CHAPTER 1

SECTION II

MECHANICAL SCALES

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1.2.0 MECHANICAL SCALES, REPAIRS AND ADJUSTMENT

1.2.1 EVEN BALANCE SCALES

The most simple and yet the most accurate scale is the even arm scale with suspended pans, as illustrated by Figure 1.2.1. Very little explanation is needed. The pivot distances must be equal. A perfect parallel and gauge parallel of the pivots will insure a consistent accuracy and sensitivity. The pivot line should be neutral. The body mass of the lever is so distributed that there is slightly more weight below the pivot line than above, in order to create sufficient stability.

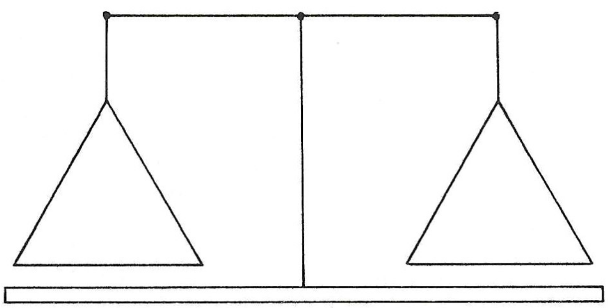

Figure 1.2.1. Even Arm Scale

Figure 1.2.2 illustrates the French "Beranger" System of an even arm scale. This scale has its platforms located above the lever system. It is widely used in Europe, but it is very rare in the United States. It is shown only because of its interesting system.

Figure 1.2.3 illustrates the "Roberval" system. This system is widely used in the United States. It uses parallelogram to stabilize the platters.

This scale is a simple even arm scale having two platters above the lever, with two vertical stems passing through the base of the scale. These stems are connected with one or two check rods to a central stud which is rigidly mounted to the base, exactly beneath the fulcrum.

On this type of scale, the distance A, B, C and D must be of equal length. Distances E, F and G must be equal length also. The bearings must be of the deep, sharp angles, sharp bottomed "V" type, in order to prevent creeping when the load is placed on points H, K, L or O.

The longer the distances E, F and G are, the better the scale, because the creeping

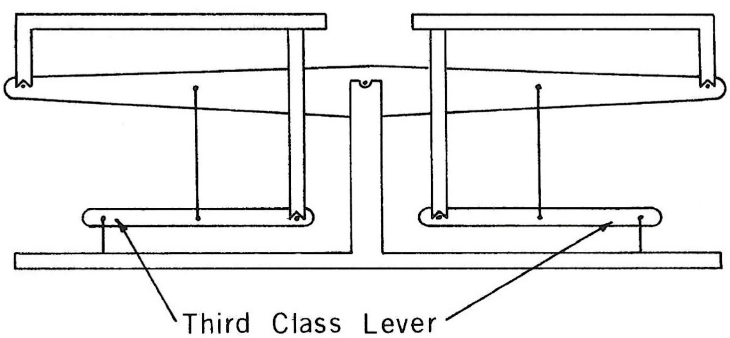

Figure 1.2.2. French "Beranger" System

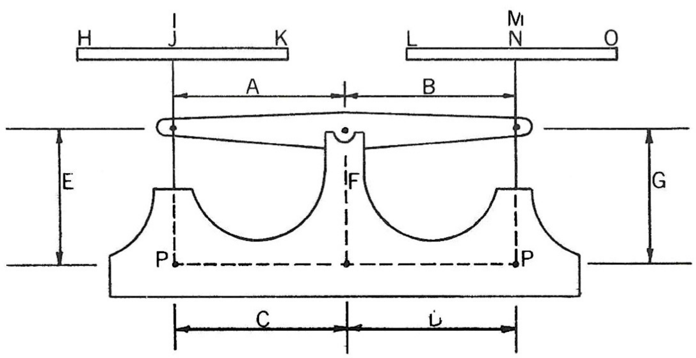

Figure 1.2.3. "Roberval" System

tendency of the bearings on the pivots decrease, as the length of the stems are increased.

