July 29, 1958 J. M. MAHONEY 2,845,223

BOAT CALCULATOR

Filed April 5, 1957 2 Sheets-Sheet 1

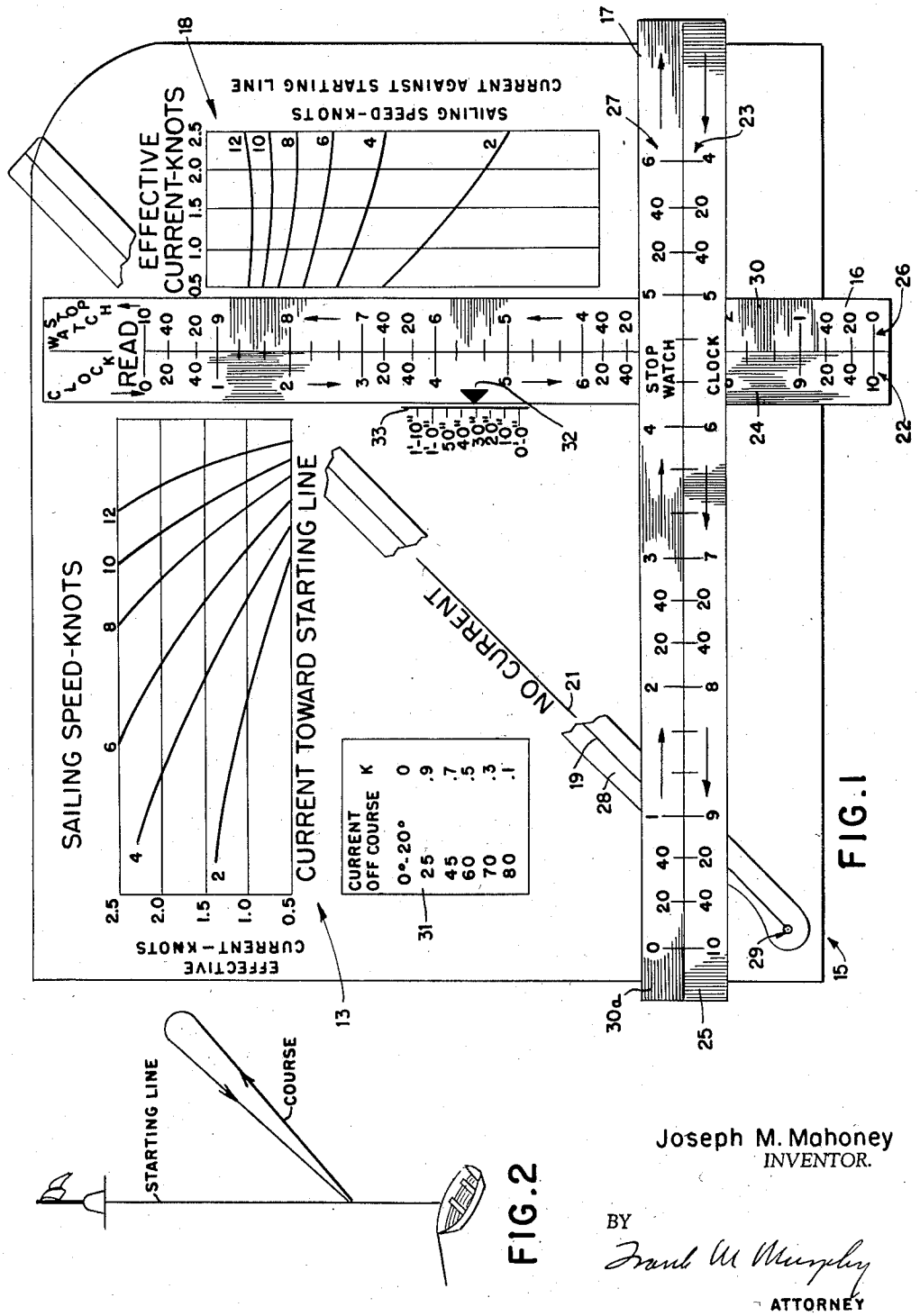


FIG. 1

FIG. 2

Joseph M. Mahoney
INVENTOR.

