Cary Mangum, W6WWW
7200 Eagle Road
Fair Oaks, Calif.

a 38′ Tower

With Self Supporting Construction

This home-made wooden tower was built by the author and originally installed on a 45 x 120 foot lot in Los Angeles where it remained for some 4 years before taken down, strapped into a 12′ x 2′ x 2′ bundle and shipped to the new QTH via a freight line at a very reasonable price of approx. $13.00 for the entire tower! (for some 500 odd miles).

The tower is easy to construct and looks good. It is a composite unit of 4 sections and a top. Assembly is made as a unit for each section and then the sections are joined as explained later. With but one exception all joints are bolted together both for ease of construction and to make disassembly possible.

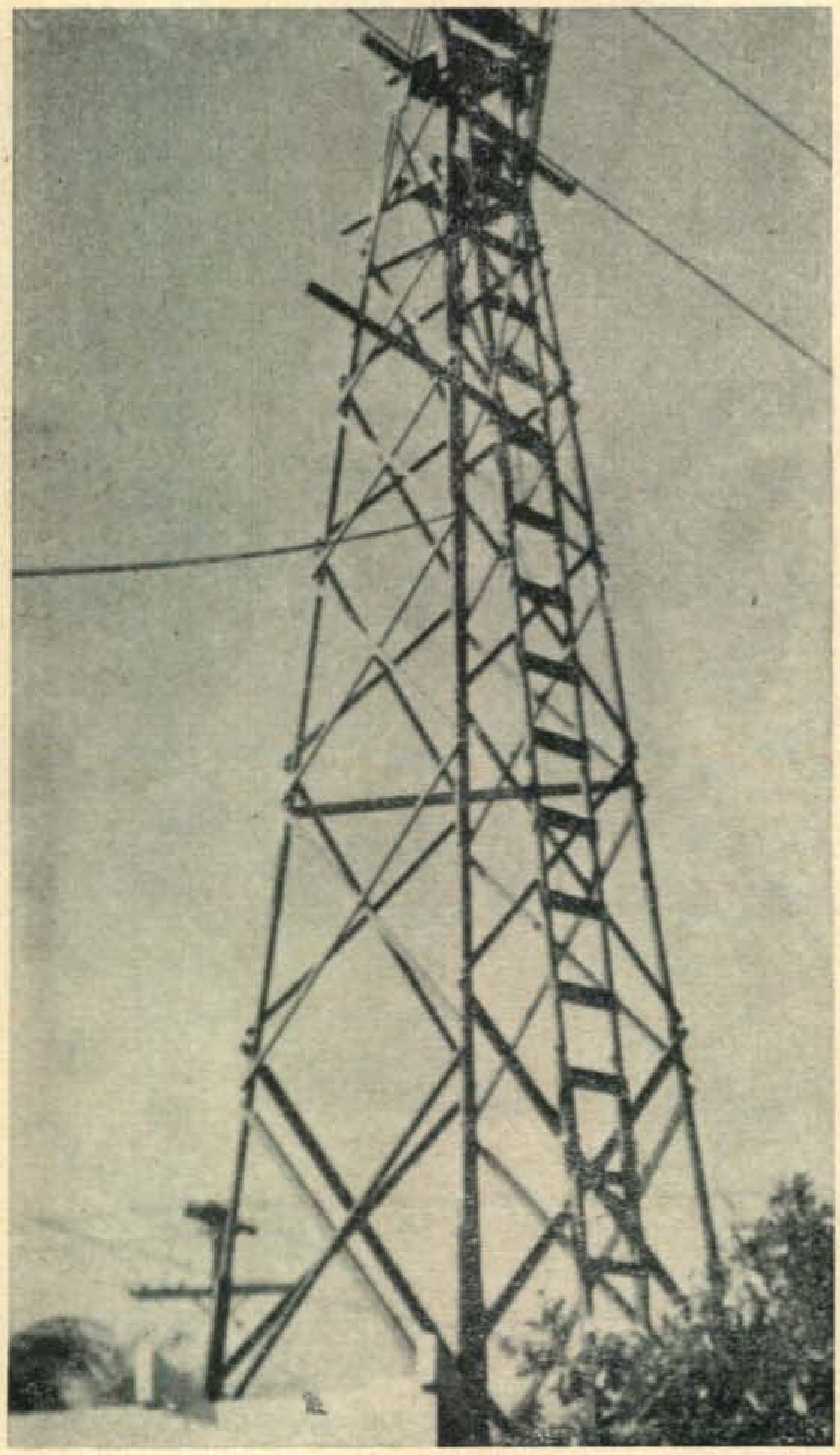
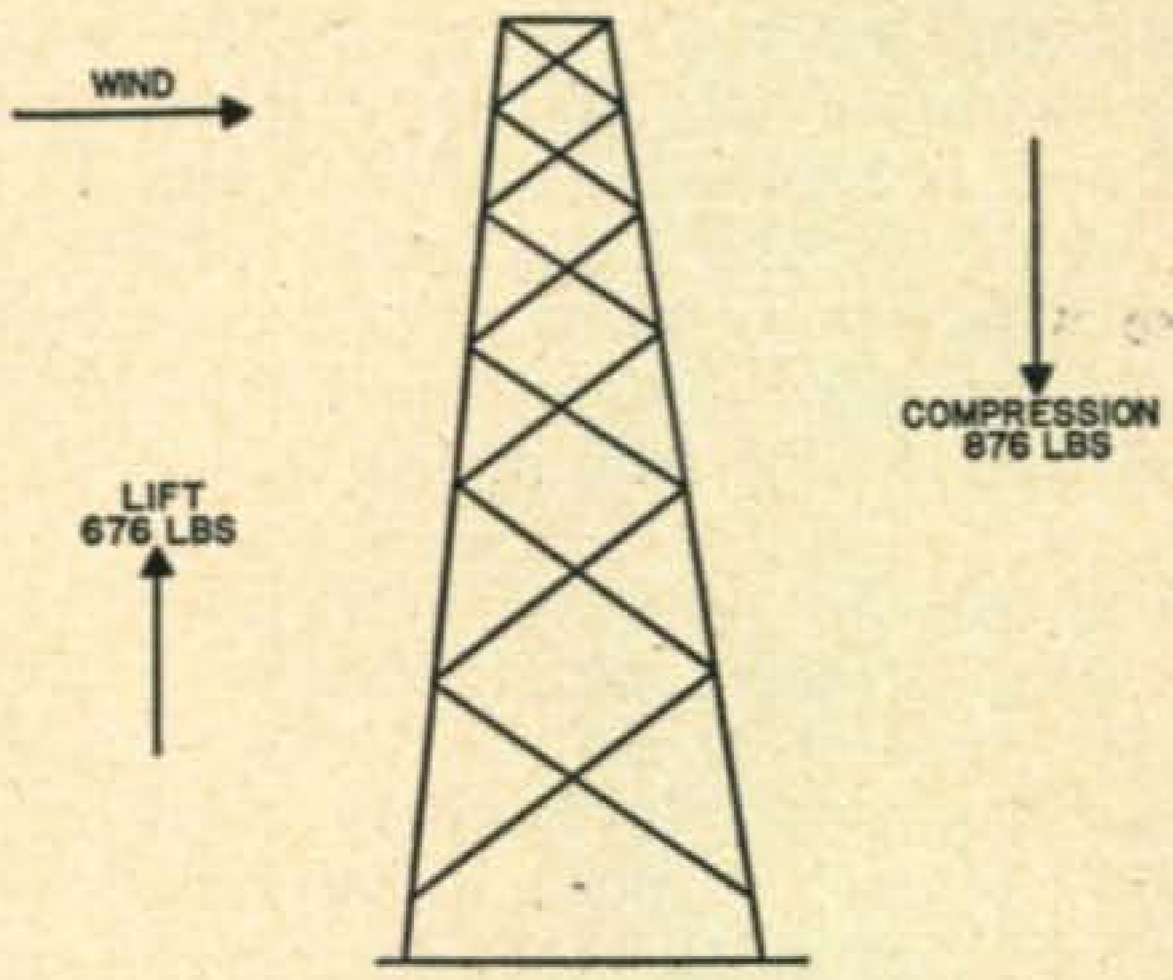


Fig. 1.



Design Considerations

As guy wires are not used a 4 sided tower was decided on as it is easier to build, and distributes the various forces better. The weight of the tower, beam, drive mechanism and the forces of the wind ultimately resolve themselves into two forces. One is lift which is the force applied by the wind against the side *against which* the wind blows, while the other (compression) is the force applied against the opposite side. Compression can also be called the "push" on the opposite side from the wind against the ground. See *fig 1.*

In order to keep the tower from blowing over from the forces of the wind (once upright it cannot fall over from its own weight, only the force of the wind) the anchors at each leg must be at least equal to the force of lift. To be safe even in the highest winds several safety factors must be considered to give ample margin for very high winds. One ham we know anchored his tower to his garage roof after reinforcing it. Even so you could see the roof undulate in a high wind. It is safer to anchor the self supporting tower direct to ground using any of a number of different type anchors.

