Designation: D1118/D1118M – 95 (Reapproved 2017)

Standard Test Method for Magnetic Rating of Asbestos Fiber and Asbestos Textiles[1]

This standard is issued under the fixed designation D1118/D1118M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the procedure for the determination of the magnetic rating of asbestos fiber and asbestos textile products. This test method is used primarily for testing asbestos insulating materials.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 **Warning—**Breathing of asbestos dust is hazardous. Asbestos and asbestos products present demonstrated health risks for users and for those with whom they come into contact. In addition to other precautions, when working with asbestos-cement products, minimize the dust that results. For information on the safe use of chrysoltile asbestos, refer to "Safe Use of Chrysotile Asbestos: A Manual on Preventive and Control Measures."[2]

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific safety hazard, see .*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D123 Terminology Relating to Textiles

D2100 Specification for Asbestos Textiles Used for Electrical Insulating Purposes

D2590 Test Method for Sampling Chrysotile Asbestos

D2946 Terminology for Asbestos and Asbestos–Cement Products

D2947 Test Method for Screen Analysis of Asbestos Fibers

D3879 Test Method for Sampling Amphibole Asbestos (Withdrawn 2009)[4]

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

2.2 *ASTM Adjuncts:*

Metallic Analyzer Drawings[5]

3. Terminology

3.1 For definitions of other textile terms used in this test method, refer to Terminology D123. For terms relating to asbestos, refer to Terminology D2946.

3.2 *Definitions:*

3.2.1 *asbestos fiber, n*—The hydrous magnesium silicate serpentine mineral designated as chrysotile and having the empirical formula $Mg_3Si_2O_5(OH)_4$.

3.2.2 *atmosphere for testing textiles, n—for asbestos*, air maintained at a relative humidity of 50 ± 2 % at 70 ± 2°F [21 ± 1°C].

3.2.3 *magnetic rating (MR), n*—an empirical value reflecting the effect of the magnetic particles, such as magnetic iron compounds, in asbestos material as measured by a magnetic effect analyzer. It is not a quantitative measure of the magnetic particles in the material. — Magnetic rating is affected by the

[1] This test method is under the jurisdiction of ASTM Committee C17 on Fiber-Reinforced Cement Products and is the direct responsibility of Subcommittee C17.03 on Asbestos - Cement Sheet Products and Accessories.

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[2] Available from The Asbestos Institute, http://www.chrysotile.com/en/sr_use/manual.htm.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] The last approved version of this historical standard is referenced on www.astm.org.

[5] Available from ASTM International Headquarters. Order Adjunct No. ADJD1118. Original adjunct produced in 1986.

quantity, concentration, particle size, shape, and orientation of the magnetic particles in the material.

3.2.4 *unit magnetic rating (1 MR), n*—a calibrating standard with an MR of one is defined as containing 0.18 g of U.S. National Institute of Standards and Technology standard sample No. 29(a) or iron ore (magnetite) uniformly distributed over the space specified for a 10-g test specimen (19 mm [0.75 in.] diameter by 73 mm [2.875 in.] long), by dispersion in a magnetically inert material. A10-g specimen has one unit magnetic rating when it produces a magnetic effect equivalent to that of 0.18 g of standard magnetite as described above. Conversely, a 10-g specimen producing a magnetic effect such that the resulting induced current in the magnetic analyzer galvanometer is *k* times that of the 0.18 g of standard magnetite as described above, would have a magnetic rating (MR) of *k*.

4. Summary of Test Method

4.1 The unknown electromagnetic effects of a sample of asbestos-containing material is compared with those of a reference standard in a magnetic analyzer. The inductive imbalance caused by the magnetic particles in the asbestos samples is amplified and measured with the magnetic analyzer.

5. Significance and Use

5.1 This test method for the determination of magnetic rating is considered satisfactory for acceptance testing of commercial shipments of asbestos fibers, papers, felts, yarns, rovings, textile products, rigid sheet products, and granular or powdered products.

5.2 Magnetic rating is one of the measurements used for determining the suitability of an asbestos material for electrical insulation.

5.3 The electrical insulating properties of asbestos materials vary inversely with the magnetic rating. Therefore, a low magnetic iron content is required for good electrical insulating.

5.4 The types of asbestos textiles classified by magnetic rating are described in Specification D2100.

6. Apparatus

6.1 *Magnetic Analyzer*—Either the Mapes type analyzer or the Turner & Newall[5,6] type analyzer may be used. Other analyzers using an inductance bridge and functioning on the same principles may be used if agreed upon by the interested parties.

6.1.1 The Mapes type analyzer is described in Annex A1.

6.1.2 The Turner & Newall[6] type analyzer is described in Annex A2.

NOTE 1—The apparatus and procedure described in this revision of Test Method D1118 are preferred. The method and apparatus described in previous issues of Test Method D1118 may be used if agreed upon by the purchaser and the seller.

6.1.3 *Magnetic Analyzer Accessories,* including *specimen tube, holder, spacer rod*, and *stopper.*

6.1.4 *Calibration Standards,*[6]supplied by the vendor of the magnetic analyzer, or prepared as in A3.5.1 to A3.5.10.

7. Hazards

7.1 **Warning—**see .

