FACULTY OF ENGINEERING

DESIGN AND PRODUCTION ENGINEERING DEPARTMENT

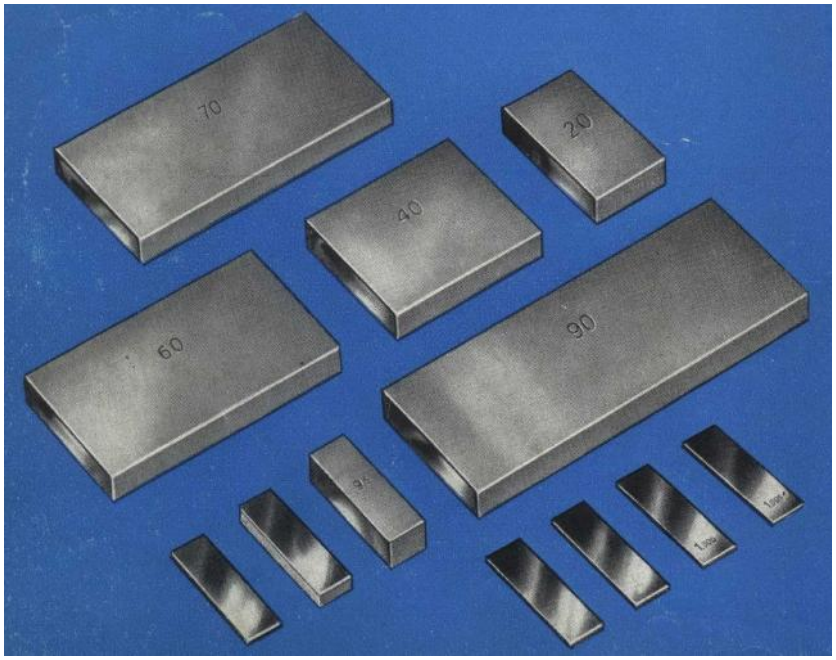
Credit Hour System

Metrology Lab 1 – MDP 240

Report On:

(2)

Gauge Blocks



Metrology laboratory

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Prepared by: Dr. Mohamed Ahmed Awad

Gauge Blocks

The Origin of Gauge Blocks

The earliest type of length standard was known as the Polhem Stick so named after the Swedish inventor Christopher Polhem. The exact date of his invention is unknown, what is known is that sticks of this type were in use prior to 1700. This in itself is somewhat unusual as at that time there was no requirement for the early locksmiths, clockmakers and the like to make anything other than parts that fitted together on an individual basis as no interchangeability was ever considered.

The mass production armaments factories in the 19th century and the requirements of interchangeability of, in particular the firing mechanism that often failed in the battlefield, lead to the inevitable introduction of gauges for all stages of manufacture. Unfortunately this also resulted in the production of many thousands of gauges and so the problem of interchangeability remained, in that there was no record of which gauge had been used to produce what firing mechanism for what weapon. This was by no means a problem that was limited to England and Europe in the United States of America the problem was highlighted during the Wars of Independence and the Civil Wars between the North and the South.

In 1894 the Swedish State placed a large order for the manufacture of Rifles from the German Mauser Factory. The weapons ordered were to be inspected by a commission set up by

