CHAPTER 1

SECTION I

MECHANICAL SCALES

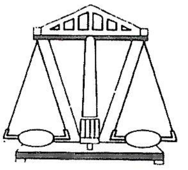

TABLE OF CONTENTS

CHAPTER 1

SECTION 1

MECHANICAL SCALES

PAGE

CHAPTER 1 - SECTION I
MECHANICAL SCALES

1.0 PRINCIPLES OF MECHANICAL WEIGHING

1.1 INTRODUCTION

An object is placed on a scale, and the weight of this object is read on an indicator. What has happened? What is the weight? Exactly what is this scale? These are some of the basic questions which must be answered if we are to fully understand the scale.

Weight can be defined as the force which an object or body is attracted toward the center of the earth. This force is gravity. Science tells us that the force exerted by gravity upon any body is proportional to the mass of that body. The mass of any body is merely the quantity of matter comprising it. The weight of an object is, then, no more than the measure of the force of gravity acting upon that object.

The scale is defined as a device for weighing, comparing, and determining weight or masses. Based on our definition of weight, we can then say that a scale is an instrument for measuring the force of gravity. What has happened in the scale to give us this measurement? The body or unknown force was balanced against a known body or counterforce to produce the indication. This does not apply to spring scales. On a spring scale the body is not balanced against another equal body, but against the force of a spring. Therefore, using the same spring scale in different localities will indicate a difference in weight for the same body. The only reason that the spring scale is acceptable as a weighing device, is that it is usually used in the same locality, and is calibrated to the G force of that locality.

The actual weighing on a mechanical scale is accomplished through a series of levers which divides and transmits the force of the object to a lesser, known counterforce in the dial. This tells us briefly what has happened but not how. If we are to understand how, then it is necessary to understand the principles of leverage.

1.2 PRINCIPLES OF LEVERS

1.3 THE LEVER

The lever is a simple tool that enables a person to exert a much greater force than the power applied, or vice versa. According to their application, levers are classified as first, second, and third class.

The seesaw at the playground, a pair of scissors, a pair of pliers, the crowbar, and the claw hammer are first class levers.

The wheelbarrow, the nutcracker, and once more the crowbar applied in a different manner, are second class levers.

While the purpose of the first and the second class levers is to decrease the amount of power needed to lift a certain load, the third class lever requires a power that is greater than the load to lift same. It is the least frequently used lever of the three.

When a father takes his son to a seesaw at the playground, and there is a playmate of equal weight, the boys will be using a first class, even arm lever while having their ups and downs.

If his son finds no playmate of equal weight, the father may sit on the seesaw with him and not realize that he is applying the principles of scale construction to amuse his son. Unwittingly he has put to use a multiplying, first class lever. The son, representing "power" requires a longer span or arm, (in the future the term "arm" will be used.) to lift the father, who represents the "load" on a shorter arm.

If we leave the father and son in the same position, but change the terminology by saying that the father is the "power" on a short "power arm", and the son is the load on a long "load arm", then the same lever becomes a first class, dividing or reducing lever, producing the same effect as a third class lever, which we shall discuss later.

A first class, reducing lever is never used singly as a scale. It would be highly impractical to use a two pound weight to weigh one pound of sugar. It becomes practical when the total multiple of a lever train in the understructure of a scale has to be reduced. This may be necessary in order to meet a lower multiple requirement of a new indicating element, which is intended to replace the original.

The ratio of an even arm lever is 1:1. The ratio of a multiplying lever is always greater than one. For example, a multiplying lever can be 1.5:1, or 20:1. The first number of the ratio is always greater than 1. With a reducing lever the first number is always less than 1. For example: .25:1, .5:1, or .75:1.

This fact proves the first class lever to be most versatile. It can be used as even, multiplying, or reducing lever.

Figure 1.1 illustrates a crowbar used as a first class even lever. The power pressure has to equal the load pressure.

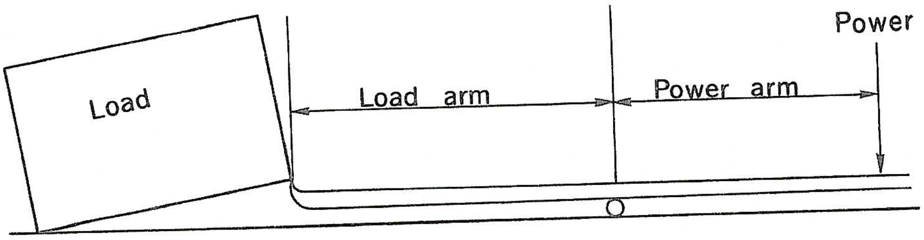

Figure 1.1. First Class Even Lever

Figure 1.2 illustrates a crowbar used as a first class multiplying lever. In this case considerably less power is needed to lift the load.

Figure 1.3 illustrates a crowbar being used as a first class reducing lever. The box at the end of a long load arm requires a heavier pressure (power) on the shorter power arm to lift it.

