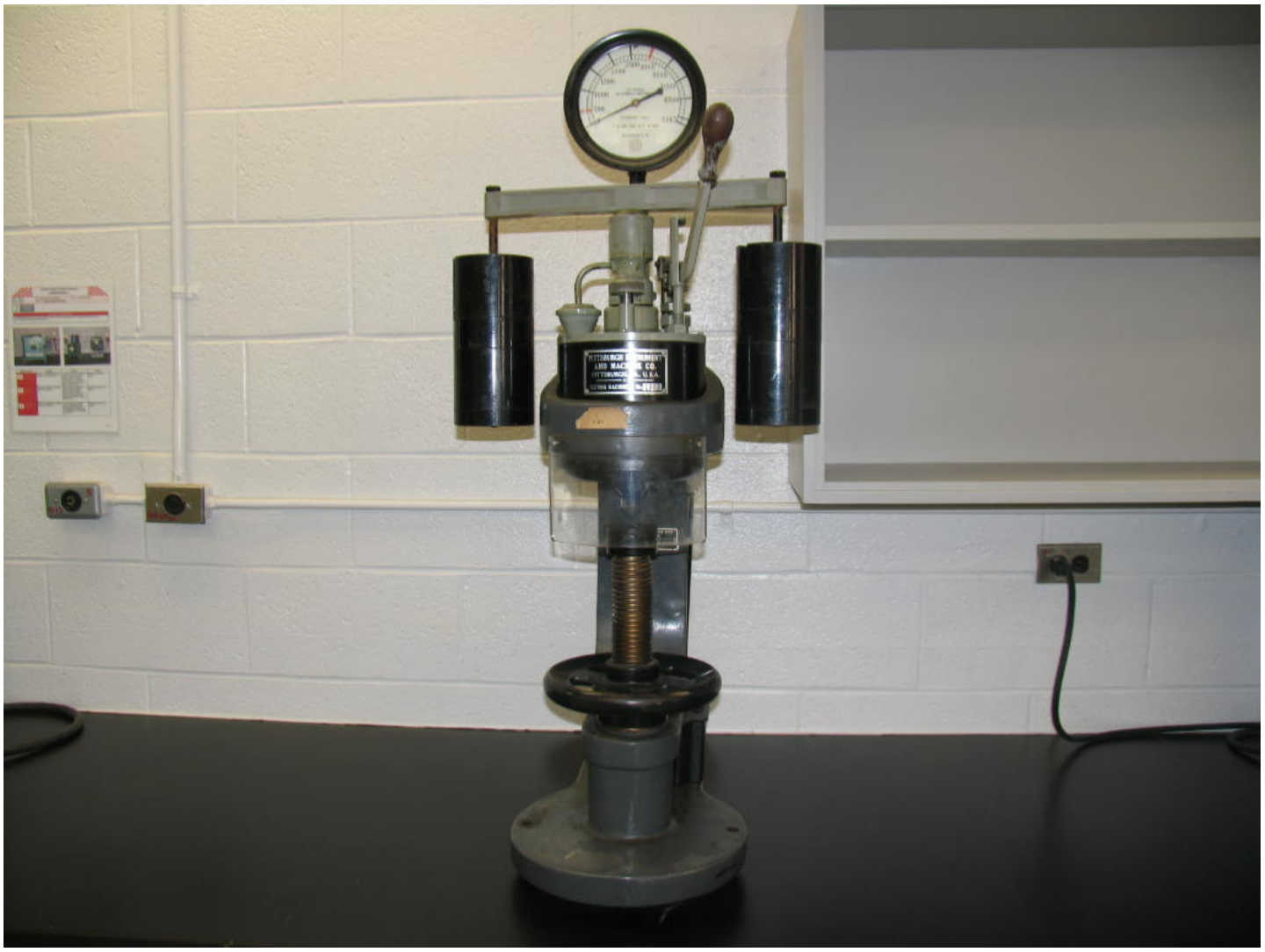
STANDARD OPERATING PROCEDURE AND SAFETY GUIDE FOR HARDNESS TESTERS

(Located in Rm. C-23 Head Hall)



Prepared

June 26, 2010

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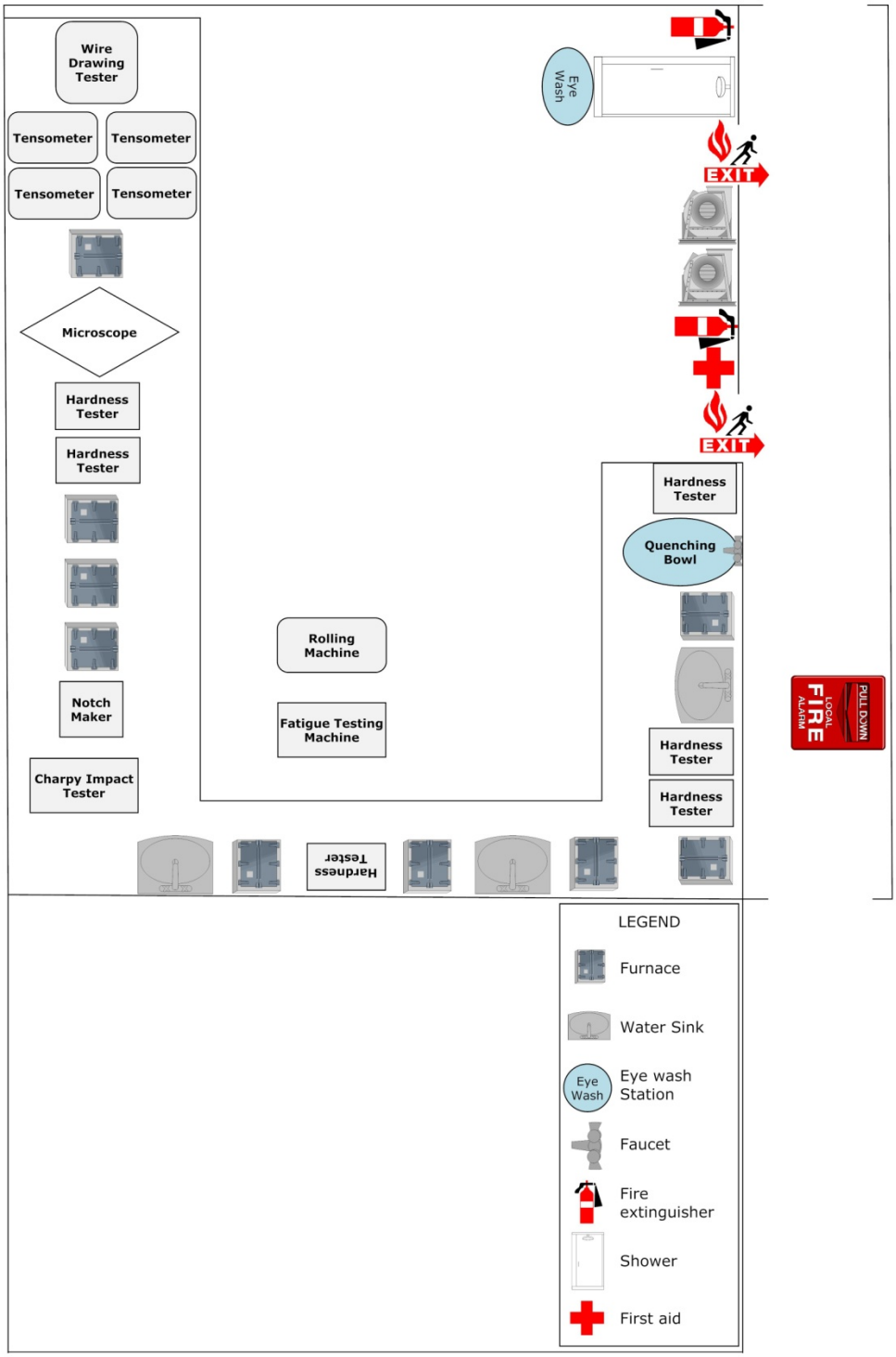
C-23, Head Hall floor plan



1. Scope

1.1 Objective

This standard operating procedure is intended to provide operating instructions and safety information for the Department of Mechanical Engineering's Hardness tester apparatus located in C-23, Head Hall. This document is intended as a guideline and supplement to proper training that must be provided by qualified personnel before the apparatus is operated. The aim of this document is to ensure that safe work practices have been developed for the apparatus experimental work. This SOP is primarily concerned with the apparatus operating procedure, hazards involved with the apparatus use and safety precautions that must be taken to avoid injuries.

1.2 Regulations

This document has been developed in accordance with the Environmental Health and Safety Office of the University of New Brunswick.

2. Apparatus Overview and Objective

2.1 Apparatus overview

There are four different models of hardness testers installed in C-23 Room. The model name and numbers are given as follows:

	Model name	**Model number**
a.	CLARK	C 12 - A
b.	CLARK	CR - 8
c.	WILSON	103 R
d.	PITTSBURGH (Brinell hardness tester)	1862

a) CLARK (C 12 - A):

The CLARK hardness tester uses the Rockwell hardness test to measure the Rockwell Hardness of the material. The Rockwell test is a hardness measurement based on the net increase in depth of impression as a load is applied.

The CLARK hardness tester has an **elevating screw** with **telescoping cover**. The telescoping cover protects the threads of the elevating screw from dust and grit. The **oil reservoir** completely encloses the elevating screw and supplies lubricant to the elevating screw. The elevating screw can be raised

or lowered by means of a **capstan**. Turning the capstan in counterclockwise direction lowers the elevating screw. Turning the capstan clockwise raises the elevating screw. The **tripping mechanism** of the hardness tester trips the major load for indentation on the material specimen. The tripping mechanism also requires lubrication. The major load is applied by lowering and tripping the **operating** lever. There is a **knurled screw** on the **dashpot control** that speeds up or retards the application of **major load**. The knurled screw should be turned counterclockwise to increase the speed and clockwise to decrease the speed of application of major load. The dashpot serves as a shock absorber to prevent the major load from falling too fast and thus producing impact loading, or possibly damaging the **penetrator**. Material specimens to be tested are placed on the proper **Anvil** on the top of elevating screws. There are different anvils provided for different material specimens: a Raised “V” Anvil (for testing small size material specimens); “V” Anvil (for testing medium size round and cylindrical material specimens); and a Standard 3.5 inch Anvil (for testing large, round and cylindrical parts). Many other Anvils are available for testing different material specimens. The Standard 3.5 inch Anvil is the type that is normally used by students for performing tests. The Hardness testers come already equipped with Standard 3.5 inch Anvils. Please refer to Appendix “B” (Standard Equipment, page 16) to see the details and description of different Anvils.

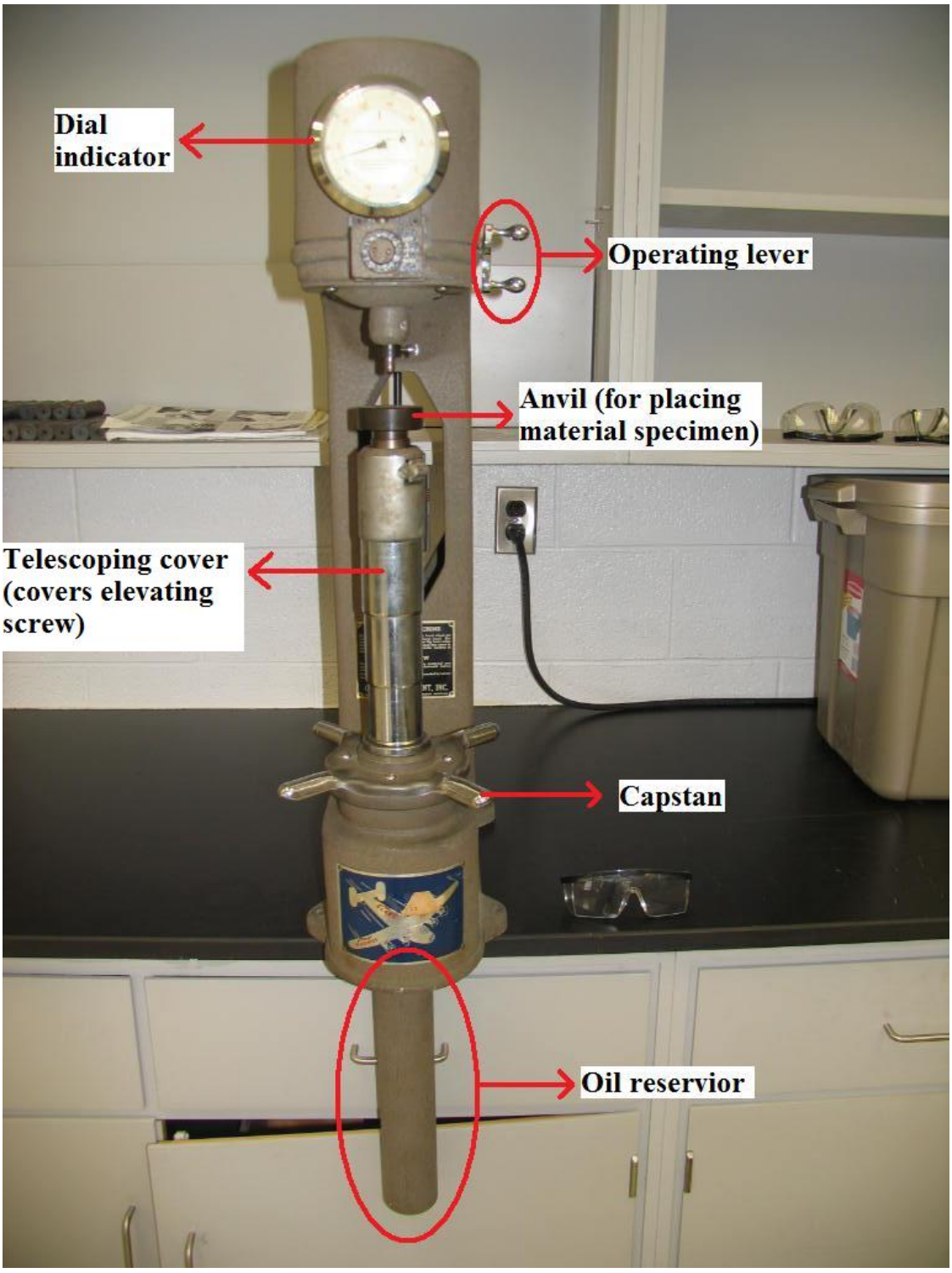


Figure 1: CLARK Hardness Tester (Model C 12 - A)

Harness is measured by indenting the specimen material with a **penetrator.** There are three types of penetrators provided with the hardness testers: a 0.0625 inch hardened steel ball penetrator for testing of medium soft metals

such as Aluminum; a 0.125 inch hardened steel ball penetrator for testing of very soft metals such as copper; and a CLARK Diamond cone penetrator for testing of hard materials such as steel. The penetrator is mounted on a **spindle** that holds the penetrator firmly by means of a **Thumb screw**.

