THE U. S. COAST AND GEODETIC SURVEY STANDARD AUTOMATIC TIDE GAUGE

by

PAUL SCHUREMAN, CHIEF OF SECTION OF TIDE REDUCTIONS,
U. S. COAST AND GEODETIC SURVEY, WASHINGTON.

(Extract from the *Manual Of Tide observations* U. S. Coast and Geodetic Survey Special Publication N° 196, Washington, 1935).

NOTE :

There have been some recent changes in the standard automatic tide gauge. One of these changes permits the pencil screw to be removed for cleaning without disturbing the wiring. Another change is an improved hour-tripping hook more easily adjustable for any desired length of hour mark.

DESCRIPTION

The present standard automatic tide gauge used by the Coast and Geodetic Survey is a development of the Stierle gauge adopted by this Survey many years ago. A float operates in a vertical box or pipe to which the slow moving tide has free access while the more rapid moving waves resulting from winds are largely damped out by the relatively small size of the inlet to the box. The rising and falling of the float operates a worm screw (6) on the gauge which moves a pencil to and fro across a wide strip of paper which is moved forward by clockwork. The combined motion of pencil and paper gives a continuous graph showing the rise and fall of the tide.

Names of parts. — For convenience of reference there are given below the names applied to different parts of the standard automatic tide gauge. The numbers correspond to those given in figures.

1. Time clock.
2. Motor clock.
3. Clock case.
4. Supply roller.
5. Tension springs.
6. Pencil screw.
7. Pencil arm return spring.
8. Pencil screw ball bearing.
9. Binding screw for pencil screw bearing.
10. Counterpoise drum.
11. Float drum.
12. Float drum clamping nuts.
13. Float drum clamping nut wrench.
14. Main roller.
16. Tension weight drum.
17. Receiving roller.
18. Receiving roller release buttons.
19. Winged nuts securing clock unit.
20. Datum pencil rod.
21. Datum pencil clamp.
22. Datum pencil holder clamping nut.
23. Datum pencil holder.
24. Datum pencil.
25. Datum pencil clamping screw.
26. Hour tripping rod.
27. Clamping screws, tripping rod assembly.
28. Hour tripping weight.
29. Hour tripping lever.
30. Hour tripping lever clamping screw.
31. Hour tripping lever spring.
32. Hour tripping arm binding screw.
33. Hour tripping arm.
35. Carrier wheel.
36. Hour tripping hook.
37. Recording pencil.
38. Recording pencil holder.
39. Recording pencil clamping screw.
40. Recording pencil holder adjusting screw
41. Pencil arm.
42. Recording pencil weight.
43. Pencil arm bearing.

Clock Unit. — The clock unit consists of two clocks mounted on a frame. Facing the unit, the clock on the left (2) is the *motor clock* which has for its function the turning of the main roller at a uniform rate, thus regulating the forward movement of the record paper. The clock on the right (1) is called the *time clock* and has for its function the striking of the hour marks on the record. By use of two clocks, the time clock is relieved of unnecessary work and may therefore be more accurately regulated to

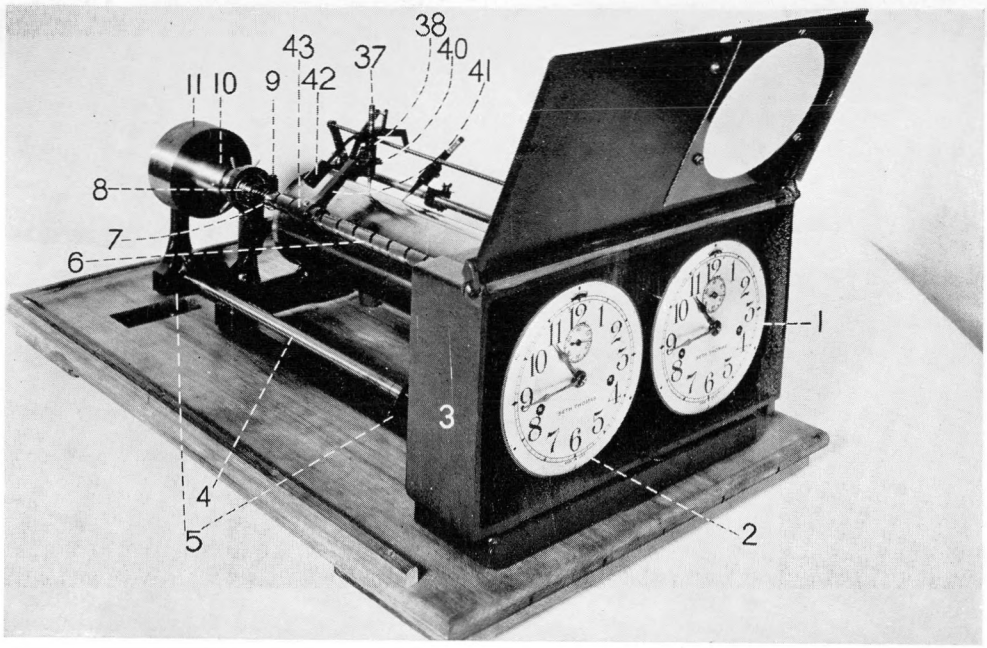

FIG. 1.