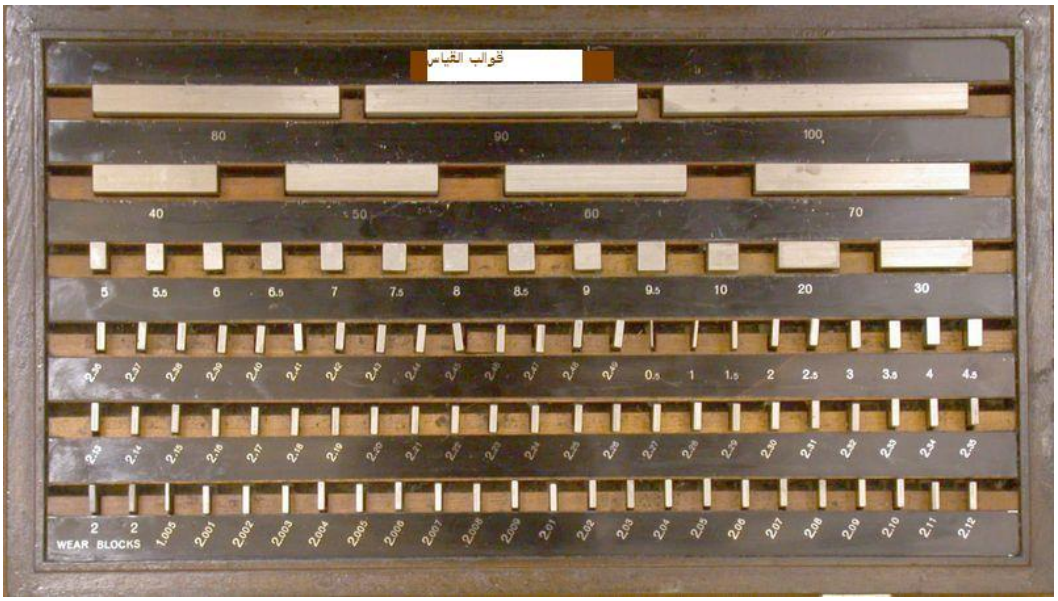
the Swedish State and a member of this commission was the armourer inspector Carl Edvard Johansson. When C.E. Johansson saw how things were arranged at the Mauser Factory, he realised that many thousands of gauges would be required to be manufactured before the Rifles could be made in Sweden. So upon completion if his commission in 1896 and during his return journey home he had the opportunity to consider and idea that he had for a relatively small number of gauge blocks that might possibly be made so that in combination with each other they would provide all the measurement figures required in the manufacturer of rifles. Thus the revolutionary idea of - The Combination Gauge Block Set - was conceived.

Block (or slip) gauges are often called *Johannsen* after the name of the one originated them.

Material: Slip gauges are made of hardened alloy steel (62 RHN) of the highest volumetric stability, hardness, and resistance to abrasion. It must also resist corrosion satisfactorily.

Shape and dimensions: A gauge block is a fixed gauge having the shape of a right parallelepiped or a cylinder with two flat parallel measuring faces; as shown in the figure. The opposite faces are lapped flat and parallel to definite thickness within tolerance of 0.02 μm.

They are made in sets of almost the same rectangular cross-section (9x30mm) but of different thickness to enable building up of any dimension within its ranges.

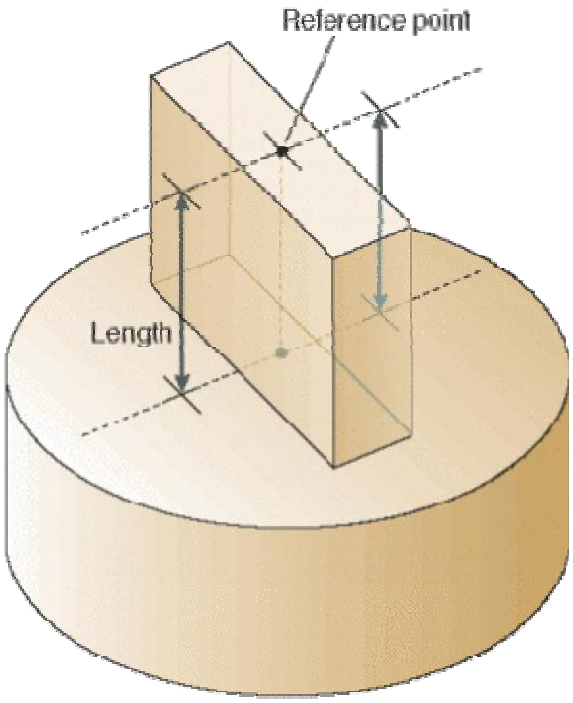


Treatment of the gauge blocks: They are first hardened to resist wear and carefully stabilized so that they are independent of any subsequent variation in size or shape. The longer gauge in the set and length bars are hardened only locally at their measuring ends.

After being hardened, the blocks are carefully finished on the measuring faces to such a fine degree of finish, flatness, and accuracy that any two such faces when perfectly clean, may be wrung together (Steps of wringing are fully explained later).

