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Mass Measuring on Conveyor Belts - An Overview

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MASS MEASURING ON CONVEYOR BELTS
AN ESCOM OVERVIEW

1. SUMMARY

The paper deals initially with the basic weighing equation and the various components of a mass measuring system. The regulation's pertaining to payment massmeters by the Department of Trade and Metrology are explained. The importance of weighing accuracy is highlighted by a typical example from within Escom. A general overview of mechanical, electro-mechanical, hybrid and nuclear massmeters is given. The paper concludes by discussing the importance of the correct maintenance of conveyor massmeters.

2. INTRODUCTION

Continuous weighing of material as it is carried along a conveyor belt can offer economic advantages to management in process control, in stock control and in accounting, provided that the errors can be guaranteed to fall within a specified tolerance, typically better than +/- 0,5% of the material weighted.

Plant operators, mining, industrial and power personnel have a historical suspicion of conveyor massmeters. Experience has shown that contrary to the supplier's specification of +/- 0,5% the obtainable accuracy is often +/- 5.0% or worse.

The reasons for the wide difference between the expected and obtainable accuracies will be explained during the paper.

3. BASIC MASSMEASURING EQUATION

To obtain accurate results from a system which attempts to weigh a product when it is moving is not easy. Flow rates of the product always vary and occasionally the belt speed also varies.

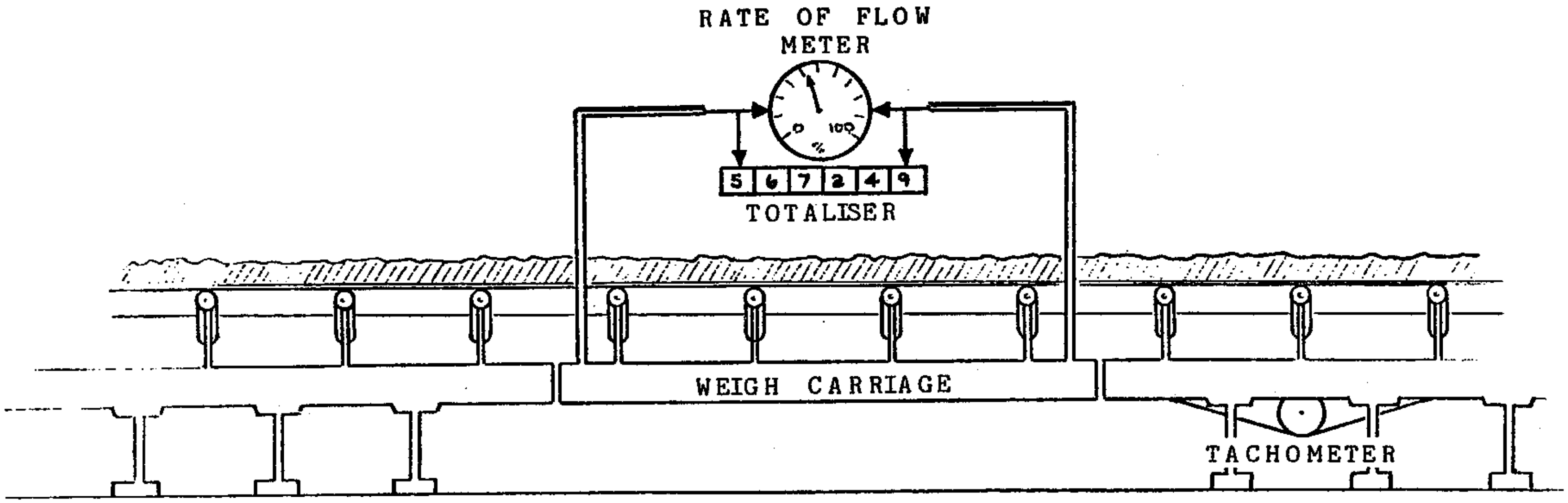
The conveyor massmeter attempts to satisfy the following equations:-

Tons per Hour = [KG/m x m/sec] k.

K = A constant

The measure of kg per metre (mass) is obtained from the weigh carriage and metres per second (belt speed) is derived from a speed sensing device, located normally on the tail pulley and called a Tachometer.

