USER'S RESOURCES BOOK

WEIGHING ACADEMY

Weighing History

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Content

1 History of the measurement and comparing of the weight from Antique till today

1.1 Origin of the need of measurement and comparing of the weight

Weighing or comparing the weigh is relayed to the humankind from its very beginning. Already a primaeval man when dividing the food speculated whether he got the bigger and heavier piece of meat than his fellow. And then first quarrels which were solved by the foundation of the weighing method had already begun.

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Picture of people preparing the mammoth

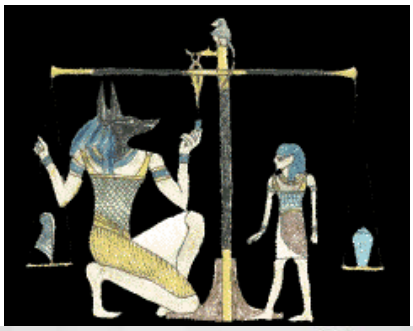
When the time went by, in times when the exchange business started to develop, the need of weighing was sharply developing and the man came to the conclusion that if he does not weigh his products objectively, he will pray on himself.

However, one reason for the introduction of the precise weighing was the collection of different fees, tariffs and taxes in a form of precious metals or in natural form so that he could control how much was money was delivered. In the ancient time the precise weighing was very important, which is proved by paintings on walls of pharaohs crypts and some preserves scales and weight units.

1.2 Types of scales in a history

The very first type of scale was the **isosceles scale,** with the hanging product on its one side and with the weight unit on its other side to reach the balance. According to the summary of each weight unit, the total weight of the product was determined.

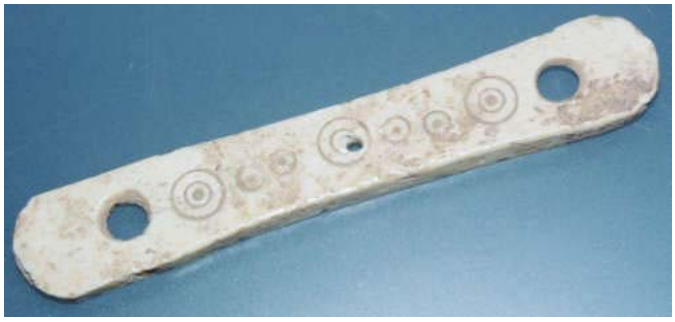
This first type of scale was invented more than 3000 years ago and it can still be seen in different modifications in different independent cultures, which is proved by the discovered scales from different place in the world.



Wall painting in the pyramid

Roma isosceles scale

Two kinds of old Roman scales



Peruvian isosceles scales

Scale for coins

Persian scale with the weight unit in a wooden case

Persian isosceles scale

1.3 Weight unit

Weight units are as old as sales. There was used the lead tin, copper, bronze for weighing in the Antiquity. Sometimes the weight unit was made from big hew-roughly stones. Weight unit used to be made in sets of several pieces.

Persian weight unit

Set of weight unit 2000 years old

Definition of weight unit - Technical educational dictionary 1939

"Weight units in a weighing or scaling meaning are metal bodies of specific shapes that have the certain number of weighing units (gravimetric units). They are used either to weigh unknown weight of some product or to weigh demanded amount on scales (Weight units and adjusting all scales). Weight units are the basic tools for the manufacturing of all types of scales.

1.4 Mass units

1.4.1 Old mass units

We know many different kinds of mass units in which scales and weight units were calibrated. In the old Czech Bible "Kralická" we can find the mention about mass units as follows:

Firstly only gold and silver used to be weighed, other materials used to be measured. There were no coins, just grains, sticks or pieces of metals in various shapes. The base of the scale (mass unit) was **ąekel** (**sikl**), in our bible **lot**, called **lot of sanctuary.** It was kept in a stall as **normal.** 60 lots were one **mina/pound.** 60 pound were **centner** or **hrivna** (**talentum**). In gold a lot has16g, later on it had approximately 11g. Gradually it was counted only 50 lots per libra. In silver the weight was a little lower: lot had 14g, pound had 700g and center had 42g.

In the bible there are listed following scales: (with approximate conversion)
1 **gera** = 0.8g
20 ger = 1 **lot** = 16g
60 lots = 1 **pound** = 960g
60 pound or mins = 1 **hrivna** or **centner** (**talent**) = 58 kg.