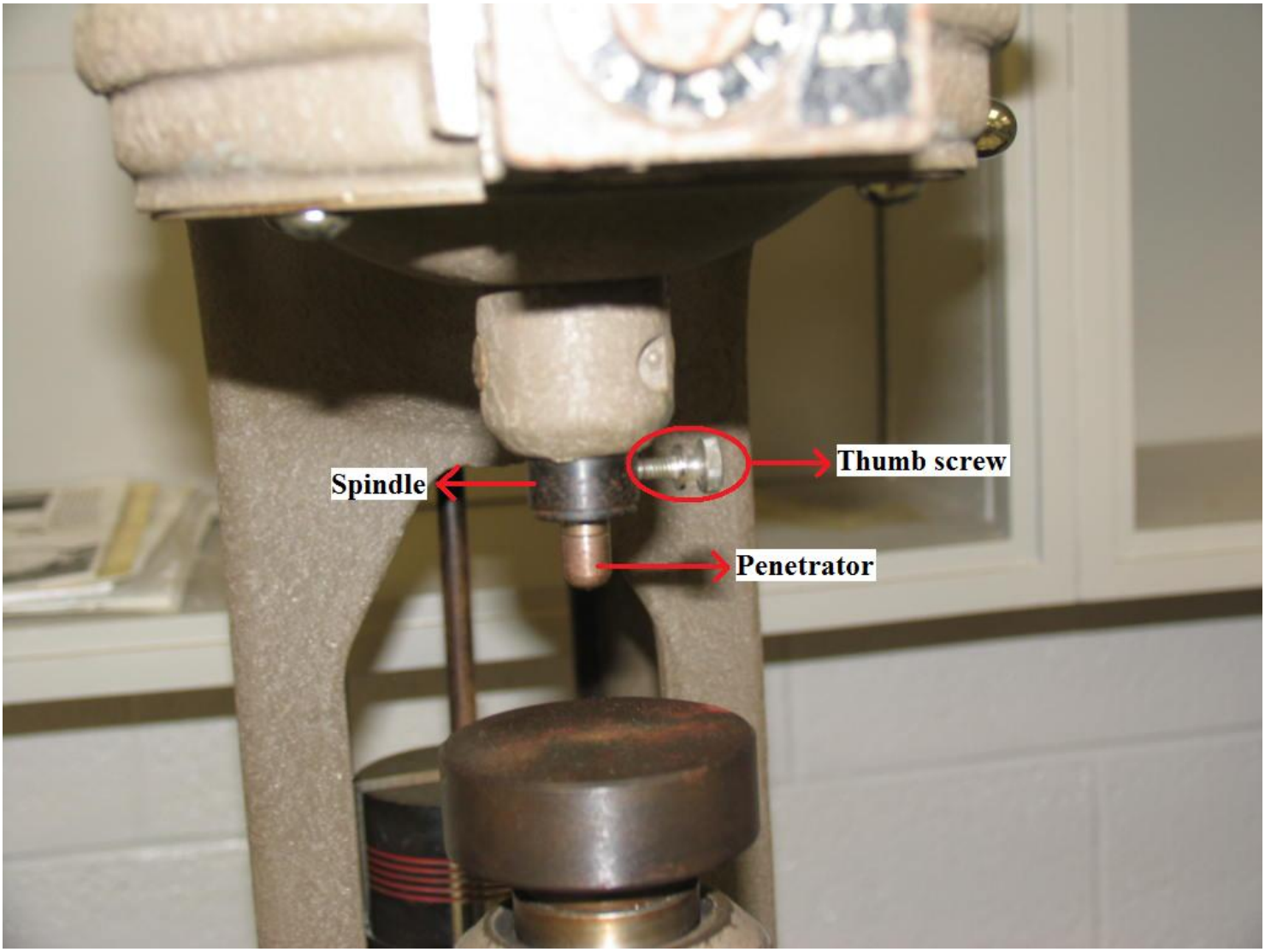


Figure 2: CLARK hardness tester (Model C 12 - A)

The **metal dust cover** covers the dashpot control and the tripping mechanism on the hardness tester. There is also a **Dial indicator** mounted on the top of the hardness tester that measures and indicates the hardness value of specimen material. The larger the value is, the greater the hardness of specimen material. There are different scales provided for measuring the hardness of the specimen material. The selection of the penetrator, the major

load and the reading scale depends on the hardness scale chosen from the scale selection chart.

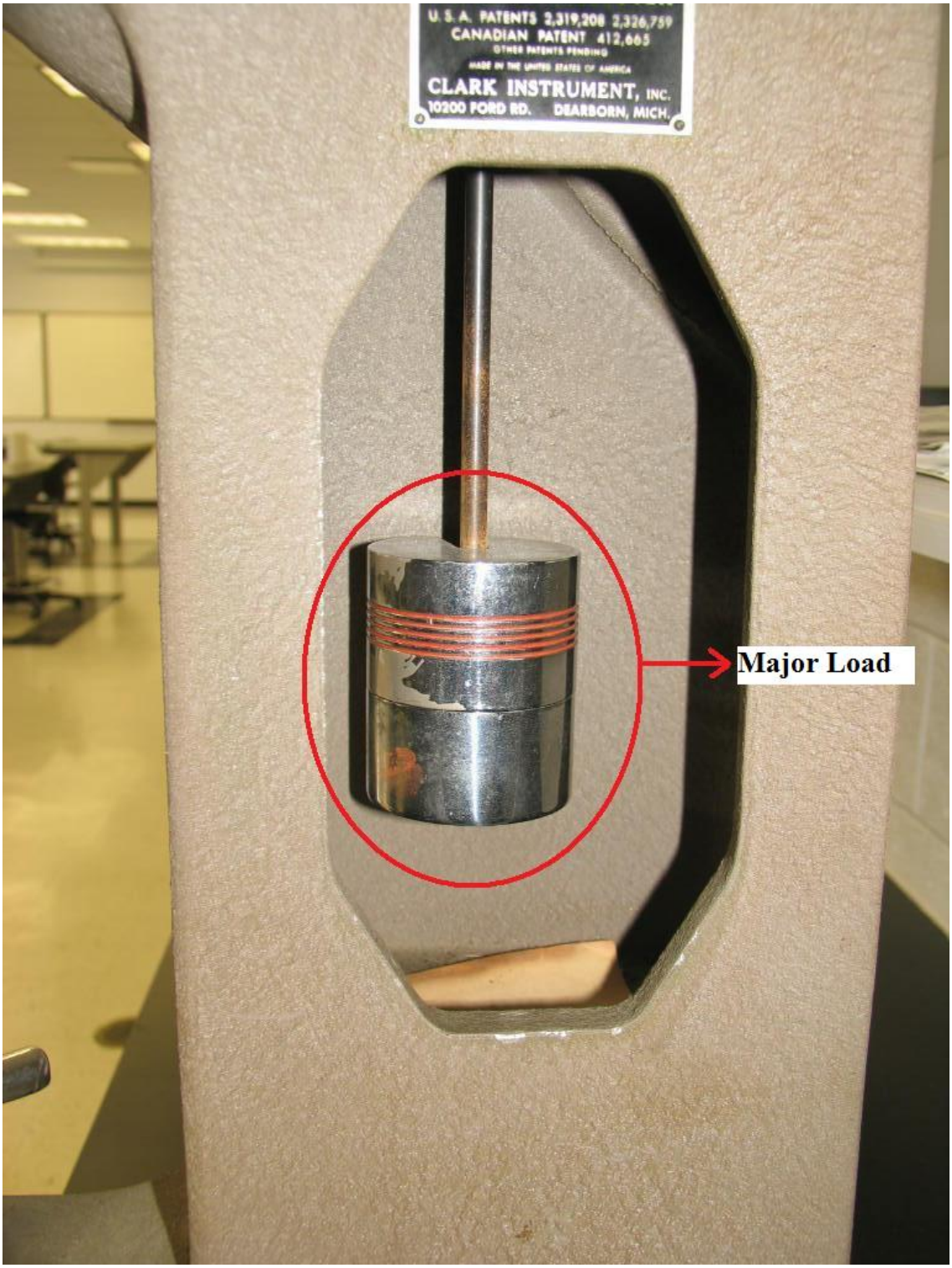


Figure 3: CLARK Hardness Tester (Model C 12 - A) major load

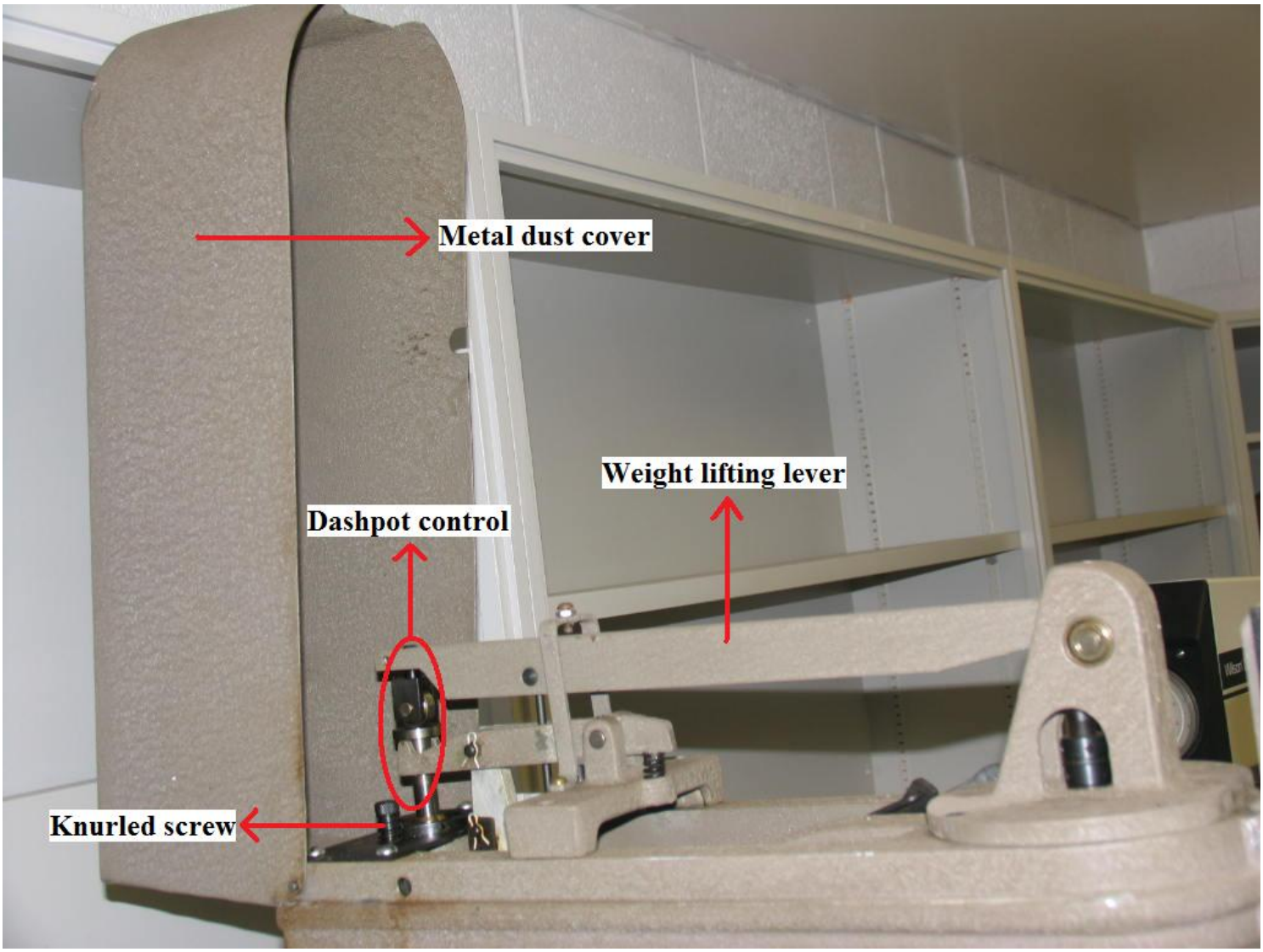


Figure 4: CLARK Hardness Tester (Model C 12 - A) metal dust cover

b) CLARK (CR - 8):

The components of this model of hardness tester are almost the same as C 12 - A, but with CLARK CR - 8 model there is no oil reservoir provided for lubricating the elevating screw. The oil is only provided to the **dashpot control** for absorbing the shock of impact caused by the application of load. The **major load** is applied on the material specimen by means of an **operating handle**. There is a **main beam** that lifts or lowers the major load through the **beam receiver** and the **lifting lever** with the help of the operating handle. Please refer to Appendix "C" (Clark Instrument Model CR - 8 operational manual) for more details.