BASIC COMPONENTS OF A MASSMETER



$$\text{TONNES PER HOUR} = \left[\frac{\text{KG}}{\text{METRE}} \quad \times \quad \frac{\text{METRE}}{\text{SECOND}} \right] K$$

Fig 1

The above equation seems simple but in practice the massmeter designer must consider belt tensions, drive power, belt length, inclination, belt construction, stiffness and idler spacing. In all cases the supplier must custom design the massmeter to meet the conveyor parameters.

3.1 BASIC COMPONENTS OF A MASSMETER. (Fig 1)

According to the S.A. Department of Trade and Metrology, which must approve the design of all payments massmeters, the following components must be present:-

3.1.1 A conveyor belt which travels on a roller track.

3.1.2 A load receptor comprising that portion of the belt which is passing over the measuring length of the massmeter at any instant, and a belt supporting structure.

3.1.3 A load transmitting device.

3.1.4 A load measuring device which shall include an indicating and totalling device.

3.1.5 A belt-travel pick-up device.

3.1.6 A zero-load setting device.

3.2 CONVEYOR BELT AND ROLLERS

The conveyor belt passing over the load receiving structure of a conveyor belt massmeter shall be:-

3.2.1 Endless and any joints shall be smooth.

3.2.2 Made of a material suited to the material of which the mass is to be measured.

3.2.3 Of such finish and so arranged, together with with the rollers, that the material on the load receptor does not move relative to the belt or cannot come into contact with any part not on such load receptor.

3.2.4 Of virtually constant mass per unit length and be kept at a virtually constant tension.

3.2.5 Provided with any necessary device for cleaning of the belt.

3.2.6 The length and speed of travel of the belt passing over the receiving structure of a conveyor belt massmeter shall be so limited as not adversely to affect the acccuracy of the massmeter.

3.2.7 The outer conveyor rollers on the load receptor and the nearest rollers not on the load receptor of a conveyor belt massmeter shall be in the same plane and the axes of all the said rollers shall be at right angles to the direction of travel of the belt.

3.3 FEEDING OF MATERIAL

The device of feeding the material on to the belt of a conveyor massmeter shall be arranged so that-

3.3.1 The arrival of material on the belt does not adversely affect the operation of the massmeter.

3.3.2 The feed of material is in the direction of travel of the belt unless the feeding takes place at a distance from the massmeter of more than the distance between three rollers.

3.3.3 The rate of feed may be controlled.

3.4 Material accuracy requirement for payment massmeters.

3.4.1	Grain, grain products, sugar or similar free-flowing materials.	0,25% in excess or in deficiency
3.4.2	Cement, coal, ore or similar materials.	0,5% in excess or in deficiency.

3.5 Zero accuracy requirement for payment massmeters.

3.5.1 The zero load setting device of a conveyor belt scale shall be so arranged that an average zero can be achieved within 0.1% of the capacity of the of the massmeter over any number of complete revolutions of the unloaded belt.

4. THE IMPORTANCE OF ACCURATE WEIGHING IN ESCOM.

4.1 In Escom most of the newer power stations have the facility to test and calibrate the payment massmeters with respect to large capacity static weigh bins. These bins can hold approximately 450 tons and are accurate to 0,1% or better of the bin capacity.

Escom Power Stations receive their coal supplies from collieries located near to the stations. Escom's coal bill is approaching R1 000 000 000 per year, and it is essential that the payment massmeters are accurate, reliable and can be easily calibrated and checked.

4.2 ESCOM/COLLIERY COAL ACCOUNTING

A typical example is a medium sized Eastern Transvaal Power Station where the coal consumption is 500 000 tons per month at a cost of R13,18 per ton.

i.e. Approximately R80 000 000 per year.

The assizable accuracy of the payment massmeters is better than +/- 0,5% i.e. +/- R 400 000 per year.

Therefore, the objective in Escom is to reduce the error payment band to better than +/- 0,25% i.e. +/- R200 000 per year.

