# Elementary Motion-Picture Design Perspective

**A TUTORIAL PAPER**

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**Motion-picture and television frequently require productions formed by synchronization of a number of visual images. The view camera and frame-cut methods of coordinating arrested motion are briefly described, and the latter is also applied to set construction. There are drafting methods for translating an art director's sketch into a three-dimensional full or scale-size set construction in forced or natural perspective. The determination of miniature setups, coordinating location photographs with set dimension, and assuring accurate perspective interlock of rear-projection plates to foreground construction is discussed. Geometric methods are also described for determining aspects of the camera station point when not recorded by the cameraman at the time of original exposure.**

VISUAL TECHNICIANS operating in the realm of motion-picture production and television have devised various means of locating and relocating the position of a subject at the focal plane of the recording medium. A popular method of synchronizing a subject action to another preconceived movement is to erect a view camera to one side of a stationary motion-picture camera. An artiste may be called upon to enter the scene, arresting his movement at center stage. At this point a costume change is designed to take place and his movement continued out of frame. At the point of arrestation an accurate figure is traced over the outline of the artiste's image, optically delineated on the ground glass of the view camera. The actor is then released for his costume change. When he returns he is instructed to occupy his former position by a technician who synchronizes the live body position with that drawn on the camera ground glass.

A more technical method of synchronization is that of the frame-punch assembly made by Mitchell Camera Corp. With it a single frame is accurately cut from a strip of motion-picture negative or positive image film. This frame-cut is then inserted in the telescope of the camera to lie in the same focal plane as the raw stock will occupy when the camera body is in shooting position. The image contained in the frame-cut can serve as a guide when viewed in concert with the area fielded by the objective lens. Applications are in model or actual set building, artiste location, effect superimpositions, juxtapositions, or split-matte shots, background shooting for either traveling matte composites or transparency projection.

Models and false perspective sets can be built by setting up such a camera aligning the perspective of the construction to that contained in the frame-cut image by constant recourse to camera viewing and material set adjustment. Special effect technicians, art directors and set draftsmen are fully aware that this time-consuming procedure need not be followed because sets can be smoothly interlocked in a perspective sense by good drawing-board planning. In this way, relative sizes and positions of objects can be accurately calculated when the focal lengths of the lenses to be used are known. The method is equally applicable to all the manipulations previously mentioned, whether used in feature film production or in production of commercial promotional advertising or television setups.

Every lens has, with respect to final screen aspect ratio, a horizontal (plan) or vertical (elevational) angle. It remains to translate these camera lens angles onto a length of transparent plastic for drawing-board use. A horizontal line is scored on the material. At one end of this line a hole is drilled, large enough to admit a pencil lead and from this station point, a specific horizontal

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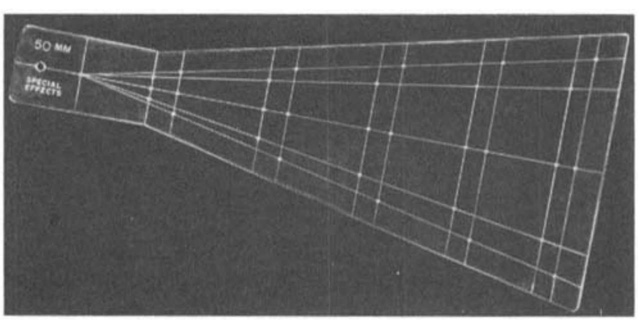


