We are often asked for drawings of railway equipment which prove difficult to find. Here is how to provide your own drawings from photographs.

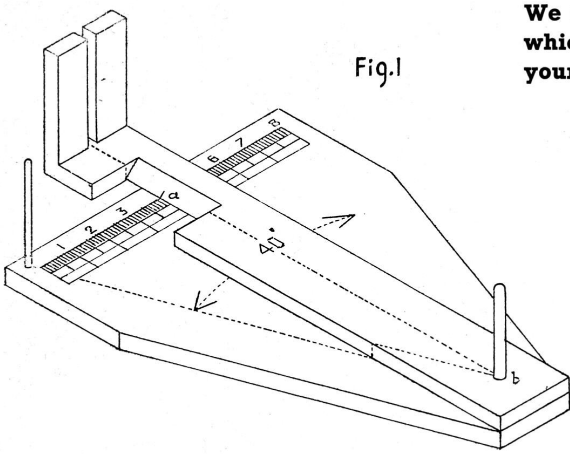

Fig.1

THE DEVELOPMENT OF ORTHOGRAPHIC PLAN AND ELEVATIONS FROM PHOTOGRAPHS

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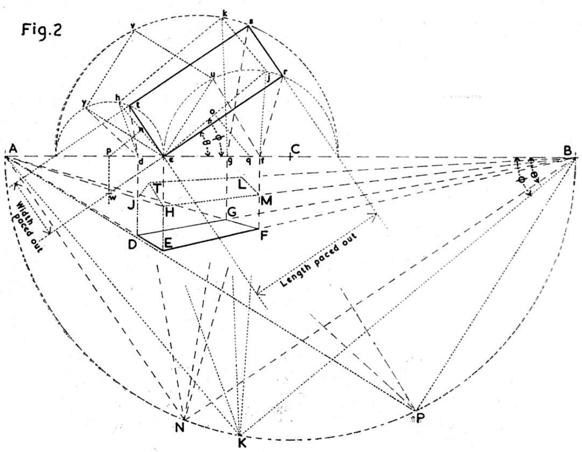
THE need sometimes arises to produce orthographic diagrams to a known scale, of some object of geometrical form (e.g. a building, or other solid capable of being " crated " within rectangles) of which a photograph or photographs are available, but little information otherwise.

A method for doing this, and for making the fullest use of the wealth of information to be derived from a well-defined photograph, does not appear to be generally known, nor does the writer know of any text-book in which it is to be found. It was, in fact, a statement to that effect which recently appeared in a sister publication which prompted the writing of the article herewith. The illustrations are concerned with diagrams developed from a photograph of a building, but the constructions are equally applicable to any regular, or more or less regular object.

The statement referred to said: " Use as much film as you can afford . . . take plenty of close-ups of details . . . take broadside elevations, etc." I hope to show how *one* angled (i.e. not broadside) photograph can be made to furnish all the information necessary, but this is not to decry the value of additional photographs as a check when plotting, or to show features on the opposite side of the building not visible in (and perhaps differing from those in) the principal photograph.

A word here about dimensions, heights, etc., in which connection the author of the statement suggested a tape, and yearned for a ladder. The latter I shall hope to show is not needed. As regards the former, well, if we can get right up alongside the building, and accurately record its length and breadth, so much the better, but minus the ladder, we still lack heights and, further, unless we know how to translate the photograph perspective into actual orthographic dimensions, we should also have to measure and record, on the spot, a host of lesser dimensions such as doors, windows, etc.—a labour I hope to prove unnecessary.

Fig.2



Moreover, the building may often lie within an enclosure to which we have not access, in which case a basic dimension (not necessarily an all-over) must be determined by measuring an equivalent distance outside the enclosure. For instance, to arrive at the length, take up a position from which the far corner of the end of the building is just becoming coincident with the near corner, and from there walk parallel to the side of the building until the same conditions obtain at the other end. A measuring tape *could* be used but, unless the building was very small, it would need to be fleeted several times, with risk of error, whereas, if we have calibrated our normal stride, we arrive at a measurement sufficiently accurate for our purpose. Even if our pacing is not *absolutely* parallel to the side of the building. Because the *exact* measurement doesn't matter a hoot. Our objects are (*a*) to keep the *relative proportions* correct, and this we shall achieve if we use the same stride in measuring the width, and (*b*) to ensure that the scale of the diagram conforms to the scale by which we wish to work. The dimensions obtained by pacing may not be *exact*, but for them to depart so far from the truth as to cause the resultant diagram to be manifestly out of scale would occur only if our stride were very erratic indeed.

