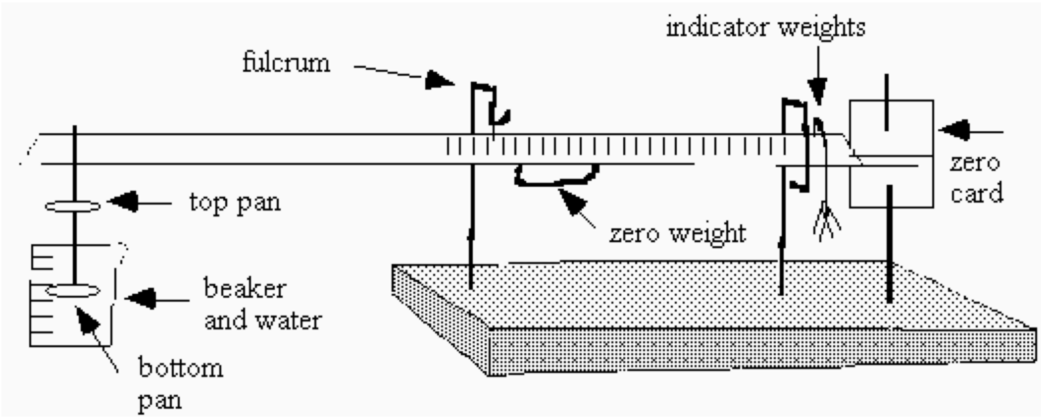
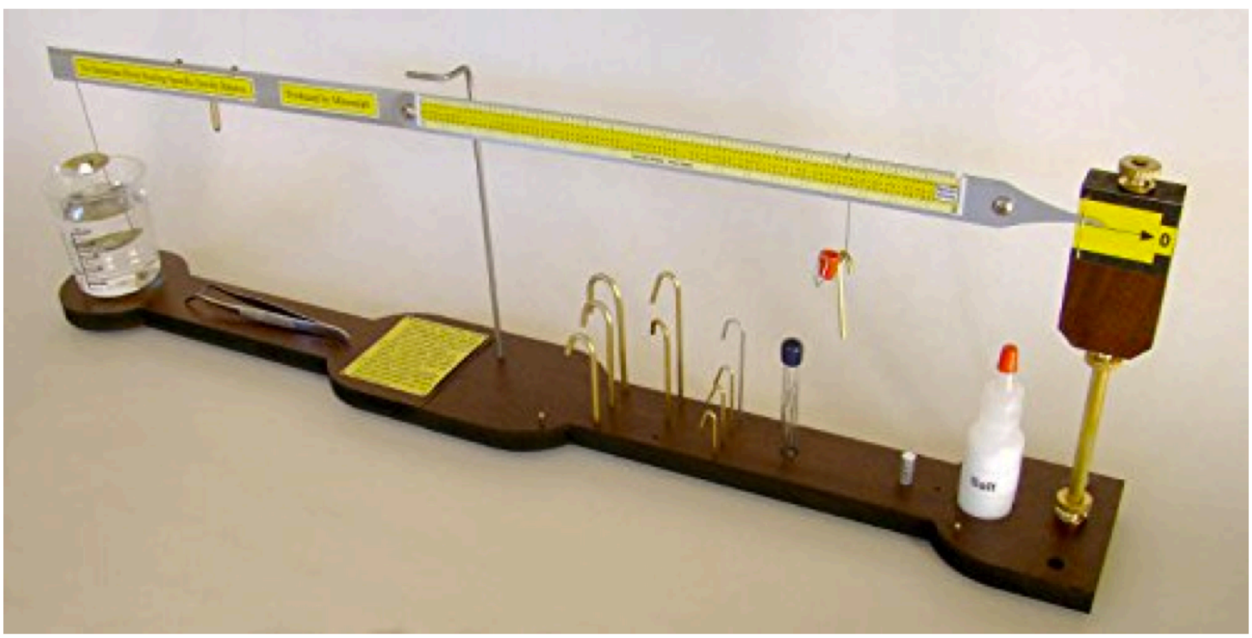
Construction of a Hanneman Specific Gravity Balance
By W. Wm. Hanneman, Ph.D.

With edits by Barbra Voltaire, BSc, FGG, GG



Do it yourself kit available here:

https://www.shannonsminerals.com/shop/index.php/shannonsminerals/laborprogramm/gemmologie/hanneman-specific-gravity-balance-1.html



Commercially available Balance available here:

http://www.amazon.com/gp/product/B00Q268XI2/ref=as_li_tl?ie=UTF8&camp=1789&creative=9325&creativeASIN=B00Q268XI2&linkCode=as2&tag=gemsandwhywelove&linkId=H5T7MVWBBPHV4JN6

Some time ago (1968 to be precise) Dave Smith of the Four Clover Mine came to me and said, "Bill, what the rockhound needs is a good specific gravity balance. Do you think you can make one? Being extremely modest by nature I replied immediately, "Of course," Later, I found I should have kept my mouth shut.

First, I had to convince myself that there really was a need to measure specific gravity (S.G.). This was easily done when I plotted the SG of the gemstone minerals and saw just how well they were separated. This is demonstrated on the xext page in Table 1 which lead to the development of my original gemstone identification scheme.

Now, I was really hooked. I had an identification scheme all right, but no balance to make it work. So I sat down to figure out just what kind I needed.

There were, at the time, balances on the market which could be used for SG measurements. Ohaus made a nice one for about $40 , but it was not sensitive enough for small gemstones and thumbnail mineral specimens. (About 5 grams or 25 carats was the smallest sample one could measure accurately.) You could also get a good diamond balance for around $100 (now, well over $1,000) and up, if you wanted to weigh smaller stones.

In either case, you have to go to a lot of trouble to measure the SG or density. Numerically, there is no difference between SG and density so long as the result is expressed in no more than 2 decimal places. If you want to consider the thirds decimal place, you must consider temperature.

First, you have to weigh the stone in air, then in water and subtract one number from the other to determine the loss of weight on immersing the stone in water and then divide the value into the weight of the stone in air. After you've done that once or twice you probably won't care if you ever determine another SG in your lifetime.

