South America, Europe, Australia, Asia and Africa. I updated and revised the book in December 1999. Since 1990 I have also been doing a lot of pinhole photography. My article "Pinhole Photography—History, Images, Cameras, Formulas", written in 1996, is available at web servers in Europe, the US and Australia and was reviewed by the international photo magazine *Zoom* in their November–December 1999 issue.

I am currently an adviser and head of information at the Norwegian Language Council, an agency under the Norwegian Ministry of Cultural Affairs.

In my spare time I enjoy reading—my interests range from philosophy and the social sciences to poetry. I enjoy listening to jazz and classical music, spending time on the Internet and outdoors—and doing photography or woodworking. My main interest in photography is landscapes. I lead a quiet and simple life and do not usually write articles like this about myself.