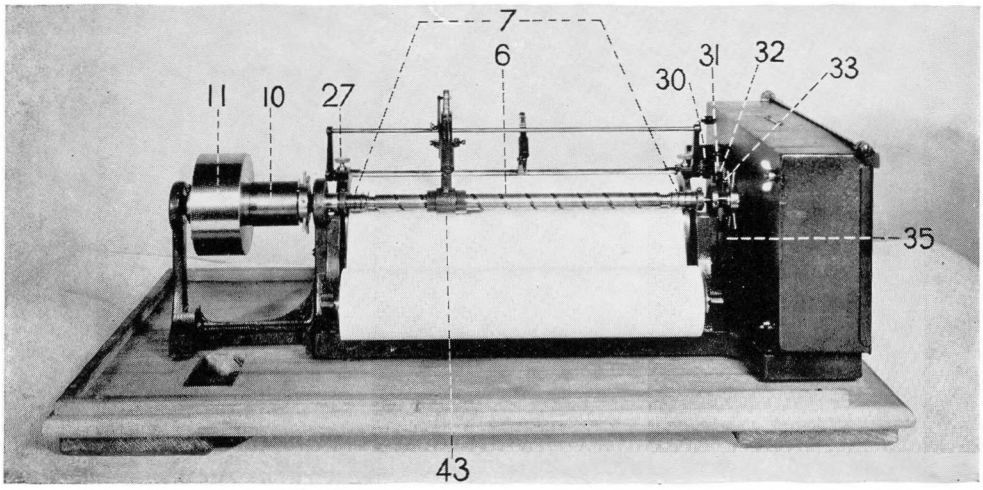

FIG. 2.

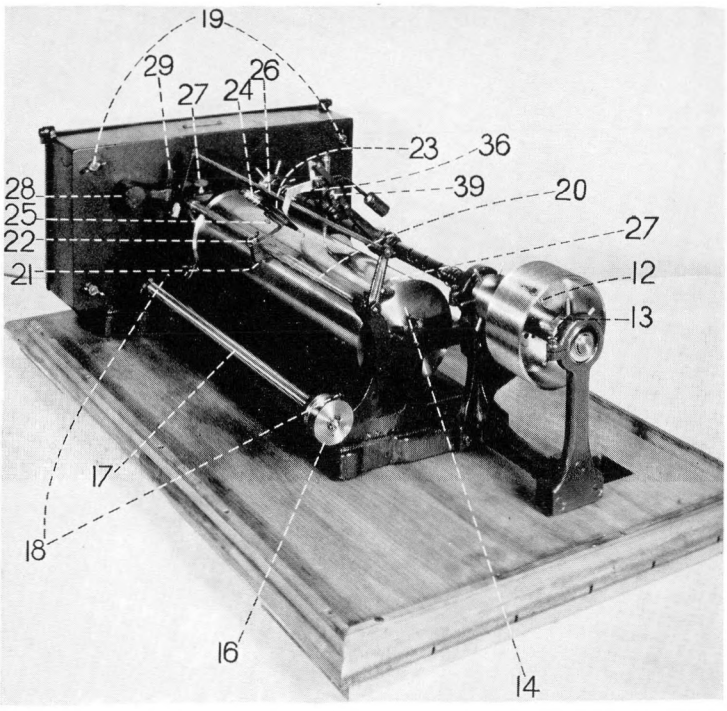

FIG. 3.

keep and record the correct time. The use of two clocks has the additional advantage of aiding in the securing of a continuous record since the stopping of either one of the clocks over a limited period of time will not cause a complete loss of the record, which may be interpreted through the functioning of the remaining clock.

When the clock unit is in position, a spindle operated by the motor clock extends through the back of the clock case and has secured to its extremity a toothed carrier wheel (35), which actuates the main roller of the gauge when engagement is made through a hinged carrier arm attached to the latter. Projecting from the time clock through the back of the clock case is a spindle carrying a short arm (33) which is actuated by a cam in the clock. This operates the hour-marking device which is described below.

Each clock has an 8-day movement and may be regulated and corrected as similar clocks in ordinary use. To avoid injury to the hour-marking device of the time clock, however, the minute hand must not be turned backward when between 10 minutes before and 5 minutes after the hour "12". The hour hand may be turned in either direction, and if it is necessary to turn the clock backward within the limits noted above, it may be accomplished by turning the hour hand back a full hour and the minute hand forward to the correct time.

