CHAPTER 3

SECTION I

ELECTRONIC SCALES

TABLE OF CONTENTS

CHAPTER 3

SECTION 1

ELECTRONIC SCALES

		PAGE
3.0	THEORY OF ELECTRONIC WEIGHING	3-1
3.1	INTRODUCTION	3-1
3.2	STRAIN MEASUREMENT	3-1
3.3	WHEATSTONE BRIDGE	3-1
3.4	LOAD CELL OR LOAD TRANSDUCER	3-4
3.5	LOAD BEAMS	3-4
3.6	MECHANICAL INSTALLATION	3-4
3.7	ELECTRICAL INSTALLATION	3-5
3.8	OPERATION	3-5
3.9	TEMPERATURE RANGE	3-5
3.10	LOAD	3-5
3.11	CALIBRATION	3-5
3.12	MAINTENANCE	3-6
3.13	TROUBLESHOOTING	3-6
3.14	ACCURACY/RESOLUTION	3-6
3.15	ACCURACY	3-6
3.16	RESOLUTION	3-7
3.17	CONCLUSION	3-7
3.18	WHY ELECTRONIC WEIGHING	3-7
3.19	LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT)	3-8
3.20	UNDERSTANDING THE LVDT	3-8
3.21	CHECKWEIGHING WITH INDIVIDUAL SET POINTS	3-9
3.22	BENCH AND COUNTING SCALES	3-9
3.23	TYPICAL SPECIFICATIONS	3-10
3.24	PRINCIPLES OF OPERATION	3-10
3.25	MICROPROCESSOR COMPUTATION PROCEDURES	3-10
3.26	FACTORS AFFECTING ACCURACY	3-12

PAGE

3.27 MECHANICAL SCALES CONVERTED TO ELECTRONIC...... 3-12

3.28 LOW PROFILE AND DECK SCALES........................ 3-13

3.29 ENVIRONMENTAL CONSIDERATIONS...................... 3-14

3.30 LOAD LIMITS.. 3-14

3.31 ELECTRICAL INSTALLATION............................. 3-14

3.32 TROUBLESHOOTING.. 3-15

CHAPTER 3 - SECTION I
ELECTRONIC SCALES

3.0 THEORY OF ELECTRONIC WEIGHING

3.1 INTRODUCTION

The trend of scale applications today is toward electronic equipment. In the supermarket, we find that meats, produce and dairy products are being weighed on electronic prepackaging scales. In industry, a growing number of special applications require load cell scales, whether the requirements are for a platform, truck tank, hopper, crane or thrust measurement scale. Customers desire some of the features these units offer and are willing to sacrifice economy to get them. More and more young men educated in electronics are coming into responsible positions in industry, and are specifying electronic equipment. As scale people, we only need to be familiar with the outstanding features and basic concepts of electronic weighing; we do not need to be electronic experts.

It is not difficult to grasp electronic weighing principles. Keep an open mind as you progress through this discussion, and don't worry if you "don't know a thing" about electronics.

Electronic weighing uses various electrical principles to convert force (i.e., motion) into electrical output. There are quite a few methods of accomplishing this, including: Linear Variable Differential Transformer (LVDT - which lends itself to light capacity systems like Checkweighers); Capacitance; Resistance; Nuclear; Hydraulic cell with electrical transmitter; and the Strain Gage Load Cell.

Most of these are either low in accuracy or involve very complicated arrangements to convert load to an easily-read indication. The Strain Gage Load Cell offers repeatability, good physical protection, high accuracy, and relatively simple indication.

3.2 STRAIN MEASUREMENT

To understand the operation of the Strain Gage Load Cell, a short introduction to strain measurement is required.

The terms strain and linear deformation mean nearly the same thing, and as used in engineering, refer to the change in any linear dimension of a body, usually due to the application of external forces. Bonded strain gages are used to measure this change in dimension of a body.

As illustrated in Figure 3.1, a strain gage is really a very fine length of special wire. . .

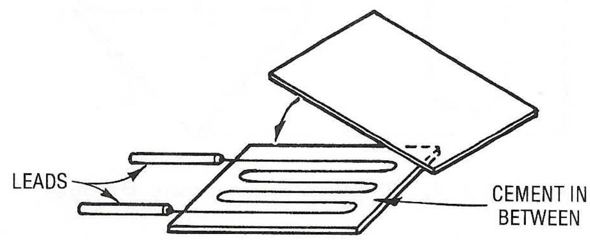


Figure 3.1. Strain Gage

bent back and forth in a "grid" and laid on a piece of insulating paper or plastic, and another insulating piece laid over the top (with cement in between). Heavy leads are soldered to the ends. These Strain Gages can be made very small, sometimes only 1/64" long. If we bond a Strain Gage to a piece of metal, and pull on the metal and stretch it slightly the strain gage will "go along" with the metal as long as it stays securely bonded. In other words the fine wire of the strain gage stretches slightly along with the metal. As the gage wire stretches, its diameter is reduced which increases the electrical resistance of the gage wire

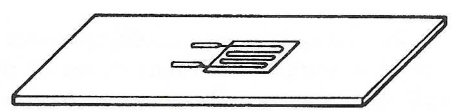


Figure 3.2. Bonded Strain Gage

3.3 WHEATSTONE BRIDGE

To provide an electrical output signal it is necessary to connect the bonded strain gages into a Wheatstone Bridge. All of the gages have the same resistance value, therefore, the Bridge is balanced. (Figure 3.3)

A battery attached to the input leads will cause the electrons to flow equally through A and B, and will flow equally through C and D, until the two currents join and flow back to the battery. There is no flow through E because the pressure is the same at 1 and 2. (Figure 3.3)

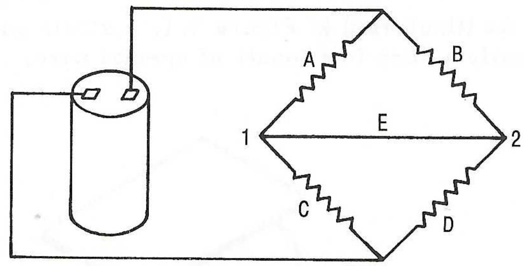


Figure 3. 3. Typical Wheatstone Bridge

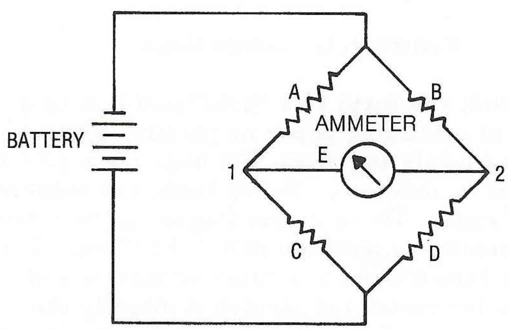


Figure 3. 4. Wheatstone Bridge

To unbalance the bridge, we'll increase the resistance of A and D by stretching the wires, and we'll put an indicator of electron flow in E.

Let us see what happens to the current flow. When it enters the bridge, most of the current will flow through B, because of the higher resistance in A. Then when it gets to 1 and 2 there will be a flow from right to left through E because of the higher resistance in D and lower resistance in C. There still is some flow in A and D.

The ammeter pointer will move in the direction of flow, and will show us how much flow.