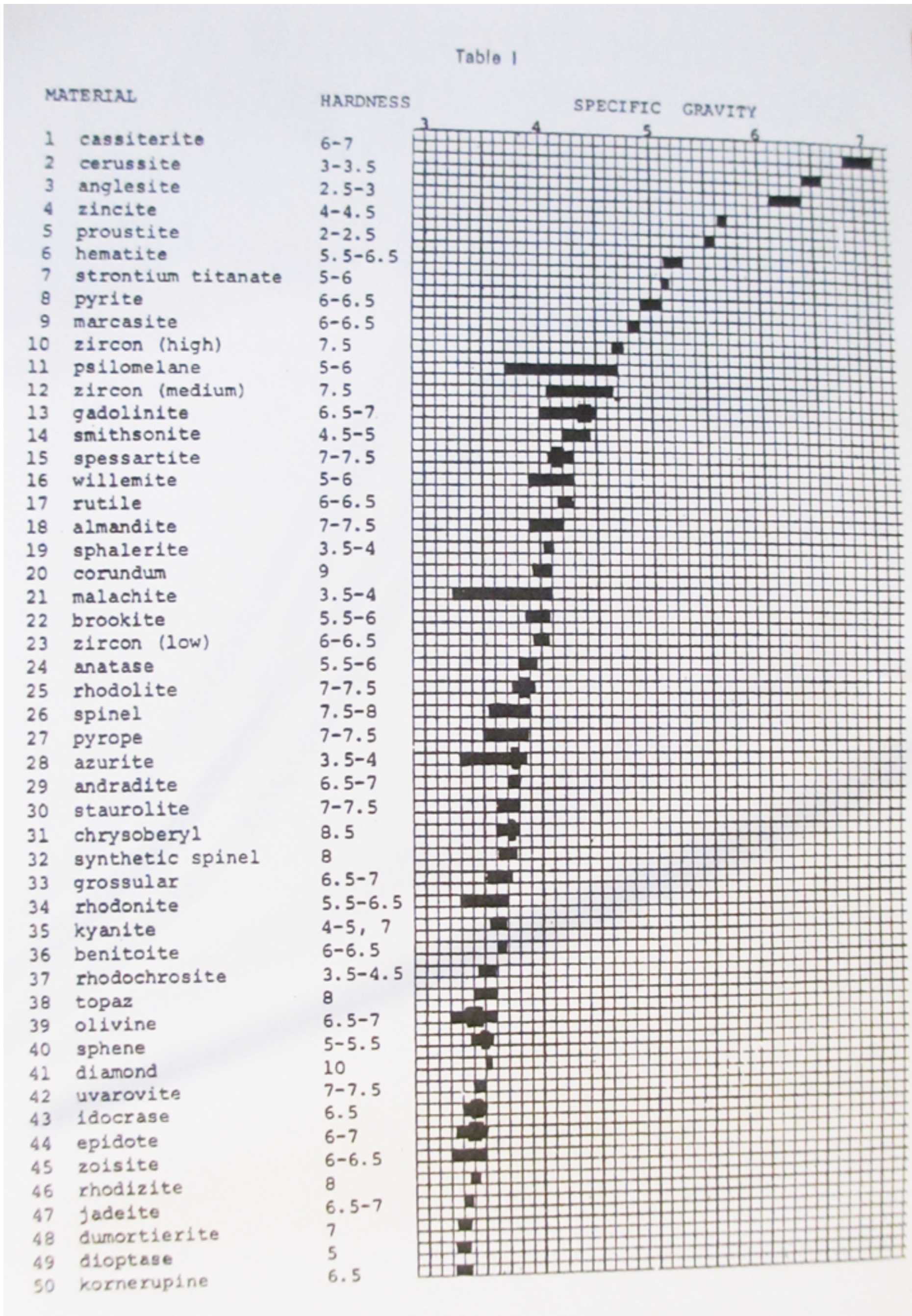
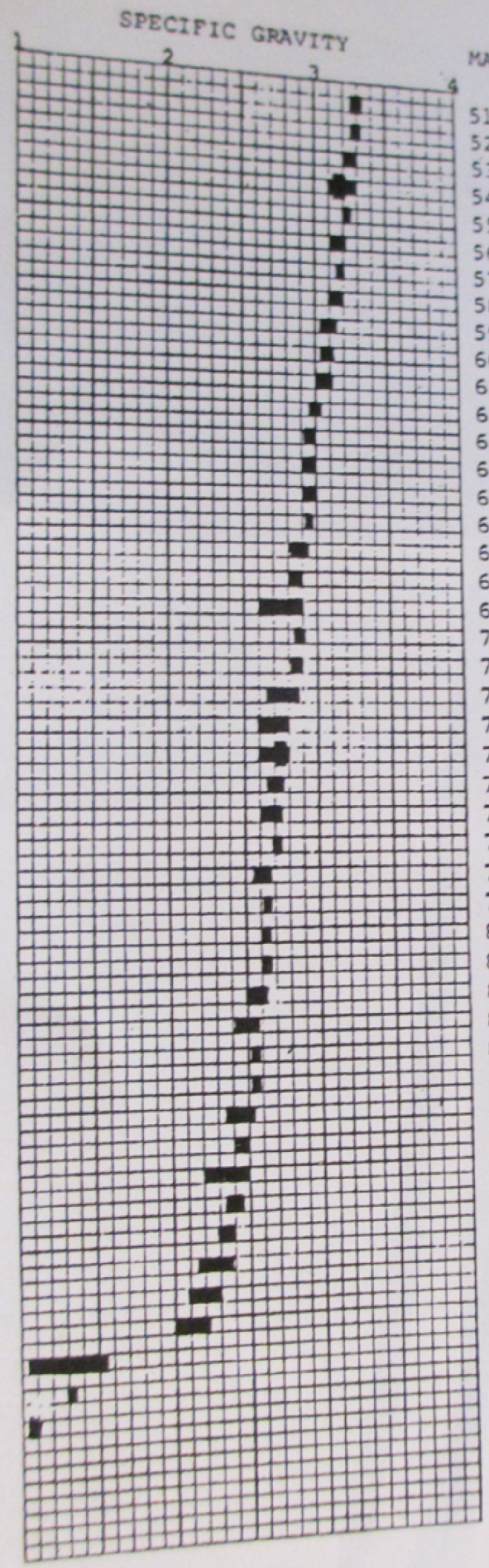


Table 1

	MATERIAL	HARDNESS
1	cassiterite	6-7
2	cerussite	3-3.5
3	anglesite	2.5-3
4	zincite	4-4.5
5	proustite	2-2.5
6	hematite	5.5-6.5
7	strontium titanate	5-6
8	pyrite	6-6.5
9	marcasite	6-6.5
10	zircon (high)	7.5
11	psilomelane	5-6
12	zircon (medium)	7.5
13	gadolinite	6.5-7
14	smithsonite	4.5-5
15	spessartite	7-7.5
16	willemite	5-6
17	rutile	6-6.5
18	almandite	7-7.5
19	sphalerite	3.5-4
20	corundum	9
21	malachite	3.5-4
22	brookite	5.5-6
23	zircon (low)	6-6.5
24	anatase	5.5-6
25	rhodolite	7-7.5
26	spinel	7.5-8
27	pyrope	7-7.5
28	azurite	3.5-4
29	andradite	6.5-7
30	staurolite	7-7.5
31	chrysoberyl	8.5
32	synthetic spinel	8
33	grossular	6.5-7
34	rhodonite	5.5-6.5
35	kyanite	4-5, 7
36	benitoite	6-6.5
37	rhodochrosite	3.5-4.5
38	topaz	8
39	olivine	6.5-7
40	sphene	5-5.5
41	diamond	10
42	uvarovite	7-7.5
43	idocrase	6.5
44	epidote	6-7
45	zoisite	6-6.5
46	rhodizite	8
47	jadeite	6.5-7
48	dumortierite	7
49	dioptase	5
50	kornerupine	6.5