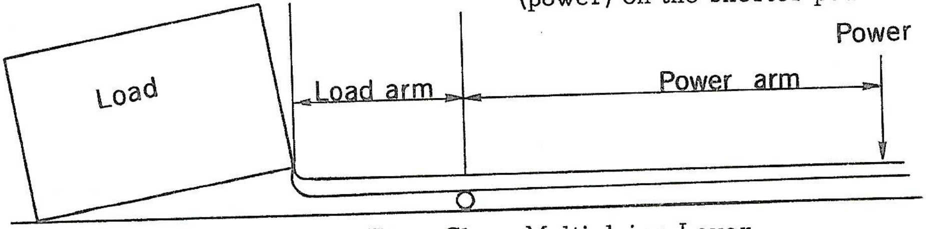

Figure 1.2. First Class Multiplying Lever

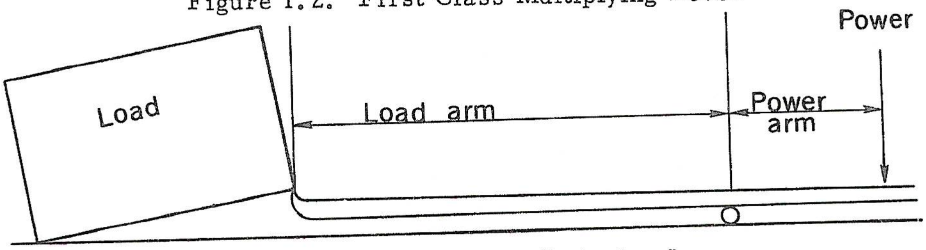

Figure 1.3. First Class Reducing Lever

A second class lever is always a multiplying lever. Figures 1.4 and 1.5 illustrate second class levers. Figure 1.4 has a shorter load arm than Figure 1.5 and as a result, requires less power to lift the load.

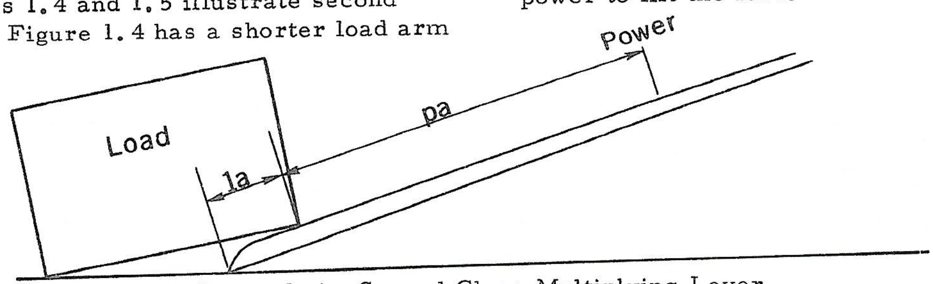

Figure 1.4. Second Class Multiplying Lever

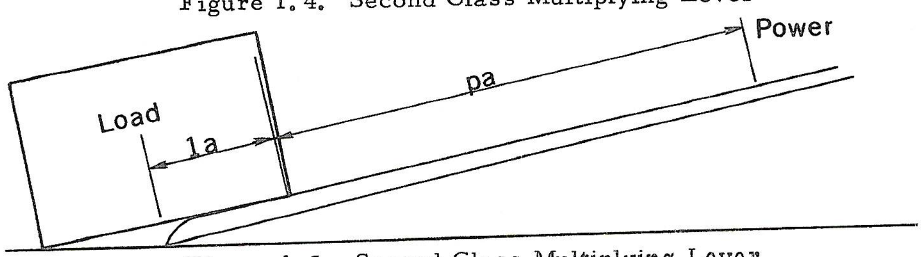

Figure 1.5. Second Class Multiplying Lever

In both cases when the power arm is lengthened, the power that is necessary to lift the load will be decreased, and when the load arm is lengthened, the power will have to be increased.

The action of the third class lever can best be explained by Figure 1.6. A steel bar is held at its center in one hand, with one end stuck under a work bench. A 10 lb. weight is hung on the other end. This weight will exert a 20 lb. pressure on the hand.

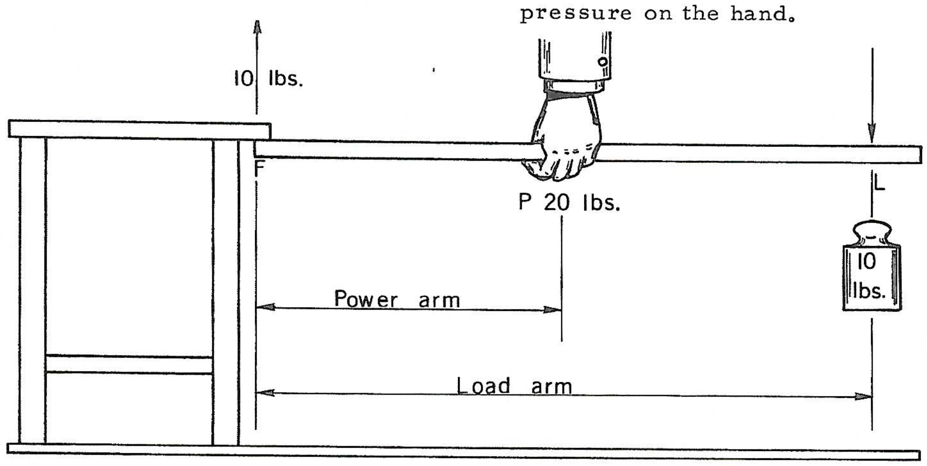

Figure 1.6. Third Class Lever

The weight of the bar is an ever present load and can be ignored in this case. It may be called a dead load. If the bar was a part of a lever train in a scale, its weight would be counterbalanced by a balancing arrangement on the indicating element. The ten pound weight hung on the load end of the bar in Figure 1.6 creates a downward thrust of 10 lbs and at the same time creates a 10 lb. upward thrust at the other end of the bar. The sum of the upward and downward pressures creates a 20 lb. pressure on the hand. Thus in this case, the power necessary to lift the load has to be doubled.

The action of this lever becomes third class only if point "F" is anchored and becomes the fulcrum point, and the power point "P" is suspended on the load pivot of another lever.

1.4. SENSITIVITY

Sensitivity is the term used to describe the amount of structural displacement caused by the addition of any weight to any portion of a balanced structure, and depends on the distribution of mass above and below the fulcrum.

Applying this to scales, sensitivity is the amount of beam travel from balance position to the new point of equilibrium, when a certain unit of weight is placed on the platform. It should not be confused with "Sensitivity Requirement".