Now let it be admitted right away that a photograph, however detailed, with no other data at all, is of little use to us by itself. We must have one major dimension, such as length, exact if we can, but a reasonable approximation to it will serve. And to supplement this we must also have *either* one other major dimension, at right angles to the first, *or*, the angle subtended by the building at the lens of the camera, plus one other angle to a prominent feature. Given these, all other information, including heights, roof-angles, details, etc., can be extracted from the photograph.

As regards the subtended angles, few among us, one would suppose, will have available a theodolite, or even a sextant. However, the construction of a simple " triangulator," along the lines indicated in Fig. 1 (which, by the way, is an isometric projection, not perspective) should be within the capacity of the amateur workshop, and give results sufficiently accurate. The diagram is intentionally crude, demonstrating principles rather than constructional details. The lower edge of the bevel, where it rests on the baseboard, is in the same vertical plane as (*a*) the slot in the foresight and (*b*) the pivot pin, which also serves as the backsight. The other pin is the foresight for alignment on the L.H. vector of the angle. The scale could be radial, but the straight one is easier to make. The units (preferably decimal) do not matter so long as the distance *ab* (on the baseboard —a constant) is measured in the same units. The measurement determining the angle is taken from the point where the bevel intersects the scale. The scale is at right angles to the mean line of sight, and we can therefore reconstruct the triangle on the drawing-board, and either measure the angle, or take it out from mathematical tables. The scope shown in the diagram is 40 deg.—see next paragraph. The instrument could be held in the hand, but preferably should be given more stable support, such as the roof of the car, or an adaptor on the camera tripod.

Let us now consider procedure at the site. Try to select a position from which to take the picture at which the building subtends an angle of not more than 30 deg., and which gives a good view of both a side and an end. As regards relative height, it is to be expected that most often the ground where you are standing and the base of the building will be on or near the same level, but avoid being much higher (or lower, for that matter) as this would introduce convergence of the verticals. It would also diminish the heights due to perspective—this, however, can be allowed for. Let your picture be as large as your camera, and the need to keep the subtended angle within 30 deg., will permit, and:

(i) Pace out length and width as already described, or,

(ii) Pace out one dimension only, and in addition measure the horizontal angle θ between the L.H. extreme vertical and a conspicuous (but not near central) vertical, and also ϕ between the latter and the extreme R.H. vertical.

One or other of the above completes, with the photograph, the minimum essential data, and we are now ready for the drawing-board.

(*a*) Mount the photograph on the drawing-board.

(*b*) Project (Fig. 2) the principal horizontals, and define the vortices *A*, *B*. *TL*, *HM* and *EF* all converge at *B*, but for *A* we must rely on *HJ*, *ED* only, since *G* is not visible.

(*Note*—Although, at this stage, we are about to consider projection of an *area* only, for the better definition of the vortices employ the roof-tops, etc., also.)

(*c*) Join the vortices, defining horizon *AB*.

(*d*) Bisect horizon at *C*, and with this as centre draw the semi-circle, radius *CA*, around the photograph. The position from which the picture was taken lies somewhere on this semi-circle.

The semi-circle, centre *p*, radius *pe*, is the path traced out by the L.H. corner of the plan.

A similar construction on *ej* gives us point *q*. With centre *q* and radius *qe* draw the semi-circle above the horizon.

Suppose our pacing to have determined the length as *a* units and the breadth as *b* units, so that their ratio is as *a* to *b*.

From *p* drop a perpendicular, and along this measure a distance *pw*, equal to *qe* (radius of the R.H. semi-circle) multiplied by the above ratio a/b. Join *w* to *e*, and project to cut R.H. semi-circle in *r*.