	MATERIAL	HARDNESS
51	axinite	6.5-7
52	diopside	5-6
53	enstatite	5-6
54	spodumene	6-7
55	sillimanite	6-7
56	andalusite	7-7.5
57	fluorite	4
58	apatite	5
59	lazulite	5-5.5
60	euclase	7
61	tourmaline	7-7.5
62	danburite	7
63	phenacite	7.5-8
64	nephrite	6-6.5
65	datolite	5-5.5
66	brazilianite	5.5
67	prehnite	6-6.5
68	lepidolite	2.5-4
69	turquois	5-6
70	pollucite	6.5
71	beryllonite	5.5-6
72	beryl	7.5-8
73	bowenite	5.5-6
74	steatite	1.5-2.5
75	labradorite	6
76	scapolite	5-6.5
77	calcite	2.5-3
78	cordierite	7-7.5
79	quartz	7
80	oligoclase	6
81	quartz (chalcedony)	6.5-7
82	serpentine	2.5-4
83	variscite	4-5
84	microcline	6
85	orthoclase	6-6.5
86	obsidian	5-5.5
87	lazurite	5-6
88	chrysotile	2-3
89	moldavite	5.5
90	apophyllite	4.5-5
91	sodalite	5-6
92	chrysocolla	2-4
93	opal	5-6.5
94	plastics	2-4.5
95	jet	2.5-4
96	amber	2-2.5

It was pretty obvious that my balance had to be cheap, sensitive, easy to operate, read SG directly without any arithmetic and yet not be too delicate. Figure 1 shows the final design. Closeups of the components are shown in Figs 2A, B and C.

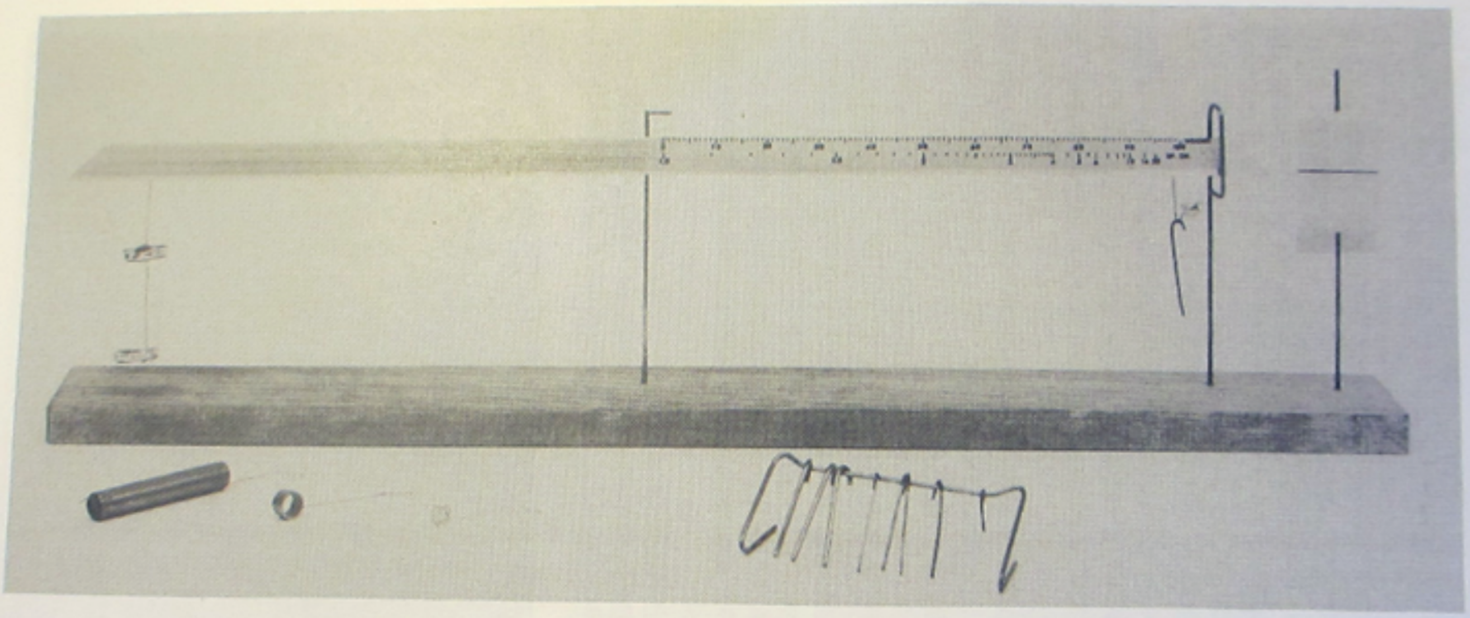


Fig. 1. Hanneman Direct Reading Specific Gravity Balance

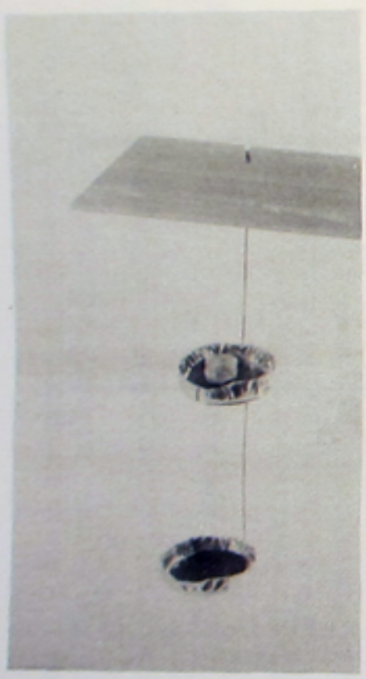
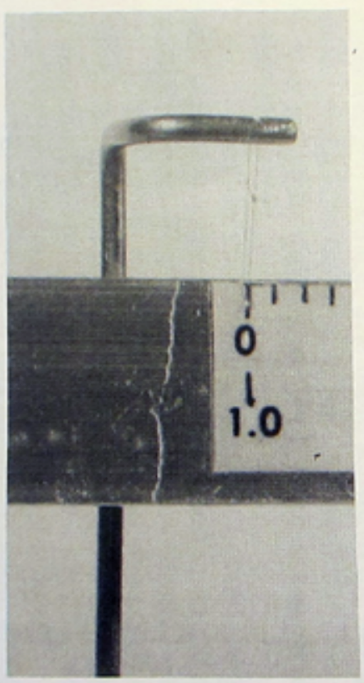