It is found that the phenomenon of wringing occurs due to molecular adhesion between a liquid film (whose thickness may be between 6 and $7*10^{-6}$ mm) and the mating surfaces. When two gauges are wrung together, they adhere so that considerable force is necessary to separate them. The overall dimension of a pile made of two or more blocks so joined is exactly the sum of the constituent gauges. It is on the property of wringing units together for building up combinations that the success of system depends since by combining gauges selected from a suitably arranged combination. Almost any dimension may be build up.

Measuring faces: The top measuring face is that face on which the size is marked. If such marking is on a side face, then the right hand measuring face is the one which forms the right hand boundary of the surface on which the size characters are marked, assuming that the characters are upright to the observer.



Grades of Slip Gauges:

Four sets of different classes (grades) are available:

Grade AA (grade 00) for high scientific accuracy and for reference.

Grade A (grade 0) for calibration purposes.

Grade B (grade 1) for inspection purposes.

Grade C (grade 2) for general workshop use.

The accuracy of different grades is such that if the accuracy of the workshop grade is unity, then the other is twice, three, and six times that of the workshop respectively.

The grades could also be designated as:

i) Reference grade

ii) Calibration grade

iii) Inspection grade

iv) Workshop grade

Slip gauges are available in sets; both in inch and metric units. The five usual sets available in inch units contain 81, 49, 41, 35 and 25 pieces respectively.

For example, in the 81-piece set, the slip gauges are arranged in the following order:

No. of pieces	From	To	Step
9	0.1001″	0.1009″	0.0001″
49	0.101″	0.149″	0.001″
19	0.050″	0.950″	0.050″
4	1.000″	4.000″	1.000″

Slip gauges provide means for building any length standard up to 450mm or 12″ by wringing the blocks together.

Building up size combination:

Any dimension should be built up with the smallest possible number of blocks. Thus the number of joints, and accordingly the sources of errors can be reduced. This can be done by starting with the selection of the gauge block that provides the smallest decimal of the required length.

Measurement done in the lab: An experiment was done to measure the diameter of a double end plug gauge, using the inch units. The diameter measured was estimated to be around 2″.

Trial number	Estimated size	Blocks used				Result
		1st	2nd	3rd	4th	
First trial	2″	2″	_____	_____	____	Larger
Second trial	1.99″	0.14″	0.15″	0.7″	1″	Smaller
Third trail	1.995″	0.145″	0.85″	1″	____	Smaller
Forth trail	1.9975″	0.1005″	0.147″	0.75″	1″	Smaller
Fifth trial	1.9995″	0.1005″	0.149″	0.75″	1″	Fitting

An example of the calculations done for this measurement is shown:

To measure 1.9995″

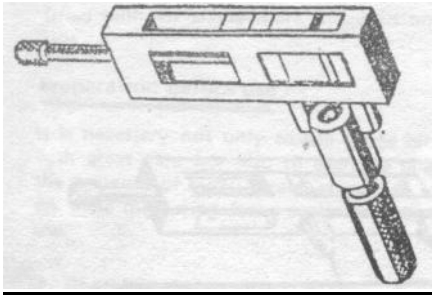
1.9995″

Used size	0.1005″
remainder	1.8990″
Used size	0.149″
remainder	1.75″
Used size	0.75″
remainder	1″
Used size	1″
Remainder	0

Practical use of slip gauges:

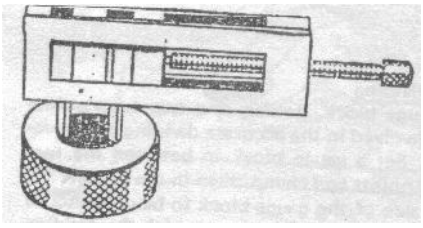
.Outside measurement

A gauge block, holder, plain and half round jaw are involved in the outside measurements. Set a gauge block in between two jaws and clamp them in the holder. The reliability of the measurement depends upon how nearly the combination duplicates the distance between the reference and measured points (the distance between the two jaws). To have an accurate measurement, change gauge blocks until the workpiece to be measured can be felt tight enough between the two jaws and there is no perceptible wobble whatsoever.



.Inside measurement

A gauge block, holder, and two half round jaws are involved in inside measurements. Set a gauge block in between the two jaws and clamp them in the holder. The jaws are of known thickness that is added to the calculations of the length.