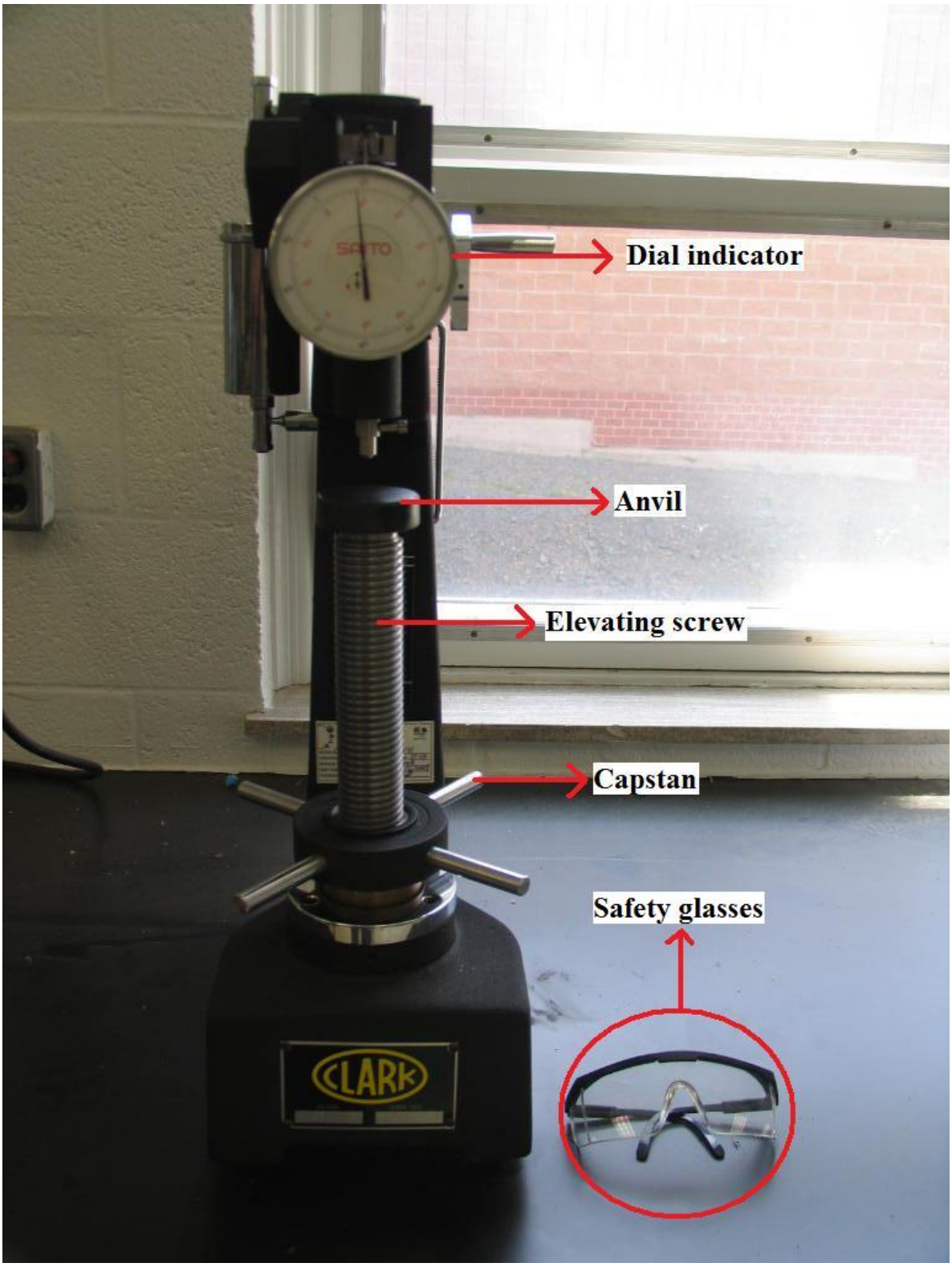


Figure 5: CLARK Hardness Tester (Model CR - 8)

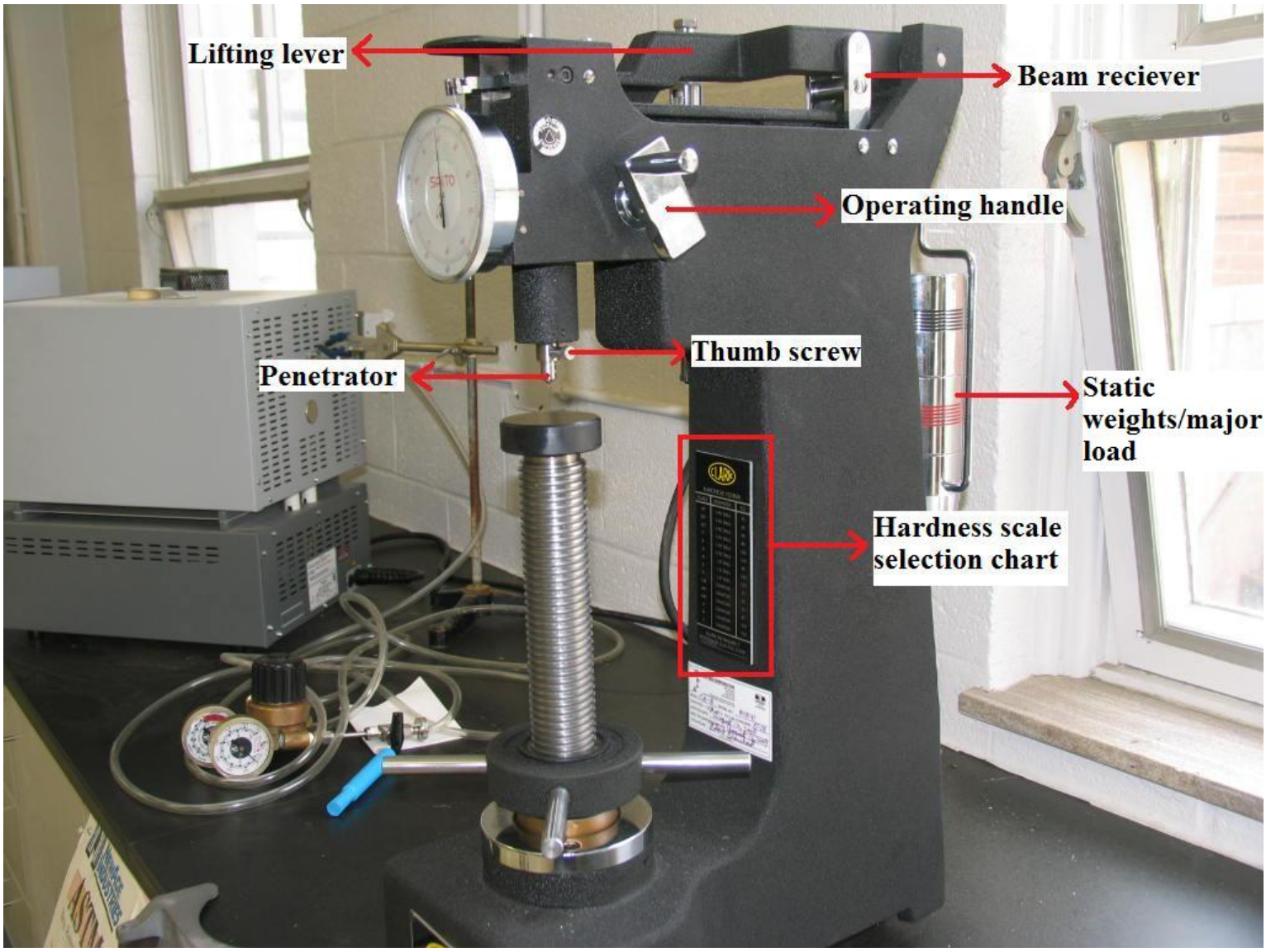


Figure 6: CLARK Hardness Tester (Model CR - 8)

Figure 7 shows the dashpot speed adjustment screw which can be turned counterclockwise or clockwise to increase or decrease the speed of the application of major load/static weights.

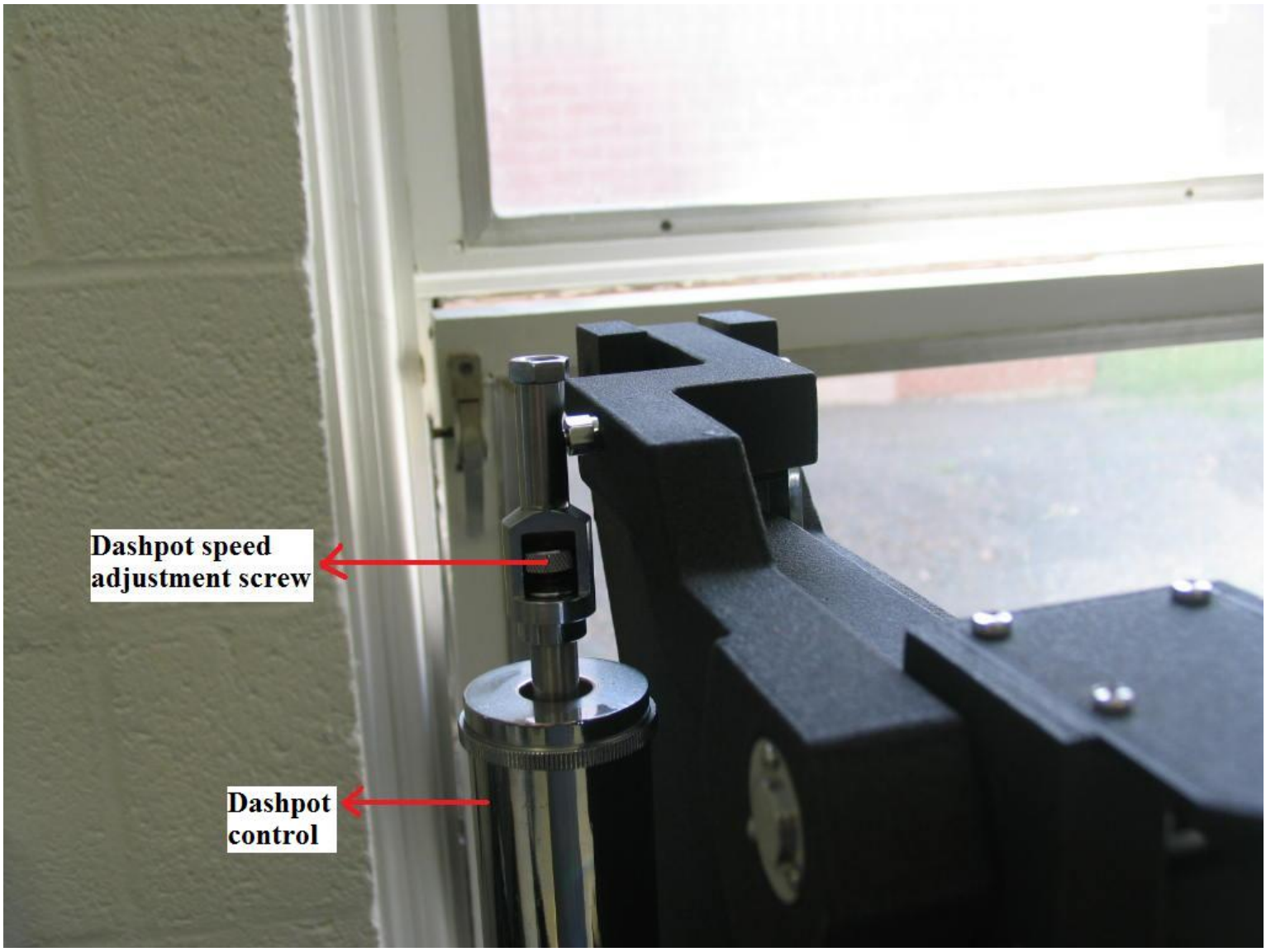


Figure 7: CLARK Hardness Tester (Model CR - 8)

c) WILSON 103 R:

The WILSON 103 R hardness tester has the same components as the CLARK (C 12 - A), with the exception that the major load/static weight is adjusted with the help of the **major load adjusting dial** instead of adjusting the major load manually in case of CLARK hardness testers. The WILSON hardness tester is more user friendly as the major load being applied on the specimen material can be changed simply by turning the major load adjusting dial. **The dial should be always turned clockwise**. **Do not turn the static weight adjusting dial counterclockwise. Only make changes to the major load via the major load adjusting dial when the operating**

handle is in forward direction. (Please see Figures 8 and 9 for a description of the WILSON 103 R Hardness Tester components).