Fig. 2B. The pans



Fog. 2A. The beam suspension

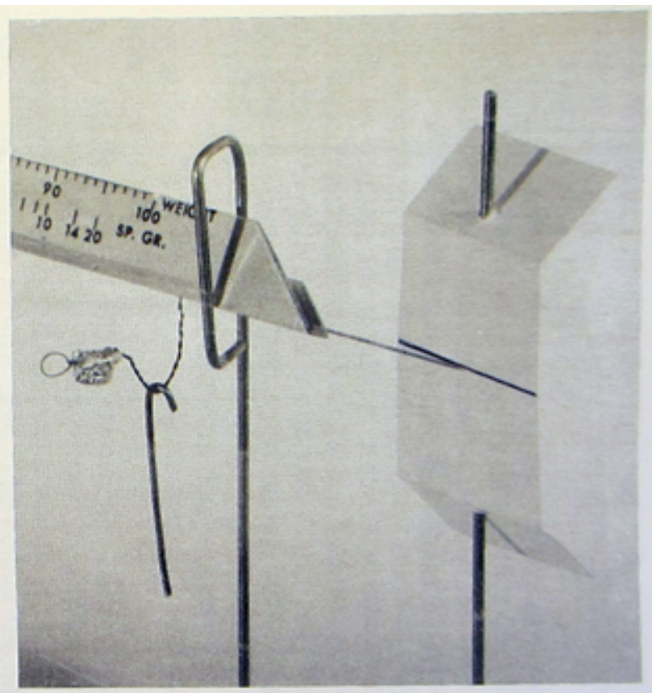
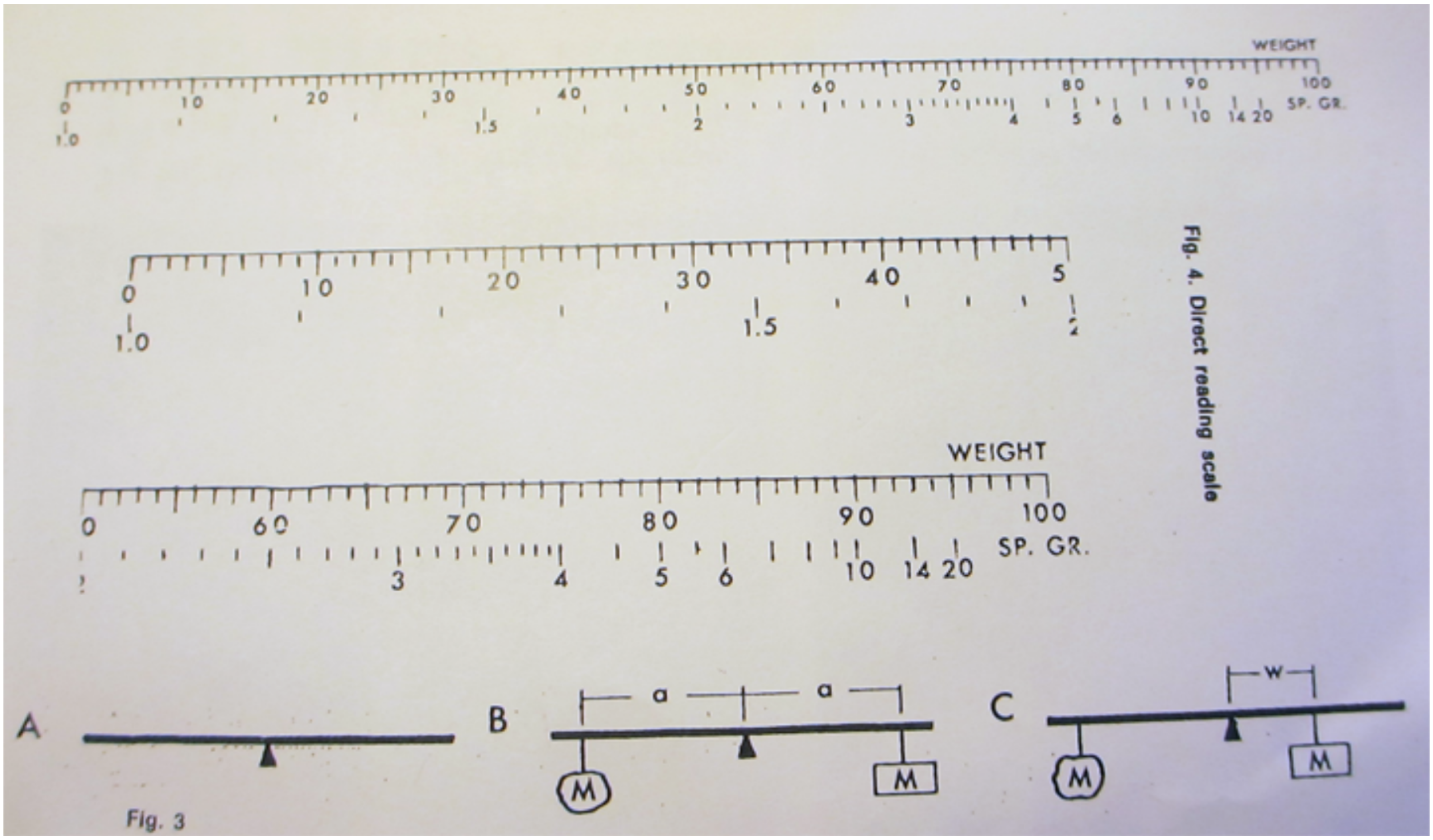


Fig. 2C. The pointer assembly

Today, the balances I have made are beginning to become Collector's Items. However Mineralab (1-800-749-37660 PRESCOTT, AZ, 86305 is now making a Deluxe Model of the Hanneman Balance Described below.

But first, I'll try to impress you with my mathematical ability by telling you how I solved the problem of the direct reading scale. This is a perfect example of how each new generation rediscovers the wheel. After I had accomplished this feat I felt quite sure I couldn't he the only one to have ever done this, so I went to the library. Sure enough, a Professor Rogers at Stanford had done the same thing 25 years previously. I wouldn't be a bit surprised if Archimedes himself had figured it out. However it does give an interesting insight into how this balance works so I shall explain it briefly below. If you don't like arithmetic, just skip over it.

We all know that we can make a balance by balancing a stick on a knife edge (Fig. 3A). If we hang at a distance (a) to the left of the knife edge a stone having a mass (M) we can balance the stick again by adding an equal mass (M) at a distance (a) to the right of the knife edge. (fig.3B), Now, if we immerse the stone in water it will appear to weigh less and the and the mass (M) will have to be moved towards the knife edge (new distance-w) to again balance the stick (Fig 3C).