BY

Frank M. Murphy
ATTORNEY

July 29, 1958 J. M. MAHONEY 2,845,223

BOAT CALCULATOR

Filed April 5, 1957 2 Sheets-Sheet 2

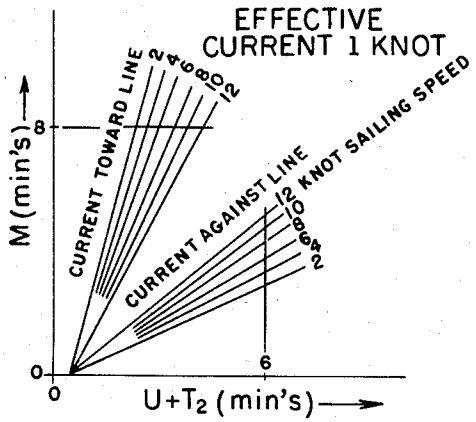


FIG. 3

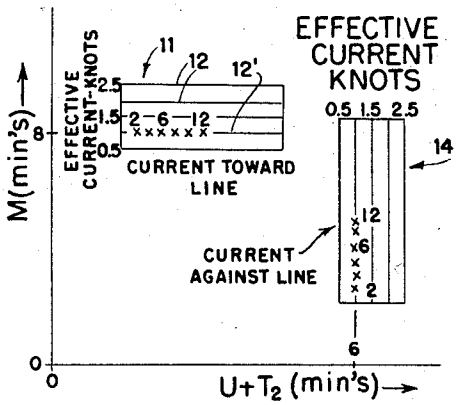


FIG. 4

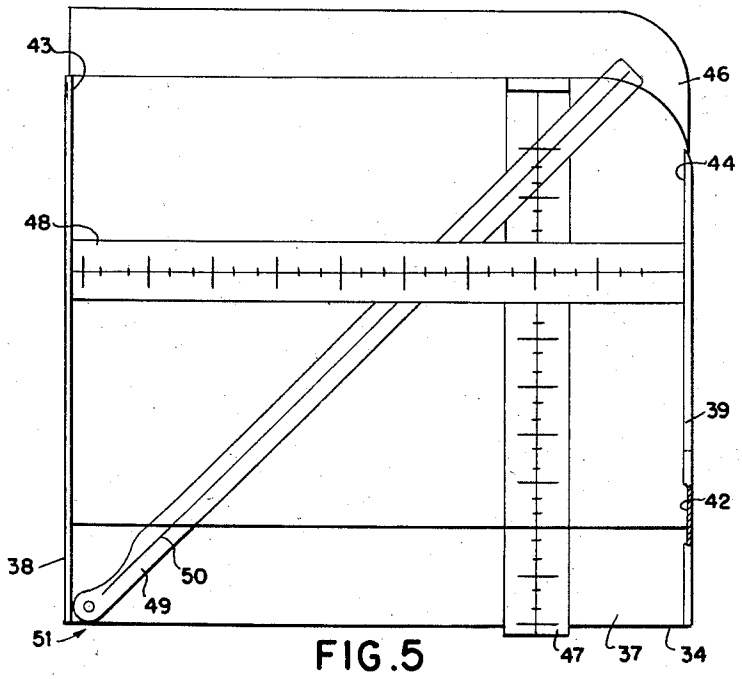


FIG. 5

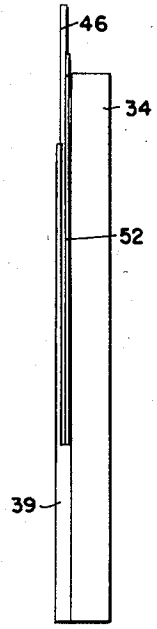


FIG. 7

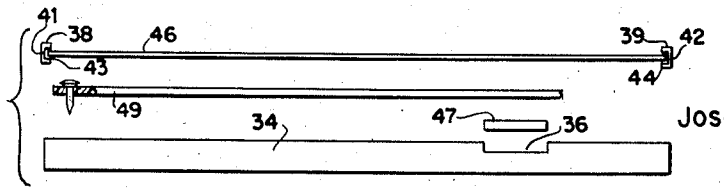


FIG. 6

Joseph M. Mahoney
INVENTOR.

