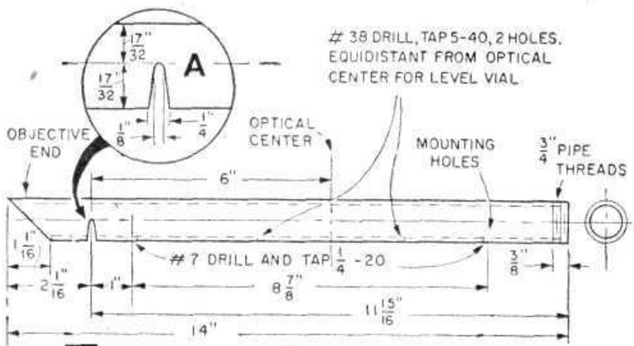
Engineer's Level

DESIGNED to be easier to operate and capable of taking more abuse than a transit, this engineer's level can be used for such outdoor jobs as landscaping, septic tank installation, drainage ditching, setting concrete forms or any task requiring level or grade sighting (Fig. 1). It can be made in one evening with hand tools.

1 Using engineer's level on a camera tripod to set concrete forms.

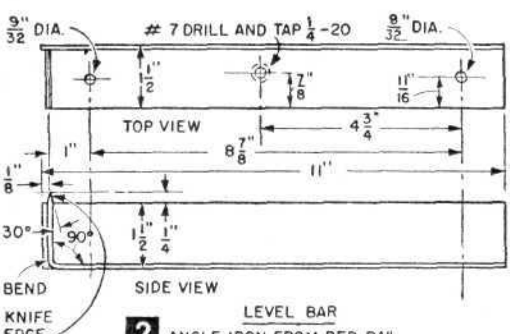
By THOMAS E. RILEY

The instrument consists of two major parts: The sighting level tube or telescope to which a level vial is attached, and the level bar. It is supported by a camera tripod with or without a tilting head. The tilting head will enable the user to set up the instrument more easily but, on the other hand, detracts somewhat from the stability.



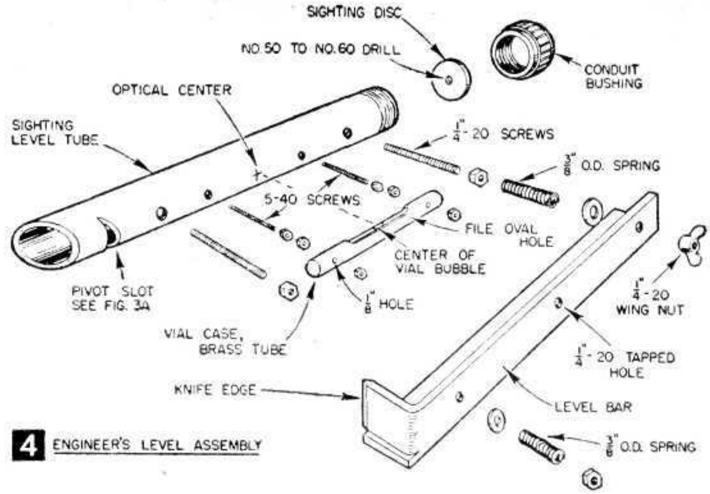
3 SIGHTING LEVEL TUBE, 3/4 PIPE OR CONDUIT

Make the level bar (Fig. 2) first. Use angle iron taken from an old bed rail because structural angle iron is too heavy and thick at the corner. With a hacksaw make a cut 2 in. long as close as possible to the vertical side. Then bend up the 2 in. cut end. Since the bed rail steel may be brittle, heat the area to be bent to a dull red. Check the bent end with a square to make sure it is exactly 90° and saw off the extending vertical side 1/8 in. beyond the bent section. File the top edge of the bent end down to 1 3/4 in. above the bottom edge of the bar and parallel to it. Then file both sides to a blunt knife edge. Finally draw the file lightly across the length of the knife edge to be sure the edge is a straight line parallel with the bottom. This knife edge is the one crucial point in the construction of the instrument because it serves as the "Y" support of the level, the pivot bearing and horizontal crosshair. Drill the two 9/32 in. holes and tap the middle hole 1/4-20 to fit any camera tripod head.



LEVEL BAR
2 ANGLE IRON FROM BED RAIL

To make the level tube, cut pipe threads on one end of a 14 in. length of 3/4 in. standard pipe and saw the other end at an angle as in Fig. 3. Scribe a line lengthwise on the bottom of the pipe parallel with the sides. Measure and mark 11 15/16 in. from the threaded end for the location of the center of the pivot slot. Cut this slot 1/8 in. wide and file to the wedge shape (Fig. 3A). Round the bottom of the cut with a small rat tail file or abrasive cloth around a nail. The slot should extend exactly halfway through the pipe. Now lay out, drill and tap the two mounting holes on the scribed line and mark the optical center point.