From preserved sources we know for example these **ancient** mass units:

- 1 roman pound (as) = 12 uncia = 345 grams

- 1 uncia = 6 sextula = 8 denarius = 24 scrupulus = 28,75 grams

- 1 scrupulus = 2 obolus = 6 siliqua = 1,20 grams

With the development of the business there was a big chaos in using different kinds of mass units. In Europe /except England/ there were made some experiments for unification of mass units. These efforts were not successful and definite unification began with the introduction of Parisian metric convention from 1875 that was accepted by European countries besides Anglo-Saxon countries where remained weighing in other units for a long time.

Before a year 1875 so called **Vienna mass units** were used in the majority of continental Europe.

- 1 karat = 0,000 206 kg
- 1 denar = 0,001 096 kg
- 1 kventlik = 0,004 375 kg
- 1 lot = 0,017 501 kg
- 1 mark (hrivna) = 0,280 668 kg
- 1 pharmaceutical pound = 0,420 045 kg
- 1 customs pound = 0,5 kg
- 1 pound = 0,560 06 kg
- 1 customs cent = 50 kg (10 customs pound)
- 1 cent = 56,006 kg (10 pound)

Examples of other used mass units:
/weighing precious metals and precious stones/

- 1 Vienna hrivna of silver = 16 lots á 4 kventliks
- 1 Vienna hrivna of gold = 24 karats á 12 grans (grains)

English mass units:
/For pharmaceutical scales – Apothecaries weight/

- 20 grains = 1 sruple
- sruple = 1 drachm = 60 grains
- 8 drachm = 1 ounze = 480 grains

/For business scales – Avoridupois weight/

- 16 ounce = 1 pound (pound) = 7000 grains

Note:
In some countries pound is still used as the mass unit (1 pound = 0,453 kg)

1.4.2 Contemporary mass units

Nowadays the basic unit of the SI system is **1 kilo** (kg).
Acceptable derived unites are: microgram (µg), milligram (mg), ton (t).

The *metric convention* was signed by representatives from 17 countries on May 20th 1875. Then, an **International office for weights and measure** was built on its basis in Sévres close to Paris and it was controlled by the International committee for weights and measure. Metric convention came into effect on 1st January 1876. The metric system (because the basic unit was 1 meter) set up by the agreement had only two mass units in that time: **meter** and **kilo.**

Originally the **kilo** was derived just from the meter. It was the weight of 1 dm^3 of clear water at 4°C (at this temperature the water has the highest density). Gradually this derivation was left and there was found the new mass unit, so called **etalon**. This etalon is the international prototype of kilo from which other national etalons are derived.

Prototype of kilo

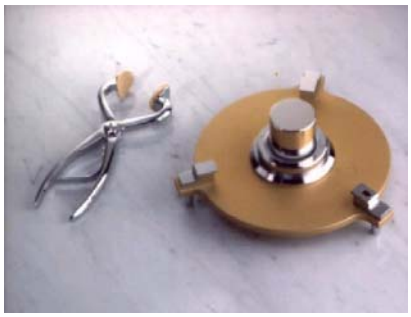
Definition of kilo

Kilo is equal to the weight of international prototype of kilo that is preserved in International office for weights and measure in Sévres close to Paris.

There exist a lot of national/state copies in the world. The prototype of kilo was made from the alloy of platinum and iridium (rate 9:1).

On the etalon there are connected other national etalons (produced with the highest preciseness of weight) that are preserved in various countries, e.g. in the Czech Republic:

ECM 120-1/00-007	**Weight ETALON**	
Category according to the specialization	Quantity	Unit
weight	**weight**	**kilo**
Semi-finished stadium	Value, range	Uncertainty
Approved as the state etalon in CR	**1kg + 0,165 mg**	**0,004 mg**



Etalon is defined as the weigh unit of 1 kilo made from the alloy of platinum and iridium whose value of weight is determined by the connection to International prototype of kilo that is preserved in BIMP (International office of weights and measure) close to Paris. Etalon is realized as the Pt-Ir one kilo prototype, No.67. The etalon = 1 kilo equilateral cylinder from the alloy of platinum and iridium.

