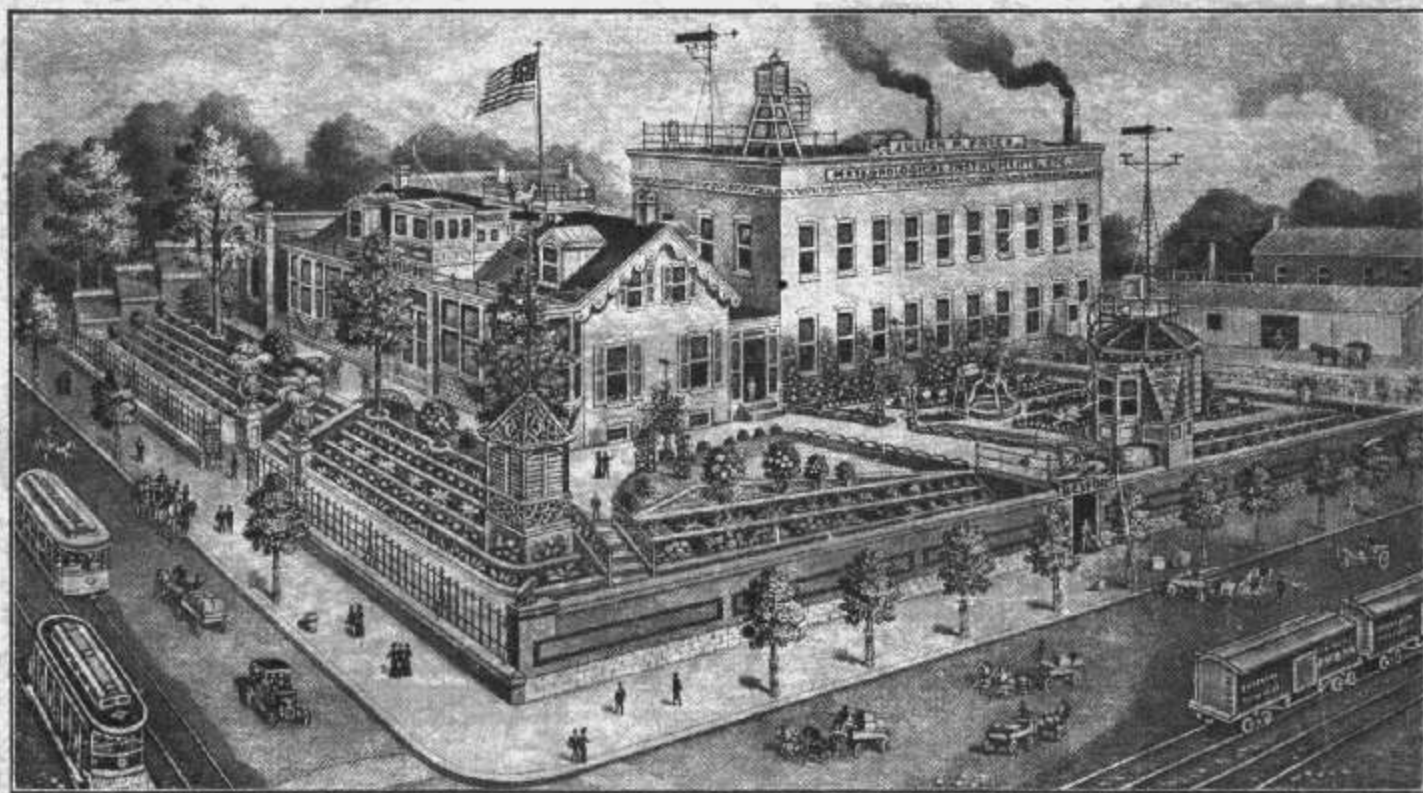


(CIRCULAR RG.)

C551.5078
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1910

INSTRUCTIONS
FOR THE
INSTALLATION, CARE AND MANAGEMENT
OF
FRIEZ'S STANDARD PATTERN
RAIN AND SNOW, AND
TIPPING-BUCKET RAIN-RECORDING
GAGES.



PUBLISHED AT
BELFORT OBSERVATORY
BALTIMORE, MD., U. S. A.
1910

Friez (Julien P.), Baltimore

(CIRCULAR RG.)