**Fig. 1. Scribed and drilled plastic showing elevational and plan angles for drawing board application.**

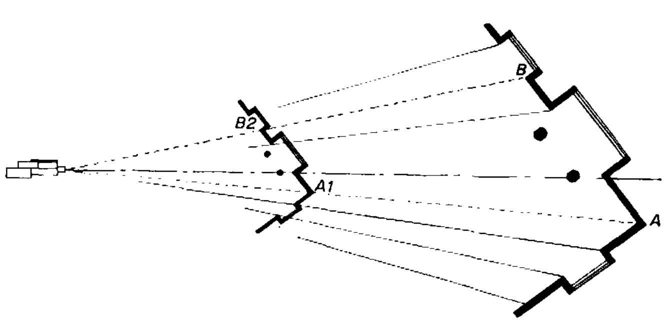



**Fig. 2. Proportional reduction of scale to camera position being station point from set area.**

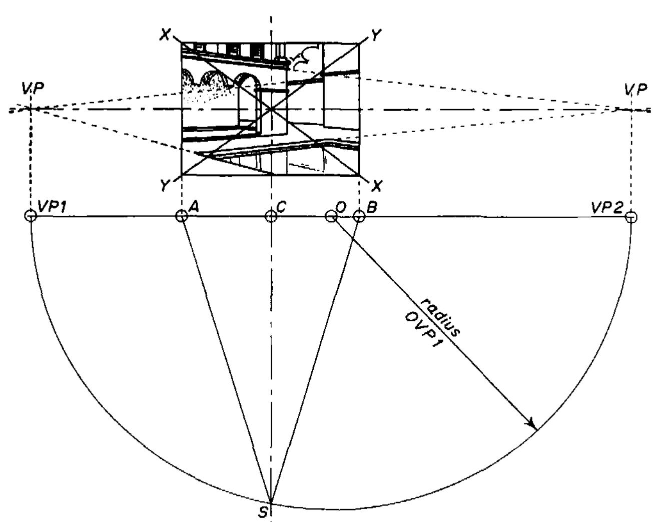



**Fig. 3. Determination of focal distance from an untrimmed print by use of vanishing points. Center of vision determined by diagonals *XX YY*.**

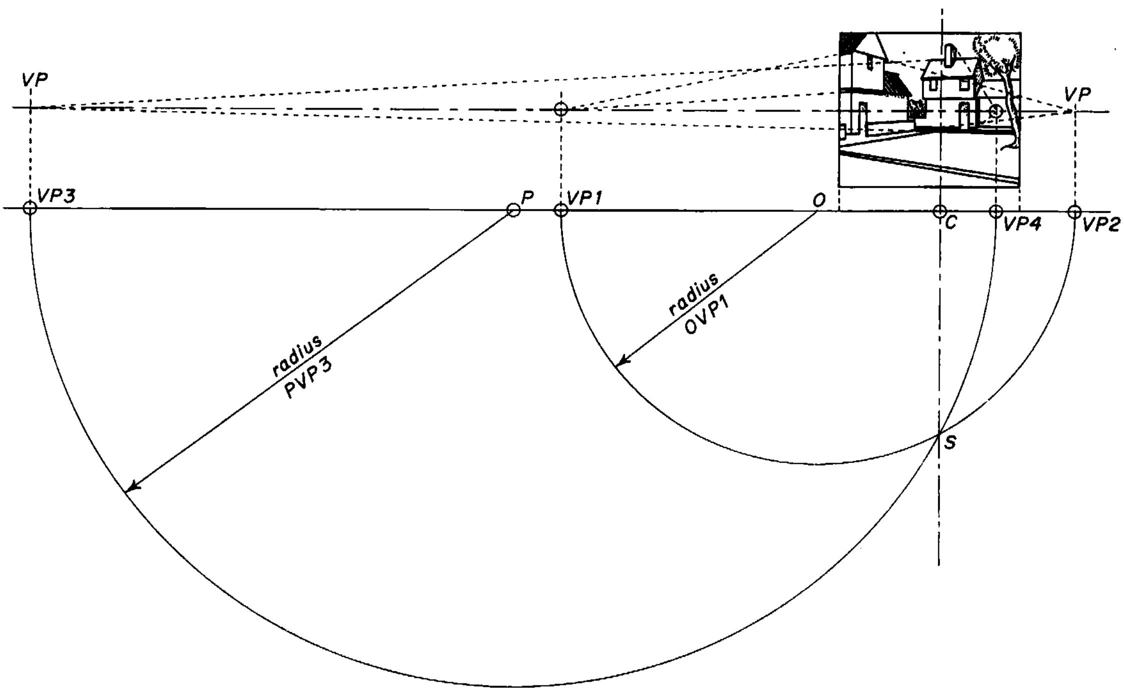



**Fig. 4. Resolving the center of vision and focal distance where two sets of vanishing points for right-angled subjects exist.**