1.5 Conversion tabs of weight quantity

(present and historical units)

mark (state)	abbreviation		weight (kg)
kilo	kg	1	
metric cental	q	100	
ton	t	1000	ton is secondary mass unit if SI
metric karat	Kt	0,0002	
metric grain		0,00005	unit used by jewellers

Nuclear mass unit at 1,6605655E-27
(Nuclear mass unit is secondary mass unit of SI, so called unitary unit that is 1/12 of weight of the aluminium isotope with the protonic number Z=6 and nucleon number A=12)

metric technical mass unit 9,80665 also used as **hyl**

keel (UK) 21540,19446656
(Unit used for weight measuring of coal. In a year 1695 it was determined on value of 21,2 long ton or 47 488 pound).

long ton (UK)	ton	1016,0469088
long hundredweight (UK)	cwt	50,80234544
british cental		45,359237
pound	lb	0,45359237
ounce	oz	0,028349523125
dram	dr	0,0017718451953125
grain	gr	0,00006479891
short ton (US)	ton	907,18474
short hundredweight (US)	cwt	45,359237
apoth. scruple	sc.	0,0012959782
stone		6,35029318
troy pound	lb t	0,3732417216

troy ounce	tr oz	0,0311034768
troy dram	dr.	0,0038879346
troy pennyweight	dwt.	0,00155517384
slug		12,7005863598
bes		1

Vienna mass units used in Austrian Empire countries between 1764 a 1876:

vienna cental	56,006
custom cental	50
vienna pound	0,56006

Continuation of conversion:

custom pound	0,5
pharmceutical pound	0,420045
mark (hrivna)	0,56006
mark silver weight	0,280668
vienna lot	0,017501875
postal lot	0,016666...
kvintlik	0,00437546875
sixteenth(denar)	0,0010938671875
Vienna karat	0,000205969

The end of overview of Vienna units

Cental	61,7244
Stone	10,2874
Czech libra	0,51437
Moravian libra	0,56
Silesian libra	0,5298
custom libra	0,5
hrivna	0,25317
fenik	0,001095974
talent (rom.)	40,8233133
as (Italian pound)	0,32832
pondus (Roman)	0,273 (Roman pound)
semis (Roman)	0,16416
triens (Roman)	0,10944
quadrans (Roman)	0,08208
sextans (Roman)	0,05472
uncia (Roman)	0,02736
semiuncia (Roman)	0,01368
scrupulum (Roman)	0,00114
talanton (Greek)	25,75406758386
mina (Greek)	0,429234459731
drachmé (Greek)	0,0042923
obol (Greek)	0,000725747792

(Determined on the basis of weight of the small roman coin)

obolos (Greek)	0,00071538

chalkús (Greek) 0,00009
zentner (German) Ztr 50
(Older German mass unit, it differed according the market on which it was used: 49,9 - 54,4 kg. When the metric system was found, it was determined on the value of 50 kg.)

pfund (German) 0,5
(Older german mass unit (1 zentner = 100 pfund). Previously it was equal to app. 561 g)

mark (German) 0,2805
(Older german unit mark = 1/2 pfund)
pond (Danish) 0,5 older Danish unit
shekel (Israel) 0,0141 1 shekel = 4 rebah.
rebah (Israel) 0,003525 Ancient Hebrew unit
mahnd (Arabian) 0,907 Traditional Arabian unit

Continuation of conversion:

tonelada (Spanish)	919,9	traditional Spanish unit
(1 tonelada = 2000 pounds)		
quintal (Spanish)	45,995	traditional Spanish unit
(1 quintal = 4 arroba)		
arroba (Spanish)	11,49875	traditional Spanish unit
libra (Spanish)	0,45995	traditional Spanish unit
marco (Spanish)	0,229975	traditional Spanish unit
(1 marco = 1/2 pound)		
onza (Spanish)	0,0287468	
tonelada (Portugal)	793,15	traditional Portugal unit
(1 tonelada = 1728 arratels)		

arroba (Portugal) 14,69 traditional Portugal unit
arratel (Portugal) 0,459 traditional Portugal unit (Portugal pound)
libra (Portugal) 0,45904 1 pound = 16 onça
onça (Portugal) 0,02869
libra (Mexican) 0,46039625555
deben (Egypt) 0,091
(basic unit of old-Egyptian system of weighing)

kedet (Egypt) 0,0091
(basic unit of old-Egyptian system of weighing. Later on it was called kite)

gros (French) 0,0003824296875
(Unit valid in France till 1799)

once (French) 0,030594375 1 once = 8 gros
(Unit valid in France till 1799)

marc (French) 0,244755 1 marc = 8 once
livre (French) 0,48951 1 livre = 16 onces
(Unit valid in France till 1799)

tonneau (French) 979,02 1 tonneau = 2000 livres

(Unit valid in France till 1799)

ons (Dutch)	0,1	Dutch unit, today it is equal to 0,1 kg.
bremja (Russian)	4242,52	older Russian unit
tonna (Russian)	2121,26	older Russian unit
berkovec (Russian)	163,792204807	older Russian unit
pud (Russian)	16,3792204807	older Russian unit
funt (Russian)	0,408233133	older Russian unit
lot (Russian)	0,0127572854	older Russian unit
zolotnik (Russian)	0,00425242845875	older Russian unit
dolja (Russian)	0,00004429613	older Russian unit
tovar (Bulgarian)	128	traditional Bulgarian unit (tovar = 100 oka)
oka (Bulgarian)	1,28	traditional Bulgarian unit