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FG422

1910

INSTRUCTIONS

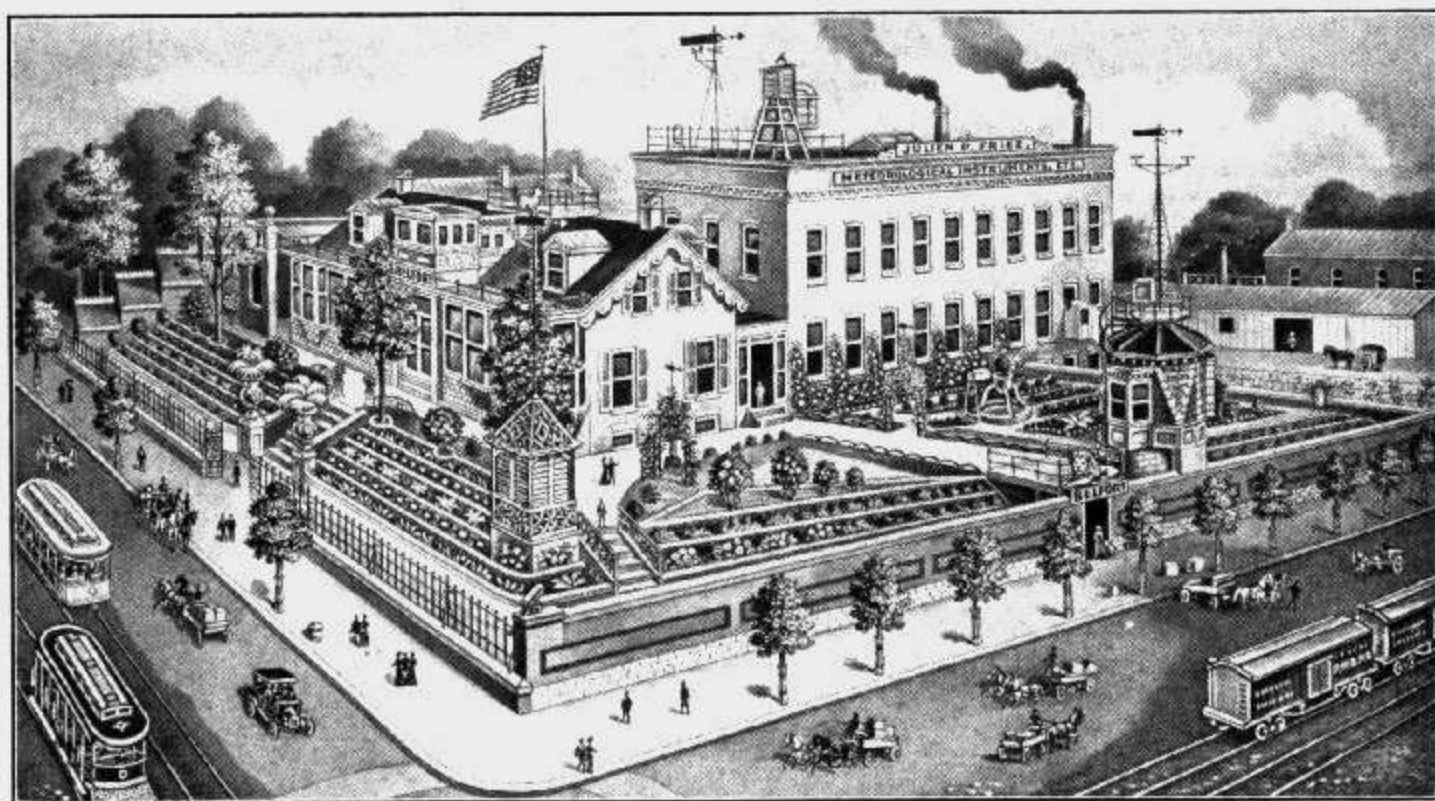
FOR THE

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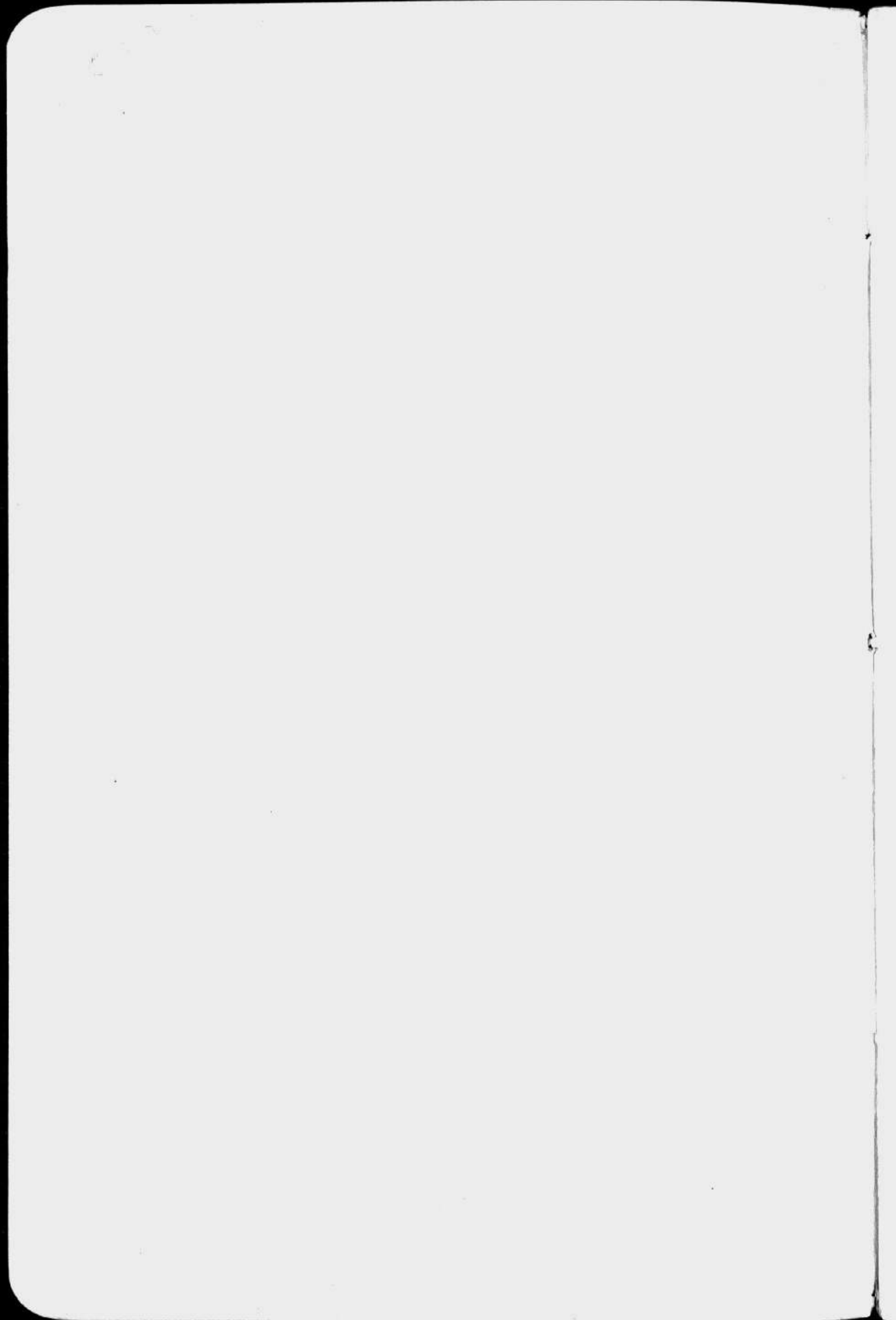
FRIEZ'S STANDARD PATTERN

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THE MEASUREMENT OF PRECIPITATION.

1. Rain, snow, hail, etc., are all included under the general designation, precipitation.

Rain.—The amount of rain falling at any time is measured on the basis of the depth of water which would accumulate on a level surface if all of it remained as it fell and none flowed or soaked away or was lost by evaporation.

Snow, hail, etc., are measured both on the basis of the actual depth of the precipitation; also, and more definitely, by first melting the snow or hail and thereby obtaining the equivalent depth of melted precipitation.

EXPOSURE OF GAGES.

2. The exposure of gages is a very important matter. The wind is the most serious disturbing cause in collecting precipitation. In blowing against the gage the eddies of wind formed at its top and about the mouth carry away rain, and especially snow, so that too little is caught. Snow is often blown out of a deep gage after once lodging therein.

a. Rain gages in slightly different positions, if badly exposed, catch very different amounts of rainfall. Within a few yards of each other two gages may show a difference of 20 per cent. in the rainfall in a heavy rainstorm. The stronger the wind the greater the difference is apt to be. In a high location eddies of wind produced by walls of buildings divert rain that would otherwise fall in the gage. A gage near the edge of the roof, on the windward side of a building, shows less rainfall than one in the center of the roof. The vertical ascending current along the side of the wall extends slightly above the level of the roof, and part of the rain is carried away from the gage. In the center of a large, flat roof, at least 60 feet square, the rainfall collected by a gage does not differ materially from what is collected at the level of the ground. A gage on level, open ground, with a tight board fence 3 feet high around it at a distance of 3 feet, will collect 6 per cent. more rain than without the fence. These differences are due entirely to wind currents.

b. Care should therefore be taken in selecting a place for the location of the gages as the value of the records is sometimes greatly impaired by improper exposure. It is scarcely necessary to say that every precaution should be taken to protect gages from the interference of unauthorized persons and animals. Select, if possible, a position in some open lot unobstructed by large trees, buildings, or fences. Low bushes and fences, or walls that break the force of the wind in the vicinity of the gage are, however, beneficial, if at a distance not less than the height of the object. Such a place, in general, affords the best exposure. Gages should be exposed upon roofs of buildings only when better exposures are not available; and, when so located, the middle portion of a flat, unobstructed roof, generally gives the best results.

3. Fully equipped observatories should also have in addition to the self-recording raingage one of the standard 8-inch rain and snow gages. The latter is useful in warm climates and seasons for check measurements of rainfall in cases of emergency, and, in cold climates and seasons, the "overflow" forms a convenient *snow* gage and receptacle for other kinds of precipitation at temperatures below freezing. Where two separate gages are thus employed, they should be given as nearly as possible the same exposures, not nearer than 4 feet to each other.

4. Snowfall is preferably measured as depth of water rather than by the thickness of layer it forms on the ground. When it can not be measured by melting, it is customary to take *one-tenth* the measured depth of the snowfall on a level open place as the water equivalent of the snowfall. The relation between the depth of snow and depth of melted snow is very different in different cases, depending on the wetness of the snow. The equivalent depth of water in some cases is as great as one-seventh of the depth of snow, and in others may be as small as one thirty-fourth. It is always best to reduce snow to a liquid condition for measurement, and the simplest way of doing this is to add to it a known volume of water sufficient to reduce it to a state of slush. (See paragraph 11, second method.)