angle corresponding to a selected lens is drawn to the line of a perpendicular scored at the opposite end of the material. The initial horizontal line will accurately bisect the angle. The intersection of the perpendicular by the lens angle will be consistent with the known aspect ratio equidistant above and below the horizontal. The vertical angle corresponding to an ele\ational view in drafting parlance will then be scored in the plastic after the same fashion. This angle at the point of intersection with the perpendicular will indicate screen proportion height. To facilitate drafting procedures, holes may be drilled in the material at each line intersection (see Fig. 1).

When a camera is aligned to field a subject, the choice of camera lens, the height of that lens, its depression or elevation, degree of cant or twist and depth of field at point of focus, are considerations of its station. The site of the camera is therefore declared a station point, synonymous with the station point previously designated on the clear plastic form. This lens angle can be overlaid on a set plan and the amount of set within the field of any selected lens will be readily apparent. Lines drawn through locations on the set plan point projected back to the Station Point will progressively and proportionately reduce scale until a point is reached where a model or glass shot insert section can be located and be accurately aligned to the full scale set (Fig. 2). Simple measurement on the scale drawing will determine the depth of field required to hold in sharp focus the full-size set and the foreground insert. This will in turn determine the lens diaphragm setting. In conjunction with the speed rating of the recording medium to be used, the keylight foot-candle reading can be assessed. Lamps capable of providing the illuminant level can then also be preplanned.

The camera angle is employed to translate an art director's sketch into to a three-dimensional, full- or scale-size set construction in forced or natural perspective, and in determination of hanging miniature setups, translation of location photographs to set dimension, and accurate perspective interlock of rear-projection plates to a foreground set.

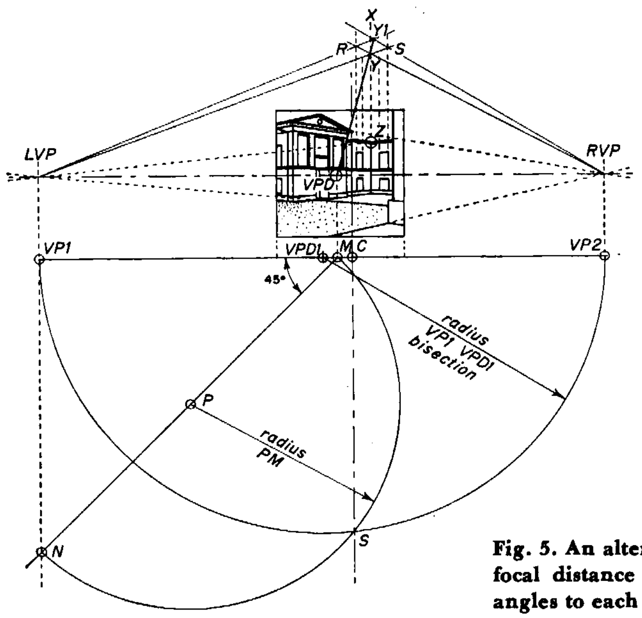
Before such planning can proceed, it is desirable to have a print from the full negative area of the original exposure and it is necessary to ascertain certain essentials:

(1) the center of vision,
(2) the focal distance which will automatically resolve the horizontal camera angle,
(3) the angle of cant,
(4) the angle of tilt, and
(5) a height or width of a common object within the picture.

