

THESIS
DESIGN FOR A
SURVEYOR'S PLANE TABLE
WITH
SHIFTING CENTER

For Degree of C. E.

J. H. STEELE

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Surrounding plus

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With A Shifting Center /

Being A
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A Design for a Surveyor's Plane Table With a Shifting Center

The Plane Table cannot be said to be a very extensive use in America. The great majority of surveyors employed in other than Government work neither possess nor use a plane table, its use being practically confined to the United States Geological Survey, the Coast and Geodetic Survey, and a few state surveys. The reason is that the instrument is heavy, clumsy, and awkward to move, and that it is very difficult to set it up so that a given point on the drawing paper is directly over a given point on the ground. Yet, when this instrument is properly set up and oriented, the facility with which it can be used for rapid surveying ought to count heavily in its favor. The motive for the above proposed design was found in a remark made by Professor Baker in his text book, "Engineer's Surveying Instruments", to the effect that plane tables are never made with shifting centers, owing to the difficulty of mechanical design, but that it would be a great convenience if they could be so made.

In plotting traverses with the plane table by the radiation method or any modification thereof, it is desirable to set the center of the instrument over a given point on the ground, and, rotating about that center, as with the transit, take sights at the various points to be plotted. In plotting

THEORY OF THE EARTH AND ITS HISTORY

CHAPTER I. THE EARTH

The Earth is a sphere, or nearly so, and is composed of a solid mass of matter. It is surrounded by a thin layer of water, and is covered by a thin layer of air. The Earth is divided into four main parts, or continents, by the great oceans. These are Asia, Europe, Africa, and America. The Earth is also divided into many smaller parts, or countries, by rivers, mountains, and other natural features. The Earth is the only planet in our solar system that has a large body of water on its surface. The water on the Earth is made up of hydrogen and oxygen, and is essential for life. The Earth is also the only planet in our solar system that has a large atmosphere. The atmosphere on the Earth is made up of nitrogen, oxygen, and other gases, and is essential for life. The Earth is the only planet in our solar system that has a large solid surface. The solid surface on the Earth is made up of rocks, minerals, and other solid materials, and is essential for life. The Earth is the only planet in our solar system that has a large body of water, a large atmosphere, and a large solid surface. These three features are essential for life, and are what make the Earth a unique planet in our solar system.

by the instrument being placed on the ground, it is necessary to set some given point of the paper above the line on the ground the point occupied on the ground. To quote from Professor Baker: "To satisfy these conditions with any considerable degree of accuracy requires great patience and care. The difficulty is that having placed the point on the board over the point on the ground, it is necessary to destroy this condition in turning the board" to make the direction of the lines on the board and the ground coincide. In either method the use of a shifting center similar to that of a transit would be of great assistance.

The other disadvantages of the plane table, namely its heavy wires and other wires, would have considerably less weight if the instrument could be set up more easily and quickly and with less lifting and manipulating of the tripod legs. Therefore it is believed that if a successful shifting center can be designed for a plane table the field of usefulness of that instrument will be very much widened. The accompanying design is offered as an attempt at a solution of the problem.

Any such proposed design must be practicable from the view point of the manufacturer and from that of the observer in the field. It must not add materially to the weight of the instrument as at present; also, it should be as rigid as present constructions, and the shifting center should have a range of movement somewhat greater than that of an ordinary transit.

A plane table with a shifting center could, of course, be designed with a levelling head similar to that of an ordinary transit; that is, with long centers and four levelling screws producing rotation about an axis through the center of a ball and socket joint. The great weight of such

a design which, however, is not impracticable. For the sake of light and the plan of having three levelling screws is always adhered to in designing a plan-table levelling head.

As will be seen by referring to the accompanying drawing in the design herewith submitted the drawing board is fastened as usual with three brass screws to a revolving frame. This frame revolves about a vertical center of motion transmittal into the levelling head. The exterior rim of the frame rotates and revolves upon a circular path provided for it on the finished upper surface of the levelling head, which carries the usual clamp and slow motion tangent screw. The levelling head on its rim, on a six inch circle, three brass levelling screws of the type more common on other instruments, which are introduced into it and stand with their feet on the surface of the cover plate of the tripod head. A center screw whose lead is a portion of a sphere depends from the under surface of the levelling head at its center, through a circular opening in the tripod head cover plate, and carries on its threads a center clamp and a center nut. The center clamp supports the shifting center which is a three bladed plate, the blades being equidistant. Each blade projects through an opening in the tail of head, one blade projecting through that portion of the tripod head which projects to receive each tripoaling. This shifting center is free to move horizontally in any direction when unclamped.