The tower has 27 square feet of wood on one side. Doubling this (for two sides) and adding 6 square feet for the beam, we get a maximum of 60 square feet normal to the wind (ie: the wind blows against a total of 60 square feet of wood) a 60 MPH wind, (which is the minimum safety factor we would recommend although it is in excess of the California requirement) will apply a lift of 676 pounds at two legs and a force of 876 pounds compression at the other two legs. Since compression is the down thrust, obviously it is necessary only that the anchor equal the lift weight, as the earth will take the additional compression unless you place your anchors in very wet or swampy soil. Therefore the anchor at *each* leg must weigh at least 676 pounds. Seems like a lot but it really isn't. A 21 inch cube of concrete weighs that much. That's only 23″ x 23″ x 23″ for Adobe soil (a 23 inch cube). So at our QTH we dug a hole 23 x 23 x 23 (inches) and built a platform which was inserted in the bottom of the hole, an anchor properly nailed to that (see *fig 2*) and then the dirt was poured back in the hole.

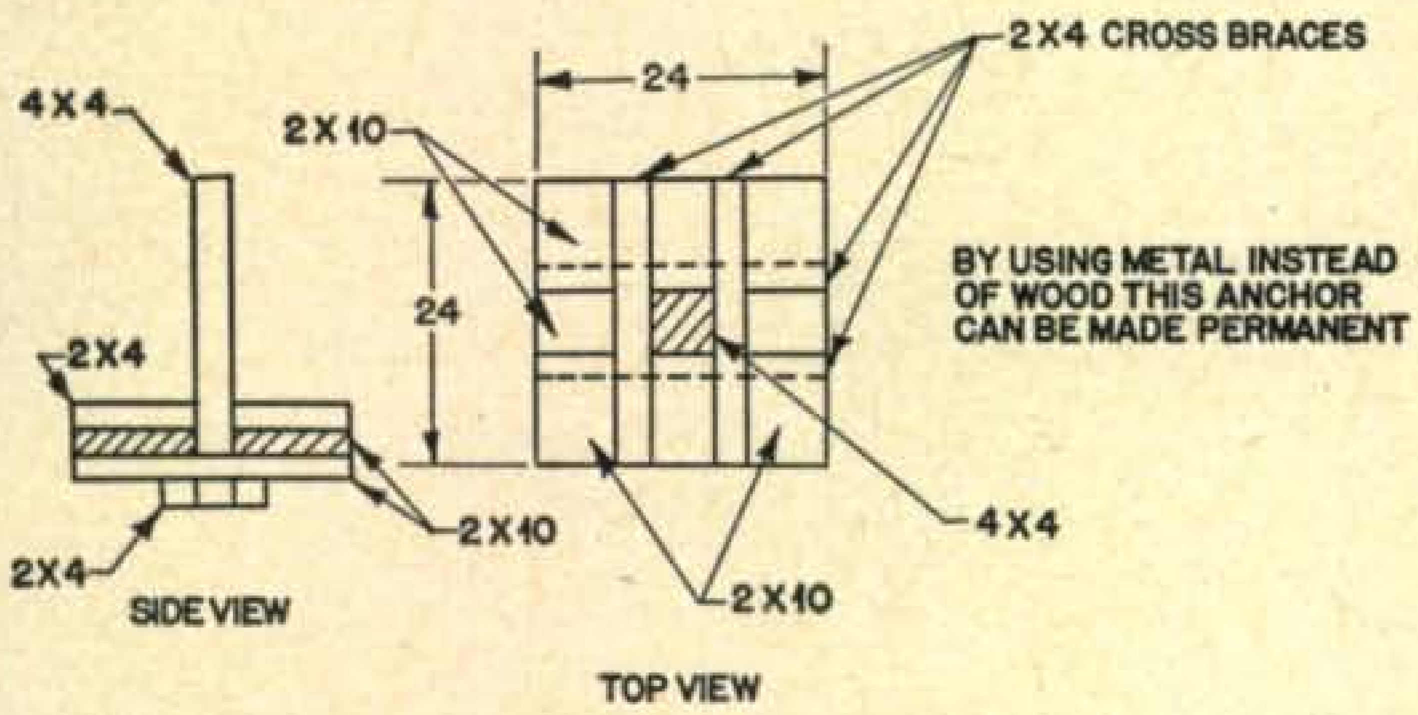


Fig. 2.

When placing those anchors use a spirit level from the top of each anchor to the others (on a straight board turned on its side) and make sure each and all four are level. This eliminates having to level the tower after it's raised into the upright position.

I used wood (mahogany and oak) for anchors as they were to last only a few years, although properly creosoted and coated with asphalt they would probably last 10 or more years. For a permanent anchor use an iron plate instead of wood. If concrete is used, before pouring the cement in place be sure and have ample reinforcing rods and some method of making the anchor lift the entire weight of the anchor itself, not just the top ½ or 1/3 of it!

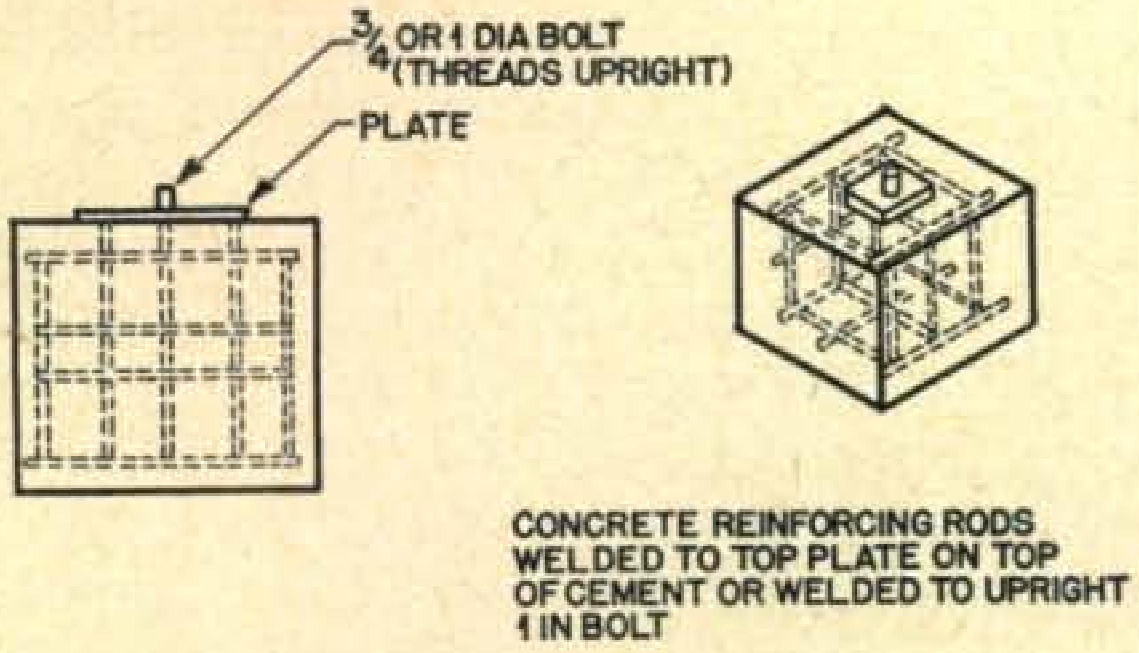


Fig. 3. Concrete Anchor

For a greater safety factor dig a hole 36″ x 36″ x 36″ (or its equivalent deeper but smaller in width and length) and fill it with concrete, or large heavy rocks, except for the top 1½ foot. Fill in around the rocks with either a thin (not too thin) mixture of concrete or soil and water, preferably adobe or clay soil if available, to the level of the rock. Top that off with 1½ feet of soil well packed and plant some grass on top. Oh yes! Don't forget to put the anchor upright in place before filling the hole. The 36 x 36 x 36 (inches) cube will withstand a 100 mile an hour wind, being 4020 pounds at each leg!

However, I personally found this to be unnecessary as this tower withstood all Southern California had to offer for more than four years, which included gusts over 75 miles per hour. Use of the larger anchor is necessary only in those cases where year in and year out winds in excess of 60 miles per hour, or where you are exposed to hurricane conditions. One factor that will help to reduce the wind drag is to place one leg, not one flat *side* of the tower, facing the prevailing wind direction. This changes the air flow around the tower and it is recommended that the leg be placed facing the direction from which comes the strongest winds in your local. In our new QTH the winds are either North or South. The solution here is to put one leg at the North and one at the South and the sides of the tower then run Northeast and Southwest and Northwest and Southeast. See *fig 4*.