(Same unit is used in Turkey and east Midlands)

Continuation of conversion:

tael, tahil 0,0378
(traditional mass unit used in the east part of Asia. During the colonization it stemmed on the value of 37,8 g. In Japan there was used the value of 37,51 g)

maud 37,3242
(Indian unit varying according the area. In times of colonization it was determined on 82,286 libras (1 maud = 40 seer))

seer 0,9331
(Indian unit varying according the area. In times of colonization it was determined by Englishmen on 2,05715 libras)

tola 0,011664
(Indian unit varying according the area. In times of colonization it was determined by Englishmen on 180 grains)

tan (China)	50	traditional Chinese unit; today = 50 kg
jin (China)	0,5	

(traditional Chinese unit 100 jin = 1 tan = 50 kg)

liang (China) 0,05
(traditional Chinese unit. The noted unit is valid nowadays; previously liang 37,8 g)

qian (China)	0,005	noted unit is valid nowadays
kwan (Japan)	3,75	1 kwan = 6,25 kin
kin (Japan)	0,6	

1.6 Other types of scales in history:

With the development of mankind there arose the need of new scales from the following reasons. One reason was the requirement of more precise weighing and the second reason was the possibility of manipulation with the material. Other types of scales are spring scales and range scales.
Spring scale is the scale where, besides the weight of load, there is the push of spring that is deformed and the weight of load is deducted on the scale

Hanging spring scales, so called coiners:

English coiner with two ranges

Range scale is the type of scale where the load is mostly placed on the platform and the weight is through the gear box transmitted on the shoulder of scale with the certain transmission ration. There are weight units hanging on the shoulder or, at the newer types of scales, balancing unit to reach the balance.

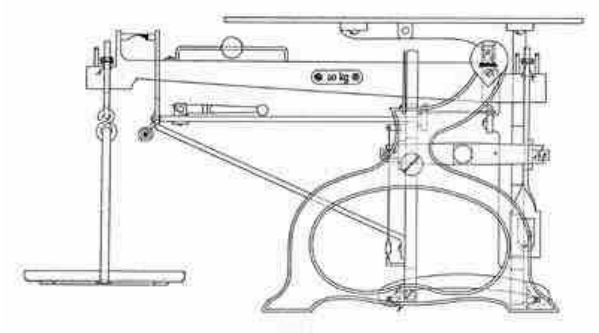
This type of scale is the revolutionary invention because there was no need to use the weight unit as heavy as the load but the lighter weight unit according the transmission ratio. Platform scale is an example of this type of scale with the transmission ratio 1:10 what means that to weigh 200 kg it could be used the balancing unit of 20 kg max. Some of these types of range scales are also used today (mostly scales for high weight)

Scales:

Platform scale from 1900

Official gauge

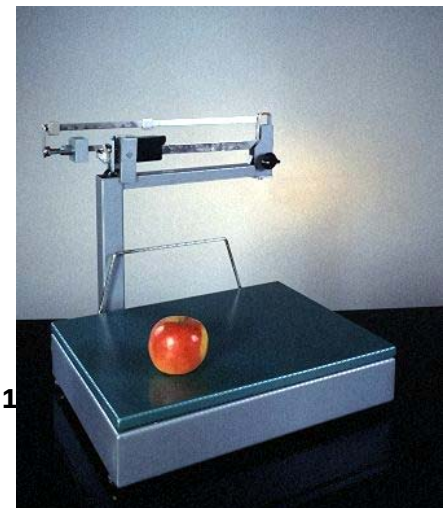
Detail of the balance indicators on platform scale



Scheme of the drawing of the metallic scale.

Some types of range scales are produced in the modern style nowadays. These scales can be used in places without the electric current.