"Sensitivity Requirement", or its abbreviated form "SR", is a term used when determining the amount of weight necessary to move the weighing beam from the center to the top or bottom of its travel limits.

Returning now to the lever, which is the most important component of a scale, it will be found that the ratio, center of gravity, mass, and weight, have an important role in its construction.

It has already been established that levers have three or at least two pivots; a fulcrum, a load and a power pivot. The imaginary line that touches the edges of these pivots, is the pivot line.

1.5 POINTS OF PRESSURE

All levers have three points of pressure. The power point, the load point, and the fulcrum point. To receive the various applied pressures, pivots or shafts are fitted into the levers. From now on, these points will be referred to as pivots.

At the same time, all levers have two arms. A load and a power arm. The load arm is always the distance between the load and the fulcrum pivot. The power arm is always the distance between the power and the fulcrum pivot.

As a result, the basic construction of all three lever types is the same. In other words, any one lever could be used as a first, second, or third class lever. The factor that determines the class of a lever is its application.

As in Figure 1.3 a first class lever always has its fulcrum pivot between the load and the power pivots, and the power and load arms extend to the right and left of the fulcrum pivot. In Figure 1.4 the fulcrum pivot of a second class lever is at one end, and the load arm is always contained in the power arm. The fulcrum pivot of a third class lever, Figure 1.6, is also at one end, but in this case, it is the power arm that is contained in the load arm.

Memorizing the following key letters will prove to be helpful when calculating.

P = power
pp = power pivot
pa = power arm
L = load

lp = load pivot
la = load arm
F = fulcrum
fp = fulcrum pivot
M = multiple

Figures 1.7, 1.8, 1.9, 1.10 and 1.11 clearly illustrate the various positions of pivots and arms.

If the pivot edges of a lever are on an absolute straight line, as illustrated by Figure 1.12 and the mass of the lever is equally distributed above, below, right and left of the edge of the fulcrum pivot, then this lever will be neutral, supersensitive, and useless as a scale.

Should the body of the lever be slightly heavier below the fulcrum pivot, a pendulum effect will be created with a resultant stability. The lever in this case could be used as an equal arm scale. The heavier the mass below the fulcrum pivot, the less sensitive the lever will be.

Figure 1.13 illustrates a neutral lever with an indicator and a gravity ball attached to it. If a pan is hung on the load and power pivots, the lever becomes an equal arm scale. The purpose of the gravity ball (a) is to stabilize the otherwise neutral lever. The sensitivity of the lever can be adjusted by raising or lowering the gravity ball.

