

ice roads, the tracks may be fitted with angle steel grousers bolted to the shoes. This gives the engine a firm bite on any road bed.

For loading operations the tractor may be equipped with a spool or windlass attachment. This consists of a cast iron drum which takes the place of the stationary pulley attachment on the smaller model, or is placed on the rear counter-shaft of the larger tractor. The engine can thus be made to do the work of another team and driver.

Operators are plentiful. Thousands of young men who enlisted in the "Tanks" have returned from France where they gained much practical experience in the handling of tractors. Many of these men had tractor experience before they entered the service and were selected for the tanks on this account. Now they can qualify as experienced tractor operators. These men have been used to hard knocks and accustomed to discipline. Furthermore, and most important, they are not of the Bolshevik element. The average tractor logging outfit is doing the work of ten teams with ten drivers; and many plants will welcome the system as a means of relief from the high cost of horse feed and the I. W. W.

The belt tread tractor with its powerful motor and crawling ability can be put almost anywhere. On the west front the engines crawled in and out of shell holes and pulled their loads over battle-torn roads and made good. The tractor can do all these things in the woods.

At every camp there is more or less extremely rough yarding to be done. Here the tractor is called upon to repeat its war-time performances. The writer recently witnessed the operation of a tractor known as a "10-ton artillery model" at a camp near Dover, Idaho. This big tractor is built narrower and with much greater clearance than the models previously described. It has a steel track made up of one piece links and is very long and flexible. There are six truck wheels on each side. It is driven with a 55 h. p. heavy duty motor.

This tractor would dash into the timber, climbing over stumps or crawling over low spots in the soft earth. The steel tracks would drape over a log like a rope. Then the machine would spin around a standing pine, grab a 1,500-foot log and snake it back to the road almost as quickly as we can tell the story. The ease with which this engine negotiated rough going was remarkable. It is easy to understand the respect with which Ludendorff's men regarded the tanks. For the belt tread tractor is the tank converted to uses of peace.

### THE PULFRICH SEXTANT.

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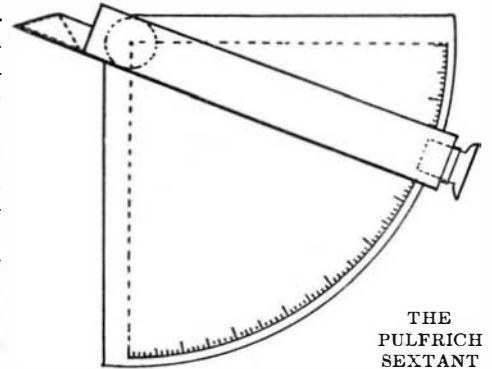
HITHERTO observational navigation has been impossible at night. With the coming of darkness, the horizon vanishes and with it all possibility of taking an altitude. On land, artificial horizons consisting of surface of quicksilver, molasses, etc., are substituted, but at sea those are impossible. A horizonless sextant has long been a great desideratum and attempts have been made to obtain the necessary level surface from which to measure an altitude by attaching a spirit level to an ordinary sextant, but the success has been meagre. The reflected image of the observed object is brought into line with the bubble and the observer tries to estimate when the centre of the moving bubble coincides with the object.

Many years ago, I was shown such a "bubble" sextant by a nautical instrument maker in San Francisco. He told me that he rarely sold one and that they were of use only in certain cases where a result having a wide margin of unknown error was better than having no measurement at all.

Several years ago the first horizonless sextant which could lay any claim to accuracy, was constructed by Dr. Carl Pulfrich, head of the department of instruments of precision, (Mess-Abteilung), of the Carl Zeiss works of Jena, Germany.

Dr. Pulfrich represents a type hitherto rare outside of Germany, viz., a man of high scientific attainments engaged in commercialized science. Had it not been for his patient and ingenious experimentation, it is doubtful if we should have had such an instrument for many years. When he has once decided that an idea is feasible and desirable, there are few men able to put it into practical form, as is evidenced by the many valuable instruments he has produced.

The figure represents the instrument diagrammatically. It is essentially a sector carrying an arm which supports a small telescope. In front of the objective is an isosceles reflecting prism, rigidly attached, its base being parallel to the axis of the telescope. The sector which is graduated, and the arm which moves over it, are pivoted at the center of the arc, and the whole is supported on a handle behind the sector (not shown) as in an ordinary sextant. The pivot is supplied with ball bearings and has practically no friction.



The arm with its appurtenances, clamping screw, vernier, shade glasses, etc., which are not shown, is accurately balanced about the pivot, so that the instrument, which is weighted, always hangs in precisely the same position. There is a spring (not shown), worked by the pressure of a finger, which clamps the sector so that it cannot oscillate, and at the same time removes all pressure from the ball bearings. The graduations, for equal arc, are twice as many as in the ordinary instrument, for here a quadrant is a quadrant and not an octant. The prism serves as a collimator. The rays of a star pass partly through the prism and partly through clear air, so that it is possible by adjusting the area blocked by the prism to have the direct and reflected images of equal brightness.

As the instrument pendulates, the direct image moves one way and the reflected image the other way, but twice as far. By a touch of the finger, it is easily possible to bring the pendulation to a stop momentarily, and this momentary coincidence of the two images gives us our measurement. Even with a slight movement, it is easy to judge when the excursions of the reflected image, above and below the direct image, are equal, and this gives us our point. There is no such thing as "Dip" to be corrected for, and there are conditions of the atmosphere, resulting in an abnormal refraction of the horizon line, when the readings by this instrument will be more accurate than by the ordinary sextant. The radius of the sector is about 4 inches and the instrument weighs under a pound.

I visited the Zeiss works in 1908 and again in 1911. During the latter visit, I was easily able to confirm what Dr. Pulfrich had previously told me, viz., that it was possible with this instrument to measure an altitude accurately to one minute of arc. This is all that is required for accurate navigation. The manipulation of the instrument is as easily acquired as that of an ordinary sextant.

The present interest in the instrument lies in the fact that we are now entering upon an era when trans-ocean voyages in airships will undoubtedly become matters of routine, and navigation will have to be done with Pulfrich sextants. Certain portions of the ocean are habitually covered with low-lying fogs, but the airship sails over these and for the greater part of the time, both day and night, sights will be obtainable.

The instrument will be a boon to explorers enabling them to lighten their impedimenta by dispensing with heavy flasks of mercury troughs, etc., hitherto necessary for artificial horizons.