BY

Frank W Murphy

ATTORNEY

United States Patent Office 2,845,223 Patented July 29, 1958

2,845,223

BOAT CALCULATOR

Joseph M. Mahoney, Yonkers, N. Y.

Application April 5, 1957, Serial No. 651,000

1 Claim. (Cl. 235—61)

This invention relates to navigation and provides a calculator for use in plotting a maneuver of a boat, for example.

The calculator of the invention will be best understood by considering a particular maneuver which it may be used to plot. Such a maneuver is the movement of a yacht executed immediately preceding the start of a race. This maneuver is depicted in Fig. 2 of the accompanying drawing and reference is made thereto. Exactly ten minutes before the start of a race, a warning gun is fired, and the yachts competing must cross the starting line at or after the expiration of the ensuing ten minute interval, i. e. at or after the starting time. During the ten minute interval, each yacht executes a maneuver the purpose of which is to have the yacht cross the starting line going in the direction of the race course at or shortly after the starting time. Commonly, the maneuver comprises crossing the starting line heading in a direction away from the direction of the race course, holding this heading for a period of time, and then coming about and heading for the starting line. The first yacht to cross the line after the starting time has a very significant advantage over the other yachts. However, crossing the line before the starting time results in a great disadvantage since when this occurs the yacht must go back and cross the line again. Hence, each skipper tries to start coming about at such a time that his yacht will cross the line after but near the starting time.

Heretofore, the time to start coming about has been estimated with the aid of the Vanderbilt formula which is:

$$\frac{M+U}{2}=U+T_2$$

where

M=total time for the maneuver (difference between time yacht crosses line heading away from direction of race course and the starting time)

U=time required to make a 180° turn

T_2=time for returning to starting line after making 180° turn.

The term $U+T_2$ gives the answer in the usually desired form as it is the time remaining when according to the formula the yacht should commence coming about.

It will be observed that this formula does not take into account either sailing speed or current. That sailing speed is not accounted for need be of no significant consequence as this can be made substantially the same for both legs of the maneuver by sailing away and sailing in the direction of the race course with the wind abeam of the yacht course. That current is not accounted for is significant, however, and renders the formula merely a means of obtaining a rough approximation of the solution, i. e. the time to start coming about. Hence when this formula is used, coming about is delayed a significant time after the time indicated by the formula in order to insure that the starting line will not be crossed early.

The magnitude of this delay is determined by a mental estimation of what the sailing conditions required.

I have invented a calculator which can be adapted for use in plotting a starting maneuver and can be provided with means for taking current into account. The calculator of the invention comprises a base having mounted thereon elements for constructing a maneuver graph applicable under conditions existing during the maneuver. The elements comprise a horizontal axis and a vertical axis each having a scale laid out thereon, an arm having a line marked thereon pivotally secured to the base of the calculator, and a parameter graph of two variable conditions which are constant during the maneuver. The parameter graph is keyed to the horizontal and vertical axes so that a point on the parameter graph is a point on the maneuver graph applying for the parameter graph conditions represented by the point, and the maneuver graph for the conditions represented by a point on the parameter graph can be formed by moving the arm to have the line thereon pass through the point on the parameter graph.

When the calculator of the invention is used as a calculator for the starting maneuver of a yacht race, the horizontal and vertical axes can each have a time scale laid out thereon, one scale representing total time for the maneuver (M) and the other representing the time at which the yacht should commence to come about $(U+T_2)$. The parameter graph can be of current and sailing speed. Advantageously, the calculator is adapted for use with yachts requiring different periods of time for making a 180° turn by mounting one axis so that it is movable in the direction in which it extends and mounting a time adjustment scale on the calculator base alongside the movable axis. An index mark on the scale of the movable axis can be provided for use in positioning the movable axis relative to the time adjustment scale. Thus, by manipulation of the movable axis, it can be set relative to the pivot point of the arm mounted on the base so that the calculator is adapted for construction of a maneuver graph for the particular yacht with reference to which it is used.