The center of vision in an untrimmed photograph is at the geometric center of the print. With an untrimmed print of a right-angled object, the focal distance is determined by the use of vanishing points (Fig. 3). Two vanishing points (*VP*) for planes at right angles to each other are found and projected down to form *VP*1 and *VP*2. The width of the photograph is projected down to this line at *A* and *B*. Line *VP*1 *VP*2 is bisected at *O* and radius *O VP*1 is set to describe a semicircle. *AB* is bisected by vertical downward projection of the geometric center formed by intersecting diagonals *XX YY* to *C*. A perpendicular from this point intersecting the semicircle at *S* determines that *SC* is the focal distance. Angle *ASB* indicates the plan lens angle.

The center of vision of a trimmed print may be found in the process of resolving the focal distance (Fig. 4). Where two sets of vanishing points for right-angled subjects at different angles to one another on plan are to be found, the focal distance can be determined when the print has been trimmed. Two vanishing points for two buildings are projected to common line *VP*1 *VP*2 *VP*3 and *VP*4. *VP*1 *VP*2 is bisected at *O*. A semicircle with radius *OVP*1 is described. *VP*3 *VP*4 is bisected at *P*. Another semicircle with radius *PVP*3 is described to intersect the first semicircle at *S*. At *S*, a perpendicular is drawn to meet common line *VP*3 *VP*2 at *C*. *SC* is then the focal distance and the line of the center of vision. Since this line does not bisect the width of the print, the print is known to be trimmed.

Figure 5 shows another method sometimes applicable. In this right-angled building, two windows of equal width occur in planes at right angles to each other. The two vanishing points are defined as before. The line of the window edges is projected to a convenient height. From the vertical point *Z* formed at the junction of the two right-angled wall-faces, a perpendicular is produced to *X*. An arbitrary line is drawn from the lefthand vanishing point (*LVP*) to



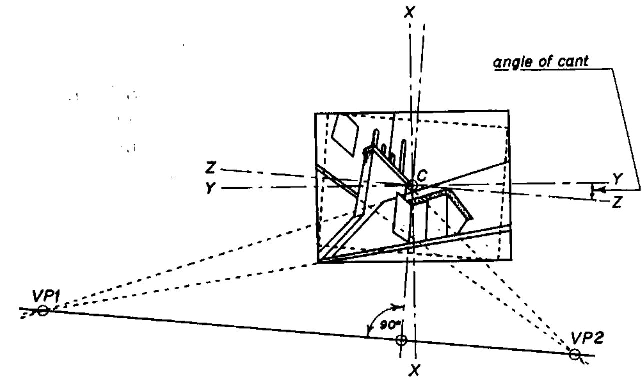




**Fig. 6. A method to determine degree of camera cant or twist using two vanishing points.**

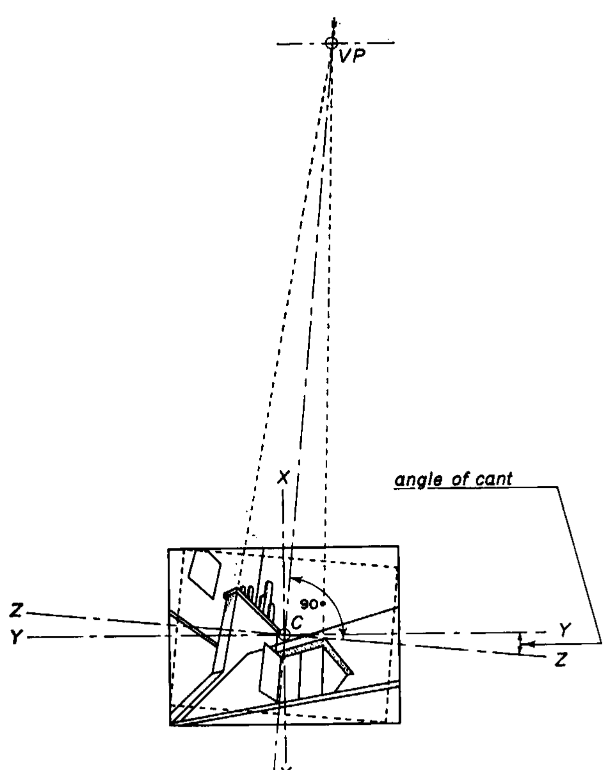
**Fig. 5. An alternative method to resolve center of vision and focal distance using two windows of equal width at right angles to each other.**