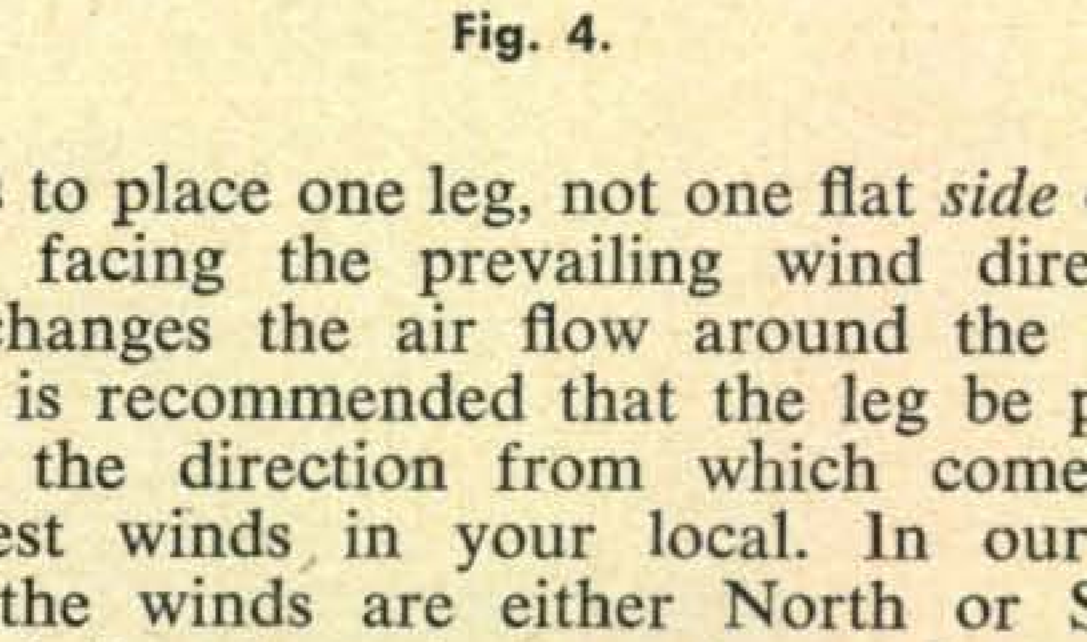


Fig. 4.

Construction

Obtain 4-12 foot 2″ x 4″ (2x4). Use grade No. 1 select, without knots, either Douglas Fir or its equivalent (ie, pine, etc). Notch one end of each 12 foot 2 x 4 nine inches deep to accept

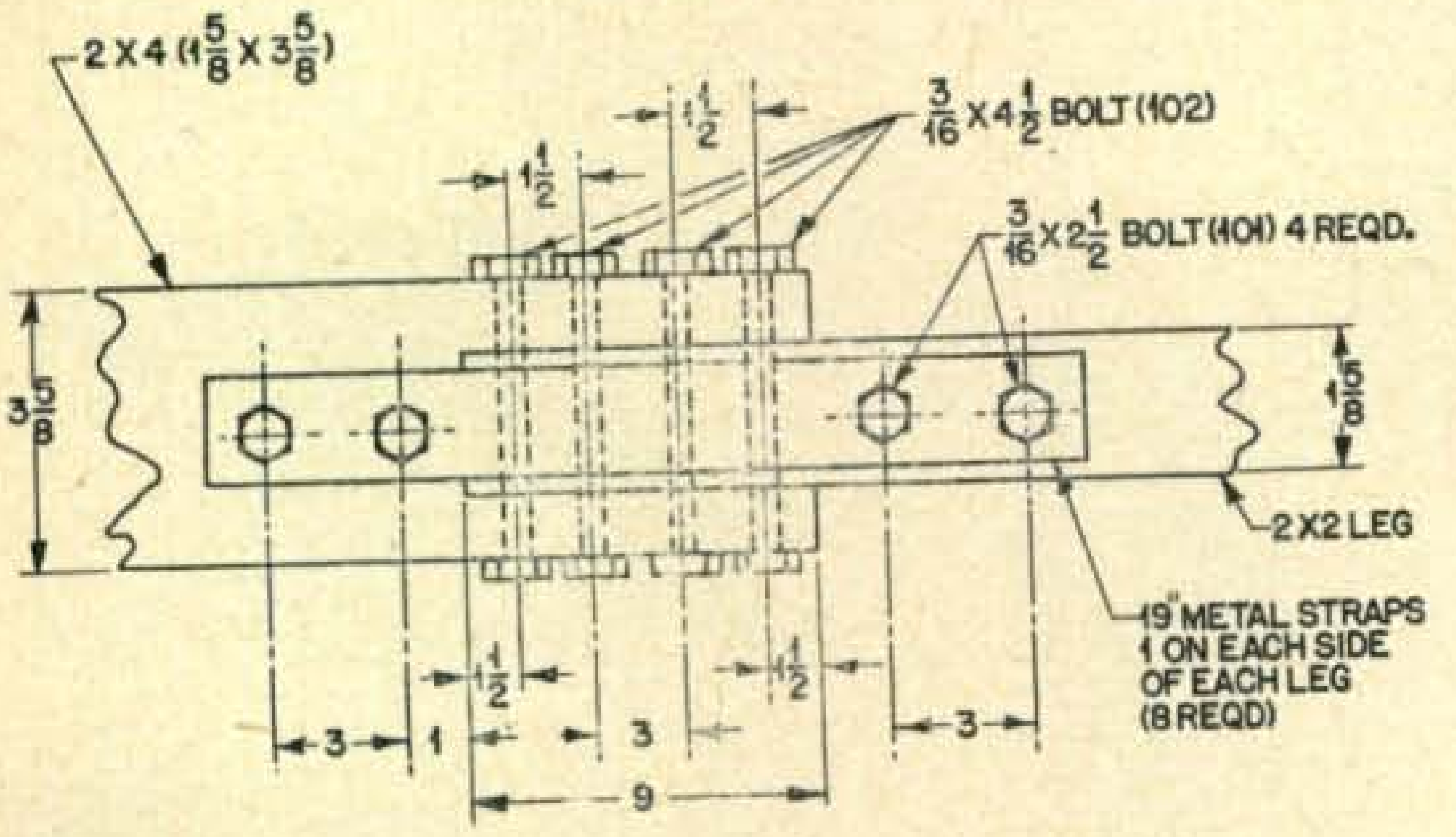
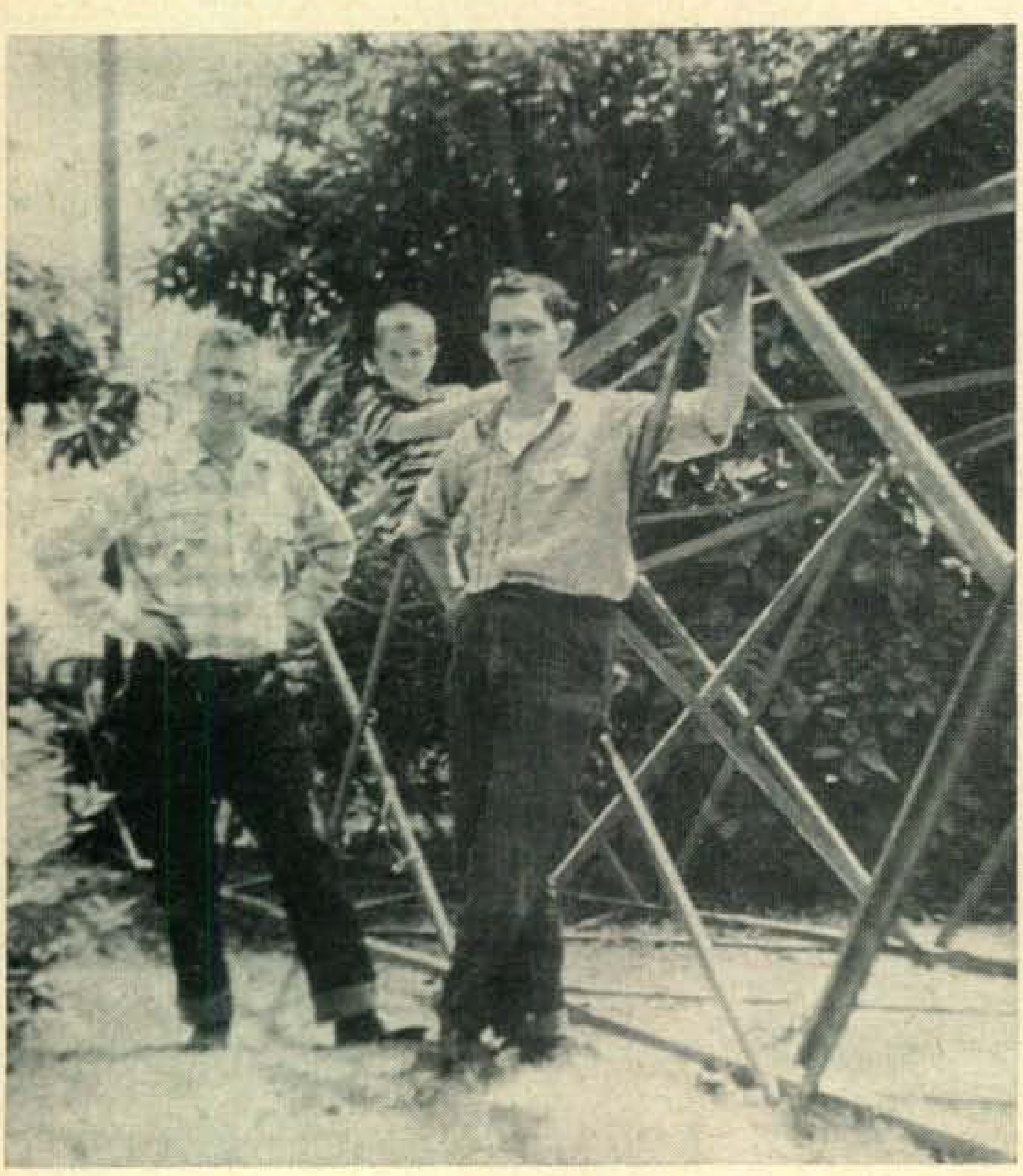