If we take a square column of steel, instead of a flat strip, and glue a gage on each side, and mount that column on a firm base, it will appear as in Figure 3. 5. If we put a load on top, the column would get a little shorter. The gages on the front would get shorter, and the diameter of the wire would increase. At the same time, the column would also get fatter, and the gages on the sides would be stretched, and the wire diameter would decrease.

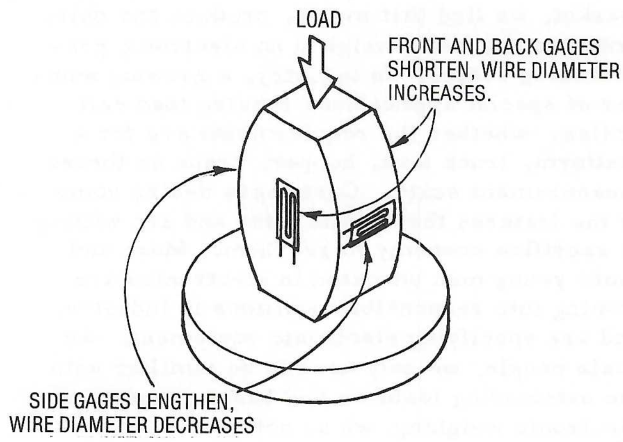


Figure 3. 5. Gaged Column

We now label the gages as shown, and wire them into the form of a "4 arm Wheatstone Bridge", hook it to a battery, and connect an ammeter. At no load all the gages would have the same resistance and there would be no current flow through the ammeter.

Under load, gages A and D stretch, wire diameter decreases, and resistance increases; gages B and C get shorter, wire diameter increases and resistance decreases.

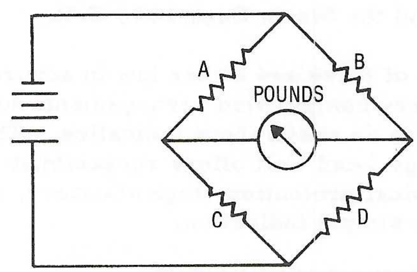


Figure 3. 6. Wheatstone Bridge

Now we do have current flow through the ammeter and the pointer moves.

As a matter of fact we now have a rough sort of a scale, and we could calibrate the meter in pounds, rather than amps. A load in the opposite direction could be put on the cell

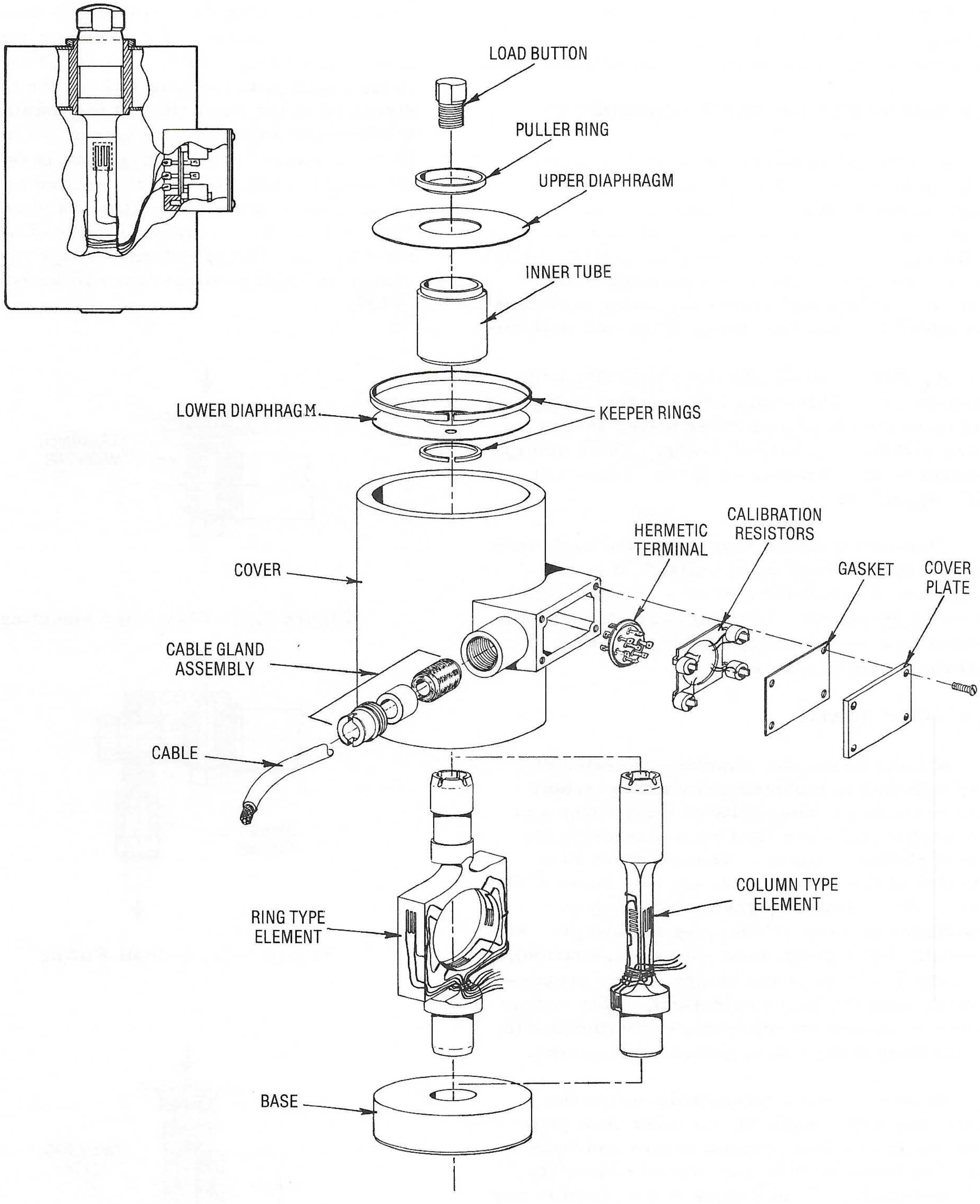


Figure 3.7. Typical Load Cell Construction

(a tensile load rather than a compressive load as we have shown here) and resistance of gages B and C would increase, resistance of gages A and D would decrease, current would flow in the opposite direction through the ammeter and the pointer would swing in the opposite direction.

3.4 LOAD CELL OR LOAD TRANSDUCER

Several other things are added to gaged column to make a load cell complete; things such as two flexible diaphragms, a load button added for compression cells (or threaded holes for tension cells), and a protective outside shell. The gages are wired together in the form of a bridge and some "trimming resistors" are added to make the output of the cell uniform.

A cable is wired into the small attached junction box. This cable has 4 wires: 2 go to and from the battery or other power source; these are the "excitation" leads. The 2 others connect to the ammeter or head. These are the "signal" leads.

This construction represents the basic idea for all "Strain Gage Load Cells." It is not correct to refer to the cell as a "Strain Gage" as many people do. The cell uses Strain Gages bonded to a column, ring, beam, or other "strain sensitive element".

3.5 LOAD BEAMS

A Load Beam is a simplified version of a load cell that is mounted horizontally rather than vertically. Simplicity of installation and low profile make the load beam desirable for use in platform scales. The operation is a function of the deflection of the load beam element. Deflection changes the strain gage resistance thereby unbalancing the bridge. As a result, for a given input voltage (excitation), the output voltage of the bridge varies proportionally with the load (deflection). This change can be displayed on appropriate instruments in engineering terms, e.g.,pounds, kilograms.