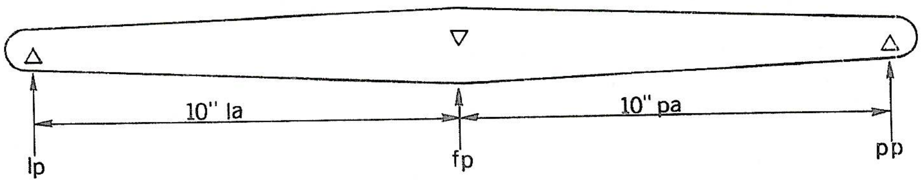

Figure 1.7. First Class Even Arm Lever. 1:1 Ratio

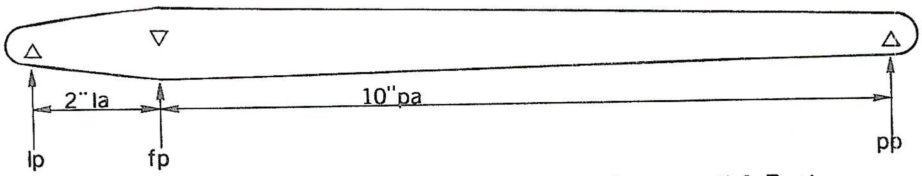

Figure 1.8. First Class Multiplying Lever. 5:1 Ratio

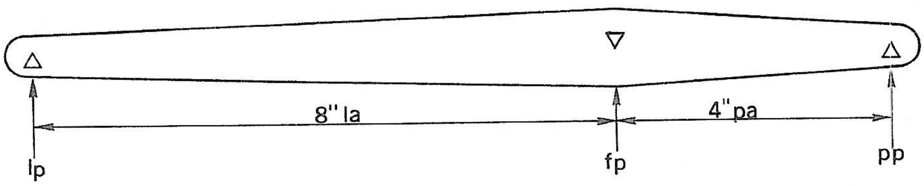

Figure 1.9. First Class Reducing Lever. 5:1 Ratio

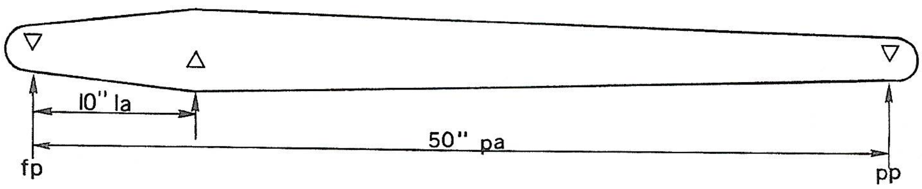

Figure 1.10. Second Class Lever. 5:1 Ratio

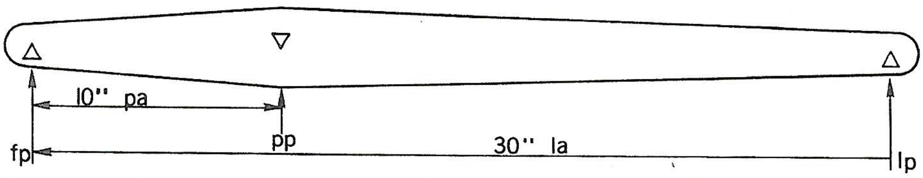

Figure 1.11. Third Class Lever. 333:1 Ratio

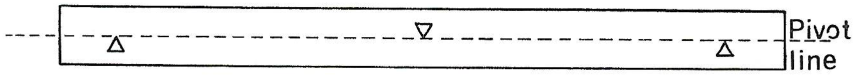

Figure 1.12. Even Arm Scale

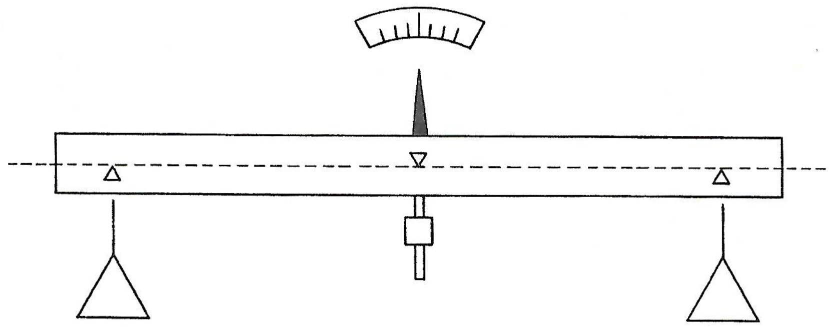

Figure 1.13. Neutral Lever

With the lever indicator pointing to the center line of the chart, a 1/4 ounce weight on the right hand pan will move the indicator to the right. For the purpose of illustration, it may be assumed that it will point to the second graduation. After the 1/4 ounce weight is removed, and a 10 pound weight is placed on each pan, the indicator will again point to the center line. If the lever is solid and does not deflect under the load, a 1/4 weight placed on the pan will again move the indicator to the second graduation. This indicates that the sensitivity of the lever is constant.

The reason for this is that the pivots are on a straight line, and any load added to the lever, through the medium of the pivot edges, will not affect the distribution of mass above or below the fulcrum pivot.

Should the edges of the load and power pivots be below the straight line, passing under the edge of the fulcrum pivot, as illustrated by Figure 1.14, the sensitivity of the scale will decrease as soon as pans are hung on the pivots. In the trade, this condition is described as the lever having an "open range".

The sensitivity of this lever can be increased by raising the gravity ball "a". With the aid of this ball, the sensitivity may be increased to the point of neutrality; or beyond that, to unstability. However, when a load is placed on the pans, the sensitivity will decrease. The bigger the load, the less sensitive the lever will be.

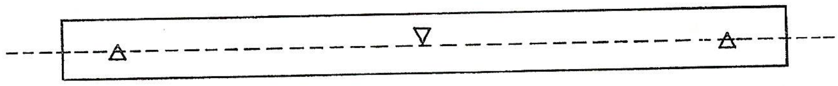

Figure 1.14. Open Range Lever

The reason for this lack of constancy is due to the fact that, by loading the pans, the mass of the lever body is actually being increased below the fulcrum pivot line, through the medium of the edges of the lp and the pp. It has already been established that by increasing mass of the lever body below the fulcrum pivot, its pendulum effect will also be increased. This in turn will mean that the lever will have to overcome a multiplying factor as it travels on an arc.

On the other hand, if the edges of the lp and the pp are higher than the edge of the fp, as illustrated by Figure 1.15, the opposite effect will take place. In the trade, this condition would be called a "closed range".

When pans are hung on such a lever, it will become unstable (top heavy). It is possible to stabilize such a lever by lowering a gravity ball, similar to "a" of Figure 1.14, below the pivot line. However, as the pans are being loaded, the increasing load will gradually overcome the stabilizing effect of the gravity ball through the medium of the high lp and pp edges; and as more weight is added, it will become first neutral, and finally unstable (top heavy).

To be able to construct a lever or weighbeam, with no deflection, it might be necessary to "over dimension" the body, making it very heavy and clumsy. The inertia of such a beam would be great. It would require more time to pick up momentum when a phase of oscillation has been completed, and the return swing is about to take place, than would a lighter beam.

To insure a reasonably uniform sensitivity, without over dimensioning a lever or beam, a slightly closed range is used.

In order to decrease the initial load of the lever system, to save material and also to minimize inertia, the levers are usually streamlined and made as light as possible. This, in turn, inevitably results in deflection.

If the deflection is not too great, and is not of a permanent nature, (that is to say it is a flexible deflection) then it can be compensated by a closed range in the pivot line. A permanent deflection will render a scale useless.

Deflection in any lever will decrease its sensitivity. If the lever is correctly proportioned, it will also change its ratio.

A correctly proportioned lever with a 10:1 ratio must have a similar deflection factor. In other words, if the load arm deflects .001 of an inch, then the power arm should deflect .010 of an inch to maintain the lever ratio. Metal compression is another factor that has to be considered; however, in commercial scales this is taken care of simultaneously with deflection so that it does not impose any additional problems.

The use of a closed range to compensate for deflection can be utilized only in scales with predetermined, one spot indication. These are the beam scales. It may also be used in scales equipped with balance indicators that have only a zero indication.

A closed or open range may not be utilized in scales with predetermined sensitivity. These are the scales with graduated charts - each graduation representing a certain weight value.

Using a neutral pivot line on a flexible lever would result in a gradual loss of sensitivity due to the increase in mass below the fulcrum pivot caused by the sinking of the load and power pivots.

Levers and beams are usually so constructed that the larger mass of the lever body is below the pivot line. This produces sufficient pendulum action to stabilize the scale. The closed range, on the other hand, has an opposing effect. It tends to make the scale unstable.