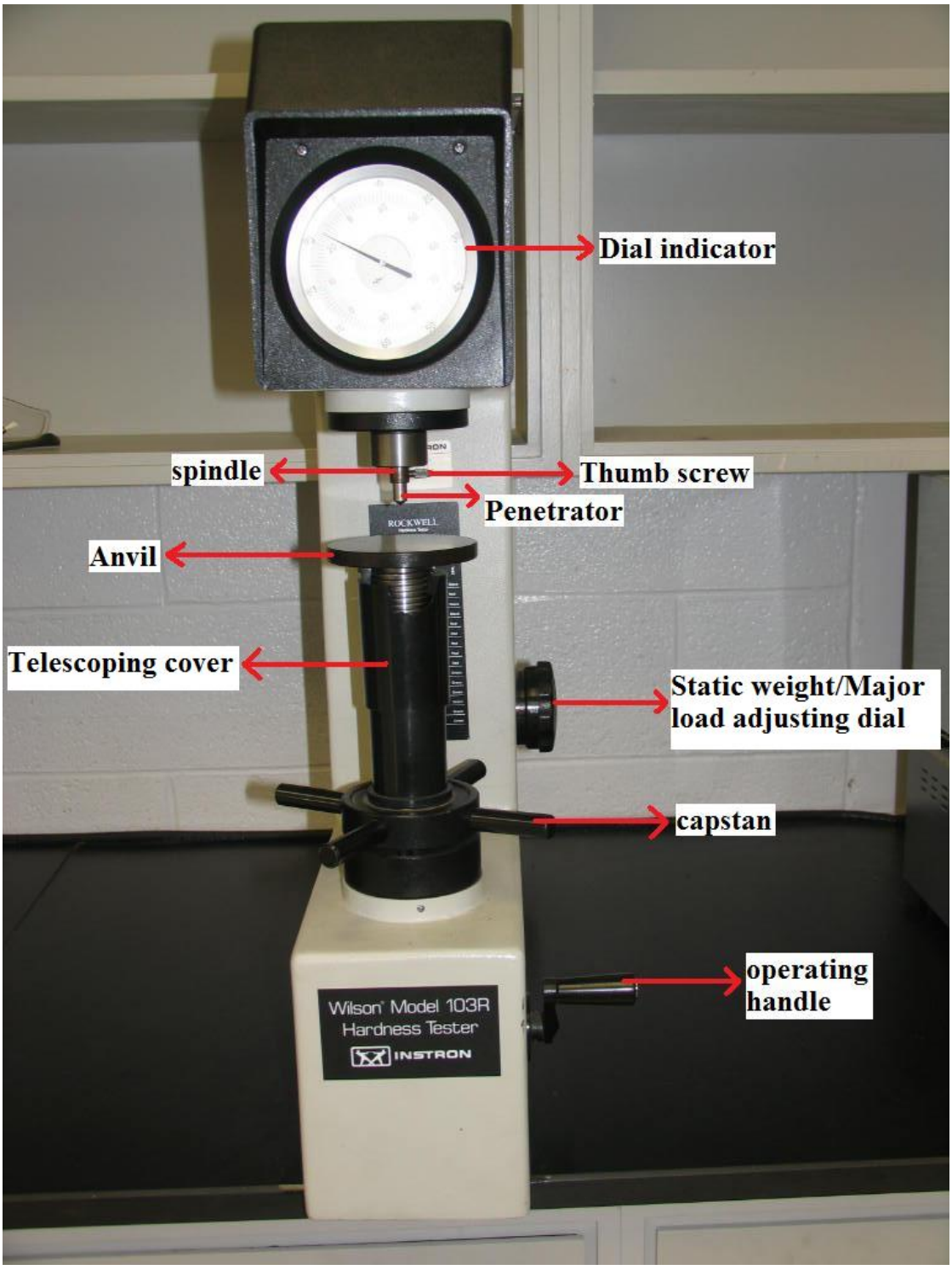


Figure 8: WILSON 103 R Hardness Tester

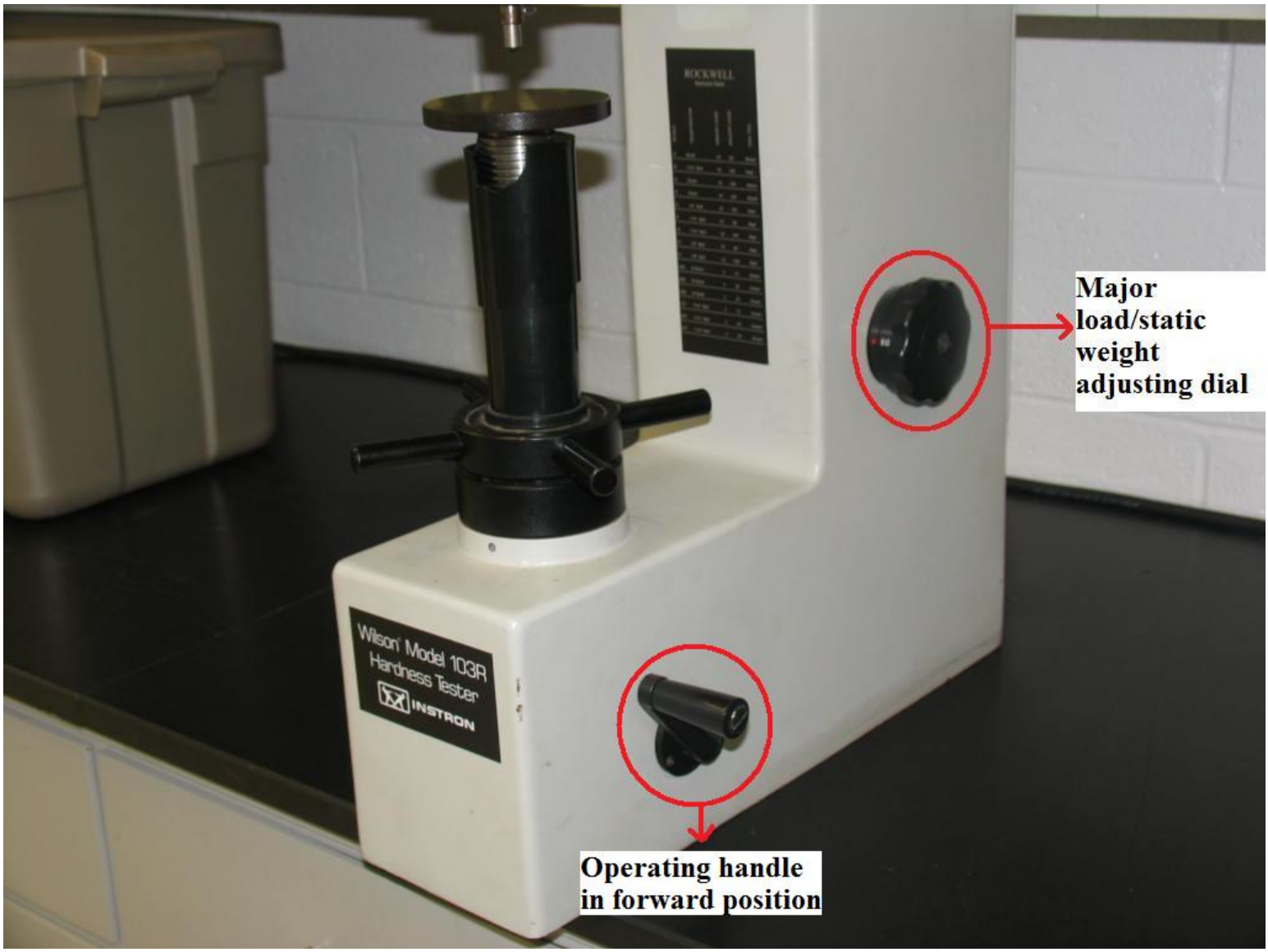


Figure 9: WILSON 103 R Hardness Tester's major load/static weight adjusting dial

d) PITTSBURGH Brinell Hardness Tester (1862):

The PITTSBURGH Hardness Tester is used for measuring the Brinell hardness of the specimen material.

Brinell hardness is measured by forcing a hard steel or carbide sphere penetrator of a specified diameter under a specific load into the surface of a material specimen. A measurement of the indentation that remains after the test is made with the **indentation magnification viewer**. Please refer to Appendix "D" (Material Hardness, 3.2 Brinell Hardness Test) for more details on Brinell hardness test.

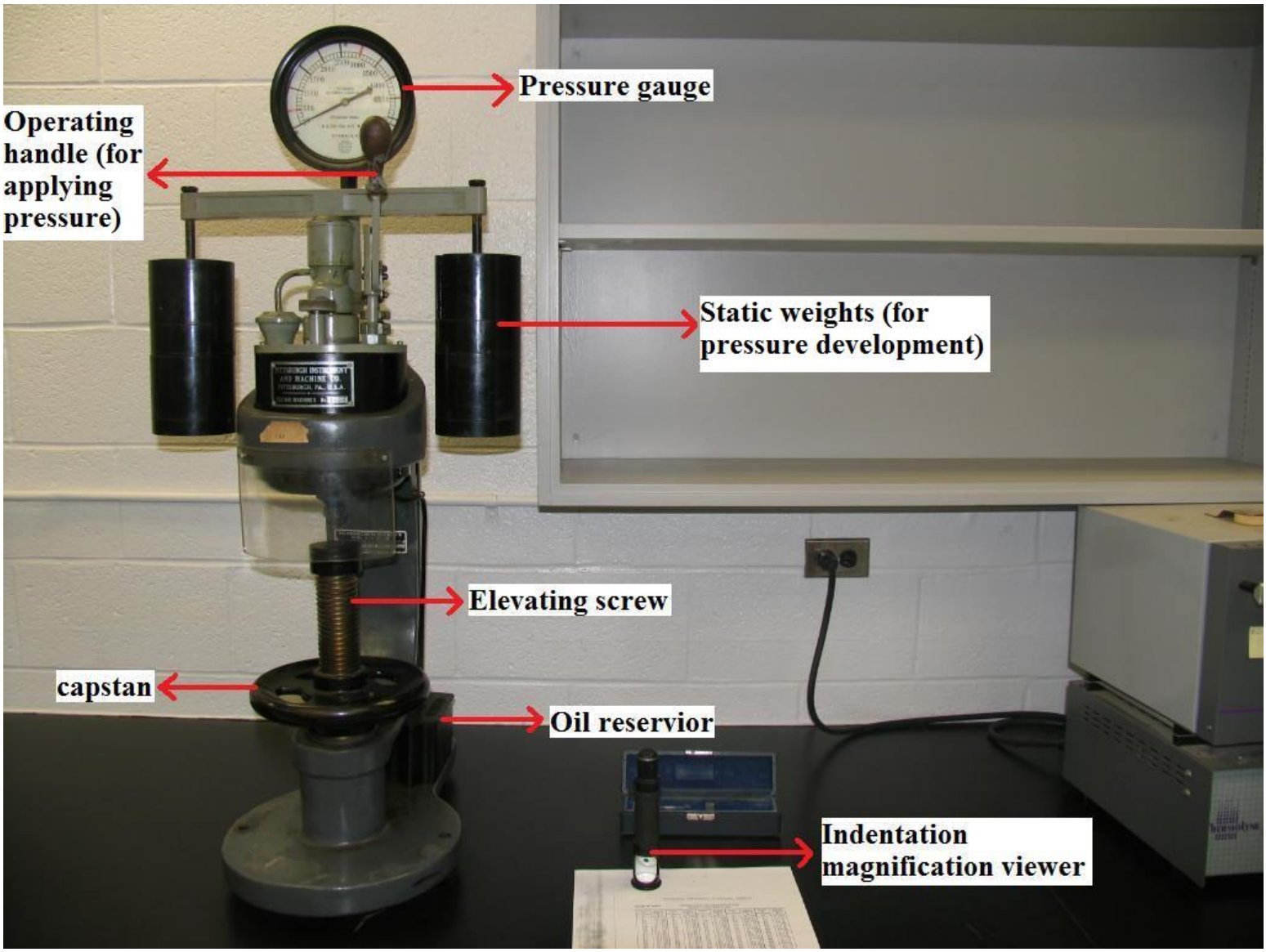


Figure 10: PITTSBURGH Brinell Hardness Tester

The hardness tester applies pressure to the **penetrator** to make an impression into the surface of the specimen material. The pressure is applied using the **operating handle**. The **Knurled** screw (see Figure 11) is turned fully clockwise to ensure that it is completely closed. The specimen material on the **elevating screw** is raised by turning **capstan** until it contacts the penetrator. The operating handle is moved up and down continuously to increase pressure on the penetrator. The work achieved by lifting the **static weights** via the operating handle increases the pressure on the penetrator. The **pressure gauge** on the top of apparatus shows the pressure applied on the specimen material. The load/pressure is applied constantly for almost 10-

15 seconds. The operating handle is released and the knurled screw is unscrewed to release pressure. The material specimen is removed from the anvil and the depth of the impression is measured with the indentation magnification viewer. There is an oil reservoir in the apparatus that lubricates the mechanics of the operating handle and hydraulically lifts the static weights used for applying pressure. Please refer to Appendix “D” (Material Hardness, 3.2 Brinell Hardness Test) for details on amount of load for soft, medium and hard material specimens. Also see Appendix “E” (PITTSBURGH Brinell Hardness Tester) for more details.