Beams are used extensively within the scale industry. Applications other than platform scales include dynamometers and conveyor systems including overhead conveyors and monorails. Load Beams can be used in any weight and force application where horizontal mounting can be accommodated.

3.6 MECHANICAL INSTALLATION

It is recommended that the load beam mounting end with the two holes be mounted on a flat smooth surface of the support structure with high strength bolts. The force or weight is transmitted to the free end, in the exact direction of the centerline of the loading hole of the free end as shown in Figures 3.8 and 3.10. If the measured force, (displaced parallel to the hole's centerline) is transmitted at another point of the beam's centerline, as shown in Figure 3.9, the accuracy of the load beam is maintained. The sensitivity change for 25% change in axial moment arm will be less than .025%.

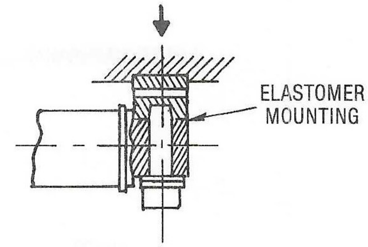


Figure 3.8. Elastomer Mounting

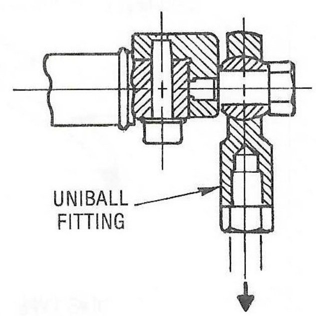


Figure 3.9. Uniball Fitting

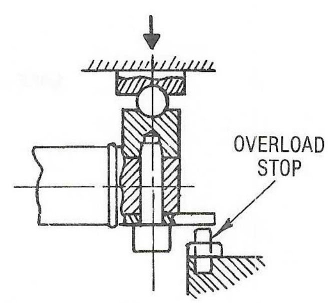


Figure 3, 10. Overload Stop Arrangement

Figure 3.10 displays a simple but efficient overload stop arrangement.

Figure 3.11 shows the force being transmitted to the beam's free end through a wire rope fitting.

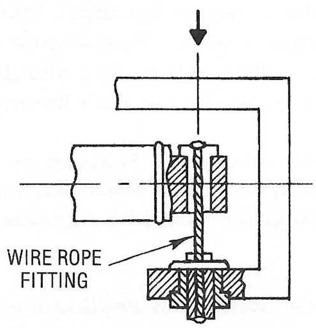


Figure 3.11. Wire Rope Fitting

Torsional-free attachments, flexible and fixed directly on the centerline, as shown in Figures 3.9, 3.10 and 3.11, correct for any adverse force components. If the applied force will exceed the rated load capacity of the load beam by more than 50%, it is recommended that an overload stop be installed to take all of the applied force above 140% of rated load. (See Figure 3.10). Linkages for transmitting the force through the centerline of the loading hole can also be constructed with spherical washer sets and through bolts. Neoprene shock pads mount with attached threaded studs or uniball rod ends.

3.7 ELECTRICAL INSTALLATION

The tinned lead ends of the load beam cable can be soldered directly to terminal blocks of a readout instrument or junction box. These leads can also be fitted with solderless terminals where removable connections are desired. Use a high grade 60/40 solder and rosin flux, where solder connections are used. Thoroughly clean all joints before and after soldering.

Recommended excitation voltages for load beams are listed in the specifications. Bridge polarity can be reversed, if desired, by reversing the Black and Green (input) leads or the Red and White (output) leads.

The use of a waterproof junction box is recommended where cable leads terminate outside an instrument case at outdoor installations. Moisture can be prevented from entering the lead ends of the load beam cable by filling the junction box with a potting compound. A special explosion-proof junction box should be used where explosive vapors or materials are present.

3.8 OPERATION

The load beam(s) should be tested with the associated readout or instrumentation system, after installation. This test will serve as a check of the mechanical and electrical installations as well as overall system performance. Instruments used with load beams should be equipped with a zero set control for adjusting the no-load output of the beam to zero. A zero set with sufficient range to cancel output resulting from tare weight on the beam plus 5% of rated beam output will be adequate in most cases.

3.9 TEMPERATURE RANGE

Load beams perform best when operated within a temperature range of +15°F to +115°F. Maximum safe operating temperature with minimum change in performance is 0°F to +150°F. Load beams can operate only intermittently at temperatures up to 180°F. However, the zero output of beams operating at these higher temperatures must be checked frequently. When ambient temperature at the load beam exceeds the safe temperature range, special precautions must be taken to insure that actual beam temperature is held within the specified limits. These precautions are necessary whether or not the beam is being operated. All load beams used on a multiple load beam arrangement should be operated at a uniform temperature within 5° where high accuracy is required.

3.10 LOAD

Most load beams can be loaded up to 150% of rated load with no adverse effects. Overloads in excess of Safe Overload Rating may permanently affect the accuracy and performance of the load. Shock loads having peak values in excess of 120% of rated cell capacity may also affect calibration and should be avoided.

3.11 CALIBRATION

Load Beams are carefully checked and calibrated at the factory before shipment. The accuracy of the instruments and standards used for these checks are directly traceable to the National Bureau of Standards. A certificate of calibration and traceability is furnished with each load beam supplied by the manufacturer. This certificate defines the direction of loading, the full scale output (mV/V), terminal resistance, zero balance (mV/V), and insulation resistance of the particular beam. The data included in this certificate can be used as a reference where independent calibration checks are performed.

Load beam calibration can be accurately checked by applying a known load to the beam and then comparing the output with the original data on the calibration certificate. Linearity of a load beam can be checked by applying the known load in smaller increments and recording the output at each load point. The deviation between these points and straight line performance represents linearity error. Load beam calibration should be checked whenever the beam has been accidentally overloaded beyond its safe overload rating. The load beam cannot be changed through external adjustments and any load beam displaying calibration error should be returned to the manufacturer for service.

3.12 MAINTENANCE

Load beams do not require any maintenance other than the application of touch up paint to areas which become scratched or chipped during service.

3.13 TROUBLESHOOTING

To determine the cause of erratic or incorrect operation of the measuring system, make the following checks:

a. Check instrument power and fuses.

b. Check that the connections to the instrument are correct and tight.

c. Check instrument performance independently following recommended procedure.

d. Check continuity of interconnecting leads.

e. Check junction box connections (where used).

f. Check resistance between a lead of the interconnecting cable and ground with a 50-volt megohmmeter. Resistance should be greater than 100 megohms.

g. Disconnect the load beam cable leads from the instrument or junction box. Measure the resistance between the input leads and between the output leads. Resistance should be as specified. Ohmmeter used should not apply more than 10 Volts to the load beam bridge.

h. Check insulation resistance between a lead of the cable and the beam with a megohmmeter. Resistance should be greater than 100 megohms.

i. Check insulation resistance between cable shield and the load beam with a megohmmeter. Resistance should be 100 megohms or greater.

3.14 ACCURACY/RESOLUTION

We are in an age of rapidly changing scale technology with electronic digital indicators, load cells and computers. Many new terms appear in our everyday communications, while some of the older terms are being used in new and sometimes incorrect ways.