Fig. 5a. 2x4 & 2x2 Leg Joint

a 2 x 2, which will be the second section of the tower leg. (See *fig 5a*). Be sure this notch is in the center of the 2x4 and don't split it! Next obtain 8-8 foot 2" x 2" (2x2) and 4-10 foot 9 inch 2" x 2" (2x2). These 16 pieces form the four legs being 2 x 4, 2 x 2, 2 x 2, 2 x 2 for each leg. The cross (X) bracing ties the legs together and gives the strength required. These X braces are cut to length and drilled in pairs. *Fig 7* shows a typical brace. All lumber must be free of knots, preferably No. 1 select grade, have a good tight grain, be straight and have no defective places that will weaken the structure. Actually we used No. 2-2x4 for our legs with some partial knots, because nothing else was available and we have absolutely no trouble, but it would be best where possible to use No. 1 select grade, which means that you can select the pieces. If you treat that lumber-man correctly and tell him what you want without using the term select you will usually get the select grade without paying the extra price for it.



Start with the large 12 foot base section as the first unit to be made. In assembling the base section start by laying out two of the 2x4 on the ground so that their *base* ends are exactly 8 feet apart (center to center) not parallel but tapering together slightly at their upper end, *level* each of the legs. (We are assuming that at this point you have properly prepared the wood for assembly by painting it with a primer coat, letting it age for at least

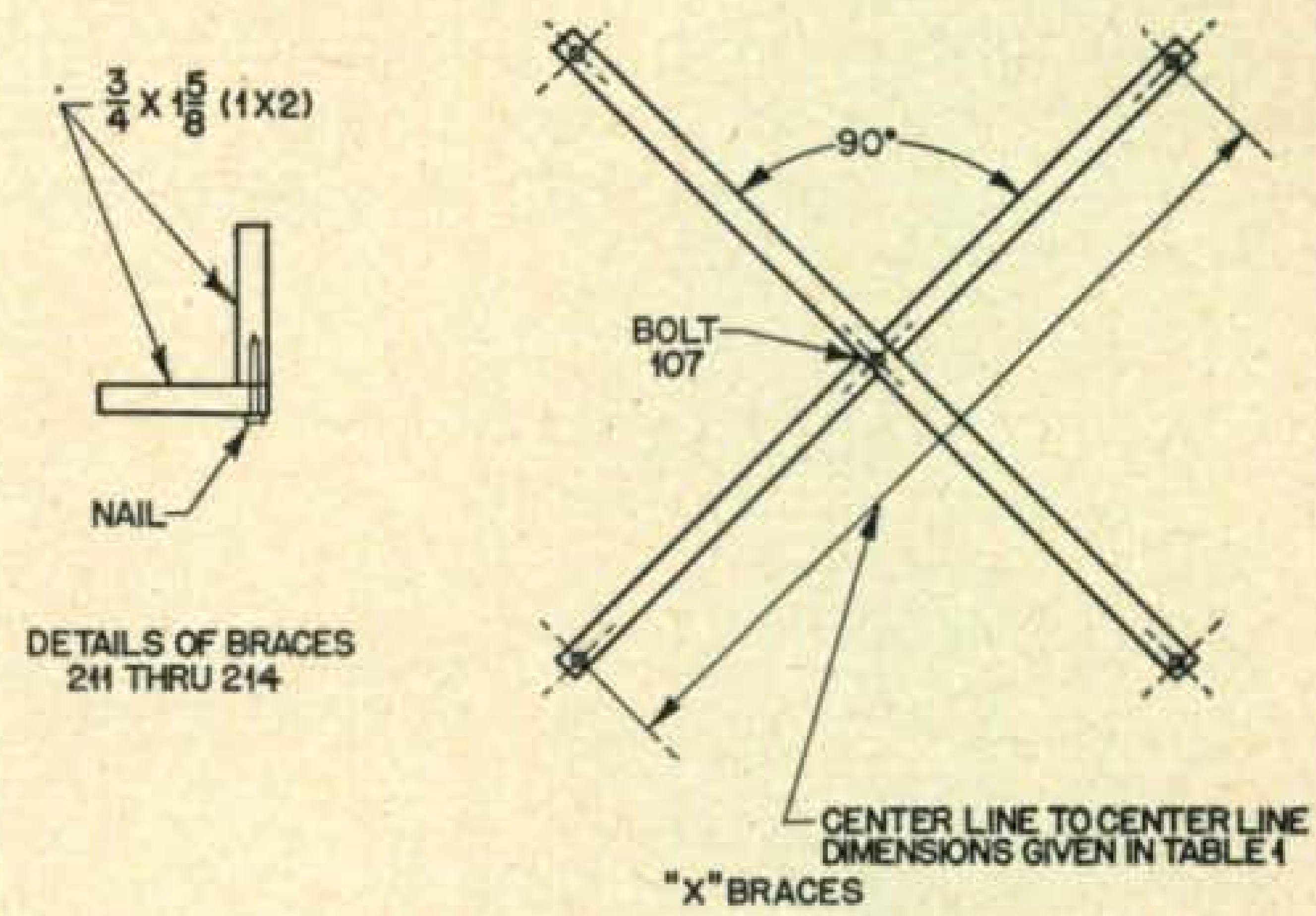


Fig. 7.

1 week, then following up with at least two coats of high quality outside oil paint, properly dried. If any doubt exists as to the best procedure consult a local painter or lumber yard). Now with those legs level, proceed to drill the holes as shown in *fig 9,* making sure your holes are true and well centered. The first hole which is for the lowest connection for the first cross brace is 13" up from the bottom end, and drilled through the *narrow* side of your 2x4 (ie, drill passes through the wood starting on the narrow side and runs through the wood parallel with flat side . . . see the picture!!! this is important). We used a ¼ inch drill with a small burr on it for the ¼ inch holes and they are good and tight. The 3/16 holes by using 3/16" drill with burr on the shaft. (We made the burr with a vise and pair of pliers).

