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SIGNAL BUILDING

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ILLUSTRATIONS.

(Figures 1 to 26 relate to reconnaissance and have therefore been omitted from this publication. See page 1.)

SIGNAL BUILDING.

INTRODUCTION.

The greater part of the material contained in this publication has been taken directly from Special Publication No. 93, "Reconnaissance and Signal Building," without change. A revised manual for reconnaissance, entitled "Manual of Reconnaissance for Triangulation", has recently been issued by the Coast and Geodetic Survey as Special Publication No. 225 and supersedes part I of Special Publication No. 93. Part II of the older manual is covered by the present publication.

The present manual is intended to serve as a guide for field personnel of the Coast and Geodetic Survey or others who have occasion to construct wooden towers, large or small, which may be required in connection with field survey operations. For many years this type of tower, frequently referred to as "signal", was used on triangulation to elevate the instruments and observers above the trees or other obstructions and to overcome the curvature of the earth in order to make distant stations visible. Since the development of the portable steel tower in 1927 [1] the use of wooden towers has declined so that today they are used principally for instrument stands or low towers, or in isolated regions where steel is not suitable or available. However, it is certain that this occasional need for wooden towers will be a continuing one.

Low stands are usually built of lumber because it is more economical than steel, and occasionally a triangulation party using steel towers may find at some station a condition requiring a tower before the steel can be brought in or where it cannot be transported without great difficulty.

If considerable time has elapsed between the building of a wooden tower and the observations, there is certain to be some looseness of the structure due to shrinking or warping of the lumber. Such a tower is unstable and subject to vibration and twist. Observations made from it would not be reliable. For this reason it is necessary that all wooden towers (including low instrument stands) be thoroughly inspected and tested and that all nails and spikes be well set up just before the observations are made. For a low stand, especially on unstable ground, a platform should be built to support the observer so that there will be no vibration transmitted to the instrument. If it is not practicable to build a platform, the earth immediately around the foot of the tripod legs should be removed in order that the weight of the observer will not be transmitted through the ground as a pressure against the tripod legs and also to make the observer less likely to touch the tripod. All low stands should have a shelf between the tripod legs near the ground and this should be loaded with rock or other material to give a steady stand.

[1] A description of the portable steel triangulation tower and instructions for its use are contained in Special Publication No. 158, "Bilby Steel Tower for Triangulation."

On pages 27–43 of this publication, information is furnished for the construction of various types of hydrographic signals. For further information on this subject reference should be made to "Hydrographic Manual," Special Publication No. 143, Revised (1942 edition). The illustrations herein retain the same numbers assigned to them in the former publication. Numbers 1 to 26, which applied to reconnaissance, are omitted.

Plans and specifications for various types of signals and illustrations showing the operations of construction are given in the following pages. For each type of signal the working drawing shows one side of the signal, with dimensions of timbers used. It is not always practicable to get timber of the specified dimensions at the local lumberyards. In such cases other dimensions must be substituted and the necessary sizes built up by spiking together two or more timbers. This will prevent loss of time, and the signal will be sufficiently rigid for all purposes. The great majority of tall wooden signals built since 1910 had the legs built up by spiking together 2 by 6 inch or 2 by 4 inch timbers.

A wooden triangulation signal is a combination of two independent structures, one having three legs and called the inner tower or tripod and the other four legs and called the outer tower or scaffold. These two towers must not touch or be fastened together at any point. The service required of a signal when used by two observing parties working at different stations in the same figure is, briefly, that the outer tower must support the observer and the tent which protects him and his instrument from the sun and wind and must, at the same time and without interference with the observer or his work, support a light keeper and the lamp or heliotrope. The inner tower must support the instrument with such stability that, except in a strong wind, its motion in azimuth will never be so rapid or so irregular as to affect seriously the accuracy of the measurement of angles, and that its disturbance in level will never be so rapid or so great as to inconvenience the observer by making frequent adjustments necessary. It is not practicable to build the tripod so rigid that observations can be made in a high wind, but its vibration due to light or moderate winds must not be so great as to interfere seriously with accurate pointing. Signals must be strong enough to stand without injury in all ordinary winds and in most storms. It is not good economy to build them so heavy and strong as to withstand the most violent storms.

CONSTRUCTION OF 60-FOOT SIGNAL.

A completed signal 60 feet high to the instrument is shown in Figure 27. The various steps in the process of framing and erecting such a signal are given in the following general directions in approximate order of time, it being understood that two or more processes may sometimes be carried on simultaneously.

FRAMING THE TRIPOD.

The first step is the framing of the tripod legs and of one side of the tripod with all the material lying on the ground. In Figure 28 it is assumed that timbers of the dimensions specified are to be used and

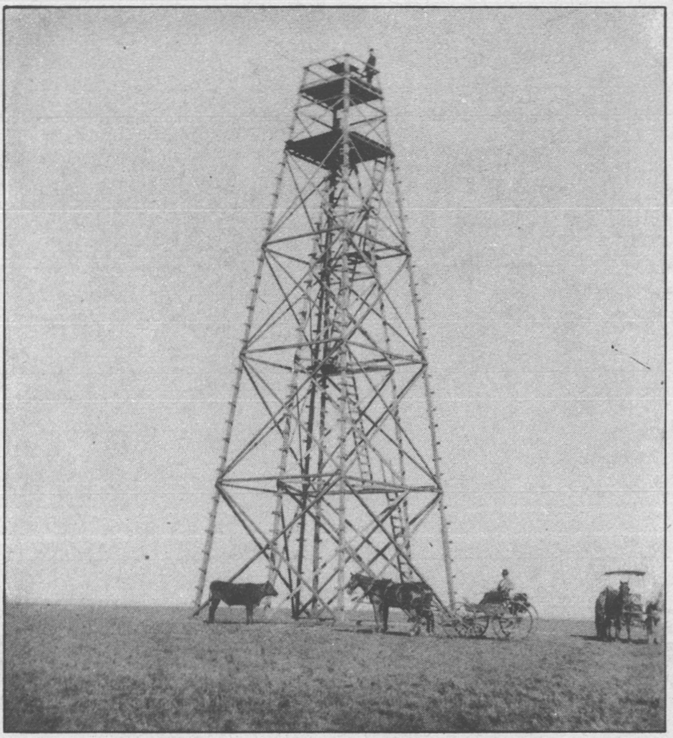

FIG. 27.—COMPLETED 60-FOOT SIGNAL.

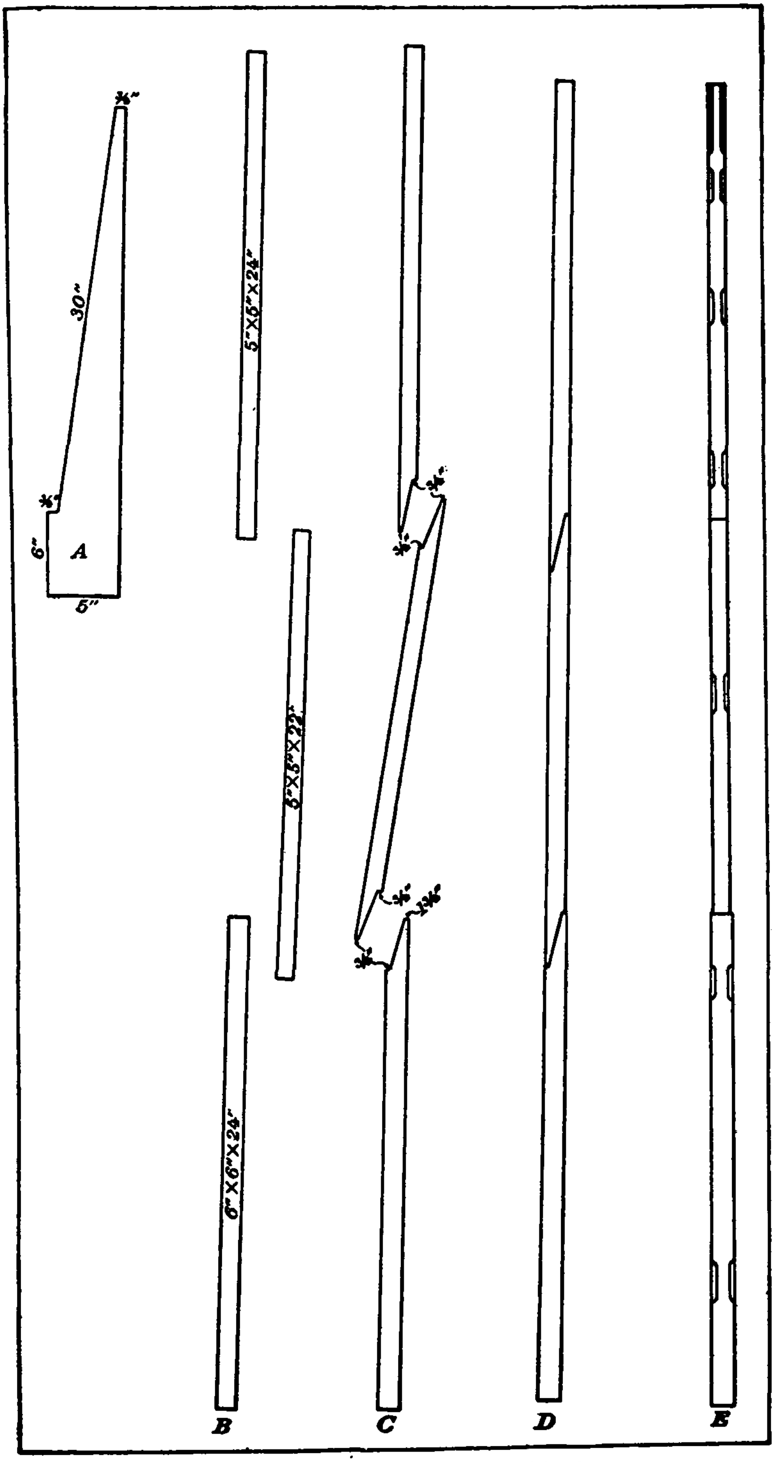

FIG. 28.—Scarf pattern and framed legs of signal.

that they are not to be built up by splicing. *A* is a pattern used in making the scarfs, *B* shows the positions in which the timbers are laid before the work of framing begins, *C* shows the scarfs cut, *D* shows the parts of one leg nailed together, and *E* shows the leg chamfered ready for framing. All scarfs are nailed together except

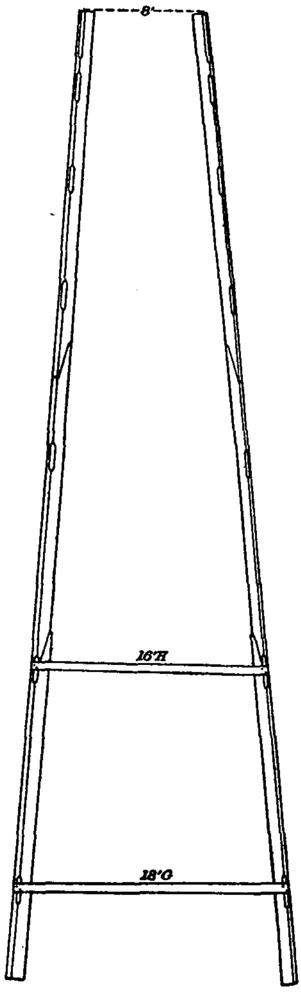

FIG. 29.—Side of tripod for 60-foot signal partly framed.

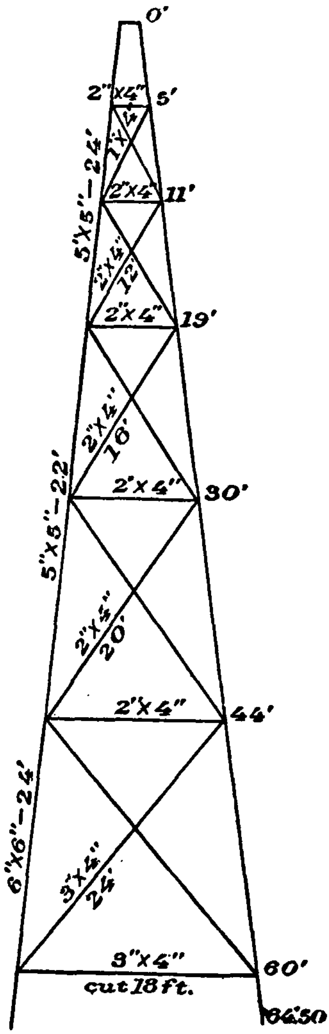

FIG. 30.—Working drawing of side of tripod for 60-foot signal.

on unusually tall signals. (See pp. 17–19.) Figure 29 shows tripod legs Nos. 1 and 2 with two of the horizontal ties in place, the legs being in such a position that the chamfers which form a bearing surface for the ties and diagonals are horizontal. The chamfers as seen in this position are 2 feet long, cut 1 inch back from the corner on the top and

2 inches on a side. They are marked for cutting with chamfer patterns made of two pieces of board 2 feet long nailed together to make a form which fits over the corner of the leg. It is recommended that, in general, the legs of the tower be built up of 2 by 6 inch or 2 by 4 inch timbers, for such timbers are more easily handled, and they can be spiked together more quickly than the scarfs can be cut on the large timbers. By properly breaking joints, as indicated on pages 49 and 50, there is little loss in rigidity or strength.

In framing the first side of the tripod cut the bottom horizontal tie to the length given in Figure 30 if the height of the tower is to be 60 feet. For other heights of towers consult the table on page 45. Place the two legs to be framed in the position shown in Figure 29 and nail on the first and second ties, *G* and *H*. The length of the horizontal tie *H* is such that for a 60-foot tripod the legs when straight will be about 8 feet apart at the top, as shown in Figure 29. For tripods of other heights the distance apart at the top when the legs are straight will vary with the height and is to be fixed by the judgment of the builder as to the amount of curvature to be put into the legs. After nailing the first two ties draw the upper ends of the two legs toward each other, thus putting a bend into each one of them, and nail on the successive ties, beginning at the bottom. The lengths of all the ties above *G* are to be such as to give the legs the desired bend, the tops of the legs being brought a little closer together as each successive horizontal tie is nailed on. When the tie 5 feet from the top is nailed on, the tops of the two legs should meet, as shown in Figure 30. The distance along the legs to each horizontal tie is given in Figure 30, reckoned from zero at the top. The ends of the ties should be cut off with the same slant as the leg, leaving 1½ inches overhang. Each panel must then be squared by using a steel tape to make the two diagonals of the panel equal in length. Time should not be spent in cutting the diagonals of the panels to measure. Instead, they should be laid in place and sawed off, each end parallel with the horizontal tie, and nailed fast, the panel having already been sprung to its proper position. The portions of the ends of the diagonals which project beyond the end of the horizontal tie should then be sawed off. Use two nails in each end of the horizontal ties and diagonal and one nail where each pair of diagonals intersect. Use sixtypenny nails for all 3 by 4 inch pieces and fortypenny nails for all 2 by 4 inch pieces. The dimensions for each part of a side of a 60-foot tripod are given in Figure 30.

Call the side of the tripod framed first No. 1. Cut the horizontal ties and diagonals for sides Nos. 2 and 3 by laying each piece on the corresponding piece of side No. 1 and cut to match, thus avoiding any necessity for measurements with a tape or square. Mark a cross with a pencil on the top end of each diagonal. Lay out in order each piece for sides Nos. 2 and 3 in a convenient location ready to send aloft, the nails all being started. When picking each timber up to lay it out in its proper position, face the top of side No. 1, and when laying it down face the triangulation station. This will bring each piece right end to when it is picked up and sent aloft.

FOUNDATION HOLES.

A stake with a nail in the top may be used for a temporary station mark. The holes for the foundation are laid off and staked according to the ground plan shown in Figure 31, all measurements being made from the temporary station mark. For locating the holes it is convenient to use a small theodolite (fig. 32) and a steel tape. The angles shown on Figure 31 are counted from zero at the foot of tripod

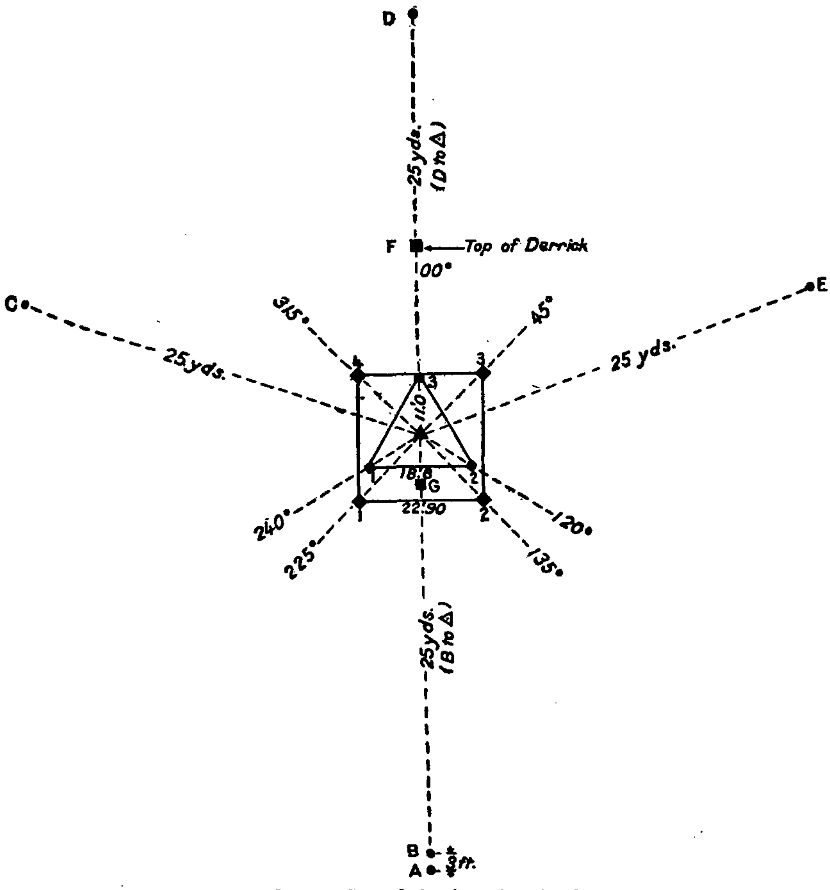

FIG. 31.—Ground plan for 60-foot signal.

leg No. 3. If possible, the orientation of the signal should be such that no line of sight from the head of the tripod will be obstructed by a scaffold leg. The holes for the tripod legs and the scaffold legs are all made 3 feet wide, 3½ feet long, and 3½ to 4 feet deep.

Spend no time in bringing the bottoms of all the holes accurately to the same level, but after they are dug and the tripod footplates set take a round of levels, either with a carpenter's level or with the small theodolite (fig. 32) used as a leveling instrument, using footplate No. 3 as a bench mark. Then cut legs Nos. 1 and 2 to correspond with the differences found, No. 3 having already been cut to the exact

FIG. 32.—FOUR-INCH THEODOLITE.

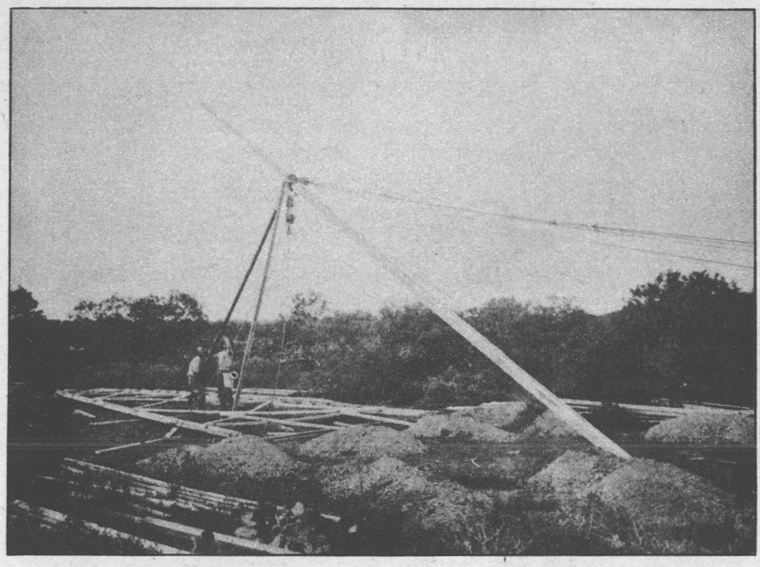

FIG. 33.—RAISING THE DERRICK.

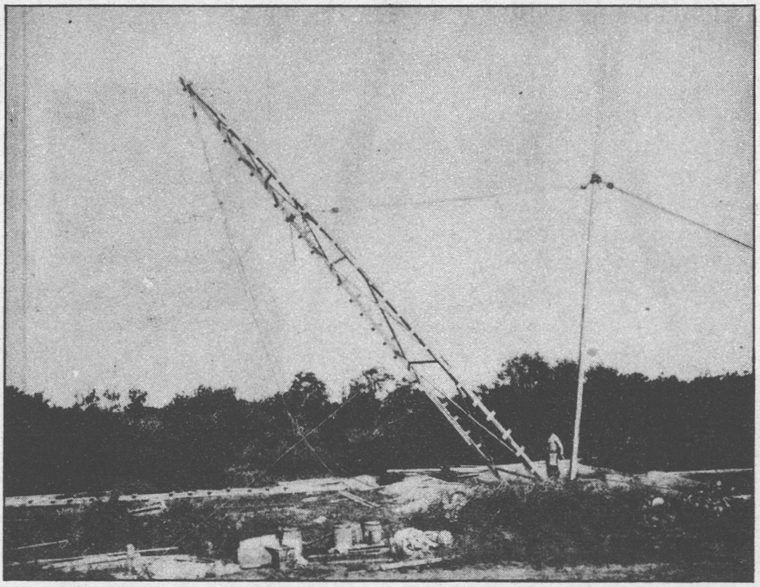

FIG. 34.—RAISING ONE SIDE OF TRIPOD FOR 60-FOOT SIGNAL.

length shown in Figure 30. The holes for the tripod legs should be dug first. Do not delay raising the tripod while waiting for the holes for the scaffold legs, as they can be dug after the tripod is raised. After the scaffold footplates have been set, take a round of levels on them, using the lower horizontal tie at the No. 3 tripod leg for a bench mark, it being exactly 4½ feet above its footplate. Cut off each scaffold leg as much above or below the 4½ footmark already on it as the corresponding footplate is above or below No. 3 tripod footplate as shown by the levels. It is necessary to keep the correct relation in height between the ties on the scaffold and those on the tripod in order to make the observing floor come at the right height in relation to the top of the tripod.