Preparation before use

Necessary aids for using gauge blocks:

Name	Function
Soft linen cloth, lint-free tissue, clean chamois leather.	Used as an underlay on a surface plate, to wipe off rust-polishing oil and to clean the measuring surfaces.
Solvent	To remove the rust-polishing oil.
Optical flat	To inspect the measuring surfaces of gauge block for burrs, flatness and wringing condition. Measuring surface of the flat is identified by an arrow mark engraved on the side.

Checking the burrs with an optical flat:

Apply any solvent such as benzene on the measuring faces of optical flat and gauge block, wipe dry with a lint-free tissue. An optical flat is slightly pushed on the measuring face of a block. Burrs can be detected and located with fringes. If the fringes disappear when the optical flat is firmly pushed on, the measuring face of the block is free from burr. Fringes will be located just around the burr.

Fringes as shown in the figure can be detected even if dust exists in between the block and the optical flat. In order to tell if the fringe is caused by dust or by burr, slide the optical flat slightly. If the fringe remains unmoved, the block has burrs. If the fringes move

with the optical flat, then the fringe owes to an inferior surface or burrs of the optical flat.

The burrs on the surface of a gauge block can be removed by rubbing it firmly on an Arkansas stone. This procedure will not produce any dimensional wear of the block.

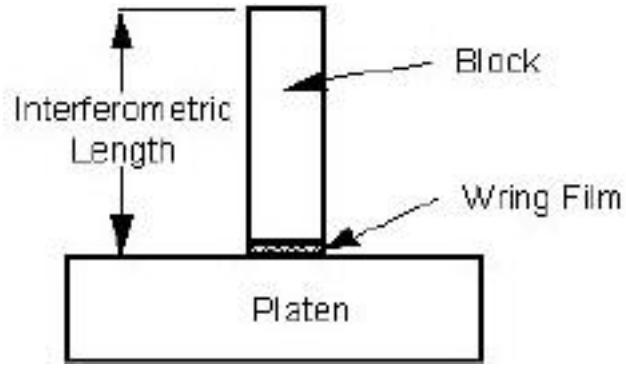
Cleaning before wringing:

The gauge blocks are treated above a leather sheet with a clean cloth. A blower hairbrush may be used to remove the dust that will settle on the measuring faces if there is a delay before wringing the cleaned blocks.

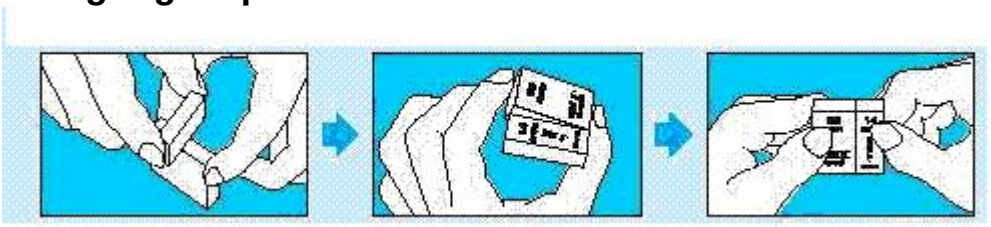
It is preferred that gauge blocks are placed on a heat sink. This is a surface that helps the blocks to reach the ambient temperature.

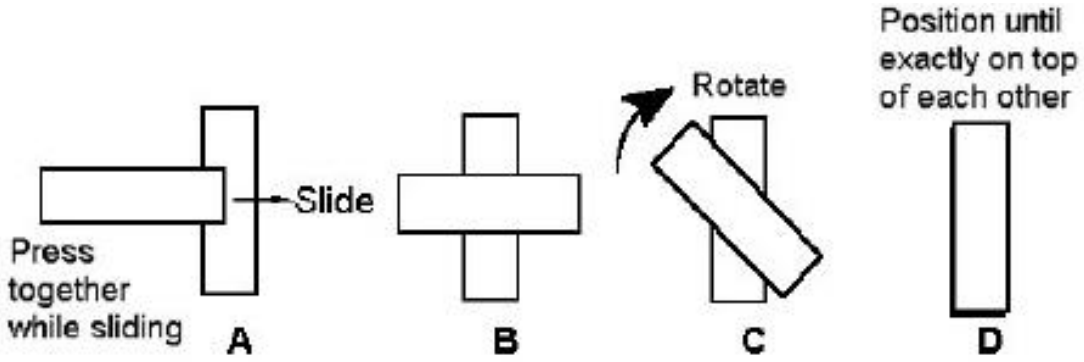
Wringing gauge blocks

If two sufficient flat and smooth surfaces are brought intimately together, they will adhere. This is *wringing*.