8. Sampling, Test Specimens, and Test Units

8.1 *Sampling:*

8.1.1 *Chrysotile Fiber*—Sample chrysotile asbestos fiber in accordance with Test Method D2590.

8.1.2 *Amphibole Fiber*—Sample amphibole asbestos fiber in accordance with Test Method D3879.

8.1.3 *Asbestos Textiles:*

8.1.3.1 Refer to appropriate ASTM standards for the lot size of each type of material to be tested.

8.1.3.2 Take sufficient samples at random from each lot to prepare specimens as directed in 8.2.

8.1.3.3 Refer to Section 11 for conditioning requirements.

8.1.4 *Papers, Scrims, Felts, and other Nonwoven Products*—Refer to appropriate ASTM standards for the lot sizes and conditioning requirements.

8.2 *Test Specimens*—Test at least five specimens per sample.

8.2.1 *Asbestos Textiles:*

8.2.1.1 *Cloth and Lap*—Sample cloth or lap products by cutting across the warp strips 73 mm in width and of sufficient length to give a mass of 15 ± 0.1 g. Roll these specimens into a scroll with an external diameter just less than 19 mm for insertion into specimen holders.

8.2.1.2 *Roving, Wick, Rope, Yarn, Thread, Tubing, and Tape*—Cut enough pieces 73 mm in length to get a mass of 15 ± 0.1 g. To adjust the mass precisely, when sample dimensions allow it, cut the last portion of piece needed lengthwise. If dimensions are too small to cut lengthwise, as in the case of a thread, cut across the length. Cord the pieces to form a cylindrical bundle with a diameter just less than 19 mm and wrap this with a sheet of paper 73 mm in width to facilitate introduction into a specimen holder.

8.2.2 *Papers, Scrims, Nonwoven Products, and Felts*—Cut across the machine direction into strips 73 mm in width and long enough to give a mass of 15 ± 0.1 g. Roll these specimens into a scroll with an external diameter just less than 19 mm for insertion into specimen holders.

8.2.3 *Granular or Powdered Products*—To 15 ± 0.1 g specimens add sufficient nonmagnetic diluents, such as those described in A3.5.2, to increase the bulk enough to fill the specimen holder cavity with moderate compaction. Load the diluted specimen into a sample holder in small pinches by means of a funnel, and depress to the required volume by pressing with the stopper or with a tamper. Remove the tamper and maintain the volume required by means of the stopper.

8.2.4 *Asbestos Fiber:*

8.2.4.1 Take an approximately 2-kg [4-lb] sample of asbestos as directed in Test Method D2590 for chrysotile or Test Method D3879 for amphibole fiber.

[6] The apparatus known as the "Turner and Newall Magnetic Analyzer" can be purchased from Turner and Newall Ltd., Asbestos Fiber Laboratory, Trafford Park, Manchester 17, England. Detailed information on the preparation of calibration standards is available from ASTM International Headquarters, 100 Barr Harbor Drive, W. Conshohocken, PA 19428. Request Adjunct ADJD1118.

8.2.4.2 Spread the sample of asbestos fiber on a smooth working surface in layers to form a pile of uniform thickness approximately 10 mm [0.5 in.] thick.

8.2.4.3 Using tweezers, take five 3 ± 0.1-g pinches in small increments, being careful that the total cross section of the pile from top to bottom is taken, including all particles that may have become segregated.

8.2.4.4 Load the specimen into a holder by means of a wide-mouthed funnel, in several pinches, and pack each pinch into place with the spacer rod. Each pinch must include a complete cross section of the specimen and the specimen must not be sprinkled into the funnel. Adjust the height of the specimen with the spacer rod to 73 mm [2⅞ in.], and maintain the height with a stopper.

9. Preparation of Apparatus

9.1 For Mapes type analyzers, energize the apparatus and permit it to warm up for 20 min to become stable. Then balance the secondary coils with the balancing coil until the deflection of the indicating instrument is a minimum at full sensitivity.

9.2 For Turner & Newall[6] type analyzers, turn the sensitivity switch S1A to the MR6 position (see Fig. A2.3), and energize the apparatus with a 115-V, 60 Hz supply. Balance the apparatus by adjusting the balance screw to bring the galvanometer deflection to zero. Throw the sensitivity switch to the MR1 position, and rebalance the apparatus, locking the balancing screw in place.

10. Calibration and Standardization

10.1 For Mapes type analyzers, proceed as in A1.5 to A1.8.7 of Annex A1.

10.2 For Turner & Newall[6] type analyzers, proceed as in A2.8 to A2.8.2 of Annex A2.

11. Conditioning

11.1 Condition all samples (without preconditioning) for a minimum period of 4 h, or until the material shows no progressive change in mass of more than 0.1 % after an exposure of an additional 0.5 h, in an atmosphere having a relative humidity of 50 ± 2 % at 21 ± 1°C.

12. Procedure

12.1 *Using Mapes Type Apparatus:*

12.1.1 Set the analyzer to give full-scale deflection with an MR6 standard, and insert the test specimen holder adjusting its position to produce maximum response.