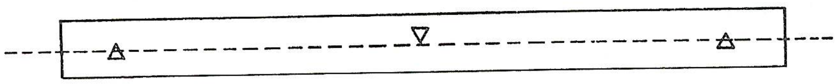

Figure 1.15. Closed Range Lever

The stabilizing effect of the lever body has to be greater than the unstabilizing effect of the closed range, when the scale is in an unloaded condition. As the scale is being loaded, a gradual deflection will take place, which will eventually eliminate the range. This stabilizing effect of the lever body must remain active until the load and power pivots sink to the level of the fulcrum pivot. Should the stabilizing effect of the lever mass be insufficient and become nullified, before the pivot line becomes neutral, the scale will become unstable at this point. A further increase in load will probably deflect the beam far enough to reestablish stability. Any further increase in load will result in a gradually increasing loss of sensitivity. There is no set formula to determine the amount of closed range necessary for satisfactory operation. It can be best established by trial.

1.6 SCALE DESIGN

There are three very important factors to be taken into consideration when a scale is being constructed, installed, or overhauled. These three factors are: Ratio or Multiple, Sensitivity, and Friction.

1.7 RATIO-MULTIPLE

The scale is one of the most ancient devices invented by man, but for many centuries the even arm (even balance) scale was the only type in existence. It had one central fulcrum pivot, two even arms, and two suspended pans, as illustrated in Figure 1.16.

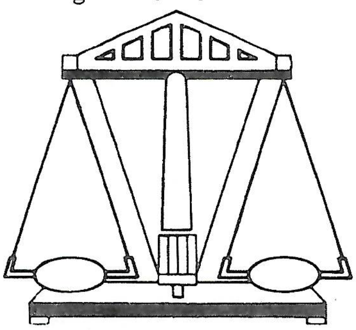

Figure 1.16. Even Arm Balance Scale

This is the most simple type of scale and admittedly, the most reliable one, even to this day. For precision weighing it is unequalled.

On the other hand, the even arm scale would be a very clumsy affair in this modern age. It would be time and labor consuming to attempt to weigh a ton of coal on an even arm scale.

To achieve more speed with less labor in weighing, a new type of scale was developed. This new approach has many variations. The simplest form is a single lever using a ratio. The more complex scales incorporate a system of levers coupled in parallel and series in order to counter balance very heavy loads with a much lighter counter load (power).

It is this relativity between the load and the power necessary to counter balance it, that is called the "Ratio" or "Multiple".

1.8 FIGURING LEVER MULTIPLES

By using one simple formula, the ratio of any class of lever can be determined.
The length of the power arm divided by the length of the load arm, equals the ratio or multiple.

$$\frac{pa}{la} = \text{Ratio or M}$$

Figure 1.7 illustrates a first class, equal (even) arm lever. It requires no calculation. The load and power arms are identical in length. The ratio is 1:1.

Figure 1.8 illustrates a first class multiplying lever. The "pa" is 10 inches, and the "la" is 2 inches long. The ratio is 5:1.

$$\frac{pa}{la} = \frac{10}{2} = 5$$

Figure 1.9 is a first class reducing lever. The load arm on this lever is 8 inches long and the power arm is 4 inches. The ratio is .5:1.

$$\frac{pa}{la} = \frac{4}{8} = .5$$

Figure 1.10 illustrates a second class lever. The load arm is 10 inches long, and the power arm is 50 inches. The ratio is 5:1.

$$\frac{pa}{la} = \frac{50}{10} = 5$$

Figure 1.11 is a third class lever. It has a power arm of 10 inches and a load arm of 30 inches. The ratio is .333:1.

$$\frac{pa}{la} = \frac{10}{30} = .333$$

Combination, or more commonly known as "Middle Extension Levers" are used in the understructure of four section, Motor Truck Scales. They act as even arm extension levers for the end sections, and as multiplying levers for the intermediate sections. The ratio of the even arm is 1:1, and the multiplying factor is 10:1. Figure 1.17 serves as an illustration.

To repeat, there are four factors to be considered. These four factors are the load arm (la), load (L), the power arm (pa), and the power (P) to lift the load.

Occasion may arise when three of the above mentioned factors are known, but one factor is missing. There is a simple formula to help find this missing factor. It should be kept in mind that the load arm always make a pair, and the same applies to the power and the power arm. The complete pairs are always placed above the dividing line and the single factor below. Following are the four variations of the formula.

$$\frac{P \times pa}{L \times ?} \quad \frac{P \times pa}{? \times la} \quad \frac{L \times la}{P \times ?} \quad \frac{L \times la}{? \times pa}$$

Assume that the lever illustrated by Figure 1.8 has a load arm of 2 inches and it is required that a 2 lb. power lift a 10 lb. load. The power arm necessary to do this is unknown. The L and the la form a pair and for this reason, they will be placed above the dividing line. The pa is missing. Consequently, P will have to be placed below. The positioning of the factors now indicate the procedure.

$$\frac{L \times la}{P} = \frac{L\ 10 \times la\ 2}{P\ 2} = 10, \text{ the missing pa.}$$

A second alternative, still using the dimensions of Figure 1.8, may have an unknown load arm. In this case the formula would be set up in the following way:

$$\frac{P\ 2 \times pa\ 10}{L\ 10} = 2, \text{ which is the la in inches.}$$

In the third alternative, the power may be the unknown factor. This would give us the following setup.

$$\frac{L\ 10 \times la\ 2}{pa\ 10} = 2, \text{ which is the power in pounds.}$$

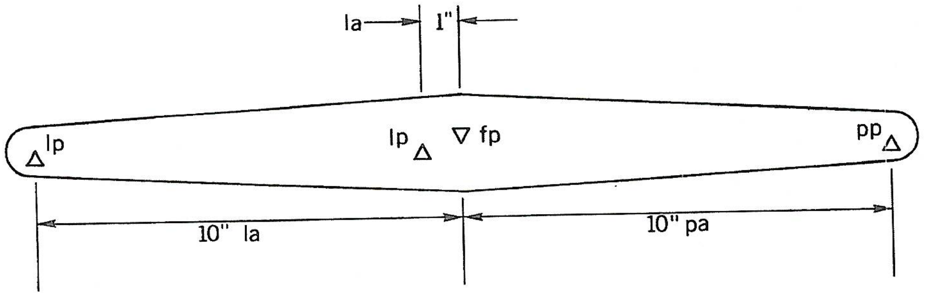

Figure 1.17. Middle Extension Lever

Assume now that the load is the unknown factor. Set up the formula and find out what it should be.