intersect *XZ* at *Y*. *Y* is connected to the righthand vanishing point *RVP* by a straight line. Where *RVP Y* intersects the outer extremity of the lefthand window frame projected, point *R* is determined. Where *LVP Y* intersects the outer extremity of the righthand window projected, point *S* is determined. A line from *RVP* is drawn through *S* and a line from *LVP* is drawn through *R*. At the point of intersection, point *Y*1 is formed.

A line is produced from *Y*1 through the point *Y* until it cuts the horizon line at *VPD*. A perpendicular from *VPD* to cut *VP*1 *VP*2 at *M* is drawn and continued at 45° to a perpendicular extended from *VP*1 at *N*. *MN* is bisected at point *P* and a semicircle radius *PM* is described linking *MN*.

*VP*1 *VP*2 is bisected at *VPD*1 and with radius *VP*1 *VPD*1 a semicircle is described from *VP*1 to *VP*2. Where the two semicircles intersect, point *S* will be located. A perpendicular from *S* to *C* on *VP*1 *VP*2 will establish the center of vision and focal length. Since this line does not bisect the width of the print, a trimmed print is indicated.

The angle of cant or twist is resolved by forming a horizon line between two vanishing points *VP*1 and *VP*2 (Fig. 6). A line *ZZ* is drawn parallel to the horizon line through *C* the geometric center of the frame. A perpendicular is then projected at 90° to the horizon line through *C*. A truly horizontal center



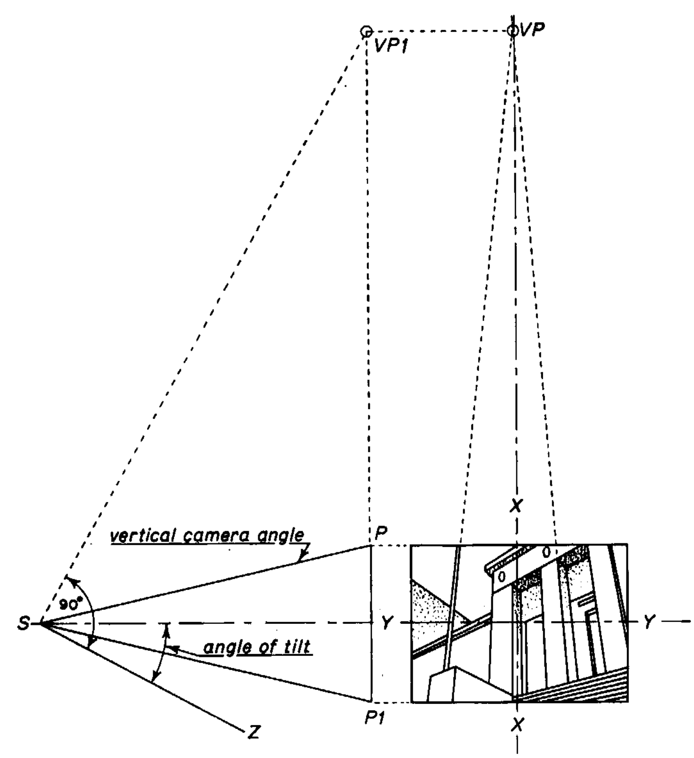




**Fig. 7. A further method to determine degree of camera cant using a single vanishing point.**

**Fig. 8. Resolving the degree of upward tilt with single point perspective.**

line *YY* and a truly vertical center line *XX* must then be struck through *C*. Angle *YCZ* will indicate the angle of cant.

The angle of cant can be resolved using a single vanishing point. In Fig. 7, the photograph is set-up on the drawing board and a true horizontal center line *YY* is made through the geometric center *C*. A truly vertical center line *XX* is then erected through *C*. By perspective continuance, *VP* is substantiated and connected to *C* by a straight line. *ZZ* is then drawn at right angles to *VP C* through *C*. Angle *YCZ* indicates the angle of cant. The photograph is then righted by this degree.