12.1.2 Note the galvanometer reading.

12.1.3 If a voltage divider is fitted, and if the galvanometer reading is less than half scale, then switch the divider to the appropriate scale, calibrate with the corresponding standard, and determine the magnetic rating of the test specimen under these conditions.

12.1.4 Repeat the above procedure for the other four specimens.

12.2 *Using Turner & Newall*[6] Type Apparatus:

12.2.1 Start with the selector switch in position 10 to establish the proper testing range and carefully insert the loaded specimen tube into the apparatus as far as it will go. If the reading exceeds 3.0 on the upper set of graduations of the meter scale, record the indicated reading as the MR of the specimen to the nearest 0.2 MR unit, otherwise proceed as follows:

12.2.1.1 When the reading in 12.2.1 is less than 3.0, turn the switch to the 3-MR range. If the reading exceeds 1.0 on the lower set of graduations, record the indicated reading as the MR of the specimen to the nearest 0.1 MR unit.

12.2.1.2 When the reading in 12.2.1.1 is less than 1.0, turn the switch to 1-MR range. If the reading exceeds 0.3 on the upper set of graduations, record the indicated reading as the MR of the specimen to the nearest 0.02 MR unit.

12.2.1.3 When the reading in 12.2.1.2 is less than 0.3, turn the switch to 0.3-MR range and record the indicated reading on the lower set of graduations as the MR of the specimen to the nearest 0.01 MR unit.

12.2.2 After obtaining a reading in the above manner, remove the specimen tube, verify the zero point, and recheck the calibration using the appropriate magnetic calibration standard for that range. Reinsert the specimen tube and verify the MR value of the specimen.

12.2.3 Proceed as directed in 12.2.1 and 12.2.2 on the remaining specimens.

NOTE 2—The procedure here described is applicable only under those conditions wherein the magnetic particles being tested exhibit no directional properties or when the particle distribution is such as to give the ultimate in random orientation. The magnetic particles present in chrysotile asbestos, however, are most frequently needle-like or acicular, and as such exhibit directional properties with regard to magnetic permeability. Therefore, there must be an understanding as to the extent of the fibrous characteristics and the grain size distribution of the magnetic particles present in the sample under test if a proper evaluation of the resulting magnetic rating is to be truly factual. In view of the fibrous characteristics of the magnetic particles and the resultant directional magnetic properties, the method of sample preparation and the placement of the sample in the sample holder must be carefully pursued in an endeavor to obtain a test specimen that will exhibit a maximum in random orientation.

13. Calculation

13.1 *Results Obtained on a Mapes Type Analyzer:*

13.1.1 Multiply the galvanometer reading by the value of the standard used to set full-scale deflection of the galvanometer, and divide this product by the maximum scale value produced by the specimen to obtain the magnetic rating of the specimen.

13.1.2 *Example*—Full-scale deflection was set with the MR3 standard. The scale is calibrated from 0 to 100. The reading on the specimen was 62. The magnetic rating is calculated as follows:

$$MR = 3 \times 62/100 = 1.86 \quad (1)$$

14. Report

14.1 Report whether the apparatus used was the Mapes or the Turner & Newall[6], or some other type of apparatus.

14.2 Report the average magnetic rating of at least five specimens for each sample.

14.3 State that the specimens were tested as directed in ASTM Test Method D1118. Describe the materials or products sampled and the method of sampling used.

14.4 Report the average magnetic rating.

15. Precision and Bias

15.1 *Interlaboratory Test Data*[7]—An interlaboratory test was run in 1969 in which 13 samples were each tested in 7 laboratories using 1 operator per laboratory; each operator tested 2 specimens of each sample. All 26 specimens of each material came from the same lot. The components of variance for magnetic rating results expressed as coefficients of variation were calculated to be:

Single-operator component	4.4 % of the average
Between-laboratory component	9.4 % of the average

[7] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D13-1021.

15.2 *Precision*—For the components of variance reported in 15.1 two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences listed below.

Number of Observations in Each Average	Critical Differences Percent of Grand Average for the Conditions Noted[AB] Single-Operator Precision (Repeatability)	Between-Laboratory Precision (Reproducibility)
1	12.2	28.7
2	8.6	27.4
5	5.5	26.6
10	3.8	26.3

[A] The critical differences were calculated using $t = 1.960$ which is based on infinite degrees of freedom.
[B] To convert the values as listed above to units of measure, multiply the average of the two specific sets of data being compared by the critical differences expressed as a decimal fraction.

NOTE 3—The values of the critical differences in this table should be considered to be a general statement particularly with respect to between-laboratory precision. Before a meaningful statement can be made about two specific laboratories, the amount of statistical bias, if any, between them must be established, with each comparison being based on recent data obtained on randomized specimens from one sample of the material to be tested.

15.3 *Bias*—The true value of the magnetic rating of asbestos fibers and textiles can be defined only in terms of a specific test method. Within this limitation, Test Method D1118 for testing magnetic ratings has no known bias.