Drill all the holes in both edges of the 2x4, then the crossbraces. Now assemble the crossbraces in their respective positions on the legs and bolt into place. Notice that the base of the legs are 8 feet center to center, while at the lowest joint between X brace and leg (narrow side) the dimension is only 7' 9 27/32", and at the upper joint of leg and lower brace, the dimension is 6' 7½". The large composite drawing shows how these dimensions progress up the tower. It is important that your base section be trued up. After finishing the two sets of sides for the base section, butt the base end up against a straight surface, such as a garage wall. Using a straight edge running perpendicular to the garage wall make sure the angle of each leg as it changes inward from that perpendicular is equal, *then* and not before, should all the bolts for that section of two legs and an X brace be tightened, and the center bolt No. 107 have its hole drilled and the bolt put into place and tightened. By doing this the bolt at the center of the X brace should then be in the center of each of the cross members and the angle formed should be 90°. By spending the time to true up the bottom section this way, you eliminate a lopsided tower. The tower is constructed on an angle of 4° 46″ from the perpendicular. After *each* of the two sides of the base section have been assembled, trued and bolts tightened then place them on edge, assemble the side brace, and true up and

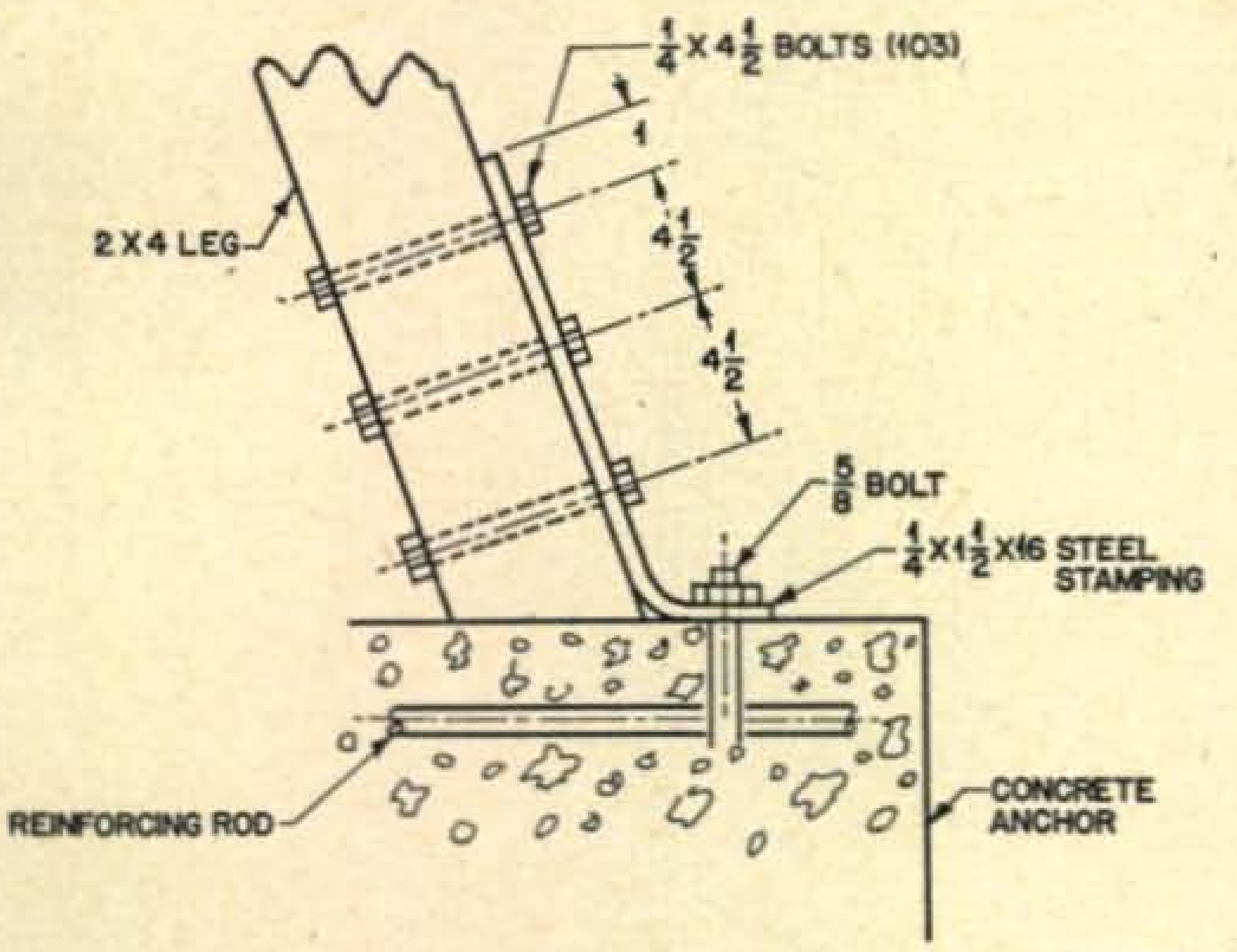


Fig. 8. Typical leg attachment to anchor

tighten, thus completing the entire base section. Note that the crossbraces are in pairs, opposites being alike, while the crossbraces removed by 90° (ie, the other 2 pairs) are also in pairs but their dimensions are slightly different as they join the legs at a point some 4″ to 6″ removed from the other joint. Also notice that the two lowest sets of crossbraces are reinforced by a 1 x 2 piece fastened at right angles to the brace.

After making the base section, true it up, then make the second section. It is much easier to assemble each section if you first level the two legs you are going to join with braces. If properly leveled with a spirit level, there cannot be any error in making the section true, for once leveled it just "ain't" possible to get it off! After the section is made join the two sections being absolutely sure each of the two sections are level and level with each other. Now join the bottom legs where they lay on or near the ground after leveling, and the "top" legs just naturally fit in place. That is why leveling each section is so important. If a drill slips or the rule slips and one of your braces was drilled slightly off it will result in one of the legs not matching up properly. Don't let it worry you. Notice that in assembling each section of the tower you are able to attach only one X brace to each section (except top section) before joining it to another section. This

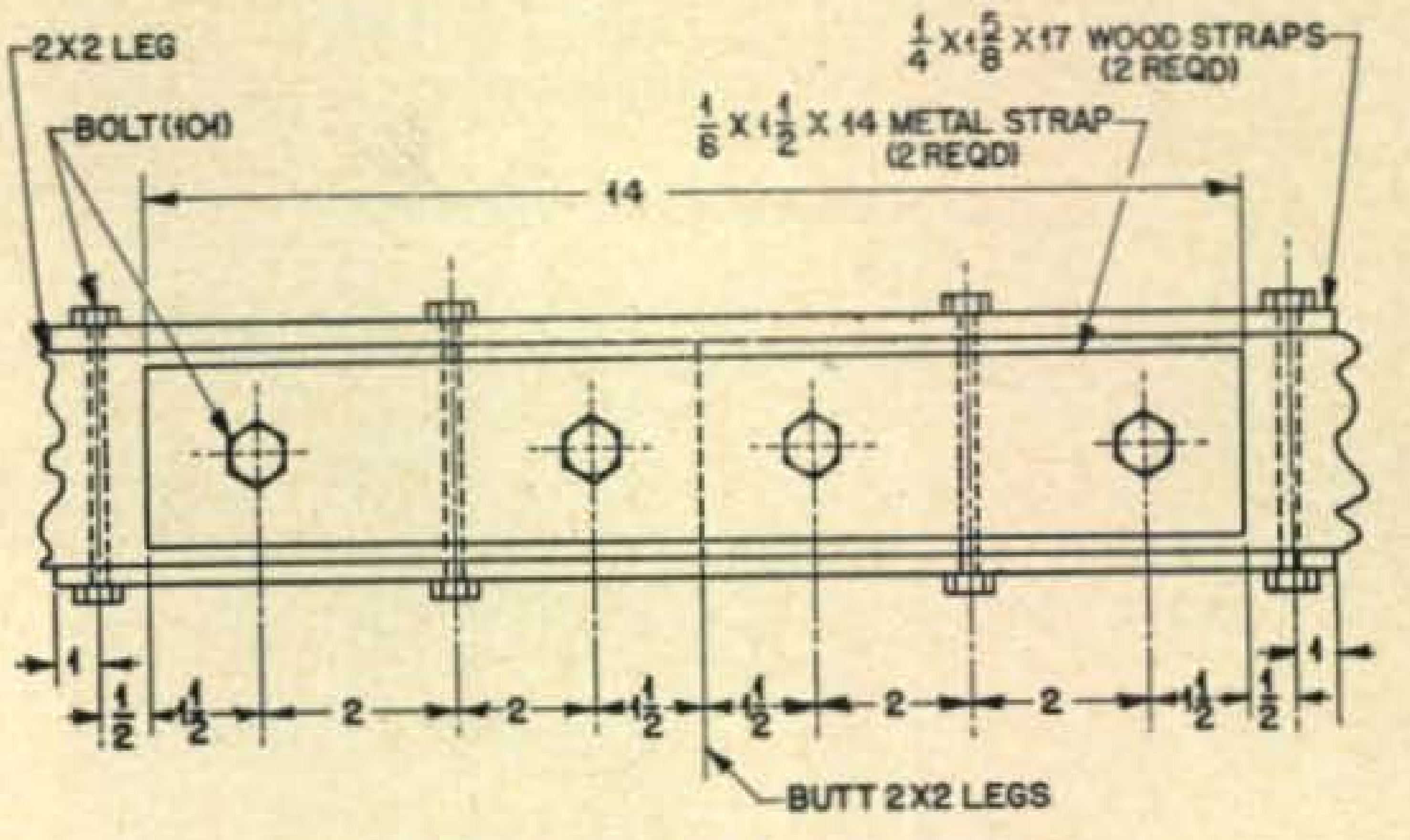
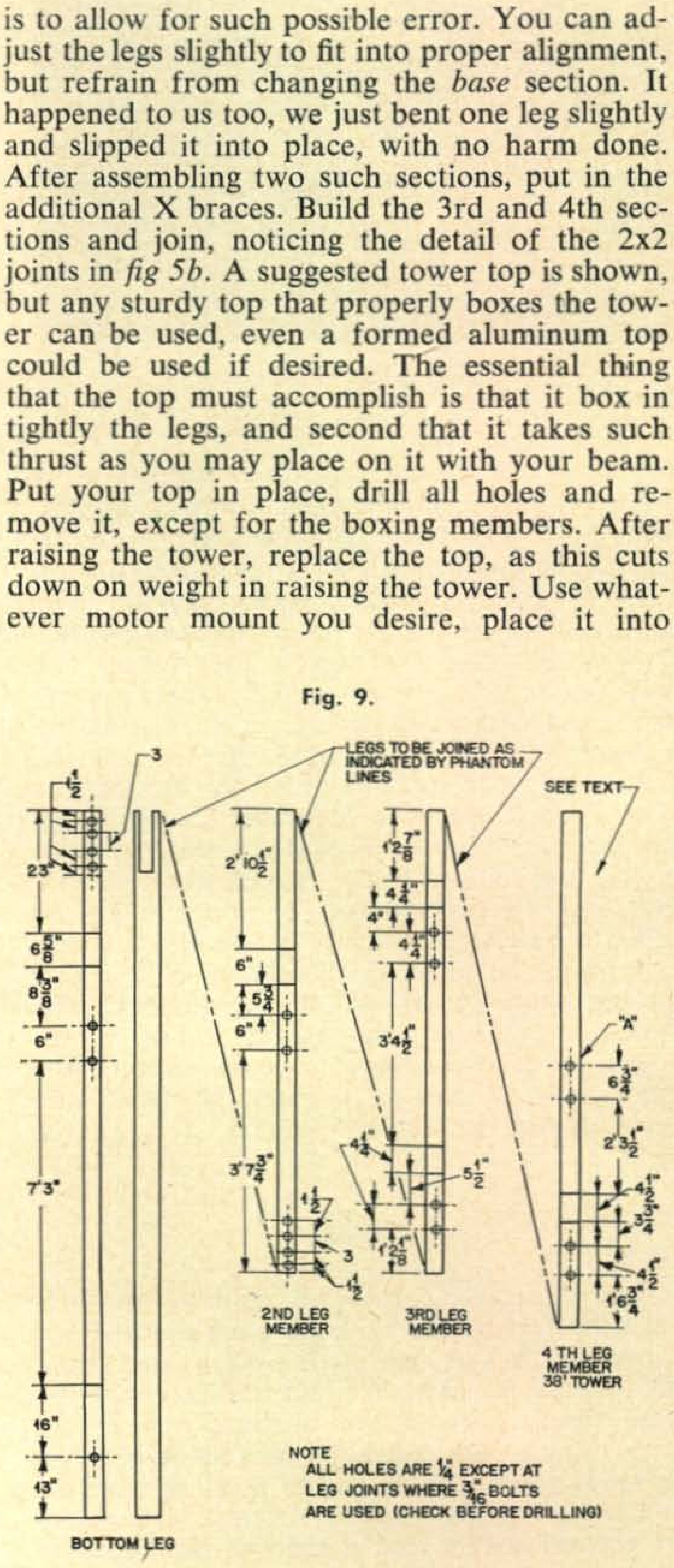