The invention will be better understood by reference to the accompanying drawing, of which:

Fig. 1 is a schematic representation of a calculator according to the invention;

Fig. 2 is a schematic representation of the maneuver carried out by a yacht immediately preceding the commencement of a race;

Fig. 3 and Fig. 4 are schematic representations depicting a manner in which a parameter graph for a calculator according to the invention may be constructed;

Fig. 5 is a plan view of a calculator of the invention showing the physical structure thereof;

Fig. 6 is an expanded front elevation of the calculator shown in Fig. 5; and

Fig. 7 is an end elevation of the calculator shown in Fig. 5.

The formulas which are the basis of the calculator depicted in the drawings are derived by assuming that sailing speed away from the line is equal to sailing speed toward the line and that the component of the current perpendicular to the course can be neglected. The sailing speeds may be made substantially equal by sailing with the wind abeam of the course as is indicated in Fig. 2, and, if the course away from the line is substantially equal to the course toward the line as is also indicated in Fig. 2, the effect of the current component perpendicular to the course, like the effect of the wind, will be substantially the same on both legs and hence can be neglected. Thus the component of the current in the direction of the course away from or toward the line is the effective current.

The formula applicable when the effective current is

against the line, i. e., in the direction opposite the direction of the race course, is:

$$T_1=\frac{R_2(M-T_1-U)-d}{R_1} \quad \text{(I)}$$

This formula is derived in the following manner:

$$R_1T_1=D_1$$
$$R_2T_2=D_2$$
$$D_1=D_2-d$$
$$R_1T_1=R_2T_2-d$$
$$M=T_1+U+T_2$$
$$T_2=M-T_1-U$$
$$R_1T_1=R_2(M-T_1-U)-d$$
$$T_1=\frac{R_2(M-T_1-U)-d}{R_1}$$

where the subscripts "1" and "2" denote respectively that the reference letters with which each is associated denominate variables for the leg traveled while sailing away from the starting line and the leg traveled while sailing toward the starting line, and

R=sailing speed plus or minus effective current,
T=time sailing toward or away from line,
D_1=distance along course between line and point turn is started,
d=drift while making turn,
D_2=distance along course between end of turn and line,
M=total time for maneuver,
U=time required to make 180° turn.

The formula applicable when the effective current is toward the line is:

$$T_1=\frac{R_2(M-T_1-U)+d}{R_1} \quad \text{(II)}$$

This formula may be derived in a manner similar to that in which Formula I was derived.

The turning time U of a yacht can be made constant for a given yacht by proper handling of the yacht by the helmsman and when the variables current and sailing speed are fixed, Formula I and Formula II reduce to the form $y=mx+b$, and hence T_1 is a straight line function of M, and, since $U+T_2=M-T_1$, $(U+T_2)$ is a straight line function of M. $(U+T_2)$ is the time remaining when the yacht commences to come about and the solution is in more convenient form when expressed in this manner.

I have found that for a given turning time and when the effective current is fixed and sailing speed is employed as a parameter, plotting $Mv(U+T_2)$ gives a family of straight lines all intersecting at a point. This is depicted in Fig. 3. To construct a calculator according to the invention, there are made several graphs of the type shown in Fig. 3, each for the same turning time and a different effective current, and data from these graphs is then combined on a single coordinate system of $Mv(U+T_2)$. In this way, there is placed on the single coordinate system one or more parameter graphs of the two variables effective current and sailing speed which are each constant during the starting maneuver.

In Fig. 4 there is shown a single coordinate system of $Mv(U+T_2)$ having placed thereon a parameter graph **11**. This parameter graph is for use when the effective current is toward the line and is obtained by drawing horizontal lines **12**, preferably at equal spacing, on the coordinate system, and then assigning to these lines in consecutive order values representing effective current toward the line, and then transposing points from several graphs such as the one shown in Fig. 3 to the single coordinate system and the parameter graph. For example, to obtain points on the parameter graph **11** from the family of lines of Fig. 3, the line **12'** of the parameter graph, which is for a 1 knot effective current toward the line, is extended to obtain its M axis intercept which is at 8 minutes, and then the abscissas of points on the lines of Fig. 3

for a 1 knot effective current toward the starting line which have ordinates of 8 minutes are transposed to the 1 knot effective current line, **12'**, on the parameter graph **11**. By doing this for various effective currents toward the line and then drawing a curve through each set of points representing the same sailing speed, there is obtained a parameter graph such as parameter graph **13** shown in Fig. 1.