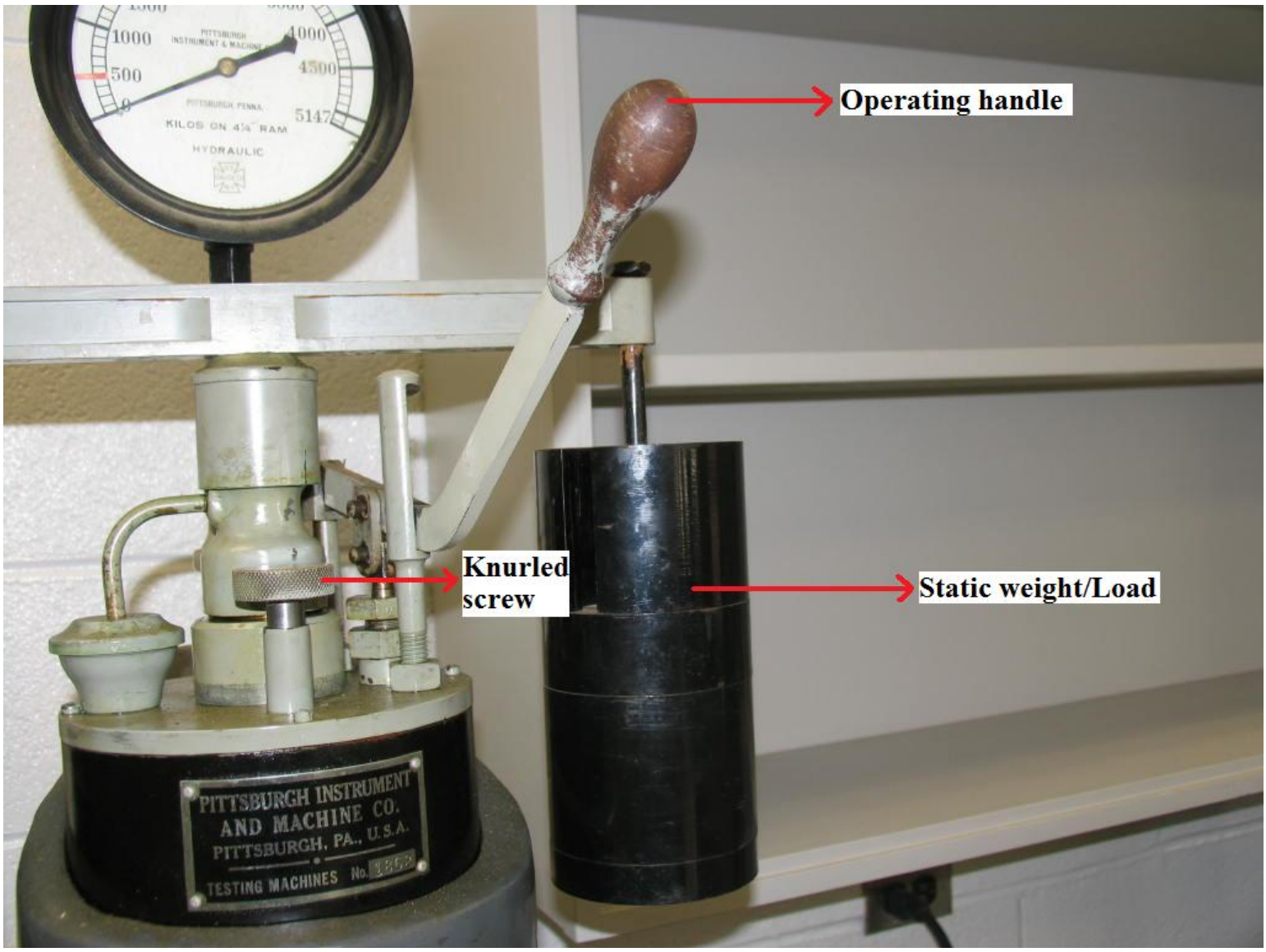


Figure 11: PITTSBURGH Brinell Hardness Tester

3. Hazards and Controls Evaluation

3.1 Possible fire event

The apparatus is not associated with high temperatures but in the event of fire due to some other high temperature associated equipment in operation, you are to evacuate the room immediately. Pull the nearest fire alarm (see C-23 floor plan). Should you return to attempt to extinguish the fire, do not do so alone. Make only one attempt and if unsuccessful leave the lab immediately. If successful, stay at the scene and have someone alert the Security and Traffic department (ph. # 4830) and the Environmental Health and Safety office (ph. # 5075). Please refer to C-23, Head hall floor plan to see the locations of fire extinguishers, fire alarm pull station and first aid kit.

3.2 Ventilation

There are no ventilation fans in room C-23 other than the fume hoods. The lab is centrally ventilated as fresh air is introduced at all times into the room. Proper ventilation system is not a requirement for the operation of apparatus.

3.3 Kinetic, Thermal and Acoustic

The hardness testers are not associated with thermal and acoustic hazards. The moving parts of the hardness testers are operating handle, elevating screw, capstan and major load/static weights. They do not pose a serious threat if they are handled carefully by the operator. The operator should wear safety goggles while using the apparatus to prevent stray metal chips from damaging his eyes.

3.4 Electrical

There are no electrical hazards associated with the hardness testers as there is no component of any of these four models that is electrically powered.

3.5 General, physical and equipment concerns

The knurled screw on the dashpot control of CLARK Hardness Tester Model (CR - 8 & C 12 A) speeds up or retards the application of major load. The knurled screw should be turned counterclockwise to increase the speed and clockwise to decrease the speed. **The knurled screw should never be turned completely out, as this will inevitably result in impact loading and chipped metals or diamonds. This creates conditions that are unsafe for the operator.**

The CLARK Hardness Tester Model (CR - 8 & C 12 A) should never be operated without an adequate supply of oil in the dashpot. Similarly the PITTSBURGH (Brinell Hardness Tester) should never be operated without an adequate supply of oil in the oil reservoir.

On the WILSON 103 R hardness tester, the major load/static weight adjusting dial should be always turned clockwise. Do not turn the static weight adjusting dial anticlockwise. Only operate major load adjusting dial with the operating handle/lever in the forward direction.

The CLARK CR - 8 Model is also provided with a dust cover to prevent the apparatus body from dust and grit. After using the CLARK CR - 8 hardness tester, cover it with Dust Cover (see Figure 12).

The test specimens provided with the apparatus, when tested should be indented on one side only. If the test specimen has indentations and impressions on both of its sides then it will give inaccurate results to the operator and is of no value to the experiment. **The test specimen should always be tested on one side only.**

3.6 Access

All personnel in the C-23 laboratory should be preauthorized by the faculty supervisor or under the supervision of authorized personnel (lab technician or teacher assistant). No person other than the faculty supervisor or specifically authorized personnel, are permitted to make alterations to, or run experiments with the hardness testers.

3.7 Training

All individuals using the hardness testers shall be required to receive training in the proper operation and maintenance of the hardness tester and its controls. Training will include such topics as the complete operation and control of the hardness tester. Training programs shall be administered only by qualified personnel at UNB.

3.8 Personal Protective Equipment

Following personal protective equipment is mandatory while using the hardness testers:

- Safety goggles

See figure below for description of safety equipment.

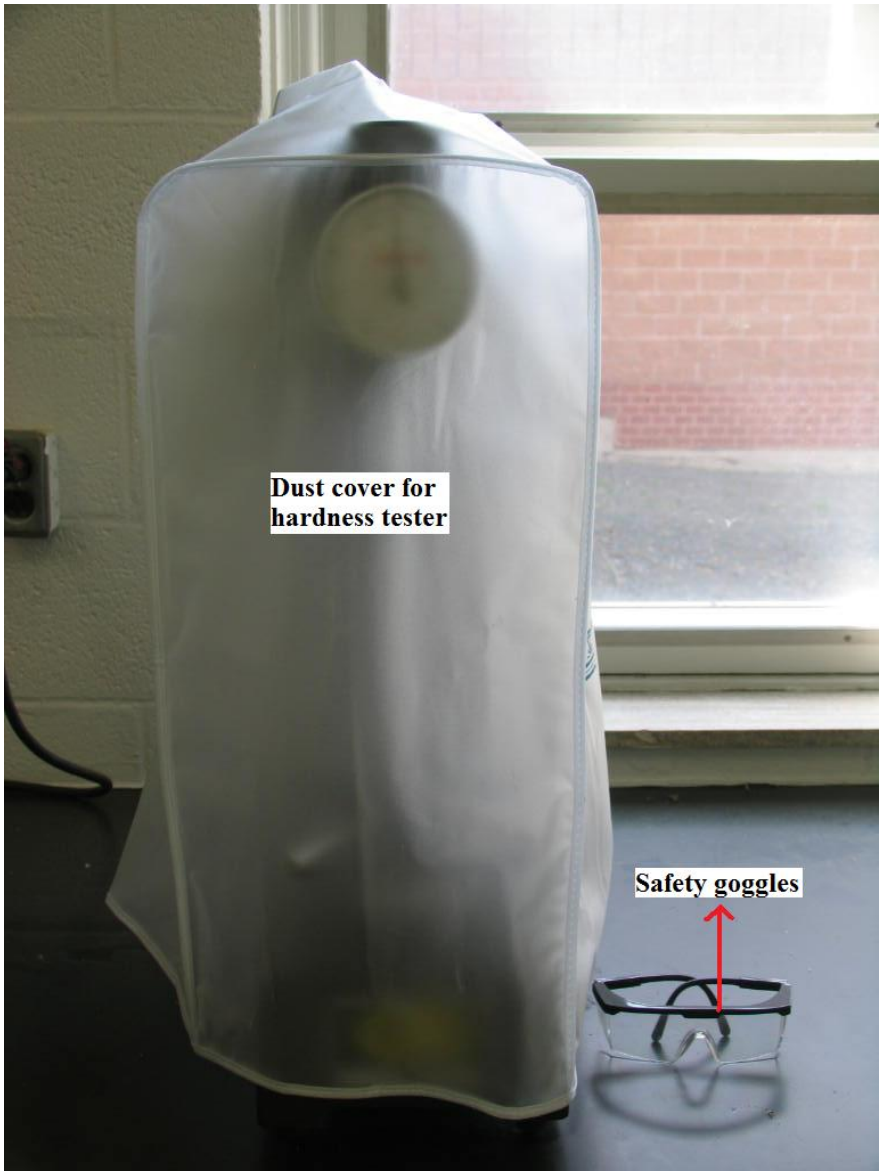


Figure 12: CLARK CR - 8 Hardness Tester Dust Cover and safety goggles

4. Operation

4.1 Qualified Personnel

These notes in the operation section will provide a guideline to the individual who has been trained by qualified personnel to operate all models of hardness testers. Only after the individual has been trained and feels confident with the hardness tester operating procedure should he attempt to operate the hardness tester by using these notes. Do not proceed if you are not properly trained or are unsure in any manner of the safe operation and safety concerns of this equipment.

4.2 Experiment preparation

Following steps should be carried out to prepare for the experiment:

- Ensure that the system's physical integrity is not compromised (cracked, broken or failed components on the hardness tester).

- Double check that the proper weight is suspended for the scale that you desire and that the proper penetrator is chosen.

- Ensure that there is sufficient oil in the dashpot of the CLARK hardness tester and in the oil reservoir of PITTSBURGH Brinell hardness tester to provide lubrication to the moving components. The WILSON 103 R does not require oil for its moving components.

- **On the CLARK hardness tester models, ensure that the knurled screw is not already turned out.** The knurled screw controls the speed of application of the major load/static load on the specimen material.