Now (a) (M) represents the weight of the stone in air and (w) (M) represents the weight of the air in water. Note the difference here between this balance and a typical diamond balance. With the diamond balance the pans are at a fixed distance from the knife edge and you weigh by adding or subtracting weight (Mass or M). With this balance the mass (M) must remain constant. The weight is measured in terms of difference from the knife edge and the SG is measured as a ration of distances.

Since we are dealing with the length, we can, arbitrarily set a=100 and determine the SG for any value of w. For instance when w=50, SG=2, when w=75, SG=4, when w=80, SG=5.

Thus, with the help of an IBM computer all the arithmetic was done for me and the computer even drew the scale shown in Fig.4 It doesn't matter how large or small the stone is that you might wish to measure. It also doesn't matter how long or short the scale is.

The next problem was to decide how sensitive the balance needed o b. The sensitivity determines directly the size of the smallest stone you can measure. First, let's look at Fig.5 It shows the maximum spread of results you can get if you have an error of only 0.01 carat in each of your weighings. As you see the resulting error increases tremendously as the sample gets smaller. With such a balance you could expect good results with a 5ct. stone and could probably get pretty good results on a 1ct. stone by taking the average value of 3 measurements.

But some investigators don't even have 1ct. to identify. So the obvious answer was to make the balance as sensitive as possible.

The heart of any balance is the knife edge or fulcrum, i.e. the point where the beam pivots. You can easily prove it yourself by trying to balance a match stick in the side of a pencil and then on a knife edge. The keener the edge, the more sensitive the balance. The more sensitive the balance, the more delicate it is, the easier to break and the harder to use. At this point, I was ready to quit. You can't make a sensitive knife edge balance cheaply.

I couldn't use a knife edge but I could hang the balance and I did. Now the sensitivity depended on the material used as the support. The finest nylon sewing thread I could find was ideal. You might think it too fragile for this purpose, but I have found it perfect. The only time I have broken the thread is when I accidentally knocked the balance off a shelf. Even then, it was back in working condition in less than 3 minutes.

The sensitivity of this balance is about 0.002 carat which is 5 times as the one considered in Fig.5. Thus you can accurately determine the SG of a 1carat stone and even measure material down to 0.10 carat.

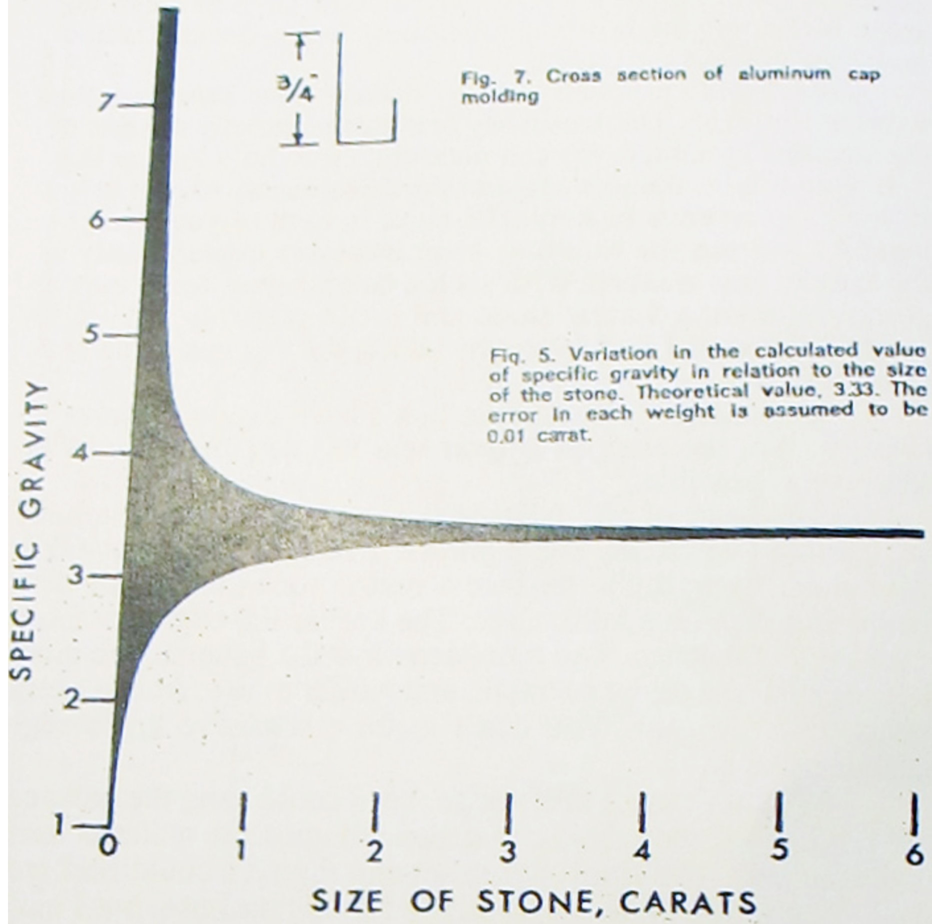


Fig. 7. Cross section of aluminum cap molding

Fig. 5. Variation in the calculated value of specific gravity in relation to the size of the stone. Theoretical value, 3.33. The error in each weight is assumed to be 0.01 carat.

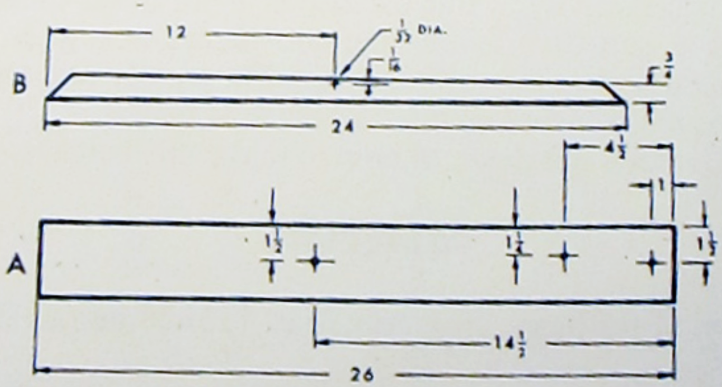


Fig. 6

W

Materials

-Wood for base approximately 1 x 3 x 26 inches (see Fig. A)

-Aluminum cap molding for beam: 3.4 x 24 inches with a cross sectional shaped like that shown in Fig7. This material is available at many hardware stores and lumber yards. It is used for applications like attaching Masonite to walls

-Rods for supports: (1/8" aluminum welding rod can be substituted for the brass rods)

-3/32" x 7 ½ " brass welding rod

-3/32" x 8 ½" brass welding rod

-3/32" x 7" brass welding rod

-Rod for counterweight holder-3/32" x 12" brass welding rod

-Soft wire for weight holder-24-28 gauge x 6"; 28 gauge x 12"

-Stainless Steel wire for pan holder: 28 gauge x 12"

-Rod and wire for counterweights- 2.5" long various diameters

-Aluminum foil for weight holder pan: 1" x 1"

-Aluminum for balance pans: .004" x 1.5" x 1.5" (2 pieces). This material can be obtained from the side of a soda or beer can.