4.3 IN-SERIES MASSMETERS.

Escom has attempted to reduce the inherent inaccuracy of conveyor massmeters by installing two massmeters in-series on the main feed belts, normally on a short measuring belt. The masses of coal recorded by each massmeter are averaged, and payment to the colliery is made on the average figure. The system protects both Escom and the colliery from overpaying or underpaying.

In addition the in-series massmeters are checking the performance of each other and any obvious discrepancy in the totals can be quickly located by running a bulk load test against the static weigh bins. The daily totals of the massmeters are monitored and if the variation between massmeters exceeds 0,5% then a bulk load test is performed to locate the offending massmeter.

5. Types of massmeters used within Escom.

5.1 Mechanical integration massmeters.

Fig. 2(a) represents the basic ball-disc integration principle. The mass or load is translated into a certain position of the ball carrier on this disc. The disc is driven by the moving belt. Hence the disc angular velocity represents a measure of belt speed.

The speed of rotation of the ball is directly proportional to the product of the disc angular velocity (Belt speed) and the position of the ball on the disc (Mass).

The ball rotation is transferred to a cylinder, which is connected to a counter through a suitable set of gears.

Fig. 2(b) Shows a variation of the ball-disc principle, the cone-wheel integrator, in which the disc is replaced by a cone.

MECHANICAL INTEGRATION

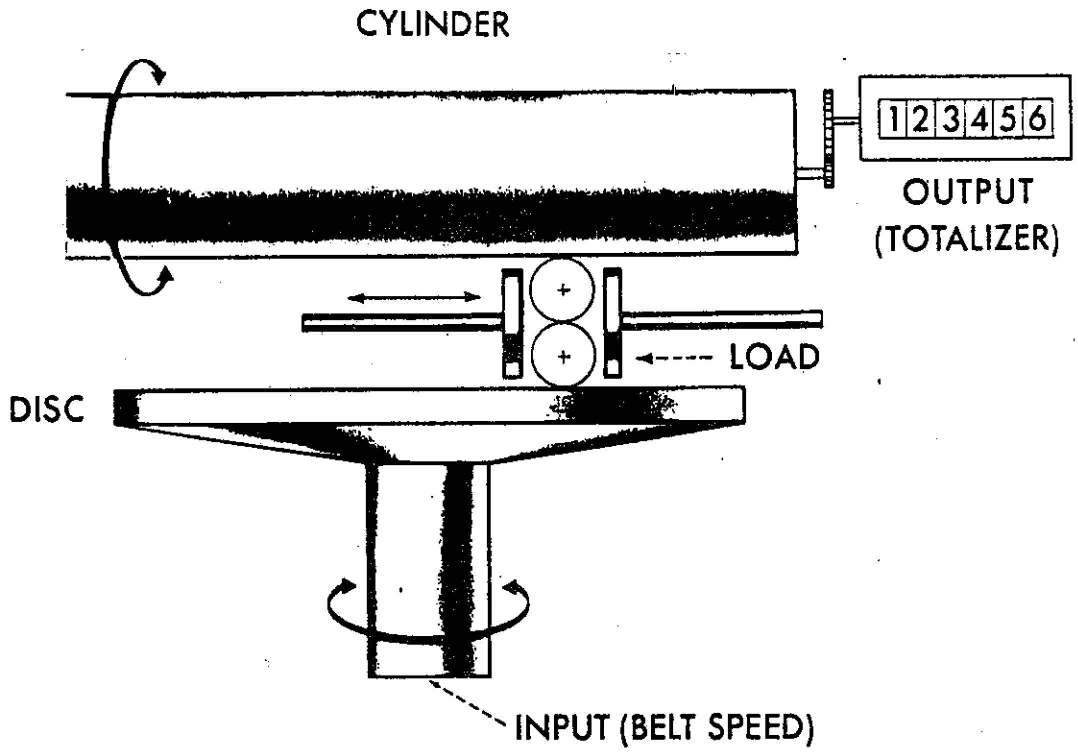


Fig 2(a)