The size of the platform also affects the performance. The smaller the platform the better the scale.

In other words, the sharper the degree of the angle between points N, O, P, the better the performance.

The one piece check rod of Figure 1.2.4 has a vertical slotted hole in the center, acting as a fulcrum point. It is slotted in order to eliminate any possible tension in the parallelogram.

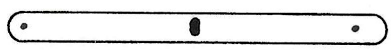

Figure 1.2.4. One Piece Check Rod

The two half check illustrated by Figure 1.2.5 have one pin in common on the central stud.

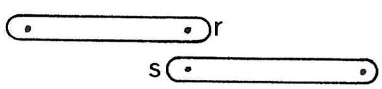

Figure 1.2.5. Two Half Check

When a one piece check rod is being installed, care must be taken to avoid any possibility of the fulcrum pin touching either the top or the bottom of the slotted hole.

The pins should fit snug in the checks, stems and stud. They should not be tight. A scale with loose pins cannot be constant. A tight fitting pin on the other hand, will create excessive friction. The pins should be made of hard steel.

The plate check of Figure 1.2.6 is better still, because the hard, knife like edges (shaded) of the check bear against the equally hard and smooth check plate and stem, with the resultant minimum friction.

If the scale is equipped with a fractional bar or tare bar, care should be taken to see that the bar runs parallel with the pivot line, in order to prevent any change in sensitivity as the poise is moved from zero to full capacity, or vice-versa. The purpose of such bars is to eliminate the necessity of using numerous small weights, or to balance off any, into which the material to be weighed is placed, in order to be able to get the net weight. Faulty bearings should be either replaced or lapped. The bearings should have a sharp clear cut bottom. Agate bearings should be glued in perfectly aligned. A mixture of litharge and glycerine will make a fine cement.

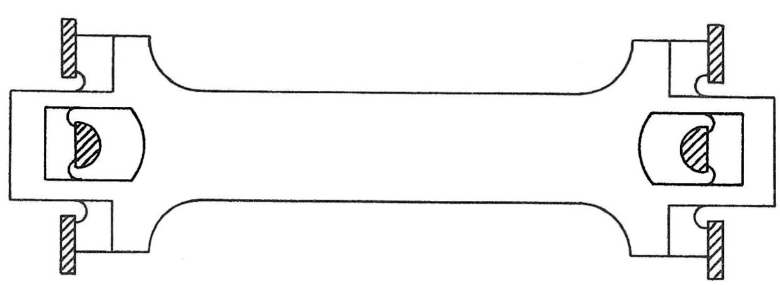

Figure 1.2.6. Plate Check

Another good cement is made of dextrine and water glass.

The pivots should be in an exact gage and in perfect parallel. The sides of the pivots must be straight. A shoulder on the pivot edge will make it impossible to adjust the scale.

Perhaps the easiest way to explain the adjustment of these scales is to refer to the position of the platform plates above or below the balance position, and for this reason the words "rise" and "sink" will be used in reference to the plates under discussion.

To convert the terms "rise" and "sink" to "plus" and "minus" the plate we are referring to must be considered.

If the plate that is being tested is the load plate, or in other words, it is the plate onto which the commodity to be weighed is placed, and sits, it is a plus (fast) error. On the scales equipped with an "Over and Under" indicator, the indication will be "Over".

The terms "over", "under", "plus", "minus", "fast", and "slow" are always used in reference to the load (L), which is the product to be weighed. The power (P) is the standard weight or poise used, and the plate on which it is placed is the power plate or weight plate.

If the load plate rises above the balance position the error will be minus, under, or slow.

Use the following procedure to adjust the scale.

Level scale. Place two equal sized weights on the scale, preferably not less than half of the scale's capacity. One on the center of plate HIJK (Figure 1.2.7) and the other on point M on the plate LMNO (Figure 1.2.8). If plate LMNO sinks, turn or hone the edge of the pivot toward the fulcrum pivot. If it rises, turn it away from the fulcrum pivot.