-Nylon thread for fulcrum, 12"

-3" x 5" file card for zero scale

-Wire for beam leveling counterweight, approximately 1/32" x 3".

-Needle or hat pin for pointer

-Varnish, glue

Construction

A. Cut wooden base (Fig 6A) to size, sand and varnish.
B. In the base, drill holes the size of the support rods. Do not drill completely through the wood. See fig 6A for the placement.
C. Drill a small hole (approximately 1/32" diameter) in the top center of the bam as shown in Fig 6B
D. Copy the scale (Fig4) at a copy center (or on your personal comp) and enlarge it 1.45 times. This will bring it back to about 10" length so as to fit the length of the beam. Alternately, you can rejoin the two pieces of the split full size scale.

   Apply varnish to the right arm of the beam and place the scale on the wet varnish making sure that the 0 point of the scale is centered over the 1/32-inch hole in the center of the beam.

   Smooth out the scale and brush varnish on top of it. Cement the pointer in place on the right end of the beam (Fig 2C)

The numerals in parentheses in the paragraphs below refer to parts shown in Fig 8. Also refer to Figure 1.

E. Take the 7 ½ " rod, smooth the ends, bend and notch as shown in Figs 9A and 2A to form the balance support (1) Insert this into the wooden base.
F. Take the beam (2) and with a needle punch a small hole at the 0 point on the weight scale. Make sure this hole is centered on the 0 line. Pass a piece of nylon thread used as the fulcrum (4) through the hole and tie a small loop. When suspended

from the notch in the balance support (1) the top of the beam (2) should hang approximately ½" from the support (see Fig 2A). Save the access thread.

G. Cut a small V-shaped notch at the 100 point of the weight scale. The accuracy of this notch will determine the accuracy of your scale. Keep the notch small, as it only has to fit the fine wire of the pans and weights (See Fig2C)
H. Accurately measure the distance from the fulcrum (4) to the notch and cut another notch (3) an equal distance to the left of the fulcrum for the balance pan (9) Also, see Fig 2B.
I. Bend the 8 ½ " rod as shown in Fig 9B to form the balance arm guide (5) and insert it into the base. Adjust the height so that when the balance arm(2) is horizontal, it is centered in the opening of the guide (5)
J. Take the 7" rod (Fig. 9C) smooth the ends and insert it into the base to act as the zero scale support (6)
K. From the file card, cut a piece measuring 4 x 1 ½ inches (Fig.9D). Draw a line across its center for the zero index. Bend, punch holes and slide the cardboard on the support (6). See figure 2C.
L. Take the 6" of soft wire and form the specific gravity weight holder (8) as shown in Figs. 9E and 2C.
M. Construct the balance pan holder (9) from the long piece of stainless steel wire as shown in Fig 9F. Cement the balance in place.
N. Make the specific gravity counterweight holder (10) from the 12-inch rod.
O. Fashion the specific gravity counterweights (11) from the 2 ½ " wires and rods as shown in Fig 9G.
P. Make the balance arm counter-weight (12) from the 3" wire as shown in Fig.9H.