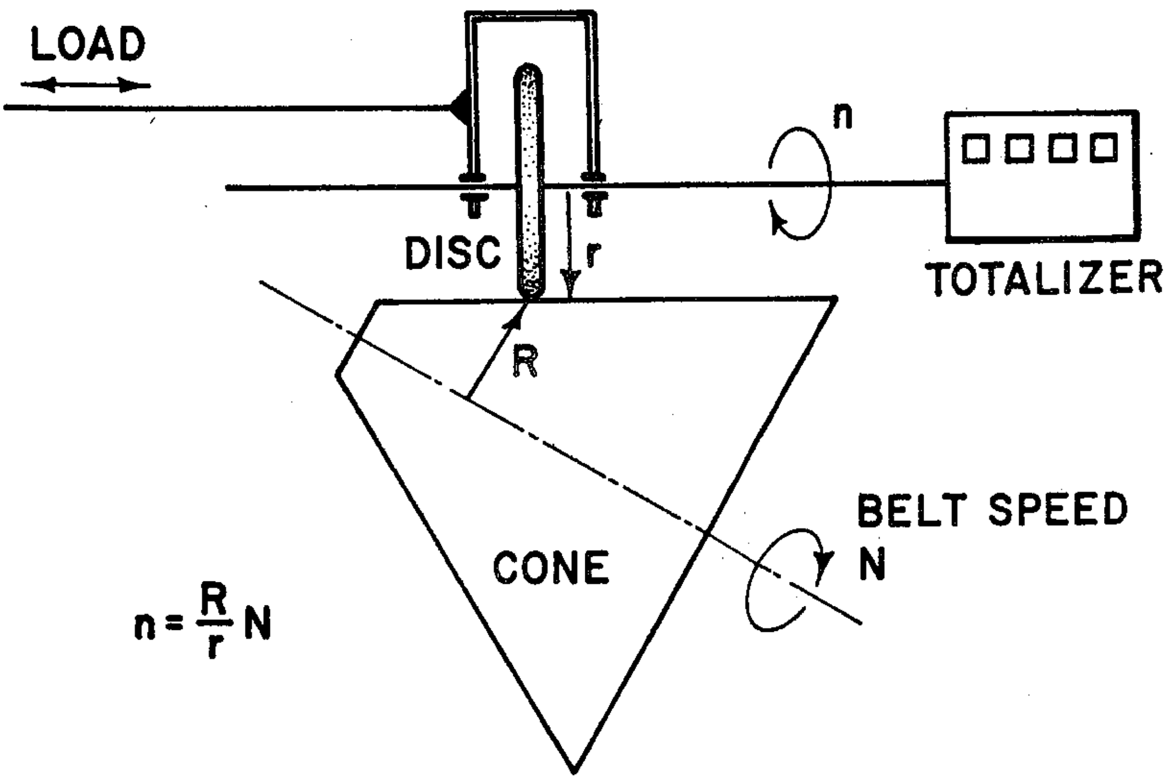


Fig 2(b)

ELECTRO-MECHANICAL (LOADCELL) CONFIGURATION

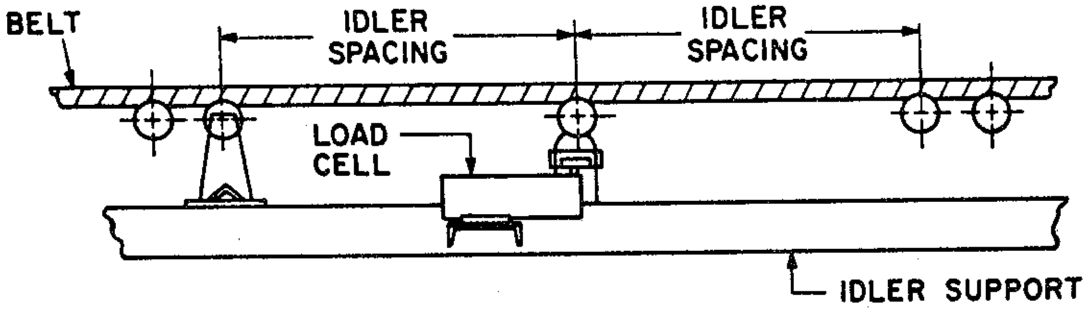


Fig 3(a)