From *e* draw *et* perpendicular to *er*.

Complete the rectangle *erst*. This is the actual floor plan which was the subject of the perspective view. Its relative proportions, indeed, its actual dimensions, scaled down, are the same as those we paced out.

From *A* draw *AN* parallel to *te*, or from *B* draw *BN* parallel to *re*, to cut the semi-circle below the horizon in *N*. *N* is the point from which the picture was taken.

Projection of any feature in the perspective view vertically up to the horizon, and through this intersection projection from *N* up to the plan, determines the position of that feature in the plan.

Since the dimensions were already known from our pacing, why not just plot the rectangle right away, and have done with it ? What, in fact, has all this elaborate construction gained us ? A very great

Fig. 3

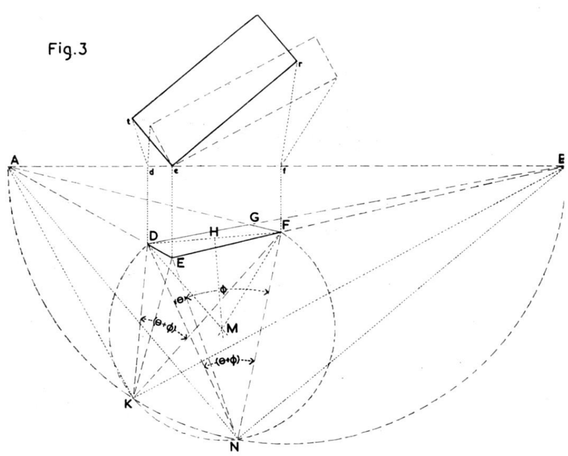
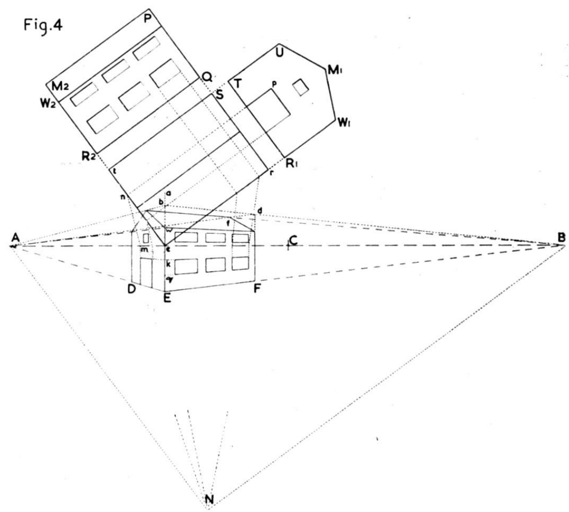


Fig. 4



For the moment, disregard the walls and roofs of the building, and consider the floor area *DEFG* (*G* being the intersection of *DB* and *FA*). Project the four corners up to the horizon *AB*, thus, *D* to *d*, etc.

The first construction to be considered will be that arising from our having measured (or paced out) two principal dimensions at right angles to each other.

Choose a point on the semi-circle from whith the picture could have been taken, say, *K*.

Join *K* to vortices *A* and *B*.

Join *K* to intersections *d*, *f*, on horizon *AB*, and project beyond to *dh*, *fj*.

From *e* (vertical projection on horizon of nearest point *E* in picture) draw *eh* parallel to *KA*, intersecting with *dh* at *h*.

From *e* draw *ej* parallel to *KB*, intersecting with *fj* at *j*.

Then *e*, *h* and *j* are three of the corners of the plan of a rectangular area which, viewed from *K*, would be seen in perspective as *DEFG*.

But this rectangle (unless, as is most unlikely, we happen to have chosen *K* correctly) will not be of the *relative* proportions demanded by our measurements.

Actually, dependent on the position on the semi-circle from which the picture was taken, *any* rectangle could be seen in perspective as *DEFG*. Improbable as it may seem, it could even be a square, as is shown by applying the above construction from *P* as viewpoint, when the plan emerges as *euvy*.