The footplates are 2 by 12 inches and 3 feet long. The bottom of each hole should be carefully smoothed, so that the footplate will have a firm bearing on the ground, and the plate should be placed in such a position that the leg will rest on it near the center.

RAISING TRIPOD SIDE.

One or more sections of a leg of the scaffold may be used as a derrick for raising side No. 1 of the tripod. The derrick should be about two-thirds the height of the tripod. Posts for attaching guys should be set as shown in Figure 31, *A* and *B* being the positions of the posts for the back guys, *C* and *E* for the side guys, and *D* for the forward guy. *F* represents the position of the top of the derrick when laid out ready for raising and *G* the foot of the derrick. Before raising the derrick put on the side guys and make them fast to the posts at *C* and *E*, leaving about 2 feet of slack. A double-fall or winch tackle should be used for the back guy to *B*. Before beginning to raise the derrick put on the hoisting tackle, so that it will be ready for use when the derrick is up. One set of guys will do for a derrick 40 feet high, but a second set of guys, placed about halfway up, should be added for a higher derrick to prevent buckling when the side of the tripod is being raised.

The posts for guys should be 4 inches square, or an equivalent size of round timber. For high signals, where there is a heavy strain on the back guy and post or in any case in which the holding power of a guy post is uncertain on account of soft ground, an auxiliary guy post should be used. The second post should be placed beyond the first, and the two posts should be connected by a short guy attached to the top of the main guy post, 2 feet or more above the ground, to prevent it from being drawn forward, and attached to the auxiliary guy post as near the surface of the ground as possible.

Start the derrick up by using props (fig. 33) and then raise with the back guy fall. When raised, the derrick should rake back about 4 feet, so that when the heavy strain comes in raising the side of the tripod it will stand about vertical, as shown in Figure 34.

Before raising the tripod cleat the legs, using strips 1 by 4 by 16 inches spaced about 16 inches. Drag side No. 1 of the tripod back with the hoisting fall of the derrick, using handspikes to assist if necessary, until the feet come to the edge of the tripod holes Nos. 1 and 2, as shown on the ground plan (fig. 31). Put on a bridle rope about one-third the distance down from the top of the tripod. Near the point where the bridle rope is attached attach four guys—two to lead backward and two forward. Put a footrope on each leg 1 foot from the bottom, lead it to guy post *D* (fig. 31), and after pulling it taut take two complete turns. Attach a hoisting line on each tripod leg near the top before commencing to hoist the side. These hoisting lines are light ropes passing through single blocks and are used in hoisting the ties and diagonals while framing up the tripod. Hook the block of the hoisting tackle in the bridle mentioned above, run the loose end of the fall through a snatch block made fast to the foot of the derrick, and take it to the rear end of the motor truck or the wagon, as the case may be. By using a double fall a truck or good pair of horses will raise one side of any signal up to 90 feet in height. Figure 34 shows side No. 1 of a 60-foot tripod being raised to position.

When side No. 1 of the tripod is in a standing position and the backward and forward guys have been made fast to the posts *B* and *D*, the hoisting tackle should be taken off side No. 1, overhauled, and used in raising the third leg of the tripod, as shown in Figure 35. For the third leg three guys are required, one to each of the posts *C*, *D*, and *E*, as shown on the ground plan (fig. 31). A hoisting line is made fast near the top and the leg raised to its final position, as shown in Figure 36. The horizontal ties and diagonals are then nailed on sides Nos. 2 and 3 of the tripod, beginning at the bottom, two men working aloft while two men below send the timbers up in their proper order, using the hoisting lines. The tie at the top of each panel should be put on ahead of the diagonals. To make the pieces fit in place, it will be necessary for a man on the ground to spring the legs into position by means of the guys and hoisting lines. The tripod head is to be made very rigid at the top by planking up solid the top 3 feet of the tripod with 2 by 12 inch plank.

LEG ANCHORS.

When the tripod is completed, nail the feet to the footplates and put on the anchors. To construct an anchor, take two 2 by 4 inch pieces 3 feet long and spike them on opposite sides of the foot of the leg parallel to each other. Fill in with earth to a level with the top of these pieces, then nail two more pieces of the same size on opposite sides of the leg at right angles to the first two. Lay boards or any other pieces 2 or 3 feet long across the top of the lower pieces, and after filling in earth level with the second set of anchor pieces lay shorter blocks or boards across them, too. This construction makes an anchor platform about 3 feet square. Fill the hole to the top, keeping the earth well tamped. All the legs of both the tripod and scaffold are to be anchored in this manner.

When the tripod has been anchored, cast loose the backfall and guy of the derrick and let it tip in against the tripod. Shift the hoisting falls to the tripod head, one on the side toward the derrick and the other on the opposite side. The derrick is then lowered with the fall on that side.

FRAMING THE SCAFFOLD.

Begin the scaffold by scarfing and splicing the legs or building them up in the same manner as described above for the tripod. Mark the lines for the horizontal ties as shown in Figure 37. Lay out legs Nos. 3 and 4 on the forward side of the tripod and legs Nos. 1 and 2 on the rear side. The bottom horizontal tie and the top floor tie are to be cut to the lengths given on the working plan (fig. 37) and nailed in their places as there indicated. As the intermediate horizontal ties are nailed on, force each leg out so as to give it the desired bend. The foreman, standing at one end of the side being framed and directing the men as they nail on the ties, may determine the amount of bowing or bending by estimation. After the ties are nailed in position they should be sawed off even with the outer side of the legs. Next square each panel, commencing at the bottom, by making its two diagonals of equal length, using a steel tape, and nail the diagonals in position. It should be noticed that none of the horizontal ties, except the ones at the top and bottom, are cut to measure, and no measurements are necessary to fix the lengths of the diagonals. When the framing of the first side of the scaffold has been completed, cut the horizontal ties and diagonals for the other three sides by using this first side as a pattern. Side No. 3, as well as side No. 1, may be framed fully before raising, except for signals more than 90 feet in height, which must be raised in two or more sections, as explained on page 17. All four legs of the scaffold should be cleated. (See p. 7.)

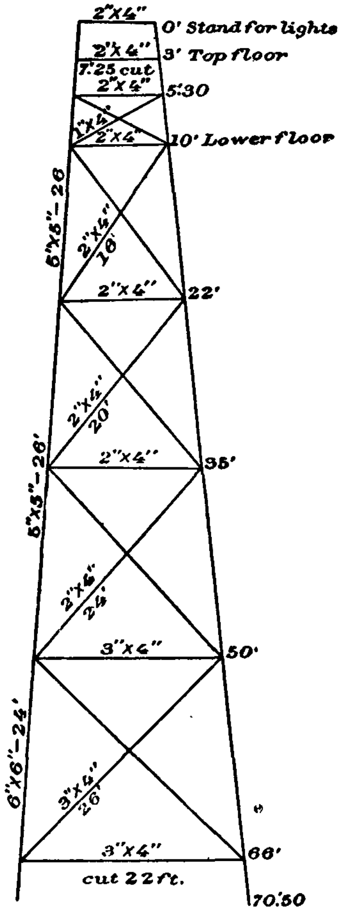

Fig. 37.—Working drawing of side of scaffold for 60-foot signal.

RAISING THE SCAFFOLD.

First make the bridle rope fast on one leg of the side to be raised, hook the hoisting tackle from the top of the tripod in it, and turn the side of the scaffold over, so that the ties and diagonals will be on the under side. Figure 38 shows this operation of turning over. Next make the bridle rope fast for raising and raise the side to a standing position, as shown in Figure 39. In a similar manner turn side No. 3 over, as shown in Figure 40, and raise it to a standing position, as shown in Figure 41. Next let two men go aloft and nail the ties and diagonals on sides Nos. 2 and 4, while two men below send up the timbers in order, as shown in Figure 42. It is best to complete one panel on one side and then shift to the other side, and so on to the top. The legs may now be anchored down and the necessary floors and ladders constructed to complete the scaffold, as shown in Figure 43.

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The lower floor of the scaffold is at the height indicated in Figure 37, and the tripod can be cut off to the exact height required by the observer. The height of the observer and the height of the instrument telescope above the foot of its leveling screws will determine the height of the top of the tripod head above the floor. This must be known beforehand. The upper floor is placed 3 feet below the top of the scaffold in position to support the light keeper. A table 3 by 3 feet is constructed at the center of the top of the scaffold for supporting the lamps and heliotropes.

Two trapdoors should be made in the lower floor, one where the ladder comes up at leg No. 1 or No. 2 of the scaffold and the other in another corner of the floor, to be used in hoisting the instrument. The door for hoisting should be placed at leg No. 3 or No. 4 of the scaffold in order to obtain the best clearance of the tripod and the ladder timbers. The floor timbers must be spaced to give ample clearance for the instrument box.

The wall of the observing tent is a strip of canvas 4.6 feet wide reaching around the outside of the scaffold, with the two ends overlapping at one corner. The bottom of the wall is made fast to the lower floor by hooking the loops over nails driven in the floor. The top of the wall is made fast in the same manner to the horizontal tie on the scaffold 5.3 feet below its top. The roof of the tent is a tarpaulin which fits over the top floor and carries four canvas curtains which overlap at the four corners of the scaffold and also overlap the wall of the tent to which they may be tied. The space of 7 feet between the top and lower floors of the scaffold is thus inclosed, making a room with a floor 9 feet square for the observer. The tent requires no poles or extra timbers for its support.

DESIGNS OF SIGNALS OF VARIOUS HEIGHTS.

In the case of an obstructed line, on which the obstruction is not discovered until the towers have been built, the difficulty may be overcome by building up a superstructure on the signal at each end of the line, such as was constructed on the top of a 60-foot signal at station Burson, shown in Figure 44. The lamps and heliotropes can then be posted at the top of the superstructures and a clear line obtained without increasing the height of the tripods. The superstructure shown in Figure 44 is of the same type as the scaffold for the first 24 feet. For the remaining 48 feet the superstructure is 2 feet square, and the legs are parallel. The horizontal ties are 4 feet apart. Two sides of the superstructure were framed on the ground in sections 12 feet long and hoisted to position with hoisting lines. The horizontal ties and diagonals for the other two sides were cut by using the first side as a pattern and were hoisted aloft with hoisting lines. Two sets of wire guys (No. 12 smooth wire) were put on the superstructure—one set at the top and the other set 24 feet lower. The guys were made fast to special posts set for the purpose. This type of superstructure proved to be sufficiently stable, and it could safely be built to a height of 150 feet above a scaffold. In posting his light the light keeper went up the inside of the superstructure and passed out to a seat constructed 2 feet below the table which was made for the lights and heliotropes at the top of the structure.

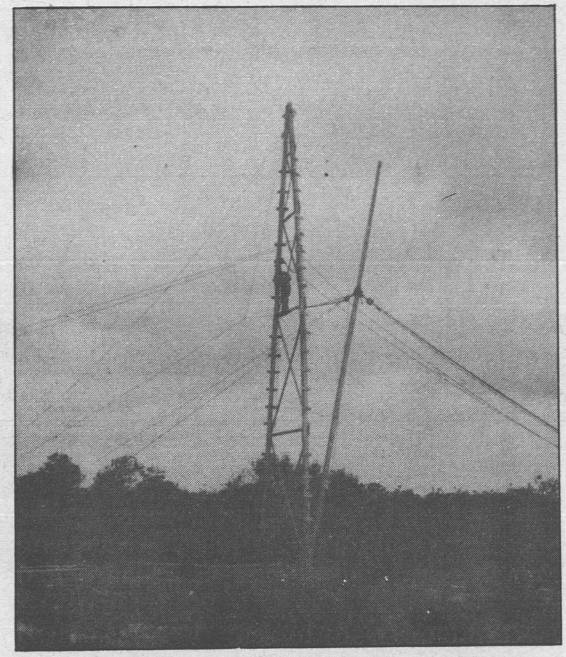

FIG. 35.—SHIFTING TACKLE BEFORE RAISING THIRD LEG OF TRIPOD.

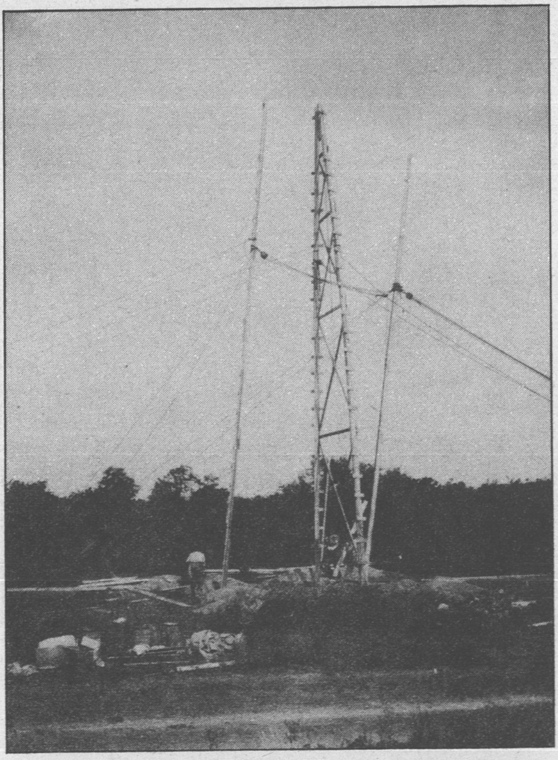

FIG. 36.—RAISING THIRD LEG OF TRIPOD FOR 60-FOOT SIGNAL.

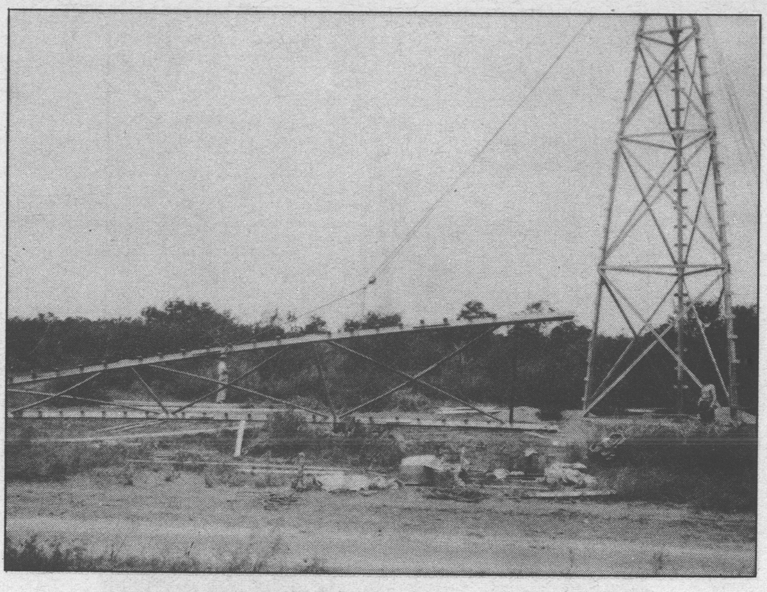

FIG. 38.—TURNING OVER FIRST SIDE OF SCAFFOLD.

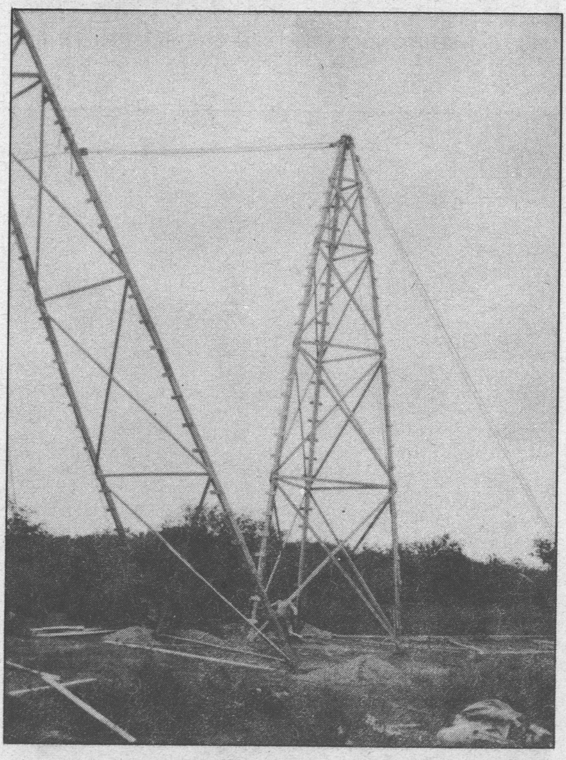

FIG. 39.—RAISING FIRST SIDE OF SCAFFOLD FOR 60-FOOT SIGNAL.

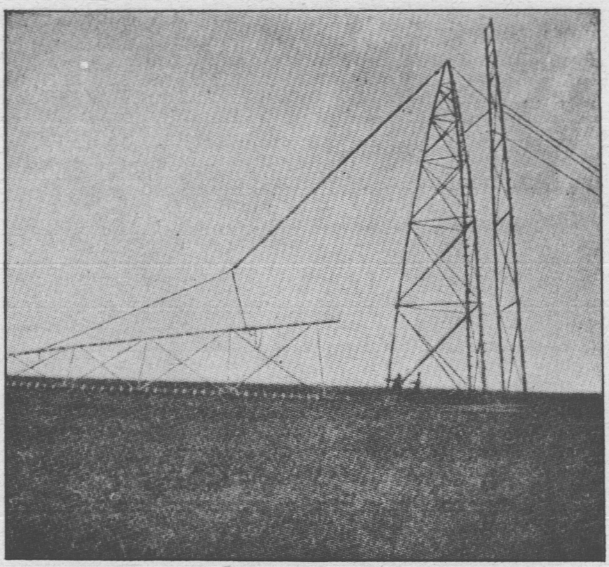

FIG. 40.—TURNING OVER SECOND SIDE OF SCAFFOLD.

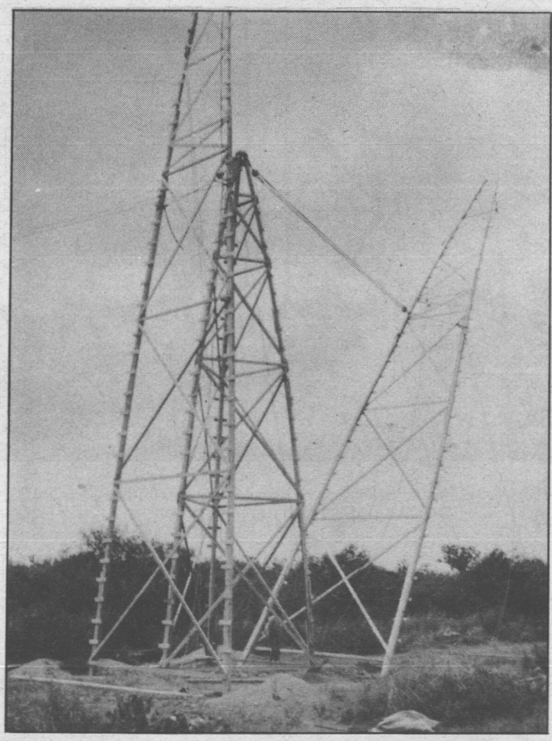

FIG. 41.—RAISING SECOND SIDE OF SCAFFOLD FOR 60-FOOT SIGNAL.

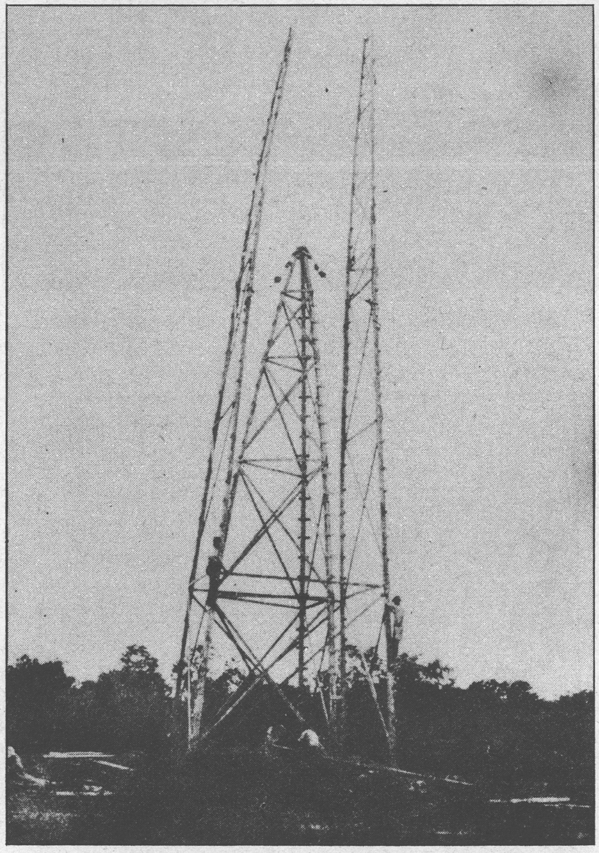

FIG. 42.—TWO SIDES OF SCAFFOLD FOR 60-FOOT SIGNAL IN STANDING POSITION.

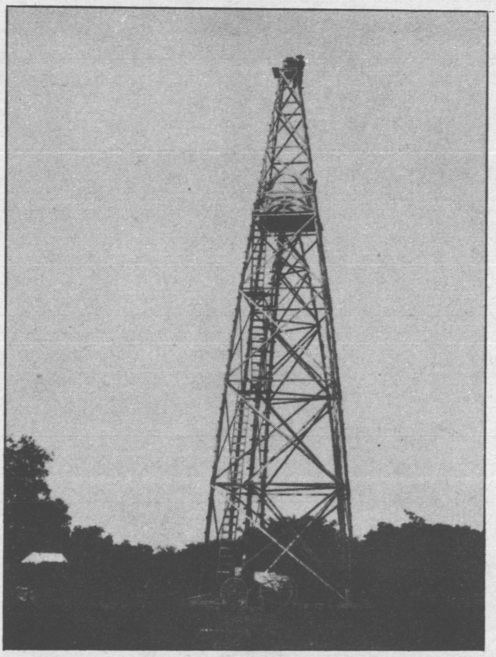

FIG. 43.—COMPLETED 60-FOOT SIGNAL WITH 20-FOOT SUPERSTRUCTURE.