It is always best to turn the pivots when adjusting if the pivots have a round shank. Honing a pivot will result in a loss of range. Turning the pivot may also result in the loss of range if the pivot holes are not properly spaced. If the pivots edge is on the high position of the arc it describes when it is being turned, then when we make any adjustments by turning the pivot in either direction, its edge will be lowered, with the resultant loss of range and sensitivity.

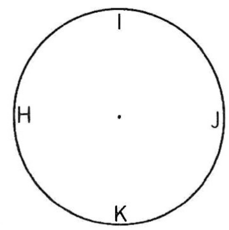

Figure 1.2.7. Plate HIJK

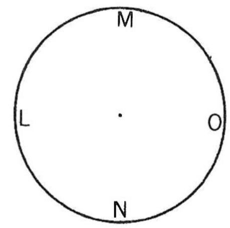

Figure 1.2.8. Plate LMNO

When position M has been corrected, move weight to the position N. Correct any possible errors in the same manner.

When M and N are correct, move weight to center of plate on Figure 1.2.8. Now, test and adjust points I and J on Figure 1.2.7 in the same manner.

With this accomplished, place weight on the center of the plate on Figure 1.2.7. Test L and O. If the weight is on L and the plate sinks, lengthen stem G of Figure 1.2.7. If it rises, shorten it.

Lack of symmetry in the parallelogram will cause an opposing but equal error on L and O. If L is plus, O will be minus. Consequently, when position L is corrected, the adjustment will also correct O. Should it happen that L is correct and O is still a little in error, it may be caused by too much play in the check rods. This may be corrected by using thicker pins. It may be also caused by the bearings. If the bottoms of the bearings are not sharp enough, it will be impossible to equalize L and O.

When points L, M, N, O are correct, move the weight to the center of the plate on Figure

1.2.8. Adjust points H and K in the same manner.

Perhaps a little rhyme will help to memorize the adjustments.

"On the fulcrum side the plate is low.
Lengthen stem to read zero."

Figures 1.2.9, 1.2.10, 1.2.11 and 1.2.12 may also help to show the cause of the error.

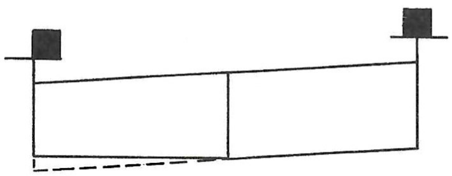

Figure 1.2.9. Cause of Error

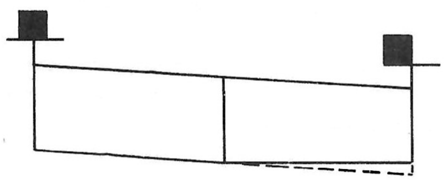

Figure 1.2.10. Cause of Error

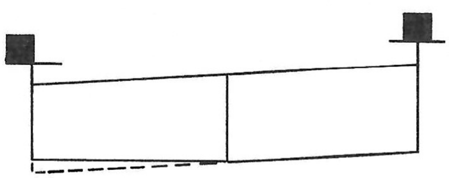

Figure 1.2.11. Cause of Error

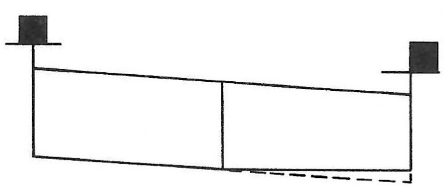

Figure 1.2.12. Cause of Error

On Figures 1.2.9 and 1.2.10, when the weights are placed at points nearest to the fulcrum pivot and the plate sinks, the error is caused by a short stem which reaches only to the solid line. This line represents the check and should be lengthened to reach the broken line.

On Figures 1.2.11 and 1.2.12, the weights are at points farthest from the fulcrum pivot. In this case, the plate sinks, indicating that the stem should be shortened to the point where the broken line cuts the stem.