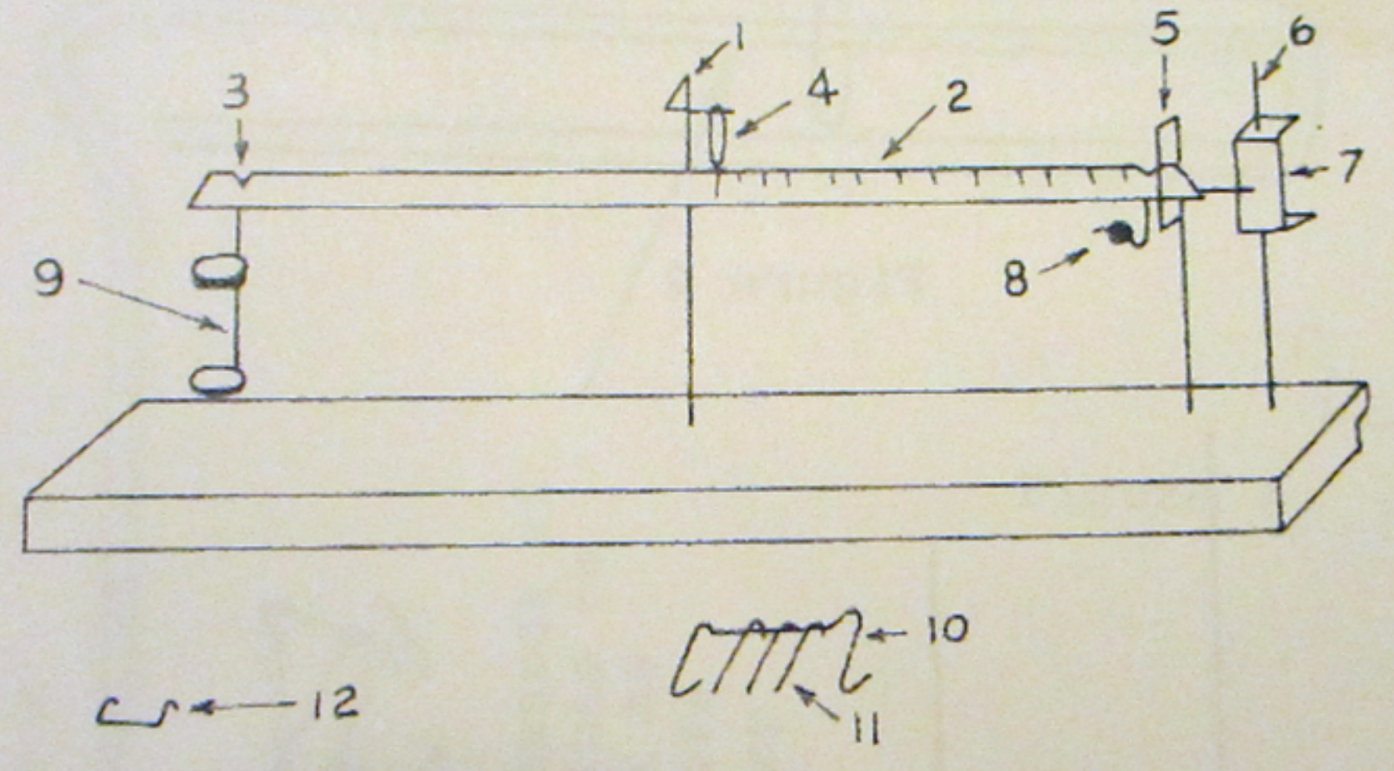


Fig. 8 Schematic diagram of Hanneman Balance

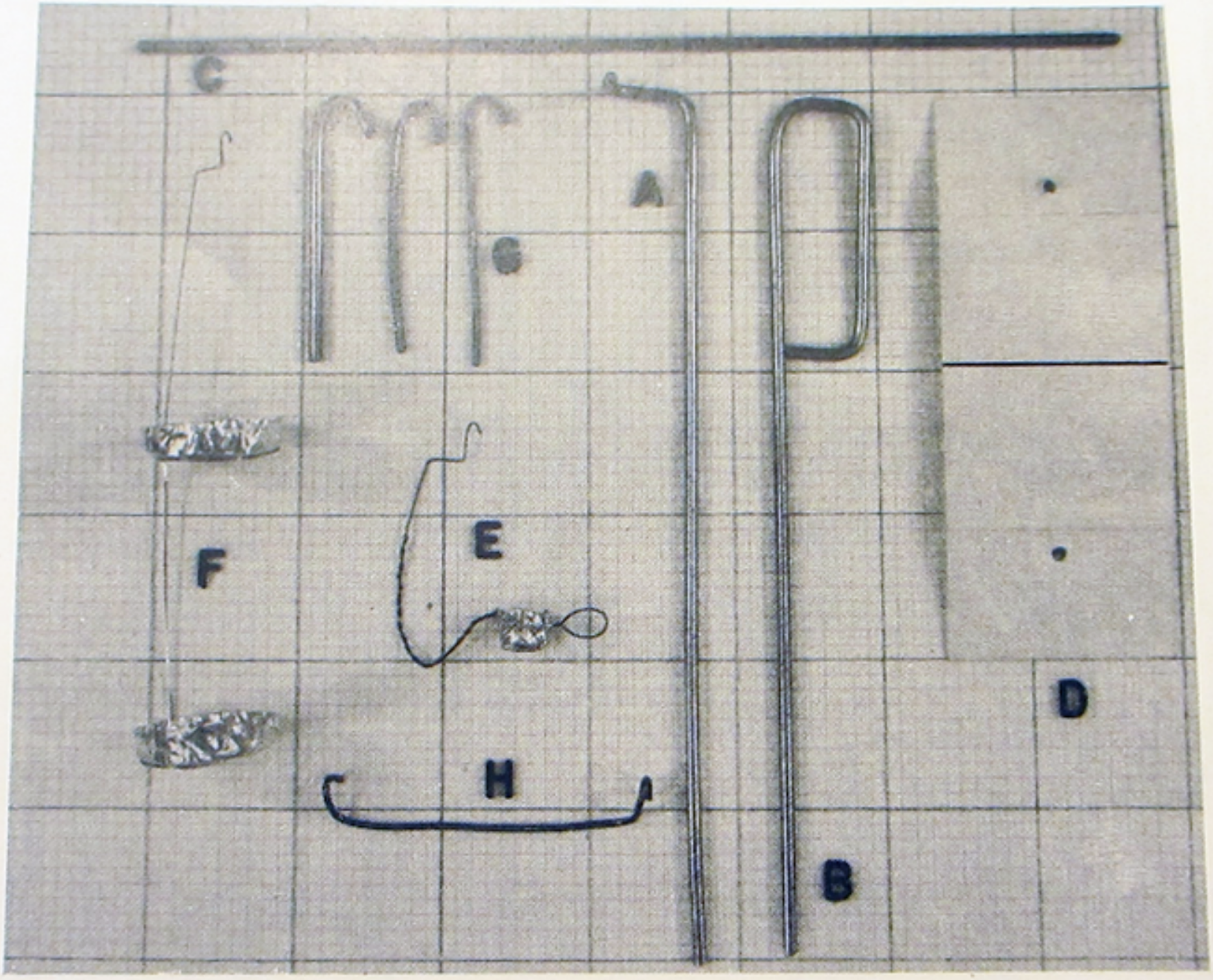


Fig. 9 Finished components. The heavier lines on the background mark off 1-inch squares.