Description of standard 8-inch rain and snow gage.

5. The gage consists of the following parts: (See Fig. 1.)

- The receiver at top;
- The overflow attachment (snow gage) outside;
- The rain measuring tube, inside;
- The iron tripod support, and
- The rain measuring stick (shown at left in cut).

The top cylindrical portion of the receiver is exactly 8 inches in diameter, inside, and is provided with a funnel-shaped bottom, which

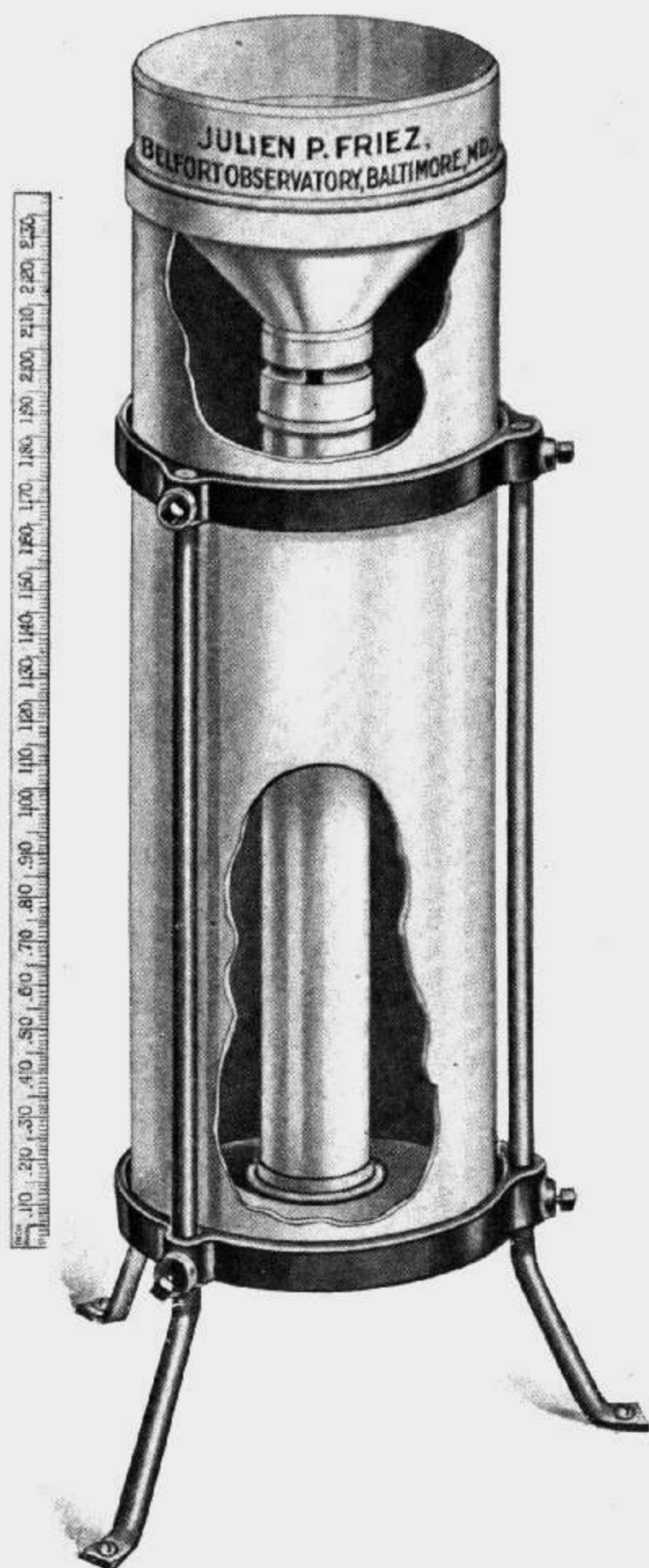


FIG. 1.—Standard Rain and Snow Gage complete, on iron tripod support.

conducts rain falling into the receiver into the tall cylindrical measuring tube, the total height of which, inside, is exactly 20 inches.

The diameter of this tube is much smaller than the large receiver, being only 2.53 inches. In consequence of this a small amount of rain falling into the receiver and flowing into the measuring tube fills the latter to a depth greater than the actual rainfall in proportion as the area of the receiver is greater than the area of the measuring tube. In the standard gages of the United States Government the depth of the rainfall, in accordance with this principle, is magnified just ten times. The receiver has a sleeve which slips over the inner tube and prevents loss of rainfall. When the rainfall is very heavy the inner tube may be filled to overflowing. In this case the excess of rainfall escapes between the sleeve and the tube and is retained in the outside, overflow, attachment, where it can be measured afterwards, as will be described. The inside diameter of the overflow attachment in the standard gages is just 8 inches, and this portion of the instrument may be used as a *snow gage*, as explained in paragraph 11.

6. The measuring stick is best made of a strip of straight-grained cedar 0.5 of an inch wide, 0.08 of an inch thick and 24 inches long, and graduated into inches and tenths of inches. Remembering that the actual depth of the rainfall is magnified ten times, as explained above, it is plain that if we find the water 10 inches deep in the measuring tube, then the *real* rainfall must have been only *one* inch deep, or if the water in the tube is only *one-tenth* of an inch (or written as a decimal, 0.1 of an inch) deep, then the rainfall must have been only *one-hundredth* of an inch (or written as a decimal, 0.01 of an inch).

RAIN-GAGE SUPPORT.

7. *Iron tripod support.*—Fig. 1 also illustrates the gage mounted in the standard iron tripod support, which, when erected upon a roof platform, is easily secured by screws through the feet. When a ground exposure is selected for the gage, it will be sufficient to drive down three substantial wooden stakes until about flush with the surface, screwing the feet of the tripod to these. If the ground is so hard that the tops of the stakes are bruised in pounding, it will be best to stop driving a few inches short of the surface; saw off the projecting stakes to the proper level and thus secure firm holding wood for the screws in the stakes.

TO MEASURE RAINFALL AND SNOWFALL.

RAINFALL.

8. The depth of the water is measured by inserting the measuring stick into the gage through the small hole in the funnel. When the

stick reaches the bottom of the measuring tube it should be held for one or two seconds, and then quickly withdrawn and examined to see at what division of the graduation the top of the wet portion comes. The numbering of this division, *as stamped on the stick*, gives, as has just been explained, the actual depth of rainfall, and in making out records and reports *the decimal expressions* should always be used.

9. After measuring and recording in this way the precipitation found in the gage, the top should be removed, the measuring tube lifted, emptied and drained, and the gage put in position again. After emptying the gage carefully, replace the measuring tube so that the bottom stands within the ring or bead in the middle of the bottom of the overflow, and in putting on the receiver see that it passes over the measuring tube and rests squarely down upon the overflow.

10. When the amount of rain that has fallen more than fills the measuring tube, some care is required to determine the total rainfall. First carefully remove the receiver so as not to spill any of the water in the measuring tube, which should be exactly full. If some water has been slopped out and the measuring tube is not exactly full, the amount of water remaining must be accurately measured with the stick, as already described. The tube is then lifted out slowly and carefully, so as not to spill any of the water into the overflow, emptied, and allowed to drain a moment or so. The water remaining in the overflow is now poured into the measuring tube, being careful not to lose any, and measured in the usual way. Suppose we find this to be 0.47 inch rainfall, then, remembering that the measuring tube is just 20 inches high, the total rainfall will be 2 inches plus 0.47 of an inch = 2.47 inches. Or, in case some water was spilled from the measuring tube, the 0.47 inch should be added to the first measured amount to give the total rainfall.