Example of contemporary range scales:



Scale up to 200 kg Scale up to 15 kg

1.7 Preciseness of mechanical scales:

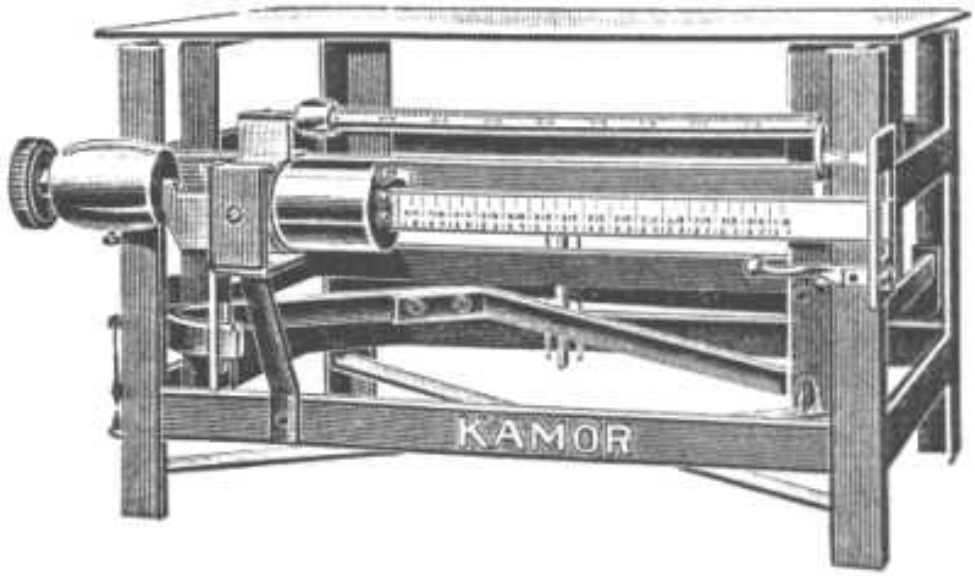
Using the mechanical isosceles scales and range scales the maximum preciseness is influenced by the construction of the scale and the exactness of balance weight units. In general we can say that the maximum reproducible exactness is in the range of 1000 to 2000 of parts when using the best mechanical scales.

It means that the range of scale, e.g. 200 kg is divided either into 1000 or into 2000 parts.

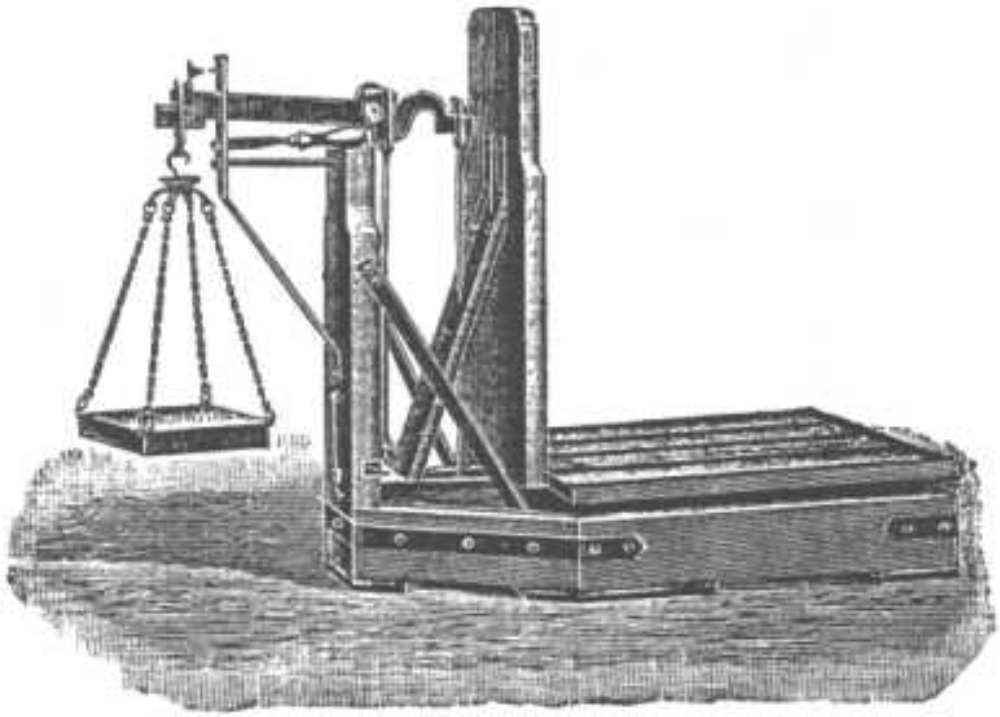
Example: scale 200 kg 1000 parts part 200 grams e.g. 0,1%

Mechanical scales are produced only occasionally. Besides the specific types of mechanical scales, mostly electronic scales are used.