Fig. 5b. 2x2 leg joints

is to allow for such possible error. You can adjust the legs slightly to fit into proper alignment, but refrain from changing the *base* section. It happened to us too, we just bent one leg slightly and slipped it into place, with no harm done. After assembling two such sections, put in the additional X braces. Build the 3rd and 4th sections and join, noticing the detail of the 2x2 joints in *fig 5b*. A suggested tower top is shown, but any sturdy top that properly boxes the tower can be used, even a formed aluminum top could be used if desired. The essential thing that the top must accomplish is that it box in tightly the legs, and second that it takes such thrust as you may place on it with your beam. Put your top in place, drill all holes and remove it, except for the boxing members. After raising the tower, replace the top, as this cuts down on weight in raising the tower. Use whatever motor mount you desire, place it into

Fig. 9.

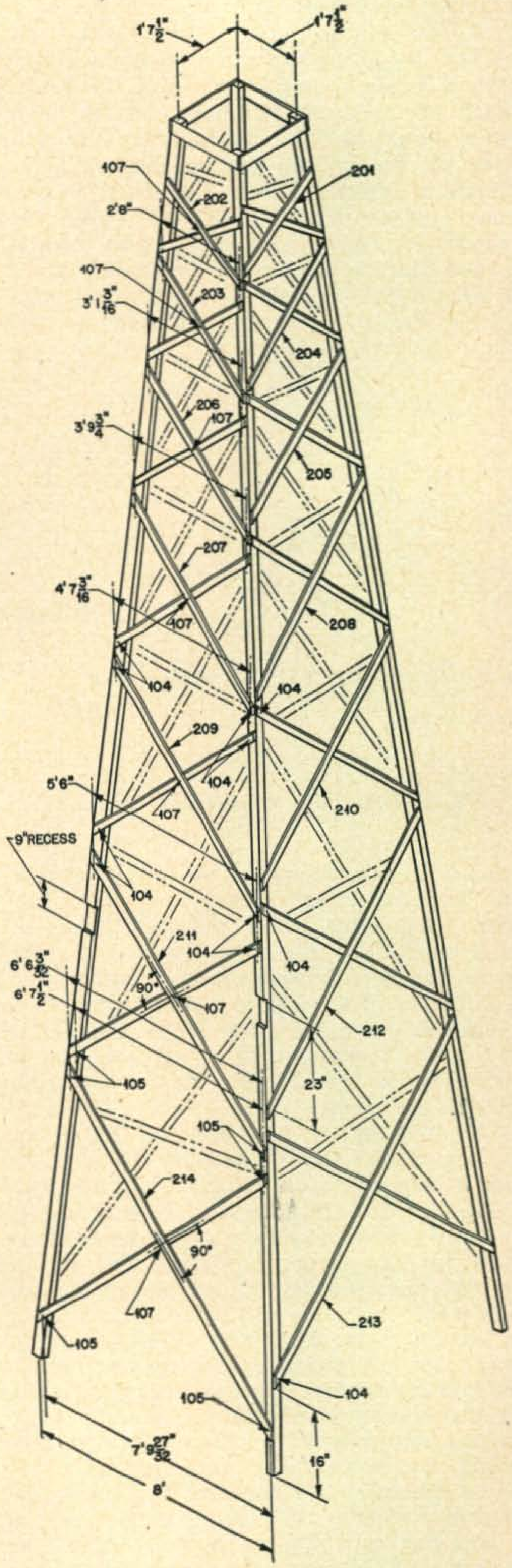


Showing detail of mounting

position, predrill, and remove it for the same reason, replacing it when the tower is upright. From *fig 9* note that the upper section of the last 2x2 is not predrilled. This is left to you to fit to your particular motor mount. The motor should be placed below the top, with a thrust bearing at the top of the tower. The mounting in this fashion makes motor repairs easier, and reduces the strain on the top mount or motor if the beam were directly on the motor and it were mounted on top of the tower. Install the last X braces as might be appropriate. Point A, *fig 9* is the starting point for the uppermost brace, which we made 3′ 8¾″ and wherever it hit the opposite leg we drilled a hole and attached it and left it there. As long as the angle at the center of the X is not less than 70° it will be satisfactory. The photos show how we mounted our motor mount to all four legs to assist boxing the upper portion and distribute the twist and thrust of the motor and the wind upon the beam and motor.

Now Raise It!

With the tower completed, anchors in place, place the legs of the tower against the anchors if possible. In our case, as the photo will show, this was not possible. We had to raise the tower some distance from the anchors because of large trees in the yard, by raising it between the trees, then walking it into position over the anchors. This we did by driving stakes into the ground at the base of the two legs lying on



Constructional details of entire tower. Above left "Recess" should not be recessed, the 9" only indicates slot length where leg joins.