Wringfing steps





Wringing of comparatively thick gauge blocks:

Bring the gauge blocks into slight contact at right angles as shown in the figure.

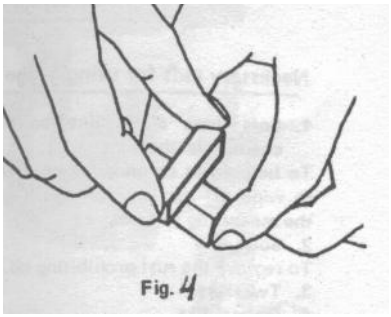


Fig. 4

While pressing blocks slightly together, turn them through 90º. Slide the blocks from side to side each other under light pressure until wringing begins to take place, as shown in the figure.

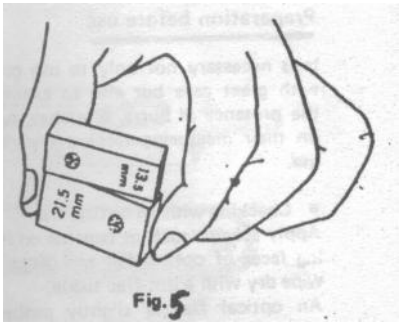


Fig. 5

Be sure that the gauge blocks wrung satisfactorily by pulling them as shown in Fig.

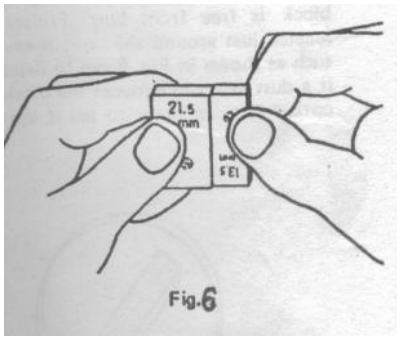


Fig. 6

***B-Wringing of thin gauge blocks*:**

Thin gauge blocks are likely to bend by wringing force when two thin gauge blocks are wrung together without any supporter. In order to avoid this, use a thick block that is hardly bent, as a base on which thin blocks are wrung to build up a required dimension. The thick block is removed after the required dimension is built with thin blocks.

Wringing Steps

- Overlap the edges of measuring faces giving a light pressure and when wringing begins to take place; Fig 7),

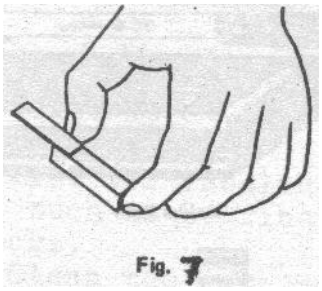


Fig. 7

Slip one over other pressing lightly together; (Fig. 8)

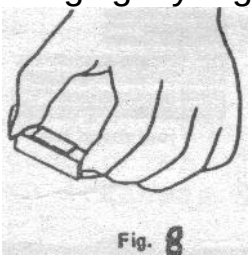


Fig. 8

- Wipe clean with lint free tissue the measuring face of the wrung thin block; (Fig. 9)

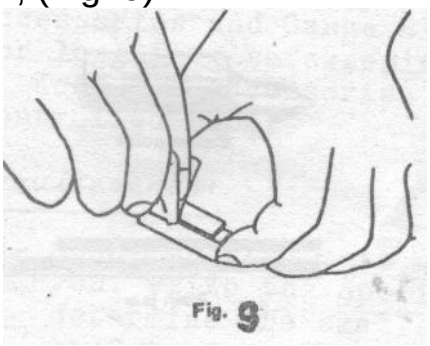


Fig. 9

and push an optical flat on the measuring face to check if the wringing is satisfactory without any bending; (Fig. 10).

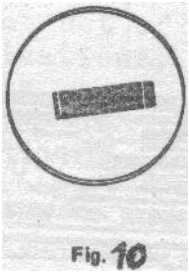


Fig. 10

- Wipe clean the measuring face again, and wring another thin block; Fig 11 checks the measuring face with optical flat bending.