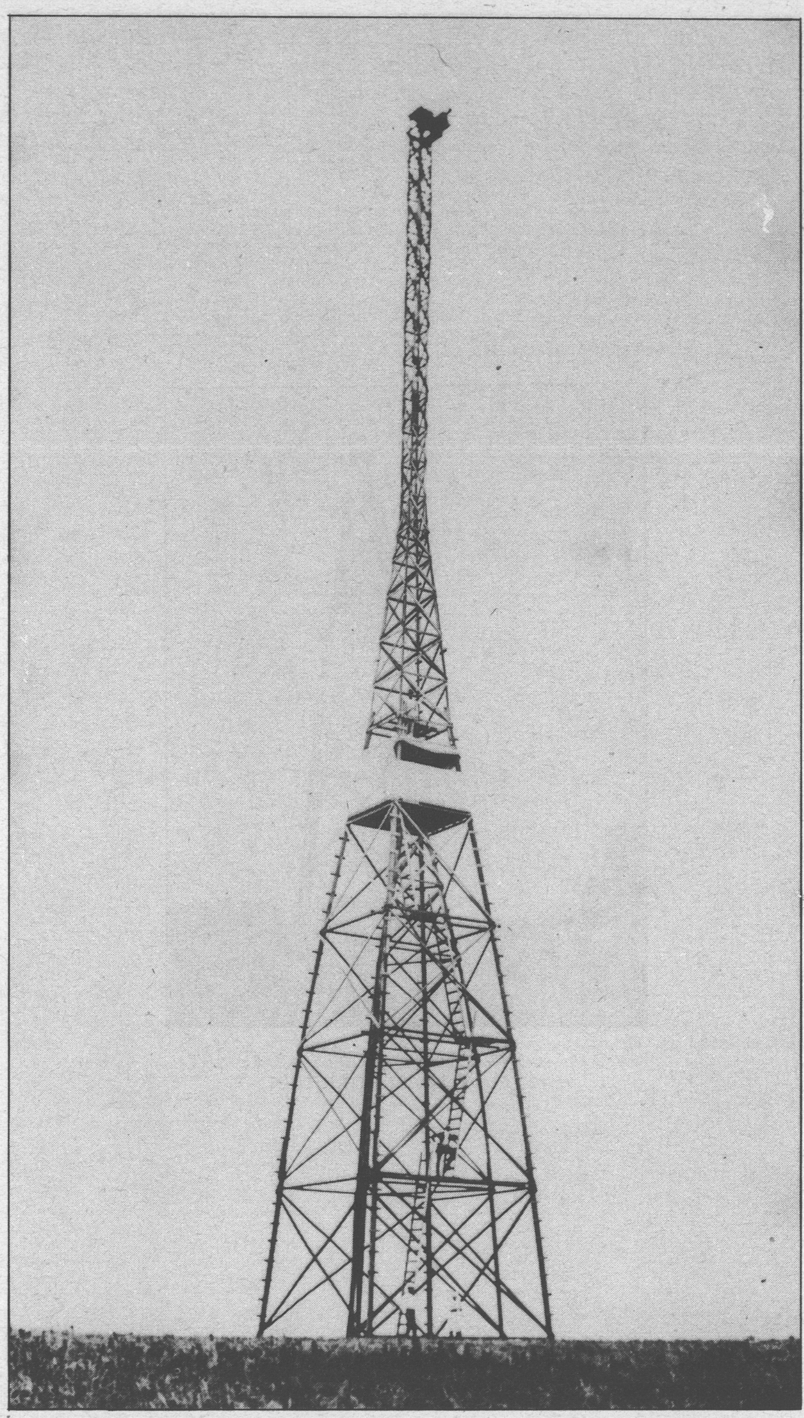

FIG. 44.—SIXTY-FOOT SIGNAL WITH HIGH SUPERSTRUCTURE.

For scaffolds of different heights the top portion of the signal down to a point 10 feet below the top is the same for all. The following table gives the lengths of the lower horizontal tie for tripods and scaffolds of different heights. The first column is the distance from the top of the tripod to the lower horizontal tie of the tripod as measured along the tripod leg.

Length of tripod leg.	Length of lower horizontal tie of tripod.	Length of lower horizontal tie of scaffold.
Feet.	*Feet.*	*Feet.*
10	6	10
15	7.5	11.5
25	10	13.5
45	14	17
60	18	22
75	19	23
100	20	25

The dimensions given in the table are fixed directly by measurement. The lengths of the intermediate horizontal ties and of all the diagonals are fixed as indicated in the preceding description of the process of framing and construction. The legs for the scaffolds are in each case 6 feet longer than the tripod legs, except for a signal for which no top platform is needed, in which case all the legs are of the same length. When a 10-foot tripod is used, the diagonals of the scaffold should reach from the bottom tie to the tie which is between the two floors, 5.3 feet below the top of the scaffold. In all other respects the scaffolds and tripods of different heights correspond in design to those shown in Figures 43 and 44, and any of them may be made with or without superstructure or light stand. The list of material required for any height of signal can be determined quickly by making working drawings to scale similar to those shown in Figures 30 and 37 and scaling off the lengths required for each side.

For signals higher than 75 feet the design shown may be extended by putting on other sections at the bottom somewhat heavier than the lower section of the 75-foot signal. Signals not greater than 90 feet in height may be framed and raised as just described, and no bolts need be used. If the signal is more than 90 feet, a section of a side 75 to 90 feet high may be raised as one piece, and the higher sections must than be framed separately, raised to position, and fastened with bolts to the top of the first section, as shown in Figure 45.

ADVANTAGES OF THE SLENDER TYPE OF SIGNALS.

Some of the points of advantage claimed for the slender signals over those formerly used by the U. S. Coast and Geodetic Survey, and especially over the broad ones described in Appendix 10, Report for 1882, are given below.

There is only about one-half as much lumber per vertical foot in the slender signals as in the broad. This not only reduces greatly the cost of the material required for a signal of given height and the cost of hauling the material, but also considerably reduces the cost of construction.

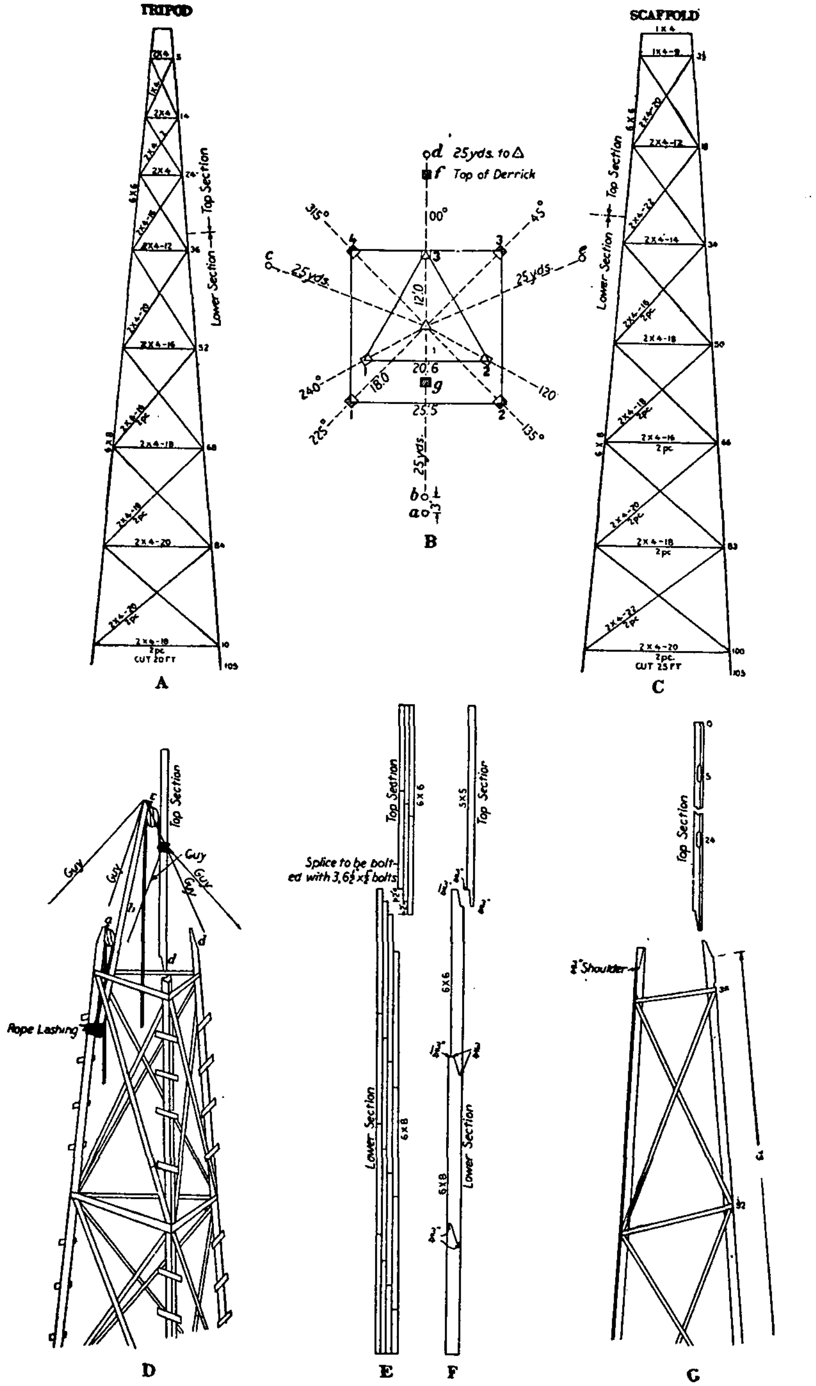

FIG. 45.—Working drawings for 100-foot signal showing arrangement of tackle for raising top section of tripod.

Much less area is exposed to wind pressure for a signal of given height in the slender signals than in the broad ones, and therefore much less strength is needed. More important than this, however, is the fact that the horizontal ties and diagonals, which are the relatively light pieces in the structure, are very much shorter in the slender than in the broad signals, and therefore the vibrations of these pieces due to wind are much less in the slender signal. These vibrations impart a tremor of short period and small amplitude to the instrument and also to the floor supporting the observer and are likely to prevent observations in a strong wind long before there are any other troublesome motions of the signal or any danger of collapse. Experience indicates that observations may be continued in a stronger wind without screens on a slender signal than on a broad one.

The bowing of the legs of the slender towers during construction puts the posts and horizontal ties under a moderate initial strain, which adds greatly to the stiffness of the structure and somewhat to its strength.

As the observing tent for the slender signal is supported on the outside of the tower, every part of the floor space is available for use, and it is possible to work as comfortably on a floor 9 feet square on the slender scaffolds as on a floor 12 feet square on the broad ones, where other styles of observing tent are used. This reduction in the size of the floor is important, as it allows a corresponding reduction in the size of the signal throughout its whole height.

The second or upper floor and the table for the light make it possible for the heliotroper or light keeper to show his light to a second observer on another station with the light or heliotrope mounted directly over the station instead of in an eccentric position and without the slightest interference with the observer below.

The slender signals, although they contain much less lumber than the broad ones and have a much smaller spread of base for a given height, are no more apt to collapse in a strong wind than the broad ones. Experience indicates that either type is sufficiently strong to make the losses by collapse very small.

When there is but one observing party, the upper floor is left off, and the tripod and scaffold legs are the same length.

TOOLS AND TACKLE NEEDED TO ERECT A HIGH SIGNAL.

The following tools and tackle are necessary for a party of four or five men engaged in building tall signals not over 90 feet high:

Tools.

Axes	2	Pick	1
Adz	1	Plane	1
Bevel	1	Plummet	1
Bits, assorted	6	Rules	3
Brace	1	Saw, compass	1
Chisel, cold	1	Screw driver	1
Chisel, wood	1	Set, saw	1
Digger, posthole	1	Shovels	2
Hammers, heavy	3	Spade	1
Hammers, claw	1	Spud	1
Handsaws	4	Square, 2-foot	1
Hatchets	2	Tape, steel, 50-foot	1
Level, carpenter's	1	Trowel	1
Mattock	1	Try-square	1
Oilstone	1	Wrench, monkey	1

Tackle.

Blocks:	
Double, 8-inch, with hook, patent bushed	4
Single, 6-inch, with hook, patent bushed	4
Snatch, 7-inch, with hook	2
Rope:	
$\frac{1}{2}$-inch for hoisting lines, 200-foot pieces	4
$\frac{5}{8}$-inch for guys, 110-foot pieces	15
Rope—Continued.	
$\frac{5}{8}$-inch for slings, 2-foot pieces	4
$\frac{3}{4}$-inch for main tackles, 500-foot pieces	2
$\frac{3}{4}$-inch, 12-foot pieces	4
$1\frac{1}{8}$-inch for bridles, 40-foot pieces	2

GENERAL OBSERVATIONS.

RAISING THE SIGNAL.

Figures 33 to 45 illustrate the principal steps in raising the signal. These illustrations are intended to assist the inexperienced signal builder to make fast each guy and hoisting tackle in its proper place and to show the steps taken in raising each part of the signal. If the hoisting tackle is made fast too near the top of the part to be raised, the timbers will buckle and break. On the other hand, if the hoisting tackle is made fast too low down, it will have the same effect, only the buckling will be in an opposite direction. It is necessary to fasten the tackle on the part to be raised so it will be well balanced. A three-quarter ton motor truck will raise one side of any tripod or scaffold, with superstructure attached, up to 90 feet in height. Where a motor truck can not be used, the signal can be raised with a team of horses or by hand power with a winch or extra tackle.

SUPERSTRUCTURE.

The superstructure is designed to elevate the heliotrope or lamp in order to raise the line of sight above an obstruction near the middle of the line between the two stations, and thus avoid the necessity for building higher tripods and scaffolds.

For example, a line may require a 50-foot signal at each end to clear obstructions near each station, but to overcome curvature and to clear an obstruction near the middle of the line would require a 75-foot signal at each end of the line. This would mean the addition of 25 feet to the bottom of the 50-foot tripod and scaffold and would nearly double the cost of material and labor. In such cases it is more economical to build a 50-foot superstructure on top of the 50-foot scaffold at each end of the line and mount the heliotrope or lamp at the top of the superstructure.

The superstructure is constructed by first extending the scaffold legs about 20 feet. (See fig. 43.) At this point the corner posts have approached within 2 feet of each other on a side. The superstructure is then extended 2 feet square to any desired height. (See fig. 44.) It can safely be built to a height of 150 feet above the tripod head. A set of four guys of No. 12 wire should be put on the upper superstructure about every 24 feet and secured to anchor posts set about 175 feet from the signal and on line with the diagonals of the ground plan of the signal. The top superstructure is identical with the superstructure on the hydrographic signal, of which detailed specifications are given on page 30. (See fig. 62.)

When it is known that a superstructure is needed, the part extending 20 feet above the top of the scaffold legs should be framed and raised with the scaffold, as shown in Figures 41, 42, and 43. Two men can then extend the superstructure to any required height at any convenient time after the signal has been erected. Figures 62, *B*, and 64 show the splice where the upper sections of the superstructure are joined to the lower or base section at a point 20 feet above the scaffold. The instructions for the special hydrographic signal on page 30 give in detail the method of framing and constructing the superstructure.

USE OF YARD STOCK TIMBERS FOR 60-FOOT SIGNAL.

In a timbered country where there are local sawmills it is often convenient to place orders at the mill for the lumber required for a signal, and in such cases it may be advisable to specify the lengths and sizes of timbers called for in the preceding plans and specifications. In many regions, however, it may be difficult to procure timbers of the specified sizes and lengths, and the local lumber yards must be depended upon for the lumber needed. No time should be spent in attempting to find timbers of special lengths or dimensions. In general, the local yards carry a stock of 2 by 4 inch and 2 by 6 inch timbers ranging from 12 feet to 20 feet in length. Where the plans for a signal call for 6 by 6 inch timbers for the legs, the legs may be built up from 2 by 6 inch pieces. Any length may be used, but usually the 16-foot lengths are the most convenient to haul and are preferable to use, as is indicated below.

The legs for a 60-foot signal should be about 64 feet long and 6 inches square. They can be built up by using twelve 2 by 6 inch pieces 16 feet long for each leg. First lay four 2 by 6 inch pieces 16 feet long end to end and cut the ends to match. This can be done by sawing the end of one timber to match the end of the timber it joins, and it is not necessary to use a square. Next place four more 2 by 4 inch pieces 16 feet long end to end on top of the lower four pieces, starting 4 feet from one end. This breaks the joints 4 feet and gives a 4-foot overrun at one end, which is sawed off and used to fill in the 4-foot space at the opposite end. The upper set of timbers should be nailed temporarily to the lower set, using tenpenny nails near the center of the timber in width and 2 or 3 feet apart. The third set of timbers is next placed on in the same manner as the second set, but starting 8 feet from one end to give 4-foot lap on the joints of the second set. The 8-foot overrun can be sawed off and used to fill in the 8-foot space at the opposite end. The third set of timbers should be nailed temporarily with tenpenny nails in the same manner as the second set.

The tripod legs should next be marked for the ties and chamfers and should then be spiked with fortypenny nails. The nails should be spaced about 20 inches apart and should be staggered to come about 1 inch from alternate edges, except where chamfers are to be cut. Care should be taken to place the nails so they will not be hit with the tool used in cutting the chamfer. One or two spikes should be driven about 6 inches from the end of each 2 by 6 inch piece at the joints. This applies to the middle set of timbers as well as to the two outside sets. After spiking the top side as indicated above turn the leg top side down and drive spikes near each joint and at any intermediate place along the leg where necessary to draw it together.

To the bottom or lower portion of the legs of all signals 60 feet or more in height should be added a 2 by 6 inch piece 16 to 24 feet long, making this portion of the leg 6 by 8 inches. There should also be a 2 by 4 inch piece about 3 feet long spiked over each outer joint where the 2 by 6 inch timbers butt together.

In framing the scaffold lay the legs out in position for the ties and diagonals with the 2 by 6 inch timbers on edge. This gives the legs a greater strength and stiffness when raising. The cleats or steps are also nailed on with the legs in the same position and help to bind the 2 by 6 inch timbers together.

Ties and braces.—It is often necessary to build up or splice the ties and diagonal braces. A single piece of 2 by 4 inch timber up to 20 feet in length will usually give a sufficient strength and stiffness, but longer lengths should be partly doubled. For instance, if a diagonal 24 feet long is called for, take two 2 by 4 inch pieces 18 feet long and let them overlap 12 feet in spiking them together. This will make the brace 4 inches square on the overlap and by 2 by 4 inches for 6 feet at each end and will give the greatest strength and stiffness at the middle of the brace where it is needed.

It will be noted in the specifications on page 41 that the footplates called for are 2 by 12 inches and 3 feet long. The footplates can be made of two 2 by 6 inch pieces placed side by side with a 1 by 4 inch cleat nailed across each end to bind the two together. Lumber 2 by 6 inches can also be used in boxing up the head of the tripod where 2 by 12 inch pieces are called for.

BUILDING THE LADDERS.

The side bars of the ladders are 2 by 4 inch pieces, and the steps are 1 by 4 inch pieces 2 feet long. The steps are spaced 14 inches center to center or top to top. Figures 43 and 44 show the ladders in position. It will be noted that the ladders are inside the scaffold on the side formed by legs Nos. 1 and 2, and that there is a landing at each tie of the scaffold. The length of each ladder section is the space between the ties on the scaffold for which it is made.

In making the ladders the 2 by 4 inch side bars are laid side by side on the ground and the spaces marked for the steps. The bottom ends of the side bars are cut to a miter of 1 in 6 to give the ladder the proper slant when it is set in position on the landing. In nailing, place the top edge of the step to the line and drive one nail in each end of the step about 1 inch from the lower edge. After the ladders are made the hoisting lines are rigged inside the scaffold frame on legs Nos. 1 and 2. The top landing and top ladder are set first and then the next lower one, and so on down to the bottom ladder, which is set last. There should be a clearance of 2 inches or more between the ladder timbers and the tripod. After the ladders have been set in place a second nail is driven in each end of all the steps.

TRIPOD AND SCAFFOLD SIGNALS 100 FEET OR MORE IN HEIGHT.

The following directions are supplemental to the general directions on the preceding pages of this publication and are intended to supply the necessary additional information for framing and erecting signals 100 feet or more in height where it is necessary to raise them in two or more sections.

Figure 45 shows the complete working drawings of a tripod and scaffold signal 100 feet in height. *A* is one side of the tripod; *B*, the ground plan; *C*, one side of the scaffold; *D*, the lower section of the tripod erected; *E*, one leg of the signal built up of 2 by 6 inch timbers; *F*, one leg of the signal made of solid timbers scarfed and spliced; and *G* shows one side of the lower section of the tripod and one leg of the top section.

HOLES FOR LEG ANCHORS.

The position of the holes for the leg anchors of the scaffold and tripod is shown in *B*, Figure 45. The holes should be about 3½ feet square and 4 feet deep. In some places it may not be practicable to dig the holes the required depth on account of rock. In such cases the holes should be made larger in cross section, longer anchors used, and a large cairn of rock built up over the anchors. Sometimes the signal must be built on a solid rock outcrop, where no holes can be made. In such cases long anchors are put on in the usual manner, and a large cairn of rock is built around each leg on top of the anchor. It should be remembered that the object of the anchors is to hold the legs down, and a sufficient volume of material should be placed on the anchors to accomplish this purpose.

FRAMING THE TRIPOD.

The first step in building the signal is to frame the tripod legs. They may be made of solid timbers or built up by spiking together 2 by 6 inch pieces, as shown in *E* and *F*, Figure 45. In either case the legs must be made in two sections, the lower section about 75 feet long, and the two sections put together with ½-inch carriage bolts 6½ inches long.