SNOWFALL.

11. During the winter season, especially in those climates where the precipitation is nearly all in the form of snow, it is sufficient to expose only the overflow attachment in the support as a *snow gage*, removing the receiver and measuring tube to the house, as these parts can not be used for measuring snow, and even if rain should occur it is very apt to be frozen while in the measuring tube, generally bursting it and rendering it worthless or highly inaccurate.

First method.—The snowfall collected in the overflow attachment is measured by first placing the vessel in a warm room until the snow is melted. The water is then carefully poured into the measuring tube and measured just as though it were rainfall.

Second method.—The above method is objectionable, because it often requires considerable time, and is liable to be inaccurate, owing

to the loss of the snow or water by evaporation. The following plan is much better, if carefully conducted, so as not to spill and waste the water: Take the overflow into the room and pour into it, carefully, *one measuring tube full to the brim* with water, preferably warm water. This in general will mostly melt, or at least reduce to a very fluid slush a considerable snowfall. The measuring tube should be again carefully filled to the brim from the melted contents of the overflow and emptied; whereupon the remaining water in the overflow should be carefully measured in the measuring tube, thus giving quickly and easily the depth of melted snow.

12. In addition to this measurement by the gage a measurement will be made of the actual depth in inches of the snow on the ground. Select a level place of some extent, where the drifting is least pronounced, and measure the snow in at least three places. The mean of these measurements will give the snowfall, which is to be entered in the column of the report headed "depth of snowfall in inches," and whenever it is impracticable to melt the snow as described in the preceding paragraphs, one-tenth of this mean will give an approximate value, in water, for the snow which could not be melted. This value must be set down in the proper column of the record in precisely the same manner as rainfall or snow melted in the gage. After snowfall has once been measured the same snow should not be measured at subsequent observations. Any fresh snow, however, should, of course, be measured and recorded as falling between the regular hours of observation.

INSTRUCTIONS FOR USE OF FRIEZ'S SELF-RECORDING TIPPING-BUCKET RAIN GAGE.

DESCRIPTION OF GAGE.

13. The gage comprises five principal sections or parts, namely:
- (1) The rain collector and inclosing case, which are in three pieces.
 - (2) The bucket frame with electrical contacts.
 - (3) The tipping bucket.
 - (4) The tripod support for the whole, as above, and
 - (5) The rain measuring tube and stick.
- All as shown in Fig. 2.

The collector and the middle section are separately detachable from the lower section of the inclosing case, in order to facilitate access to all the parts.

The top section, called the receiver or collector, is made of a sharp-edged brass rim, accurately 12 inches in diameter, inside, and pro-

vided with a funnel-shaped bottom and a small tubulure at the center so that all the water falling within the collector is conducted to a point directly over the center of the tipping-bucket bearings. The

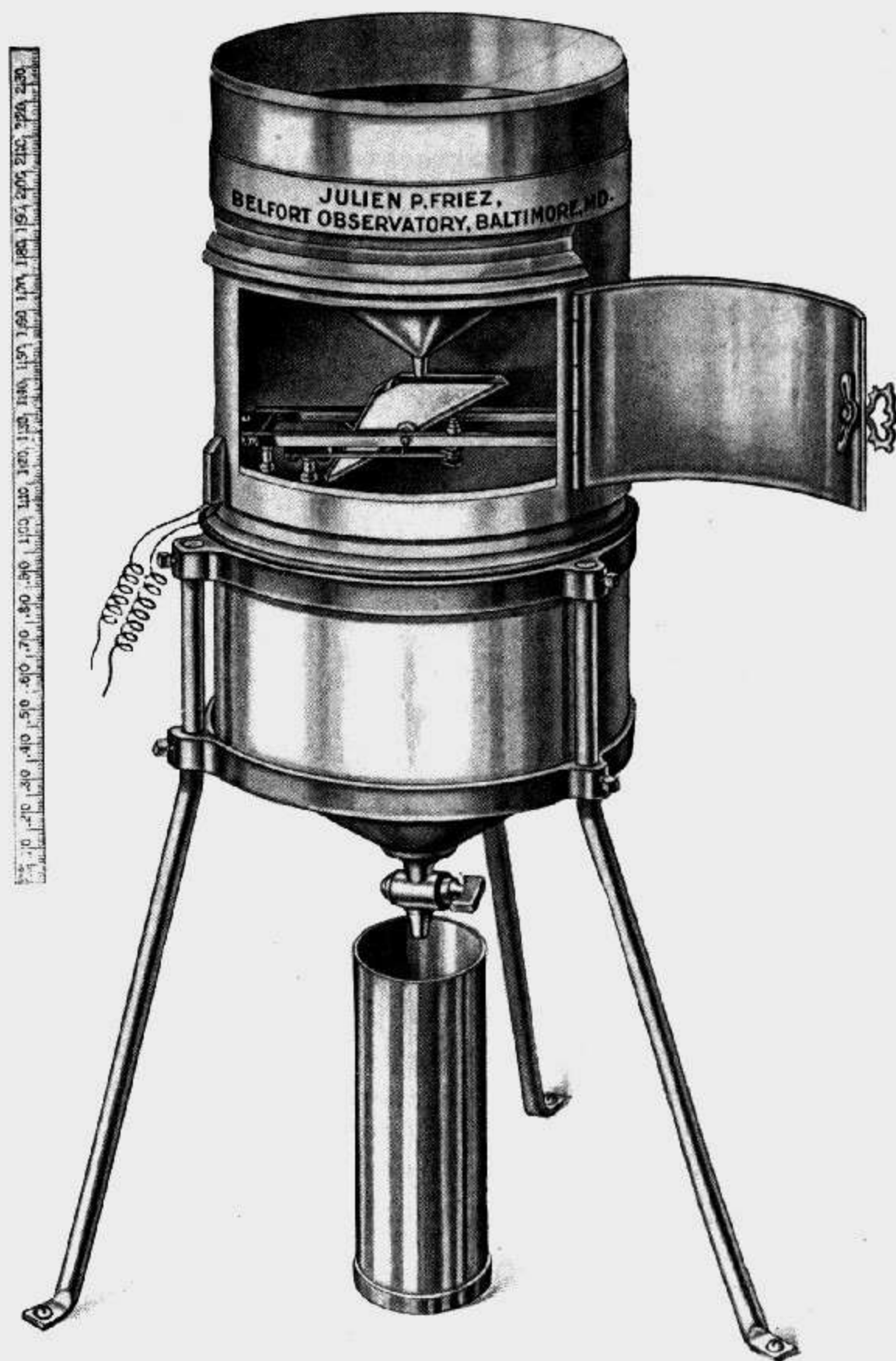


FIG. 2. Standard Tipping-Bucket Raingage, complete; door open, showing mechanisms.

middle section is made of galvanized iron, with a hinged door, as shown in the cut, and the lower section, or reservoir, is also of galvanized iron, and provided with a brass stopcock at the bottom, for

emptying the gage of water. The brass bucket is divided by a central partition into two equal compartments, as indicated. This bucket is mounted on suitable bearings placed below the center of gravity. Two knife-edge stop pins on the side of the bucket opposite that shown in the cut, limit the movement of the bucket on its axis and permit it to rest in one of two positions, in which either one or the other of the compartments of the bucket is presented in such a manner that it will receive and retain the water delivered through the funnel of the collector. The weight of the bucket and the position of its center of gravity have been so adjusted in relation to its supports that when one of the compartments has been charged with the quantity of water representing one one-hundredth of an inch of rain in the 12-inch gage, the bucket tips over upon its bearings, emptying the water from the one compartment, and at the same moment presenting the other compartment to receive the incoming water. The water thus delivered from the buckets is retained in the reservoir section for subsequent measurement in bulk.