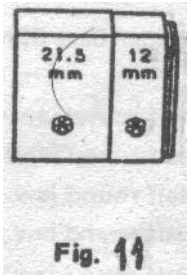


Fig. 11

- Slide and remove the thick block used as a base.
- Leave the wrung blocks on a surface plate or a heat sink for thermal stabilization as shown in Fig. 12.

Fig. 12

- Wringing can not be expected with gage blocks unless the blocks have sufficient flatness smooth surfaces free from burrs, scratches or dusts. The greatest care should be taken in using gauge blocks not to give rise to burrs, bruises, or rust on their measuring faces.
- The blocks should never be left wrung together for any length of time. Slide the blocks apart.

Gauge Block Accessories

Gauge Block Accessories are especially manufactured to extend the high accuracy of gauge blocks into the field of fast accurate temporary gauging. They are popular in inspection departments, tool rooms, machine shops and on small batch production.

Gauge Block Holders

The gauge block holders are hand made to assure burr free side and fixing faces. The rack pattern locating grooves provide rapid adjustment and prevent the gauge block combination from slipping or moving. Available with capacities up to 1000mm

Radiused Measuring Jaws

With cylindrical shoulders for inside or outside measurements, normally supplied as pairs with combined diameters ranging from 4mm to 40mm.

Control Points, Scriber, Centre Point and Knife Edge Jaws

Control Points

For checking exact distances between lines and points.

Scriber

For marking accurate heights.

Centre Point

To make up of marking compasses.

Knife Jaws

For measuring recessed external diameters

Plain & Parallel Jaws

For out side and inside measurements (Plain Parallel Jaws and not internal diameters)

THE EXPERIMENT

Main Objective

To study the different set of slip gauge Blocks, specifications, grades and their applications.

Apparatus

Two sets of slip gauges Blocks;
Accessories of gauge blocks;
Surface Plate
Optical Flat
Rust Prohibiting Oil
Solvent
Soft Cloth;
Arkansas Stone;

Requirements

1. *Study the two sets of slip gauges blocks given to you. Write the specification of each of them and determine the smallest and largest size that can be formed by them.*

2. *Write the different grades of slip gauges and the uses of each type*

3. *Use the given slip gauge blocks to build up the following standards:*

1. **24,999mm**

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.....

.....

3. **39,063mm**

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.....

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2. **1,502mm**

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.....

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4. **83,313mm**

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Explain the correct method of wringing slip gauges and state wringing film. Also, state the factors that should be observed to protect the gages against wear, damage and incorrect usage?

4 *Show by means of neat sketch the accessories of slip gauges, Name of each and state the function of each of them.*

5 *Use the slip gauge blocks, holders and the correct jaws to measure the external and internal dimensions of the given product.*

6 *Write briefly the types and the sources of measuring errors and how to minimize them during measurements.*

7 *If the coefficient of thermal expansion of the measured part is *$10^{-6}/^{o}c$*, read the ambient (lab.) temperature and calculate:

The actual dimensions of the part at standard room temperature ($20^{o}C$).

The minimum and maximum dimensions of the part if it will be observed in working temperature between ^{o}C and ^{o}C

Results & discussion

Appendices

The Care and Use of Gauge Blocks

British Standard Reference : BS 4311 : Part 3 : 1993

General Use.

The greatest care should be exercised in protecting the gauges and their case from dust, dirt and moisture. When not in use, the gauges should always be kept in their case and the case should be kept closed. The gauges should be used as far as possible in an atmosphere free from dust. Care should be taken that the gauges do not become magnetized or they will attract ferrous dust.

Preparation before Use.

If the gauges are new or have been covered with a protective coating after being last used, most of this coating may be removed with an appropriate solvent (dewaterised mentholated spirits for example). Gauges should finally be wiped with a clean chamois leather or soft linen cloth. This wiping should be carried out in every instance before a gauge is used, irrespective of whether it has been stored, coated or merely returned temporarily to the case uncoated.

It is, however, undesirable to aim at removing all traces of grease since a very slight film of grease is an aid to satisfactory wringing.

Care in Use.