The parameter graph may be positioned on the single coordinate system at any location desired, and, advantageously, a separate parameter graph **14**, Fig. 4, is provided for current against the line.

Referring now to Fig. 1 where there is schematically represented a calculator according to the invention, there is there shown a single coordinate system **15** comprising a vertical axis **16**, a horizontal axis **17**, parameter graphs **13** and **18**, operating line **19** and no current line **21**. The vertical axis indicates the time available M in which to make the starting maneuver, i. e. 10 minutes less time elapsing between firing of the warning gun and crossing the starting line going away from the direction of the race course. The horizontal axis indicates the time $(U+T_2)$ at which the yacht should commence coming about. The vertical axis **16** and the horizontal axis **17**, respectively, have laid out thereon elapsed time scales **22** and **23**, for use when the skipper uses a clock, and remaining time scales **26** and **27**, for use when the skipper uses a stop watch which indicates time remaining. Advantageously, in order to minimize the possibility of error in the use of these scales, the background of the elapsed time scale of each axis is the same color and the background of the remaining time scale of each axis is the same color and the color of the elapsed time scale backgrounds is different from the color of the remaining time scale backgrounds. Such a color arrangement is depicted in Figure 1. As there shown, the backgrounds of the elapsed time scales **22** and **23** are indicated at **24** and **25**, respectively, to be red, and the remaining time scales **26** and **27** are indicated at **30** and **30***a*, respectively, to be blue.

Parameter graphs **13** and **18** are obtained in the manner hereinbefore described with reference to parameter graphs **11** and **14** shown in Figure 4. When derived in this manner, the parameter graphs are for a given turning time and this may advantageously be 30 seconds.

The operating line **19** is inscribed on an arm **28** which is pivoted at point **29**.

The coordinates of the pivot point **29** on single coordinate system **15** are obtained in the course of obtaining the parameter graphs **13** and **18**. In obtaining the parameter graphs, for several effective currents, and using sailing speed as a parameter, the total time M for the starting maneuver is plotted against the time $(U+T_2)$ to commence coming about, and several families of straight lines (one family for each effective current) are obtained. The lines of each family intersect at a single point and this point is the same for all the families. The coordinates of this point are employed as the coordinates of the pivot point **29**.

No current line **21** is inscribed on the single coordinate system and indicates the position which the operating line **19** should be in when no current is running.

To operate the calculator it is necessary to know the existing conditions sailing speed and effective current. The sailing speed can be determined from the yachts speedometer. The strength of the current can be obtained from current tables, the direction by noting the wake of the starting buoy, and the effective current can be calculated by using a factor taken from correction table **31** positioned on the single coordinate system **15**. When the sailing speed and effective current have been determined, the arm **28** is positioned so that the operating line **19** overlies the no current line or a point on one of the parameter graphs **13** and **18** which represents the effective current and sailing speed. The time

($U+T_2$) to come about is then determined by moving horizontally from the point on the verticle axis **16** representing total time M for the maneuver to the operating line **19** and then vertically down to the horizontal axis **17** where the answer ($U+T_2$) is read. Advantageously, the horizontal axis is made slidable in the direction perpendicular to the direction in which it extends. When so arranged the answer can be obtained by moving the horizontal axis to the representative point on the vertical axis and then reading the answer directly off the horizontal axis where the operating line meets this axis.

In order to adapt the calculator for the construction of maneuver graphs for yachts having different turning times, the vertical axis **16** is made movable in the direction in which it extends and is provided with an index mark **32**, and a turn time adjustment scale **33** which indicates seconds required for a 180° turn and is disposed alongside the movable scale on the single coordinate system **15**. The calculator is adapted for use with a particular yacht by moving the vertical axis so that the index mark **32** is opposite the reading on the turn time adjustment scale **33** indicating the time required for the yacht to make a 180° turn. The vertical axis is then properly set relative to the pivot point **29** for the starting maneuver calculation. If desired, the horizontal axis **17** can be made movable in the direction in which it extends so that adjustment for turning time could be made with the horizontal instead of the vertical axis. However, the physical construction of the calculator is simplified by making it so that the adjustment is made with the vertical axis rather than the horizontal axis.