The rest of the framing is done in accordance with the general directions for framing a 60-foot signal, as given on pages 36–50 of this publication, except that the horizontal ties and diagonal braces on the top section should only be nailed in place temporarily. Call the first side of the tripod framed No. 1 and cut the horizontal ties and diagonals for sides Nos. 2 and 3 by laying each piece to be cut on the corresponding piece on side No. 1 and cut to match.

Next remove the ties and diagonals from the top section of side No. 1 and lay them out ready to be sent aloft. Then unbolt the top section of the legs and proceed with raising the lower sections of side No. 1 and of the third leg in the same manner as in raising a 60 or 75 foot tripod. After putting the ties and diagonals on sides Nos. 2 and 3 of the lower section, attach the anchors and fill in the foundation holes.

RAISING THE TOP SECTION OF THE TRIPOD.

To raise the top section of the tripod it is necessary to use a derrick, as shown in *D*, Figure 45. The top section of a tripod leg can be used for the derrick and may be placed on either leg No. 1 or leg No. 2 of the tripod, but the top section of the same leg as that on which it is placed should be used. After the top sections of the two other legs have been set in place, shift the hoisting block and rope to them and hoist to place the top section of the leg used as the derrick.

In *D* (fig. 45), *a* is the block and rope for hoisting the derrick, *b* is the derrick, *c* is the block and rope for hoisting the top section of the leg, and *d* and *d′* are the top and lower sections of the leg splice to be bolted. The derrick is hoisted aloft inside the tripod with the block and rope *a*. The rope is made fast to the lower end of the derrick, and a lashing is put around near the top of the derrick to fasten it to the standing rope, and thus keep the derrick upright while hoisting. When the top of the derrick is about at *a*, three guy ropes are put on and carried out to the guy posts *b*, *c*, *e*, as shown in the ground plan *B*, Figure 45, and the lashing around the top of the derrick is then removed. The block and hoisting rope *c* are then attached to the top of the derrick, and the derrick is hoisted to the necessary height for hoisting the top sections of the two other legs of the tripod. The foot of the derrick is lashed to the top of the leg, as shown in *D*, Figure 45.

The top sections of the two other legs can then be hoisted to place and bolted. As each top section is sent aloft two guy ropes are put on, as shown in *D*, Figure 45, and carried to guy posts. As soon as the top sections of all three legs have been bolted in place, the horizontal ties and diagonals for the top section are put on and the tripod completed.

FRAMING THE SCAFFOLD.

The legs of the scaffold may be made of the solid timbers (*F*, fig. 45), or they may be built up (*E*, fig. 45), but in either case they must be framed for raising in two sections and be put together with bolts at a splice about 75 feet from the bottom. Lay out legs Nos. 3 and 4 on the forward side of the tripod and Nos. 1 and 2 on the rear side and proceed with the framing in accordance with the general directions given for a 60-foot signal, except that the diagonal braces for the panel where the lower and top sections are joined should be nailed only temporarily. All other diagonals and all the horizontal ties on the two framed sides can be nailed securely. The ties and diagonals for the other two sides should next be cut and laid out ready for sending aloft.

RAISING THE SCAFFOLD.

Before starting to raise the scaffold remove the diagonals on the panel where the top and bottom sections are joined and take the bolts out of the leg splices. Carry the two top sections to the base of the tripod and lean them against the tripod in position to be sent aloft. The first section of the scaffold may then be raised by following the directions for raising the scaffold of a 60-foot signal. After completing the first section overhaul the hoisting tackle and attach the bridle ropes a few feet above the centers of the two framed sides of the upper section and hoist them aloft. As each of the two framed sides of the upper section is raised transfer the hoisting lines and guys from the lower section to it. The hoisting lines should be attached near the top and the guys near the bridle rope. When the two sides of the upper section have been raised to the required height, two men aloft can put the bolts in at the splices, and the scaffold can then be completed in accordance with the general directions for a 60-foot signal.

PLUMBING SIGNALS AND MARKING STATIONS.

VERTICAL COLLIMATOR.

An instrument called a vertical collimator is used for centering the tower over the mark at a previously established station, for placing a mark under a new tower, or for centering a theodolite or lamp over a station mark.

The collimator shown in figure 46 consists primarily of a telescope of the "broken" type, that is, one having a 45° mirror between the objective and the eyepiece to bend the light rays at right angles. The objective end of the telescope is mounted vertically in a bracket collar which is supported by a tribrach with three leveling screws. The eyepiece end is horizontal and can be rotated about a vertical axis through an angle of about 300°. The cross hairs mounted on the diaphragm of the eyepiece can be adjusted to the optical axis of the telescope by pointing on some object and swinging the eyepiece end of the telescope around the vertical axis. A level bubble is attached normal to the vertical element of the telescope and revolves with it.

The collimator is so constructed that it can be mounted on an ordinary theodolite tripod. The tripod should have an adjustable head which will permit of some horizontal motion of the instrument to facilitate plumbing the collimator over or under a definite point.

The adjustment of the instrument is simple. The level is first adjusted by the ordinary method in order to make the bubble remain in the center as the telescope is rotated about the vertical axis after the instrument has been leveled. The eyepiece is then adjusted by pulling it out or pushing it in until the cross wires are in focus and there is no apparent shifting of their intersection, when the telescope is pointed on some object, as the eye is moved horizontally over the eyepiece. The intersection of the wires is then adjusted to make the pointing on the object remain fixed as the telescope is rotated about the vertical axis. This adjustment is made by turning the capstan-headed screws in the collar of the eyepiece and thus shifting the diaphragm which carries the wires. At least three of the screws should be loosened when making the adjustment and they should not be set up too tight when the adjustment is completed. When the instrument has been placed in perfect adjustment and when it has been properly leveled by centering the bubble in two positions of the eyepiece end of the telescope at right angles to each other, the line of collimation will be a line with a right-angled bend and with one leg truly vertical.

If a vertical collimator is not available, the centering can be done with a transit or a theodolite. The theodolite should be in good adjustment. Make certain that there is no parallax in the eyepiece

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by adjusting it until there is no apparent movement of the intersection of the wires over an object on which it is pointed when the eye moves back and forth in front of the eyepiece. Also see that the stride level is in good adjustment. Set up the theodolite at a distance from the tower about equal to the height of the tower and level it carefully by using the stride level. Using the slow motion screw, point on the center of the tripod, or light stand, that is, on one of the marks which will be used in centering the theodolite and light. Plunge the telescope down to the ground under the tripod and mark upon a horizontal board a line coinciding with the path of the collimation axis as it crosses the board. Move the theodolite to a point about 90° around the signal and repeat the process. The intersection of the two lines will be vertically below the center of the tripod head or light stand. If the mark is already established, the reverse process can be used to plumb up to the tripod head.

PLUMBING OVER AN OLD STATION MARK

When a signal is built over a previously established station mark, the opening between the three legs at the top of the tripod should be approximately centered over the station mark before the tripod legs are anchored. If the footplates have been carefully leveled and measurements for placing them made with reasonable care, the tripod head will seldom be more than 1 inch off center when the signal is erected. If necessary, however, the tripod can be shifted on the footplates or one leg wedged up to bring the center of the tripod head approximately over the station mark. To center the hole in the cap plate directly over the station mark, set up the collimator over the mark, and adjust and level it. Move the cap plate until the hole marking the center is directly in line with the vertical line of sight and then secure the plate to the top of the tripod head.

PLUMBING IN A NEW STATION MARK

In general, the signal is built first at a new station and then the station mark is put in place. A small stake is used for the central point in laying out the ground plan of the signal. After the tower has been built, a point on the ground directly beneath the hole in the cap plate of the light stand is determined as follows: Set up the collimator on its tripod over the approximate location of the station and adjust and level the collimator and attach the plumb bob. By sighting through the collimator at the cap plate a close estimate can be made of the distance the collimator must be moved to place it directly beneath the hole in the cap plate. A piece of board may be placed on the ground beneath the plumb bob and the point marked on the board for the new trial centering of the collimator. The collimator is then centered roughly over the new trial point by use of the plumb bob, and then is again accurately leveled. Usually the collimator is now close enough to the vertical line through the hole in the cap plate so that the final adjustment can be made on this second trial by shifting the adjustable tripod head. After the collimator has been so placed that it is apparently in the vertical line through the station, its adjustment should be tested by turning the eye end of the telescope around the vertical axis of the instrument and watching for any apparent movement of the cross hairs on the object.

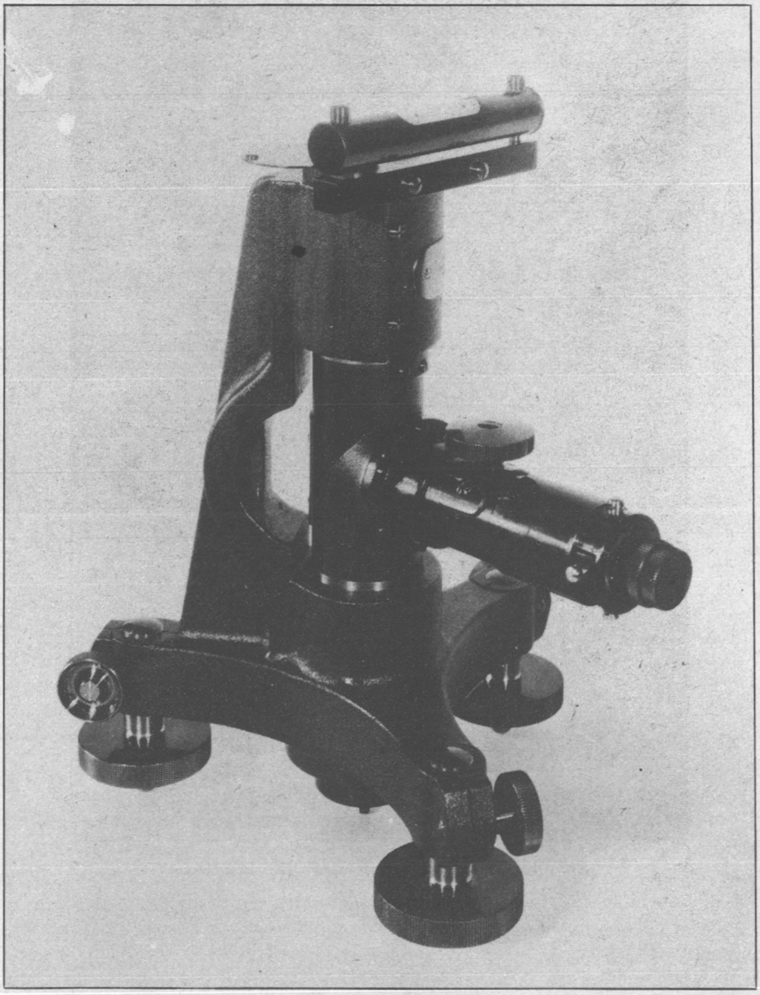

FIG. 46.—VERTICAL COLLIMATOR.

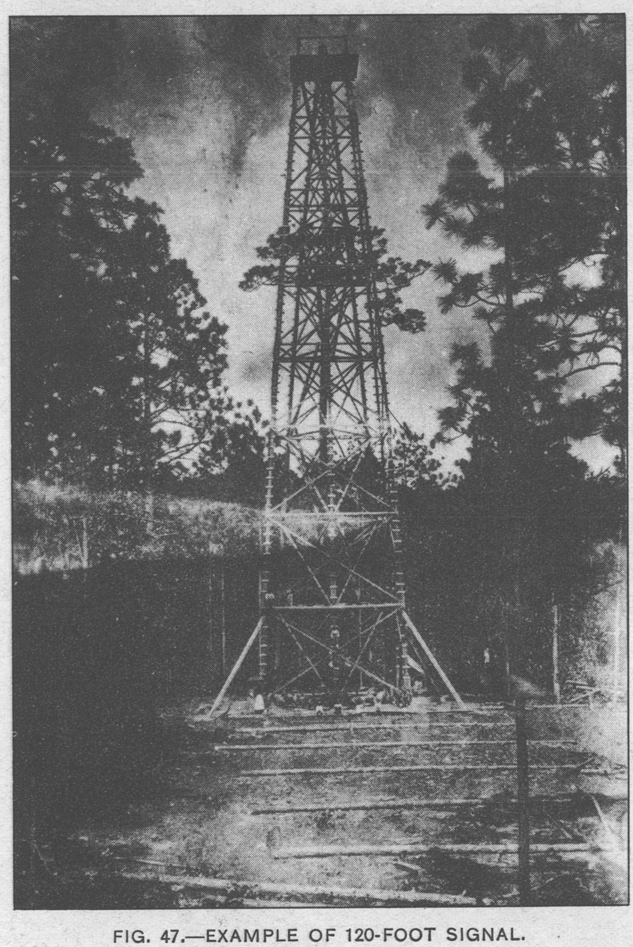

FIG. 47.—EXAMPLE OF 120-FOOT SIGNAL.

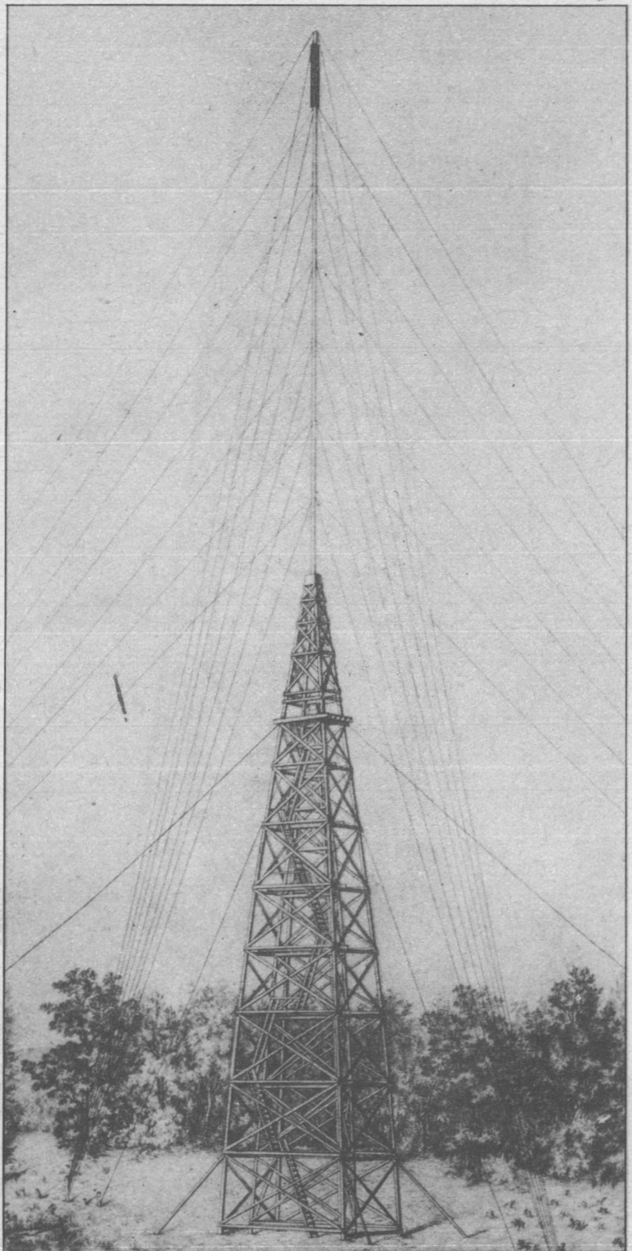

FIG. 48.—EXAMPLE OF 120-FOOT SIGNAL WITH SUPERSTRUCTURE AND POLE.

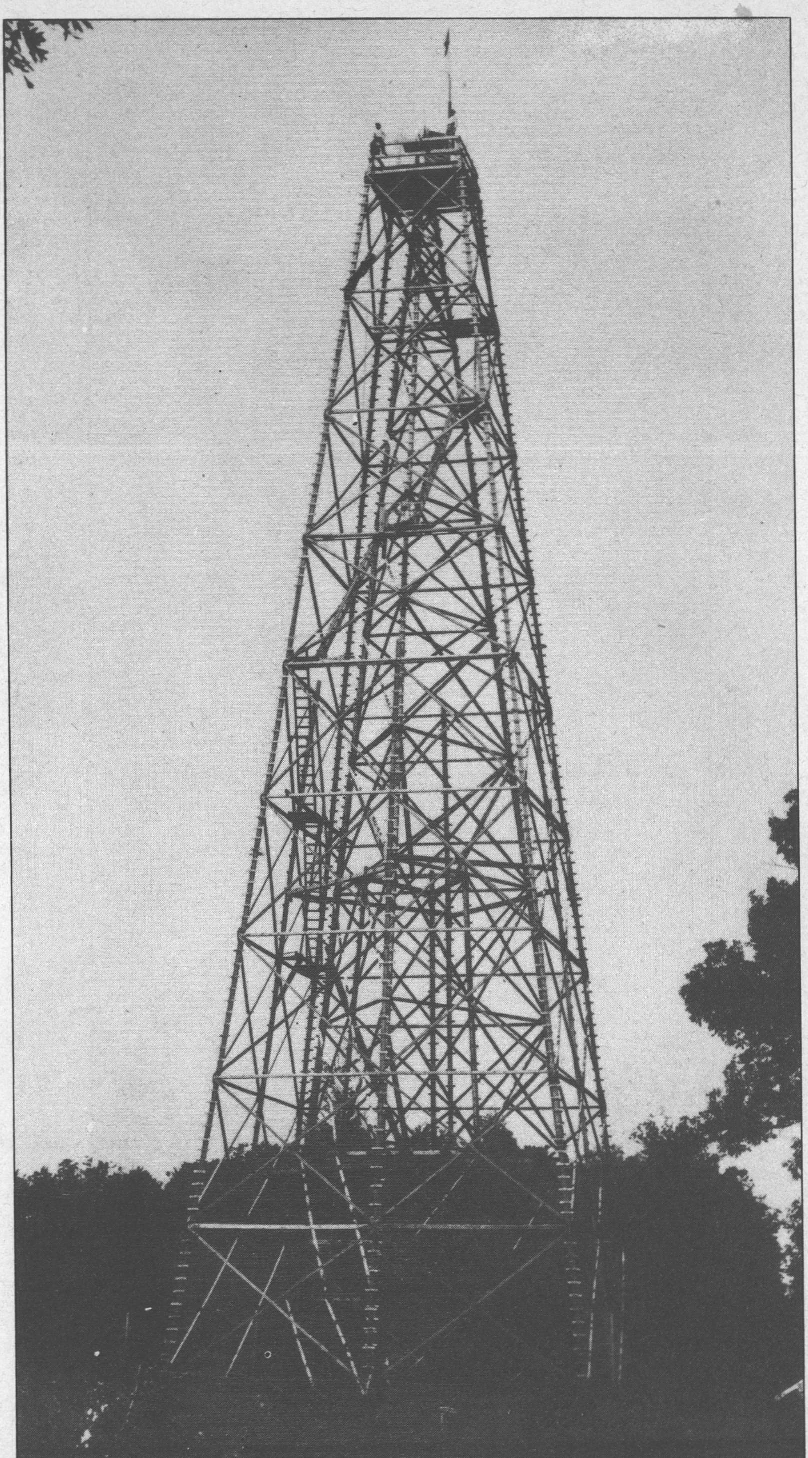

FIG. 49.—OLD TYPE OF SIGNAL.

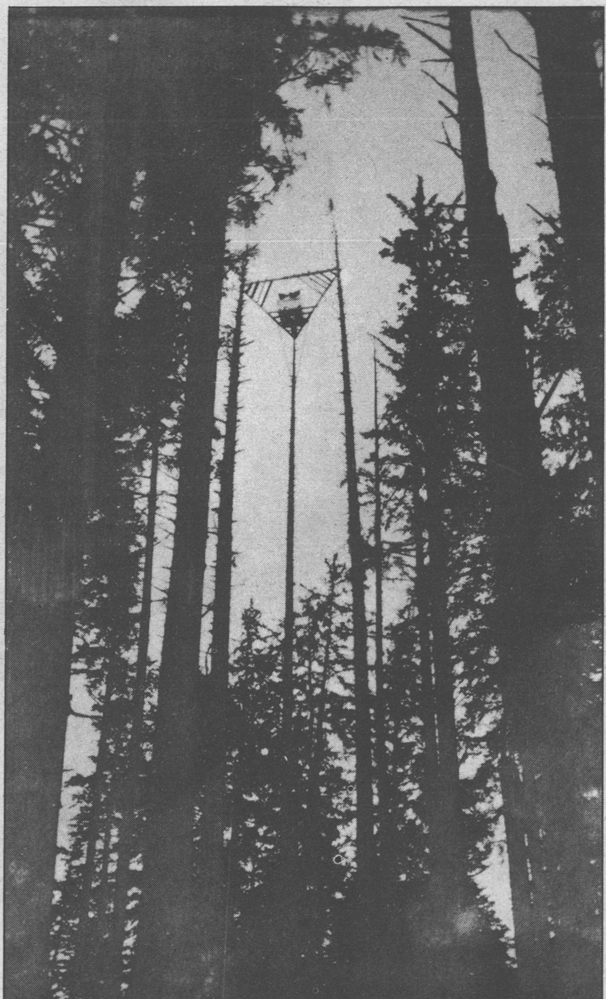

FIG. 50.—TRIPOD SIGNAL MADE OF THREE TREES.