16. Keywords

16.1 asbestos; magnetic; Mapes; products; rating; test; Turner & Newall

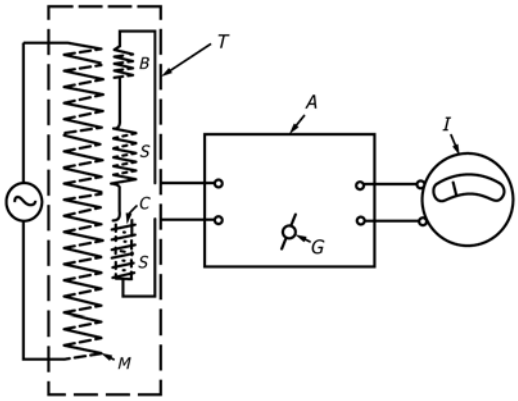
ANNEXES

(Mandatory Information)

A1. MAPES TYPE APPARATUS

A1.1 *Principle of Operation of Apparatus*—A schematic drawing of the apparatus is shown in Fig. A1.1. The apparatus consists of a testing solenoid *T* having a primary winding *M* to produce a strong magnetic field, and secondary windings *S* and *B* to measure the change of flux caused by the specimen, and a Class A audio amplifier, *A*, to increase the signal sufficiently to operate an indicating instrument *I*. This apparatus operates from a 115-V, 60-Hz ac power supply. The secondary winding *S* is wound in two equal sections and connected so that their voltages oppose each other when the primary winding *M* is energized. Coil *B* is used in series with *S* to balance out any small voltage difference between the two sections, so that the voltage to the amplifier is zero when no specimen is in the coil. Under this condition, a small amount of magnetic material in one section of *S* will cause a small voltage at the input to the amplifier due to the increased magnetic flux in that section. This voltage is amplified sufficiently by *A* to be read by instrument *I*. It has been found that the readings of *I* are nearly directly proportional to the magnetic rating up to a magnetic rating of six. The primary and secondary windings of the testing solenoid, the amplifier gain, and the indicating instrument sensitivity can be varied as long as the overall amplification is sufficient to give a full-scale deflection for the standard corresponding to the maximum scale value.

A1.2 *Testing Solenoid*—The testing solenoid shall have a primary winding of 17 layers of 1.45 mm enamelled single cotton covered copper wire (approximately 4200 turns). This coil shall be wound on a compound tube 57.15 mm in outside diameter, with an inside diameter of 50.8 mm, a length of 457 mm, and end flanges 130 mm square by 25 mm in thickness. Inside of and concentric with the primary winding is the main secondary winding. This winding shall be in two sections on a compound tube 50.8 mm in outside diameter, with an inside diameter of 25 mm, and a length of 457 mm having two winding spaces each 76.2 mm in length, with a diameter of 38.1 mm located an equal distance from the ends of the tube and 28.67 mm apart. Each section shall be wound with one



A—Amplifier
B—Balancing coil
C—Test Specimen
G—Amplifier gain control
I—Indicating galvanometer
M—Magnetizing coil
S—Secondary coils
—Alternating current source
T—Test solenoid

FIG. A1.1 Schematic Diagram of the Mapes Analyzer

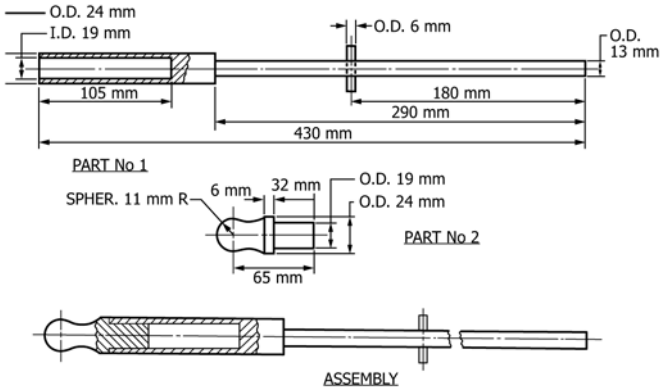


FIG. A1.2 Specimen Holder

layer of 0.254 mm enameled single silk covered copper wire (approximately 220 turns). These coils shall be electrically connected so that their voltages are opposing each other. A small sliding coil, *B*, Fig. A1.1, shall be connected in series with the secondary winding and is used for fine adjustment of the secondary voltage. This coil shall be made to slide in the end of the secondary winding coil form with provision to lock it in place at any position up to 50 mm inside the form. The winding space for the sliding coil shall be 25 mm outside diameter with an inside diameter of 22 mm and a length of 6 mm. The number of turns on this coil is determined during test as follows:

A1.2.1 Energize the primary coil from a 115-V, 60 Hz ac source and measure the voltages across the secondary coils.

A1.2.2 Then connect these coils in series so that their combined voltage is near zero.

A1.2.3 Then, using a more sensitive indicating instrument, remove turns from the stronger section one turn at a time until it is within one turn of being exactly equal to the other section.

A1.2.4 Then wind the sliding coil with a sufficient number of turns so that the sections are exactly balanced at some point within its limits of motion and unbalanced in opposite directions at the extreme positions the sliding coil can take. This final balancing is usually made with the complete analyzer apparatus, and the proper balance is indicated when the indicating instrument will show an appreciable deflection with the balance coil at one extreme of its limits of motion and then decrease to approximately zero and then increase to an approximately equal unbalance as the coil is moved to its other extreme limit.