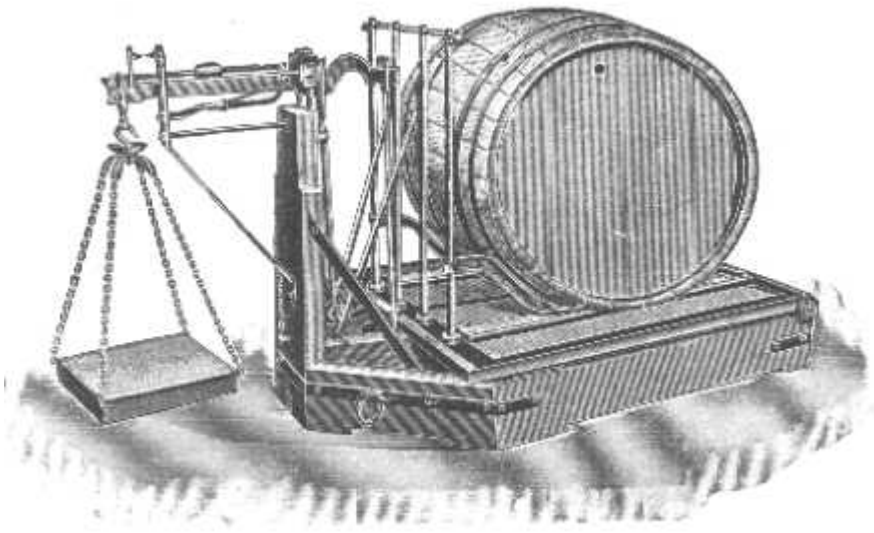
1.7.1 Different types of mechanical scales in history:



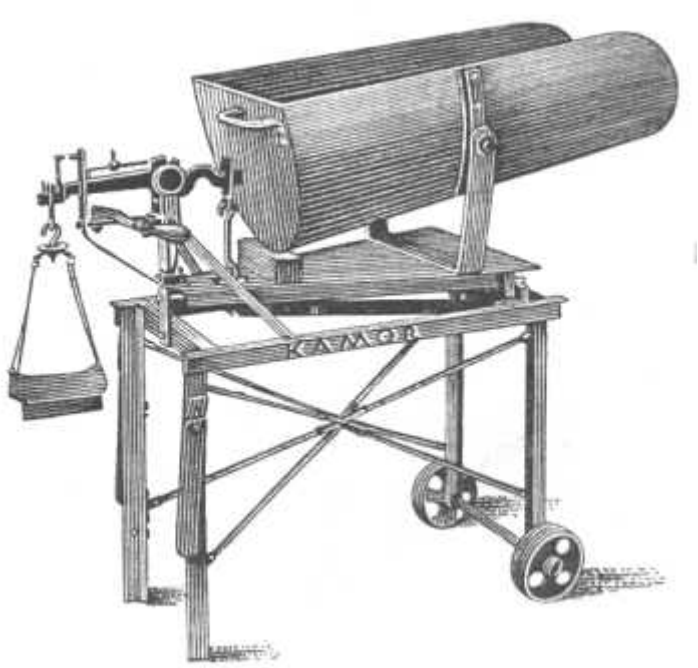
School sample of a scale



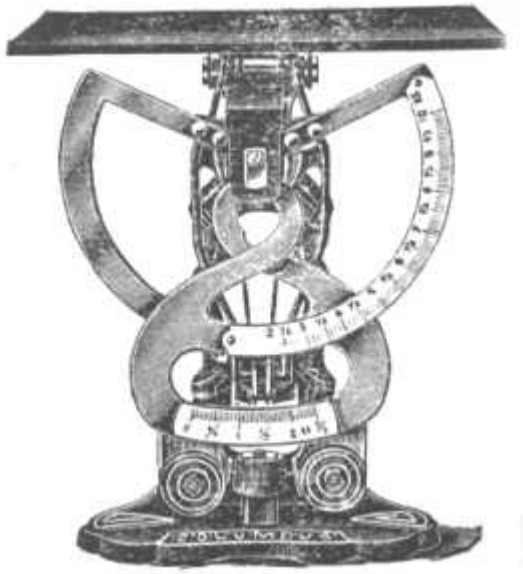
Classical platform scale



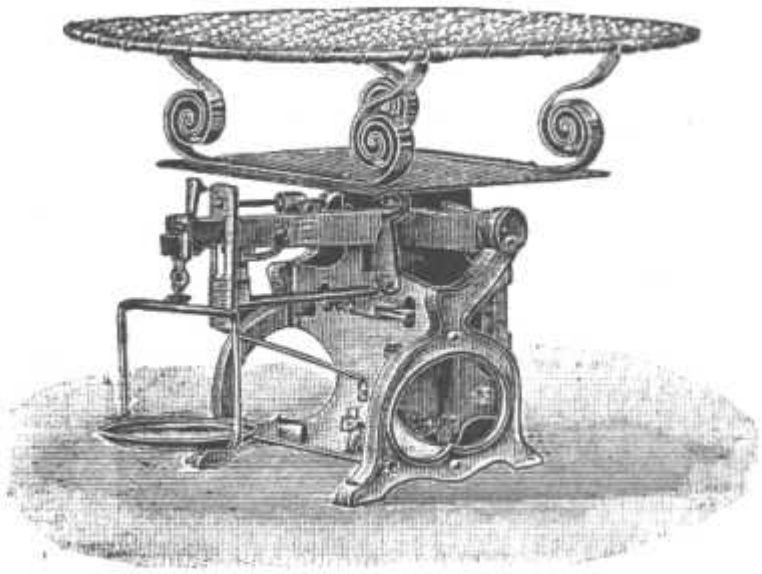
Scale for barrels



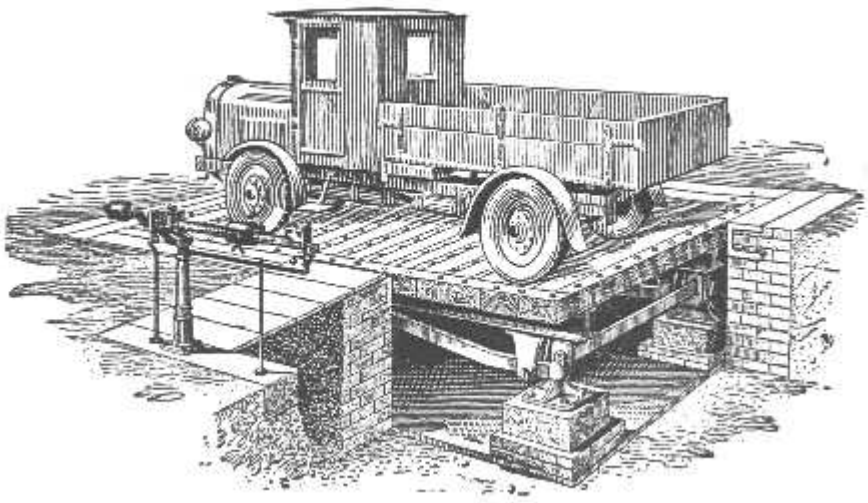
Scale for crops (e.g. potatoes) enabled easy pouring into the bag or basket



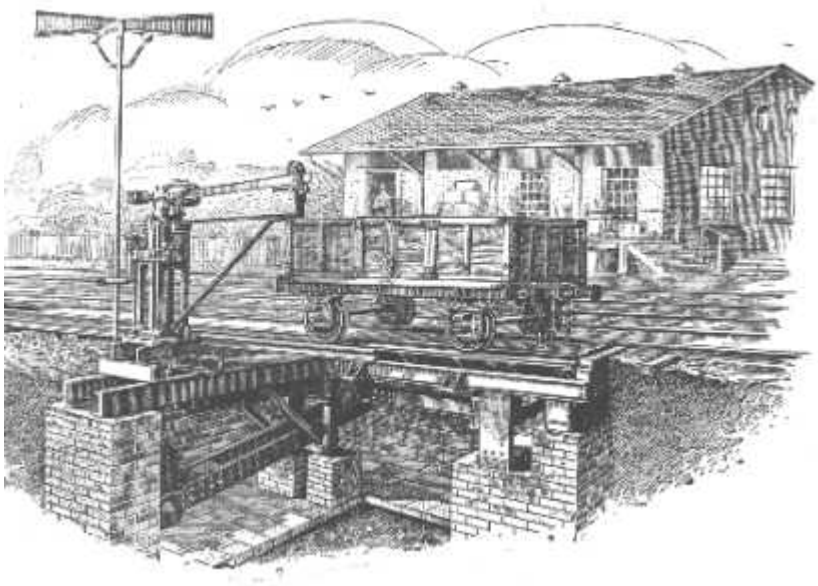
Scale for letters and packets



Scale for weighing infants and babies



Scale for cars



Scale for wagoons for Austrian-Hungarian railways

1.8 Electronic scales:

With the development of the electronics in turn of seventieth and eightieth of 20th century there was a push of electronic scales that can reach the higher preciseness and bring much more comfort to users (electronic tara of packages, possibility to print weighing protocols, connection to control systems). It was a boom of electronic scales. First type of electronic was electro-mechanic scale that combined the mechanic connection with electronic evaluation. Nowadays due to the mass production of modern components used for the assembling scales there exist hundreds of producers manufacturing different models of electronic scales thorough the world. These scales are incomparably precise than mechanical scales and more economically effective although the production requires the very neat and soft work.