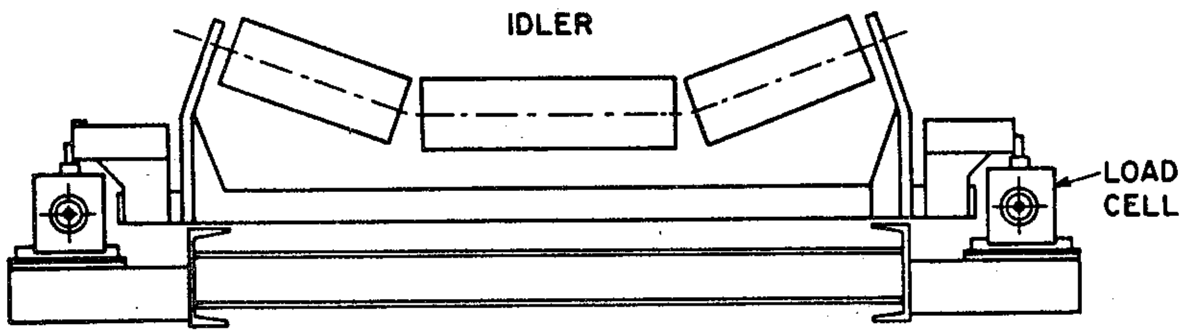


Fig 3(b)