A1.3 *Test Specimen Holder*—Test specimens shall be placed in a wooden or plastic holder to facilitate setting them in and removing them from the testing solenoid (Fig. A1.2) . This specimen holder shall be slightly less than 25 mm in external diameter so that it will easily slide inside the secondary coil. It shall be made with a handle at one end and a cork at the other end leaving a space 19 mm in diameter by 73 mm in length for the test specimen. The handle shall be made with a stop, and its length shall be such that the specimen holder is centrally located under the nearest section of the secondary winding when the stop is against the solenoid.

A1.4 *Amplifier*—(See Note A1.1.) The amplifier shall be a two-stage resistance-coupled Class A amplifier, using a pentode (type 57) for the first stage and a triode (type 56) for the second stage. The input is transformer coupled with a high secondary-to-primary-turn transformer. The secondary of the input transformer is shunted by a resistance to change from the high sensitivity scale to the low sensitivity scale. This shunt circuit is controlled by a switch mounted on the amplifier panel. The amplifier gain is controlled by varying the screen grid voltage of the type 57 tube with the potentiometer *G*, Fig. A1.1. The indicating instrument *I*, included in the amplifier, is a dc milliampere meter with a sensitivity of 1 ma for a full-scale deflection. This instrument is used with a copper oxide instrument rectifier for use on alternating current. It is coupled to a 30-henry choke in the output of the type 56 tube by means of two 2-μf capacitors.

NOTE A1.1—An amplifier of more recent design with solid state circuitry can be used to advantage.

CALIBRATION AND STANDARDIZATION

A1.5 *Preparation of Standards*—Prepare calibrating standards with MR values of 0.5, 1, 3, and 6 in manner described in Annex Annex A3.

A1.6 *Analyzer Calibration*:

A1.6.1 If the apparatus is fitted with a voltage divider, set this at the most sensitive range, and increase the amplifier gain control to the maximum.

A1.6.2 If the galvanometer does not register zero, this indicates that the two secondary coils are not in complete balance. Balance the secondary coils by moving the balancing coil closer to or farther from one secondary coil until a zero reading on the galvanometer is obtained, as described in A1.2. This setting should not have to be readjusted unless the coils are jolted or some significant parameters have changed.

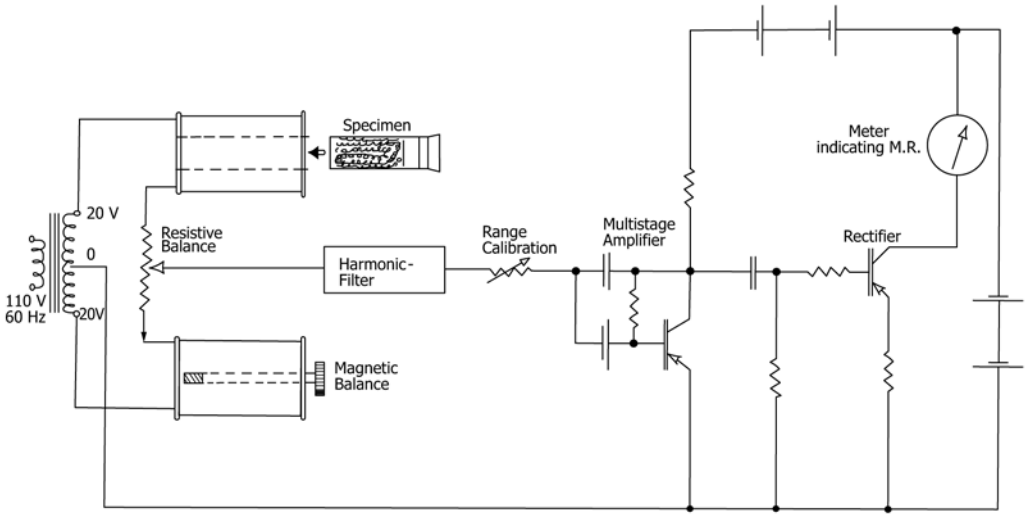


FIG. A2.1 Schematic Diagram of Turner & Newall[5] Magnetic Analyzer

A1.6.3 If a voltage divider is used, set this at the MR1 range.

A1.6.4 Set the amplifier gain control at its minimum value.

A1.6.5 Insert the MR1 standard described in Annex Annex A3, into the core of the proximate secondary coil. Adjust its position to maximize the galvanometer deflection.

A1.6.6 Raise the amplifier gain control until full-scale deflection of the galvanometer results.

A1.7 *Calibration With a Voltage Divider*:

A1.7.1 If a voltage divider is fitted, switch it to the MR3 and MR6 scales and note the galvanometer readings. If these readings are respectively ⅛ and ⅙ of full-scale, then the response of the system may be considered linear. Otherwise, draw a calibration curve which may be used for interpreting galvanometer readings.

A1.7.2 Insert each of the other standards in turn, using the corresponding voltage divider setting and note the resulting galvanometer deflections. If these are all full-scale, then the standards are all acceptable. If some standards are judged to depart too much from their intended value, substitute new standards.

A1.8 *Calibration Without a Voltage Divider*:

A1.8.1 For apparatus not fitted with a voltage divider, or fitted with a voltage divider that does not provide all the ranges corresponding to each calibration standard, proceed as follows:

A1.8.2 Decrease the amplifier gain control to the minimum setting and insert the MR6 standard, adjusting its position to produce maximum galvanometer deflection.