Figure 8 demonstrates an example of resolving an upward tilt. Draw horizontal axis, *YY*, and vertical axis, *XX*, then take two diminishing verticals and produce upwards to meet at perspective point *VP* on the vertical axis *XX*. Produce *YY* and erect at a convenient distance from the edge of the photograph a vertical *PP*1 equal in height and parallel to the edge of the photograph. The vertical camera angle *PSP*1 about the horizontal axis *YY* is then drawn. From *VP* produce a line parallel to axis *YY*. Produce *PP*1 parallel to axis *XX* to intersection point *VP*1. Connect *VP*1 and *S* and from *S* erect *SZ* perpendicular to line *VP*1*S*. Angle *ZSY* becomes the angle of tilt the camera makes with the horizon. Angle of tilt down would be decided by producing diminishing verticals in a downward direction and establishing a similar construction.

Angle of tilt can also be decided using the construction of Fig. 9. Draw horizontal axis *YY* and produce. Set up at a convenient distance from the edge of the photograph *PP*1 parallel to the photographs' vertical edge and of the same height. Set up the known camera angle fielding *PP*1 on the horizontal axis *YY* produced establishing *S*. Vanishing points *VP* and *VP*1 are determined and connected by a straight line. *PP*1 is then produced until it intersects *VP VP*1 at *Z*. When *ZS* is connected by a straight line *ZSY* becomes the angle of tilt the camera makes with the horizon.

There are many geometric methods of computing the essential data required for drawing-board planning. The few illustrations presented serve only to demonstrate that it is possible to deduce this information from photographs having no recorded data made at the time of the exposure. Such deduction becomes more complex when the rising front or swing back facility of a camera has been used at the time of the original exposure, and also when it is deemed necessary to deduce the ramifications of an art director's sketch to faithfully reproduce, through the discipline of an optic, lines having no true perspective.

Draftsmen therefore are exceedingly interested that the requisite data be accurately recorded by the cameraman when exposures are made for process work of all types. One further measurement is required: a dimension within the scene. With this information, the construction of a plan and elevational drawing from a photograph may proceed.

If no actual measurement of an object within the scene was made by the cameraman at the time of original exposure, conventional heights, such as for doors, banister rails, window sills, fire hydrants, etc., can be assumed. In Fig. 10, a door height of 7 ft 0 in. is approximated. A horizon line established by production and connection of two vanishing points across the photograph cuts the door height between floor level and lintel at the horizontal center line of the picture. Assuming an overall height of 7 ft 0 in., the distance between the horizon line and the floor level down one door jamb can be established by comparative scale as 4 ft 6 in.

The vertical camera angle *SP*1*P*2 is set up against one edge of the photograph, or sketch, the center line of the angle being the horizontal bisection of the picture height. Below and parallel to this center line, a ground line is drawn. A scale height of 4 ft 6 in. is established. *P*1 *P*2 is extended to encompass the span of the horizontal camera angle at *P*3. *S*1 is positioned on a perpendicular from *S*.

To locate the position of the door opening on the oblique elevation, points *A* and *B* are projected horizontally to *P*1 *P*2 at *A*1 *B*1. *A*1 *B*1 are then connected to *S* by straight lines. The ground line is crossed at *A*2 *B*2, being the location of the door opening at floor level. From *A*2 *B*2, perpendicular to the ground level, lines are drawn across the camera plan angle.

From points *A* and *B*, vertical lines are directed to *A*3 *B*3 on the bottom edge of the photograph. These points are projected at 45° to cut *P*2 *P*3 at *A*4 *B*4. Lines are drawn connecting *A*4 *B*4 to *S*1. Where these lines intersect the perpendiculars from *A*2 *B*2 points *A*5 *B*5 are located, being the position of door opening on plan.