An understanding of basic terms relating to scale performance is necessary for effective communication. Two terms, "accuracy" and "resolution", are often used interchangeably and outside recognized definition. Their meaning is often obscure.

3.15 ACCURACY

The Scale Manufacturers Association (SMA) defines accuracy as "the degree of agreement between the result of a measurement and the nominal value of the quantity being measured." In other words, if a fifty pound test weight were placed on a platform, the closer the indication comes to reading fifty pounds, the more accurate the scale is.

Often scale accuracy is expressed in terms of percentage of allowable error, which is called "tolerance". For example, a scale may be considered accurate if the difference between the test weight value and indicated weight does not exceed 0.1 percent.

3.16 RESOLUTION

"Resolution is the minimum change in the measured variable which produces response of the instrument", according to the SMA.

In other words, resolution is the smallest amount of weight that must be placed on the platform to move the indicator on division or change the digital indication one increment.

3.17 CONCLUSION

We can say that "accuracy" and "resolution" are independent concepts with completely different meanings: accuracy referring to a scales indication relative to a nominal weight value; resolution to the minimum effective (readable) weight change, one graduation or increment.

In describing the performance capabilities of a scale, you should make a clear distinction between these terms.

Examples

1. The National Bureau of Standards Handbook 44 requires the same accuracies for all scales used in retail trade, but, as you can see from the table below, the resolution may be different for different scales.

Retail Scale Type	Resolution	Maintenance Tolerance*
Digital Indicating	0.005 lb	0.1%
Digital Indicating	0.01 lb	0.1%
Computing Mechanical	1 oz. (0.06225 lb)	0.1%

2. NBS H-44 also sets tolerances for large capacity scales and requirements for resolution:

Type	Resolution	Maintenance Tolerance*
Vehicle Scale	20 lb	0.2%
Grain Hopper	10 lb	0.1%
Livestock Scale	5 lb	0.2%

* Percent of Test Load

3.18 WHY ELECTRONIC WEIGHING

The majority of electronic weighing systems are used for one of the following purposes:

REDUCE INVENTORY COSTS - Efficient and accurate control of inventory by weight allows the user to maintain the optimum amount of material on hand for efficient production without costly excesses. Accurate inventory can also result in a reduced number of storage vessels and area, contributing to further cost savings.

REDUCE LABOR COSTS - Process automation through installation of automatic batching systems can eliminate a substantial amount of manual input. Centralized inventory control readouts obviate the need for visual inspection of storage areas.

IMPROVE PRODUCT QUALITY - Accurate batch control improves the consistency of end product quality resulting in improved product acceptance and reduces costly product rejects and rework.

It is easily understood why an electronic weigh system has advantages over a mechanical beam type system. Some of the advantages are:

1. Due to the low deflection of the load cell, a load cell based weighing system has a fast response or settling time.

2. The higher the capacity of the weighing system, the lower the cost will be of the weighing structure.

3. Remote measurements can be made.

4. The weight information can be processed directly to eliminate human error.

5. The electronic output can be integrated directly into a process computer for control and transmission of information or the generating of reports.

6. Electronic weighing systems often can be adapted to existing installations.

7. Load cells and their associated electronics are solid state devices and, therefore, are not subjected to wear such as found in the knife edges and their supports in mechanical systems.

3.19 LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT)

The linear variable differential transformer (LVDT) provides the engineer with a means for considerable improvement in weighing, gauging or position control systems. While this electromechanical transducer has been introduced only recently, its precision and speed of operation are becoming widely recognized. The LVDT offers several advantages over other types of transducers. These include elimination of friction or hysteresis, high shock resistance, electrical isolation of the output from the excitation source, high level output signal, infinite resolution, zero maintenance and infinite life. When the LVDT is used in conjunction with modular electronic controls these advantages become more significant.

Basically, using a transformer with a moveable armature, as shown in figure 3.12, the LVDT requires a-c excitation to produce an a-c output signal. The amplitude of this signal varies with the position of the armature.

Because of the a-c excitation requirement, the original LVDTs were designed to use readily available 60-cycle line signals. Early systems utilized the LVDT almost exclusively in a servo, or closed-loop system. Their low excitation frequency resulted in slow response. Furthermore, the systems were greatly affected by temperature changes. With solid-state electronics now on the scene these problems have virtually been eliminated. Excitation frequency has leaped from 60 Hz to a range between 1 and 5 kHz. LVDT output is now converted to direct current. Demodulators are now, in most cases, integral components of LVDTs, changing a-c input to a d-c output of approximately 1.5 volts. Response and accuracy are improved, and maintenance and calibration are simplified.

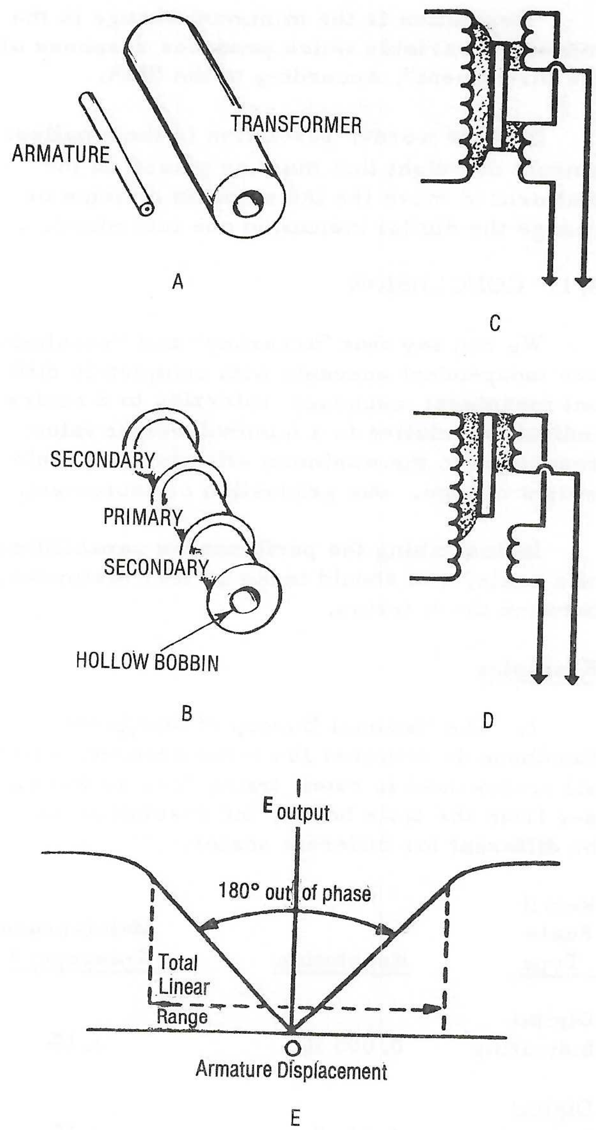


Figure 3.12. Linear Variable Differential Transformer (LVDT)

3.20 UNDERSTANDING THE LVDT

The LVDT has two basic components, the armature and the coil. (Figure 3.12A). The coil consists of a hollow bobbin containing a primary and two secondary windings, each separated from the others. (Figure 3.12B). This assembly is encased in a magnetic shield. The armature is placed within the coil, and the primary is excited with a high-frequency oscillation. This results in an induced voltage from the primary to the secondary windings. (Figure 3.12C). The secondaries are wound in a series opposition mode. When the armature is placed precisely at the mid-stroke point in the coil, induced voltage in the secondaries is equal-and-opposite and it cancels out.