A1.8.3 Raise the amplifier gain control until full-scale deflection results.

A1.8.4 Remove the MR6 standard and insert each of the other standards and note their maximum deflections. These deflections should be 1/12, ⅙, and ½ , respectively, for MR 0.5, 1, and 3 standards.

A1.8.5 Plot galvanometer readings as a function of the nominal MR for each standard. If a straight line is obtained, the system response is linear. Otherwise, the graph may be used to interpret galvanometer readings.

A1.8.6 If individual standards depart significantly from their proportional galvanometer deflections, substitute new standards.

A1.8.7 If the system response is nonlinear, but constant, then an appropriate nonlinear galvanometer scale may be substituted for the linear scale to dispense with the use of the calibration graph.

A2. TURNER & NEWALL[6] TYPE ANALYZERS

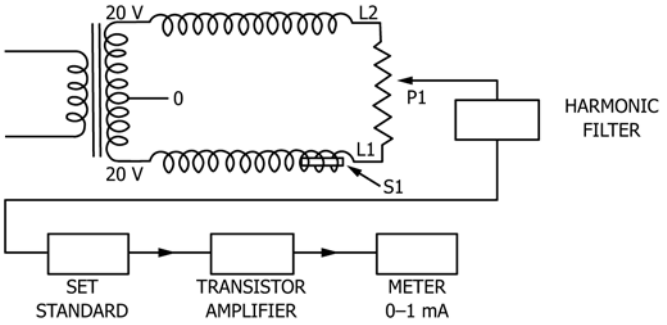


FIG. A2.2 Magnetic Analyzer—Principle of Method

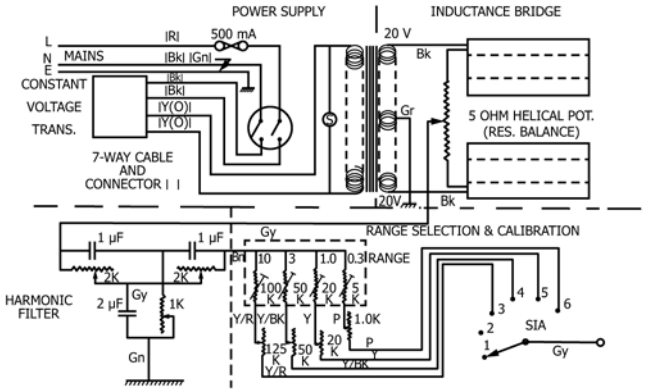


FIG. A2.3 Magnetic Analyzer—Power Supply, Bridge, Harmonic Filter, and Range Selector

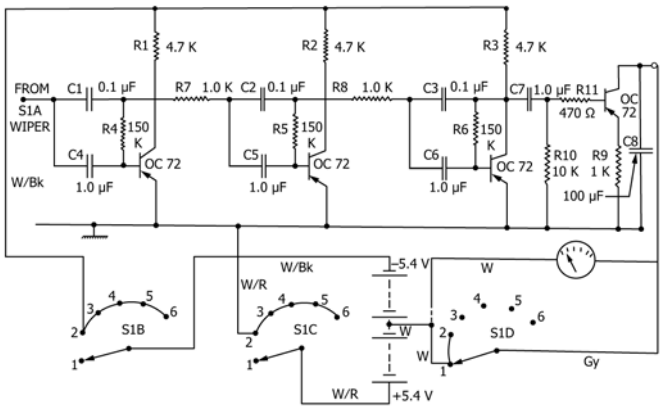


FIG. A2.4 Magnetic Analyzer—Amplifier, Meter, and Switching

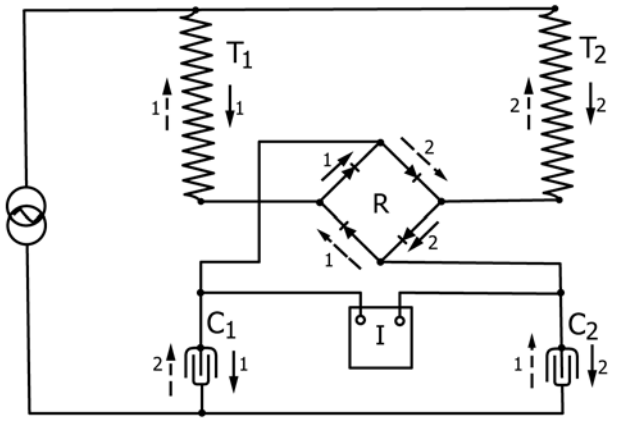


FIG. A2.5 Schematic Diagram of Apparatus

A2.1 *Apparatus*—The apparatus is illustrated in Fig. A2.1, Fig. A2.2, Fig. A2.3, and Fig. A2.4.