Fingering of the lapped faces should be avoided to preclude the risk of tarnishing and unnecessary handling of the gauges in use should be avoided lest they take up the heat of the hand. If the gauges have been handled for some time they should be allowed to assume the prevailing temperature of the room before being used for test purposes. This is particularly important in the case of the larger sizes.

When the highest accuracy is required, a test room thermostatically controlled at the standard temperature at $20^{o}C$ becomes necessary, but for ordinary purposes a sufficient degree of accuracy can be obtained if the following precautions are taken.

The work to be tested and the gauges blocks which have to be used should both be allowed to assume the prevailing temperature of the room.

Thus, a piece of work should not be tested directly after a cutting, grinding or other operation has just been completed nor should large combinations of gauge blocks be used immediately after they have been wrung together.

Wringing.

Gauges should not be held above the open case when being wrung together lest one is accidentally dropped. The gauges required should be selected and the case then closed.

Before wringing gauges together, their faces should be wiped free from dust and examined for burrs.

Ensure that the Gauge Block faces are cleaned immediately prior to wringing.

Gauge Block 'stacks' up to and including 50mm should be wrung together by bringing the faces into contact at right angles to each other, applying to a minimum pressure at his centre and then turning them through 90 degrees. Always wring the smallest length Gauge Block to the next size up when building up a Gauge Block 'stack'.

When wringing larger Gauge Block 'stacks', place the largest gauge onto a firm level surface. Bring the next size down into contact approximately 30 degrees out of true abead below the centre of the larger Gauge Block, apply a minimum downwards pressure and slide the smaller Gauge Block onto the larger Gauge Block.

If the Gauge Blocks are in a good condition, the wring will take place quite easily.

If during wringing any resistance or scratching is noted, then the Gauge Blocks in question should be examined for contamination, burrs or scratches. Damaged gauges should be returned to the manufacturer for refurbishing/replacement.

Damaged Gauges.

Damage to the gauges is most likely to occur on the edges, resulting from the gauge being knocked or dropped. Such slight burrs may be removed with care by drawing an Arkansas type stone lightly across the damaged edge in a direction away from the measuring face of the gauge. Any gauges so treated should be thoroughly cleaned before wringing.

A gauge with a damaged measuring face should preferably be returned to the manufacturer for the surface to be restored.

Care after Use.

The gauges should never be left wrung together for any length of time. Slide the gauges apart; do not break the wringing joint between them.

Immediately after use each gauge should be wiped clean and be replaced in its proper compartment in the case. It is particularly important to remove any finger marks from the measuring faces.

If the gauges are used infrequently they should be coated with a suitable corrosion preventive before being put away. The preparation should be applied to the faces with a clean piece of soft linen. A brush should not be used as this may aerate the preparation and moisture in the air bubbles so formed can cause rusting of the faces.

Building Up a Size Combination.

Where protector gauge blocks are provided, these should be wrung to the two end gauges of the size combination and must of course be allowed for in determining the blocks to be used.

<0.001" divisions								
0.1001	0.1002	0.1003	0.1004	0.1005	0.1006	0.1007	0.1008	0.1009

0.001" divisions									
0.101	0.102	0.103	0.104	0.105	0.106	0.107	0.108	0.109	0.110
0.111	0.112	0.113	0.114	0.115	0.116	0.117	0.118	0.119	0.120
0.121	0.122	0.123	0.124	0.125	0.126	0.127	0.128	0.129	0.130
0.131	0.132	0.133	0.134	0.135	0.136	0.137	0.138	0.139	0.140
0.141	0.142	0.143	0.144	0.145	0.146	0.147	0.148	0.149	

0.05" divisions									
0.050	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.450	0.500
0.550	0.600	0.650	0.700	0.750	0.800	0.850	0.900	0.950	

1" divisions			
1.000	2.000	3.000	4.000

two 0.050" wear blocks

· The metric set has 88 gauge blocks (in mm),

<0.01mm divisions								
1.001	1.002	1.003	1.004	1.005	1.006	1.007	1.008	1.009

0.01mm divisions									
1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10
1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20
1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30
1.31	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.39	1.40
1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.48	1.49	

0.5mm divisions									
0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	

1cm divisions								
10	20	30	40	50	60	70	80	90

two 2mm wear blocks