1.8.1 Preciseness of electronic scales:

Using electronic scales, the reachable preciseness of weighing is very high if respecting external conditions.

Analytical and laboratory scales:

Using the extraordinary precise **laboratory scales**, the exactness of weighing (differentiation) is more than 200.000 parts on the scale range.

The very precise is laboratory analytical scale Mettler AT261 DELTA RANGE

Industrial scales and scales used in shops are usually with the preciseness (differentiation) of 3.000 – 10.000 parts in a scale range which represents exactness more than 0,05%. The electronic scales enable the extension of accuracy by the use of multi-range scales, the value of the units then depends on the range.

Example: (two-range counter scale for weighing meat)
Maximum weight is 15 kg. One part is 2 grams in a range between 0 - 6 kg, one part is 5 grams in a range 6 -15 kg.

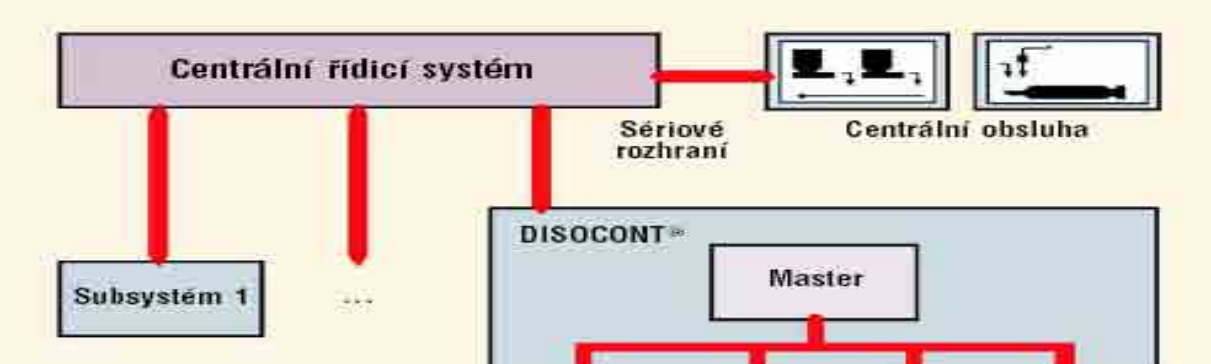
Two-range counter scale Athéna

1.9 Progression trends:

One of the biggest trends in the area of weighing is the trend heading to the complex processing of weighing data using special software that is legalized as the integral part of the weighing equipment. Scales are connected into networks and via access interfaces communicating with control systems that regulate all producing processes due to the various feedbacks. Communication between scales it today realized also through the wireless transfer by the coded transmitters or by the broadcasting via GSM portal.

Monitoring, inputs and outputs of these processes can be observed by the Internet. New models being prepared have the direct integrated Internet interface that enables for example sending error messages about the stadium of the weighing equipment towards the service organization much earlier than errors show critical and before they put the scale out of operation. In case of scales with internal special software, it will be possible to tune the scale in the remote way without personal assistance. This will bring substantial savings on time and travel costs.

Example of the proceeding with the system SHENCK DISOCONT MASTER



An example of weighing Software screen of SCHENCK company which is legalized thorough the whole Europe as the part of the scale (appointed measure) for weighing in shops. Software is installed in a regular computer but its structure and accessible privileges do not allow change data received by weighing by the usual operations of users.

The weighing discipline (better an accurate electronic measuring of weight) is the dynamically increasing discipline with the high prosperity into the future.

1.9.1 Test

magine you live in the Antiques. For your work you got obulus. What was the real weight of coin of 1 obulus?

What weight unit you have to put on the basin of the platform scale to reach the balance if there is the material of 137 kg?

Who invented the isosceles scale and when?

From which year mass units were unified in continental Europe?

What is the weight of English gentleman if you can see 187 lb (pound) on the English scale?

When was the end of the manufacturing of mechanical scales?

Which from these units do not belong to the SI system: pound, kilo, metric cent, ounce, milligram, ton, karat or grain?

Explain the principle of the isosceles scale.

Explain the principle of coiner.

Explain the principle of the platform scale ?