AUTOMATIC RÉGISTRATION.

14. The automatic registration of each hundredth of an inch of rainfall, that is, each tip of the bucket, is effected by aid of the electrical circuit—closer shown just under the bucket in Fig. 2, operating in conjunction with suitable wire connections, battery and register, as illustrated in diagram, Fig. 3. When the bucket is at rest in either of its two limiting positions a sector, attached to the bucket, stands near to, but not in contact with, the pin on the insulated contact spring. In the act of tipping, after the bucket has moved a little, the sector makes contact with the pin and rubs over it during the greater part of the subsequent motion. This effectually closes the electric circuit which is formed between the whole metallic framework, including the bucket, and the insulated spring. During the last portion of the tip of the bucket the sector slips off and moves a small distance away from the pin, thus opening the electric circuit, and also leaving the bucket perfectly free to tip with the next hundredth of an inch of rain.

15. While the contact of the sector with the pin will, in general, suffice to effectually close the electric circuit, yet in order to further insure closure it is arranged that while the contact spring is deflected, during the passage of the sector over the pin, the platinum-tipped end of the spring makes contact with the platinum point attached to the adjustable post, thus providing a second simultaneous independent closure of the electric circuit.

16. *Adjustment of contact spring.*—The contact spring is in proper adjustment when the end rests against the insulated point on the

adjusting screw and when, upon tipping the bucket the sector rather easily rubs over the pin; at the same time the platinum tip must make contact with the platinum point on the adjustable screw. If latter is but slightly touched by the sector, or is missed entirely, or if it must be pushed aside considerably and presses hard against the sector while passing, these defects may, in general, be remedied by properly turning the adjusting screw. In some cases it may be necessary to bend the spring slightly as well as to adjust the screw. All instruments are in perfect adjustment when sent out, and little or no occasion should arise for readjustment if the mechanisms are properly cared for. The holes in which the axis of the bucket rests are intentionally about twice the diameter of the pinions in order to diminish the friction to the minimum. One of the holes is slotted on top to permit the bucket to be removed for cleaning, etc. *In replacing a bucket the sector must, of course, come adjacent to the contact spring.*

17. To insure better and more positive electrical connection during the short period of contact (about three-tenths of a second) the brass frames of all these gages made since 1906 are fitted with *two* spring contacts, similar to the one mentioned above.

18. *Instructions for mounting.*—As packed for shipment the gage as a whole is practically assembled complete, except that the tripod legs are not attached, and the bucket is not mounted in its frame. The manner of attaching the iron legs to the ring supports will be readily understood from an inspection of the parts and of Fig. 2. The gage, as a whole, should be practically *level* and perpendicular; otherwise, the bucket which is controlled by gravity will not tip uniformly. All other parts being in position, the brass bucket is then inserted through the open door. *Note: This bucket must always be put in place so that its stop pins strike on the brass frame OPPOSITE the side having the slotted-hole axis bearing.*

The electrical connections are made as described in paragraph 24, and, for convenience in attaching the wires inside the gage, the two binding posts on the brass frame should come *at the left-hand front*, as shown in Fig. 2.

19. *Accuracy of measurement.*—The accuracy with which any given bucket will deliver a certain quantity of water at each tip has been made the subject of elaborate and exhaustive experimental investigations. Notwithstanding that every precaution has been taken to secure the greatest accuracy in the adjustment of the buckets, yet, owing to unavoidable irregularities in the action of the water in the buckets, and the fact that a very small discrepancy in the volume of a single tip may become quite appreciable in the total volume of one or two hundred tips, it may occasionally be found that the total volume shown by the automatic record is discrepant with the actual volume of water retained in the reservoir.

This results from one or more of several unavoidable causes. The buckets have been adjusted to deliver the proper volume of water for moderate rates of rainfall, such as most frequently prevail. During very heavy showers, when, for example, rain is falling at the rate of 5 or 6 inches per hour, each bucket will be filled to the tipping point in from six to seven seconds, or thereabouts. Inasmuch as a very small but nevertheless perceptible amount of time is required for the bucket to tip far enough to cut off the inflow of water, it is obvious that during such rapid rainfalls an appreciable quantity of water will flow into the bucket after it has begun to tip. Accurate tests show that the time required by the standard buckets to tip from the starting point to a point where the inflow of water is cut off is about three-tenths of a second. It therefore follows that when the water is flowing into the bucket at a rapid rate—such, for example, as will fill the bucket to the tipping point in six seconds—then during the three-tenths of a second occupied in tipping, water will continue to flow into the bucket, and the excess thus delivered will be about one-twentieth of the whole amount; that is, an inch of rainfall will cause the bucket to tip only about 95 times, whereas the same amount of rain at a slow rate would cause the bucket to tip 100 times. The discrepancy from this cause has been reduced as much as possible, but it can not be entirely eliminated in the case of small buckets—such, for example, as will make 100 tips per inch of rainfall.

It will be found, also, that the different hygroscopic conditions of the metal surfaces cause the water to wet the buckets in a different manner on different occasions. This will lead to a slight difference in the volume of water delivered per tip of the bucket.

After being thoroughly wetted with more or less dirty rain water, which afterwards dries away, a sediment is left upon the metal surfaces, and this alters their hygroscopic character, so that it is very desirable that at least the inside surfaces of the buckets be kept as clean as possible and free from hygroscopic sediment. The bucket may be removed from the supporting frame with great facility for this purpose, and from time to time as may be required by atmospheric conditions observers should thoroughly clean the compartments of the bucket and see that no deposits of dirt accumulate in the bearings of the axis or about the small pinions of the bucket. Special pains must be taken to avoid bending these latter, as slight changes here will have an important effect in changing the volume of water delivered per tip.

20. *Cleanliness.*—The most serious cause of error in the amount of water delivered per tip has been found to be due to the effects of dust and corrosion on the frame and stop pins of the bucket. It is absolutely necessary that dust and corrosion be frequently cleaned away from the stop pins and the points on the frame where the pins strike.

Of course the bucket and frame should be kept clean elsewhere also, but as soon as the pins and the points of contact on the frame become dirty a slight adhesion is established between the two when in contact. When the dirt at these points becomes wet or damp, as it does during long rains, the adhesion becomes aggravated and more water must enter the bucket in order to overcome the sticking at the stop pin, thus causing a more or less serious deficiency of record. The stop pins and points of contact on the frame must therefore be kept as clean as possible, and the stop pins are made with knife-edges to facilitate this.

21. *Effects of faulty leveling.*—If the brass frame which carries the bucket is not properly leveled, then one of the compartments will deliver a greater and the other compartments a less volume of water, per tip, than the normal amount. The average of the two will, however, still remain very nearly the exact normal volume, and while the errors resulting from small defects of level are not serious, yet it is desirable that when installing the gage some pains be taken to make the frame upon which the bucket is mounted as nearly level as practicable.

ELECTRICAL CIRCUITS AND BATTERY.