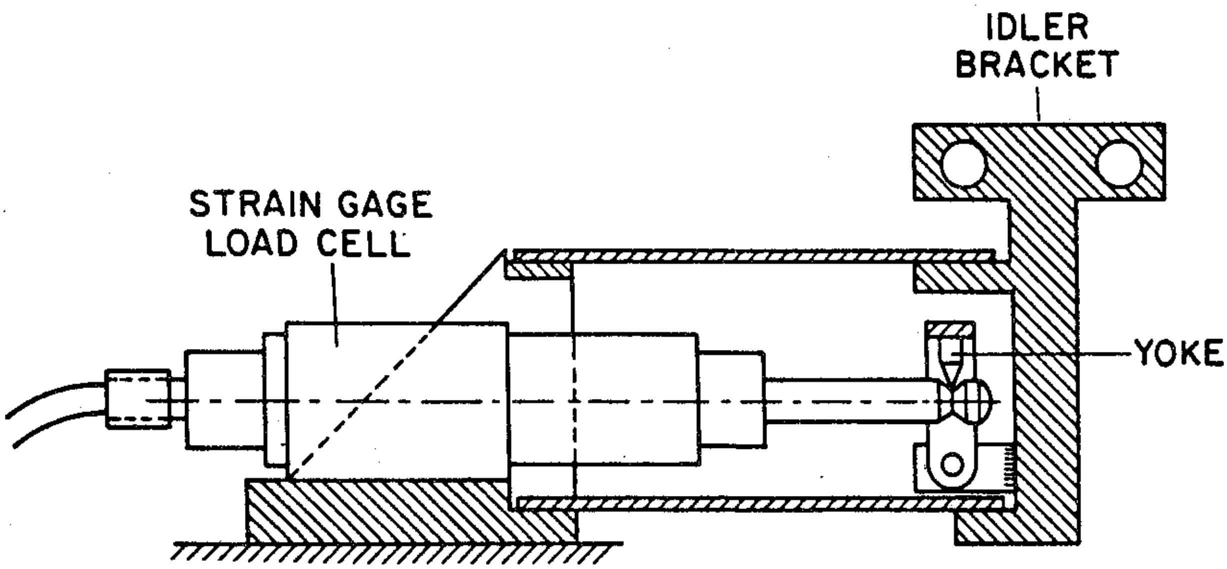
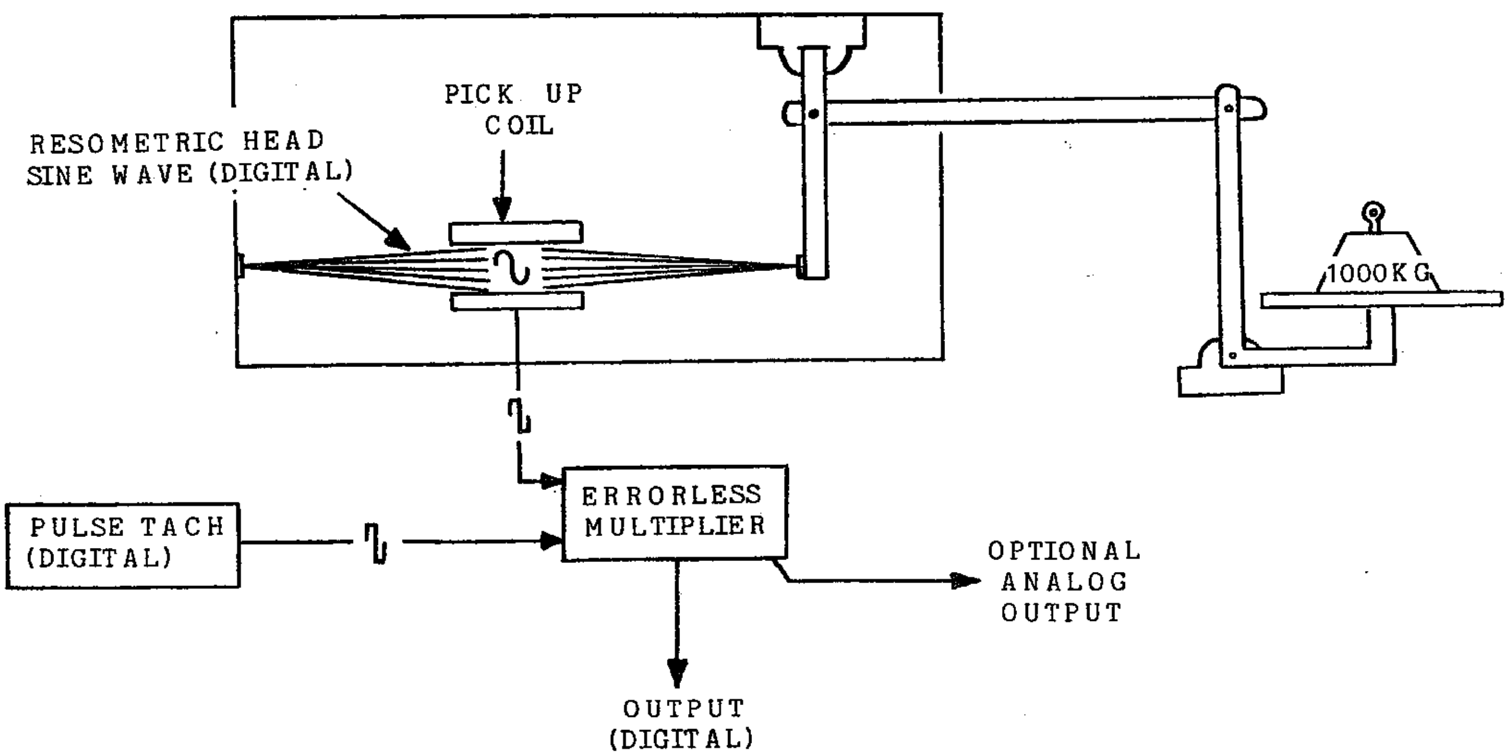


Fig 3(c)