Parts List

Legs—See Text

X Braces: 1" x 2" Douglas Fir or Equivalent #2 or better

	Pieces		Long		Drill Center holes. to center.	
#214	2 Pieces	10' 6 5/16"	"	"	10' 1 3/16"	"
#213	" "	10' 6½"	"	"	9' 11"	"
#212	" "	8' 10¾"	"	"	8' 4"	"
#211	" "	8' 10½"	"	"	8' 6 3/32"	"
#210	" "	7' 2½"	"	"	6' 10"	"
#209	" "	7' 6 3/32"	"	"	7' 1 19/32"	"
#208	" "	6' 1¾"	"	"	5' 9¼"	"
#207	" "	6' 4 1/16"	"	"	5' 11 9/16"	"
#206	" "	5' 3½"	"	"	4' 10½"	"
#205	" "	5' 1¾"	"	"	4' 9¼"	"
#204	" "	4' 4½"	"	"	4' 0"	"
#203	" "	4' 5¾"	"	"	4' 1¼"	"
#202	" "	See Text	"	"	(3' 4¾")	"
#201	" "	See Text	"	"	(3' 3⅜")	"

Brace for #214	Cut to fit
" " #213	Cut to fit
" " #212	7' 9" Long
" " #211	8" 1½' Long

Center Cross Member (Braces as in #214) — **6' 6" Long, 4 Pieces Plus Metal Angle Brackets to Connect to Leg at Ex**isting Bolt.

Straps:

Metal:

8 Pieces	1" x ⅛" x 19"	Lowest Leg Joint
16 "	1½" x ⅛" x 14"	Upper & Middle Leg Joint

Wood:

24 Pieces ¼" x 1⅝" x 17" Any thin wood — i. e., Apple Crate

(Used at Upper & Middle Leg Joints)

2-lb. #6 Galvanized Nails to Nail Bracing to Center Cross Member and #211, 212, 213 & 214.

Bolts:

Surplus Aircraft Aluminum Bolts — plated to prevent oxidation. Measure Length without head!

Bolt #	Number required.		With washer.	
104	100	3" x ¼"	"	(X Brace to Leg Bolts)
105	12	5" x ¼"	"	(X Brace to Leg Bolts, Long Side)
107	28	2" x 3/16"	"	X Brace Center Bolt
103	12	4½" x ¼" or ⅜"	"	Leg to Anchor Bolt
102	16	4½" x 3/16"	"	Lower Leg Joints
101	80	2½" x 3 1/6"	"	16 for Lower Leg Joints 32 for Middle Leg Joints 32 for Upper Leg Joints

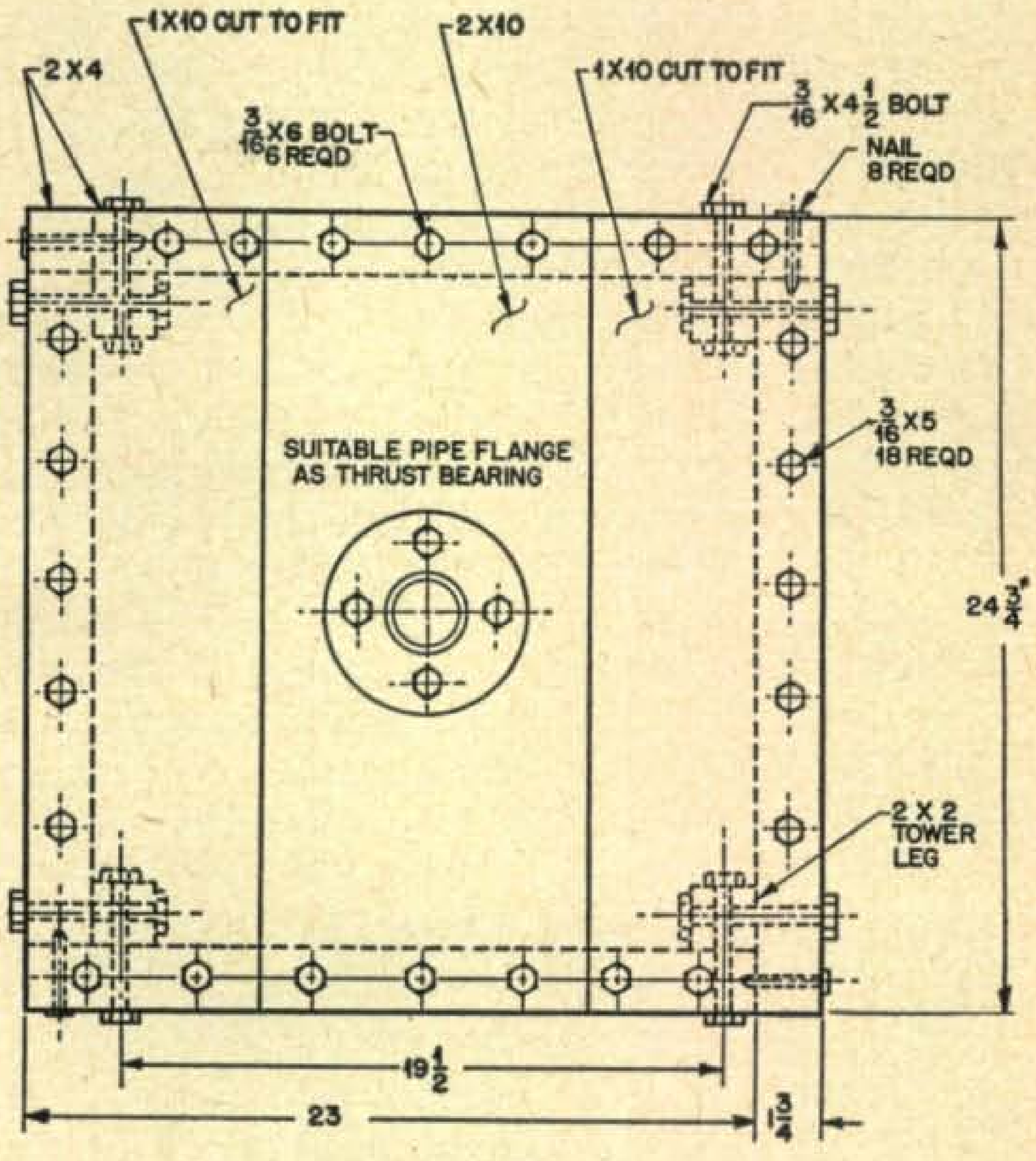
Ladder:

4 14' 2" x 2"

2 10' 2" x 2"

1" x 3" for Steps (amount depends upon width of Ladder and Spacing).

Nail steps to legs—brace each joint with wood straps (where sections join). Tie ladder to tower at lower section. Bolt upper sections to tower in at least 2 places if lower section is to be removed.