- The operating handle for the CLARK hardness tester models and WILSON 103 R hardness tester **should be forward (leaning front) before operating the equipment.**

- Prior to operating the hardness tester, the test specimen should be cleaned with oil to clear the specimen of all scratches. This will help achieve more accurate results.

- On all the models of hardness testers, mount the required Anvil on the elevating screw and clean the Anvil with some oil to remove

scratches. This practice will also help achieve more accurate results.

- Always wear safety goggles while conducting this experiment.

4.3 Lab Instructions

4.3.1 Instructor Responsibilities

The SOP of hardness testers should be read and fully understood. This document provides all the necessary information on the hardness tester operation, the hazards involved & safety precautions to be taken while using all models. The lab instructor shall remain in the room while the experiment is in progress. After the students have fully assembled and before any explanation has begun, the instructor should relay all safety precautions and hazards as outlined in Section **3**. You should inform the students that they must contact the instructor if any problems or concerns should arise during the experiment. Make the group aware of the fire extinguisher locations, fire alarm pull station and exits. Any student who is missing his or her personal protective equipment should not be allowed by the instructor to enter the laboratory C-23 or proceed with the experiment.

4.3.2 Data/Instruments display Locations and Functions

The data display instruments and their function is described as follows:

- Dial indicators - Mounted on the top of CLARK (C 12 - A and CR - 8) and WILSON 103 R model) hardness testers - Displays the hardness value of the specimen in different scales (the Large hand indicates the hardness value). It also indicates the application of minor load (complete three revolutions of Large hand) by the small hand of hardness tester touching the red point. (see Figures 12, 14 and 15).

- Pressure gauge - Mounted on top of PITTSBURGH Brinell hardness tester - Displays the pressure on penetrator in Kilopascals (see Figure below).

- Test specimens/Testing blocks - Provided with the hardness tester and protected in a safe case - Used as standard to check the hardness

testers by comparing the measured hardness value with the hardness value provided on the testing block.

- Indentation magnification viewer - Provided with the PITTSBURGH Brinell hardness tester – Measures in millimeters the impression made by penetrator of PITTBURGH hardness tester.

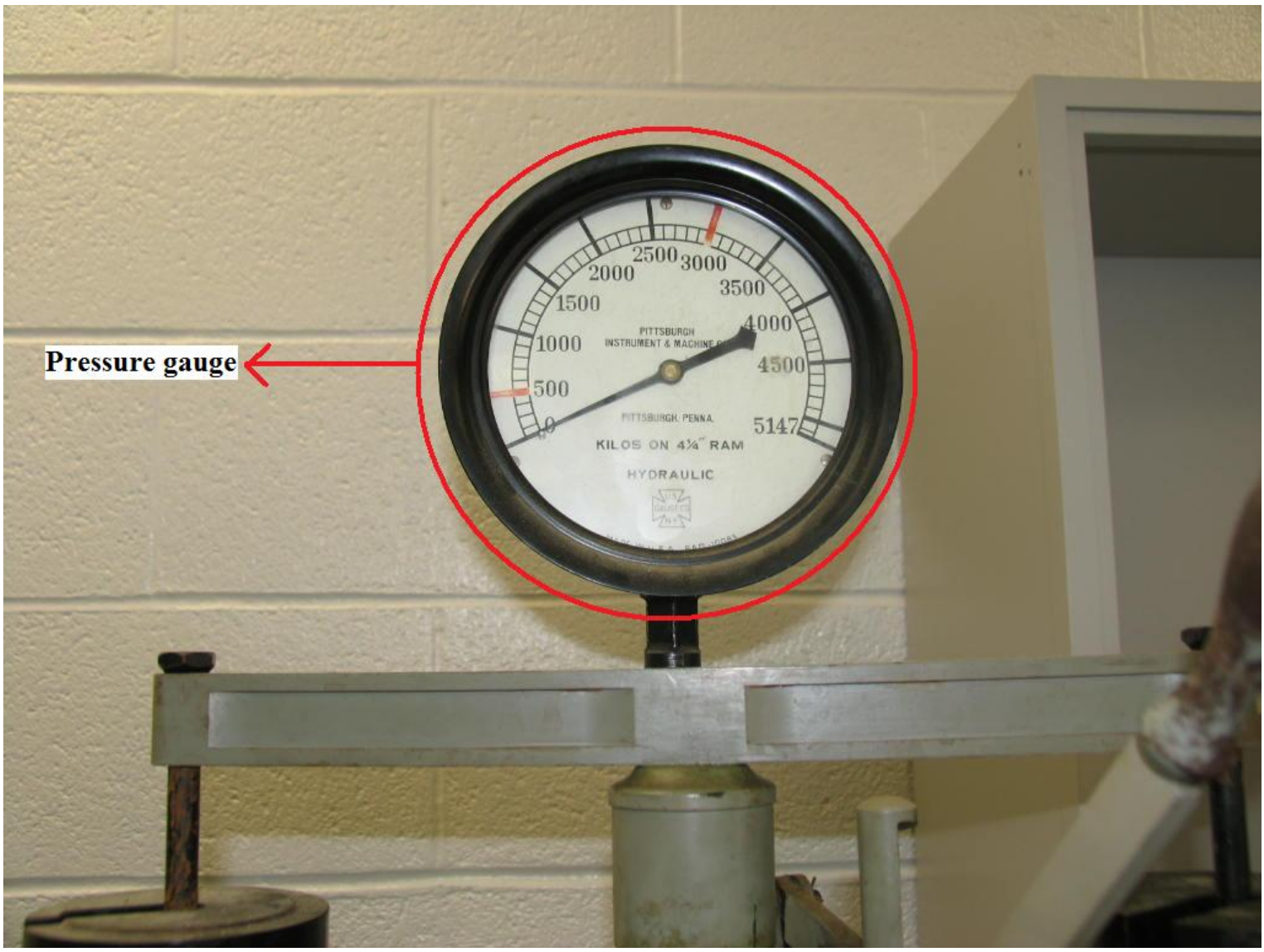


Figure 13: PITTBURGH Brinell Hardness Tester Pressure Gauge

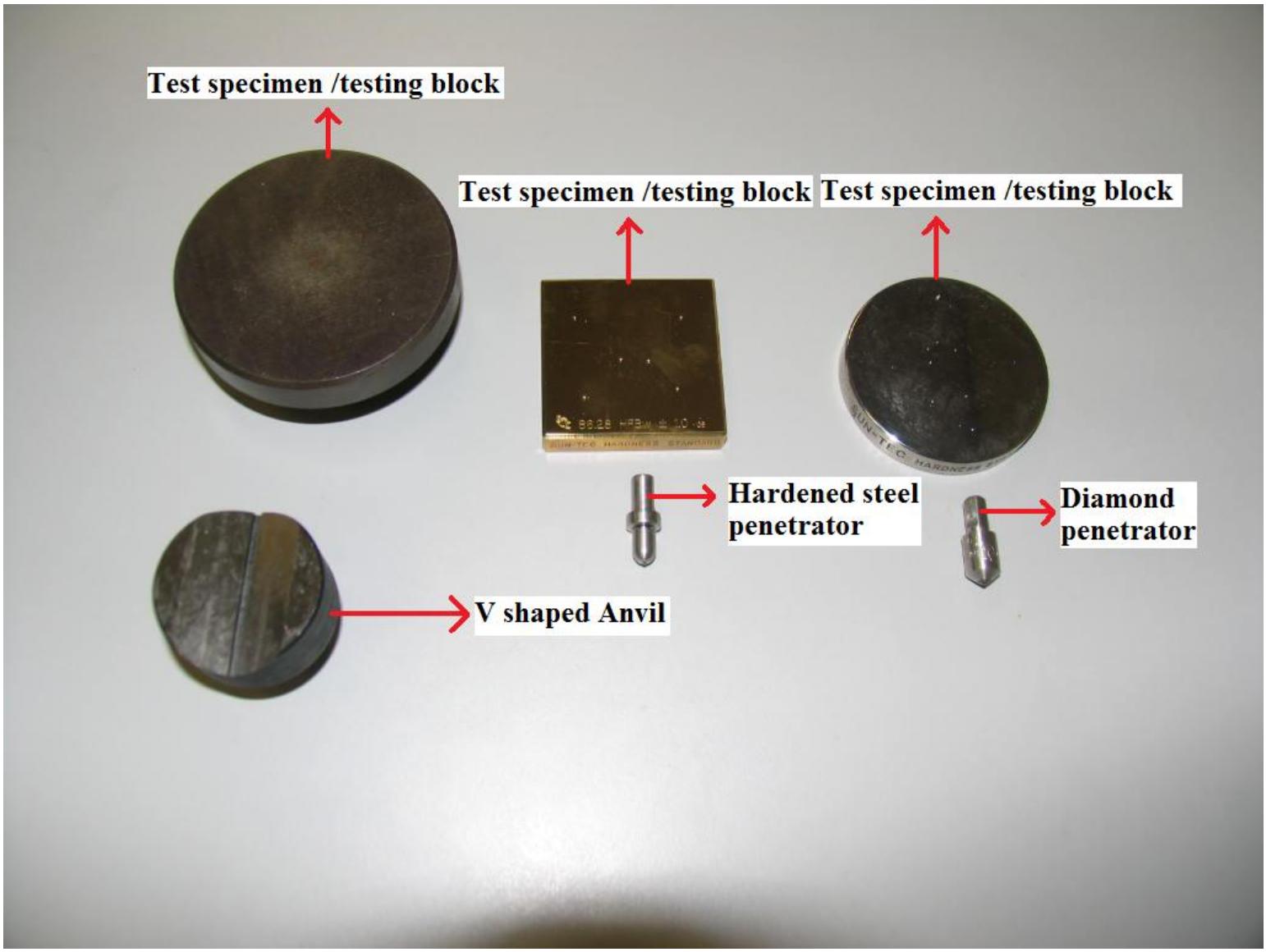


Figure 14: Test specimens, Penetrators and Anvils of Hardness Testers

4.4 Operating Procedure

4.4.1 Operation of Hardness testers

All the models of hardness testers operate in a similar way but with a few differences. The operation of all the models of hardness testers is discussed below as follows:

a) CLARK (C 12 - A):

After preparing for the experiment as mentioned in Section 4.2, follow these steps to operate and perform an experiment on this hardness tester:

1. Choose the hardness scale for the required hardness value of the test specimen.

2. From the chart that is riveted on the hardness tester, choose the appropriate penetrator and amount of load in Kg for the scale chosen. The chart will also indicate which color scale (Black or Red) to read on the Dial indicator to get the hardness value.

3. Elevate the test specimen placed on Anvil by turning the capstan until it makes contact with the penetrator.

4. Continue turning capstan until the large hand on Dial indicator has made **three complete revolutions**, which will also be indicated by the small counter hand pointing to the horizontal line. Now the minor load of 10 Kg is applied to the test specimen. After three revolutions the large hand should stop in green colored “SET ZONE” to apply correct minor load of 10 Kg.

5. Set the Dial indicator Large hand to the position labeled “SET” OR “ZERO” on the Dial indicator irrespective of the scale of measurement (Black or Red). See the figure below.

NOTE: **Never move the capstan back to adjust the large zero pointer.** Release the load and choose another spot on the sample to test.