Movement of the armature, in either direction, away from the central or null position, produces an a-c signal. The signal increases with an amplitude directly proportional to the displacement from the null position. (Figure 3.12D). Repositioning the armature in the opposite direction from the null position results in an AC signal exactly 180 degrees out of phase with that produced by the original displacement. The amplitude of this signal also increases with further displacement of the armature away from the null. (Figure 3.12E). Plotting the peak amplitude out of the secondaries against the armature displacement shows the output as a linear signal. No hysteresis is involved.

The armature does not contact the inner wall of the coil, therefore there is no friction and no component wear.

3.21 CHECKWEIGHING WITH INDIVIDUAL SET POINTS

Another important application of the LVDT is its use as a vital component in a weigh cell or load cell. The a-c to d-c demodulization, as an integral function of the LVDT, is vital in this type of application. Operation of this system, shown in figure 3.13, is similar to that described for automatic gauging, except that the relay is set up to reject an overweight or underweight container as it passes over the cell. Checkweighing is a prime example for this type of application. In a typical installation, the weigh cell, or load cell, is placed in a conveyor line. A filled package passes onto the cell, and deflection of the LVDT armature, through the applied weight on the scale platform, creates an induced voltage. This voltage is amplified and passed to relay modules set for maximum or minimum weight. Either will operate an electro-mechanical rejection system. The weigh cell or load cell system, supplemented by a properly designed mechanical handling system, can checkweigh at speed up to 200 containers per minute. Total system accuracy is approximately .25 percent of gross product weight.

3.22 BENCH AND COUNTING SCALES

Bench and counting scales are designed and built for simplicity and durability and will maintain precision under the most adverse conditions. Compact and portable, they contain no complex levers or pivots. The load beam provides quick accurate response and eliminates off-center or side loading problems. The scale depends on microprocessor technology and offers rapid switching from English to metric units.

Some counting scales are designated "count only" because no attempt has been made to calibrate these scales for weight. In a sense, these scales recalibrate themselves every time a new sample size is evaluated and an "internal" value for piece weight is entered

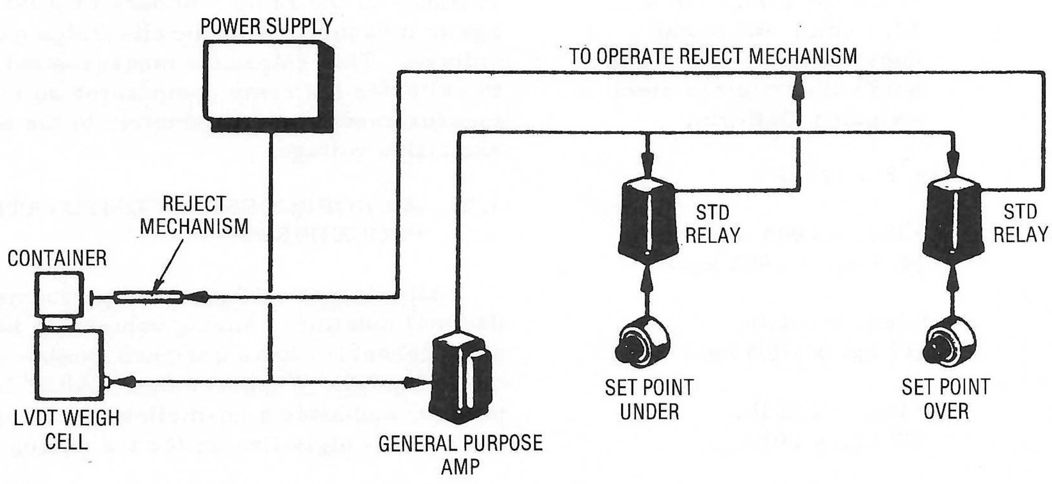


Figure 3.13. Overweight-Underweight Reject System

into memory. The internal piece weight has no meaning in terms of absolute weight but only in terms of how many times it can be divided into a new weight soon to be placed on the scale. By avoiding all reference to absolute weight, it becomes possible to intermix load cell platforms and electronic assemblies at will without going through any span or range adjustments.

The bench or counting scale is designed for minimum maintenance. The electronics consists of four modules, each easily disconnected for rapid replacement - power supply, main circuit board, panel assembly and load cell assembly. See Figure 3.14.

3.23 TYPICAL SPECIFICATIONS

Controls	ON/OFF Switch Pounds/Kilogram Pushbuttons Zero Pushbutton (provides Auto Tracking Zero and can also be used for Tare purposes.)
Resolution/ Linearity	Up to 1 part in 2500
Display Resolution	Resolution will not change when using LBS/KGS pushbuttons.
Display	Bright, 0.56" high LED, 5 active digits plus polarity. In-motion inhibit of zero. Display blanks an overload and indicates "OL".
Housing	14 in. x 15 in. x 5 in. (35.6 cm x 38.1 cm x 12.7 cm.) All metal construction. Black and gold with stainless steel weighing platform.
Ambient	$20^{o}F - 120^{o}F$
Capacity Ranges	10 lbs. x .005 lb. (4.5 kg. x .002 kg.) 25 lbs. x .01 lb. (11 kg. x .005 kg.) 50 lbs. x .02 lb. (22 kg. x .01 kg.)
Capacity Ranges (Cont'd)	100 lbs. x .05 lb. (45 kg. x .02 kg.)
Handbook 44	Meets all applicable H-44 requirements
Power Input	117/230 Vac + 10% - 15% 50/60 Hz. 30 watts maximum.
Shipping Weight	Approximately 25 lbs.

3.24 PRINCIPLES OF OPERATION

A balanced ±7.5V supply (derived from ±15V) provides excitation for a 2mV/V load cell, whose 0-30mV output signal is amplified to a 0-5V signal. This signal is processed in a 6 pole low pass filter to eliminate vibration and then converted to a 0-200,000 BCD number by means of a voltage ramp, 1 MHZ clock, and voltage comparator. Five such conversions occur per second. The entire conversion process is closely controlled by the microprocessor. The microprocessor is too slow to count the individual 1 MHZ clock pulses directly. Instead, clock pulses are accumulated in a 9 stage binary counter until an overflow occurs. The microprocessor counts these overflows and, after the ramp is complete, generates sufficient additional pulses to advance the counter to one more overflow. This final step provides all the information needed to assemble a six digit BCD number over the range of 0-200,000 which represents weight.

After each tare command, and at regular one minute intervals, the microprocessor switches to the ramp comparator's input voltage to measure the load-cell-bridge excitation voltage. This reference measurement is used to calibrate the ramp comparator so that all measurements are ratiometric to the bridge-excitation voltage.