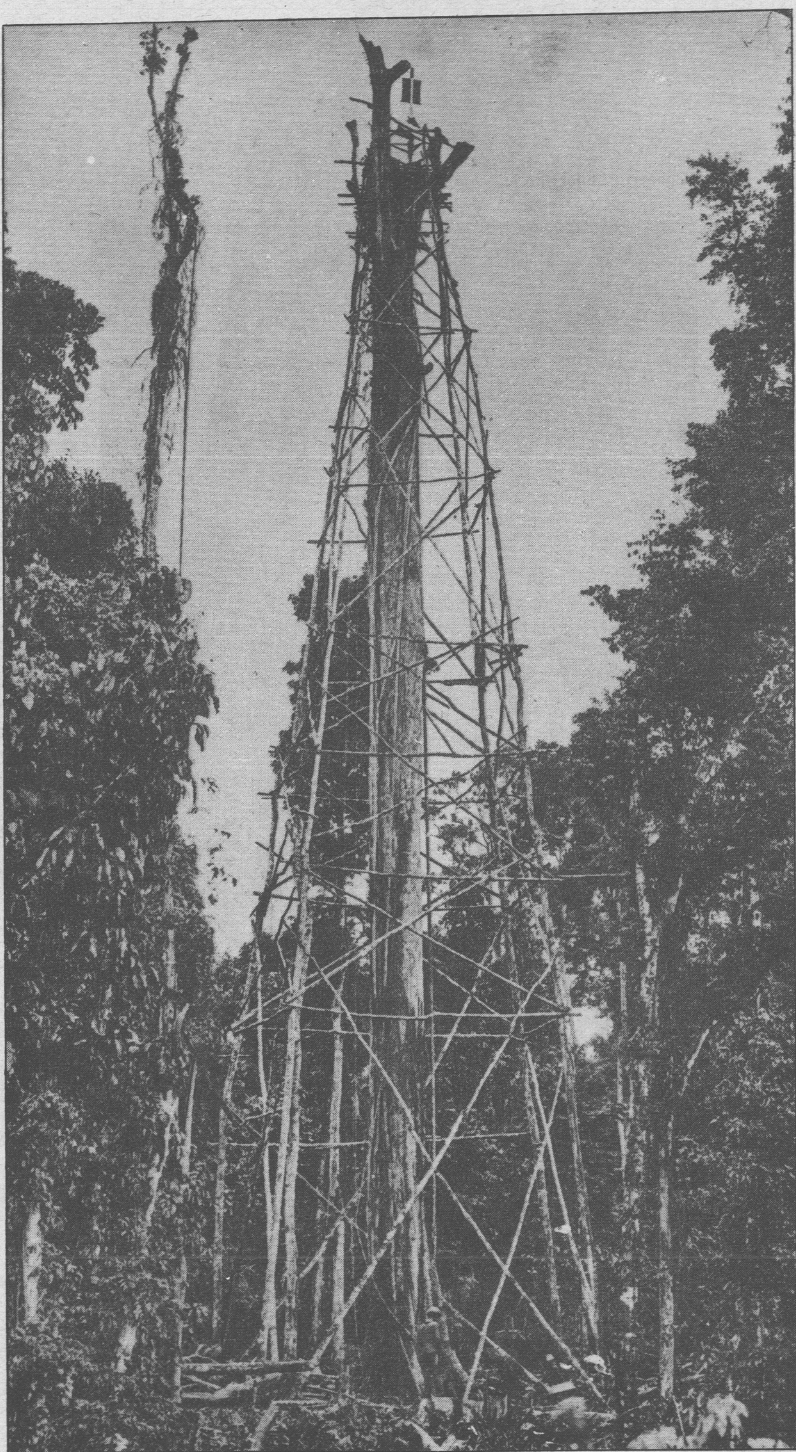

FIG. 51.—SIGNAL CONSISTING OF TREE IN PLACE OF TRIPOD AND OF SCAFFOLD MADE OF POLES.

LOCATION OF SURFACE AND UNDERGROUND MARKS.

When marking a station with both underground and surface marks it is necessary to construct a bench over the points to hold a position from which to center both marks. The most practical method is to drive 2 by 4 inch stakes approximately in line with the station on opposite sides and each about 1 foot from the edge of the hole which has been dug for the concrete mark. The stakes should be driven firmly into the ground and should project about 1 foot. Place a piece of 1 by 4 inch board across the top of the stakes and drive a nail through one end of it into the top of the corresponding stake. The board should then be carefully set until one edge touches lightly the plumb line of the collimator. A nail should then be driven part way into the top of the other stake alongside of the board and a fine notch cut on the edge of the board where the plumb line from the collimator touches it. The underground mark and surface mark can then both be plumbed in from this mark on the board. When the bench is not in use the board can be swung around out of the way, leaving it attached by the single nail to the one stake. The free end should be supported in this position to prevent strain on the stake. The board can be swung back into exact position when needed, provided the stakes have not been disturbed.

The marking of a new station normally is done by the building party after the signal tower has been erected. Several days may elapse before the tower is used by the lightkeepers or observing unit. Regardless of the care that may have been used by the building party in centering the mark under the tower, the observing unit should always test the centering with a collimator when it reaches the station and should determine accurately any eccentricity of the tower. If there is any eccentricity, and the lights were shown eccentrically for the observations already completed on the station, the records should indicate this clearly. If the tower is then recentered, the records should show clearly what observations were made to and from the true station. Extreme care in centering instruments and lights is very important on first- and second-order triangulation. Even on third-order triangulation, the centering must be done carefully, especially on short lines, if satisfactory triangle closures and accurate results are to be obtained.

VARIOUS TYPES OF SIGNALS

TRIPOD AND SCAFFOLD SIGNAL 120 FEET IN HEIGHT

Figure 47 shows a 120-foot signal with a shore brace 6 inches square on each scaffold leg set at an angle of about 45°. The top end of each brace is notched to fit the corner of the scaffold leg and spiked fast just below the second tie, as shown in the figure. The lower end is set on a footplate and anchored in the same manner as the legs of the scaffold. The shore braces serve as additional anchorages and relieve the strain on the base of the scaffold legs in time of a heavy blow. Otherwise the signal is constructed in the same manner as the 100-foot signal. The signal shown in Figure 47 was raised in one section by using the tall tree directly back of the signal as a derrick.

TALL SIGNAL WITH SUPERSTRUCTURE AND POLE.

Figure 48 shows a 120-foot signal with a 40-foot superstructure and 115-foot pole. The top of the pole is 275 feet above the station mark. The pole is made of timbers 4 inches square and 18 feet long spliced with a 2-foot scarf. The tripod and scaffold are the same as shown in Figure 37. The legs of the superstructure are 2 by 4 inch timbers and the bracing 1 by 4.

Before hoisting the pole an opening 4½ inches square was made in the cap block on the tripod head and the same size opening in the board on top of the superstructure, the center of each opening being directly over the station mark. The pole was hoisted inside the tripod. Sections were added to the bottom of the pole as it was hoisted aloft. When the top of the pole passed through the top of the superstructure, the targets and top guys were put on. The pole was then hoisted 16 feet higher, and the next set of guys were put on the pole just above the top of the superstructure. A set of guys was put on at each splice, or 16 feet apart, as the splice came above the top of the superstructure in hoisting. When the top of the pole was about 35 feet above the top of the superstructure, a turn was taken around the guy posts with each guy, leaving about 2 feet of slack in each guy. As the pole was raised the guys were slackened as needed. When the pole had been raised to the desired height, the bottom end was about 6 feet above the tripod head and was held in place by a guide made of two 2 by 4 inch pieces placed across the superstructure on opposite sides of the pole, with their ends spiked to ties of the superstructure. Two pieces of 1 by 4 inch boards were nailed at right angles to the guide timbers to hold the foot of the pole. At the top of the superstructure two 2 by 4 inch pieces were nailed to opposite sides of the pole to rest on crosspieces on top of the superstructure, and thus support the weight of the pole.

The pole was made about plumb and approximately the same strain taken on each guy. It was then carefully plumbed with a small theodolite or transit and all guys made fast securely. The two top sets of guys, which held that part of the pole to which the target was attached, were made fast to separate sets of posts, and not more than three guys altogether were made fast to any one post. The target shown on the top of the pole is a 7-inch stovepipe painted black. Other types of targets may be used on a signal of this kind.

OLD TYPE SIGNAL.

Figure 49 shows a tripod and scaffold signal 152 feet high. This is the old-type signal with the large base. There is no bow in the legs, and on account of the large base it is necessary to have an additional leg extending part way up in the middle of each side of the scaffold and tripod. This type of signal requires about double the amount of lumber per vertical foot required for the type shown in Figure 47, and the cost is about double that of the slender type. It has a greater exposed surface to the wind and a greater vibration on account of the extra legs and the long ties and diagonals.

TREE SIGNALS.

Figure 50 shows a signal made of three trees. The trees were trimmed up and sprung toward each other with rope tackles. Timbers were then spiked across to form a triangle, as shown in the illustration. These timbers supported the floor for the observer and also a stand on which the instrument was mounted. Since the observer and instrument were not on independent supports, the station was occupied with a repeating theodolite and the observer stood in one position while the pointings and readings were made. The height of the instrument was 187 feet above the station mark.

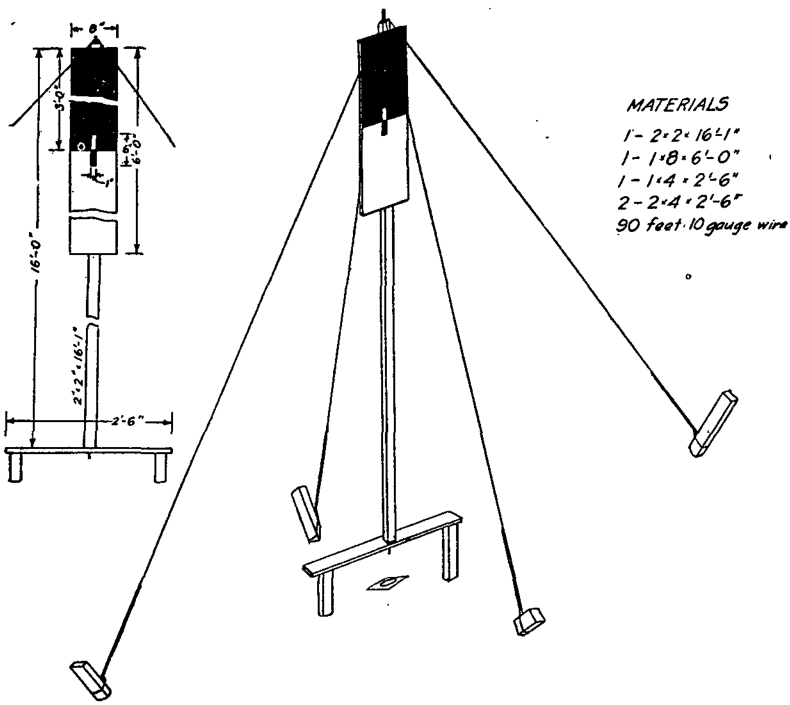

Fig. 52a.—Diagram of a pole signal.

Figure 51 shows a scaffold constructed of poles around a large tree. The tree was used in place of the tripod to support the instrument and the scaffold supported the observer. This type of signal was built because it was not practicable to get lumber to this station; neither was it practicable to clear the lines to make the stations intervisible from the ground. This illustrates one solution of one of the many problems that may be met in extending triangulation over a timbered country.

POLE SIGNAL.

Figures 52a and 52b show two different types of pole signal each held in a vertical position by wire guys with the foot of the pole resting on a low bench. The bench may be made of two stakes driven in the ground on either side of the station mark, with a piece of scantling placed across on top and nailed to them. The foot of the pole should have a spike driven at its center projecting about an inch, and when the pole is erected this spike should be placed in a hole bored in the crosspiece of the bench directly over the station. Each set of guys should consist of four wires of No. 12 smooth galvanized wire. The number of sets depends upon the height of the pole. The pole is easily lowered when the station is occupied by loosening the guy or guys on only one side. The guys on the other three sides are not loosened from their anchors. To replace the pole it is only necessary to stand it up on the bench and fasten the loosened guy or guys on the one side. The centering of the pole or that part on which observations are made should be tested

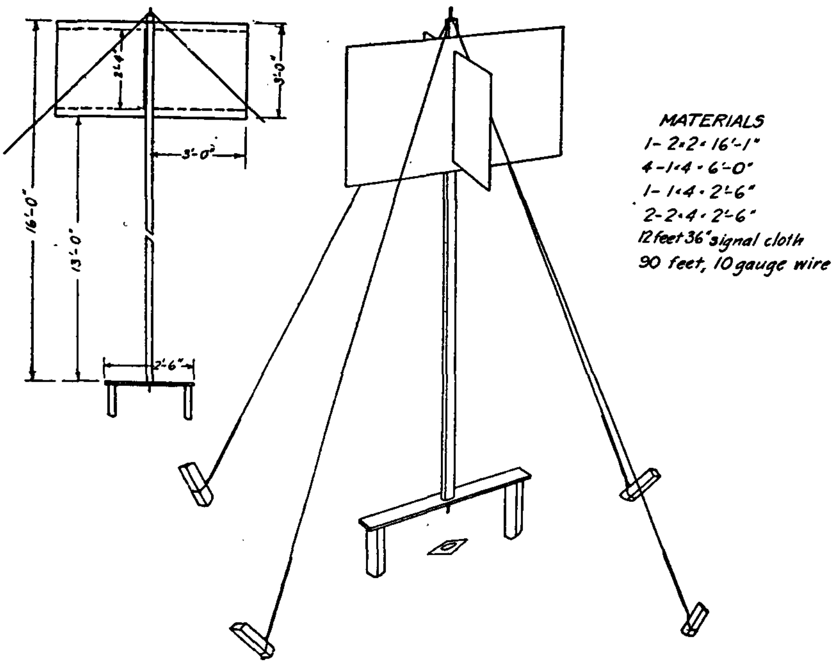

FIG. 52B.—Diagram of a pole signal (another type).

after the pole has thus been replaced, but it will usually be found that it has not been disturbed. A pole signal is a very satisfactory signal on secondary or primary triangulation when the station is to be occupied with a theodolite mounted on its own stand or when the station is not to be occupied.

SIGNALS FOR PRECISE TRAVERSE.

On precise traverse it is seldom necessary or advisable to build high tripod and scaffold signals. The maximum height is about 40 feet, and the height most commonly used is from 4 to 16 feet for the tripod stand. All signals of this type are made of 2 by 4 inch timbers for the legs and 1 by 4 inch pieces for braces.

Figure 53 shows a tripod stand used at all stations where it is only necessary to elevate the instrument to the height of the observer's eye when he is standing on the ground. This type of tripod can be used at nearly all stations. If it is found necessary to elevate the instrument a few feet higher, it can be done easily by spiking on 2 by 4 inch pieces to lengthen the tripod legs and adding the necessary braces of 1 by 4 inch pieces to make the tripod rigid. A temporary observing platform (fig. 54) can then be built around the tripod.

Figures 55, 56, and 57 show other signals used on traverse work. Figure 58 shows the working drawing of a 30-foot signal.

Targets.—On precise traverse many of the lines are short and targets are used for day observations. Care must be taken in the use of targets to avoid phase and to have that part of the target on which observations are made directly over the station mark. It has been found by experience that the only target that will satisfy these conditions and requirements is a flat surface facing directly on the line to be observed, and the flat board target shown in Figure 59 has proved to be the most satisfactory. This target is a board ⅞ inch thick by 6 inches wide and projects about 6 feet above the tripod head. The top half is painted black and the lower half white. It is used on lines 1 mile or more in length. For shorter lines a 1 by 4 inch target projecting 4 feet above the tripod head is sufficient. The targets should be made of well-seasoned lumber of No. 1 grade and should be given two coats of good paint. A number of targets can be made in camp and painted ready for use.

Portable tripod and scaffold signals.—On precise traverse where the character of the country makes it necessary to erect tripod and scaffold signals of 16 to 20 feet in height at the majority of the stations time and money can be saved by the use of portable signals that can be moved from station to station. Any signal up to 20 feet in height can be easily transported on a motor truck or on a small trailer attached to a motor velocipede car, if such are used.

Figure 60 shows several tripod and scaffold signals nested on a trailer. The large tripod shown is 20 feet high when erected. Smaller tripods are nested inside the larger one. Two or more of the larger tripods may be nested if necessary.

Figure 61 shows the 20-foot portable signal, consisting of tripod and scaffold erected over the station. It will be noted that the signal is complete except for the floor to support the observer. The floor used for this purpose is 6 by 7 feet made of ⅞-inch boards in three sections. The floor is only needed while the observer is at work on the signal and so is moved with the observer. Six or more of the portable signals are necessary to keep the work moving. The building and observing parties work as a combined party.

The tripod of the signal shown in Figure 61 is nailed together and transported whole. In framing the scaffold sides Nos. 1 and 3 are framed, and the ties and diagonal braces are nailed in place. The ties and diagonals for sides Nos. 2 and 4 are framed and put on with bolts. Each piece is numbered on the ends and the same number placed on the leg of the scaffold at the place where the brace bolts on. When the signal is taken down to be moved forward, it is only necessary to remove the bolts from the ties and diagonals on sides

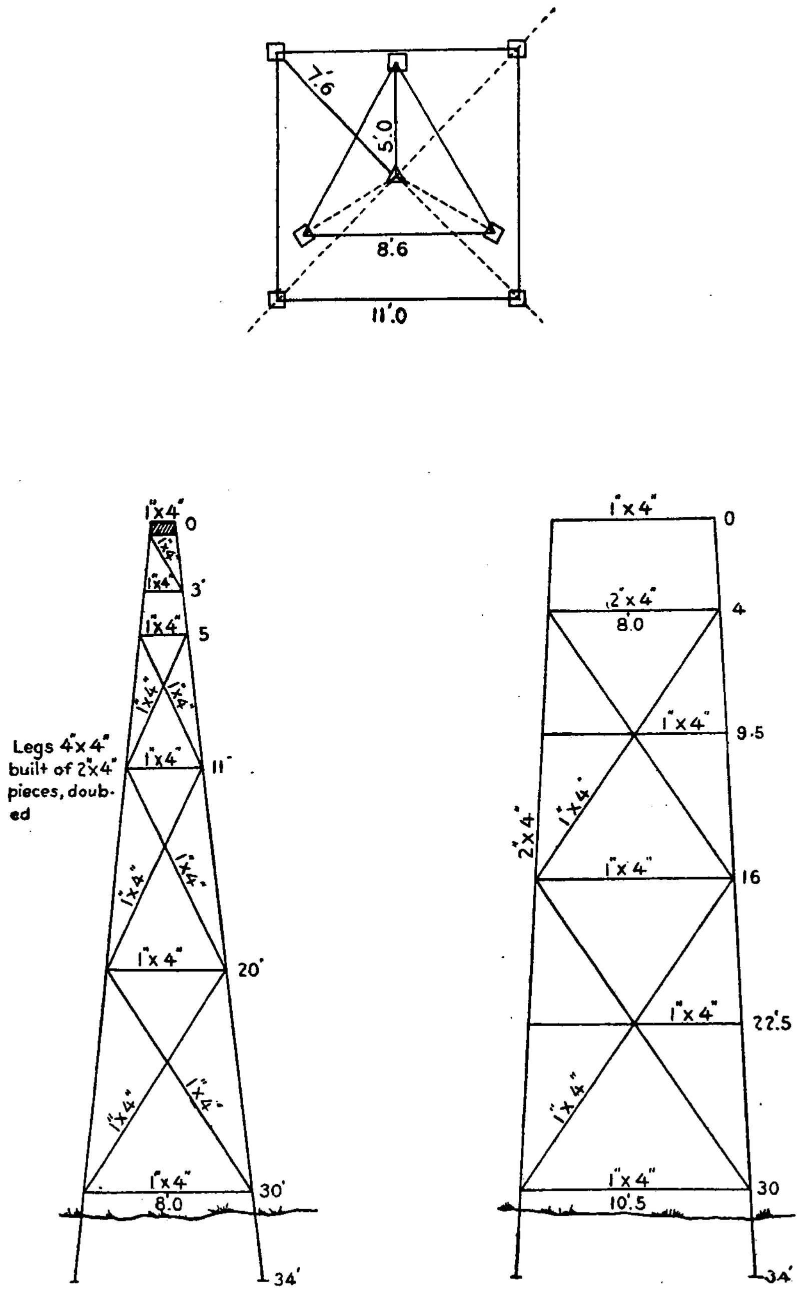

Fig. 58.—Working drawing of 30-foot traverse signal.

FIG. 53.—INSTRUMENT STAND.

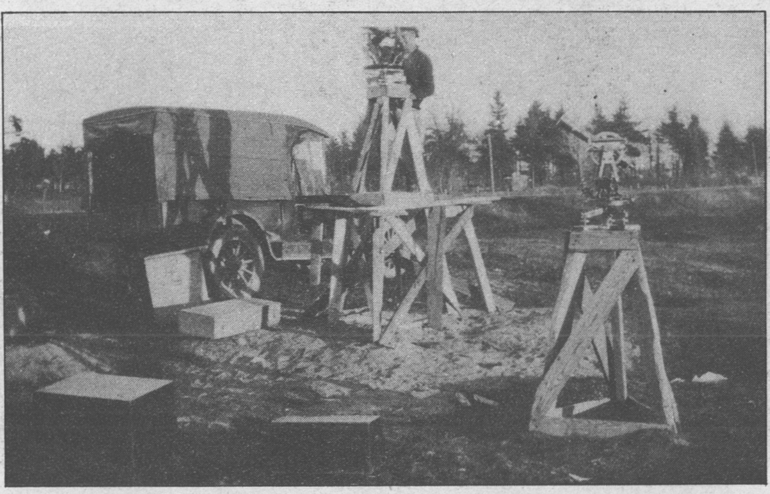

FIG. 54.—INSTRUMENT STAND AND PLATFORM FOR OBSERVER.

FIG. 55.—EXAMPLE OF SIGNAL USED ON TRAVERSE.