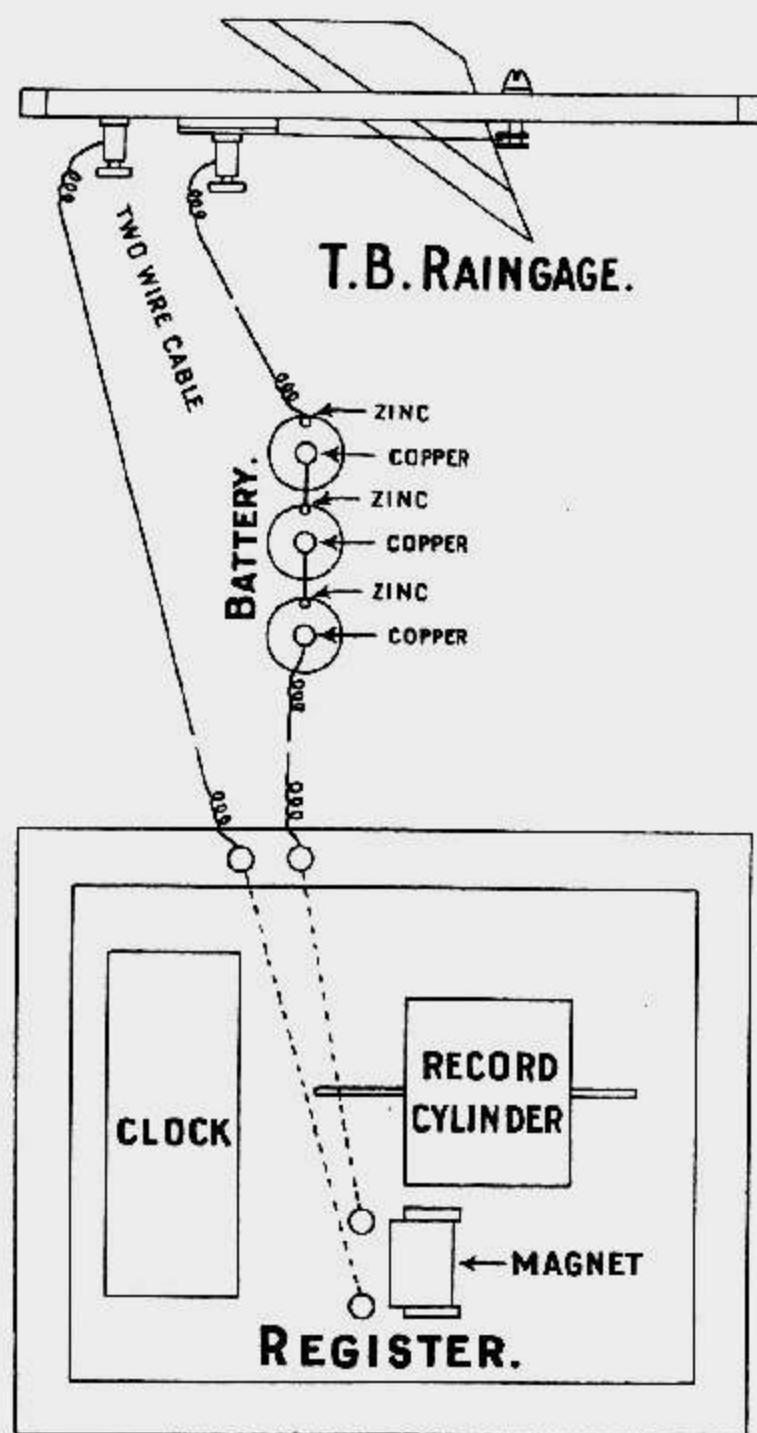


FIG. 3.—Conventional diagram of circuits.

22. This diagram shows clearly the arrangement of the very simply electrical circuits required with this apparatus, as ordinarily installed on a circuit where the rain gage is located not more than 300 feet distant from its register, under which condition a battery of 3 cells is employed. The register and battery are, of course, placed in the office, or observatory, indoors, in any arrangement or location that may be most convenient or desirable.

23. *Wires and Cables.*—A 2-conductor cable is usually employed between the battery and gage, and, where the latter is given a *ground* exposure, a *lead-covered* cable should be used (if for a permanent installation), as this cable may readily be buried underground out of the way, and no special conduit is required. For *roof* exposures of the gage—the standard okonite 2-conductor cable will last for many years. Or, 2 single-conductor heavily insulated wires may be used instead. All wires and cables should be run by the most direct route convenient, and so installed as to be the least liable to injury or short-circuiting.

24. *Circuits.*—The gage being located at the place desired, strip back the insulation on the ends of the wires for a few inches; scrape the copper wires until clean and bright; pass them up through the outlet in the tank of gage provided therefor, into the interior, and bend cable over so as to hold in position. The two wires are then to be inserted into their respective binding posts of brass frame of bucket, as indicated in drawing. The other end of the cable, or wires, will then be similarly stripped of insulation, wires scraped bright, and one carried direct to one of the binding posts of the register; splicing securely with office-wire, if desired, for neat installation. The remaining end is carried to the zinc, or negative, pole of the battery. A short length of office wire, similarly treated, extending from the copper, or positive, pole of the battery to the other binding post on the register base (Fig. 4) completes the electrical circuit, and any closure of the circuit by the tipping of the bucket will actuate the armature of the magnet and cause a movement of the recording pen on the record cylinder.

25. *Batteries.*—Any form of good, primary, battery is adapted for use with this apparatus. Dry cells may be employed for temporary work, but they are generally of short life and are not recommended. The battery should be set up carefully in accordance with the manufacturer's leaflet of instructions accompanying the same, and are to be connected together in series, as shown in the diagram, viz: copper to zinc, thus insuring the greatest electromotive force. Enamelled steel cells are recommended, being much more durable than glass.

Where the gage is located at a greater distance than about 300 feet from its register, an additional cell of battery should be put in for each additional 200 feet.

Make sure that all connections of wires into binding posts are tight and secure, and where splices are required in cable or wires, the twisted wires should be well soldered and the joint thoroughly cleaned of all acid to prevent corrosion.

Test.—The circuits should be tested occasionally, either by pouring water into the gage, or by tipping the bucket back and forth by hand, to insure that everything is in good working condition.

RECORDING MECHANISMS.