3.25 MICROPROCESSOR COMPUTATION PROCEDURES

All internal arithmetic is performed in decimal notation. Analog values are immediately converted to an unsigned number in range of 0-200,000. Whenever the "TARE" button is pushed, and after a no-motion test is passed, the current digital value for the analog signal

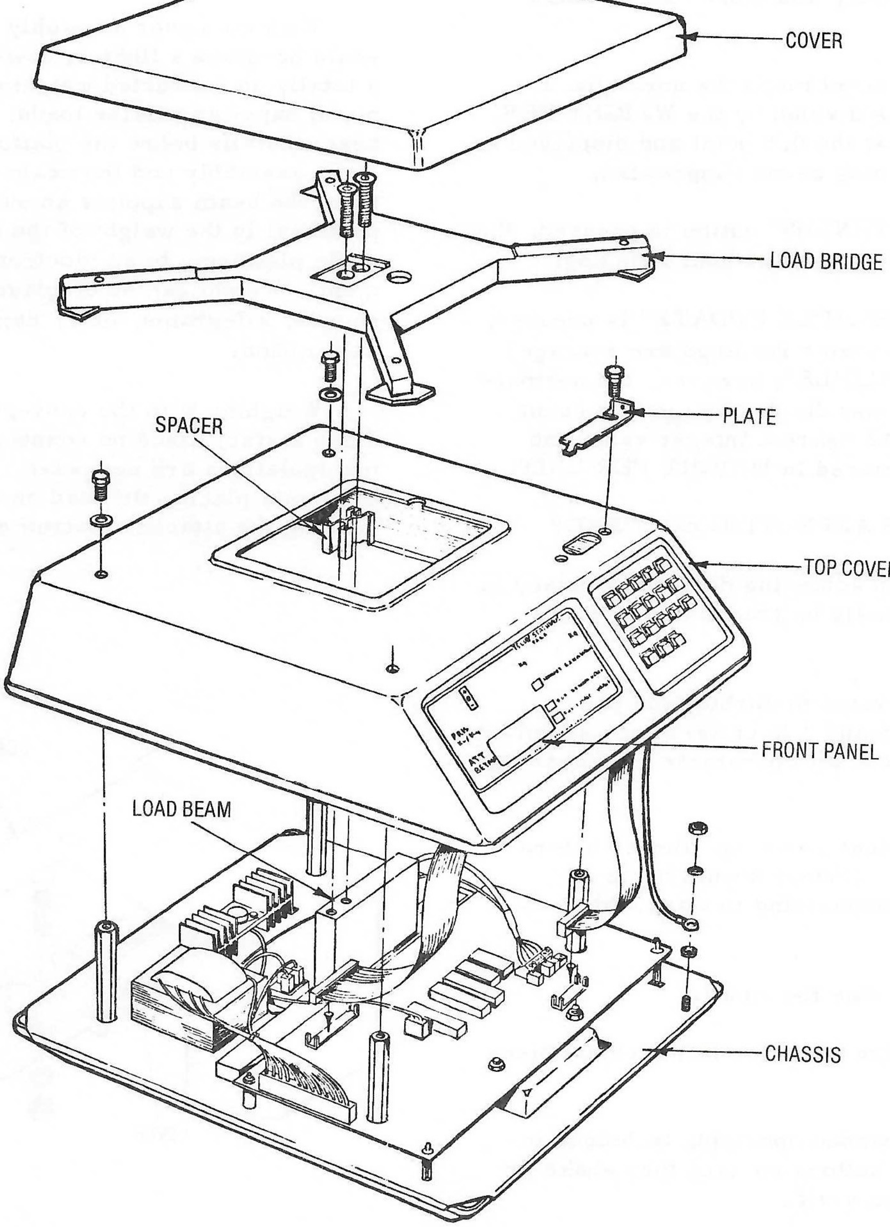


Figure 3.14. Bench Scale

is stored as the current zero. During all other operations (sample and count) the zero value is subtracted from the current analog value to yield a signed normalized number that represents weight in arbitrary units.

Whenever "SET SAMPLE" is pressed and after a no-motion test is passed, four successive meter readings are averaged, divided by the sample number, and stored as WEIGHT PER UNIT.

During the count mode the normalized meter reading is divided by the WEIGHT PER UNIT, rounded at the 0.5 point and displayed as a count with leading zeros suppressed.

When the "TENTHS" button is pressed, the tenths digit is displayed without rounding.

When the "SAMPLE UPDATE" is pressed, four successive meter readings are averaged as with "SET SAMPLE"; however, the normalized reading is now divided by the last count rounded off to the nearest integer value and this new value stored in WEIGHT PER UNIT.

3.26 FACTORS AFFECTING ACCURACY

Problems in achieving desired accuracy in counting can usually be traced to one of the following:

1. Air currents disturbing the pan (especially for 5 and 2 lb units) often caused by rapid movement of an operator's hand near the pan.

2. Insufficient warm-up allowed before using the scale. (Power should be on 20 minutes before attempting to work with very small parts.)

3. Sample size too small.

4. Excessive variation in individual piece weight.

5. Heavy handed operating technique involving pushing buttons so hard they shake or deflect the entire scale.

6. Power line shared with heavy industrial electrical equipment.

If attention is given to the foregoing considerations, effective, satisfactory, maintenance-free service can be anticipated.

3.27 MECHANICAL SCALES CONVERTED TO ELECTRONIC

Ordinary portable mechanical scales can be easily and inexpensively converted to electronic weighing platforms by replacing the entire upper assembly (vertical column, connecting rod, beam, counter weights, etc.) with a Load Beam.

With the upper assembly removed, the scale becomes a lighter, low-profile unit with a totally unobstructed weighing surface, capable of handling bulkier loads. A small size beam installs below the platform, between the lever assembly and the scale frame. In operation, the beam supplies an output voltage, proportional to the weight of the load placed on the scale platform, to an electronic readout instrument. Weight can be displayed in terms of pounds, kilograms, etc., depending upon initial calibration.

Weighing with the converted scale is also much faster, since no counter weight or poise manipulations are necessary; weighing consists of simply placing the load on the platform and reading the attached instrument.

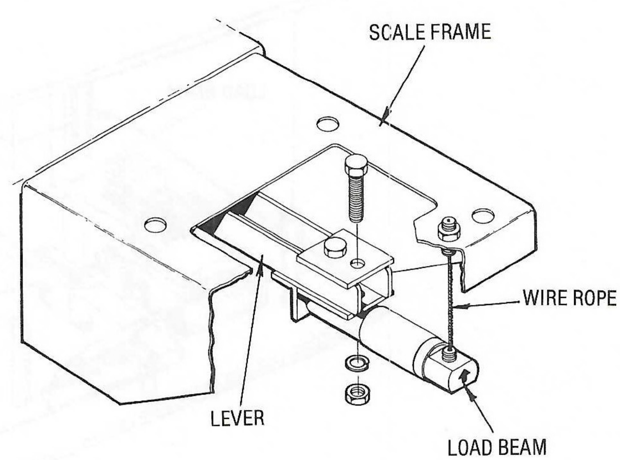


Figure 3.15. Final Conversion Installation

An alternate method of conversion is the installation of a load cell in a steelyard rod.