HYBRID (ELECTRO-MECHANICAL) MASSMETER

Fig 4



NUCLEAR MASSMETER

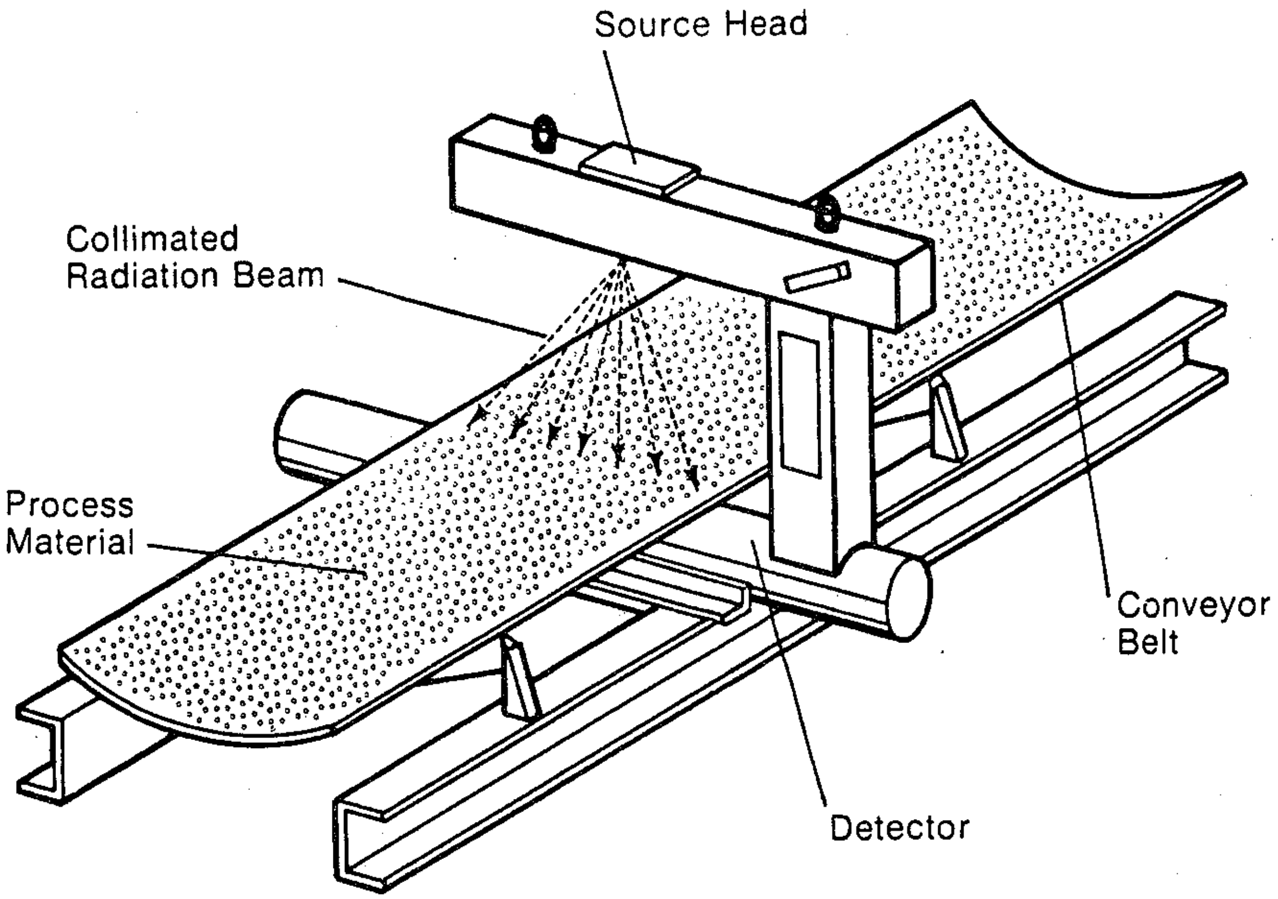


Fig 5(a)