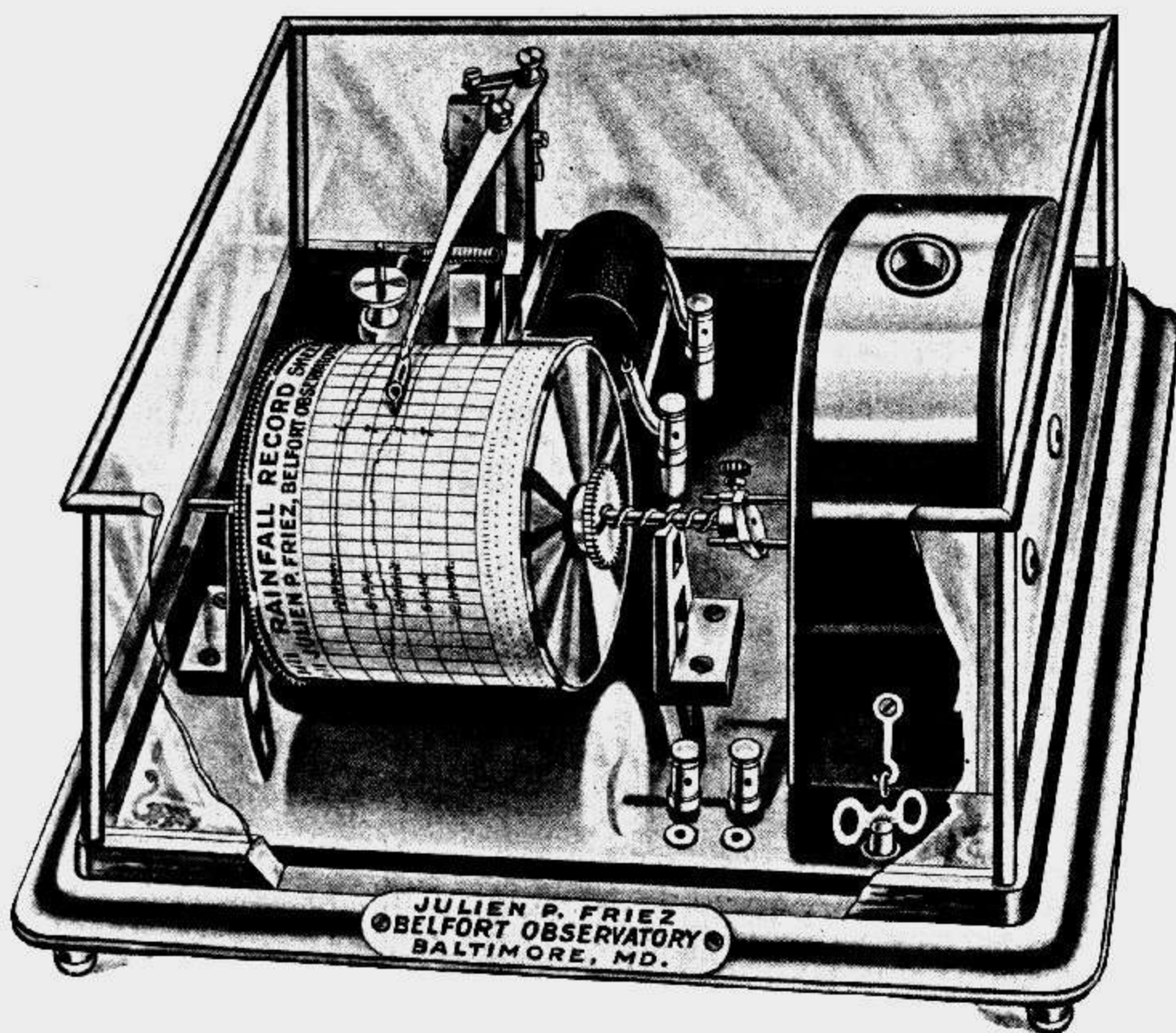


FIG. 4.—Rainfall Register.

26. *Recording mechanisms.*—Automatic registration of rainfall from the apparatus already described is secured by electrical connections with suitable register placed in the office or observatory, either single or quadruple as may be in use. The single register, for rainfall only, is clearly shown in the above cut, Fig. 4, with part of glass cover case removed to give a better view of the mechanisms and a sample record as actually produced. The surface of the recording drum of these registers necessarily moves at a comparatively rapid rate (2 inches per hour). Nevertheless, in order to render the registration of the most rapid rates of rainfall perfectly legible, the

recording pen traces its record in a zigzag line of steps, each step representing a hundredth of an inch of rain. One complete zigzag contains just ten steps, and while in the majority of cases the individual steps are perfectly legible, yet in records of very rapid rates each individual step can not always be discerned, but the groups of five steps, as marked by the lateral extremities of the zigzag trace, are perfectly conspicuous and legible under even the most rapid rates.

27. The recording pen on the zigzag marker upon examination will be found to be easily adjustable laterally, and observers should arrange it so that the entire zigzag trace falls properly within the available space on the record sheet.

28. The record sheets are changed daily at 12 noon. To do this the whole pen arm is lifted a short distance upon the staff supporting it and turned to one side, thus providing free access to the cylinder, which is then disconnected from the clock, lifted out, the old sheet taken off and the new one put on. In replacing the pen care must be exercised to place the steel pin within the groove of the cam wheel which produces the zigzag motion. The clock will be wound once a week.

When the pen of the rainfall magnet has been lifted from the sheet temporarily, care should be exercised not to in any way disturb or move the armature of the magnet, or to make any change in the position of the ratchet cam, except such as results from the closure of the electric circuit. If these parts are not disturbed the pen, when replaced, will continue its trace of steps in proper sequence relative to the original trace. By this precaution the pen may be lifted from the sheet for a short time while record is being made, and while a few steps of the cam may be taken during the interruption of the record and of which no corresponding trace is made, yet an examination of the record with respect to the complete zigzag will, in general, show what number of steps less than ten were lost.

29. *Check readings.*—Owing to the unavoidable sources of error in the volume of the water delivered per tip of the bucket under various circumstances, as explained in paragraph 19, it is necessary that when rain has been recorded the total volume of water in the gage shall be checked with the automatic record, and for this purpose the observer will enter upon the record sheet the "stick measurement" of the gage at the time the sheet is changed.

30. *Check readings, how made.*—To ascertain the total volume of water in the gage the water retained in the reservoir will be drawn off into the brass measuring tube, with which each gage is provided, and the amount measured in hundredths of an inch by stick in the usual way.

31. Observers are cautioned against using the small brass measuring tube belonging to the ordinary (8-inch) gage for measuring the rainfall collected in the tipping-bucket (12-inch) gage. If, from necessity, the small tube is used, the apparent depth of rainfall measured in the smaller tube must be divided by 2.25, in order to ascertain the true depth of rainfall in the 12-inch gage.

32. *Precautions against freezing.*—As the tipping-bucket gage does not record snow, or similar precipitation in the solid form, observers will use all necessary precautions to prevent the collection of partly melted precipitation which may subsequently freeze in the buckets to their injury, or otherwise make the gage unserviceable. When such injuries are probable, the cylindrical portions of the gage should be either removed to the office; temporarily covered over or stored indoors during the freezing weather.

33. *Register pens.*—Only the standard register pens should be used with these instruments. This pen is shown in top, end and side views



FIG. 5.

in Fig. 5, and holds a sufficient quantity of the Special Register Ink to last for one week. The pen should be removed from the instrument from time to time and thoroughly washed in water, scraping the parts of the pen a little with a knife blade to remove dried sediment from the ink that is not washed off by the water. In cleaning the pen care must be exercised not to spread or otherwise injure the points. In order to give the most satisfactory results these points must be quite sharp and must very nearly touch each other. Otherwise, too wide a mark will be made on the form, and the records will be indistinct. If, after cleaning, the flow of ink does not start, draw the edge of a thin sheet of paper between the points of the pen.

34. *Ink for pens.*—Only the *Special Ink* provided for registering instruments of this kind should be used. The ink should be replenished in the pen when sheets are changed, and only enough applied to insure a sufficient supply during the next 24 hours. The quantity of ink required depends, of course, on the amount of rainfall being recorded. Avoid smearing the ink on the outside of the pen or over the clips which secure the pen to its arm. These precautions will, in a measure, prevent an accumulation of dried ink and dust about the sides of the pen.

35. *To start the flow of ink* in a new or freshly filled pen, draw a piece of writing paper carefully between the points, so as to wet the inside faces, but in such a manner as not to bend or deform the points or spring them too far apart.

36. The adjustment of the pen should be such as to insure the lightest possible contact at all parts of the sheet. It is found that observers in many cases adjust the pen so that it presses too hard against the cylinder, thereby wearing away the point much more rapidly than is necessary and at the same time clogging it with particles of paper. *Be careful to avoid this fault.* The best way to judge of the amount of pressure between the pen and cylinder is to catch a pencil point under the end of the arm near the pen. The amount of pressure to the spring arm may be judged from the force required to lift the pen from the paper.

37. The pen arms of single and quadruple registers should be curved so as to cause the extreme point of the pen only to come in contact with the paper. It is also an advantage to bend the pen itself a little just back of the rounded portion, thus causing the point to touch the paper at a high angle.