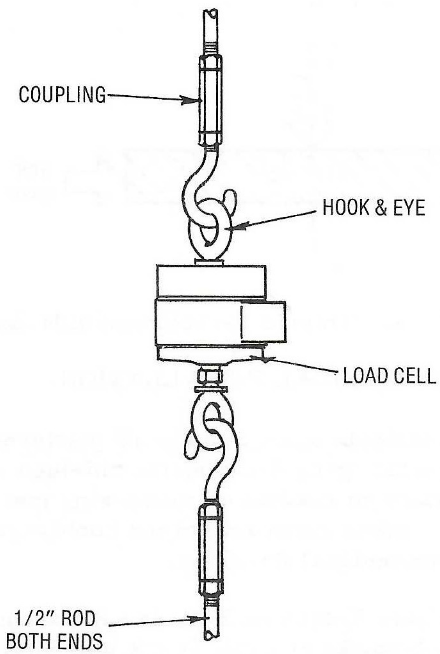


Figure 3.16. Typical Steelyard Conversion

3.28 LOW PROFILE AND DECK SCALES

Low Profile and Deck Scales are rugged electronic weighing platforms capable of unit weighing up to 20,000 pounds, depending upon capacity specified. The platforms are compact, self-contained units shipped ready for connection and immediate use. Although the individual elements, suspension, and overall construction differ slightly, platform operation is basically the same for all types. Each platform uses four strain gaged sensing elements to which is transmitted, through the suspension system, the force of a load placed on the platform. This force changes the stress pattern in the sensing elements which are electrically connected together to produce an output voltage proportional to the applied weight.

Each type of platform consists of a base structure, four load beams, a suspension assembly for each beam, a suspended platform, horizontal checks, overload stops, and a junction box. The Low Profile scale has a removable ramp at each end to permit loads to enter and exit the platform. The Deck Platform transducer can be installed on any level, load bearing surface or recessed into the floor.

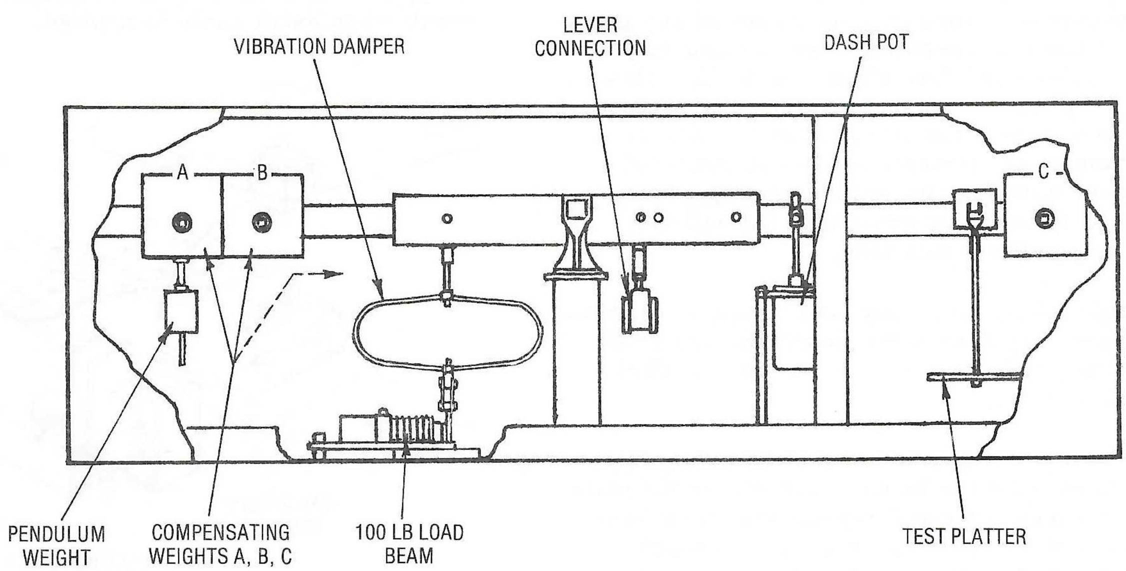


Figure 3.17. Typical Conversion/Heavy Capacities/Tank Scales

If recessed, the mounting arrangement must allow sufficient side clearance to insure accurate operation. Care must be taken to keep the platform clear of structural members and waste accumulation. Mounting pad surfaces must seat on ground support coplanar within 1/32".

3.29 ENVIRONMENTAL CONSIDERATIONS

The platforms are temperature compensated for operation between -15°F and 150°F and can be stored indefinitely at temperatures ranging from -65°F to 200°F. In system applications, the narrowest temperature range of a given system component (signal conditioner, printer, etc.) should be used as the determining factor when choosing system location. Although the platforms are built for operation in harsh environments, system location should be relatively free from dust, unusual temperature extremes, high humidity, and vibration. The system, especially control instrumentation, should not be located in areas containing explosive or corrosive vapors or in the vicinity of strong magnetic fields, e.g., large power transmission cables, welding equipment, high voltage transformers, etc. The latter is expecially important when considering the placement and run of transducer cabling.

3.30 LOAD LIMITS

Maximum unit, side, and overload limits vary between platform types. Refer to the specifications before placing a load on any platform. The non-operating overload capacity of both the Deck and Low Profile is 500%. This limit is specified non-operating. When the maximum rated load of a platform is exceeded, the transducer elements strike the overload stops and will sustain, without damage, and overload to the limit specified, but will not, however, indicate this load.

Side loads, i.e., any load acting 90 degrees to the primary axis of the platform, are rated separately and are also non-operating. (Refer to Figure 3.18).

Maximum unit loads are rated in terms of psi. Load must not be concentrated on the platform in excess of rated capacities. A cylinder of mercury for example, will exert a much greater unit load than would a load of sheet steel weighing twice as much.

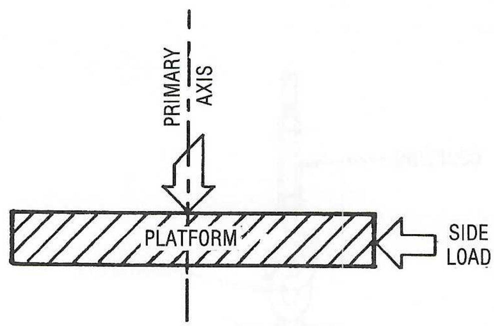


Figure 3.18. Graphic Illustration/Side Load

3.31 ELECTRICAL INSTALLATION

Electrical connections to all platforms are by connector or by 4-conductor shielded cable. Connections to readout or measuring instrument are made according to the connector code in the dimensional drawings.

A Cable Extension Box, is used when an existing transducer cable is not long enough to reach the readout device. The cable extension box contains a single terminal strip. The cable extension boxes, if used, should be installed where they can be easily reached by the four-conductor transducer cables. The platforms have been calibrated at the factory for the length of cable supplied. A loss of approximately 0.28% of the output for each ohm of applied resistance in the output leads will result when extra cable is applied.