When the center clamp is screw ed up tight the shifting center is held firmly against the under surface of the tripod head cover plate, bringing the feet of the levelling screws to bear on the upper surface of the said plate with sufficient

1. *Journal of the American Medical Association*, 1997; 277: 1033-1038.

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The usual 1/2" x 1/2" x 1/2" and 3/4" x 1/2" x 1/2" long brass bolts. Plate III shows the frame and other details. The frame is made as light as possible and provision is made for oiling the bearing surfaces if necessary. Plate IV shows the levelling beam and other details. The continuity of the rim of the levelling beam, on which the frame rotates, has to be interrupted to allow for the clamp yoke. If, under stress, as indicated on the drawing, be followed in manufacture, to tactile need result. If made in quantities the clamp screw could more economically be made in two parts, the stem being threaded into the beam. Plate V shows minor details. The center screw has its lower end fashioned to take a wire hook to support a plumb line under the center of the instrument. This wire hook could be made large enough to prevent the check nut getting lost, if there seemed to be danger of that in field operations. Of course the ordinary plumb line will support the plumb hook at points on the drawing other than at the center. The specification of the tangent spring is tentative. Experience might suggest a stronger or a weaker spring. Plate VI shows the shifting center. It is ribbed on the bottom for stiffness. Plate VII shows the trip of beam and cover plate. They stiffen each other, and are fastened together with machine screws placed so as to prevent buckling of the cover plate. Ridges on the latter limit the travel of the levelling covers.

When working on the framing board a slight movement of the instrument will affect the levelling covers with considerable leverage. The upper surface of the cover plate should not be so level smooth that the center plug cannot

being the following: (a) fast enough to allow use with enough friction to prevent rotation when the instrument exercises ordinary care.

In giving dimensions on these drawings no tolerances have been specified, for the reason that tolerances are best determined after considerable experience in construction. All parts are made of non-magnetic metals in reference to those who wish to use a compass with the plane table.

If made of the materials specified on the drawings, the design of plane table movement will weigh $14\frac{3}{4}$ pounds. The corresponding parts of the Herffal and Taper standard design of plane table, supporting the same size drawing board, weigh $15\frac{1}{4}$ pounds. If, however, the tripod stand and plate of the accompanying drawings be made of aluminum-silic alloy two-thirds aluminum, one third zinc -- as it readily admits to, the weight of the whole mechanism will be reduced to $13\frac{3}{4}$ pounds. The corresponding parts of the plane table used by the United States Coast and Geodetic Survey and described in the report of the Superintendent for 1903 weigh $18\frac{1}{2}$ pounds. It, however, supported a larger drawing board, namely 24 x 30 inches.

The alidade of any plane table may be used on the board of the one here described, the alidade forming no part of the present design.

In light of the fact that no tolerances have been specified, it is assumed that tolerances are not intended to be applied. The experience in manufacturing of similar parts of other machines is referred to those who wish to use a comparison with the plane table.

If made of the materials specified on the drawings, this design of plane table movement will weigh 14 1/2 pounds. The corresponding parts of the Kewell and Tress standard design of plane table, supporting the same size drawing board, weigh 12 1/2 pounds. If, however, the tripod head cover plate of the accompanying drawings be made of aluminum-alloy -- two-thirds aluminum, one third zinc -- as it readily might be, the weight of the whole mechanism will be reduced to 12 1/2 pounds. The corresponding parts of the plane table used by the United States Coast and Geodetic Survey and described in the report of the Superintendent for 1905 weigh 12 1/2 pounds. If, however, supported a larger drawing board, namely 34 x 50 inches.

The slides of any plane table may be used on the board of the one here described, the slides forming no part of the present design.

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