In fact, as the observation point moves around the semi-circle, the L.H. and R.H. corners of the rectangle also trace out semi-circular paths, tangential at *e*.

Bisect *eh* at *n*, and through *n* draw *np* at right angles to *eh*, and intersecting with *AB* at *p*.

deal. As will be seen when we proceed to heights, we can now, by projecting the photograph up from *N*, correctly locate every door or window, or other salient feature, in its true position and proportion on the plan—without having needed to observe and record all this secondary detail at the site. Furthermore, if denied access, some of the detail might not have been measurable at the site. Pacing out the length, alignment with the end locates our starting point, but how do we know when we are exactly opposite a door or a window ?

Before proceeding to deal with heights, let us consider the case in which the data supplementary to the photograph consist of one linear dimension and two subtended angles.

The early stages of the construction on the drawing-board are exactly the same as those already given in connection with two linear dimensions, up to the establishment of the horizon, and the projection thereon of the corners of the perspective view.

Development of the construction beyond this is dependent on the well-known property of the circle, viz, that the angles in the same segment of a circle are equal to one another.

Let the end-wall subtend angle θ at the viewpoint, and the side-wall the angle ϕ, i.e. the whole building subtends the angle $(\theta + \phi)$.

Join *DF*. (Fig. 3.)

Bisect *DF* at *H*. The normal *HM* drawn through this passes through the centre of a circle in which the chord *DF* subtends the angle $(\theta + \phi)$.

From *D* draw a line *DM* making the angle 90 deg.—$(\theta + \phi)$ with *DF*, intersecting with *HM* at *M*. (Or *FM* making the same angle with *FD*.)

With centre *M*, and radius *MD* or *MF*, draw a circle cutting the semi-circle *AKNB* at *K* and *N*. Either of these points could, as regards the overall angle subtended by the whole building, be that from which

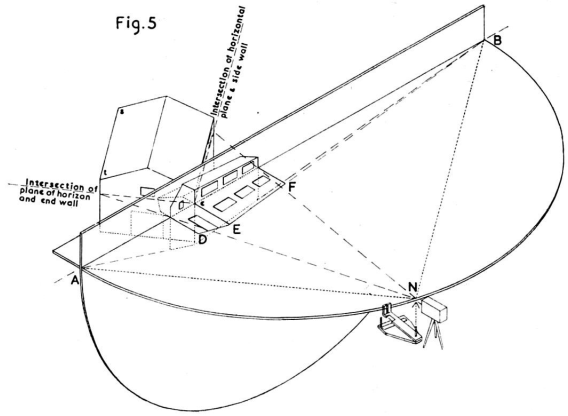


Fig. 5

the picture was taken, but only at N does the end-wall subtend θ, and the side-wall ϕ. Hence we have located and confirm N as the viewpoint for the picture.

Join *AN*, *NB*.

From e draw et parallel to *AN*, and er parallel to *NB*.

From N project up dt to cut et in t.

Similarly locate r.

Once again we have arrived at the actual floor plan, correctly situated and orientated in respect to the camera position.

Fig. 4, omitting construction lines, shows all the vital information, i.e. horizon, vortices, viewpoint, etc., in correct relation to *DEFG*, and also to plan *erst*, but the photograph has now replaced the perspective view of the floor, in order to determine heights.

The only heights in the photograph which are on the same scale as the orthographic dimensions of the plan are those which in plan lie in the vertical plane between A and B. In the diagram under consideration, this is the case only at corner e. This point is the plan of not only itself, but also of the points w, k, q, etc., in the photograph. All other heights in the photograph are diminished (or, had there been any between *AB* and the observer, increased) by perspective.

We can therefore transfer the actual length *Ee* to the side and end elevations *Re*, *We* and $R_1\ W_1$—the height of the eaves. To determine the height of the roof, suppose that the building, instead of having sloping roofs, were flat topped, its roof being the same height as the gable. Its nearest corner would then be at b (the projection from A through the apex of the gable). *Eb* is, therefore, the height of the gable on the scale of the plan, and can be inserted in the elevation ($R_2\ M_2$).