A2.2 *Principle of Operation*—A simplified schematic diagram is shown in Fig. A2.5. The apparatus consists of a series-parallel network of two duplicate test coils T_1 and T_2, two duplicate capacitors C_1 and C_2, a rectifying unit R_1 and an indicating instrument I. With an ac voltage impressed on the circuit, the current flow is as indicated by the arrows in Fig. A2.5. Arrows of solid lines indicate the current flow during the positive half cycles, and arrows of dotted lines indicate the current flow during the negative half cycles. A study of this diagram will show that due to the action of the rectifier, capacitor C_1 alternately carries the positive current of coil T_1 and the negative current of coil T_2 while capacitor C_2 alternately carries the positive current of coil T_2 and the negative current of coil T_1. Therefore, if the currents in both coils are equal, a stable condition exists and no current flows in the indicating circuit. If, however, the currents are unequal, a voltage difference will arise between the two capacitors causing a current to flow through the indicating instrument I.

A2.3 *Coils*—The two coils shall be wound on a nonmagnetic and nonconducting coil form approximately 6 in. in length with an inside diameter of 1 to 2 in. and shall have several thousand turns each (Note Annex A1). They shall be as nearly identical in resistance and inductance as is practicable.

NOTE A2.1—In one satisfactory apparatus the coils were layer-wound with 10 000 turns of 0.5 mm enameled copper wire on a spool 171.5 mm in length with an inside diameter of 44.5 mm and having end flanges 10 cm in diameter by 1.6 mm in thickness.

A2.4 *Capacitors*—The capacitors shall be of high quality and have equal reactances (Note Annex A2).

NOTE A2.2—In one satisfactory apparatus the capacitors were 10-μf pyranol capacitors insulated for 330 V, ac.

A2.5 *Rectifying Unit*—The rectifier shall be made from two conventional full wave copper oxide rectifiers as shown in Fig. A2.6. Fig. A2.6(*a*) is the conventional full wave rectifier with the dc terminals marked "+" and "–" and the ac terminals marked "~". Fig. A2.6(*b*) shows the connections to be made between two conventional rectifiers to give the desired rectifying unit for this apparatus. Fig. A2.6(*c*) is a simplified sketch of Fig. A2.6(*b*) corresponding to the sketch of the rectifier unit in Fig. A2.5.

A2.6 *Indicating Instrument*—The details of the indicating instrument are shown in Fig. A2.7. This shall consist of a portable galvanometer G, a resistance network for adjusting the

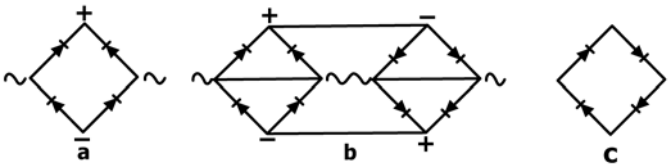


FIG. A2.6 Schematic Diagram of Rectifiers and Connections

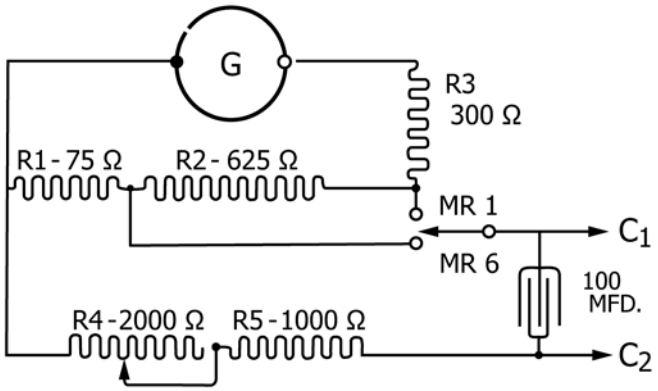


FIG. A2.7 Schematic Diagram of Indicating Instrument

overall sensitivity and for changing the scale range, and a capacitor for bypassing any alternating current that may be present. The galvanometer shall have the following characteristics:

Galvanometer resistance, ohms	50
Period, s	3
Sensitivity, μ amp per 1-mm scale division	0.040
Extreme critical damping resistance, ohms	700
Scale length, mm	100

The resistance network shall be made up of stable resistors having low-temperature coefficients. The values of these resistances are approximate as final adjustment must be made for the particular equipment being used. The capacitor shall be a 50-V electrolytic capacitor.

A2.7 *Test Specimen Holder*—The test specimen holder shall consist of a wooden or plastic tube 25.4 mm in outside diameter, with an inside diameter of 19.05 mm, and a length of 111.125 mm and with two stoppers that extend 19.05 mm into each end of the tube.

A2.8 *Calibration and Standardization*:

A2.8.1 With this apparatus the balance is greatly affected by the proximity of any magnetic materials, as such material changes the inductance of the coils. For this reason magnetic materials should not be used except those that are unavoidable and whose effect can be balanced out, such as the capacitors and the assembly bolts through the rectifier. If these parts are magnetic, the coils shall be mounted with their axes horizontal and parallel, with the capacitors and rectifiers located midway between them. There shall be at least 8 cm between the side of the coils and the capacitors. A simple balancing arrangement consists of a nonmetallic plug, capable of fitting tightly into the end of one of the coils, with a magnetic machine screw through its center. The center of the plug should be drilled and tapped so that the machine screw can be screwed in or out of the coil. A locking nut should be used to hold this screw in place after balance has been obtained. The length and size of this screw can be determined when the procedure described in A2.8.2 is performed.