The formula as explained above, is applicable to all types of levers.

1.9 TOTAL MULTIPLE

The total multiple of a lever system is the final multiple of all the levers coupled in series.

Figure 1.18 shows three levers that are coupled in series. The lever "A" has a multiple of 10 and it is a second class lever. The multiple of lever "B" is 2 and it is also a second class lever. Lever "C" is a first class with a multiple of 10.

By multiplying the multiple of lever "A" with the multiple of lever "B", and then multiplying the result with the multiple of lever "C", will result in the total multiple of the lever system.

Ten multiplied by two equals twenty. Twenty multiplied by ten equals two hundred. The total multiple of the lever system is 200.

Figure 1.19 illustrates the effect of a first class reducing lever in a lever system (train).

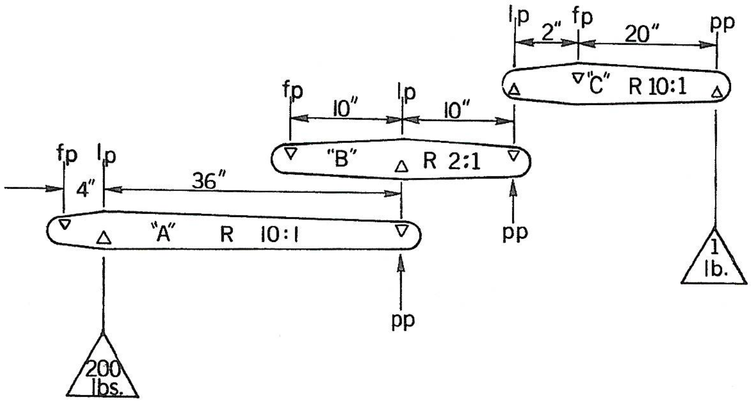

Figure 1.18. Multiple Lever System

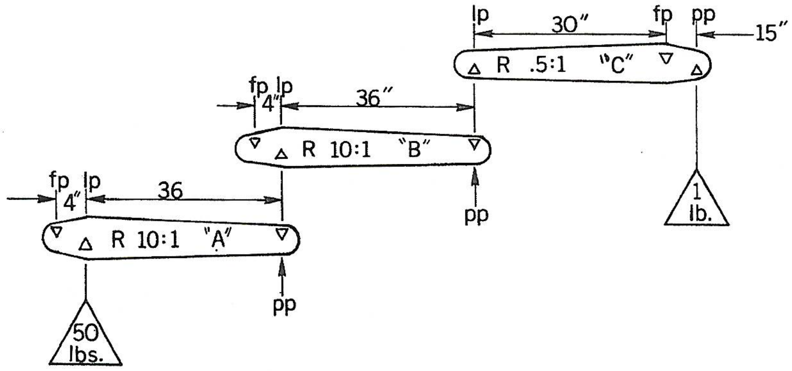

Figure 1.19. Multiple Lever System (Train)

Lever "A" is a 10:1 second class lever and is coupled in series to lever "B". Lever "B" is also a 10: 1 second class lever, and is in turn coupled in series to lever "C", which is a first class .5:1 reducing lever. The total multiple of this lever train (system) is 50.
10 x 10 = 100   100 x .5 = 50

This type of lever system is rare and used in conversions, to reduce an already existing multiple.

The lever system of Figure 1.20 includes a third class lever. A third class lever is always reducing in its effect.

Lever "A" is a 20:1 second class lever coupled in series to the third class .5:1 reducing lever "B". Lever "B" in turn is coupled to the 2:1 first class lever "C". The total multiple of this system is 20. 20 x .5 = 10
10 x 2 = 20. This type of lever system is also rare.

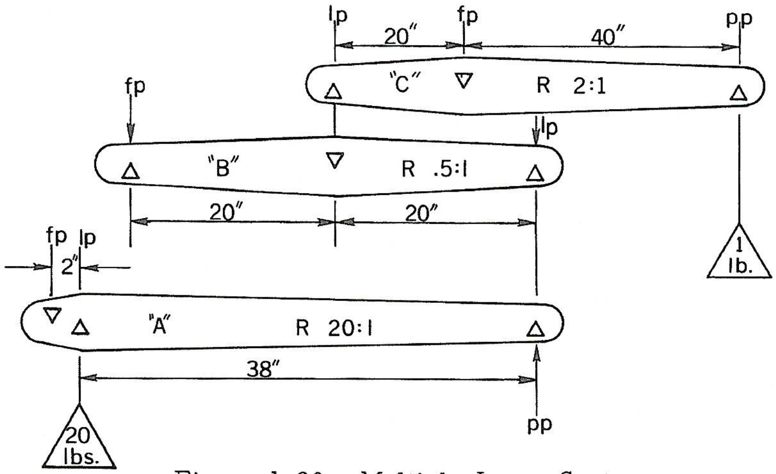

Figure 1.20. Multiple Lever System

1.10 LEVERS IN PARALLEL

In order to facilitate easy, unobstructed loading of the load receiving element (most frequently called the platform), ways and means had to be devised to support it. The most common system used on heavy duty scales has its platform above the levers. Depending on the size and capacity of the platform, it is supported on any number of points. Most commonly the number of points is 4, 8, 10, or 14. In order to accomplish this, levers had to be coupled in parallel and in series. Figures 1.21, 1.22 and 1.23 should be helpful in understanding the difference.