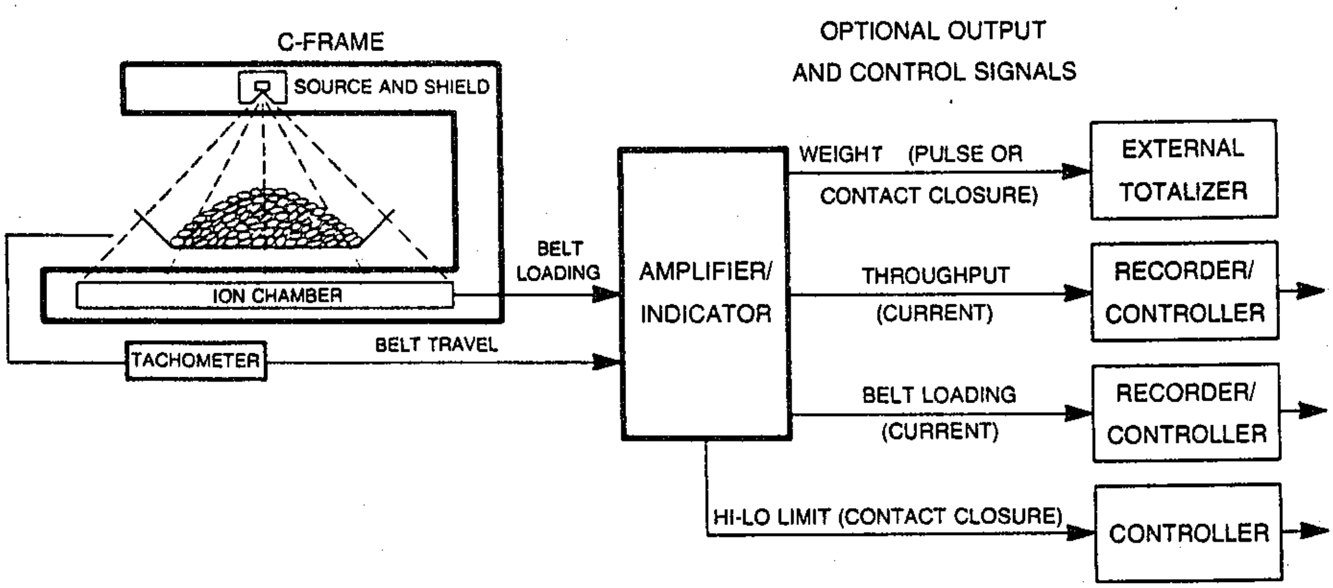


Fig 5(b)

5.2 Electro-mechanical (Load-cell) massmeters (Fig. 3)

Fig. 4 Demonstrates three examples of the use of strain-guage load cells to measure the mass component. Normally the arrangement shown in Fig. 4 (b) is used for payment massmeters. Four load cells support the weigh carriage and the outputs from the load-cells are connected in parallel.

5.3 Hybrid electro-mechanical massmeter. (Fig. 4)

The hybrid massmeter uses a different type of mass determination transducer. The load-cell is replaced by a resonator wire which is kept vibrating at its natural resonant frequency by a magnetic drive. The natural resonant frequency changes as the force applied to the wire changes and the variations of frequency are fed, in digital form, to an electronic multiplier. The principle is shown in Fig. 5.

5.4 NUCLEAR MASSMETERS (Fig. 5)

Nuclear massmeters utilise the principle of absorption of nuclear radiation to measure conveyor belt loading. They have no moving parts, and make no physical contact with the conveyor. Fig. 6 shows the basic configuration of a nuclear massmeter. Because of the non-contact principle, they can be used effectively on non-standard types of conveyor e.g. vibrating, drag chain and airslide, apart from conventional conveyors.

Nuclear massmeters are not assizable at least to the South African Department of Metrology standards due to their inherent non-linearity.

6. ACCURACY OF PAYMENT MASSMETERS.

Accuracy and reliability of massmeters is totally dependant on good maintenance.

6.1 Sources of Error.

6.1.1 Build-up of spillage on the weigh carriage which affects the no-load or zero setting of the massmeter.

6.1.2 Alignment of weigh-idlers with respect to the approach and retreat fixed idlers. During initial installation the assembly is accurately aligned to within millimeters, but time and accidental knocks can seriously misalign the idler sets. A small misalignment can cause serious undetected errors.

6.1.3 Payment massmeters must be fitted with weigh-class idlers which have been manufactured to tight tolerances to reduce excentricities.
Off-set idlers reduce the accuracy of the massmeter and should not be used on payment massmeters.

6.1.4 Weigh Idlers must be sealed units. No grease points are permitted.

6.1.5 The condition of return idlers should be checked to ensure the underbelt is not striking the weigh-carriage.

6.1.6 Only gravity take-up tensioners should be used on on conveyors fitted with payment massmeters.
The belt tension in the weighing area must remain as constant as possible and screw type tensioners are not recommended.

6.1.7 The mechanical structure supporting the conveyor belts and weighing assembly must be free from excessive vibration.

6.1.8 Conveyor belt joints must be vulcanised. The use of steel belt clips causes weighing errors.

7. CONCLUSIONS.

Escom requires reliable and repeatably accurate massmeters. The main source of inaccuracy has been identified as poor maintenance and every effort has been made to educate the personnel concerned with the measuring equipment to appreciate the constraints of weighing in motion.

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