PREPARATION OF RECORDS.

38. *Beginning and ending of precipitation.*—The precise time of beginning and ending of precipitation can not be obtained from automatic records with uniform accuracy under all conditions. The beginning and ending of sudden and heavy showers may be shown with very considerable accuracy, but the record of very gentle rain and snow falls, however, may begin an hour or more after the very first precipitation. Observers should, therefore, as far as possible, make eye observations from day to day of the time of beginning and ending of the several periods of precipitation that occur.

Such eye observations may be recorded on the automatic record sheets (Forms No. 1015 A and Met'l, 1017—Met'l) by direct and reversed check marks, thus, (✓) (∨), accompanied by the letters B and E, respectively, said check marks being placed alongside the record at the points corresponding in time on the sheet to the observed times of beginning or ending of precipitation. Whenever the time of beginning or ending is doubtful, the entry should be accompanied by a query mark (?). Any information that will aid in determining the hourly amounts and rates of rainfall, when imperfectly recorded, should be given if records are to be comparable with those of the Weather Bureau.

The characters B. D. N. or E. D. N. will be used to denote the beginning and ending of precipitation during the night.

When the amounts by register and stick measurements for each observation are discordant by 10 per cent. or more, a brief explanation of the cause of the discrepancy should be noted on the form upon which the disagreement appears.

39. *Correction for errors.*—In the case of the records from the tipping-bucket gage, it must be remembered that, in addition to accidental errors, due to defective action of the recording mechanisms, there will also frequently be found a discrepancy between the recorded and measured amounts, which is apt to increase with the rate of rainfall, and varies slightly with different gages, and even with the same gage under different circumstances, as regards cleanliness, moisture, etc. The observer must, therefore, apportion the corrections with reference to different rates of rainfall, remembering that hours of heavy rainfall should receive greater corrections than hours in which the rainfall is at a slower rate.

In general, the method of apportionment, illustrated in the following examples, will be employed in correcting the automatic records for discrepancies referred to above.

Example 1.—The recorded amount of precipitation is 1.14 and the amount by stick measurement 1.23, showing a deficiency in the recorded amount of .09. This amount must be added to the record; that is, at the rate of 1 tip for each 12 tips recorded ($1.14 \div .09 = 12$; *dropping all fractions*). Therefore, in each group of *twelve* recorded tips one extra tip will be added, and the record thus corrected will equal the stick measurement.

Example 2.—The recorded amount is .86 and the measured amount .80, showing an excess in the recorded amount of .06. One tip must, therefore, be stricken out in each group of 14 recorded tips ($.86 \div .06 = 14$).

In performing the divisions indicated in these examples, the observers should *drop all fractions*.

40. In many cases the exact point at which a tip is added or stricken out is not of great importance, but, in general, these corrections should be made at those portions of the record showing a noticeably rapid rate.

The points at which tips are stricken out in accordance with the foregoing instructions will be indicated on the record sheet by a small cross mark (\times), in red ink, and the points where tips are added by a caret (\wedge) immediately underneath the point; such marks will not be used for any other purpose on rain-gage record sheets.

Postscript.—This Circular of Instructions has been compiled from a perusal of all available literature on the subject, and from a personal knowledge of the apparatus itself which I have manufactured and used at Belfort Observatory for many years. It is hoped the pamphlet may prove useful to all engaged in meteorological work, and it is presented—

With the Compliments of

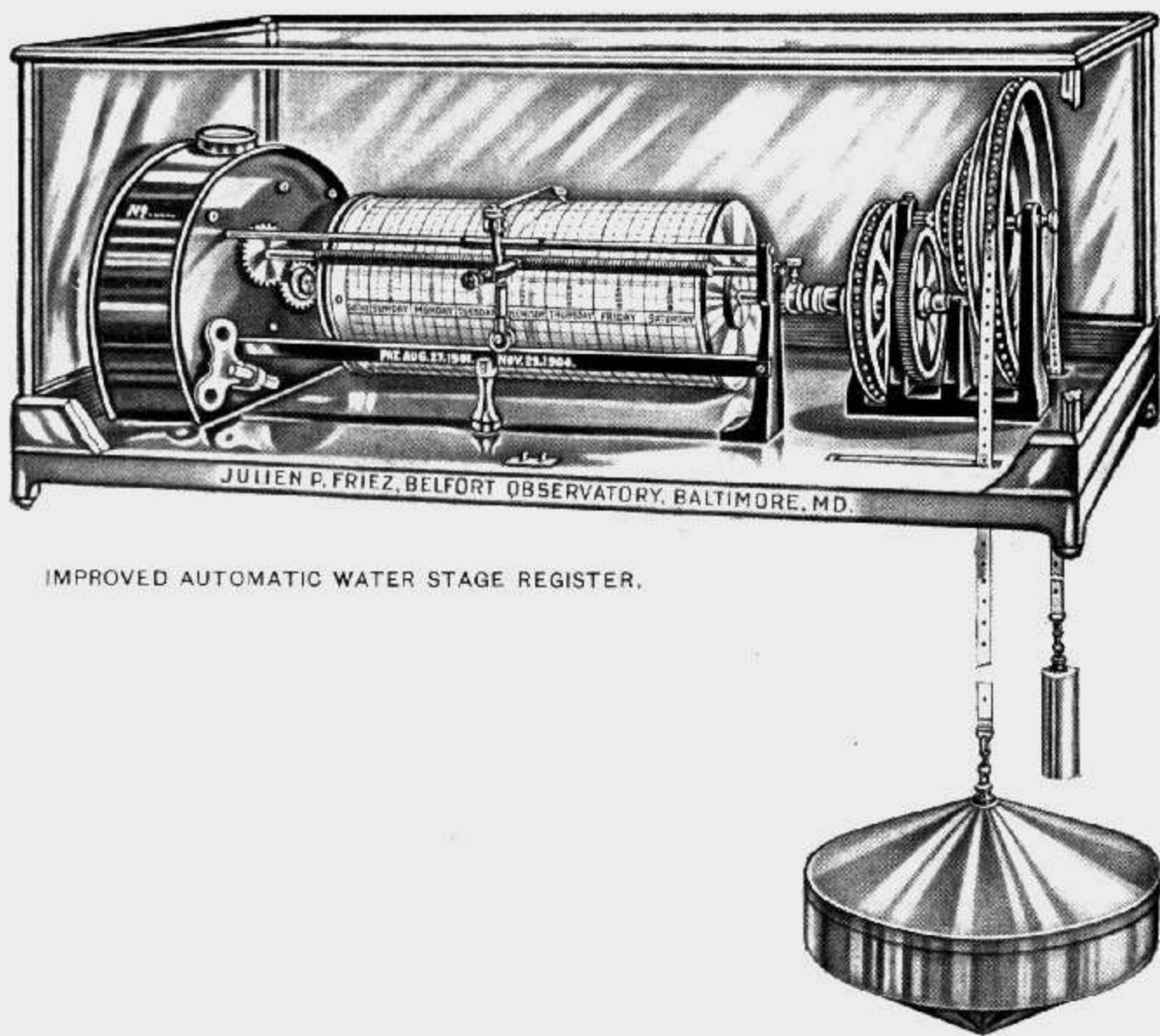
JULIEN P. FRIEZ,

BELFORT OBSERVATORY,

Baltimore, Md., U. S. A.

1230 E. Baltimore St.

(Dec. 21, 1909.)



IMPROVED AUTOMATIC WATER STAGE REGISTER.