If either clock runs consistently fast day after day, the regulating lever should be moved slightly toward the letter "S"; and if consistently slow, the lever should be moved toward the letter "F", care being taken not to move the lever so far as to introduce an error in the opposite direction. If the loss or gain in any one day is less than 3 minutes, it is, in general, inadvisable to move the regulator unless there has been a similar loss or gain on a number of consecutive days.

The clock unit is secured in the clock case by four winged nuts (19) on the back of the case, and is interchangeable with other units when replacement is necessary. In older types of the standard tide gauge, the two clocks were mounted independently in the clock case, the time clock on the left and the motor clock on the right.

Rollers. — There are three rollers on the gauge, which are designated as the *supply roller*, the *main roller*, and the *receiving roller*. The *supply roller* (4) is a solid rod on which the blank roll of paper is placed. This rod is readily removable from the gauge and is passed through the hole in the center of the blank roll. When on the gauge it is held in place in its bearings by tension springs (5) on each side. These springs also press against the ends of the roll of paper and keep it from unwinding too fast so that the paper will be held taut between the supply roller and the main roller. The pressure of the springs may be regulated by slightly bending them.

The *main roller* (14) is a hollow cylinder 12 inches in circumference and has attached to its axis at one end a hinged carried arm which engages with the carrier wheel geared to the motor clock. Through this connection the roller is rotated at the rate of one turn in 12 hours, thus feeding the paper forward at the rate of 1 inch per hour. Near each end of the cylinder sharp steel pins are set at 1-inch intervals to keep the paper from slipping over the roller and insure that its movement will correspond to that of the roller.

The *receiving roller* (17), which is designed to receive the completed record, consists of a solid core with one side flattened and an outer shell in which a slit runs its entire length. With the slit opposite the flattened side of the core, the end of the paper is inserted and then secured in place by a slight turn of the shell. The roller is held in place in its bearings by pins which may be released by pressure on the buttons (18) at each end. At one end of the receiving roller there is a small drum (16) provided with a pawl and ratchet, upon which is wound a cord attached to a weight. A silk fish line is generally used for the cord, which is designated as the *tension cord*. The weight, known as the *tension weight*, serves to wind up the record paper on the receiving roller, and by keeping a tension on the paper also assists the motor clock in turning the main roller. A weight of 12 ounces to 1 pound is generally satisfactory for this purpose, and when used with a movable pulley the extra weight of the latter largely offsets the diminished strain on the tension cord resulting from this method of suspension.

Record paper. — The paper for the standard automatic tide gauge is furnished in rolls about 13 inches wide and containing about 66 feet in length, which is sufficient for 1 month of record. The paper is plain without any ruling. After the tide curve has been traced upon the tide roll the record is called a *marigram*.

Pencil screw. — The pencil screw (6) is a rod about 5/8 inch in diameter with a square screw thread with a 1-inch pitch, except that for a very large range of tide a

screw with a ½-inch pitch is used. The pencil screw is rotated through the action of the float as the tide rises and falls, and in turn actuates the pencil arm causing a pencil to trace the record. The threads at each end of the pencil screw are turned down to prevent the pencil arm from jamming on reaching the extreme limits of the rod, and springs (7) are provided at each end to return the arm to the threaded portion of the screw as soon as the tide reverses.

Pencil arm. — The pencil arm (41) carries the recording pencil and is actuated by the pencil screw, moving toward the clock unit on a rising tide and in the reverse direction on a falling tide. In the bearing of the pencil arm (43) is a pin which fits into the thread of the pencil screw by means of which the motion is communicated. The pencil arm contains a holder (38) in which either an ordinary or a special automatic pencil (37) can be used. A medium soft pencil is recommended.

Datum pencil holder. — The datum pencil holder (23) carries the pencil (24) which traces the datum line. Either an ordinary or special automatic pencil may be used in the holder. Attention is called to the fact that the clamping device by which the datum pencil holder is secured to the rod (20) consists of a split block (21) held together by two screws. One of the screws is covered by the spring attached to the holder proper and must be tightened before the spring is placed in position. The other screw is secured by the clamping nut (22) after the holder has been adjusted to the position desired.

Hour-marking device. — The hour-marking device is actuated by the time clock. A cam attached to the main shaft of the clock turns with the minute hand and operates a lever which is connected with a small arm (33) projecting from the back of the clock case. This arm in turn presses against the spring (31) attached to the lever (29) which is connected with the tripping rod (26). A tripping weight (28) holds the lever against the tripping arm. Beginning 30 minutes after the hour, the cam gradually swings the tripping arm and lever outward raising the weight and moving the tripping rod toward the recording pencil. The limit of the movement is reached at the striking of the hour, when the cam suddenly releases the lever causing the tripping weight to fall and the tripping rod to strike the hook (36) attached to the pencil holder. This causes the pencil to make a short hour mark parallel to the edge of the paper. The pencil is then immediately returned to its original position through the action of the pencil weight (42).