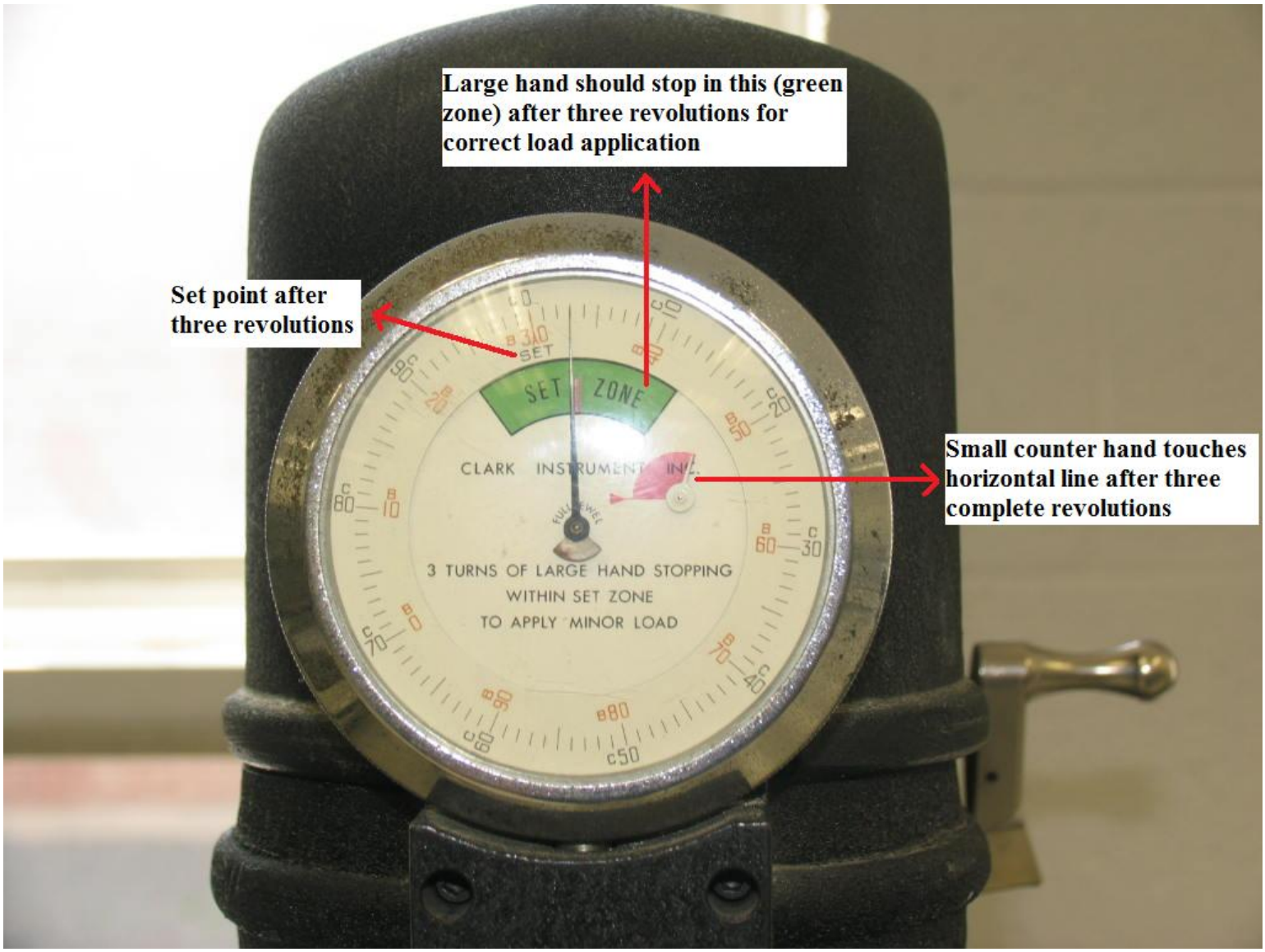


Figure 15: CLARK C 12 - A Hardness Tester Dial indicator

6. Trigger the operating lever/handle (Figure 1) of hardness tester to apply major load on the test specimen by pushing it back. When the dial hand comes to rest on the dial indicator, wait 5 seconds to pull the operating handle/lever to the front. The reading now indicated on the dial indicator is the hardness value measured by the hardness tester of the test specimen.

NOTE: Even though the user may be using a scale other than “C”, always set “0” on the black “C” scale, then read the hardness value from the desired scale.

7. Lower the elevating screw by turning capstan and remove the test specimen.

8. Clean the test specimen and place it back in safe place to prevent from corrosion and scratches on its surface.

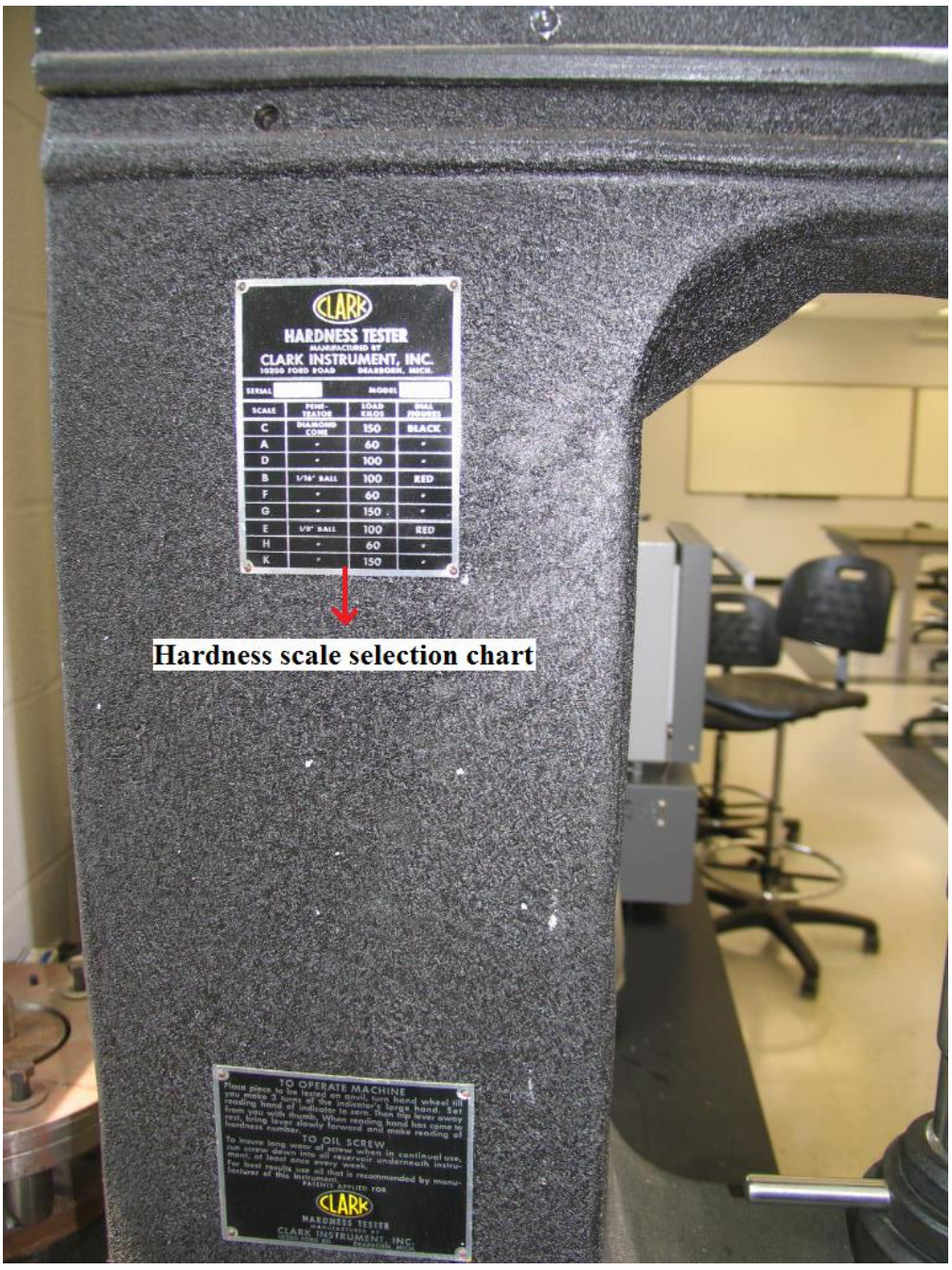


Figure 16: CLARK C 12 - A Hardness scale selection chart

Refer to Appendix “B” (CLARK Hardness tester, Follow these simple operating directions) to see the description of operating procedure.

b) CLARK CR - 8:

The operating procedure for CLARK CR - 8 hardness tester is the same as CLARK C 12 - A. Please see Figure 6 to see the scale selection chart and Figure 17 to see the dial indicator for this model of hardness tester.

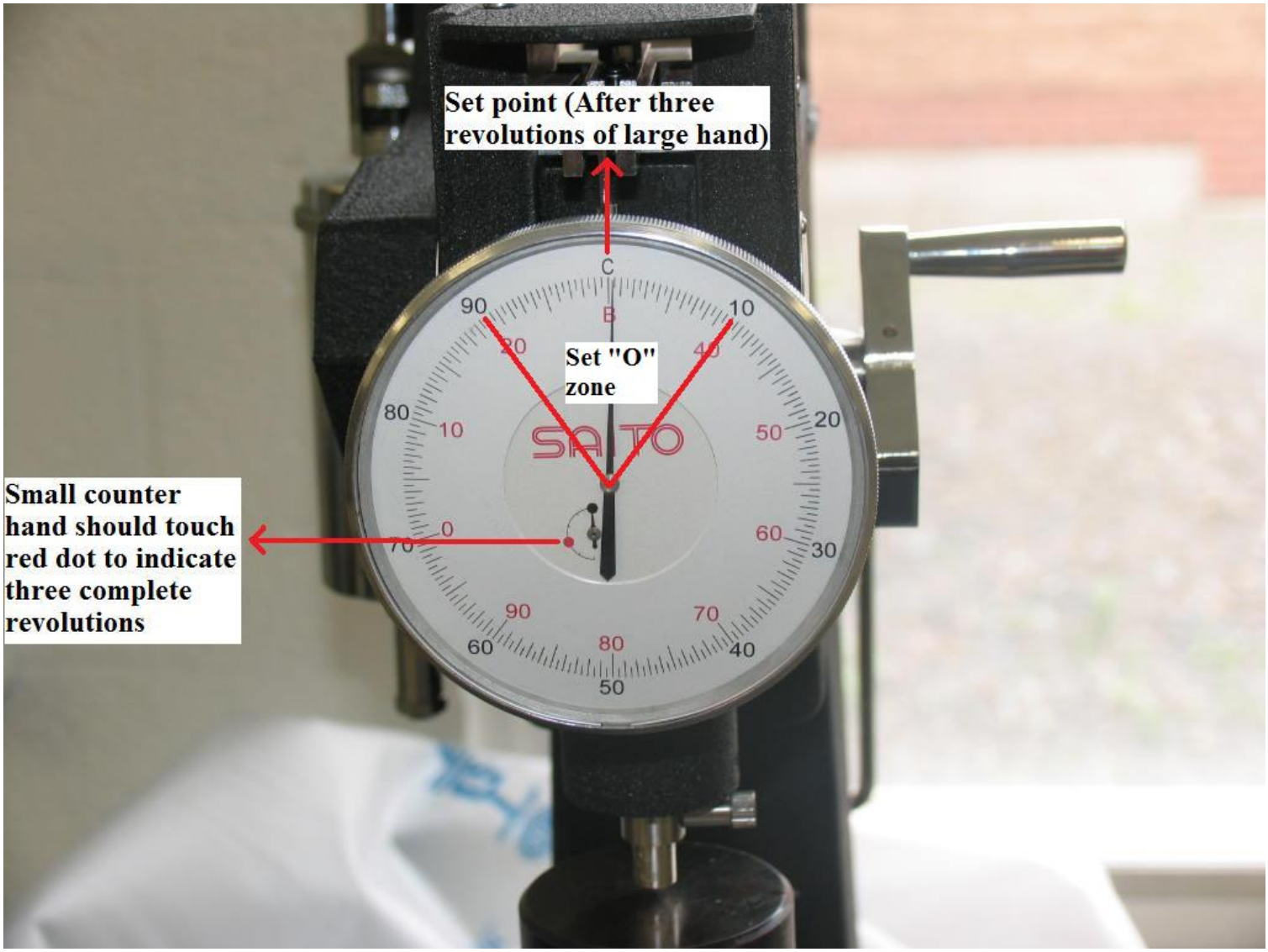


Figure 17: CLARK CR - 8 Hardness tester dial indicator

Please refer to Figures 5, 6 and 7 to see the components of this model of hardness tester while following this operating procedure. For this model of hardness tester follow Step 4 of the operating procedure of the C 12 - A hardness tester. It is necessary for the Large hand of Dial indicator to fall in a SET zone between 11'o clock and 1'o clock on the Dial indicator. It is best if the user sets it to 12'o clock. The point labeled as "C" on the dial indicator in Figure 17 is the SET point for this hardness tester model after three complete revolutions (application of minor load) of the Large hand. So in step 5, set the Large hand of dial indicator at "C" irrespective of the scale of measurement (Red or Black). Follow the operating instructions of C 12 - A model for the rest of the experiment.

NOTE: **Never move the capstan back to adjust the large zero pointer.** Release the load and choose another spot on the sample to test.

c) WILSON 103 R:

The operating procedure for WILSON 103 R model is the same as the CLARK hardness tester models. Please refer to Figures 8 and 9 to see the description of components of WILSON 103 R model and follow the operating procedure of CLARK hardness tester. Please refer to Figures 18 and 19 to see the description of scale selection chart and dial indicator for this model of hardness tester.

This model is more user friendly as the major load can be changed by turning the static weight adjusting dial clockwise. To select the weight, turn the dial clockwise until the Red dot lines up with the desired numerical value of weight. Never turn the dial counterclockwise, especially when the operating handle is leaning in a forward direction (see Figures 8 and 9). Do so, can cause equipment failure.