The projection of the top of the door from A cuts *Ee* at k, and this height *Ek* can be transferred to the elevations. Other internal features are dealt with similarly.

Note that d, the point vertically above F corresponding to the height of the gable (obtained by projecting from A through f) does not lie in the vertical plane between *AB*, and must therefore be projected up to it from B, reaching it at b.

This diagram also shows how the sides of doors, windows, etc., are projected vertically up to the horizon line *AB*, thence from N to the sides of the plan, and from there to the elevations.

Fig. 5 is an isometric view from a second observer of the three-dimensional relation between the building, the camera, and the perspective view. Imagine the *ANB* semi-circle to be a sheet of slightly frosted glass, so that objects beyond it, although distinguishable, are seen more faintly. Along *AB* stretches a vertical sheet of similar glass. The nearest corner of the building lies in this vertical plane, and is partly above, partly below the horizontal plane containing the vortices *AB*, and also the lens of the camera. The triangulator is also shown, ready to replace the camera for the measurement of angles.

If rays from the building converging on the camera lens were able to etch the glass as they pass through it, the floor of the building would be recorded on it at *DEF(G)*, conforming exactly to the floor of the building in the photograph which we have mounted on the drawing-board in this position.

Rays from those parts of the building situated above the horizontal plane containing the camera lens will all be above this plane, and therefore will not etch themselves on it, but will do so on the vertical plane stretching between *AB*.

If we now imagine the vertical glass plane to be hinged along *AB*, and rotated away from us until it becomes horizontal, the picture of the building will be complete in the horizontal plane, and will conform in every respect to our photograph on the drawing-board.

Alternatively, if we do not move the vertical plane, but hinge the horizontal plane downwards round *AB* until it becomes vertical, we now have the same perspective view standing upright.

In Fig. 6, the " photograph " is an exact reproduction of the photograph of the model of the building appearing in the article in a sister publication. (Exact even to duplicating the fact that one of the corners is slightly out of true!)

This is a more advanced problem for two reasons: (*a*) the main body of the building has the far end obscured, and has two widths, and there are three bays, etc., and (*b*) the roofs have considerable overhang.

As we have already shown, our first requirement is to develop above horizon *AB* an orthographic plan of a floor area in the photograph. There is only one such area in the photograph that has three

This is Billingborough Station, a recent M.R.N. photograph. A good practice print for the lessons taught in this article.

(the minimum) of its corners visible, and that is the smaller L.H. annexe to the main building. We *could* use this, and from the dimensions and siting thus obtained develop the plan of the remaining, and much larger, portion of the building, but it is always better to work from a major dimension inwards, whereby errors are reducing, than from a minor dimension outwards, multiplying errors. So here we will assume that the annexe is repeated at the further, hidden end of the main building by a shallow porch, flush with the end wall, and use this imaginary rectangle as our fundamental area. But how to determine its length, since the whole of the far, or R.H. end of the building is obscured.

Let us, using a provisional viewpoint, have plotted provisional plan lines of both floor and roof of the L.H. end of the annexe, and established the L.H. semi-circular locus. Bisect the floor-plan line, and at right angles to it draw the line representing the plan of the roof-peak. Projecting up from the viewpoint will determine the length of the roof. Measure inwards from the R.H. end of the roof (in plan, not photograph) an amount equal to the overhang of the roof already determined at the L.H. end of the plan (annexe). This determines the length of the floor in the plan, and enables us to complete the imaginary rectangle, and draw the R.H. semi-circle, whence, measurement having established the width of annexe to overall length of the building as being in the ratio of 1 to $5\frac{1}{2}$, we can correct the viewpoint and amend the plan in accordance with the construction already described.

Once the the true viewpoint has been established, and the plan amended accordingly, we can proceed right away to cast up all the remaining salient features, internal detail, etc. Each dotted line in the diagram, reading upwards, commences with the feature being projected. It reaches the horizon line, alters course to become one of the cone of rays from the viewpoint, and on reaching the plan alters course yet again to project to the elevations.