Some of the inexpensive types of even arm scales do not have adjustable stems. In such cases, the stem can be lengthened by drawing it out with a hammer, or by deepening the bearings. If the stems are long, the central stud will have to be lengthened to match the stems. With quite a bit of extra work the stems can be made adjustable by drilling out the cast in the stem and replacing it with a threaded stem. In most cases it does not pay to overhaul these scales, because the price of the overhaul will equal that of a new scale.

The more up-to-date even arm scales are equipped with over and under indicators. Some of these indicators are mounted on torsion tapes. In this case, the sensitivity of the scale can be regulated by the thickness of the tapes. By increasing the tension of the torsion tapes the travel of the indicator will be decreased, or in other words the scale will be less sensitive, and vice-versa.

A heavy gauge torsion tape will decrease indicator travel. A light gauge tape will increase travel.

Some indicators are mounted on ball bearings and others on pin point bearings. The sensitivity of these scales in turn are sometimes regulated by horse shoe shaped spring tapes, or pendulums.

On scales equipped with horse shoe shaped springs the travel is adjusted by lengthening or shortening the active portion of the spring. The longer the active portion of the spring, the longer the travel and vice-versa.

The scale with pendulums is adjusted by raising or lowering the pendulums. Raise to increase travel, lower to decrease travel.

"Shadowgraphs" are simple even arm scales, as far as the scale structure goes. They are well made to do a fine job of weighing. The travel of the scale is optically magnified. The indicator is either an extremely thin wire mounted on one end of the even arm lever with a magnifying lens placed between it and a small electric bulb, or the magnifying lens itself has a barely perceptible, fine horizontal scratch on its surface. The shadow of the scratch or wire is then focused and projected with the aid of two projecting lenses onto a slanting mirror, which in turn reflects the light of the lamp and the shadow of the indicator on a graduated ground glass screen.

The adjustment of the scale proper, is exactly the same as has already been described. The clearness of the indicator image is dependent on proper focusing and the cleanliness of the lenses, mirror, and the ground glass screen.

The disadvantage of this type of scale is its dependency on electricity.

The great advantage, which overshadows the disadvantage is the fact that while using a mechanical indicator, an undesirable and unavoidable friction is being introduced; whereas with optical magnification of the scale travel, no friction whatsoever is added to the unavoidable friction of the scale structures.

With a notched fractional bar the hanging poise influences the sensitivity of the scale. The weight of the poise is applied to the bottom of the notch. If the bottoms of the notches are below the pivot line, the weight of the poise will cause a loss of sensitivity. If the bottoms of the notches are above the pivot line, it will increase the sensitivity, or in extreme cases cause the scale to be indifferent and beyond that, unstable. In both cases, any increase or decrease in the weight of the poise will also cause a change in sensitivity. If the notches are in line with the "pivot line", the weight of the poise or any changes in the weight of the poise will not effect sensitivity.

The length of the poise suspending loop has no effect on the sensitivity. Its length may be increased or decreased at will, as long as the total weight of the poise and loop is not changed.

On a suspended poise, the weight of the poise may be increased or decreased by adding or removing to or from either the top or the bottom of the poise without changing the sensitivity of the scale, outside of the above mentioned effects caused by the position of the bar.

The sliding poise of a fractional bar will also affect the sensitivity of the scale in the same manner as the suspended poise, as far as the positioning of the bar is concerned.

If the weight of the poise is increased by adding to the top of the poise, and the top of the poise is above the pivot line, the sensitivity of the scale will increase. The sensitivity will decrease if the addition is made to the bottom of the poise and the bottom is below the pivot line.

The opposite effect will take place if we decrease the weight of the poise.

Care should be taken to see that the notches of the bar form a clear cut angle without an abrupt and deep cut. A cut in the bottom of the notches will not permit the poise to swing freely, thus producing a semi-rigid pendulum effect with the resultant loss of sensitivity. That portion of the poise suspending loop, which rests in the bottom of the notches, must be sharp for the same reason.

1.2.2 DAMPERS (DASHPOTS)

There are various types of dampers being used in various types and makes of scales.