To complete the oblique elevation of the door, points *C* and *D* are projected horizontally to *P*1 *P*2 then to *S* in similar fashion as before. Where the verticals erected from *A*2 *B*2 are cut, points *C*2 *D*2 are found, establishing the true scale height of the door opening. By such means, of point by point projection, the photograph is translated into set plans and elevations. The oblique elevation, however, requires translation to true elevation. Although the vertical heights are true, the horizontals being on oblique planes are not true scale dimensions. However, the plan does exhibit horizontal accuracy. Final working drawings are then compiled by taking true scale horizontal measurements from the plan and true scale verticals from the oblique elevation.

A reverse projection procedure can be followed by applying a camera angle over scaled architectural plans, or working drawings, in order to resolve how a representative set will be seen in its final

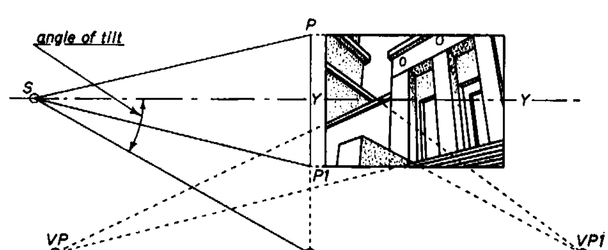



**Fig. 9. A further construction to determine degree of upward tilt with the use of two vanishing points.**

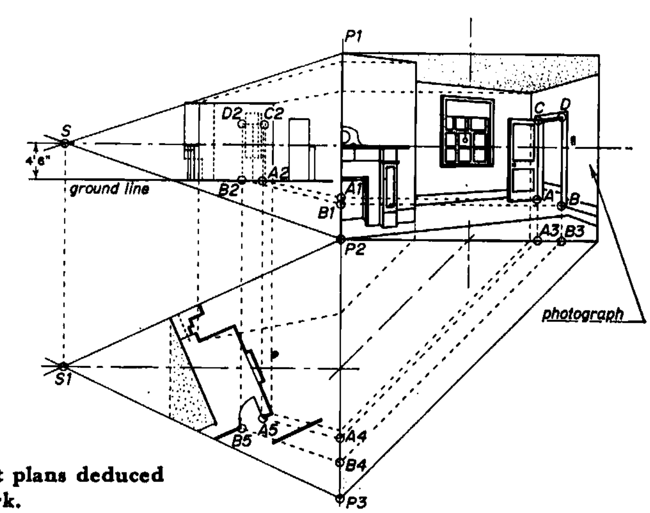



**Fig. 10. The production of scale set plans deduced from a photographic print or art work.**

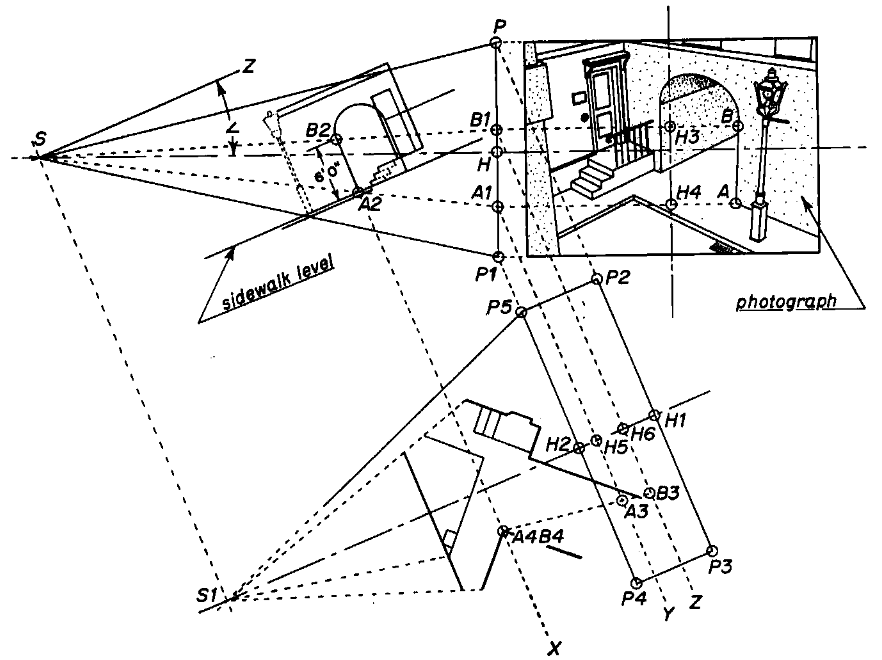



**Fig. 11. The production of scale set plans from a photographic print or art work in three-point perspective.**

aspect by any selected lens. Many problems encountered in the complexities of perspective projection can frequently be resolved in closer acquaintance with drawing-board practice and research. Alternative methods of procedure will become apparent and short cuts to ensure speedy execution will be found.

Set planning problems from photograph or sketch are deduced quite simply when the taking camera is truly horizontal and vertical and free of cant, without use of rising front, and the preferred aim is to achieve this end. However, in the interests of strong pictorial composition, a camera may be tilted into an elevated or depressed angle involving the resolution of a scene in three-point perspective. In this case, the angle of tilt being determined, the method of procedure is as shown in Fig. 11: *SPP*1, the vertical camera angle, is applied, *PP*1 being parallel to the vertical picture edge. The angle of depression is measured from *SH* to form *SZ*. At a convenient drafting distance *S*1 is located being on a line perpendicular to *SZ*. The plan center line *S*1 *H2 H*1 is drawn parallel to *SZ* which is a true horizontal line. *H2* and *H*1 are substantiated by perpendiculars drawn through *P P*1 forming the oblique projection of *P2 P*3 *P*4 *P*5. Height *AB* in the picture area is known to be 6 ft 0 in.