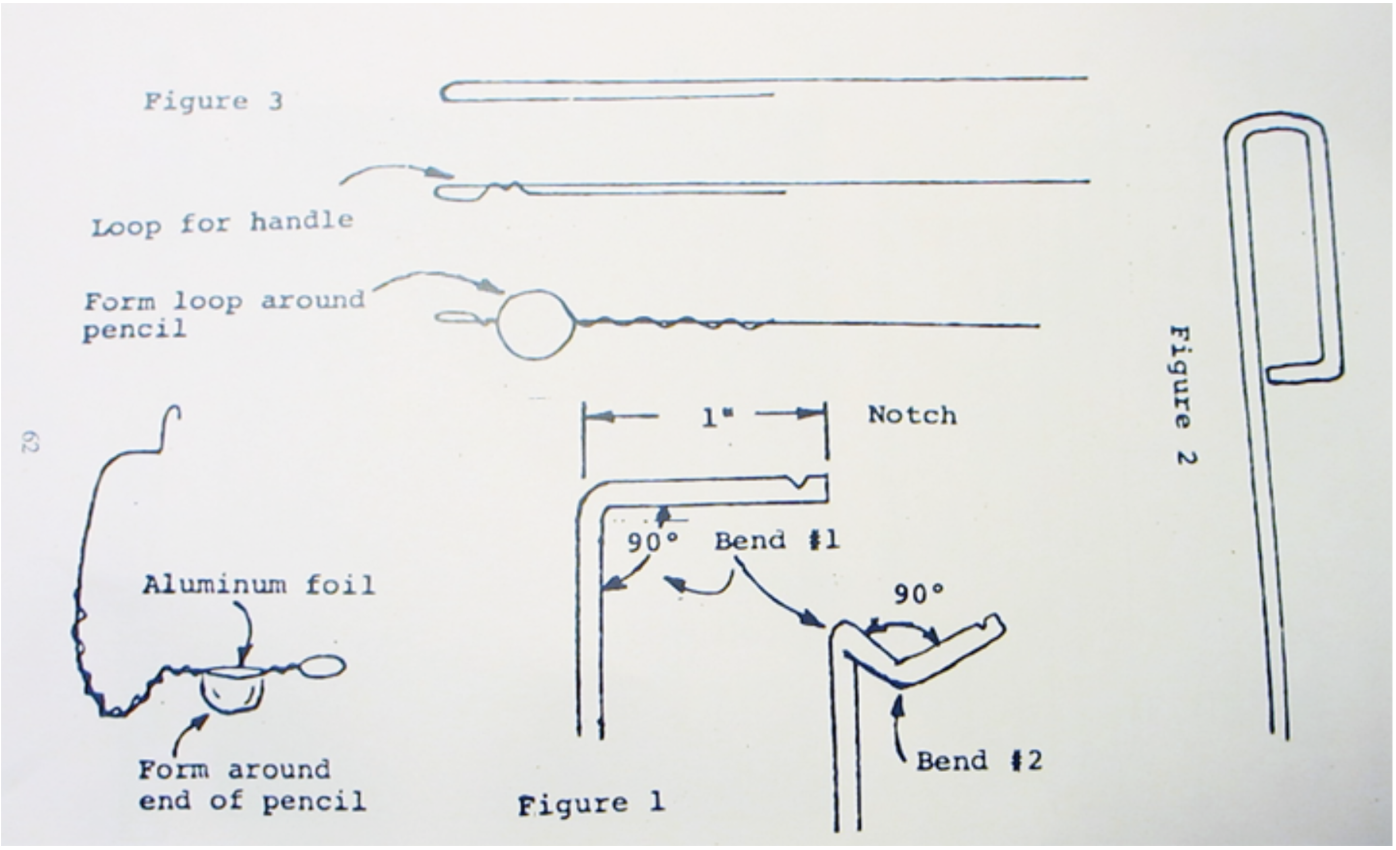


Figure 3
Loop for handle
Form loop around
pencil
62
1"
Notch
90°
Bend #1
90°
Aluminum foil
Form around
end of pencil
Bend #2
Figure 1
Figure 2

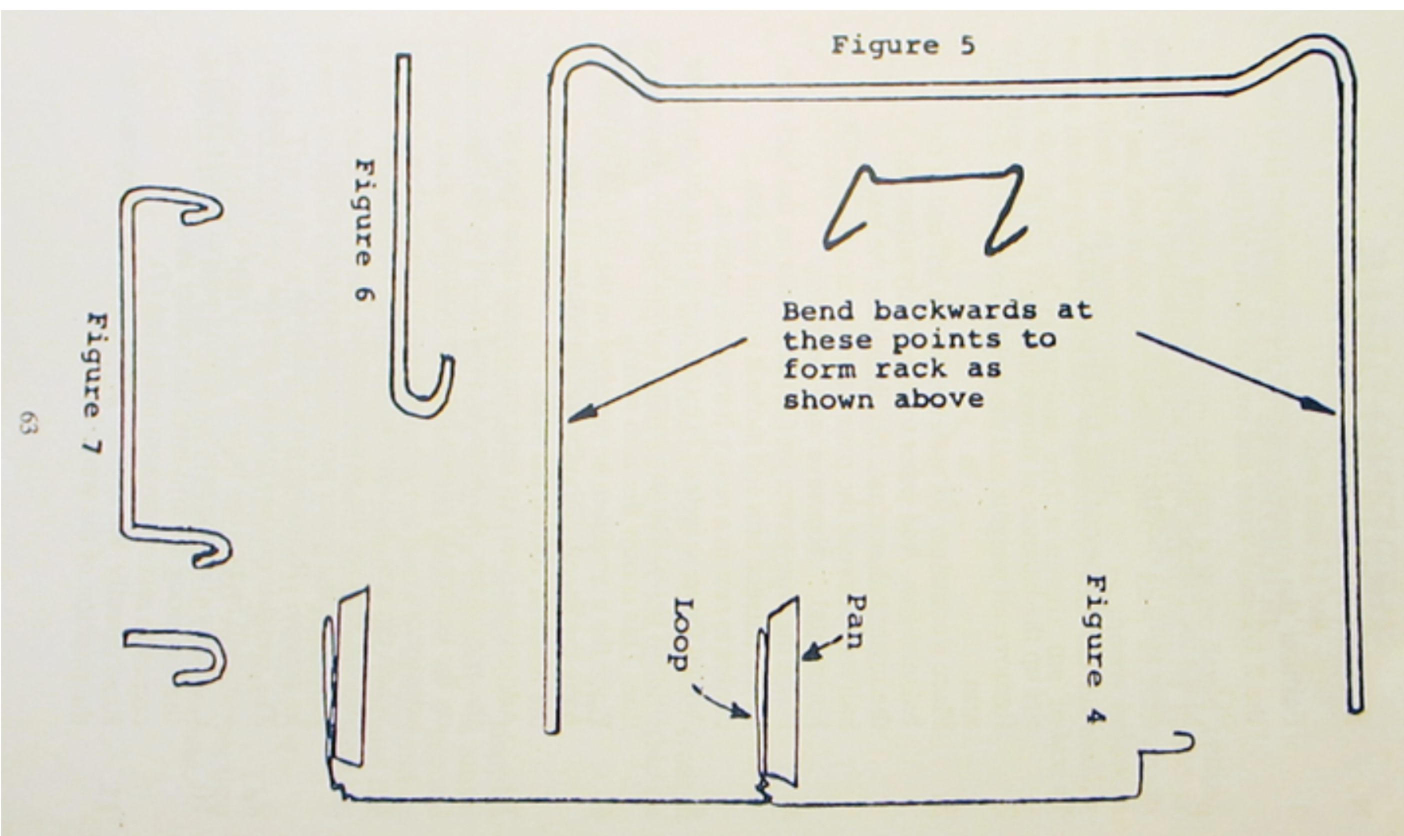


Figure 5
Figure 6
Figure 7
63
Bend backwards at
these points to
form rack as
shown above
Loop
Pan
Figure 4

Operating Instructions

1. Set up the balance as shown in Figures 1 an 8.
2. Remove all the weights and the weight holder from the right arm.
3. Place a container for water under the left end of the balance arm. Add water to completely submerge the lower balance pan (9) and then bring the level halfway between the pans when the arm is horizontal. **REMOVE ANY BUBBLES.**
4. Place the counterweight (12) in the slot on the backside of the balance arm and move it so that the arm comes to rest in a nearby horizontal position.
5. Adjust the zero index (7) by sliding it up or down on the support (6) so that the pointer coincides with the line. This is now the zero setting.
6. Place the material to be weighed on the top pan (9) and hang the specific gravity weight holder (8) from the notch at 100 on the scale.
7. Add counterweights until the pointer again lines up with the zero index. Addition of sand or salt to the cop on the holder (8) allows for very accurate adjustment.
8. When the arm is balanced once again (pointer at zero index) remove the stone from the top pan and place it in the lower pan (completely submerged in water). **REMOVE ANY BUBBLES.**
9. The weights of the right arm are now to heavy and the arm will rest on the bottom of the support (5).
10. Carefully slide the specific gravity weight holder (8) to the left along the arm until the pointer again comes to rest on the zero index line (7)
11. Read directly the Specific Gravity which corresponds to the position of the weight holder.