The most frequently used damper is the oil or kerosene dashpot. A great variety of valve systems are used to regulate the flow of oil or kerosene as the plunger sinks or rises in the pot. This in turn regulates the resistance to the movement of the scale, or in other words, regulates the number of oscillations proceeding equillibrium (balance).

The plunger should be properly adjusted for clearance in the dashpot at 1/4 and 3/4 position of the total travel. As most plungers are suspended on levers and because the point of suspension describes an arc, the plunger will not be centered at all positions of its travel range. The maximum approach toward the dashpot will be at the top, the bottom and the center of the plunger stroke. By centering the plunger at the 1/4 and 3/4 position of the stroke, the top and center positions of the plunger are equalized and the approach to the dashpot wall minimized. It is best to suspend the plunger at a point farthest away from the fulcrum point, because the longer the arm is, the shorter the back and forth movement of the plunger will be on the same degree of travel. On the other hand, the effects of friction will be more pronounced on the longer arm.

For dashpot fluid and adjustment it is always best to follow the manufacturers recommendations. These normally are as follows:

To adjust the dashpot, use the following procedure. Grasp the knurled dashpot stem top (Figure 1.2.13) and adjust in the following manner:

a. Turn clockwise to increase the damping action.

b. Turn counterclockwise to decrease the damping action.

MAINTENANCE

a. The dashpot cup should be periodically checked for foreign matter.

b. Also the 3/4 full oil level should be maintained to insure proper damping operation.

c. Under extreme usage and dusty conditions the dashpot should be checked and oil changed more frequently.

The second most widely used damper is the one used in suspended spring dial scales. This damper has a snug fitting graphite piston moving in a highly polished cylinder. The closed end of the cylinder has an air valve. By regulating the flow of air through this valve, the number of oscillations can be increased or decreased.

This is an ideal damper for suspended scales. On these scales the spillage of fluid due to the swing of the scale would cause a serious problem.

On the other hand these dampers are practically useless in a moist or dusty atmosphere or in an atmosphere saturated with chemical fumes. Moisture will swell the plunger. Chemical fumes will corrode the cylinder.

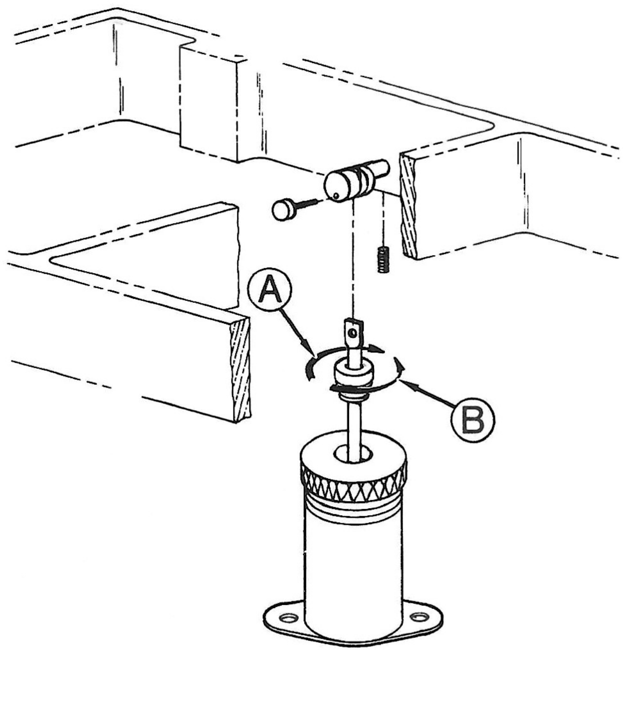

Figure 1.2.13. Dashpot Hookup

Another more or less successfully used damper is a circular tube with mercury enclosed. The bottom section of this tubular ring has a partition inside, with a small hole. Through this hole the mercury flows back and forth as the indicator swings. The speed of the flow regulates the oscillation of the scale.

A very successfully used damper is the one used on some smaller scales built for industrial purposes, built mostly of non-ferrous metals. It is the magnetic damper.