To resolve plan and elevation, project *B* and *A* horizontally to cut *PP*1 at *B*1 and *A*1. Draw from *A*1 *B*1 straight lines to *S*. Set an adjustable set square to the angle true verticals make with the camera center line *SH* and set dividers to a scale dimension of 6 ft. Slide the adjustable set square along a straight edge until the distance 6 ft 0 in. can be marked between *A*1 *B*1 at *A*2 *B*2. Then *A*2 *B*2 is the edge of the arch opening in oblique elevation. Draw sidewalk level through *A*2 which will be parallel to *S1 I1*.

From *A*2 *B*2 and from *B*1 *A*1 lines are projected parallel to the true vertical *SS*1 to *X*, *Y* and *Z*, respectively. To locate point *A* on plan dividers are set to the distance between *H*4 and *A* in the picture area. This measurement is transferred to *H*5 on *A*1 *Y* yielding *A*3 on the oblique. *A*3 is connected to *S*1 intersecting *A*2 *B*2*X* at *A*4 *B*4 which corresponds to point *A* on plan *H*3*B* is transferred to *H*6 *B*3 on *B*1 *Z* for a confirmatory accuracy check. *A*4 *B*4 is the archway edge on plan. The remaining points will be plotted using the sidewalk level as a base.

This necessarily abbreviated discourse serves only to introduce to a wider group of interested technicians an aspect of picture planning largely overlooked. Although tried geometric techniques may be applied, each individual photograph or sketch presented for translation into scale drawing terms will present its own problem for studied deduction.


The author is indebted to the instruction of the late John Gow whose expanded work on "Problems in Perspective" is referred to in the bibliographical data.


**Bibliography**


1. Alf Davis and John Gow, "Back projection and perspective: problems of perspective," *Jour. Brit. Kinematography*, pgs. 130–136, 164 Shaftesbury Ave., London WC 2, April 1948, published in concert with *Cine Tech.*, p. 96, May–June 1948, Vol. 14, as listed in *Jour. SMPTE 69:* 422, "Special effects cinematography: a bibliography," by Raymond Fielding.
2. Arthur Bridgeman Clark, *Perspective*, Stanford University Press, Calif., 1936 (8th printing in 1953).