4 ENGINEER'S LEVEL ASSEMBLY

MATERIALS LIST—ENGINEER'S LEVEL

No.	Description	Use
1 pc	1½x1½x13" angle iron (old iron bed rail)	level bar
1 pc	¾" conduit or water pipe, 14" long	sighting tube
1	¾ conduit pipe bushing	eyepiece retainer
1	15/16" dia. metal disk, 1/16" thick	eyepiece
1	3 or 3½" alcohol level vial (replacement for carpenter's level)	vial case
1 pc	½ or 9/16" dia. copper or brass tubing, 6" long	vial supports
2	5-40x1¼" long machine screws	adjustment screws
6	5-40 nuts	
2	¼-20x2" long machine bolts	
3	¼-20 nuts	
3	¼" washers	
1	¼" wing nut	
1	⅜" dia. compression spring, ⅝" long	
1	⅜" dia. compression spring, 1¼" long	

An ordinary 3-3 1/2 in. replacement level vial for a carpenter's level is to be used. Purchase the vial first then secure a piece of copper or brass tubing just large enough so the vial will slide into it. Cut the tubing off 1/2 in. beyond each end of the vial and file an oval hole in the middle of the tubing to expose the vial bubble as in Fig. 4. Drill parallel 1/8 in. holes in each end of the tube for supporting bolts and cement the vial in the tube with household cement.

To locate the exact position the vial is to be fastened to the sighting level tube, hold the center of the vial bubble marking at the optical center mark scribed on the sighting tube and spot mark the locations of the two 1/8 in. holes in the copper or brass tube on the sighting tube. Drill and tap the sighting tube for 5-40 threads.

Make the sighting disc Fig. 4 next. Cut a 15/16 in. dia. disc from 1/16 in. thick brass or steel. File and fit this disc to fit snugly inside a 3/4 in. conduit pipe bushing. Drill a small hole (about #55 to #60 drill) through the exact center of the disc and assemble to the threaded end of the sighting tube. It is important that the disc be secure. If the small hole is slightly off center, the final adjustment of the instrument will correct the error; but, if the disc moves after adjustment, the instrument will give false readings.

Before assembling the parts give them a coat of paint. A crackle finish type of paint used by radio repairmen will give the instrument a professional appearance. Do not paint the knife edge or pivot slot. After the paint dries, cut the heads off two 5-40 x 11/4 in. long machine screws and screw into the tapped holes in the sighting tube. Lock the screws to the tube with a nut on each one (Fig. 4). Place another nut on each screw, then the level vial tube and fasten with a third nut on each screw. Adjust the nuts on either side of the vial tube until the vial appears parallel with the sighting tube.

Next, cut the head off a 1/4-20 x 2 in. bolt and screw into the tapped hole nearest the sighting disc or eyepiece of the sighting tube. Lock in place with a nut on the outside of the tube. Slip a lV4-in. compression spring and washer over the bolt and assemble the tube in its position on the level bar with another washer and wingnut. Attach another 1/4-20 x 2-in. bolt into the tapped hole nearest the pivot slot with a nut on the outside as before. Place a 5/8-in. compression spring, washer and nut underneath the level bar (Fig. 4). Screw the bolt into the tube until the spring exerts tension on the knife edge bearing. Then lock the bolt to the sighting tube with the nut on the outside of the level tube and the instrument is assembled.

The level is adjusted by the collimation or peg adjustment. The object is to place the axis of the level vial exactly parallel to the line of sight through the level tube. You will need a surveyor's level rod for this adjustment and also for your surveys. One can be made inexpensively by purchasing a level rod ribbon and gluing it to a 1x3-in. board. These ribbons are l 1/2 in. wide cloth tapes with easily read graduations in hundredths of feet instead of inches. They may be purchased in any engineer's supply store.

Set up the level in a convenient area outdoors. To set it up properly, place the legs of the tripod or adjust the tilt head by eye so that the bar seems level. Next, sight the instrument on the level rod and then center the bubble in the vial by means of the wing nut. Have an assistant balance the level rod on top of a stake driven in the ground fifty feet in front of the instrument. Sight through your level at the rod, and, after carefully centering the bubble, record the reading made by the knife-edge on the rod. The assistant rodman, then picks up his rod without disturbing the stake and moves to a point fifty feet behind your instrument. Here he drives a second stake in the ground and balances his rod on it. You now swing your level around and sight on the rod again. Record this second reading after readjusting the bubble. Next, pick up the instrument and set it up directly alongside the second stake. Measure up from the top of the stake to the small hole of the eyepiece after the level bubble is centered.

Even though your instrument was not yet in adjustment, your first two readings gave you the actual difference in elevation between the two stakes Why? Because equidistant level shots eliminate the collimation error and your two shots were equidistant. Now, if you add or subtract the difference in elevation (whichever it is) to the height of your instrument above the second stake, you will know what the instrument should read on the rod when the rod is on the first stake. With the rod balanced on the first stake, adjust the level tube with the wing nut to the correct reading, disregarding the bubble in the vial. Then without disturbing the level tube, carefully adjust the level vial with the four nuts until the bubble is centered. Your instrument is now in adjustment and ready to use, but the procedure may be repeated for a check.

When observing through the level, always sight so that the rod is in the center of the horizontal knife edge. At that point any possible divergence of the knife edge from a horizontal line will be zero. A few hours study of a manual on surveying will acquaint you with the many uses of an engineer's level and with the procedures used by surveyors on complicated layouts of grade.