At the tip of the beam we find a strip of aluminum or the other non-ferrous metal moving in the magnetic field of a permanent magnet. This type of damper eliminates friction which is unavoidable in the other types.

Some counting scales are equipped with a magnetic dampener which speeds the counting operation by reducing the number of indicator oscillations. The principle of operation is as follows:

Magnet 1, Figure 1.2.14, and pole plate 2 create a magnetic field. Dampening fin 3 on terminal lever 4 is made of aluminum, a nonmagnetic material. (The fin must be non-magnetic or the magnet would attract the fin causing the pivots of the terminal lever to pull out of their bearings.) When the fin is in motion in the magnetic field, small currents are created within the aluminum fin as a result of the fin breaking the field. As the fin rises through the magnetic field, the small currents in the fin rotate in a direction which offers resistance to the direction of movement. Once the fin reaches its maximum upward position and changes its direction of travel, the small current circulating within the fin also changes direction, thus providing resistance to the downward movement of the fin. This negative correlation between the flow of currents and movement of the fin continues until the terminal lever comes to rest. Once the lever is at rest there is no current circulating in the fin as the currents are only set up by the fin in motion in the magnetic field.

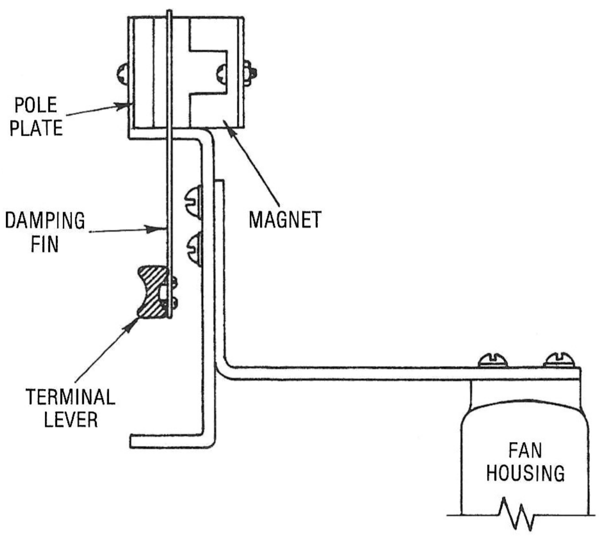

Figure 1.2.14. Magnetic Dampener

1.2.3 STEELYARDS

The next step in the evolution of the scale industry, following the simple suspended pan even arm scale, is the "Steelyard".

It is an improvement, in as much, as it is not necessary to use equal amount of weights to weigh a load as in the case of the even arm scale. The process of weighing with this type of scale is faster, and requires less labor.

The steelyard is a first class multiplying lever with a graduated power arm. It may have notches on the top side of the power arm which represents various weights, with a suspended poise acting as power, or it may have a smooth top with a sliding poise for power.

There are many variations in the types of steelyard - variations in the manner of their construction. Basically, they are the same. There is one type however, that may need explanation. It is illustrated by Figure 1.2.15.

The graduations on this type of steelyard do not begin with zero, and the poise is removed from the beam when it is balanced.

This type is generally used to weigh bales. It has no load pan. A hook is used to suspend the load. The weight of the hook is insufficient to counter balance the weight of the power arm and the poise.

To be able to counterbalance the weight of the poise, a very bulky butt end would be necessary. To eliminate this necessity, the fp is placed exactly where the zero position of the poise should be. Were it possible to hang the poise at this point, its power would be nill. It would not affect the balance. The first graduation of such a scale is a fraction of the capacity of the poise run. On the beam of Figure 1.2.15 the first graduation represents 10 lbs. and the distance between this point and fp equals the length of the load arm. If the capacity of the poise run is 100 lbs., then the distance between the 10 lb. graduation and the fp would be one tenth of the distance between the fp and the 100 lb. graduation. The weight of the poise would have to be 10 lbs. This scale cannot be used to weigh loads less than 10 lbs.