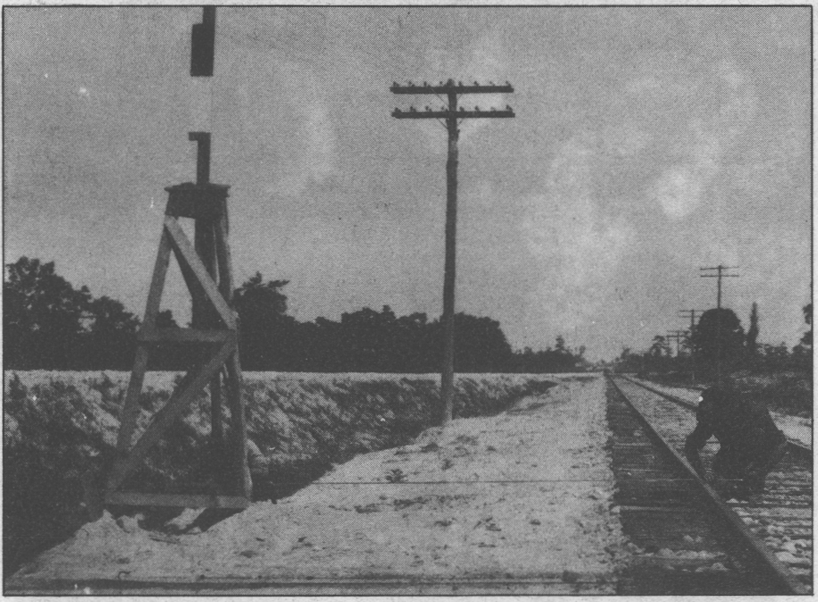

FIG. 56.—TRIPOD OF TRAVERSE SIGNAL WITH TARGET.

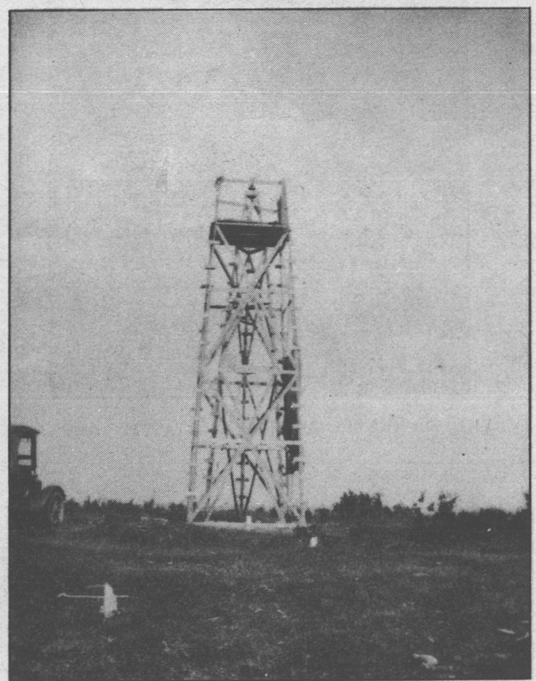

FIG. 57.—SIGNAL 30 FEET HIGH USED ON TRAVERSE.

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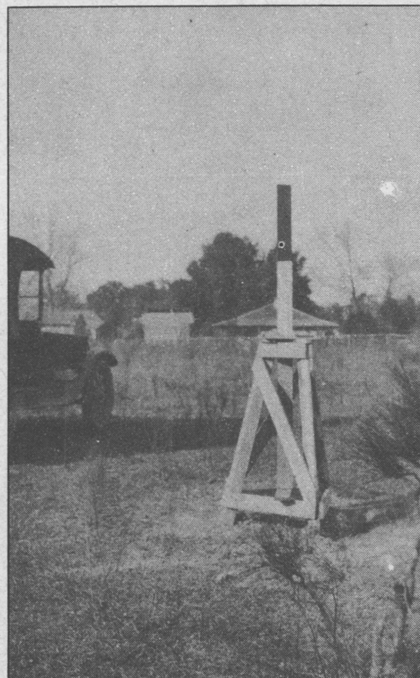


FIG. 59.—INSTRUMENT STAND WITH TARGET.

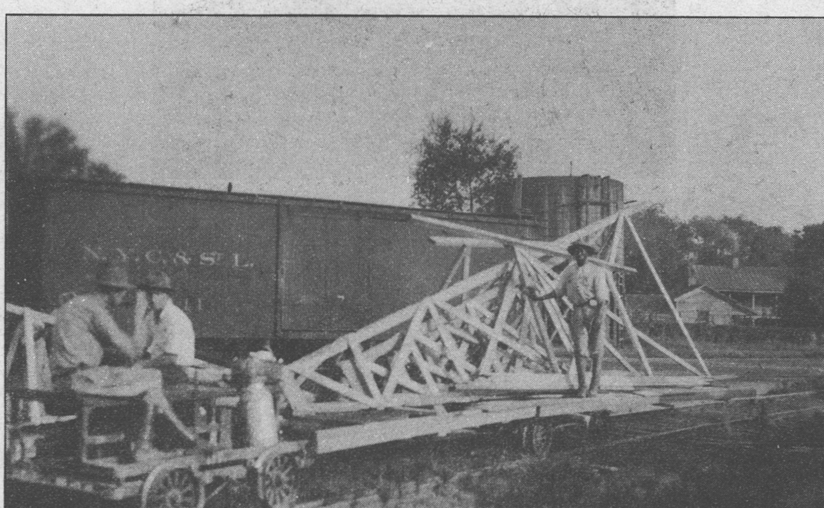


FIG. 60.—NEST OF PORTABLE TRIPODS AND MATERIAL FOR SCAFFOLDS LOADED ON A TRAILER WHICH IS HAULED BY MOTOR VELOCIPEDE CAR.

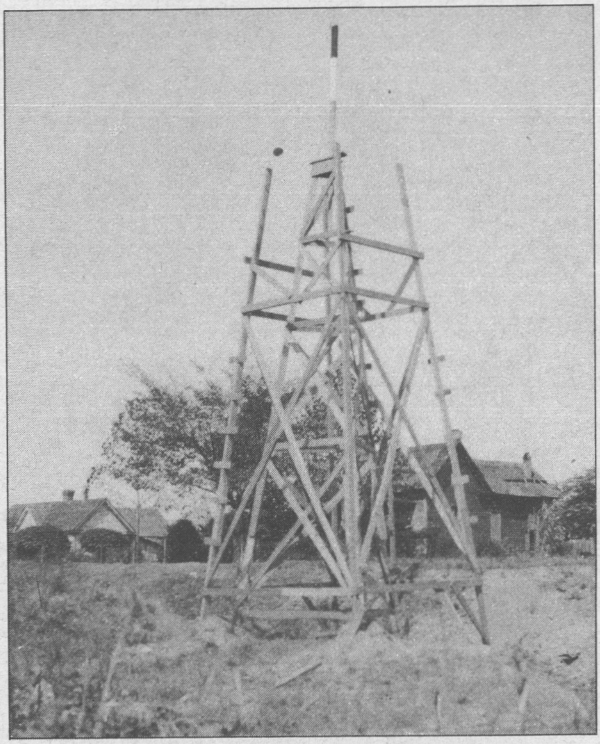


FIG. 61.—PORTABLE SIGNAL 20 FEET HIGH ERECTED.

Nos. 2 and 4. The legs for both tripod and scaffold are made of 2 by 4 inch timbers and all ties and diagonals of 1 by 4, except the ties which support the floor timbers, which are 2 by 4. Two men will erect a signal of this type in about three-quarters of an hour and will take it down in 20 minutes.

If the signal is to be erected over a mark at the intersection of two rail tangents or on line with one tangent, a temporary point on a stake should first be lined in. Set the tripod upright over the stake in approximate position by placing each leg the same distance from the mark. This will determine where to dig the hole for each tripod leg. The holes should be about 15 inches square and about 1 foot deep or to the solid subsoil. If the ground is very uneven, the tripod may be leveled by driving a 2 by 4 inch stake at each of the two low legs of the tripod and on the same slant as the leg. The low legs are then raised to bring the lower tie horizontal and nailed to the stakes. Before nailing the legs to the stakes, however, a heavy plummet should be swung from the center of the tripod head and the tripod head plumbed over the temporary mark. Each leg is anchored by driving two stakes at an angle of about 30° to each other and at a slight inclination to the vertical and nailing them to the leg. The scaffold is erected in a similar manner.

For a 20-foot portable signal the lower tie on the tripod is 7 feet long and the board at the tripod head is 14 inches long. The lower ties of the scaffold are 8 feet long and the floor tie is 6 feet long. The lower ties on both the scaffold and tripod are 2 feet from the bottom end of the legs.

HYDROGRAPHIC SIGNALS.[2]

Several different types of signals are used for hydrographic work, depending upon the general character of the coast. Along a low, flat coast it is often necessary to construct high signals to make possible the location of sounding lines several miles from shore. These high signals are sometimes built to a height of 100 feet or more and carry large targets to make them visible for long distances. They are usually spaced 4 or 5 miles apart. For the hydrographic work not so far out, smaller signals, usually about 40 feet in height, are erected midway between the high signals. Another type of hydrographic signal, which is also used in carrying triangulation along a flat coast, is known as the water signal. It is located quite a distance from shore in a depth of water as great as 13 feet, but it rests on the bottom and so is not shifted in position by the waves or the wind.

For hydrographic work so far offshore that it is impossible to see signals along the shore floating signals are sometimes used. These signals are anchored in the desired locations, and their positions are then determined by "cuts" from a ship, as follows: The ship is anchored in several successive positions near enough to the shore that the shore signals and the floating signals are visible at the same time. In each position the location of the ship is accurately determined from the shore stations, and then the "cuts" are taken on the floating signals.

[2] See Hydrographic Manual, Special Pub. 143, revised (1942) edition.

INSTRUCTIONS FOR BUILDING TALL HYDROGRAPHIC SIGNAL.

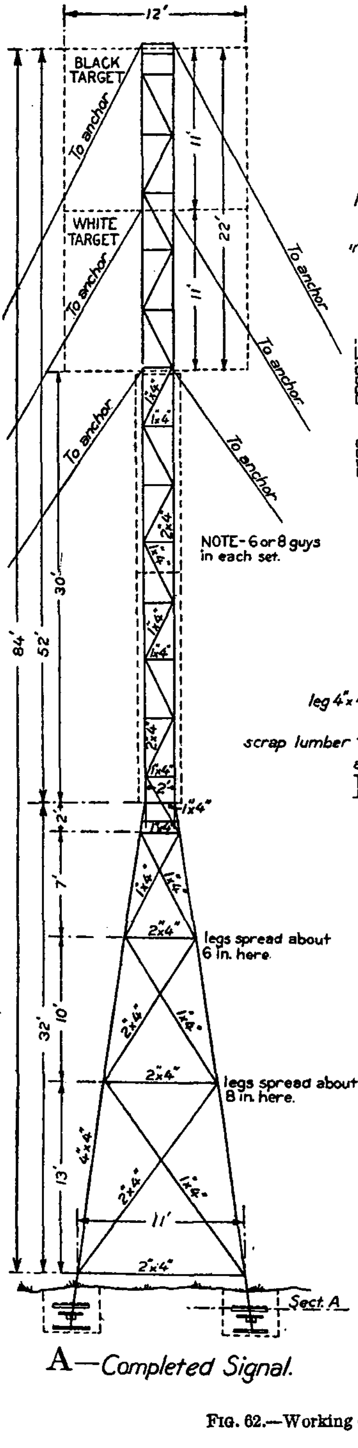
In the following instructions, signal refers to the completed structure, foundation to that part of the signal below ground, scaffold to the wide lower converging part, superstructure to the slender upright section which surmounts the scaffold, target to the broad surface fastened to the superstructure to make it conspicuous, and guys and anchors to the wires and their fastenings which are used to secure the target and superstructure against the wind.

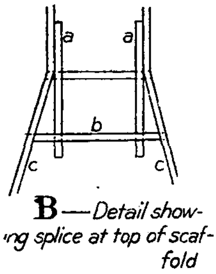
Foundation.—Stakes are driven to mark the positions for the holes, Nos. 1, 2, 3, and 4, as shown in *C*, Figure 62. The holes should be made about 3 feet square and 3 feet deep. In the bottom of each hole place a footplate 2 by 8 inches and 2½ feet long made of two 2 by 4 inch pieces held together with 1 by 4 inch pieces nailed across the ends. Spend no time in bringing the bottom of the four holes to the same level, but after the footplates are set take a round of levels with a carpenter's level, using any one of the footplates as a zero bench, and cut the corresponding legs of the scaffold to agree with the differences of elevations.

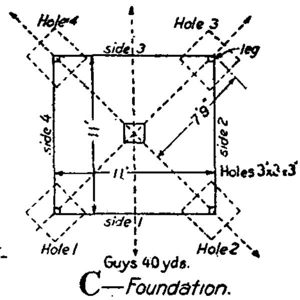
Scaffold.—*A*, Figure 62, shows the working plan for the scaffold. Outside measurements are consistently shown except in the spacing of the horizontal ties. Two of the sides of the scaffold are completely framed and assembled on the ground and raised to place with a tackle, as in the case of a triangulation signal. (See p. 9.) The horizontal ties and diagonal braces belonging to the other two sides are then nailed on.

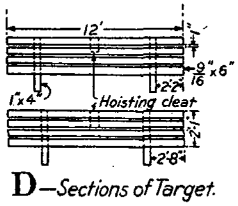
In selecting the place on the ground for laying out the two sides that are built before raising it should be observed that the ties and diagonals are placed on the outside of the scaffold, and so the first side of a signal can be framed on the ground and raised without first turning it over: but the other side must be turned over on the ground to get the ties and diagonals underneath. (See p. 9.)

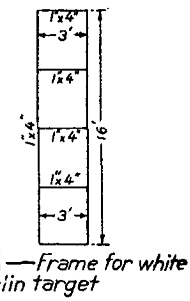
Framing.—The first step is to frame the four legs and number them 1, 2, 3, and 4. The legs are made 4 by 4 inches and 36 feet long by using 2 by 4 inch pieces and breaking joints, so that a distance of at least 4 feet will intervene between them. Strengthen each joint by nailing a 1 by 4 inch piece 3 feet long over it. Place marks on the legs for the horizontal ties at distances of 2, 9, 19, and 32 feet center to center, measuring from the top of the leg as zero. Put legs Nos. 1 and 2 on the ground in position to frame and nail on the top and bottom ties which have been cut to the length given in the working plan. As each of the intermediate ties is nailed on, force the legs apart from 6 to 10 inches, thereby giving them the desired bend. After the ties are in place, saw off the ends flush with the outside of the leg. Next square each panel by using a steel tape and making both diagonals measure the same, commencing at the bottom panel. Then lay the pieces for the diagonal braces in place and cut the ends parallel with the horizontal ties; nail in place and saw off the projecting ends flush with the outside of the leg. Use twentypenny nails for 2 by 4 inch pieces and eightpenny nails for 1 by 4 inch pieces. Call the finished side No. 1. Then cut the horizontal ties and diagonal braces for sides Nos. 2, 3, and 4 by laying each piece on the corresponding piece of side No. 1 and cutting to match. With a pencil make a cross mark on the outside of the top end of each

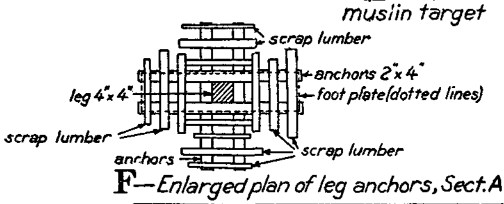












MATERIALS FOR 84 FT. SIGNAL

40 pieces	$\frac{9}{16}$″x 6″x 12′	-	240 board ft.
50 "	2″x 4″x 16′	-	533 " "
75 "	1″x 4″x 16′	-	400 " "
40 "	1″x 4″x 12′	-	160 " "

50 pounds 8 penny nails
25 " 20 " "
$\frac{1}{2}$ gal. white paint
$\frac{1}{2}$ " black "
12 yds. white muslin
$\frac{1}{4}$ pound 8 oz. tacks
2800′ smooth galv. wire #8 – 6 guys
Note: *lumber to be dressed on 4 sides*

LIST OF TOOLS

2 hand saws	1 rope, $\frac{5}{8}$ in. 125′
1 axe	2 ropes, $\frac{1}{2}$ in. 60′
1 carpenters level	1 rope, $\frac{1}{2}$ in. 200′
1 bevel	3 6 in. shingle blocks
1 try square	1 spade
2 rules	1 shovel
1 hatchet	2 paint brushes
2 clawhammers	

Fig. 62.—Working drawings for tall hydrographic signal.

diagonal and assemble the parts for sides Nos. 2 and 4 in a manner convenient to be sent aloft. Before raising the scaffold cleat the legs with 1 by 4 inch pieces 1 foot long, spaced about 2 feet apart.

Raising.—Drag side No. 1 back to holes Nos. 1 and 2 in position to raise. Attach two ropes to be used for guys after the side is up. A tackle made of two single blocks and 200 feet of ½-inch rope is used for raising the side. One block is made fast to a post about 20 yards back from the scaffold and the other is made fast near the top of the side to be raised. Start the side up by using props; then raise to a standing position with the tackle and make the two guy ropes fast to stakes.

The side opposite No. 1 is No. 3 and is made up of legs Nos. 3 and 4. It is framed in the same way as side No. 1, but before raising it must be turned over so that the ties and diagonals will be underneath. In placing the legs on the ground for framing select a position such that after the side is framed and turned over no additional maneuvering will be necessary to bring the foot of each leg to its foundation hole. When side No. 3 has been raised to a standing position, nail the ties and diagonals on sides Nos. 2 and 4 and then toenail the legs to the footplates and put on the leg anchors. Figure 63 shows the scaffold erected and the superstructure started.

Anchors for legs.—*F*, Figure 62, shows an enlarged plan of the leg anchors which form an important part of the foundation of the signal. To construct an anchor, spike two 2 by 4 inch pieces 2½ feet long on opposite sides of the foot of the leg parallel to each other. Use five twentypenny nails in each piece. Fill in with earth to the top of these pieces, then spike two more pieces of the same size on opposite sides of the leg at right angles to the first two. Nail scrap lumber across the top of the lower pieces and after filling in earth to the top of the upper pieces nail scrap lumber across those, too. Fill the hole with earth, keeping it well tamped.

Superstructure.—*A*, Figure 62, shows the front side of the signal. The dotted lines indicate the outline of the targets. The superstructure is made 2 feet square throughout. The ties and braces are 1 by 4 inch pieces. All the ties are cut 2 feet long and spaced 4 feet apart on the legs. The braces are all cut by one pattern by framing one panel of the superstructure and using a brace from that panel in marking and cutting the other braces. The legs are 4 inches square, built up of 2 by 4 inch pieces 4, 8, 12, or, preferably, 16 feet long.

B, Figure 62, shows the method of joining the superstructure to the top of the scaffold. As shown in this sketch, 2 by 4 inch pieces 4 feet long (marked "*a*") are used for splices at the top of the scaffold, and the lower end of these pieces are nailed to 2 by 4 inch pieces 2½ feet long (marked "*b*"), which are nailed across the scaffold legs.

When extra large targets are used, the juncture of the superstructure with the scaffold should be made somewhat stronger, as this point is usually the first to fail in a heavy storm. One method of securing the extra strength at this point is illustrated in Figure 64.

The legs, ties, and braces for the superstructure are all marked and cut by the pattern before sending them aloft. Send the legs up by single pieces and the braces in sets of four. One man aloft and inside the structure nails the pieces in place (see fig. 63), while one man on

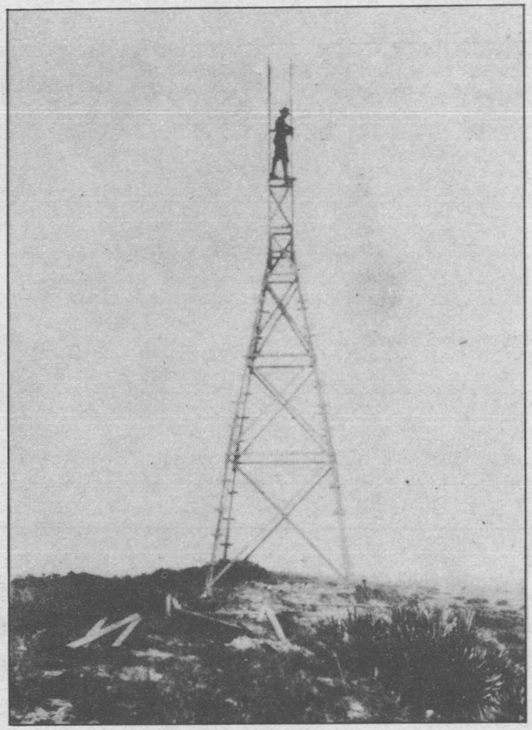


FIG. 63.—BUILDING THE SUPERSTRUCTURE OF A TALL HYDROGRAPHIC SIGNAL.

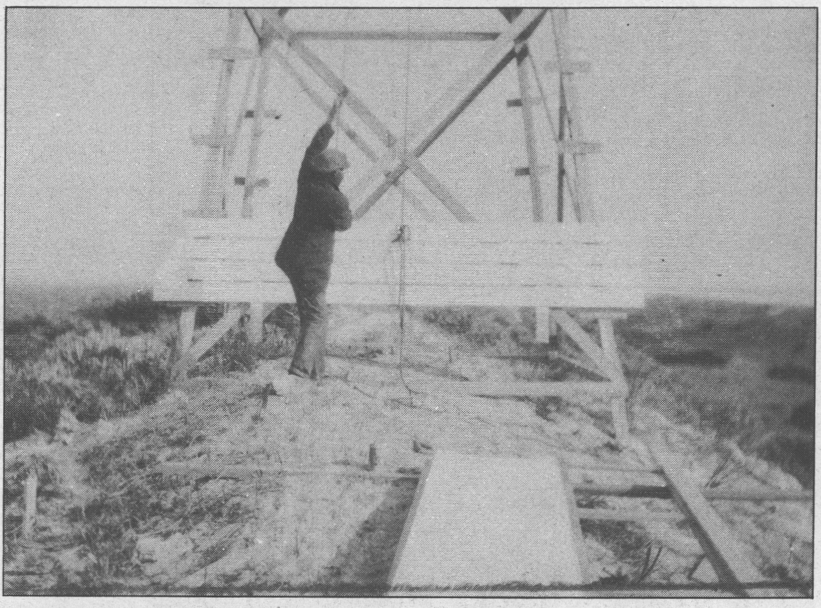


FIG. 65.—SENDING THE TARGET OF A HYDROGRAPHIC SIGNAL ALOFT.