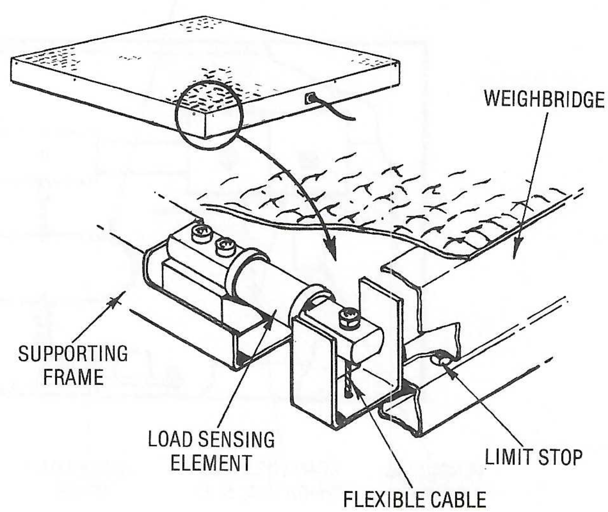


Figure 3.19. Typical Deck Scale

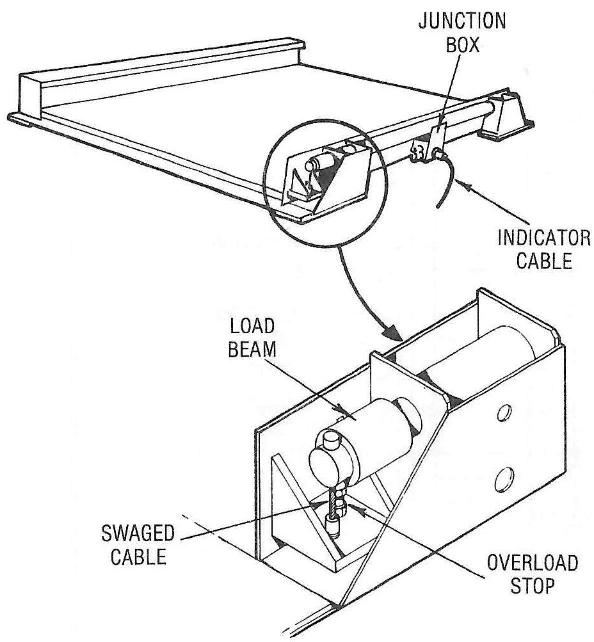


Figure 3.20. Typical Low Profile Scale

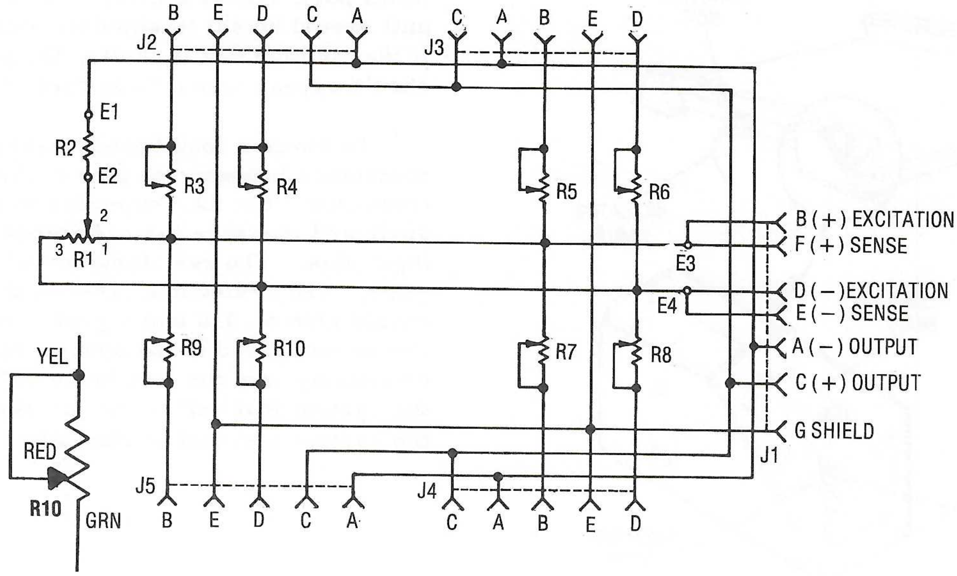
3.32 TROUBLESHOOTING

To troubleshoot a scale system problem, first determine in which scale system element the problem originates. A calibrator can be connected to the weight indicator to determine if the indicator is operating properly. If the indicator is operating properly, isolate the problem to the signal cable, junction box, or load beam.

To check the signal cable, disconnect it from the scale junction box and connect it between a calibrator and the weight indicator. A faulty cable will become apparent by improper indicator operation.

To check junction box operation, disconnect all load beam cables and connect the System Test Unit to each junction box load beam port, one at a time. The system test unit should be set to simulate four load beams. If the junction box is faulty, the problem should appear under these test conditions.

To check a load beam, measure the resistance between the pins of the load beam connector. Set the ohmmeter to the R x 100 scale and measure the resistance between the input pins. The resistance should be 350 ohms ±10%. The resistance between the output pins should also be 350 ohms ±10%. A load beam can be compared to the system test unit by connecting only the load beam under test and the system test unit to the junction box. Set the system test unit to simulate 3 load beams.



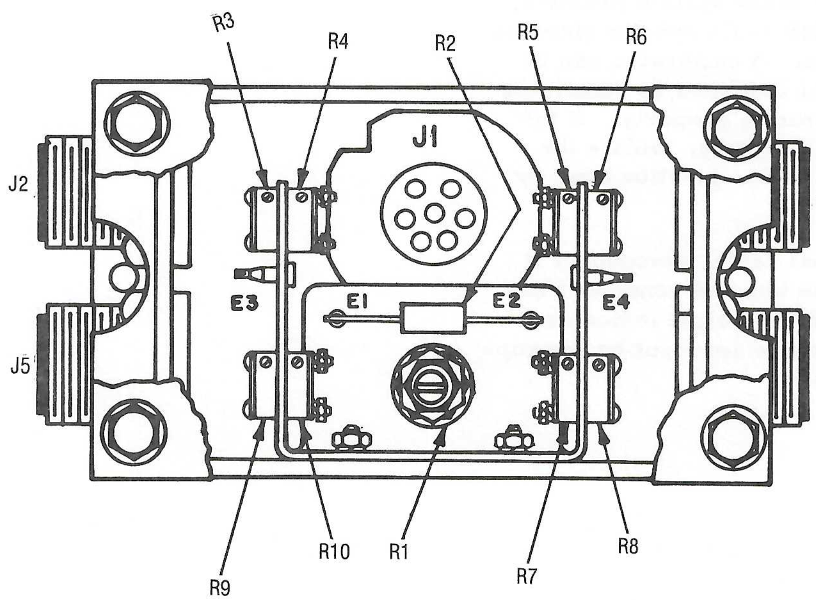


Figure 3.21. Junction Box/Schematic/Low Profile/Deck Scale

Table 3.1. Scale Troubleshooting Guide

SYMPTOM	PROBABLE CAUSE
Scale platform teeters between opposite corners.	a. mounting surface not level b. suspension needs adjustment.
Scale weighs properly only to a certain weight, but weight reading is erroneous as more weight is added to scale.	a. debris under overload stops or platform b. overload stops out of adjustment c. platform is binding on base structure, ramps, cables, etc.
Weight display is different for the same weight positioned in different locations on platform.	a. mounting surface is not level or is not solid (wood floor) b. suspension is out of adjustment c. span balance is out of calibration.
Weight indicator display is blank, or displayed weight does not change as weight on scale is changed.	a. connection in cable, junction box or Weigh Bar is opened or shortened. b. dead load offset adjustment out of calibration.
Erroneous weight is displayed.	junction box span adjustments out of calibration.
Overrange occurs before it should.	dead load offset adjustment out of calibration.
Weight display continuously changes with a fixed weight on the scale.	a. leakage path (such as moisture) in signal cable b. leakage path in junction box c. leakage path in load beam or load beam cable.

NOTE

This chart is to be used when a problem has been isolated to a cable or scale, and an indicator problem has been ruled out.