1.2.4 THE PORTABLE BEAM SCALE

The portable beam scale theoretically has five levers coupled in parallel and series. The beam "A" of Figure 1.2.16 is a first class lever. It has two multiples. One is the unchanging multiple of the power pivot and the other is the variable multiple of the poise run. It is connected in series to the nose iron (pp) of the long lever "B". The lever "B" is a solid triangular casting, with an extending

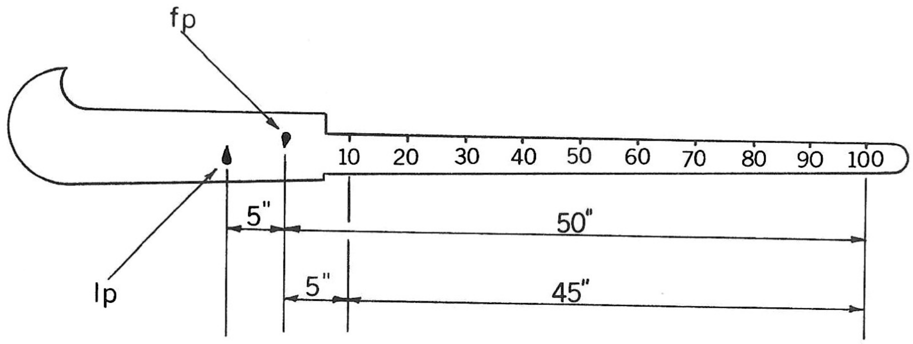

Figure 1.2.15. "Steelyard" Construction

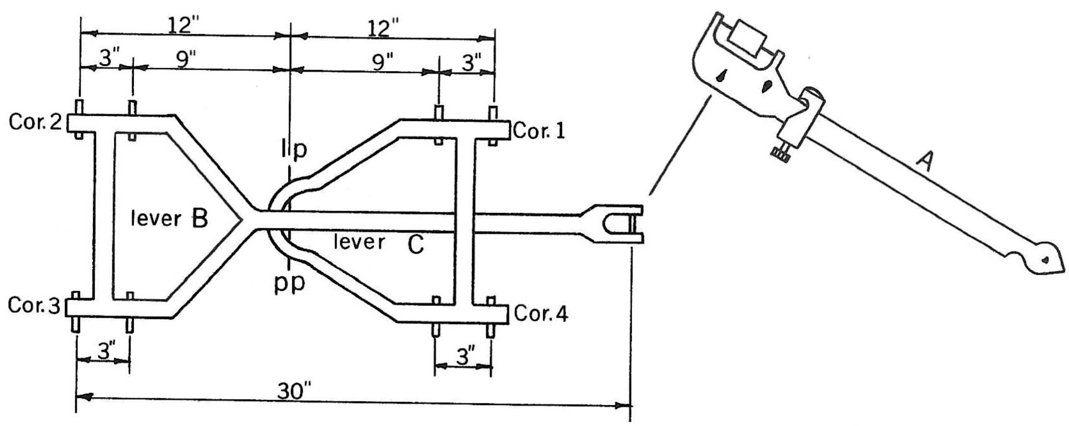

Figure 1.2.16. Portable Beam Scale

power arm. This lever is made up of two parallel levers cast into one solid unit. It has three load pivots. Two parallel load pivots to receive the load that is played on the platform and one load pivot to receive the power pressure of the lever "C". Lever "C" is also a combination of two parallel levers cast into one solid unit.

Lever "C" has a multiple of 4 and is coupled in series to the central load pivot of lever "B". Lever "B" at this point has a multiple of 2.5. Four times two and a half equals 10, which is the total multiple of lever "C" at the nose iron of lever "B". The multiple of lever "B" at corners 2 and 3 is 10. As a result the multiple of the lever system that supports the platform is 10 at all four corners. Any load placed on any point of the platform will be reduced to one tenth of its weight at the power pivot (nose iron) of the lever "B". Now if the beam has a multiple of 10, then the total multiple of the scale will be 100.

1.2.5 REPAIRING A PORTABLE BEAM SCALE

Dismantle scale completely. Clean and paint all parts. Buff the beam and sharpen the