A2.8.2 For the initial balance, the sensitivity of the indicating instrument must be greatly reduced. This can be done by connecting a variable resistance of approximately 0 to 100 Ω across the instrument connections to the capacitors. Set the resistor at 0, shorting out the instrument, energize the circuit with a 115-V, 60-Hz supply, and then increase the resistance slightly until a few millimeters deflection is obtained on the galvanometer. It will then be found that bringing a magnetic screw near the end of one of the coils will cause the galvanometer deflection to decrease to zero and then reverse as the screw is pushed further into the coil. This indicates that the screw is bringing the coils into balance and then unbalancing them in the opposite direction. Then fit the plug into the desired coil and lock the screw in the position for zero balance. Increase the shunt across the instrument and adjust the balancing screw to maintain the balance until the coils are balanced with the resistance at its highest value. Remove the resistance and readjust the balance. The instrument resistances may now be adjusted to give the desired scale sensitivities. Place an MR1 calibrating standard, as described in Annex A3, in the test coil, throw the sensitivity switch to the MR1 position, and vary *R*4 to give 100-mm deflection. If desired, a smaller variable resistance can be placed in series with *R*4 to give fine adjustment of the sensitivity. Throw the sensitivity switch to the MR6 position and place an MR6 calibrating standard in the test coil. Adjust *R*1 keeping the sum of *R*1 + *R*2 = 700 Ω, until a 60-mm deflection is obtained on the galvanometer. If calibrating standards of other MR values are available, other points on the scale can be checked and a correction curve obtained, although the deflections are nearly directly proportional to the MR values over the range of values used in this apparatus.

A3. CALIBRATION STANDARDS[6]

A3.1 The test method is based historically on measurements determined in terms of the USA National Institute of Standards and Technology (formerly National Bureau of Standards, NBS) standard sample No. 29a of iron ore magnetite.

A3.2 Any standardized iron ore magnetite calibrated against the original standard may be used as a primary calibration standard.

A3.3 Sets of primary calibration standards are held by the various manufacturers of the different types of magnetic analyzers. These are used to standardize the calibration standards supplied with each analyzer.

A3.4 To safeguard the calibration standards, a set of working standards is also supplied with each magnetic analyzer.

A3.5 For those wishing to assemble their own apparatus, secondary and working standards may be prepared as described in A3.5.1 toA3.5.10 . Since the MR values of the calibrating standards may be materially changed by tapping, dropping, or excessive handling (due to segregation and orientation) prepare standards in duplicate. Use one set as working standards and the other as pertinent reference standards.

A3.5.1 To prepare a calibration or working standard, the approximate quantity of approved magnetic standard material shall be dispersed uniformly in a powdered, inert, nonmagnetic material occupying a volume that approximates that of a test sample, namely, a cylinder of internal diameter 19 mm by 73 mm in length. An approved magnetic standard material is one that has the full recognition of the ASTM Committee C-17.

A3.5.2 A powdered aluminum oxide or zinc oxide of analytical grade, containing not more than 0.01 % iron oxides, is deemed to be a suitable inert material. It shall have a particle size distribution such that 100 % passes through a 150 µm (No. 100) sieve and 30 to 40 % is retained on a 74 µm (No. 200) sieve, when a sample of 50 g is sieved for 10 min using sieves in compliance with Specification E11 by the technique described in Test Method D2947.

A3.5.3 Take a suitable clean, nonmagnetic sample container as defined in A3.5.1 and pour into it a quantity of inert material, described in A3.5.2. Fill it to the defined volume and tamp down firmly, but not excessively so.

A3.5.4 Weigh out, in a suitable nonmagnetic weighing scoop, a quantity of standard magnetite calculated on the basis of 0.15 g approved equivalency per unit of MR, to give the required calibration value. Carry out the ensuing operations on a clean, smooth, white surface.

A3.5.5 Return about ⅘ of the entire contents of the sample container, obtained in accordance with A3.5.3, to a 250 or 300 cm^3 clean, borosilicate glass, conical flask and carefully add the contents of the weighing scoop as obtained in accordance with A3.5.4. Add the remaining ⅕ of the contents of the sample container to the weighing scoop to ensure that any adhering particles of magnetic material are taken up. Transfer these 'rinsings' to the conical flask.

A3.5.6 Stopper the flask with a clean, dry, rubber bung of such a diameter that its inner end completely fills the diameter of the neck of the flask and does not therefore present an annular crevice in which any of the particulate can be trapped.

A3.5.7 Shake the flask until, by inspection, it can be seen that the magnetic material has been properly dispersed in the inert material.

A3.5.8 Stand the flask upright and tap it gently to ensure that no material adheres to the rubber bung. Remove the bung, and carefully transfer all contents of the flask to the sample container, tamping down the material periodically so that finally it occupies the length defined in A3.5.1.

A3.5.9 If required, add a plug of clean, dry, absorbent cotton of such a size that when the tube is stoppered there is no unfilled space. Stopper the tube with a cork or rubber stopper.

A3.5.10 Using the procedure described in Annex A1 or Annex A2, check the MR of the standard against the existing primary standard. If the measured value is within 5 % of the required value, attach to the upper end of the sample tube a label bearing the legend “Magnetic Standard” with the value determined, otherwise, reject the standard and repeat the procedure from A3.5.1 starting with new material.