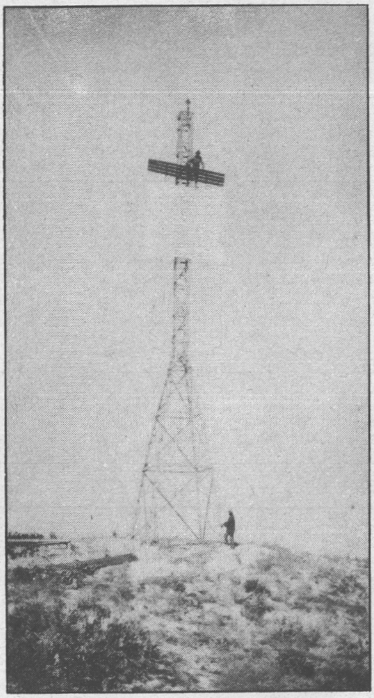


FIG. 66.—PLACING THE TARGET ON A HYDROGRAPHIC SIGNAL.

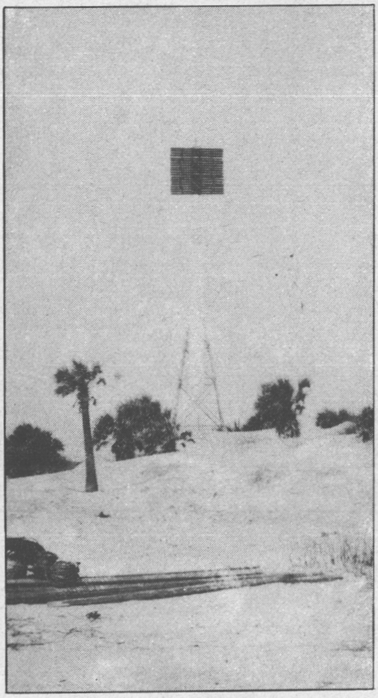


FIG. 67.—COMPLETED TALL HYDROGRAPHIC SIGNAL.

the ground cuts the pieces and sends them up by means of a hauling line. The superstructure may be built 80 or 90 feet above the ground before it is necessary to put on any of the wire guys.

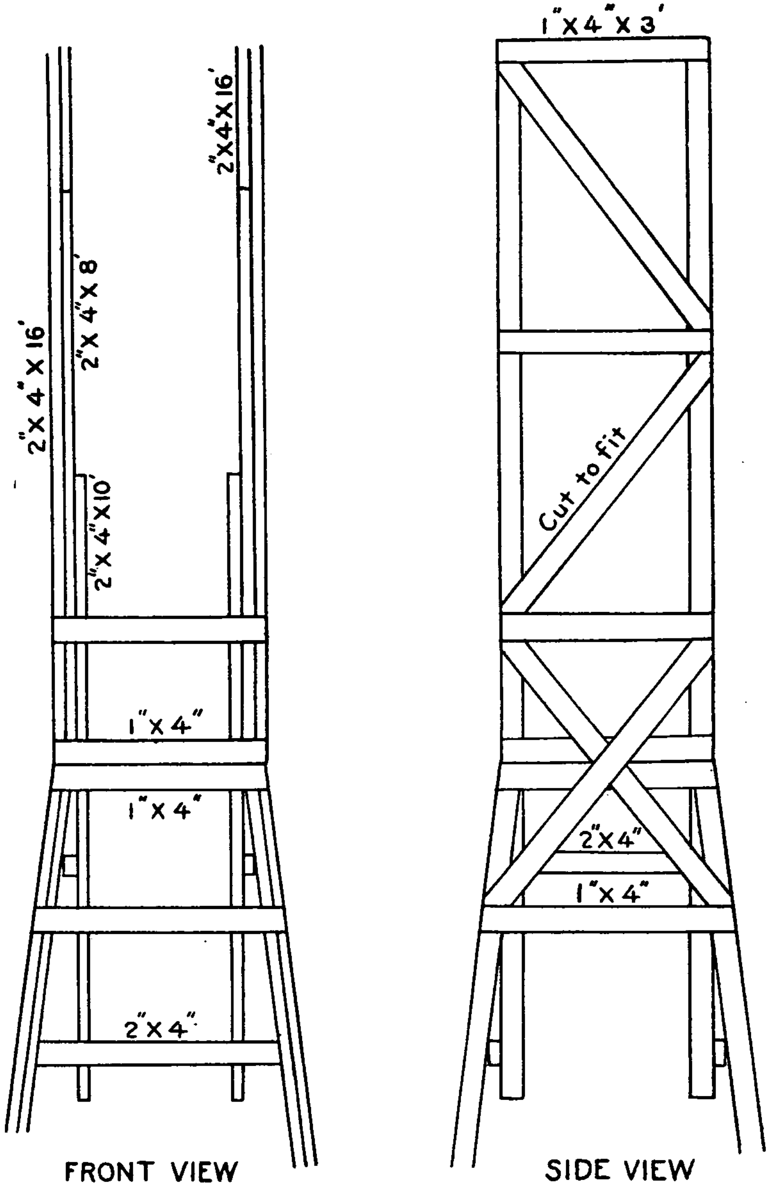


FIG. 64.—Method of strengthening the juncture of the superstructure and scaffold of a tall hydrographic signal.

Anchors for guys.—For a signal from 80 to 90 feet in height the anchors should be about 40 yards from the base of the signal. Six anchors should be used for a signal with a target showing in one direction and eight anchors for a signal with two targets at right angles to each other. There should be one anchor opposite each corner in line with the diagonal of the ground plan of the signal, and in addition there should be one anchor directly in front of each target and one directly behind.

For each anchor dig a trench 8 feet long, 2 feet wide, and about 3 feet deep. Lay an anchor timber 8 feet long and not less than 4 by 4 inches in section in the trench and fill the trench with earth to a level with the top of the timber. Then nail scraps of lumber across each end of the timber and fill in the ends of the trench with earth, leaving the middle of the trench open until the guys have been made fast. More scrap lumber is then nailed across the middle part of the timber and the trench filled. Timber for the anchors can usually be picked up on the beach.

Guys.—The guys should be No. 8 smooth galvanized wire in three sets, each set consisting of a guy to each anchor. One set is made fast at the top of the superstructure; another set 11 feet below the top, or at the middle of the target; and the third set 22 feet below the top, or at the bottom of the target. The guys are drawn taut by means of a tackle made of two single blocks carrying ½-inch rope. One block is made fast to the standing part of the guy, and the end of the guy is then passed around the anchor and made fast to the other block. With this purchase two men hauling on the rope will put a strain of about 900 pounds on the guy. When the guy is taut, it is held temporarily by a twentypenny nail driven into the anchor close up to the wire and bent over the wire. The tackle is then removed and the end of the wire wound around the anchor two or three times and made fast to the standing part. Tighten the top set of guys first and the lower set last, as this brings more nearly an equal strain on each set of guys when strong wind pressure comes against the signal.

Targets.—*A*, Figure 62, shows one side of the signal. The outline of the targets is indicated by broken lines. The top target is 11 by 12 feet in size and is painted black. Beneath it is a target of the same size but painted white. They are made of dressed boards ½ by 6 inches and 12 feet long. Each target is made in five sections of four boards each, nailed to 1 by 4 inch pieces 3 feet long, with a space of 1 inch left between the boards.

D, Figure 62, shows two sections of the target and the manner in which the 1 by 4 inch pieces are placed. These pieces project 10 inches below the board when the target is sent aloft. The lower section of the white or lower target is nailed in place first, and when the second section is sent aloft and set in place the projecting 1 by 4 inch pieces drop behind the two top boards of the section below and are nailed to them. The remaining sections are made and put up in the same way as the first two. Five of the sections are painted white and five are painted black. They are given two coats of paint and left to dry before sending aloft.

When building the superstructure, the ties and diagonals on the front side of the five top panels are placed on the inner side of the legs so as to leave a smooth surface for attaching the target. Use eightpenny nails in securing the target to the superstructure, five nails to each board in each leg. Figure 65 shows target with hauling line attached ready to be sent aloft, and Figure 66 shows man aloft setting target in place.

Frames covered with muslin are fastened to the superstructure below the target. Two of these frames, each 16 feet long by 3 feet wide (see *E*, fig. 62), are made and covered with white muslin, then sent aloft and nailed on the superstructure below the targets, as indicated at *A* in Figure 62. The completed signal is shown in Figure 67.

Notes.—The signal described above was designed to be visible for a distance of from 10 to 12 miles for hydrographic work. It is constructed at a very low cost for material and labor and yet is strong enough to withstand any ordinary wind and most storms without injury. Signals of this type of an average height of 80 feet were built along the coast of Florida in 1915 at a cost of about $1 per vertical foot, including all materials, pay and subsistence of party, and transportation of party and outfit. Two men built a signal in two days on an average after the material was on the ground.

Should it be necessary to increase the size of the target after the signal has been completed, the superstructure may be built up the required amount and additional sections of the target placed above the part already in place, but in no case should the size of a target be increased without the addition of extra guys.

TOOLS AND MATERIAL NEEDED TO ERECT TALL HYDROGRAPHIC SIGNAL.

Tools.

Ax	1	Rope:	
Bevel	1	$\frac{5}{8}$-inch, 125-foot piece	1
Blocks, single, 6-inch	3	$\frac{1}{2}$-inch, 60-foot pieces	2
Brushes, paint	2	$\frac{1}{2}$-inch, 200-foot piece	1
Hammers, claw	2	Rules	2
Handsaws	2	Shovel	1
Hatchet	1	Spade	1
Level, carpenter's	1	Square, try	1

Material for 84-foot signal.

Lumber, dressed:		
2 by 4 inches by 16 feet	pieces	50
1 by 4 inches by 16 feet	do	75
1 by 4 inches by 12 feet	do	40
$\frac{9}{16}$ by 6 inches by 12 feet	do	40
Muslin, white	yards	12
Nails:		
Eightpenny	pounds	50
Twentypenny	do	25
Paint:		
White	gallon	$\frac{1}{2}$
Black	do	$\frac{1}{2}$
Tacks, 8-ounce	pound	$\frac{1}{4}$
Wire, smooth galvanized, No. 8	feet	2,800

TALL HYDROGRAPHIC SIGNAL E.

In 1917 some tall hydrographic signals were constructed which had large board targets 16 by 50 feet and on this account required additional strength in the superstructure, guys, and anchors. The superstructure was made 3 feet square, and all joints in the legs were reinforced with 2 by 4 inch pieces, 4 or 5 feet long. Twelve anchors were used for the wire guys, two opposite each corner in line with the diagonal of the ground plan of the signal, two directly in front of the signal target, and two directly behind it. For a 100-foot signal one set of anchors were placed about 30 to 35 yards from the signal and the second set 45 to 50 yards.

Five guys were attached at different heights to each corner of the signal and four guys to the front and four guys to the back of the

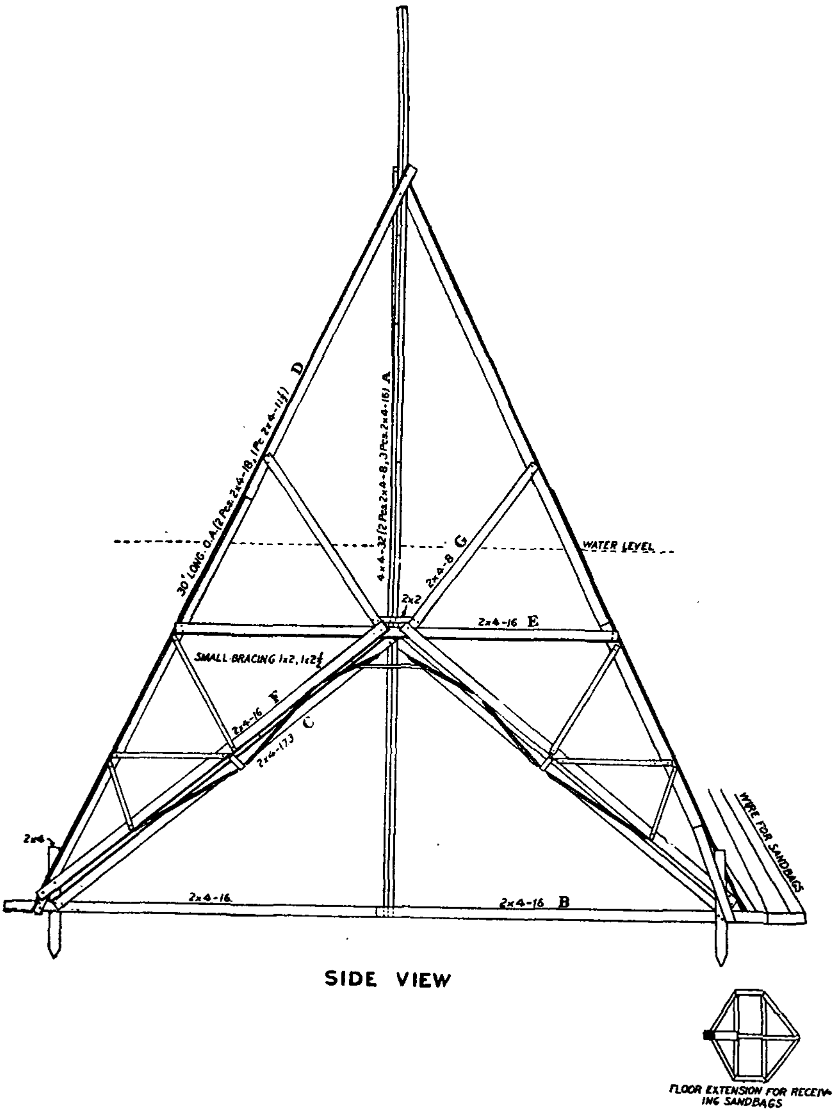


FIG. 68.—Elevation of water signal.

target. The corner guys were attached at 0, 8, 24, 40, and 52 feet from the top of the superstructure and the target guys at 4, 16, 32, and 46 feet from the top. All guys were No. 6 smooth galvanized wire except the corner guys at 0 and 40 feet from the top, which were No. 4 smooth galvanized wire. About 200 pounds of No. 4 wire and 350 pounds of No. 6 wire were required for each signal.

WATER SIGNALS FOR TRIANGULATION AND HYDROGRAPHY.

Along certain sections of the coast it is sometimes desirable to locate a station in the water some distance from the shore. In some cases the position of this station is determined by observations from land stations. In other cases it becomes necessary to occupy the water station itself with a theodolite. The signal must be built in such a way that it will not be shifted in position by wave action or wind pressure, and if it is to be occupied with an instrument it must be steady enough to permit accurate angle measurements.

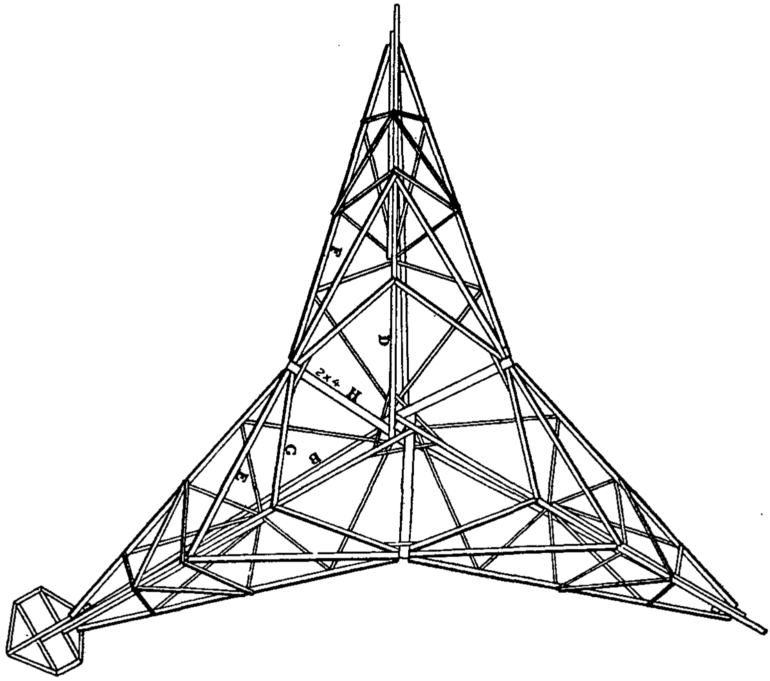


FIG. 69.—Plan of water signal.

The type of water signal described below is one that has been used successfully in depths as great as 13 feet. The elevation and plan of the tripod instrument support of this signal are shown in Figures 68 and 69, and the different steps in its construction are shown in Figure 70. The tripod has a large spread at the base to minimize the amount and effects of any unequal settling in soft bottom and has an extensive system of bracing for rigidity. A vertical stake attached to the foot of each leg of the tripod and weights in the form of bags of sand placed on platforms attached to each foot help to prevent any shift of position of the signal. The tripod is designed so that the center of bracing is well below the surface of the water where the greatest rigidity is required and to offer the least possible resistance to the waves at the surface of the water. The twisting motion caused by the waves acting unequally on different parts of the structure is by far the greatest factor to be considered in obtaining a rigid structure.

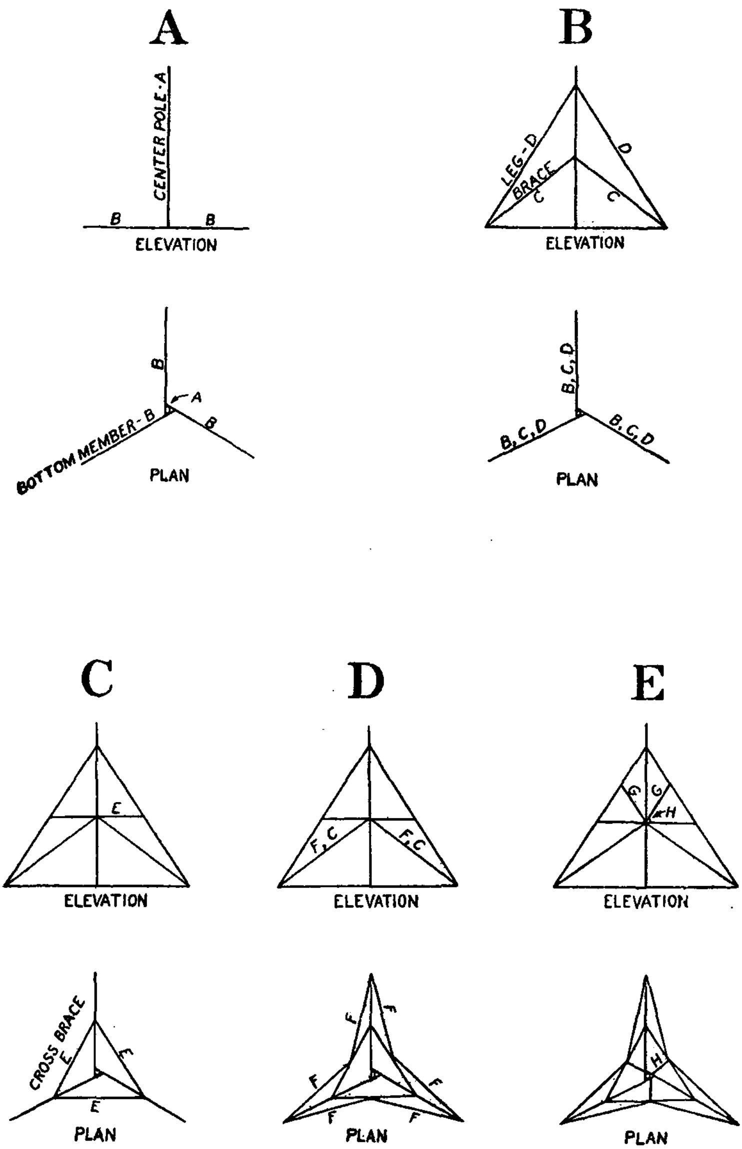


FIG. 70.—Steps in construction of water signal.

The tripod is built on shore, carried into the water and launched, towed to the desired location, and finally placed in position and weighted down. The scaffold for supporting the observer is then built independently of the tripod. The size of the structure depends, of course, upon the depth of water in which it is used. The dimensions given in Figure 68 were found suitable for a depth of 13 feet.

CONSTRUCTION.

For building the tripod a level place on the beach is selected as near as possible to deep water and not too far from where the station is to be located. The bottom section of the center pole, consisting of two 2 by 4 inch pieces 8 and 16 feet long, respectively, is placed in a vertical position and held by temporary supports. The three bottom members *B* are then placed on the ground in a level position at angles of about 120° with each other and nailed to the bottom of the center pole. Temporary braces are then nailed from each bottom member *B* to the center pole and the center pole extended by lapping on another 2 by 4 inch piece 16 feet long. The lower diagonal braces *C* (see *B*, fig. 70) are next nailed in place, and after the center pole has again been extended the upper diagonals or legs *D* are put on. The horizontal braces *E* are then nailed to the legs *D* at about the same height as the tops of the *C* diagonals. The members *F* (see *D*, fig. 70), which extend from the bottom of the legs *D* to the middle of the members *E*, are then attached, and the remainder of the construction, such as cross and diagonal bracing between the members *C*, *D*, and *F*, is done as indicated in Figure 69 in order to insure a rigid structure.

The dimensions of the various members are shown in Figure 68. The materials needed for the signal are given in the list on page 38.

Launching and towing.—Twelve men are required to carry the tripod into the water. When a depth of about 3 feet has been reached, the tripod is put down and turned over on its side. The overturning movement is controlled by attaching a line to the leg being raised and keeping this line taut after the balancing point has been passed. The water also helps to retard the movement and prevent injury to the structure. The tripod is floated in the overturned position by means of lines from the two submerged legs to the bow and stern of a whaleboat and a line from the end of the center pole to a dinghy. After the tripod has been raised just enough to clear the bottom it is towed to the ship by a launch. Barrel buoys are then substituted in place of the boats to float the signal, and the ship is used to tow it to the desired position, using care not to allow the barrel buoys to become submerged.

Uprighting tripod.—When the tripod is released form the buoys in 10 or 12 feet of water, it will tend to rest on the bottom on the ends of two of its legs. Temporary weights can be used to hold it in this position. The leg which projects out of the water can then be boarded by two men, who built the platform for holding the weights on the foot of the leg and attached four wires to different parts of the platform for use in guiding the weights when the tripod has been uprighted. The tripod is next rolled over to bring another leg up, and a similar platform with wires attached is built at the foot of this leg. After the third leg has been completed in the same way the tripod is uprighted by lifting the end of the center pole a few feet above the water, using a line to the ship if necessary.