When examining the actions of levers, we must disregard the weight of the platform, the levers, and all other permanently installed parts, because they represent a constant dead load and are counterbalanced in some manner on the indicating element. This dead load is theoretically always the same. It is there when the scale is unloaded, and it is there when it is loaded. It is only theoretically constant because under actual working conditions the dead load of a scale varies due to wear, dirt accumulation, moisture absorption, evaporation, etc. In other words, the balance condition of a scale is subject to changes and should be occasionally checked and regulated.

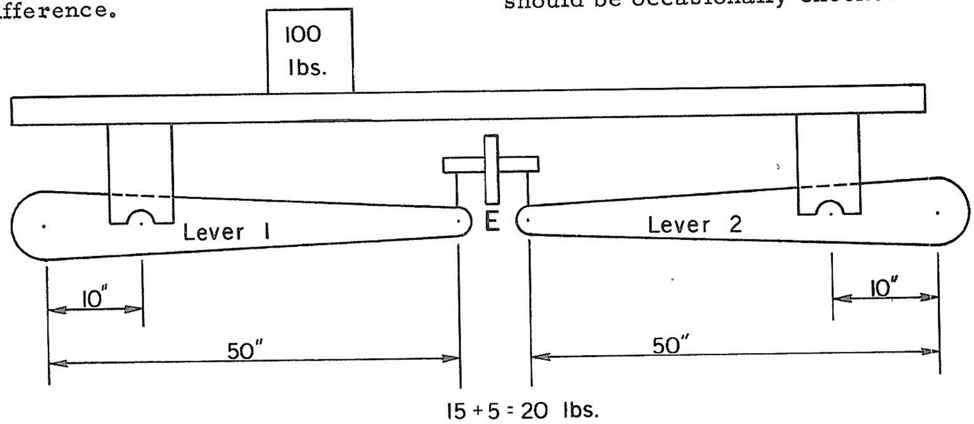

Figure 1.21. Parallel Lever

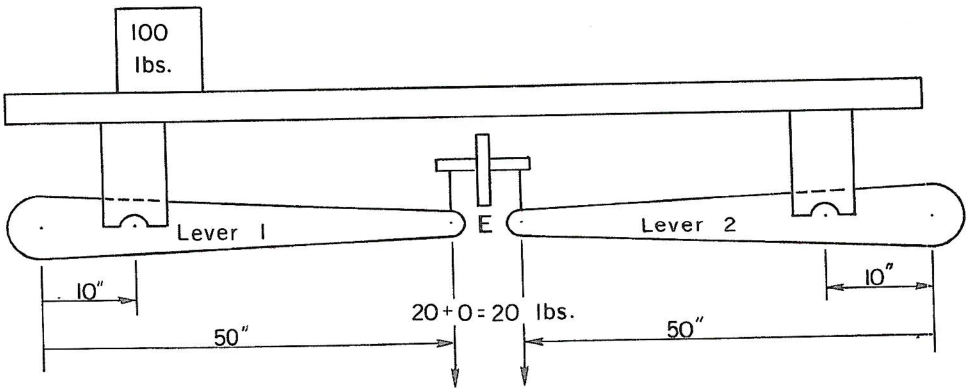

Figure 1.22. Parallel Lever

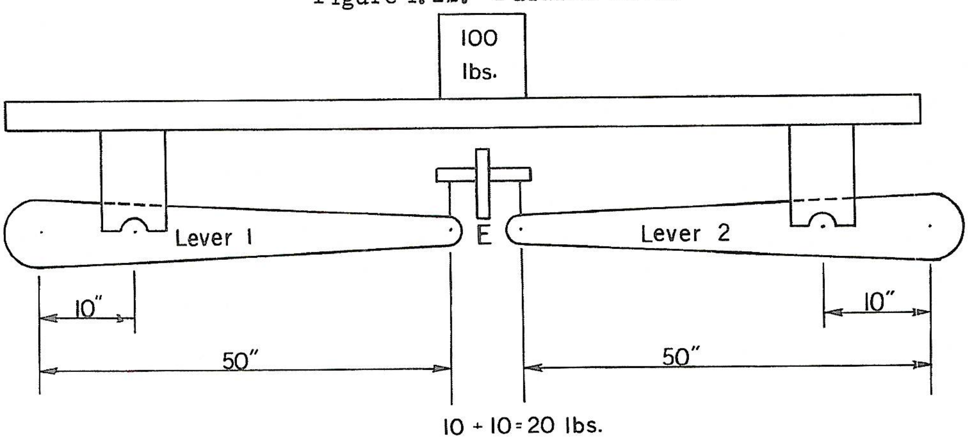

Figure 1.23. Parallel Lever

On Figure 1.21 a 100 lb. weight is placed exactly above the load pivot of lever No. 1. Assuming that the ratio of this lever is 5:1, and disregarding the weight of the lever and the platform which is already absorbed by balance, the power pivot of lever No. 1 will transmit a power pressure of 1/5th of the 100 lb. load. The pressure will be 20 lbs. The power pivot will apply this pressure load as a load on the load pivot of the end extension lever marked "E". Lever No. 2 will be inactive. Its power will be zero. Lever "E" will be loaded with 20 lbs. when 100 lbs. are placed on the platform.

When the distance between the two load pivots is divided into four equal parts, and the 100 lbs. weight is placed over the first quarter of the platform, as illustrated by Figure 1.22, the power pressure of lever No. 1 will be 15 lbs. The power pressure of lever No. 2 will be 5 lbs. The combined power pressures of the two levers, acting as a load on the load pivot of lever "E" will be the total of the two power pressures, equalling 5 + 15 = 20 lbs.