Float drum. — The float drum (11) which operates the pencil screw is threaded to accommodate the wire to which the float is attached. A set of four interchangeable drums, with circumferences of 6, 9, 12 and 16 inches, is provided with the gauge to adapt it to different ranges of tide. For very large ranges, drums 24 inches in circumference are also available. The drums now in general use are about 1 1/8 inches wide and have threads cut in the face to accommodate 18 turns of the float wire or 16 turns to the inch. Drums are also available with widths approximating 1 3/4 inches with a corresponding increase in the number of turns of the wire. There is a small hole drilled through the face of the drum near the outer edge to secure the end of the float wire. The float drum is secured to the counterpoise drum on the pencil screw by two clamp nuts (12), which may be set by a special wrench (13) provided for the purpose. When these nuts are loosened, the drum may be turned to any desired position.

Counterpoise drum. — The counterpoise drum (10) to which is attached the wire supporting the counterpoise weight, is secured directly to the pencil screw and has the float drum clamped to one side. The counterpoise drum is about 5 ½ inches in circumference and is furnished in different widths to correspond to the width of the float drum used. The counterpoise drum that is 1 1/8 inches wide will contain when filled a little more than 8 feet of wire, and the larger drums a proportionally greater length. A small clamp or hole near the inner edge of the drum affords a means for attaching the counterpoise wire. The wires are so arranged on the float drum and counterpoise drum that when one winds up the other unwinds.

Wire. — Phosphor bronze or nickel-chromium wire (N° 23 American gauge) is used to connect the float and counterpoise weight to their respective drums. The nickel-chromium wire is stronger but less pliable than the phosphor bronze wire. Since the threads on the drums are designed for this size wire it is important that it be used as any other size wire introduces a slight error in the scale of the gauge.

Float. — The float designed for standard automatic gauge has a diameter of 8 ½ inches. Assuming the weight of sea water, fresh water, and kerosene to be, respectively, 64 pounds, 62.4 pounds, and 55 pounds per cubic foot ; the corresponding buoyance

per inch of immersion of a cylindrical float of this diameter is 2.10 pounds, 2.05 pounds, and 1.81 pounds, respectively. In the normal operation of the gauge with a strain of from 12 to 16 ounces on the float wire, the float should be about one-half submerged. As a free float the immersion will be from 1/3 to 1/2 inch deeper.

Counterpoise weight. — The counterpoise weight acts upon the counterpoise drum to create a tension in the float wire and take up slack in the wire as the tide rises. It is usually connected with the drum by wire and may be either attached directly to the wire or act through a movable pulley, the latter arrangement being in general preferable. For the most satisfactory operation of the gauge, there should be a tension of 3/4 to 1 pound in the float wire. The weights recommended for different float drums will be found in the table of scale combinations below.

Scale of gauge. — The height scale of the gauge depends upon the circumference of the float pulley and the pitch of the pencil screw. The different scale combinations are shown in the table below :

SCALE COMBINATIONS.

Float drum circumference.	Pencil screw pitch.	Scale of gauge.	Range Limit		Counterpoise weight.	Counterpoise (total).	Float wire tension.
			Curve.	Extreme.			
Inches.	*Inch.*		*Feet.*	*Feet.*	*Pounds.*	*Pounds.*	*Pounds.*
6	1	1:6	6	9-14	1	2	0.93
9	1	1:9	9	13-21	2	3	.93
12	1	1:12	12	18-28	3	4	.93
16	1	1:16	16	24-37	4	5	.88
24	1	1:24	24	36-56	6	7	.82
16	½	1:32	32	24-37	4	5	.88
24	½	1:48	48	36-56	6	7	.82

In the above table the range limit of the curve shows the maximum range that can be recorded by a continuous curve with the scale indicated. Beyond this limit the pencil arm becomes disengaged from the threads of the pencil screw and further rise and fall is registered by a series of jogs near the margin of the paper. The extreme range which can be recorded by these jogs depends upon the size of the float drum. In the column for the extreme range limit two values are given for each scale. The first value is the limit when float and counterpoise drums have a width of 1 1/8 inches, and the second value when the width is 1 3/4 inches. The counterpoise weight given in the table for each scale is that recommended when the weight is supported from a movable pulley and is exclusive of the 1-pound pulley now in use. The total weight of counterpoise including the movable pulley is given in the next column. If the counterpoise weight is attached directly to its wire without a movable pulley, the weight given in the seventh column should be halved.