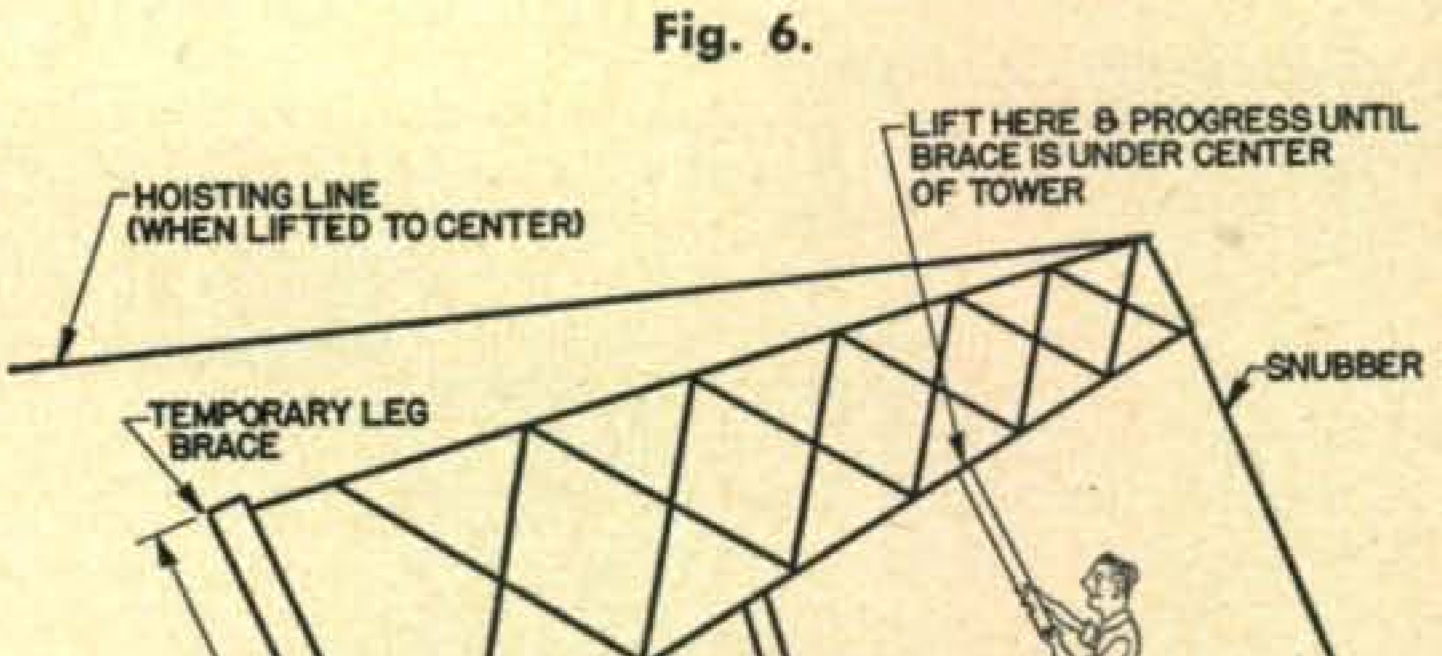


Tower top

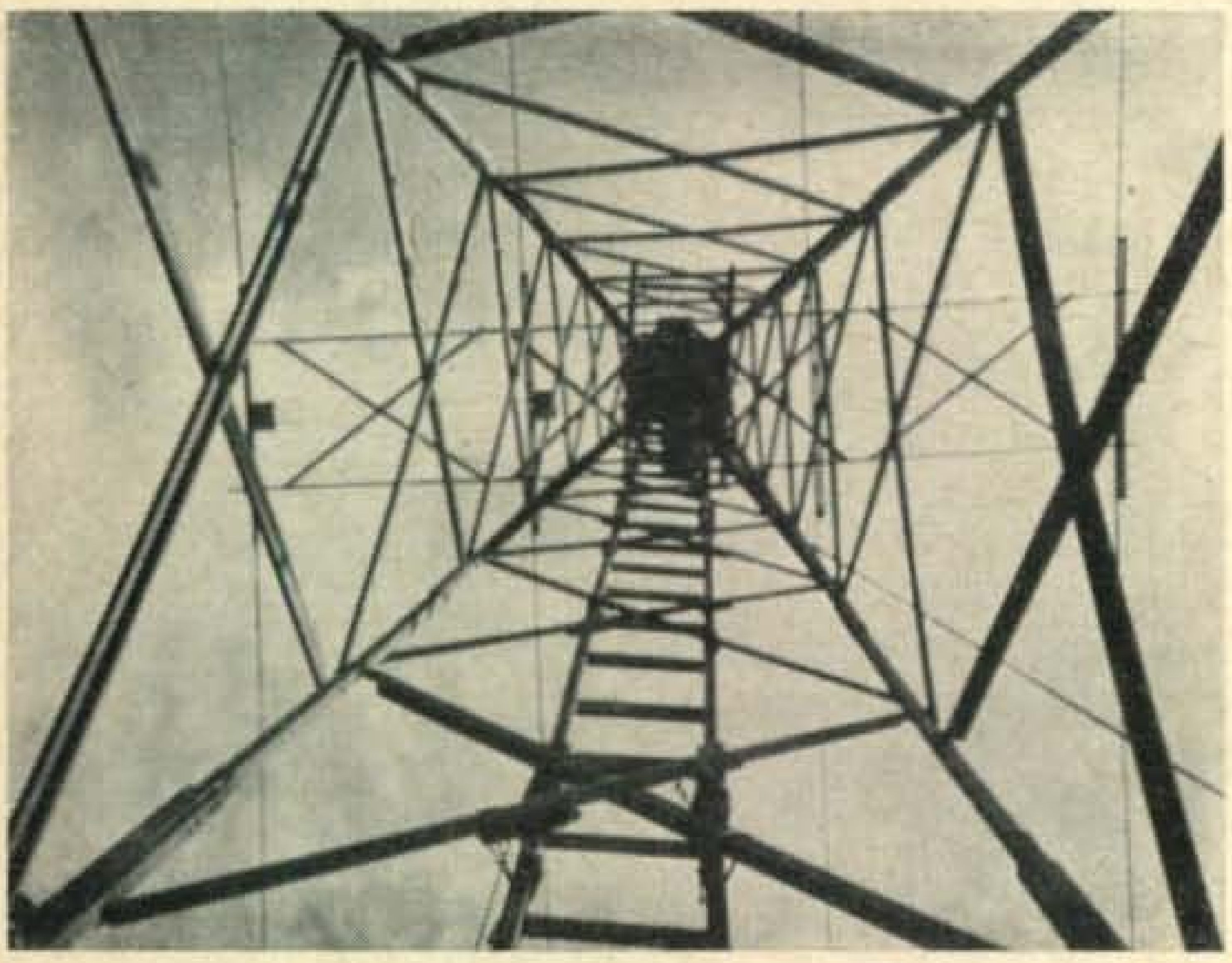
the ground to keep the tower from slipping as we raised it. We also bolted a temporary 2x4 across the base of the tower legs, right at the very ends of the legs, so that the legs would not break between the ends and the first joint (some 13" up on the leg) during the raising process. Next insert the center horizontal X brace connecting all four legs. This aids in preventing twist in raising and gives additional strength and load distribution, so put it in to stay. It will take bent metal brackets at each end to join it to the legs. Make them to fit, (cannot be precut).

Now start at the upper (small) end of the tower and start walking it up. As two or three men lift it and start walking it up have one or two more place braces under it and move the braces progressively towards the center as it is walked up further. Proceed thusly to the center of the tower (which is not the center of gravity). Now either two or three men (or a car) at the end of a *long* rope previously attached to

Fig. 6.



the top can complete the lifting process, while the men who were walking it up take hold of a snubber, also previously tied to the top, such snubber to prevent the tower from being pulled all the way over in the opposite direction after it reaches the upright position. (Believe me, it can happen!) Two men and two strong boys raised ours with no gin pole, pulleys or cars. A gin pole could be used if available and it would be much easier, as it would eliminate the walking up process, which is the worst part. (Don't ever try to take the tower down this way though. A gin pole high enough to catch the tower weight above the center of gravity, before the tower passes the point of falling is needed). We made the mistake of using clothes line for our rope to use for lifting. We



Heads up

had 200 feet as a starter. It stretched to half that again before the tower even started to move! Use ⅜" manila or larger and eliminate that problem. When we lowered this one later, we used ⅜ 3 strand manila rope with complete satisfaction.

Once the tower was upright, with one man on each rope attached to the top to prevent its turning over, we used a long 2 x 4 and levered the tower across the yard and into position on the anchors, by levering it under the temporary brace across the legs. When next to the anchors, one of us at each corner, and we lifted it into place. Now bolt it to the leg of the anchor. See *fig 8* and the photo of our particular anchor.

Now install the first ladder section, placing the base of the ladder upon a concrete or brick block set into the ground. Raise the second and third ladder sections into place using a rope over some tower X member as a pulley. Tie (or bolt if desired) the ladder sections into place along the side desired; make good joints at the ladder leg joints. We made our ladder in 3 sections, and boxed each joint with thin strips of apple box material, similar to the 2x2 leg joints except that these strips were nailed only to one ladder leg, the other riding free (for easy assembly and disassembly). If you have children, after all items are in place on the tower and no more climbing is necessary, remove the 12 foot lower section of the ladder, and store it away where the kiddies cannot get it. Otherwise they will climb that new tower! Forty feet may not seem far, but get up there for a while and look down, and just think what it would do to a child's arm or back if they fell! Safety is a good thing to keep in mind. We always take a safety rope up with us and tie ourselves onto that tower if there is work to be done up there.

When she's up, anchored, ladder in place, climb up and fasten the top and motor mount into place, hoist the motor and put it in with all wiring, etc. Light beams can be walked up the ladder; ours was a 4 element 20 meter beam, with automatic switching boxes for 8 Colinear half waves in phase on 10, and it weighed 120 pounds. So we attached two guy wires from the top to the ground at about 45° angle, slid the beam onto the guys, slid it up the guys and onto a specially built cradle, bolted it to the cradle, released it from the guy wires, swung the cradle into position, removed the cradle bolts, and bolted it to the driveshaft, dropped the cradle, and there she sat, all ready to go. We had lots of trouble with the beam and spent many a trip up and down that tower tuning it up, and finally ended up with a three element 20 meter beam. The photos show some of the work in progress. We have never had any trouble with the tower. It has exceeded even our fondest expectations. There is no reason why the tower could not be built even higher, if the same bracing is methodically continued and the anchor enlarged to compensate for the shift in the center of gravity. The necessary formulas can be found in Eshback "Handbook on Engineering Fundamentals", Pp 9-64 to 9-69. ■

Travel-Desk

One of the big nuisances in mobile operating is keeping that station log. Since this magazine might get into FCC hands we won't start anything blood curdling by speculating how many of us don't keep our mobile log up to date. Some Chicago outfit has seen the light and made everything easy for us . . . it is called the Travel-Desk and it fastens to the dash board of your car in a trice. With this you have your log right there handy, and the magnetized pencil doesn't chase itself around the floor of the car like regular ones. Dunno if you can tell from the photo or not, but the desk swings around out of the way when you have other business. Silly people didn't tell us how much the contraption costs. Probably reasonable. General Industrial Co., 5738 N. Elston Ave., Chicago 30, Illinois.