With the weight placed on the exact center of the platform, as illustrated by Figure 1.23, the power pressure of both levers will be equal. In other words, each lever will transmit a power pressure of 10 lbs. to the load pivot of lever "E", producing a total of 20 lbs. pressure.

The platform of a scale acts as a load distributor. In its action, it is similar to second class lever.

The relationship of levers No. 1 and No. 2 is parallel. On the other hand, both levers are coupled in series to lever "E" individually and collectively.

Up to this point only one end of the scale has been discussed. The other end as a similar unit is symmetrically the same, and both units or sections (as they are most frequently called), are coupled in series to the transverse lever. The transverse lever, in turn, is coupled to the indicating element. The relationship of the two sections to each other is parallel.

To find the total multiple of the scale, only one of each type of parallel levers should be used in the calculation. That is to say, that if a scale has two sections, it will have four short main levers, two long end levers, and one transverse lever. The ratio or multiple of one long end lever of type "E" and the result multiplied by the multiple of the single transverse lever, will result in the total multiple of the lever system. All the other levers should be disregarded.

During the course of construction or conversion of scales, it is sometimes necessary to design a first class multiplying lever with a specified total length. The total length is the distance between the load and power pivots. The length of the power and load arms is to be determined.

Example: To design a first class multiplying lever with a 5:1 ratio and a total length of 60 inches, the total length will have to be divided by the added total of the ratio numbers.

60" ÷ (5+1) = 10". 60" ÷ 6 = 10". The load arm is 10" long, and the remaining 50 inches becomes the power arm.

This rule applies to all ratios when calculating first class levers. If a ratio of 15:1 is required, then the total length will have to be divided by 16. For a 20:1 ratio, divide the total length by 21, and so on.

It will probably be advisable to repeat that the total length is meant to be the distance between the lp and the pp. The total length of the lever body itself has to be somewhat longer.

It may be puzzling as to why it is necessary to add 1 to the required multiple. The reason is very simple. It must be remembered that the load arm of a first class lever is not contained in the power arm. That is to say, that the load arm is on one side of the fulcrum pivot, and the power arm extends in the opposite direction. The ratio 4:1 means that the power arm has to be four times longer than the load arm. Figure 1.24 clearly illustrates this problem by using equal sized squares.

There are five squares in the total length. Four squares represent the power arm and the fifth square is the load arm. This proves that a 4:1 lever must have five equal lengths in its total.

When a second class lever has to be designed with a specified total length, the load arm can be determined by simply dividing the total length with the required ratio, without adding one. The reason for this is that the load arm of a second class lever is contained in the power arm. Figure 1.25 illustrates the fact that the la is a portion of the pa. The ratio of this lever is 5:1.

There are occasions when the ratio of a second class lever has to be changed, but the design of the scale does not permit any alterations in the distance between the load and the power pivots. The problem is to determine the new position of the fulcrum pivot.

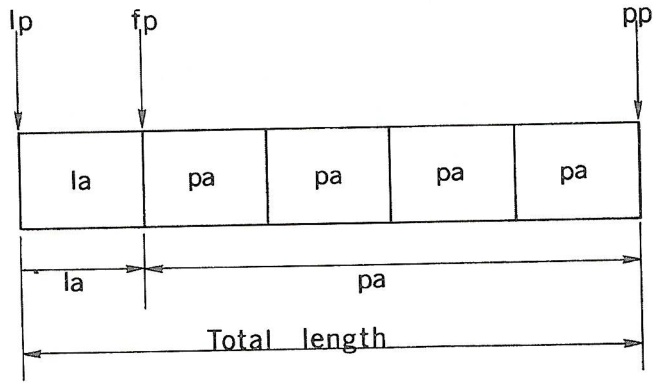

Figure 1.24. First Class Multiplying Lever Design

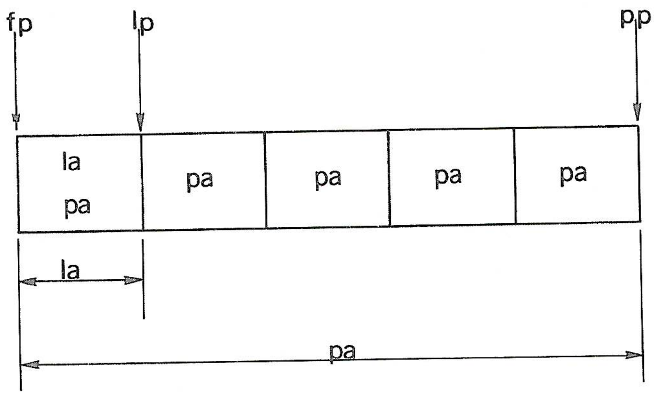

Figure 1.25. Second Class Lever Design

Example: The three to one ratio of a lever has to be changed to five to one. The distance between the load and power pivots is 20 inches.

Because the lever is second class, the load arm is contained in the power arm. The unchangeable 20 inch distance is not the power arm of the lever because it has already been established that the power arm is the distance between the fulcrum and the power pivots. As a result, the power arm is an unknown factor and cannot be divided by the required multiple.

The only way to solve this problem is to subtract 1 from the required multiple and divide the 20 inch distance by the remainder. In this case 1 out of 5 equals 4. Twenty divided by 4 equals 5. The new load arm is 5 inches long, and has to be added to the 20 inches. The result is a lever with a total length of 25 inches. This 25 inch total distance is the new power arm. To prove the correctness of the new ratio, divide the 25" pa by the 5" la. 25 5 = 5. The new ratio is 5:1 as required.

1.11 HOW TO CORRECT EXCESSIVE MULTIPLE ERRORS

Example: 20,000 on the platform reads 26,000 lbs.

Correction: Relocate load pivot on beam or any convenient extension lever.

Calculation: Multiply the required indication by the existing load arm and divide the result by the present