I have tried to explain each step as we went along, in the hope that these notes may be of value in reducing the labour at the site, restricting the expenditure of film, and making the photograph much more informative.

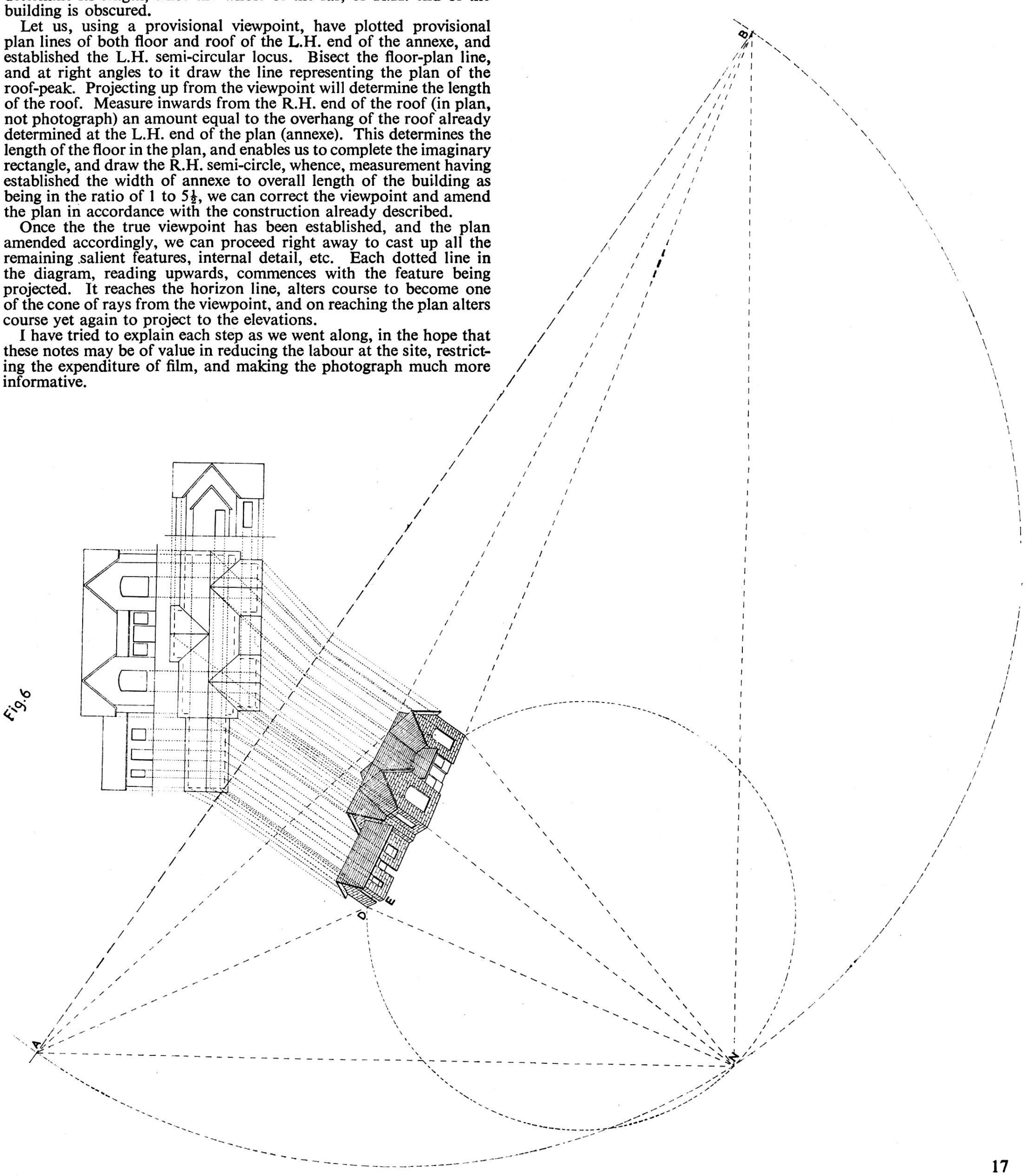


Fig. 6