About 60 cement bags filled with sand are needed to weight the tripod down. They may be placed in position by attaching a wire loop to the neck of each bag and letting this loop slide down one of the wires attached to one of the three platforms while the wire is held vertical. The bags should be lowered carefully with a slip line.

After all the bags have been lowered the guide wires should be attached securely to the tripod.

If necessary to add a superstructure to elevate the instrument, it should be built in the form of a slender tripod attached to the legs of the main tripod and properly braced. (See fig. 71.) It should not be extended more than 12 feet above the apex of the main tripod. The target is attached to the top of the superstructure in such a way that it may be detached easily. When the station is occupied, the target is removed and the instrument, mounted on its own tripod, is lashed securely to the top of the superstructure.

The observer's stand is built independent of the instrument support by driving pipes into the bottom, to each of which a scantling is lashed with wire seizing. The necessary bracing and floor can then be attached to these legs. (See fig. 72.)

LIST OF MATERIAL FOR WATER SIGNAL.

Tripod instrument support.

Bags, cement, containers for sand ballast		60
Lumber, rough:		
2 by 4 inches by 18 feet	pieces	9
2 by 4 inches by 16 feet	do	15
2 by 4 inches by 12 feet	do	4
2 by 4 inches by 8 feet	do	8
1 by 2½ inches	linear feet	72
1 by 2 inches	do	112
Marline, for tying bags	feet	140
Nails:		
Forty-penny	pounds	10
Twenty-penny	do	10
Ten-penny	do	10
Wire:		
Telephone No. 5, for guide wires	feet	240
Telephone No. 10, for attaching bags to guide wires	do	200

Superstructure.

Lumber, rough:		
2 by 4 inches by 16 feet	pieces	5
2 by 3 inches	board feet	48
1 by 3 inches	do	24

Observers stand.

Lumber:		
1 by 6 inches, for floor	board feet	14
Rough—		
2 by 4 inches by 16 feet	pieces	6
2 by 4 inches by 10 feet	do	3
2 by 3 inches by 16 feet	do	7
Pipe, 2½ inches in diameter, 20 feet long	do	3

FLOATING HYDROGRAPHIC SIGNAL, THREE-BARREL BUOY.[3]

The following type of floating signal has been used with success by parties on the Atlantic coast: Three barrels, each of 50-gallons capacity, are fastened together, bilge to bilge. They float upright and support a center pole 4 inches square by 23 feet long. A concrete counterweight, weighing about 700 pounds, is cast on the bottom of the center pole to hold the signal upright. A target of two crossed banners of bronze screening, each 6 by 8 feet, is bolted to the center

[3] See footnote on page 27.

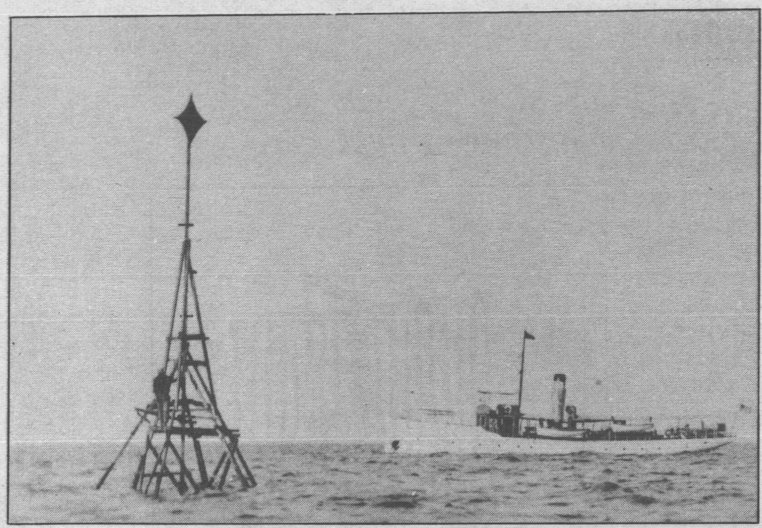


FIG. 71.—COMPLETED WATER SIGNAL IN PLACE.

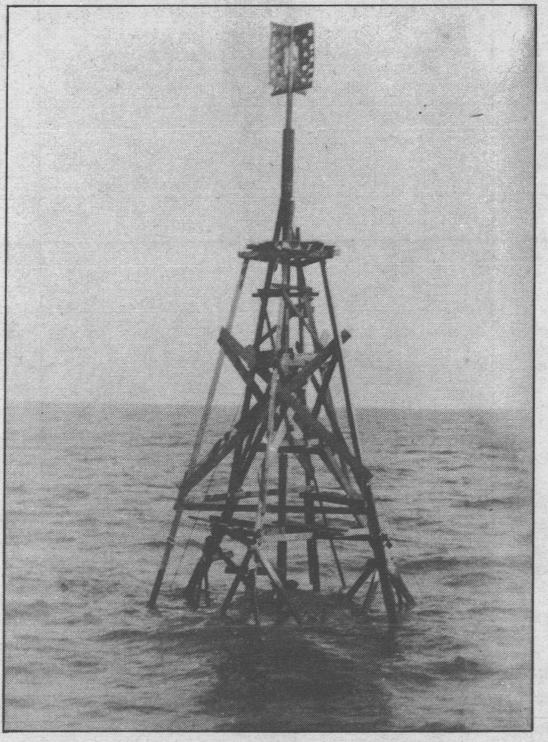


FIG. 72.—WATER SIGNAL WITH SCAFFOLD FOR OBSERVER.

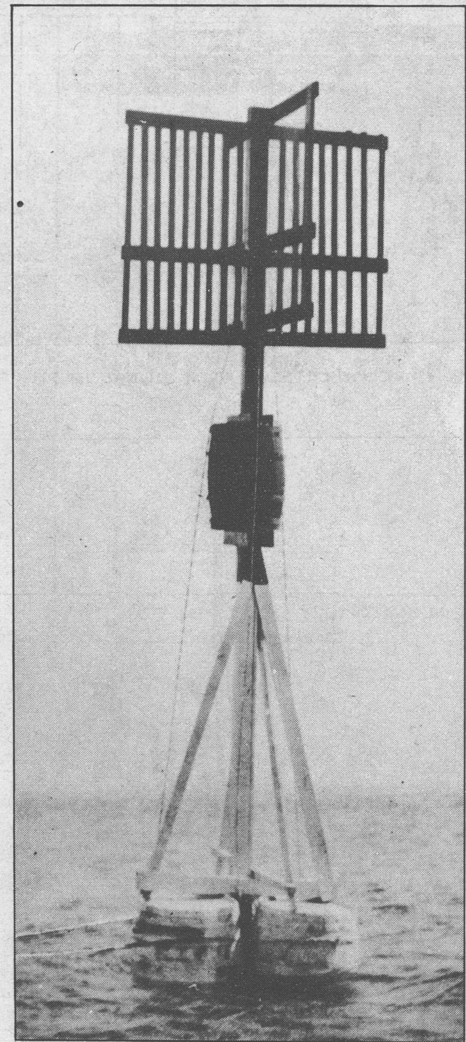


FIG. 74.—THREE-BARREL BUOY SIGNAL.

pole so as to make the top of the target about 16 feet above the top of the barrels. This target is guyed to the cross braces on the top of the barrels. A 1,500-pound concrete block is used as an anchor. The anchor line is ½-inch wire rope, except for an 18-foot section of

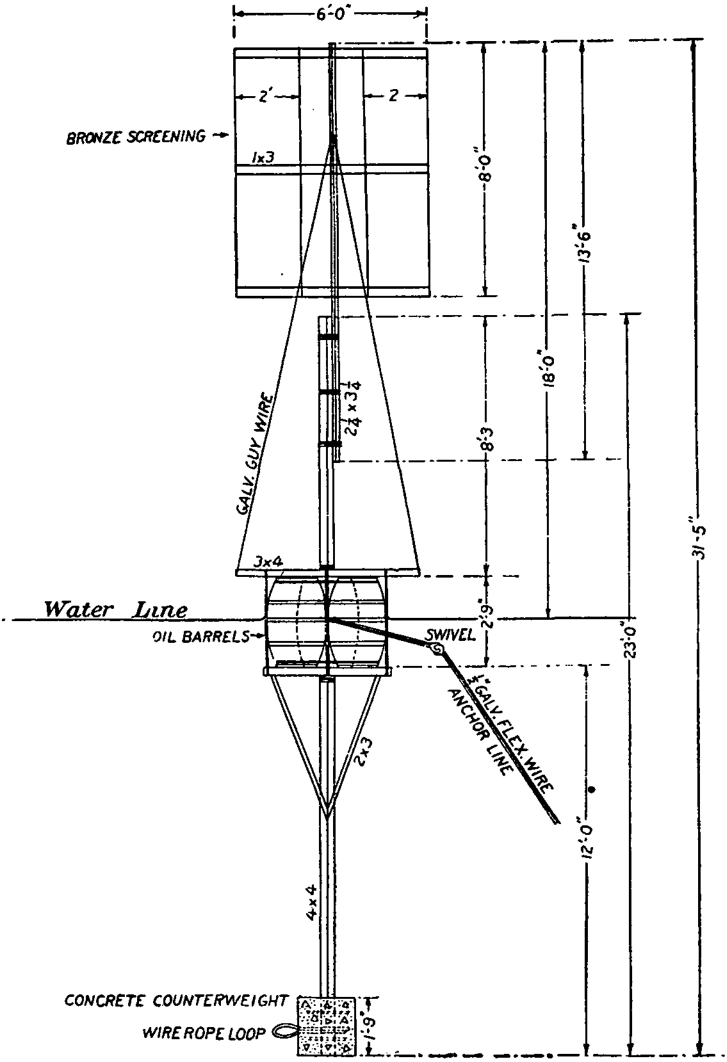


FIG. 73.—Working drawing of the three-barrel buoy signal.

chain next to the anchor, and has a thimble spliced in the upper end for shackling to the buoy.

In constructing the buoy two oi the barrels are laid side by side on their bilges and temporarily secured. The center pole is laid on top parallel with the barrels and with two of its faces tangent to their bilges. The center pole is notched slightly to receive the top barrel, which is placed on top of and parallel to the other two. This top barrel will naturally rest on one barrel and the center pole. Wooden wedges are used as necessary to fill in any space between the barrels. The three barrels are lashed together, using several turns of $\frac{1}{8}$-inch

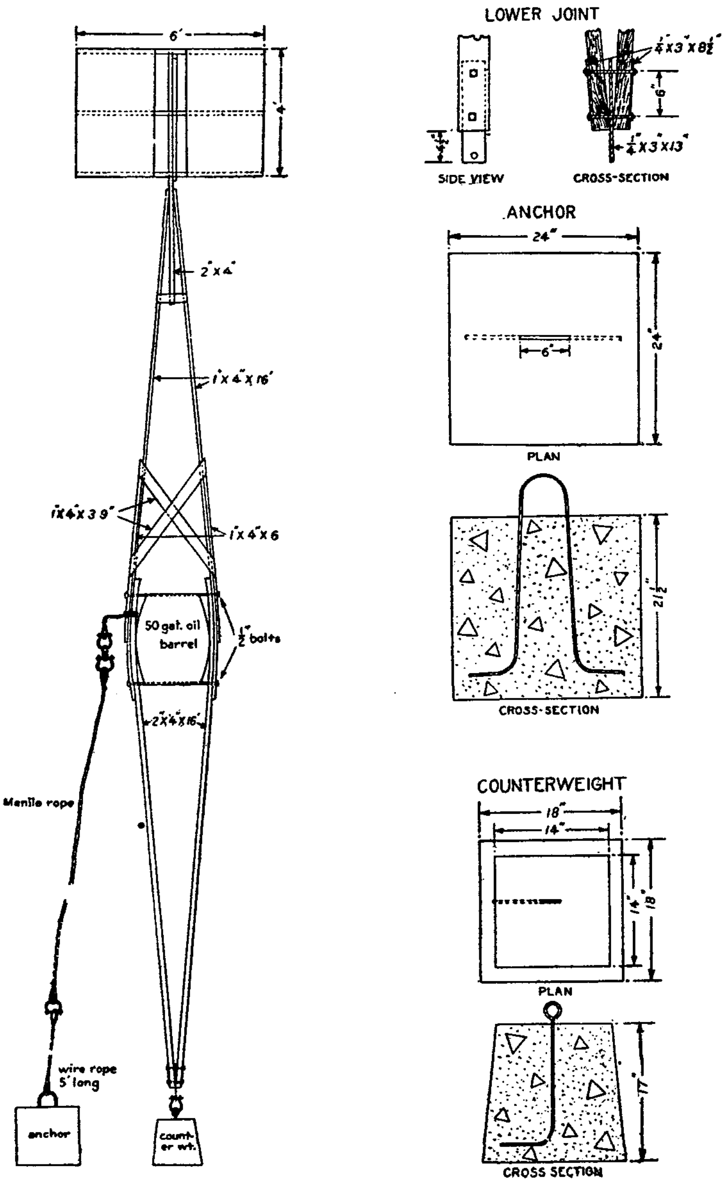


FIG. 75.—Working drawing of one-barrel buoy signal, first type.

galvanized wire at each end of the barrels just below the hoops. These two lashings are cross lashed and all are set taut with a Spanish windlass. Four cross pieces 3 by 4 inches notched to receive the chimes of the barrels are nailed to the center pole, two at each end of the barrels, and lashed together with ⅛-inch galvanized wire. These cross braces are to prevent any movement of the barrels along the center pole. The cross pieces at the top of the barrels extend about 6 inches beyond the barrels, and the guy wires from the target pole are secured to them and set taut with a Spanish windlass. Four diagonal braces 2 by 3 inches and 6 feet long are run from the bottom cross pieces to the lower extension of the center pole for additional stiffening. (See fig. 73.)

The concrete counterweight should have suitable reinforcement to secure it to the center pole. It can be cast at the same time the other work is in progress. The bottom of the counterweight should be about 12 feet from the bottom of the barrel. A wire rope loop for tackle fastening is cast in the counterweight on the same side of the counterweight as the anchor line pendant mentioned in the next paragraph and in line with it. When handling the buoy, two tackles are used, one fastened to this loop and the other to the anchor pendant, and the buoy is hoisted or lowered while horizontal.

An anchor pendant 3 feet long of ½-inch wire rope with a swivel on the free end is made fast to the buoy at the water line. The anchor line is shackled to this swivel. The target can be secured to the buoy just before lowering and can be removed immediately after hoisting. This permits two or three buoys to be nested on deck when necessary. A three-barrel buoy similar to the one described above, except for the target, is shown in Figure 74.

FLOATING HYDROGRAPHIC SIGNAL, ONE-BARREL BUOY.

The construction of the one-barrel buoy signal is clearly indicated in Figure 75. This type of signal is very simple, and the complete buoy, including anchor and counterweight, can be readily constructed aboard ship in a limited deck space. It can therefore be built by members of the ship's crew while on the working grounds. Five or more of these buoys may be conveniently nested in a limited space on deck by unshackling the counterweight and anchor and removing the target.

Experience has shown that this type of signal buoy, because of its much lighter construction, is more easily "planted" in position and picked up again than the three-barrel buoy described on page 72. The target remains visible to the observer to practically as great a distance as the target of the three-barrel buoy. It can be built very quickly and at much less cost than the three-barrel buoy.

Materials for one-barrel buoy signal.

Bar, iron, ¼ by 3 inches	feet	2½
Barrel, wooden, oil		1
Bolts, ½ by 6 inches, with nuts and washers		2
Cement, Portland	bags	4
Cloth	yard	1
Lumber:		
2 by 4 inches by 16 feet	pieces	2½
1 by 4 inches by 16 feet	do	3
Nails, eightpenny	pounds	2
Paint, black	gallon	⅛
Rod, iron:		
¾ inch in diameter	feet	9½
½ inch in diameter	do	6

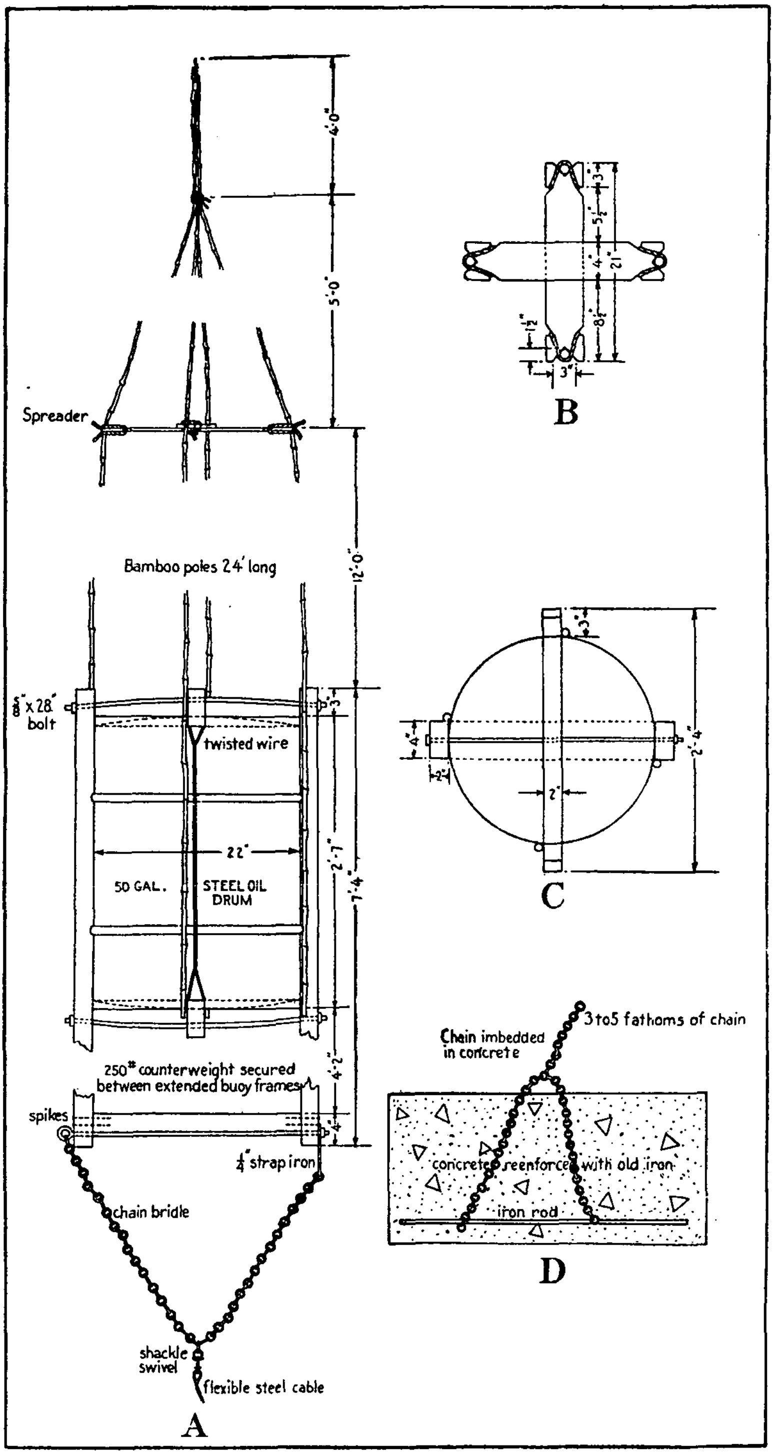


FIG. 76.—Working drawing of one-barrel buoy signal, second type.

Rope:		
Manila, 3½ inches in circumference	feet	180
½-inch stranded wire	do	5
Screen, wire, black	square feet	32
Shackles, G. I.:		
¾-inch		5
½-inch		2
Tacks, 6-ounce	package	1
Thimbles, G. I.:		
1-inch		3
½-inch		2

Another type of one-barrel buoy signal is shown in Figure 76. It is made of a 50-gallon steel oil drum, carrying a framework to which a bamboo superstructure and a suitable counterweight is attached. The drum is tested for leaks and painted with red lead. The framework is made of 2 by 4 inch pieces, notched to fit the projections on the drum, and is bolted and lashed together as shown in *A*, Figure 76. Four bamboo poles each 24 feet long are lashed securely to this framework and the tops of the poles are lashed together. A spreader shown in *B*, Figure 76, is inserted 8 or 9 feet from the top of the poles and securely lashed to them with marline.

White signal cloth is sewed to the poles between the spreader and the point where the poles come together and two black flags are attached to the top of the poles.

The counterweight may consist of junk iron, such as old grate bars, and is secured to the lower ends of two extended frame members, as indicated in *A*, Figure 76. This counterweight should weigh approximately 200 pounds.

The anchor should weigh about 700 pounds. It may be made of concrete reinforced with junk iron and should have a chain bridle properly secured, as shown in *D*, Figure 76. A convenient form for the concrete may be made of three discarded motor truck rims piled on edge. From 3 to 5 fathoms of chain should be attached to the bridle in the anchor. The anchor cable should consist of ⅜-inch flexible galvanized-steel rope with a swivel at each end, one end shackled to the chain leading from the anchor and the other end shackled to the chain bridle secured to the extended frame of the buoy. (See *A*, fig. 76.)

The anchor and the framework around the drum may be constructed ashore over week ends while the ship is in port for coal. The rest of the signal may be constructed aboard ship.

When preparing to plant a buoy the cable is secured to the anchor and is led along the outside of the rail, around the stern of the vessel, and up the port side to the buoy which is launched from the forward port davit. After the buoy is lowered into the water the vessel proceeds slow ahead full left until the buoy has cleared the port side. The wheel is then thrown full right to bring the buoy on the starboard quarter and give a clear lead to the anchor. The anchor is lifted over the side from the after starboard davit and, after all slack has been taken out of the cable, is cut away.

Fourteen buoys of this type were planted during one season and all but two remained in place until work had been completed upon them. In spite of several storms the superstructure on all buoys remained intact throughout the season.

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