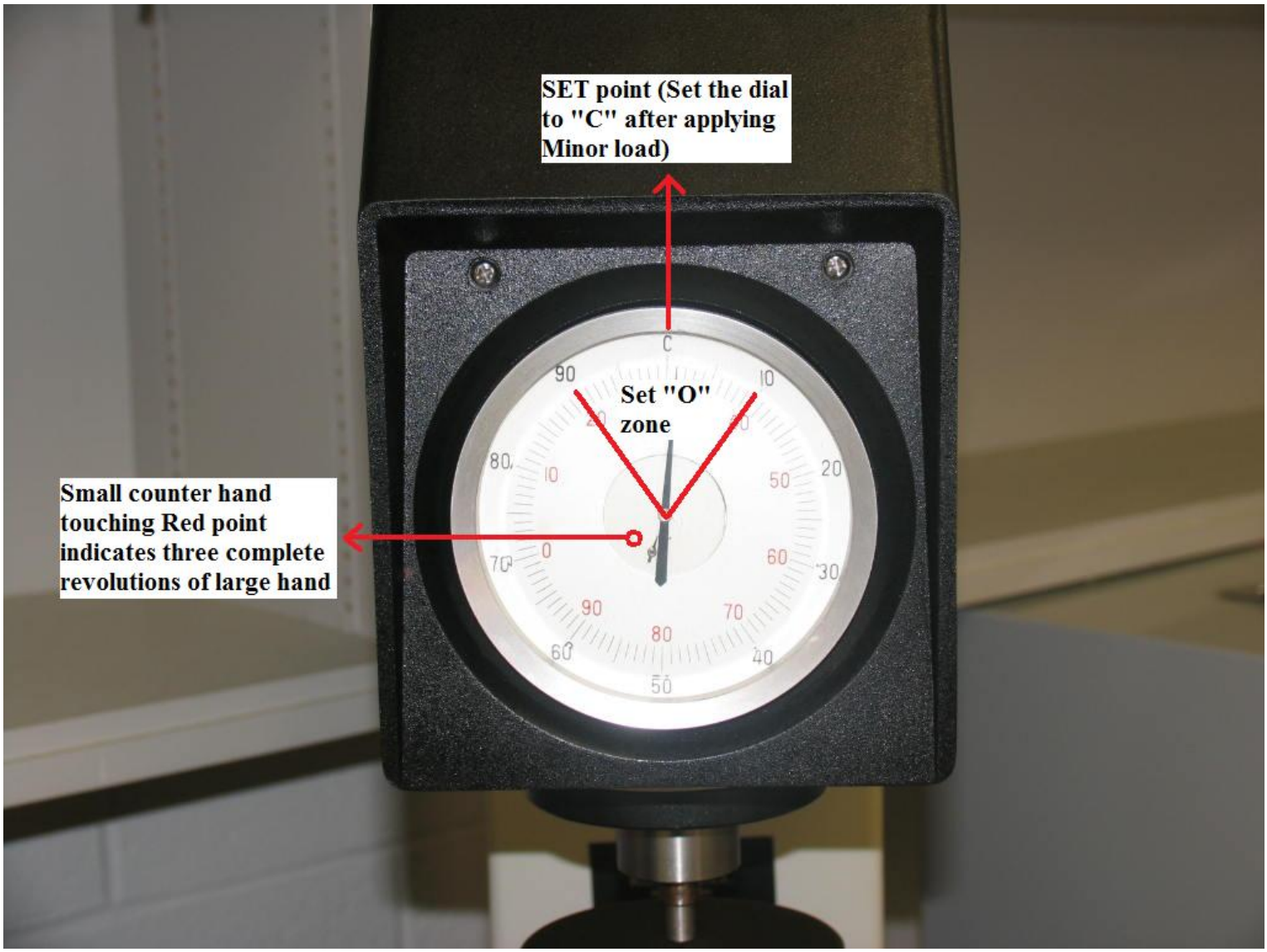


Figure 18: WILSON 103 R Hardness tester dial indicator

For this hardness tester, completion of three complete revolutions of large hand of dial indicator is indicated by the small counter hand touching the red point. After application of the minor load, the large hand is set to the point labeled as “C” as it was in CLARK CR - 8 model.

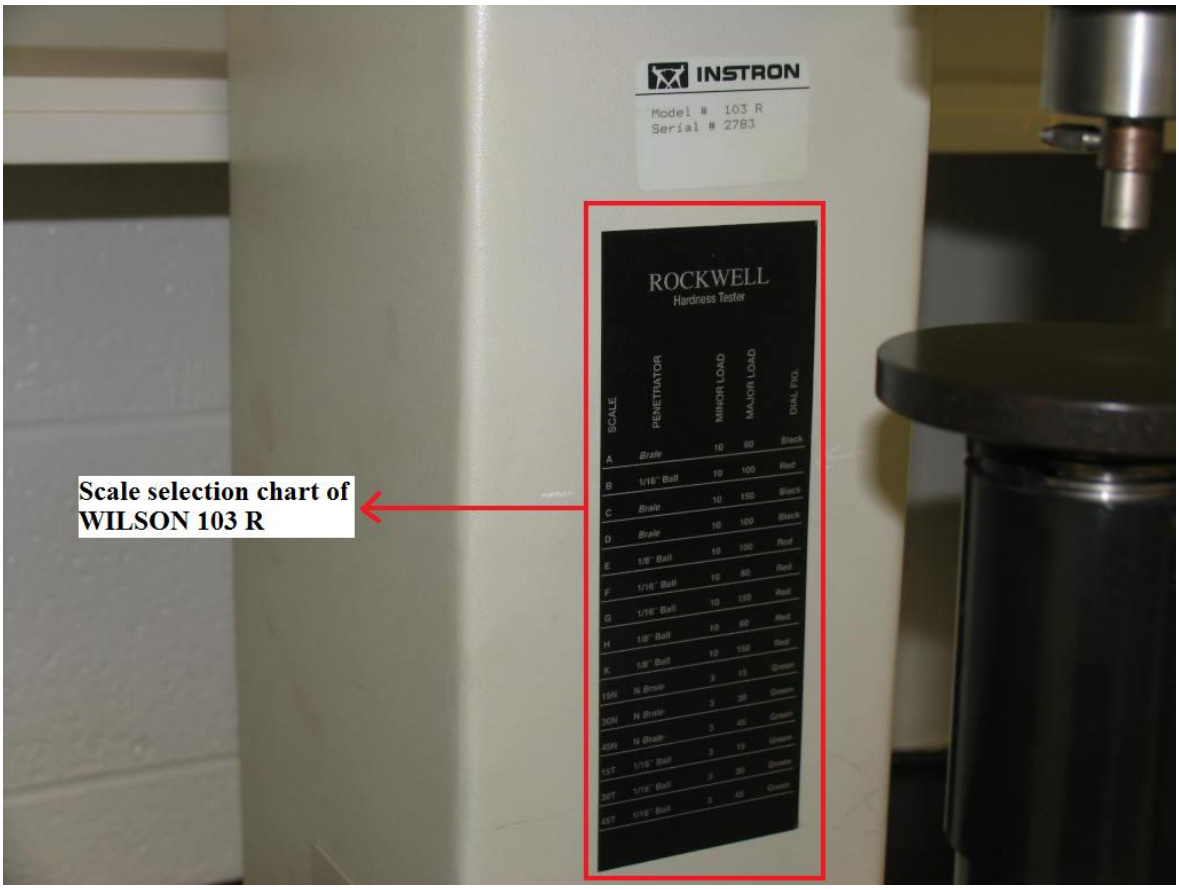


Figure 19: WILSON 103 R Hardness tester dial indicator

d) PITTSBURGH Brinell hardness tester 1862:

After preparing for the experiment as mentioned in section 4.2, follow these steps to operate and perform experiment on this hardness tester:

- Turn the capstan and keep raising the elevating screw until the test specimen is in contact with the penetrator of hardness tester.

- Ensure that the knurled screw (see Figure 10) is screwed tightly and turned fully clockwise so that moving the operating handle up and down develops pressure on the penetrator.

- Move the operating handle up and down until the pressure gauge indicates the desired pressure.

- Maintain the desired pressure for about 10 - 15 seconds by holding the operating handle.

- Release the operating handle and unscrew the knurled screw to release the pressure.

- Lower the elevating screw by turning capstan and remove the test specimen from the anvil.

- Measure the diameter of indentation on the test specimen by using the indentation magnification viewer.

- See the scale “BRINELL” hardness value corresponding to that measured indentation diameter.

- Now see the hardness values on other scales corresponding to this value on the “BRINELL” scale. Please see Figure 20 for the conversion chart that converts hardness values in different scales from diameters of indentation and other measured scales.

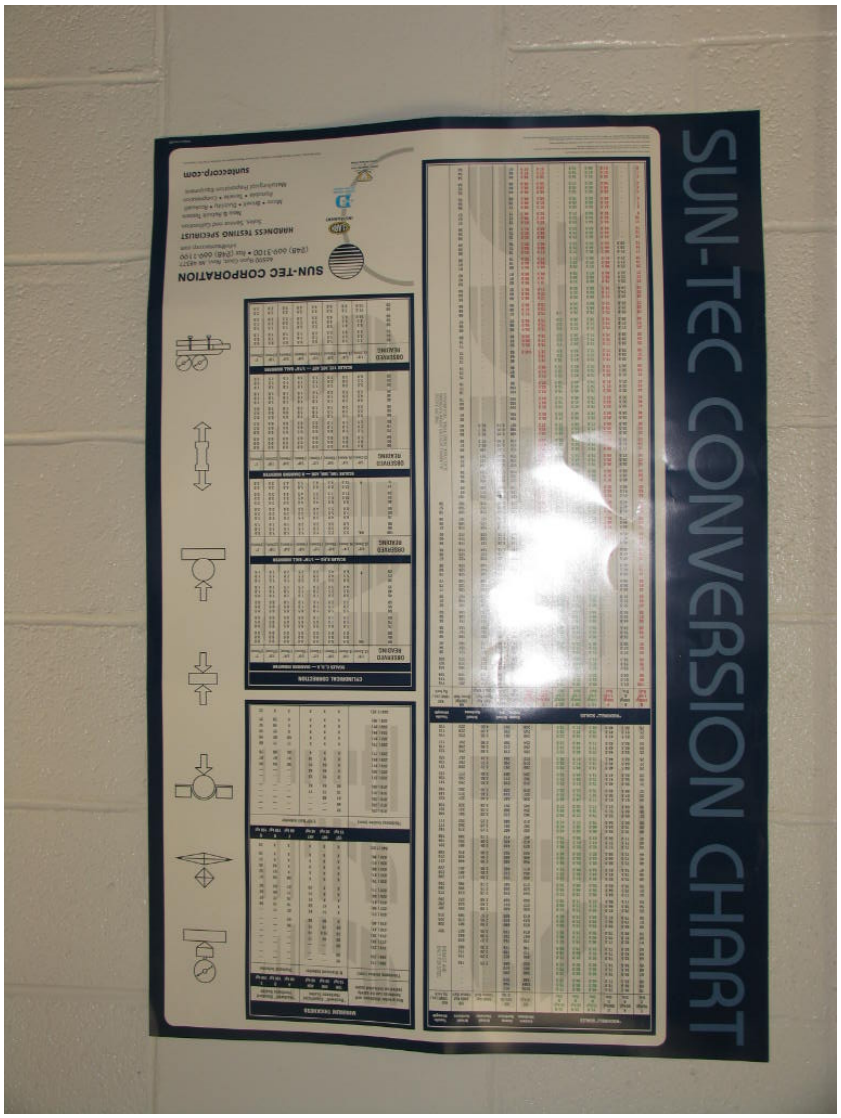


Figure 20: Hardness scales conversion chart

4.4.2 Shutdown

The shutdown procedure of all the hardness testers is identical:

- Clean the test specimen and Anvil of the hardness testers to remove any scratches after completing the experiment.

- Place the test specimen and anvils back in their cases after testing them, to protect them from corrosion and grit.

5.0 Inspection and Maintenance

Inspections at regular intervals will be performed on all the hardness testers to ensure that they are kept in a safe and well maintained condition. The inspection and maintenance includes the following:

- A weekly inspection of the elevating screw and lubricating by applying a firm pressure on the anvil at the top and then by turning the capstan counterclockwise until all of the telescoping covers are even.

- The oil level in the oil reservoirs of CLARK and PITTSBURGH hardness testers should be checked and maintained.

- The tripping mechanism of both models of the CLARK hardness testers should be lightly oiled once per month.

- The testing blocks, penetrators and anvils (see Figure 14) should be inspected monthly for any scratches and protected in a case to maintain them in good testing condition.

5.1 Periodic & Operational Inspections

Visual inspections are the responsibility of the person who is conducting experiments on a regular basis with the hardness testers and should be carried out everytime before operating the apparatus. A complete periodic inspection of the apparatus shall be performed by the person who is conducting experiments on a regular basis with this apparatus. That same person is required to alert the faculty supervisor of any deficiencies in the apparatus. Deficiencies such as those listed below shall be examined during both the periodic & operational inspection. The faculty supervisor will determine if the deficiencies will affect the safe operation of the apparatus.

a. Dial indicators and tripping mechanism.
b. Worn or corroded static weights/major load.
c. Cracked or corroded hardness tester surface.
d. The test specimen/testing blocks are corroded or their surfaces are cracked.

6.0 Typical Tests

The actual test procedure will be outlined in the lab script as issued by the professor. A typical test includes measuring the hardness value of different specimen materials. A typical field note sheet that can be used with hardness testers is found in Appendix ‘A’.

Appendix ‘A’

Appendix ‘B’

Appendix ‘C’

Appendix ‘D’

Appendix ‘E’