The turn time adjustment scale is constructed by making it for no current running. For no current running, Formula I (or Formula II) reduces to $M=2T_2+U$ and hence a graph of $Mv(U+T_2)$ employing U as a parameter gives a family of parallel straight lines. Thus, different turning times for no current running can be allowed for by making one of the axes movable.

Although the turn time adjustment scale is constructed for no current running, it can be used as such when a current is running as no significant error results when this is done.

The parameter graphs **13** and **18** are constructed for a particular turning time, and hence an error may result from the use of these graphs when the turning time is other than that for which they were constructed. However, this error will not be significant either. In fact, accumulation of errors because of the basis on which the parameter graphs and time adjustment scale are constructed will not even be significant. Advantageously, to minify possible errors, the parameter graphs and the turn time adjustment scale can be based on an average turn time, e. g. 30 seconds.

In a preferred form of the calculator of the invention, as is shown in Figure 1, the two parameter graphs **13** and **18**, which are each for a different range of the effective current, are remotely positioned from the pivot point **29**. Remote positioning of a parameter graph increases the accuracy of the calculator and the use of two parameter graphs rather than one further increases accuracy.

Referring again to the operation of the calculator, if desired, instead of determining effective current from current tables, observing the wake of the starting buoy, and then calculating the effective current, this variable may be determined by making a trial run and using the calculator to solve for the effective current.

A preferred physical construction for the calculator of the invention is shown in Figure 5, Figure 6 and Figure 7. As shown in these figures, the calculator comprises a flat base **34**, having an elongated groove **36** in its upper face **37**, and two elongated side pieces **38** and **39** fixedly secured to the upper face **37** and disposed parallel to and one on either side of the elongated groove **36** in the base. Elongated grooves **41** and **42** are disposed respectively in the confronting surfaces **43** and **44** of the side pieces **38** and **39**, and a transparent plate **46** is slidably mounted on the base with opposite edges thereof disposed in the side piece grooves. The vertical axis **47** is slidably mounted in the elongated groove **36** in the base and the horizontal axis **48** is mounted on the transparent plate. The arm **49** having the operating line **50** laid out thereon is pivoted at point **51** adjacent one end of side piece **38**, and side piece **39** is formed to provide a slot **52** disposed intermediate the base **34** and the side piece **39** so that the pivot arm may be moved over a large area of the base. Parameter graphs, not shown, are mounted on the base **34** within the area swept by the arm **49**, and preferably are remotely positioned from the pivot point **51**.

It is highly advantageous to mount the horizontal axis in the manner described, i. e. on a transparent plate which rides in grooves of side pieces secured to the calculator base, as such construction greatly facilitates manipulation of the calculator.

When the calculator shown in Fig. 5 is employed as a calculator for plotting a yacht race starting maneuver, the scales and parameter graphs thereof can advantageously be as is indicated in Fig. 1 and the calculator can advantageously be provided with a turn time adjustment scale as is shown in Fig. 1. In actual dimensions the base of the calculator can be about 7½″ x 9″, and preferably about 9″ x 11″, and the single coordinate system can cover an area of about 7″ x 8½″ and preferably about 9″ x 10″. Such a calculator is of convenient size and at the same time is of such size that errors inherent in the device due to assumptions employed in its construction will not be of significant magnitude.

Having now described my invention, what is claimed is:

A calculator comprising a flat base having an elongated groove in the upper face thereof, two elongated side pieces fixedly secured to said upper face, the side pieces being disposed parallel to and one on either side of the base groove, an elongated groove in each of the confronting surfaces of said side pieces, a transparent plate slidably mounted on said base having opposite edges thereof disposed in the side piece grooves, an axis having a scale laid out thereon slidably mounted in the base groove, another axis having a scale laid out thereon mounted on the transparent plate, said other axis being at 90° to the first mentioned axis, and an arm having a line laid out thereon pivotally secured to said base.

References Cited in the file of this patent

UNITED STATES PATENTS

1,965,017	Wellington	July 3, 1934
2,422,649	Bland	June 17, 1947

FOREIGN PATENTS

402,897	Germany	Sept. 25, 1924
423,734	Germany	Jan. 8, 1926